CRWMS/M&O

Design Analysis Cover Sheet

Complete only applicable items.

(1.)

SCPB: N/A

QA: N/A

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2. DESIGN ANALYSIS TITLE		
LAYOUT AND SIZING OF ESF ALCOVES AND REFUGE CHAMBERS		
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14. REMARKS

TBV-210-ESF is associated with ESFDR requirement 3.2.2.4.E.2 and will not be carried down to design output documents.

TBV 061-DD is associated with unqualified drill hole data used in the geologic model (Reference 5.3) and will not be carried down.

2. DESIGN ANALYSIS TITLE	
LAYOUT AND SIZING OF ESF ALCOVES AND REFUGE CHAMBERS	
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5. Revision No.	6. Total Pages	7. Description of Revision
		This document supersedes DI:BABE00000-01717-0200-00003 Rev 01 "TS North Ramp Alcove and Stubout Location Analysis" for the layout and sizing of operation and test alcoves and refuge chambers.
00	33	Initial issue.

1. PURPOSE

The purpose of this analysis is to establish size requirements and approximate locations of Exploratory Studies Facility (ESF) test and operations alcoves, including refuge chambers during construction of the Topopah Spring (TS) loop. Preliminary conceptual layouts for non-deferred test alcoves will be developed to examine construction feasibility based on current test plans and available equipment. The final location and configuration layout for alcoves will be developed when in-situ rock conditions can be visually determined. This will be after the TBM has excavated beyond the alcove location and the rock has been exposed.

The analysis will examine the need for construction of walkways and electrical alcoves in the ramps and main drift. Niches that may be required to accommodate conveyor booster drives and alignments are not included in this analysis.

The analysis will develop design criteria for refuge chambers to meet MSHA requirements and will examine the strategic location of refuge chambers based on their potential use in various ESF fire scenarios. This document supersedes DI:BABE00000-01717-0200-00003 Rev 01, "TS North Ramp Alcove and Stubout Location Analysis" in its entirety (Reference 5.6).

2. QUALITY ASSURANCE

This analysis covers the layout and size of test support and operation support alcoves. These alcoves are permanent but are not classified QA 1-7 (i.e. non-Q) by QAP-2-3. The non-Q status of these alcoves is discussed in the QA Classification Analysis of Test Support Areas (CI: BABEAF000) (Reference 5.29) and the Operation Support Areas (CI: BABEAE000) (Reference 5.30). There are no Q controls discussed in this analysis. The appropriate classification of this analysis is QA "None".

Controls associated with the field determined location and timing of construction of test support areas is not within the scope of this analysis.

3. METHOD

Analytical methods are used to establish the configuration and approximate location of the alcoves.

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

4.1.1 The analysis entitled ESF Layout Calculation (Reference 5.13) is used to determine the general layout of the ramps and main drift and provides station orientation and excavation slope.

4.1.2 The projected intersection of the geological contacts and structures in the ramps and main drift are used to approximately locate the test support and operation support alcoves. These data are taken from the Geology of ESF TS Loop (Reference 5.3, p. 29) and are shown in Table 1.

Table 1 Intersection of geological contacts and structures in the main tunnel

Name of Contact (Thermal/Mechanical Units) or Fault Structure	Approximate Station No. From North Ramp Portal
Lower Paintbrush nonwelded (PTn)/ Topopah Spring welded (TSw1) Contact @ North Ramp	11+40
Drill Hole Wash Fault @ North Ramp	21+50
Sundance Fault @ TS Main Drift (Basis for approximately locating intersection of Ghost Dance/Sundance Faults)	36+35
Abandoned Wash Fault @ TS Main Drift	57+10
Dune Wash Fault @ South Ramp	67+60
Drill Hole Wash Fault @ North Ramp Extension	11+00 (Scaled from model)

4.1.3 The determination of preliminary test alcove layouts, approximate location, size and configurations are based on communication letters (References 5.8, 5.9, 5.10, 5.20, 5.21 & 5.22) from the ESF Test Coordinating Office (TCO) to Civilian Radioactive Waste Management System Management and Operating Contractor

(CRWMS M&O). The following items are specific requirements derived from these references:

a) A 16 m offset is required from any borehole to the nearest point along the main tunnel (Ref. 5.20)

b) The TCO has requested space be provided for a work station and communication point and space for test equipment storage in the vicinity of Alcove 3 or 4 (Reference 5.21, Page 1). Similar space will be needed in the vicinity of Alcove 7.

c) The size and configuration of test alcoves will be based on the use and operation of drilling and test equipment such as the Casagrande C5S, Longyear 38, and Longyear 65 for core drilling, including a 7.5 hp dust collector, a 20 hp compressor, a working table and tools. (Reference 5.22, Attachment Page 1 and Reference 5.5).

d) Hydrologic Properties of Major Fault (HPMF) testing requires an alcove large enough to drill three 30 m boreholes in an equilateral triangle drill pattern that could be as large as 5 meters on a side. This pattern is drilled perpendicular to the fault. (Reference 5.8, Attachment 2, Page 3) (Reference 5.9, Attachment 2, Page 15 and 16).

e) Another HPMF test alcove also requires three 30 m boreholes drilled parallel to the fault. Two of the three holes are on each side of the fault approximately 3 meters; the third hole is in the fault trace (Reference 5.8, Attachment 2, Page 3) (Reference 5.9, Attachment 2, Page 15).

f) The collar of an HPMF borehole perpendicular to the fault is approximately 20 m from the fault zone (Reference 5.10, Page 2).

g) Unless otherwise specified, Alcove 6 will be constructed to intercept the intersection of the Ghost Dance and Sundance faults (Reference 5.9, Attachment 2, Page 13).

h) Unless otherwise specified, Alcove 7 will be constructed approximately midway between Alcove 6 and Station 60+00 to intercept the Ghost Dance fault (Reference 5.9, Attachment 2, Page 13).

4.1.4 From the U.S. Bureau of Mines "Development Guidelines for Rescue Chambers" (Reference 5.19), the established escape speed for personnel walking to a place of refuge is 1.52 m/s (300 feet per minute) in an underground opening greater than 2 m (80 inches) of tunnel height. The use of a self-rescuer reduces the travel speed by 15 percent, and poor travel conditions (loose ground, pools of water) further reduces the speed another 10 percent.

4.2 CRITERIA

The criteria developed in this analysis incorporate applicable Exploratory Studies Facility Design Requirements (ESFDR) (Reference 5.1) for underground test support and operation support alcoves. Specific ESFDR requirements are cited for each criteria statement.

4.2.1 The ESF shall be located, designed, constructed, and operated in a manner that protects the health and safety of the workers and the public, as specified in 30 CFR 57. [ESFDR 3.2.1.W, 3.2.1.19.1.B, 3.2.1.19.2.E.1, 3.2.1.19.2.E.2, 3.2.1.19.2.E.3, 3.2.1.19.3.B, 3.2.1.28.C, 3.2.2.4.I] .

4.2.2 Underground openings and operations shall meet personnel movement requirements. [ESFDR 3.2.2.4 E]

4.2.3 During in-situ site characterization testing, underground facilities shall be provided for at least 10 visitors at one time. (TBV-210-ESF) [ESFDR 3.2.2.4 E2]

For establishing potential occupancy of refuge chambers, the Architect/Engineer has determined that providing space for 10 visitors is adequate.

4.2.4 Refuge chambers with sufficient capacity and facilities to accommodate personnel underground and to meet all applicable Mine Safety and Health Administration (MSHA) requirements, shall be provided. [ESFDR 3.2.2.4.I.9]

4.2.5 The alcoves are to be constructed and operated with industry standard items and readily available technology. The alcove layout and size will provide flexibility to accommodate specific site conditions identified through in-situ monitoring, testing, or excavation. Components are selected to minimize the number of standard tools required for installation and maintenance. [ESFDR 3.2.1.K, 3.2.2.4.F, 3.2.2.4.P, 3.2.9.4.E]

4.2.6 The interface concerns from testing, repository design, and other affected participating organizations are to be handled during the normal course of design review. These organizations are to participate in the inter-discipline or external reviews of this design document. (ESFDR 3.2.1.Z, 3.2.1.Z.1, 3.2.1.4.H, 3.2.1.6.E, 3.2.1.6.F, 3.2.1.9.4.C.1, 3.2.2.G, 3.2.2.4.L.7, 3.2.2.4.P.2)

4.2.7 The test and operations support alcoves are to be designed to provide access for routine maintenance. The alcoves are to be designed with maintainability issues considered to the extent practical, with accommodation of initial equipment installation and facility operation. (ESFDR 3.2.1.9.3.C.1a)

4.2.8 The test alcoves are to be designed to meet the needs of site characterization testing and performance confirmation programs. (ESFDR 3.2.1.D, 3.2.1.I.1, 3.2.1.I.4, 3.2.1.K, 3.2.1.AA.4, 3.2.1.AA.5, 3.2.1.6, 3.2.2.4.B.2, 3.2.2.4.C, 3.2.2.4.C.1, 3.2.2.4.C.3, 3.2.2.4.C.4, 3.2.2.4.C.10, 3.2.2.4.D, 3.2.2.4.D.12, 3.2.2.4.D.15.a, 3.2.2.4.D.17, 3.2.2.4.E, 3.2.2.4.P, 3.2.9.A, 3.2.9.4.D, 3.2.9.4.D.3, 3.2.9.4.D.4)

4.2.9 The test and operations support alcoves are to be designed to facilitate control and collection of water. (ESFDR 3.2.2.4.D.4, 3.2.2.4.O.3, 3.2.2.4.S.8)

4.2.10 All coordinates used in the alcove design shall be in accordance with Nevada State Plane Coordinate system. (ESFDR 3.2.2.C)

4.2.11 Applicable requirements from Appendix B of the ESFDR and letters from the ESF TCO (Reference 5.8, 5.9, 5.10, 5.20, 5.21, and 5.22) are to be considered in the design of the test alcoves. (ESFDR B.2.6.3.A.2, B.2.6.3.B.2, B.2.12.3.A, 3.2.2.4.C.1, 3.2.2.4.D, 3.2.2.4.G, 3.2.2.4.P, 3.2.2.4.C.4)

4.2.12 Where feasible, refuge chambers may be co-located with test alcoves upon approval of the ESF TCO to minimize underground excavations to the extent practical. [ESFDR 3.2.2.4.D.11, 3.2.2.4.I.9, 3.2.2.4 B.]

4.2.13 The ESF is designed to accommodate a nominal scientific work force of 100 persons during full test operations. (ESFDR B.3.1.3.A)

4.2.14 Peak scientific manpower, on day shift the first few months after the Main Test Level Core Test Area (MTL CTA) test locations become available, is estimated to be 120 people distributed in all areas. (ESFDR B.3.1.3.B)

4.3 ASSUMPTIONS

This analysis will be subjected to an internal discipline and external review process and effected project participants will have the opportunity to review and accept the assumed data. That will provide adequate verification of the assumptions for the purposes of this analysis.

4.3.1 The minimum standard access drift to a test room from the main tunnel is 3.7 m wide x 3.7 m high based on the capability of the available mining equipment and the previous drift design packages accepted and constructed. (Reference 5.27). This size for a standard access drift has been adequate in the past and it is assumed that the minimum access drift size of 3.7 m by 3.7 m will be adequate in the future.

4.3.2 The size of refuge chambers is based on the following distributed population:

a) A total of 21 underground construction personnel (Reference 5.2).

b) A total of 15 support personnel consisting of management, engineering, quality control, safety, surveyor, etc. This data has been accepted by the project office (Reference 5.6).

c) A total of 10 working scientific personnel (Reference 5.4).

4.3.3 The ESF tunnel is generally constructed of noncombustible materials for potential fire to be limited generally to excavation and transportation equipment (Reference 5.11). Although fire protection will be provided for these equipment (Reference 5.12), the potential exists for a fire spreading smoke in the entire length of the tunnel. In such an emergency situation, entrapped personnel can take refuge in a refuge chamber for a period conservatively estimated to be up to 48 hours while the emergency situation is corrected.

4.4 CODES AND STANDARDS

4.4.1 30 CFR 57 - Safety and Health Standards - Underground Metal and Nonmetal Mines, July 1, 1994

1. Shelter holes shall be provided at intervals adequate to assure the safety of persons along underground haulageways where continuous clearance of at least 762 mm (30 inches) cannot be maintained from the farthest projection of moving equipment on at least one side of the haulageway, and at least four feet wide, marked conspicuously, and provide a minimum 1016 mm (40 inches) clearance from the farthest projection of moving equipment (57.9360.a.1 & 2).

2. Safe means of access shall be provided and maintained to all working places (57.11001).

3. Every mine shall have two or more separate, properly maintained escapeways to the surface from the lowest level which are so positioned that damage to one shall not lessen the effectiveness of the others. A method of refuge shall be provided while a second opening to the surface

is being developed. A second escapeway is recommended, but not required, during the exploration or development of an orebody (57.11050.a).

4. In addition to separate escapeways, a method of refuge shall be provided for every employee who cannot reach the surface from the working place through at least two separate escapeways within a time limit of one hour when using the normal exit method. These refuges must be positioned so that the employee can reach one of them within 30 minutes of leaving the workplace (57.11050.b).

5. Refuge areas shall be -

   a) Of fire-resistant construction;
   b) Large enough to accommodate readily the normal number of persons in the particular area of the mine;
   c) Constructed so they can be made gastight; and
   d) Provided with compressed air lines, waterlines, suitable handtools, and stopping materials.

   (57.11052).

6. Telephone or other voice communications shall be provided between the surface and refuge chambers and such systems shall be independent of mine power supply (57.11054).

4.4.2 29 CFR 1926 - OSHA Safety and Health Regulations for Construction, July 1, 1994

1. The employer shall provide and maintain safe means of access and egress to all work stations (1926.800.b.1).

2. The employer shall provide access and egress in such a manner that employees are protected from being struck by excavators, haulage machines, trains and other mobile equipment (1926.800.b.2)

4.4.3 California Tunnel Safety Orders (8 CCR 8400 et seq)

Mandatory compliance with California Tunnel Safety Orders is no longer required at the Yucca Mountain Site Characterization Project per Department of Energy Memorandum on March 22, 1995 (Reference 5.14).

5. REFERENCES

5.1 Exploratory Studies Facility Design Requirements, YMP/CM -0019, Rev. 1 ICN 2

5.2 Transportation of People and Supplies Exploratory Studies Facility (ESF) Construction and Operation, DI: BABFCC000-01717-6700-00002 REV 01

5.3 Geology of the Exploratory Studies Facility TS Loop, DI:BAB000000-01717-0200-00002 REV 00 (TBV-061-DD)

This TBV will not be carried down. It is based on the use of unqualified data in the geologic analysis. Qualification of this data is not required for the non-Q use in this analysis.

5.4 Letter TWS-EES-13-LV-02-93-29, Oliver to Engwall, "Starter Tunnel and North Ramp ESF and Common Support for Scientific Personnel Access," February 25, 1993

5.5 Casagrande C5S Core Drill Drawing No. 8-535001, 33074 Fontanafredda (pn), Italy, September 1994

5.6 TS North Ramp Alcove and Stubout Location Analysis, DI: BABE00000-01717-0200-00003 REV 01

5.7 Not Used

5.8 Letter LA-EES-13-LV-03-94-026, Elkins to Segrest, "Transmittal of Design and Test-Related Information for Design and Construction of Exploratory Studies Facility North Ramp (Design Package 2C) (SCPB/NA)," March 23, 1994

5.9 Letter LA-EES-13-LV-09-94-016, Elkins to Segrest, "Transmittal of Design and Test-Related Information for Design and Construction of Exploratory Studies Facility Design Package 8A (Topopah Spring Main Drift) (SCPB: N/A)," September 15, 1994

5.10 Letter LA-EES-13-LV-03-95-006, Hollins to Segrest, "Transmittal of Design and Test-Related Information for Excavation of Exploratory Studies Facility (ESF) Alcove 2 (SCPB:N/A)," March 2, 1995

5.11 Subsurface Fire Hazard Analysis, DI: BABFAH000-01717-0200-00121 REV 00

5.12 Subsurface Fire Protection Design Analysis, DI: BABFAH000-01717-0200-00114 REV 00

5.13 ESF Layout Calculation, DI:BABEAD000-01717-0200-00003 REV 02.

5.14 DOE Memorandum from Tara O'Toole to Robert M. Nelson: Approval of Yucca Mountain Site Characterization Project (YMP) Exemption from California Tunnel Safety Orders dated March 22, 1995

5.15 Letter LV.SES.HHS.11/94-030, Foust to Nelson, "Submittal of Interim Report on the Value Engineering Study for the Electrical Niches and Walkways," Deliverable Number TM 147, Contract No. DE-AC01-91RW00134, November 4, 1994

5.16 Starter Tunnel General Arrangement Plan (Sht. 2), DI:BABEA0000-01717-2100-10121 REV 03 (Drawing No YMP-025-1-MING-MG121 REV 3)

5.17 Letter LV-ES.PE.CJN.04/95.039, Nesbitt to Segrest, "ESF Electrical Niches and Walkways," April 27, 1995

5.18 The World Book Encyclopedia (Volume 21, p. 14), World Book Inc., 1990

5.19 Development of Guidelines for Rescue Chambers, Volumes 1 and 2, U.S. Department of Interior, Bureau of Mines Final Report on Contract J0387210 2, October 1983

5.20 Letter LA-EES-13-LV-04-95-050, Hollins to Segrest, "Transmittal of Design and Test-Related Information for Design and Construction of Exploratory Studies Facility Alcoves 3 and 4 (SCPB:NA)," April 28, 1995

5.21 Letter LA-EES-13-LV-04-95-047, Hollins to Segrest, "Test Coordination Office Underground Work Station and Storage Facilities for Equipment/Parts in the Exploratory Studies Facility North Ramp (SCPB: 8.3.1)," April 25, 1995

5.22 Letter LA-EES-13-LV-04-95-046, Hollins to Segrest, "Transmittal of Utility Requirements for Exploratory Studies Facility Bow Ridge Fault Alcove (SCPB:NA)," April 25, 1995

5.23 Specification Section 16475, Subsurface Substation (Packaged Equipment), CI.16.4000, DI: BABFAA000-01717-6300-16475 REV 02

5.24 Specification Section 16312, Subsurface Medium Voltage Switchgear, CI.16.4000, DI: BABFAA000-01717-6300-16312 REV 03

5.25 Letter LA-EES-13-LV-07-95-031, Hollins to Segrest, "Alcove #3 Final Design and Arrangements of Exploratory Studies Facility (SCPB:NA)," July 28, 1995

5.26 Letter LA-EES-13-LV-07-95-001, Hollins to Segrest, "Approval of Collocating a Refuge Chamber with a Test Alcove in the Exploratory Studies Facility (SCPB:N/A)", July 7, 1995

5.27 ESF Alcove Ground Support Analysis, BABEE0000-01717-0200-00001 REV 01

5.28 Subsurface General Construction Analysis, DI:BAB000000-01717-0200-00148 REV 00

5.29 QA Classification Analysis of Test Support Areas (CI: BABEAF000), DI:BABEAF000-01717-2200-00001 REV 00

5.30 QA Classification Analysis of Operation Support Areas (CI: BABEAE000), DI:BABEAE000-01717-2200-00001 REV 00

6. USE OF COMPUTER SOFTWARE

Not Used.

7. DESIGN ANALYSIS

This analysis establishes a standard nominal size and presents preliminary conceptual layouts of ESF alcoves. The analysis identifies the approximate location of test alcoves and examines their potential use as refuge chambers. An examination of the feasibility of co-locating refuge chambers with test alcoves is presented in this analysis.

Final alcove layout design is not within the scope of this analysis. Final layouts will be developed after the TBM has excavated past the location where the alcoves will be constructed. Actual in-situ conditions are required to support development of final test plans and ground support requirements. In this analysis approximate locations are determined and preliminary conceptual layouts are developed for the non-deferred test alcoves to examine feasible construction criteria for the alcoves.

This analysis only discusses the currently non-deferred test alcoves. However, any other standard alcoves that may be required in the future would be bounded by this analysis. Additionally, this analysis would be applicable to a Heater Test Alcove, if testing requirements fit within the alcove dimensions discussed here. If not, a separate layout and sizing analysis will need to be developed to support the Heater Test Alcove. Requirements for the heater test are not known at this time.

7.1 TEST SUPPORT ALCOVES

Test support alcoves in the ESF will provide a location for testing geologic features. This portion of the analysis determines preliminary test room size and conceptual layout for those alcoves considered to be non-deferrable.

Seven non-deferred test alcoves have been selected by the TCO at this time. Additional alcoves will most likely be selected in the future. Other documents address alcoves 1, 2, 3 and the conceptual layout of Alcove 4. These alcoves are mentioned here for continuity. The locations shown for the remaining non-deferred test alcoves 4, 5, 6, and 7 are based on the approximate intercept of geohydrological contacts and structures with the main tunnel.

Test rooms will allow the test community to drill coreholes in selected geologic features. The test room dimensions need to be sized to allow core drilling in a pattern specified by the TCO. The layouts presented in this analysis are conceptual at this time. The design of the final layout will be accomplished after the TBM has excavated past the potential alcove break out location and actual in-situ conditions can be determined.

The size of access drifts will be standardized for all alcoves. This will improve the efficiency of design and construction of the alcoves. The standard minimum access drift to all test rooms will have an arched roof and will be sized a nominal 3.7 m wide by 3.7 m high (Design Input, Section 4.3). Operation support alcoves will also be in arched roof and sized a nominal 3.7 m wide by 3.7 m high. This size has been used for previously developed alcoves and is well suited for utilizing standard equipment and tools for alcove construction.

The maximum access drift dimension will be 6 m wide by 4.4 m high at the intersection with the main tunnel. A width of 6 m for access drifts is the same as the width of the test rooms and is wide enough to allow for a small modular room as work station (Design Input, Section 4.1 and Reference 5.27). The height of 4.4 m will be the access drift standard maximum height. This height allows for alcove break out from the main tunnel in areas where steel sets are installed.

The angle between the alcove centerline and the main drift centerline should nominally be between 45 and 90 degrees. The alcove ground support analysis has determined this range to include an acceptable break-out angle for ground support design (Ref. 5.27). The preferred nominal grade would be +1.0% (±0.5%) for the alcoves. However, site specific criteria and test requirements may necessitate different grades. Standard water control methods can be used for controlling water in alcoves that have negative grades.

Based on currently known test plans, the HPMF drill room with three 30 m boreholes perpendicular to the fault has a nominal size of 6 m wide by 7 m high. Depth will depend upon the fault structure and will be field determined by the TCO. The second HPMF drill room with three 30 m boreholes parallel to the fault has a nominal size of 6 m wide by 5 m high. The depth of this alcove will also depend upon the fault structure and will be field determined as required by the TCO. Both rooms are sized to allow the Casagrande C5S to drill and maneuver fairly easily. The C5S is the largest piece of equipment that should have to maneuver in the test room (Attachment I). These dimensions will allow drilling the borehole patterns as requested by the TCO in their criteria letters (Design Input, Section 4.1).

7.1.1 Starter Tunnel Test Alcove 1

The starter tunnel alcove is located at Station 00+43. This alcove was completed during Package 1A construction. The layout and size of Alcove 1 are shown on Starter Tunnel General Arrangement Plan (Reference 5.16).

7.1.2 Hydrologic Properties of Major Fault (HPMF), Bow Ridge Test Alcove 2

The layout of the Bow Ridge Fault test Alcove 2 is based on TCO requirements and is located at Station 01+68.2. The layout and size are found in the ESF Ground Support Analysis (Reference 5.27).

7.1.3 Radial Borehole Test (RBT) Alcove 3, Tiva Canyon & Upper Paintbrush Contact

The layout of RBT test Alcove 3 is based on TCO requirements and is located at Station 07+54 (Reference 5.25). The layout and size are found in the ESF Ground Support Analysis (Reference 5.27).

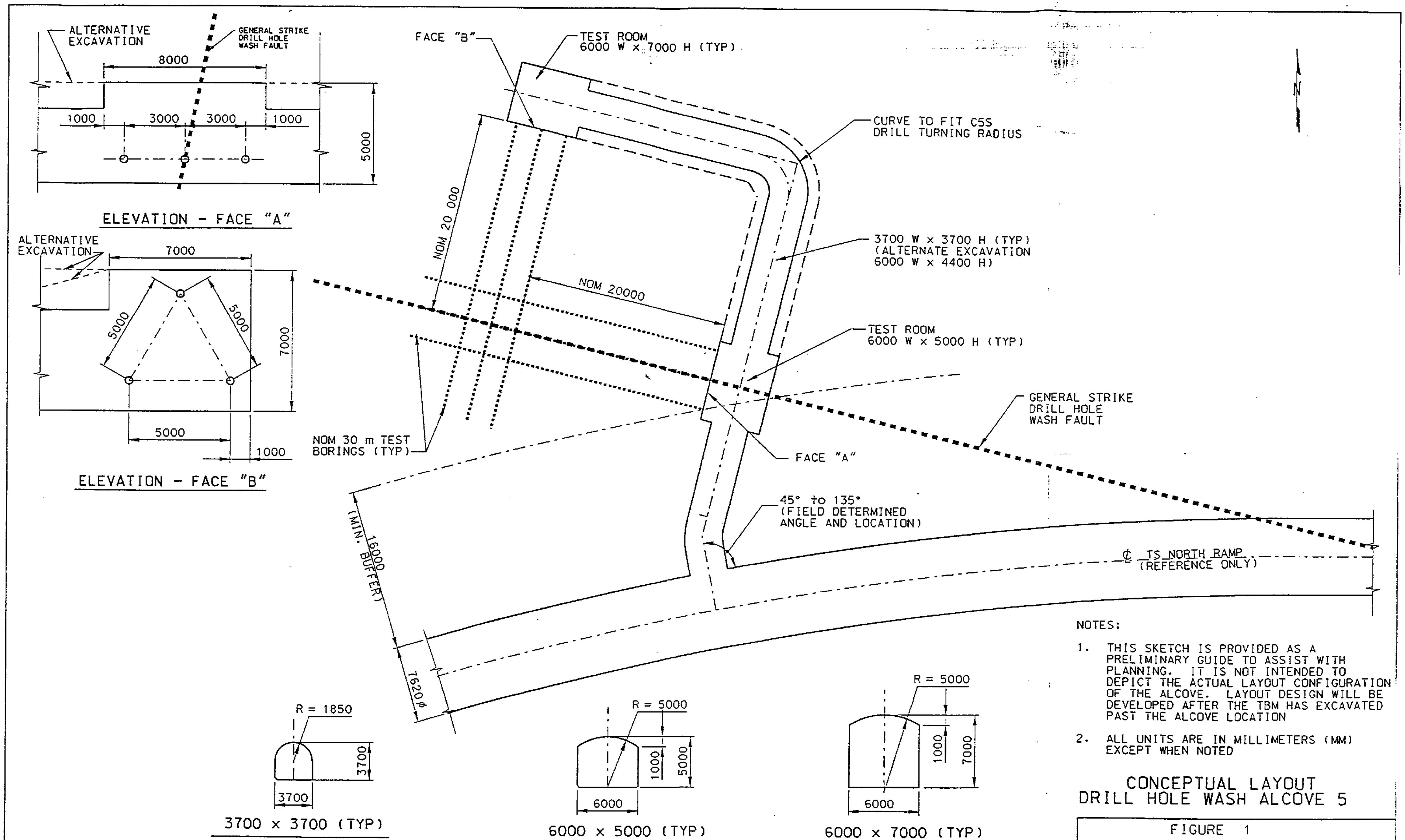
7.1.4 RBT Test Alcove 4, Upper Paintbrush & Topopah Spring Contact

The layout of RBT test Alcove 4 is based on TCO requirements and will be located at approximately Station 11 + 40 (Design Input 4.1). The layout and size are found in the ESF Ground Support analysis (Reference 5.27).

7.1.5 HPMF Test Alcove 5, Drill Hole Wash Fault

The Drill Hole Wash structure has been identified as a projected major fault that will require testing. Current information indicates that the North Ramp will intersect the main Drill Hole Wash fault in an acute angle at approximately Station 21+50 (Ref. 5.3). To meet the TCO requirement of maintaining a 16 m buffer zone from the end of the test corehole to the main drift the alcove will need to be located at some distance from the fault intercept with the main drift. This location might be near station 22+30.

The design of Alcove 5 will require considerable flexibility. The geohydrologic parameters that will decide the alcove's final location and configuration can only be determined after passing through the fault with the TBM and in-situ conditions can be determined for use in final layout design. Figure 1 shows a general conceptual layout developed for the Drill Hole Wash Fault test alcove which will satisfy the preliminary TCO requirements.



NOTES:

1. THIS SKETCH IS PROVIDED AS A PRELIMINARY GUIDE TO ASSIST WITH PLANNING. IT IS NOT INTENDED TO DEPICT THE ACTUAL LAYOUT CONFIGURATION OF THE ALCOVE. LAYOUT DESIGN WILL BE DEVELOPED AFTER THE TBM HAS EXCAVATED PAST THE ALCOVE LOCATION
2. ALL UNITS ARE IN MILLIMETERS (MM) EXCEPT WHEN NOTED

CONCEPTUAL LAYOUT
DRILL HOLE WASH ALCOVE 5

FIGURE 1

16-AUG-1995 09:21

/proj/esf_ss/mine/mosk/ss-m-sk136.dg

7.1.6 HPMF Test Alcove 6, Ghost Dance/Sundance Faults

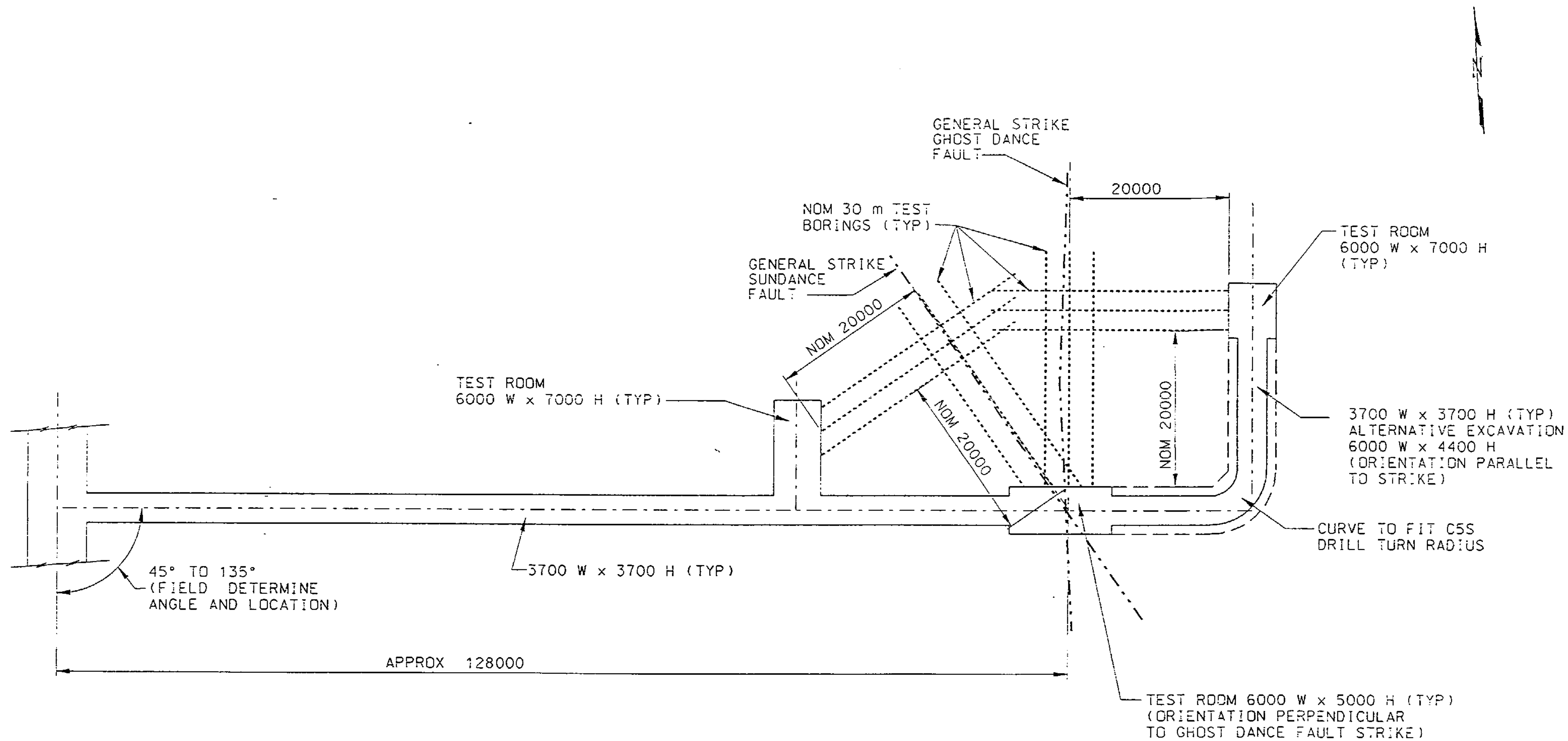
Alcove 6 will be constructed to give the TCO access to a fault zone comprised of two faults, the Ghost Dance fault and the Sundance fault. Preliminary test requirements from the TCO indicate that access to the intersection of the fault zone is preferred. Projected information shows that the TS Main Drift will intersect the Sundance fault system at approximately Station 36+35. Current information indicates that the Sundance fault structure will intersect the Ghost Dance fault trace at approximately 128 m east of the TS Main Drift. By graphical interpretation of the structures (Reference 5.3) the shortest distance to the fault intersection from the main drift will occur at approximately station 38 + 25. Figure 2 shows a conceptual layout which would satisfy the preliminary test requirements.

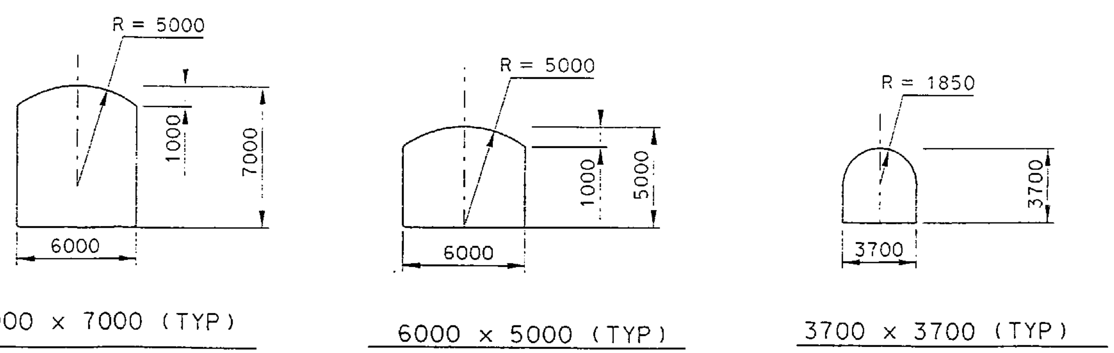
The TCO may allow geothermal boreholes ahead of the access drift towards the intersection of the Ghost Dance and Sundance faults. The geothermal boreholes will help determine the appropriate drift approach or direction and characterization of Test Alcove 6.

7.1.7 HPMF Test Alcove 7, Ghost Dance Fault

A second characterization of the Ghost Dance structure has been identified for HPMF testing. Unless otherwise specified, Alcove 7 will be constructed approximately midway between Alcove 6 and Station 60+00 to intercept the Ghost Dance fault (Design Parameter, Section 4.1). The design parameter dictates the approximate location of Alcove 7 to take off from the TS Main Drift between Station 48+50 and 49+50. For the preliminary purpose of this analysis and based upon previously used design data, Station 48+50 is selected.

A conceptual layout for Alcove 7 is presented on Figure 3. The conceptual layout would satisfy the TCO requirements for HPMF corehole drilling at this location. The TCO may also allow geothermal boreholes ahead of the access drift towards the location of the Ghost Dance fault to help determine the appropriate drift approach or direction and characterization of Test Alcove 7.





NOTES:

1. THIS SKETCH IS PROVIDED AS A PRELIMINARY GUIDE TO ASSIST WITH PLANNING. IT IS NOT INTENDED TO DEPICT THE ACTUAL LAYOUT DESIGN OF THE ALCOVE. LAYOUT CONFIGURATION WILL BE DEVELOPED AFTER THE TBM HAS EXCAVATED PAST THE ALCOVE LOCATION.

2. ALL UNITS ARE IN MILLIMETERS (MM) EXCEPT WHEN NOTED

CONCEPTUAL LAYOUT
GHOST DANCE/SUNDANCE FAULTS ALCOVE 6

FIGURE 2

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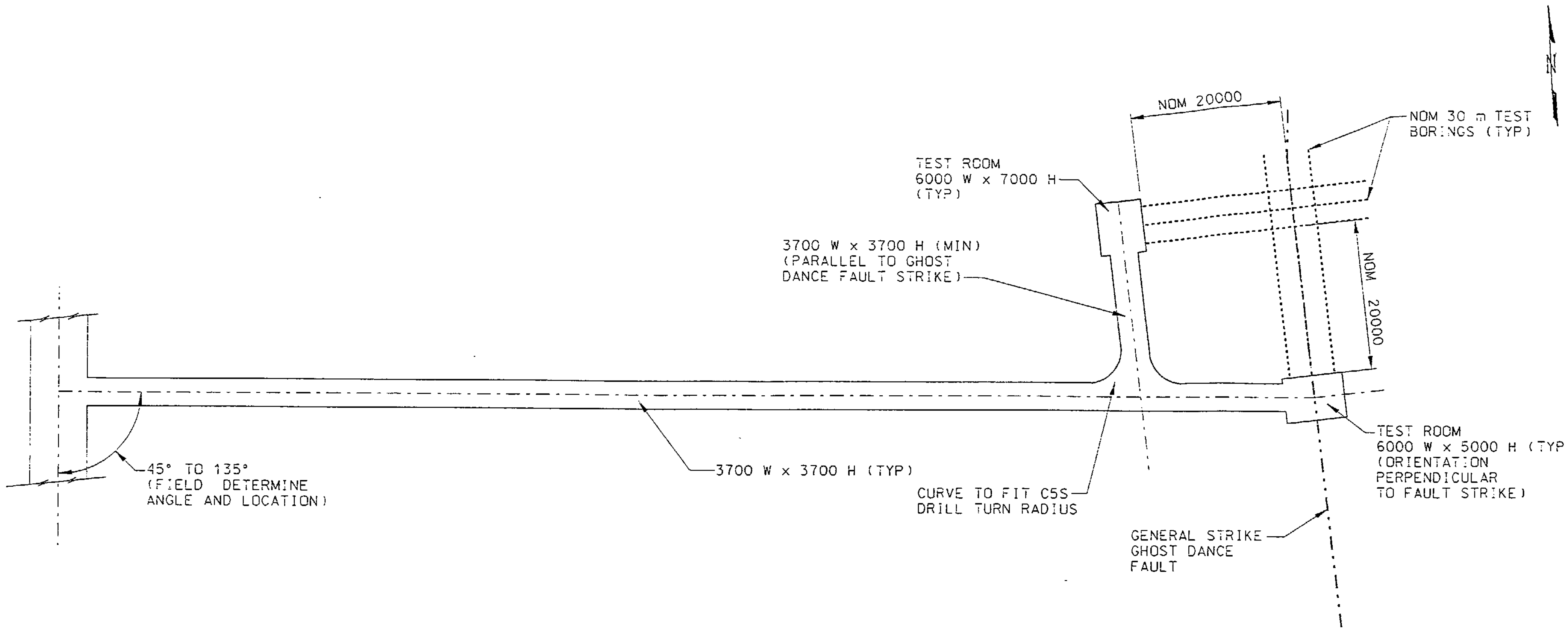

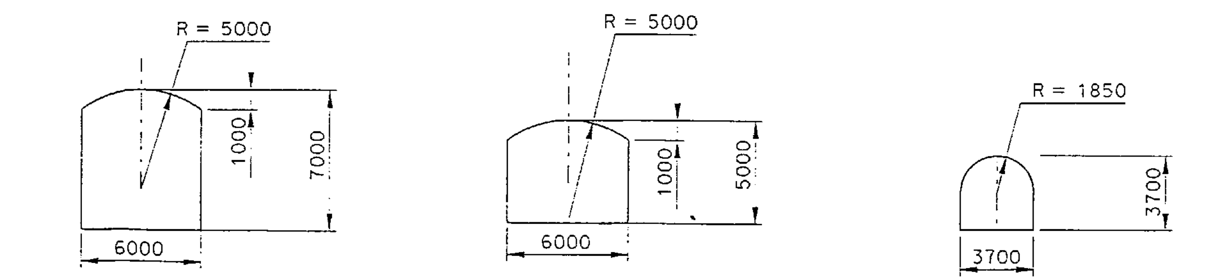

6000 x 7000 (TYP)

6000 x 5000 (TYP)

3700 x 3700 (TYP)

NOTES:

1. THIS SKETCH IS PROVIDED AS A PRELIMINARY GUIDE TO ASSIST WITH PLANNING. IT IS NOT INTENDED TO DEPICT THE ACTUAL LAYOUT CONFIGURATION OF THE ALCOVE. LAYOUT DESIGN WILL BE DEVELOPED AFTER THE TBM HAS EXCAVATED PAST THE ALCOVE LOCATION.

2. ALL UNITS ARE IN MILLIMETERS (MM) EXCEPT WHEN NOTED

CONCEPTUAL LAYOUT
GHOST DANCE FAULT ALCOVE 7

FIGURE 3

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7.2 OPERATIONS SUPPORT ALCOVES

Operations support alcoves in underground work include excavations such as shelter holes, refuge chambers, sumps and electrical niches. The original package 2C design included a number of these types of openings. The need for these alcoves is reevaluated here to determine if the number of operations support alcoves can be reduced and still support the construction and the test program in a safe manner while minimizing the impacts on TBM operation, cost, and schedule.

7.2.1 Elevated Walkways and Shelter Holes

The elevated walkway has been removed from the design of the ESF facility. A value engineering study (Reference 5.15) recommended the elimination of the elevated walkway to save unnecessary cost and schedule impacts. This recommendation has been implemented. Since the elevated walkway is not provided, it should be determined if the ESF will meet with the applicable Federal regulations for providing a safe underground walkway. MSHA 30 CFR 57.9360 requires shelter holes along haulage ways where minimum 0.76 m of clearance cannot be maintained from the farthest projection of moving equipment. OSHA 1926.800(b)(2) requires access to all work stations be provided in such a manner that employees are protected from being struck by haulage machines and trains. The ESF tunnel rail configuration has three sets of usable track inside a 3657 mm wide by 3657 mm high transportation envelope. Trains can travel on the left, right or center tracks. Unless two trains are passing on the left and right tracks, there will always be sufficient space on the tunnel invert for pedestrians to stand at least 0.76 m away from any moving train.

The conveyor is the normal means of muck haulage. Trains moving in and out of the tunnel will be transporting supplies and personnel to the working area. Most of these haulage requirements can be met with one train cycling from the surface to the TBM area. Therefore, it is expected that two trains passing each other in the tunnel will not occur often. On occasions when two trains pass each other at the same location as a pedestrian is walking in the tunnel, the pedestrian can step to the side opposite the conveyor and lean against the tunnel wall until the area is clear. This is the current practice in the ESF and is also the accepted practice on most other civil tunnel projects. An individual standing on the wing of an invert section and leaning against the tunnel wall is entirely outside the transportation envelop. This meets the OSHA requirement and satisfies the intent of the MSHA requirement.

Shelter holes will not be required since sufficient clearances are provided in the ESF for safe pedestrian travel.

7.2.2 Electrical Substation and Medium Voltage Switchgear

The specified maximum external dimensions of the medium voltage switchgear are 1.27 m (50 inches) wide and 1.83 m (72 inches) high (Reference 5.23 & 5.24). Figure 4 shows the position of the electrical equipment in the tunnel without constructing a special alcove. The constructor may install the electrical substation and the medium voltage switchgear temporarily in the tunnel as shown in the conceptual illustration of Figure 4. In this concept, there would be about 180 mm clearance between the transportation envelope and the switch gear installed 1760 mm above the top of invert. Additional clearance can be achieved if the electrical gear is mounted higher on the tunnel wall. Portable or retractable platforms can be utilized to access and maintain the electrical equipment. Emergency switches for this equipment can be wired to a location accessible from the tunnel floor.

The Package 2C design placement of electrical gear involved excavating niches or chambers in the tunnel wall. However, the electrical gear can be located on the tunnel wall with sufficient clearances maintained. Construction of electrical alcoves can be eliminated to save cost and scheduling impacts to the TBM operations. Eliminating the alcoves was approved by the concurrence letter of C.J. Nesbitt to Alden Segrest on April 27, 1995 (Reference 5.17).

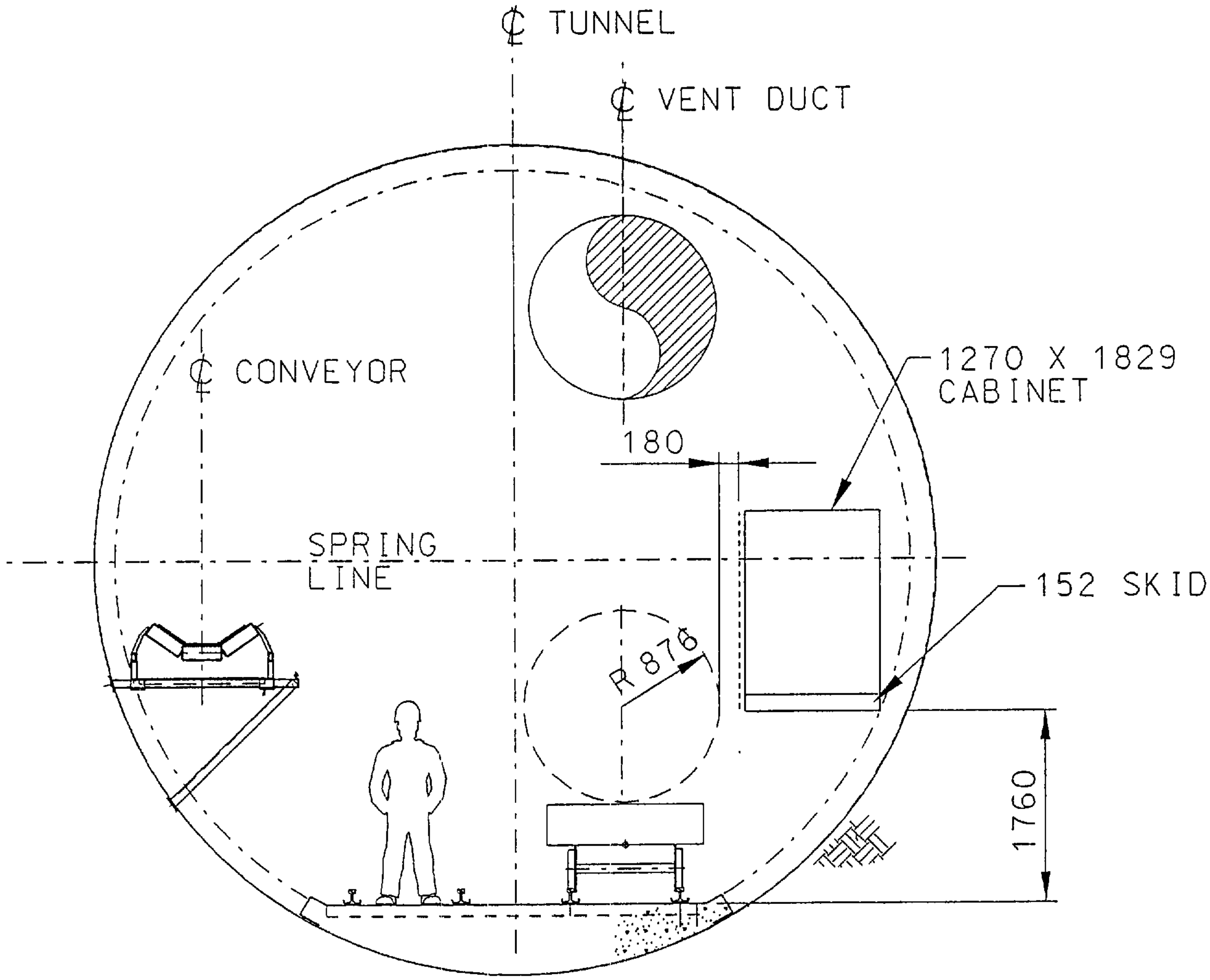
7.2.3 Subsurface Waste Water Sump/Pump Alcove

The Subsurface General Construction Analysis (Reference 5.28) has determined that construction of the permanent sump alcove shown in the Package 2C design may be deferred.

7.2.4 Refuge Chambers

In the event of an underground fire, it is imperative that personnel be able to escape to the surface or to a place of refuge. In the event the exit route is blocked, trapped personnel should have an area where protection against noxious gases and secondary fire or explosions is provided.

MSHA regulation 30 CFR 57.11050 requires that a place of refuge shall be provided for every employee who cannot reach the surface from the working place, through at least two separate escapeways, within a time limit of one hour. These places of refuge must be positioned so that they may be reached by a person within 30 minutes of leaving their work place. There is no equivalent OSHA requirement.



SECTION

CONCEPTUAL LAYOUT
ELECTRICAL EQUIPMENT POSITIONING IN RAMPS
ELECTRICAL CABINET
MEDIUM VOLTAGE SWITCHGEAR

NOTE:
ALL UNITS ARE IN MILLIMETERS (MM)
EXCEPT WHEN NOTED.

FIGURE 4

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It is an accepted idea in underground mining (Reference 5.19) that entrapped personnel may barricade themselves for protection from fire or smoke. The obvious extension to barricading is to have previously barricaded sites (chambers, shelters, etc.) provided with necessary supplies for survival while awaiting rescue. A supply of safe, breathable air is of prime importance in maintaining human life. Toxic or oxygen-depleted atmospheres reduce life expectancy to a few minutes, however, people have survived days without water and weeks without food.

The ESF tunnel is generally constructed of noncombustible materials. The potential for fire is largely limited to excavation and transportation equipment such as the TBM, muck conveyor, mobile equipment, rolling stock, electrical equipment, power cables and stationary gear boxes (Reference 5.11). Although fire protection will be provided by the installation of automatic or manual dry chemical extinguishing systems for primary fire fighting on conveyor drives, TBM, and certain equipment (Reference 5.12), the potential exists for a fire spreading smoke the entire length of the tunnel. In such an emergency situation, entrapped personnel can take refuge in a refuge chamber for a period conservatively estimated to be up to 48 hours (Design Input 4.3) while the emergency situation is corrected. Refuge chambers could also be used by personnel who are trapped underground for reasons other than smoke or fire emergencies.

Three types of refuge chambers are evaluated to determine their size, location and use in the ESF. These are: 1) excavated alcoves for permanent refuge chambers, 2) the TBM refuge area, and 3) portable inflatable refuge chambers. The TBM refuge area and the portable inflatable refuge chambers are temporary. They will not replace the excavated permanent refuge chambers. The mobile refuge chamber supplements personnel safety while permanent refuge chambers are under construction. Converting the TBM area into a refuge location and the use of portable inflatable refuge chambers is discussed in a later section of this analysis.

7.2.4.1 Permanent Refuge Chamber and Co-location of Test Alcove

The design of permanent refuge chambers must consider location, size, sealing, and provisions for necessary life saving supplies. Because of obvious cost and scheduling benefits, the feasibility of co-locating refuge chambers in non-deferred test alcoves is evaluated.

A typical refuge chamber is an underground opening provided with a life saving environment. It has a bulkhead and door that will isolate personnel from potentially toxic gases and smoke resulting from a fire in the ramp or main drift. In the ESF a refuge chamber that is co-located with a test alcove must have a door that is sized at least 2.7 m (9 ft) wide by 2.4 m (8 ft) high to allow passage of heavy equipment such as a drill jumbo, a three yard front end loader or a C5S core drill. During normal testing operations the door would normally be left open to allow unobstructed passage of equipment and personnel. In an emergency, the door must be able to be closed quickly and sealed so that the underground opening can serve as a refuge chamber. Alcove utilities for ventilation, power, compressed air and water will penetrate through the bulkhead outside the door frame.

Refuge chambers are for personnel safety in an emergency when tunnel egress is not safely accessible. Refuge chambers are used only during an underground fire. Emergency use of refuge chambers will be rare and it is logical that routine testing activities will be stopped to respond to the emergency situation. The co-location of a refuge chamber in a test area should not interfere with the functional requirements of the ESF test program. Co-locating the refuge chamber with the test alcove is feasible and with the following advantages:

- Saves design, construction, operation and maintenance costs of a separate underground opening.
- Minimizes interference to TBM operations caused by constructing additional alcoves.
- Limits the number of underground excavations to the extent practical as required (Design Input 4.2.12).

The disadvantage of co-location is that potentially mobile equipment in the refuge area may be a source of fire. This disadvantage would be the same as if a fire were located in the main tunnel at or near the entrance of the refuge chamber. If this were to occur, personnel would proceed to the next nearest refuge chamber.

The TCO has given concurrence for co-locating refuge chambers and test alcoves where feasible (Reference 5.26). Access must be maintained for the testing activities and required equipment, and the TCO utility requirements must be satisfied.

A. Location of Permanent Refuge Chamber

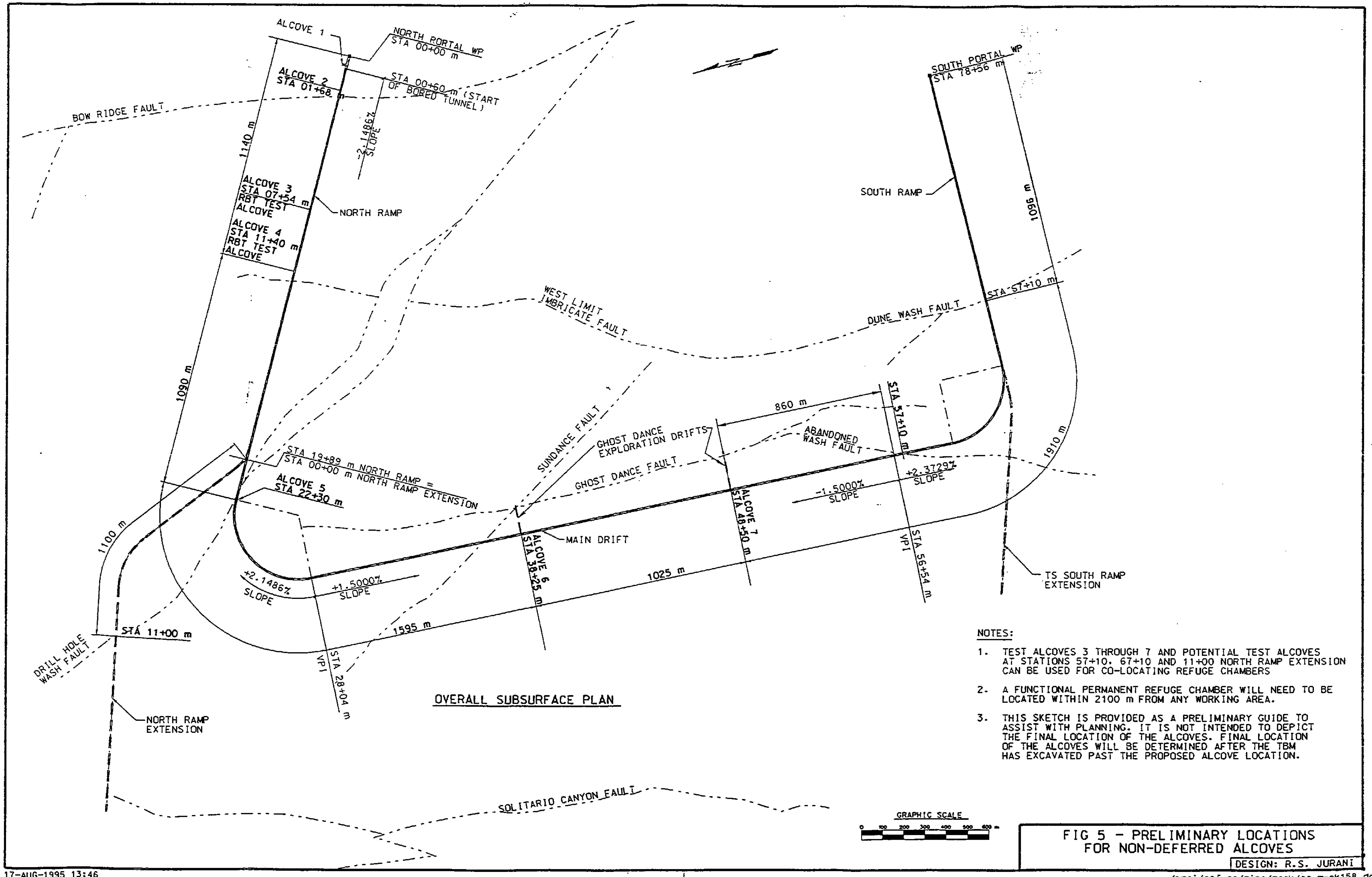
Refuge chamber spacing is based on how far a person could walk in the 30 minute time limit which is the requirement established by MSHA. An average person has a usual speed of about 4.8 to 6.4 kilometers per hour (Reference 5.18). That is equivalent to 2,400 to 3,200 m in 30 minutes. A person's normal pace may vary in an emergency. From the U.S. Bureau of Mines "Development Guidelines for Rescue Chambers" (Design Parameter, Section 4.1), the escape speed is 1.524 m/s (300 feet per minute) in an underground opening greater than

2 m (80 inches) of tunnel height. The use of a self rescuer reduces the travel speed by 15 percent or to 1.295 m/s, and poor travel conditions (loose ground, pools of water) further reduces the speed by another 10 percent or to 1.166 m/s. The tunnel invert is a better walkway than one would encounter in a mine if loose ground or pools of water were present. Therefore, the 10 percent reduction is an extra conservative reduction in walking speed. The resulting escape speed of 1.166 m/s is approximately 2,100 m in 30 minutes.

In order to meet the MSHA requirement the maximum distance between refuge chambers or from the furthest work place, the TBM would be 2,100 m. This distance is used as a guide to evaluate the co-location of refuge chambers with test alcoves. If a test alcove is located within this distance, the test alcove can be provided with a fire door and necessary emergency equipment to qualify it as a refuge chamber.

Figure 5 shows the relative location and distances between the test alcoves. They are potentially the same alcoves that will be used to co-locate the refuge chambers. To meet the MSHA requirement, an additional alcove would be required somewhere within 2,100 m from Alcove 7. An alcove at the Abandoned Wash fault at Station 57+10 or the Dune Wash fault at Station 67+10 (Design Input, Section 4.1) would meet this requirement. An additional alcove would also be required in the North Ramp Extension if that drift is developed towards the Solitario Canyon fault. A likely location for an alcove would be at the Drill Hole Wash fault at Station 11+00. These three locations are potential candidates for test alcoves however the TCO has not determined if and/or when non-deferred alcoves at these locations would be required. Figure 5 shows the approximate location of the alcoves to satisfy the requirement of locating refuge chambers within 2,100 m of each other or the nearest working face.

Since the feasibility of co-location of refuge chambers is initially determined by the location of the test alcoves, it is necessary to show the workability and effectiveness of co-locating both alcoves in one place. ESF fire scenarios have been analyzed to establish the strategic location of refuge chambers during construction of the TS Ramps, the TS Main Drift and the North Ramp Extension. These fire scenarios with possible emergency responses are shown in Attachment II.


ALCOVE 1
NORTH PORTAL WP
STA 00+00 m
ALCOVE 2
STA 01+68 m
STA 00+60 m (START OF BORED TUNNEL)
BOW RIDGE FAULT
-2.1486% SLOPE
1140 m
ALCOVE 3
STA 07+54 m
RBT TEST ALCOVE
ALCOVE 4
STA 11+40 m
RBT TEST ALCOVE
NORTH RAMP
WEST LIMIT IMBRICATE FAULT
DUNE WASH FAULT
SOUTH PORTAL WP
STA 78+56 m
SOUTH RAMP
1096 m
STA 57+10 m
1090 m
STA 19+89 m NORTH RAMP =
STA 00+00 m NORTH RAMP EXTENSION
ALCOVE 5
STA 22+30 m
SUNDANCE FAULT
GHOST DANCE EXPLORATION DRIFTS
GHOST DANCE FAULT
860 m
ABANDONED WASH FAULT
STA 57+10 m
+2.3729% SLOPE
-1.5000% SLOPE
1910 m
1100 m
MAIN DRIFT
ALCOVE 6
STA 38+25 m
ALCOVE 7
STA 48+50 m
1025 m
VPI
STA 56+54 m
TS SOUTH RAMP EXTENSION
+2.1486% SLOPE
+1.5000% SLOPE
1595 m
STA 11+00 m
DRILL HOLE WASH FAULT
VPI
STA 28+04 m
OVERALL SUBSURFACE PLAN
NORTH RAMP EXTENSION
SOLITARIO CANYON FAULT
NOTES:
1. TEST ALCOVES 3 THROUGH 7 AND POTENTIAL TEST ALCOVES AT STATIONS 57+10. 67+10 AND 11+00 NORTH RAMP EXTENSION CAN BE USED FOR CO-LOCATING REFUGE CHAMBERS
2. A FUNCTIONAL PERMANENT REFUGE CHAMBER WILL NEED TO BE LOCATED WITHIN 2100 m FROM ANY WORKING AREA.
3. THIS SKETCH IS PROVIDED AS A PRELIMINARY GUIDE TO ASSIST WITH PLANNING. IT IS NOT INTENDED TO DEPICT THE FINAL LOCATION OF THE ALCOVES. FINAL LOCATION OF THE ALCOVES WILL BE DETERMINED AFTER THE TBM HAS EXCAVATED PAST THE PROPOSED ALCOVE LOCATION.
GRAPHIC SCALE
0 100 200 300 400 500 600 m
FIG 5 - PRELIMINARY LOCATIONS FOR NON-DEFERRED ALCOVES
DESIGN: R.S. JURANI
17-AUG-1995 13:46
/proj/esf_ss/mine/mosk/ss-m-sk158.dgn

A set of scenarios for strategic access to a refuge chamber is based on the ESF configuration of one TBM driving the loop towards the South Portal. Another scenario considers two TBM operations, one unit located along the TS Main Drift and the second unit located in the North Ramp Extension. Other possible fire scenarios not specifically shown in this analysis are expected to be similar to at least one of the test cases analyzed. Attachment II shows descriptions and figures of ESF fire scenarios, site specific availability of refuge chambers, established fresh air bases, maximum potential walking distance between refuge chambers and working areas, ventilation action, the schematic of normal airflow and personnel evacuation direction. The study could be used as a guide by management in making decisions for the appropriate response in case of an actual emergency.

B. Early Warning System

When a person in the tunnel is trapped by a fire which prevents escape to the surface, walking towards a refuge chamber may be impaired by smoke and toxic gases. In most cases analyzed (Attachment II), a person walking towards a refuge chamber may potentially have visibility problems because of smoke and eye irritating gases. At the current average ventilation design of 51.92 m^3/s (110,000 cfm) in the ramp, the projected normal air travel is 2,400 to 3,200 m in 30 minutes. This is almost the same as the average walking speed of a person. Subsurface personnel are required by regulation to have self rescuers to protect them from carbon monoxide gas, but protection is not provided against eye irritating gases, smoke and oxygen deficient atmosphere.

To alleviate the problem, early alarm systems and early response in case of fire or other emergencies should be part of ESF administrative procedures. The early alarm should allow time for personnel to walk or take any other available transportation to the nearest refuge chamber and minimize visibility problems.

C. Construction Methodology and Occupancy Of Permanent Refuge Chamber

Refuge chamber alcoves will be excavated after the TBM and all trailing gear have advanced a reasonable distance beyond the alcove location. Availability of a permanent refuge chamber will be dictated by the 2100 m distance, the maximum criteria for personnel to walk in 30 minutes. Refuge chambers would be made functional by meeting the following MSHA requirements (Design Input 4.4):

a) Fire resistant wall and door are provided.

b) Adequate room to accommodate the number of people normally in the particular area.

c) Constructed to be made gas tight and provided with sealing materials and tools.

d) Have a compressed air line fitted with a respirable quality air filter and drinking water.

e) Telephone or other voice communication are provided between the surface and refuge chambers and such systems shall be independent of mine power supply.

During the ESF construction stage, each refuge chamber will be sized large enough to accommodate the personnel normally within the area of influence of each refuge chamber. The largest number of personnel within the area of one refuge chamber is expected to occur during construction of the North Ramp. The number of personnel is estimated to be (Design Input, Sections 4.2 and 4.3):

a)	Scientific Personnel	10
b)	Visitors	10
c)	TBM Crew	21
d)	Construction Support Personnel	15
	Total	56

The possibility of all 56 people trapped at one time in the same general area of one refuge chamber is low. Personnel will normally be in small groups or scattered throughout the tunnel either traveling or located at their respective work areas. However, it is possible that everyone could be in the same area. Therefore, each refuge chamber should be sized conservatively to accommodate the maximum population of 56 persons.

D. Supplies in Permanent Refuge Chambers

The layout of a refuge chamber would include an organized space to store supplies. These supplies should be arranged so they do not to interfere with equipment access to the test area. The Bureau of Mines recommends that refuge chambers should contain the following items (Reference 5.19 and Design Input, Section 4.4):

1. Compressed air supply

2. Respirable oxygen cylinders with regulators - approximately 10 (280 cu ft) cylinders

3. First aid station with stretcher

4. Blankets (for 56 persons)

5. Potable water in bottles (for 56 persons for 48 hours)

6. Dehydrated rations (for 56 persons for 48 hours)

7. Gas tester with ability to test for O_2, CO, and CO_2.

8. Disposable sanitary containers

9. Incline manometer or magnehelic pressure gauges

10. Lighting (both electric and battery)

11. Independent powered voice or telephone communication system

12. Tool box containing shovel, crowbar, hammer, adjustable wrench, screw driver, pliers, tie wires, etc.

13. Door sealant

An estimated 9 m^2 of alcove floor space will be needed to accommodate all these items.

E. Sizing of Refuge Chamber

The space required for a 1.82 m (6 ft) tall person to lie down would at a minimum be 1.18 m^2 (12.65 ft^2) (Reference 5.6). Sizing and evaluating the refuge chamber occupancy is based on this criteria without considering that in a crowded, emergency situation, this same space would accommodate personnel standing, sitting, and lying down in alternating groups. Using 1.18 m^2 per person as a guide, a refuge chamber requires about 66 m^2 of floor space to accommodate 56 people, in addition to about 9 m^2 to store their supplies. A total space of 75 m^2 will be the basis for qualifying a test alcove as a refuge chamber. Additionally, an alcove needs sufficient depth to locate and construct a fire resistant door bulkhead that can be sealed.

F. Availability of Refuge Chambers During Full Test Operations

The ESF is designed to accommodate a nominal scientific work force of 100 persons during full test operations (Design Input, Section 4.2). Peak scientific manpower, on day shift the first few months after the Main Test Level Core Test Area (MTL CTA) test locations become available, is estimated to be 120 people distributed in all areas (Design Input, Section 4.2). During full test operation there are six recommended permanent refuge chambers (Attachment II Scenarios), each with a refuge capacity of 56 people. Therefore, the ESF will have adequate refuge facility for all test support and operations support personnel, and visitors.

G. Fire Door and Sealing Materials of Permanent Refuge Chamber

The refuge chamber is required to be provided with a door that can be sealed tight in the event of a fire emergency. The refuge chamber bulkhead should be located sufficiently inside of the alcove to allow construction of an outby airlock by tunnel rescue personnel in the event of an emergency. Appropriate sealing materials should be made available in the door vicinity. The door should usually be open to provide normal ventilation and equipment passage. It must be able to be closed quickly and sealed during an emergency. Functional operation of the door may be tested during fire drills or by Safety Department personnel.

The refuge chamber should be provided with a door frame bulkhead that can accommodate a minimum 2.7 m (9 ft) wide by 2.4 (8 ft) high door opening. This size door opening will allow passage of equipment. Ventilation duct that can be made airtight must be installed within the bulkhead but outside of the door frame. The door would need to be made of metal or some other fire resistant material as indicated by the MSHA standard.

Fire doors must be sealable to allow for a pressure differential to develop between the refuge chamber and the main tunnel. The pressure differential will keep contaminated air in the main tunnel from flowing into the refuge chamber when the door is sealed. During an emergency a higher pressure in the refuge chamber can be obtained by opening the compressed air line and/or compressed air bottles. The pressure can be relieved by a manually operated low pressure relief valve in the fire door bulkhead. If the compressed air line and the bottled air are exhausted or not used, the air outside the refuge chamber will be prevented from entering the chamber by the sealed fire door. A pressure indicating device such as an incline manometer or magnehelic gauge should be installed on the bulkhead to measure the differential pressure across the bulkhead.

The door may be installed in a masonry, metal or cast-in-place concrete bulkhead. The TCO will approve the use of construction materials for the bulkhead including the sealing of edges with shotecrete or other fire rated substances.

H. Ventilation of Refuge Chamber

Refuge chamber/test alcove ventilation systems should allow exhaust air to return directly to either the main exhaust tube or the main tunnel for recycling. The ventilation duct passing through the bulkhead should be provided with vent line valve or door adapter to stop air flow through the duct if the bulkhead is utilized in an emergency and is sealed.

7.2.4.2 TBM Refuge Area

The TBM forward area must be used as a place of refuge in the event of fire located between the TBM and the nearest alcove refuge chamber, or when the location of a fire is unknown. The process would involve isolating the main ventilation from the TBM area and pressurizing the TBM area with air from the compressed air line. The TBM refuge area consists of the open space between the trailing gear and the TBM face. To convert the TBM area into a refuge area, the following procedures would need to be implemented:

1. Short circuit the main ventilation by removing a section of fan-line, decoupling and retracting the ventilation quill or removing a section of flexible duct at the outby end of the trailing floor.

2. Shut off the two on-board TBM fans.

3. Open the compressed air line to release air as near as possible to the face of the TBM.

By turning off the on-board TBM fans and short circuiting the main ventilation system, smoke and contaminated air will go directly into the main exhaust duct. The compressed air released at the TBM face will flow towards the main exhaust duct through the TBM area. This air will become the emergency air supply for trapped personnel before it will return and merge with smoke and contaminated air at the inlet exhaust duct.

The conversion of the TBM area into a place of refuge will depend on availability of a compressed air line near the TBM face. The steps enumerated above should be done in quick succession to establish the TBM refuge area. All personnel should be cognizant that the TBM refuge area is not a replacement for the permanent refuge chamber. The first choice, if feasible, will still be to use a permanent refuge chamber.

7.2.4.3 Portable Inflatable Refuge Chamber

The portable inflatable refuge chamber concept would be useful in the ESF as a supplementary protection measure while the permanent refuge chamber is being constructed or is not available. Portable inflatable refuge chambers are commercially available. (Refer to Attachment III for more information). They are made of vinyl and are packed in portable carrying cases. When one is removed from the case and inflated with regular compressed air, an enclosed room (refuge chamber) of about 5.5 m (18 ft) long x 2.4 m (8 ft) high x 1.5 m (5 ft) wide can be made. The process will take about five minutes and the enclosed room can accommodate up to eight people.

As long as compressed air is available at about 0.047 m^3/s (100 cfm), the room is fully inflated and breathable air is circulating. The disadvantages of the inflatable refuge chamber include:

1. Compressed air is required to maintain the structural configuration and as a source of breathable air.
2. Sharp objects could rupture the vinyl surface resulting in leakage.
3. Vinyl will not stand excessive heat.
4. Not rated for flood, fire, or ground support per manufacturer's specification.

However, the disadvantages are offset by the advantages of having a portable refuge chamber available at locations where no other alternative refuge is available or to supplement the TBM refuge area.

Portable inflatable refuge chambers should not be considered as replacements for permanent refuge chambers and personnel should be trained to understand this limitation.

8. CONCLUSIONS

8.1 There are seven non-deferred test alcoves currently identified by the TCO. The layout and location of Alcoves 1, 2 and 3 are established by TCO letters, previous studies and drawings. The approximate location of Alcoves 4, 5, 6 and 7 are shown in the following table:

Test Alcove No.	Name of Contact (Thermal/Mechanical Units) or Fault Structure	Figure or Layout	Approximate Station No. From North Ramp Portal
4	RBT (PTn/TSw1) Contact @ North Ramp	Reference 5.27	11+40
5	Drill Hole Wash Fault @ North Ramp	Figure 1	22+30
6	Ghost Dance 1/Sundance Faults @ Main Drift	Figure 2	38+25
7	Ghost Dance 2 @ Main Drift	Figure 3	48+50

8.2 The HPMF drill room with three 30 m boreholes perpendicular to the fault has a typical size of 6 m wide by 7 m high. Depth of the drill room will depend upon the fault structure and will be field determined as required by the TCO.

8.3 The HPMF drill room with three 30 m boreholes parallel to the fault has a typical size of 6 m wide by 5 m high. Depth of the drill room will depend upon the fault structure and will be field determined as required by the TCO.

8.4 The standard nominal size of the access drift to a test alcove or drill room is 3.7 m wide by 3.7 high. The maximum size (upper boundary) of the access drift is 6 m wide by 4.4 m high. The crown (roof) of the drift should be arched.

8.5 The plan for a Heater Test Alcove will be bounded by this analysis if the test configuration fits within the size range developed here.

8.6 The elevated walkway can be eliminated because the tunnel invert can provide the unobstucted walkway. The analysis supports the recommended elimination of the elevated walkway to save unnecessary cost and schedule impacts. Shelter holes are not required for compliance with 30 CFR 57.9360 provided the procedure discussed in Section 7.2.1 is implemented.

8.7 Special excavations or niches for electrical switchgear and transformers are not necessary during ESF construction.

8.8 To meet MSHA requirements, permanent refuge chambers need to be located and functional within a 2,100 m distance from each other and the furthest working area.

8.9 The MSHA requirement for refuge chambers can be satisfied by utilizing planned project test alcoves rather than excavating dedicated refuge chambers.

8.10 Refuge chambers may be co-located with the test alcoves if 75 m^2 floor area is available within the alcove. The co-location of a refuge chamber with a test area will not interfere with the functional requirements of the ESF test program as long as requirements in the criteria letter from the TCO are met.

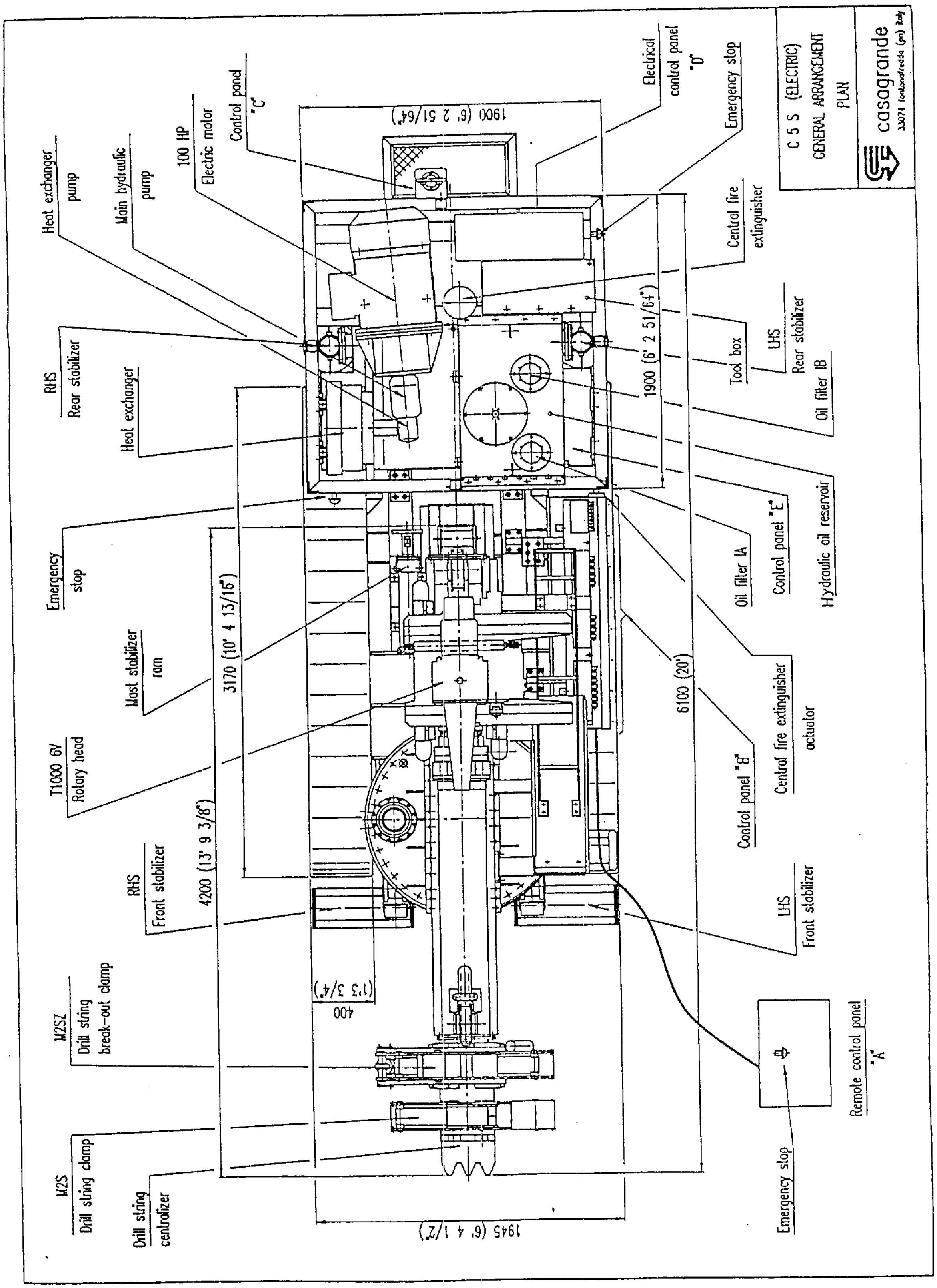
8.11 The TBM forward area can be converted into a temporary place of refuge in the event of fire located away from the TBM when a permanent refuge chamber is not available. Training of management and personnel to understand the use and limitation of the TBM refuge area, and the procedure of emergency response should be made part of the ESF safety program.

8.12 The portable, inflatable refuge chamber concept is useful in the ESF as a supplementary protection measure while a permanent refuge chamber is being constructed or is not accessible. They cannot be considered as a replacement for permanent refuge chambers, and personnel should be trained to understand this limitation.

8.13 Attachment II shows descriptions and figures for a number of typical ESF fire scenarios, site specific availability of refuge chambers, established fresh air bases, maximum potential walking distance between refuge chambers and working areas, ventilation action, the schematic of normal airflow and personnel evacuation direction. The results could be used as a guide by management in making decisions for the appropriate response in case of an actual emergency.

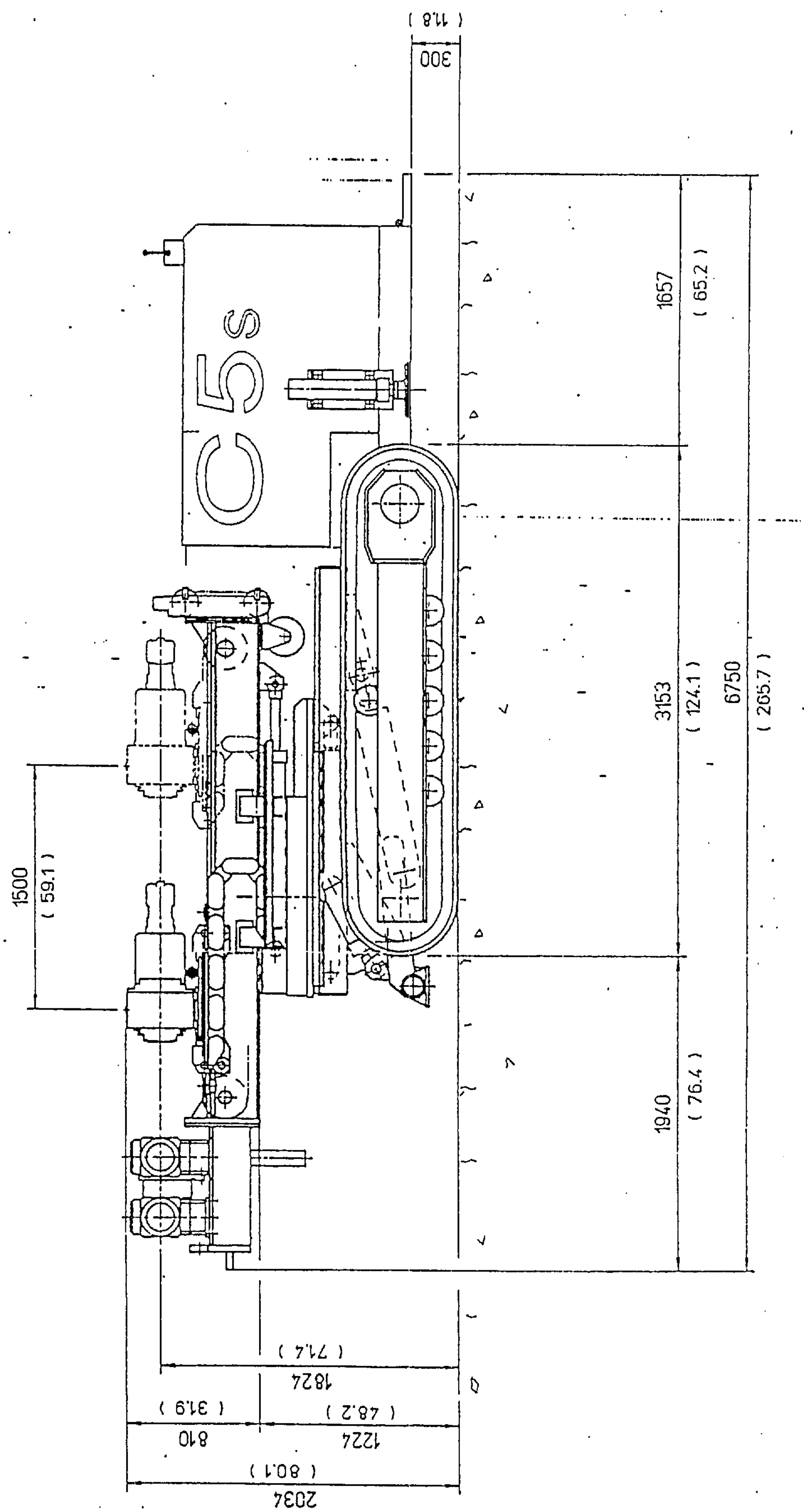
9. ATTACHMENTS

ATTACHMENT	TITLE
I	Casagrande C5S Core Drill
II	Establishing Strategic Location of Refuge Chambers
III	Portable Inflatable Refuge Chamber



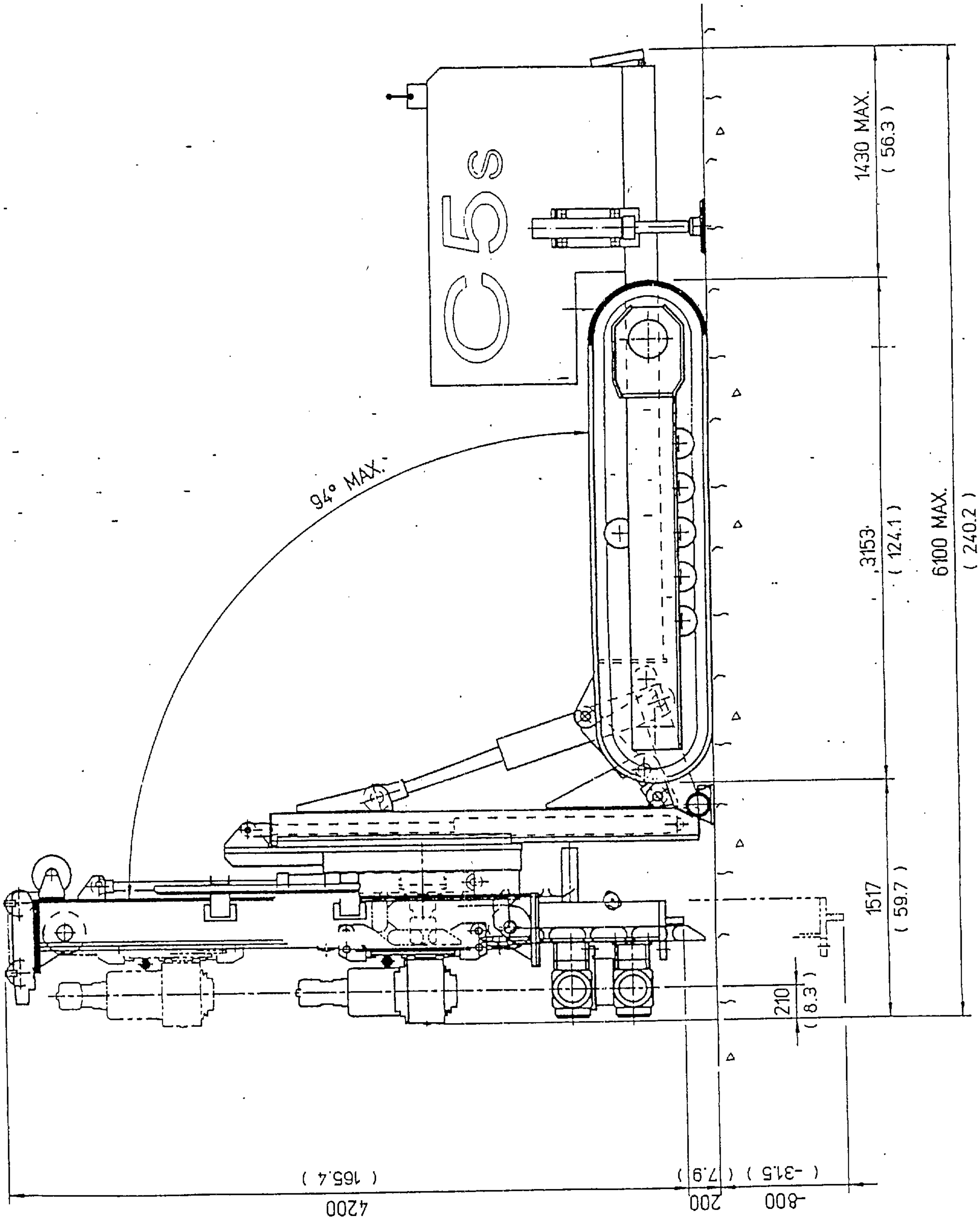
Casagrande C5S Core Drill
General Arrangement Plan

Source: Casagrande C5S Drill
Drawing No. 8-535001
33074 Fontanafredda (pn), Italy
Issued 09/1994 (Reference 5.5)



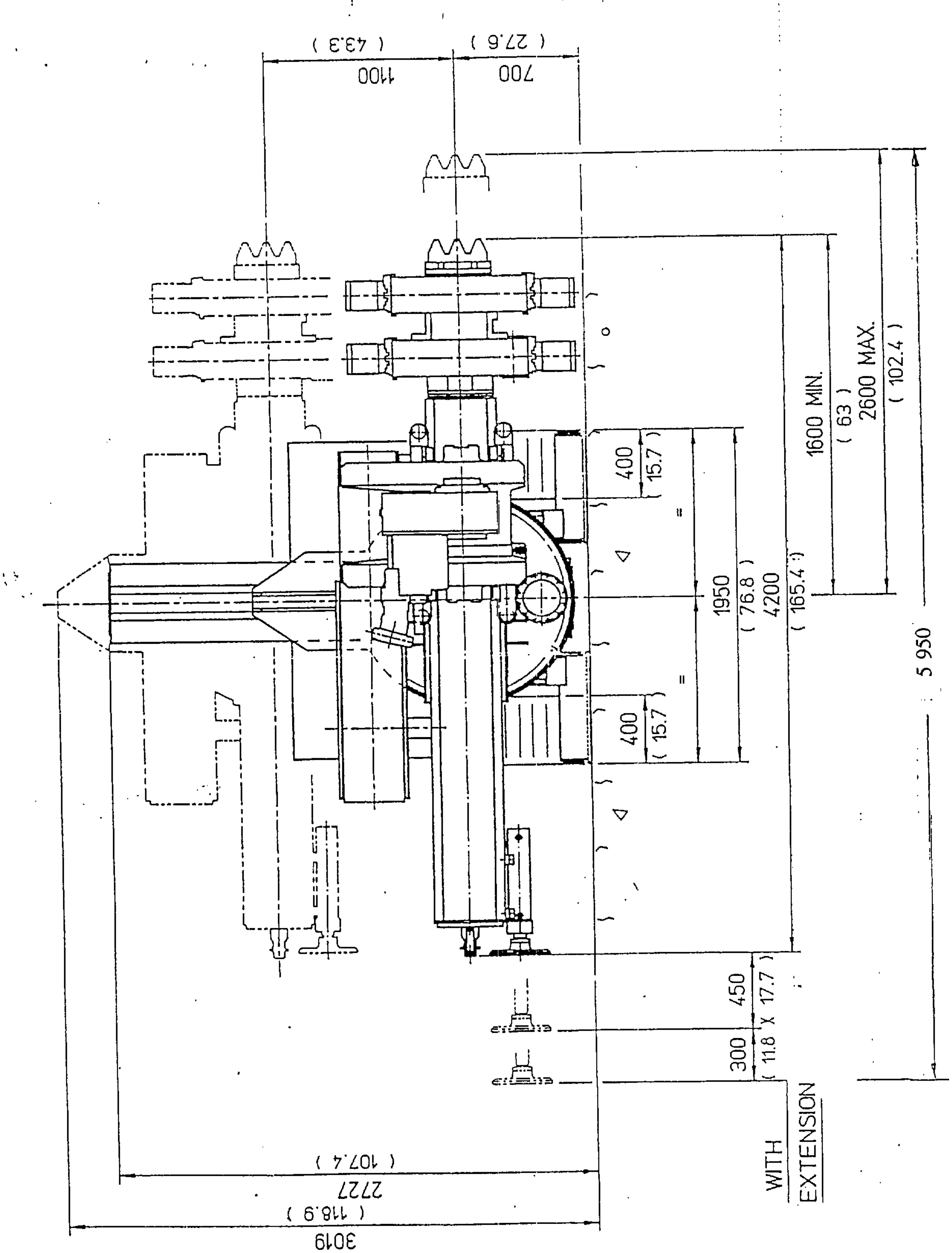
Casagrande C5S Core Drill
Tramming View

Source: Casagrande C5S Drill
Drawing No. 8-535001
33074 Fontanafredda (pn), Italy
Issued 09/1994



Casagrande C5S Core Drill
Side View Vertical Drilling

Source: Casagrande C5S Drill
Drawing No. 8-535001
33074 Fontanafredda (pn), Italy
Issued 09/1994



Casagrande C5S Core Drill
Front View Side Drilling

Source: Casagrande C5S Drill
Drawing No. 8-535001
33074 Fontanafredda (pn), Italy
Issued 09/1994

Establishing Strategic Location of Refuge Chambers

Fire Location Scenarios and Related Location of Refuge Chambers During Construction of TS Ramps, TS Main Drift and North Ramp Extension

Fifteen separate potential fire scenarios in the Exploratory Studies Facility have been evaluated. Each one shows the pre-execution of a potential emergency response when there is only one egress, i.e, the North Portal.

In this analysis, refuge chambers have been located in test alcove drifts. The intent is to save construction and maintenance costs, and to minimize alcove construction interference to the operation of the TBM.

Fire scenarios and the establishment of strategic locations for refuge chambers are based on the ESF configuration before the TBM has excavated to the South Portal. Another scenario considers the potential of two TBMs in operation. The first TBM is located along the TS Main Drift and the second TBM is in the North Ramp Extension.

Potential fire scenarios at locations different from those specifically shown in this analysis would be similar to one of the test cases analyzed. Therefore, actual emergency responses by management to a specific fire location scenario can be correlated to the test cases shown in this analysis.

The succeeding attachments illustrate cases of ESF fire scenarios, site specific availability of refuge chambers, established fresh air base, maximum potential walking distance between refuge chambers, ventilation action, and schematic of normal airflow and personnel evacuation direction.

Notes: The TBM with the trailing gear has a total length of about 158 m. For the purpose of this report, the TBM forward area where people may seek refuge is about 50 m behind the cutter head.

Construction of the Abandoned Wash Fault Alcove is selected over that of the Dune Wash Fault Alcove. This will provide more lead time to complete the alcove construction before the TBM will potentially advance beyond the 2100 m maximum distance to the nearest available permanent refuge chamber.

Establishing Strategic Location of Refuge Chambers

Case 1A: TBM at North Ramp Station 10+00 m

Fire Area: Somewhere in the North Ramp between the North Portal and Station 1+50 m

Available Refuge Chamber:

TBM Forward Area at Station 9+50 m

Fresh Air Base: North Portal to station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel:	(950-100)	=	850 m
Average potential (midpoint) walking distance to available refuge chamber for trapped personnel	850/2	=	425 m

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to reverse the ventilation.

Refer to Schematic 1A for normal airflow and personnel evacuation direction.

Establishing Strategic Location of Refuge Chambers

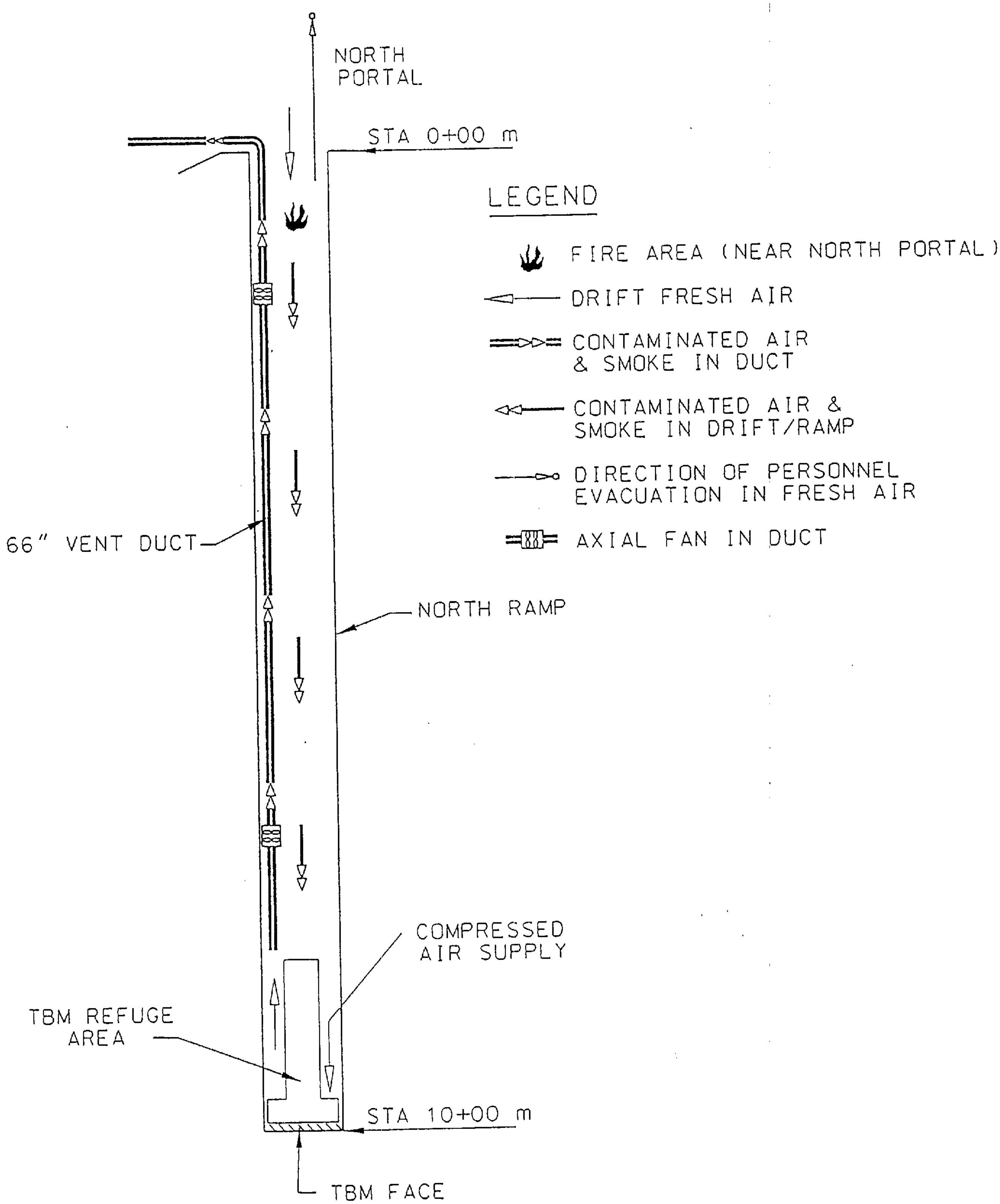


FIGURE Schematic 1A

DESIGN: R.S. JURANI

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Establishing Strategic Location of Refuge Chambers

Case 1B: TBM at North Ramp Station 10+00 m

Fire Area: Somewhere between North Ramp Station 1+75 m and Station 8+00 m

Available Refuge Chamber:

TBM Forward Area at Station 9+50 m

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel:	(950-175)	=	775 m
Average potential (midpoint) walking distance to available refuge chamber for trapped personnel:	775/2	=	388 m

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted or may reverse the ventilation to keep the fresh air to the TBM.

Refer to Schematic 1B for normal airflow and personnel evacuation direction.

Establishing Strategic Location of Refuge Chambers

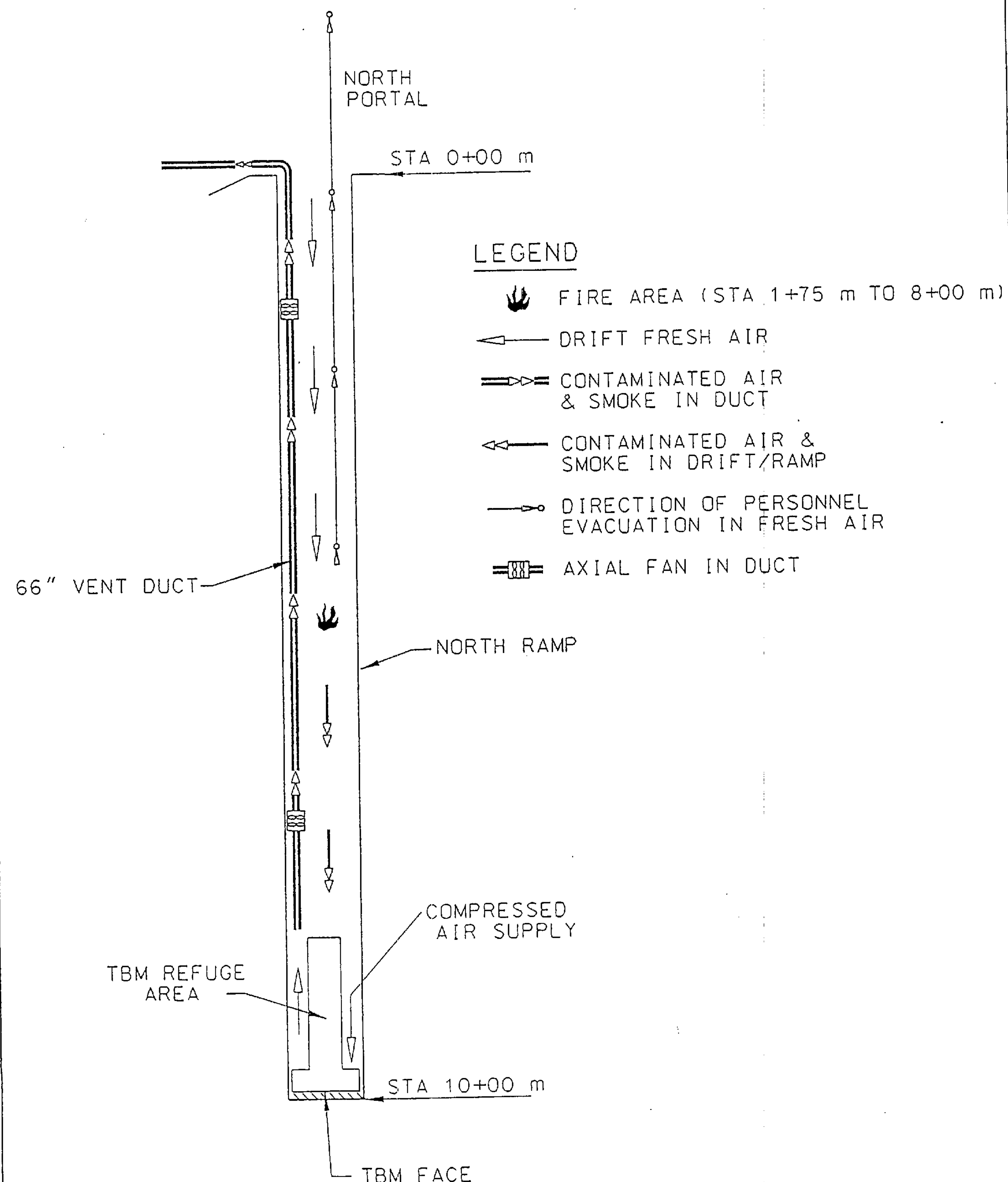

FIGURE Schematic 1B

DESIGN: R.S. JURANI

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Establishing Strategic Location of Refuge Chambers

Case 1C: TBM at North Ramp Station 10+00 m

Fire Area: TBM Area at North Ramp Station 9+70 m

Available Refuge Chamber:

None - Personnel shall exit to the surface.

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance to surface		950 m
Average potential (midpoint) walking distance to surface	950/2 =	475 m

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted.

Refer to Schematic 1C for normal airflow and personnel evacuation direction.

Establishing Strategic Location of Refuge Chambers

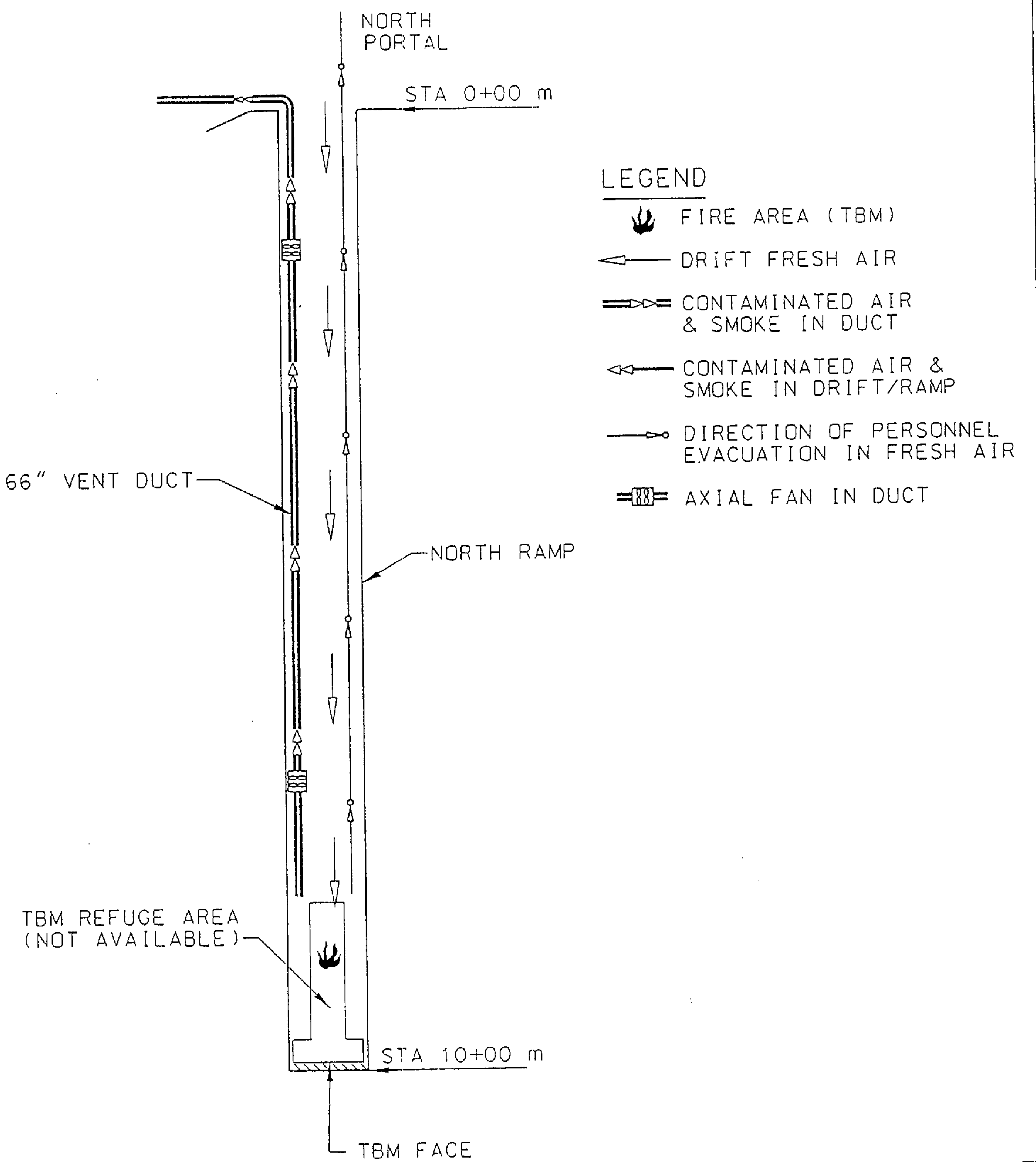

FIGURE Schematic 1C

DESIGN: R.S. JURANI

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Establishing Strategic Location of Refuge Chambers

Case 2A: TBM at TS Main Drift Station 42+00 m

Fire Area: Somewhere between the North Portal and Station 1+50 m

Available Refuge Chamber:

1. RBT Alcove at Station 11+40 m
2. Drill Hole Wash at Station 22+30 m
3. TBM Forward Area at Station 41+50 m

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel: (4150-2230) = 1920 m

Average potential (midpoint) walking distance to available refuge chamber for trapped personnel: 1920/2 = 960 m

(Temporary portable inflatable refuge chamber may be deployed between Drill Hole Wash and the TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to reverse the ventilation.

Refer to Schematic 2A for normal airflow and personnel **evacuation direction.**

Establishing Strategic Location of Refuge Chambers

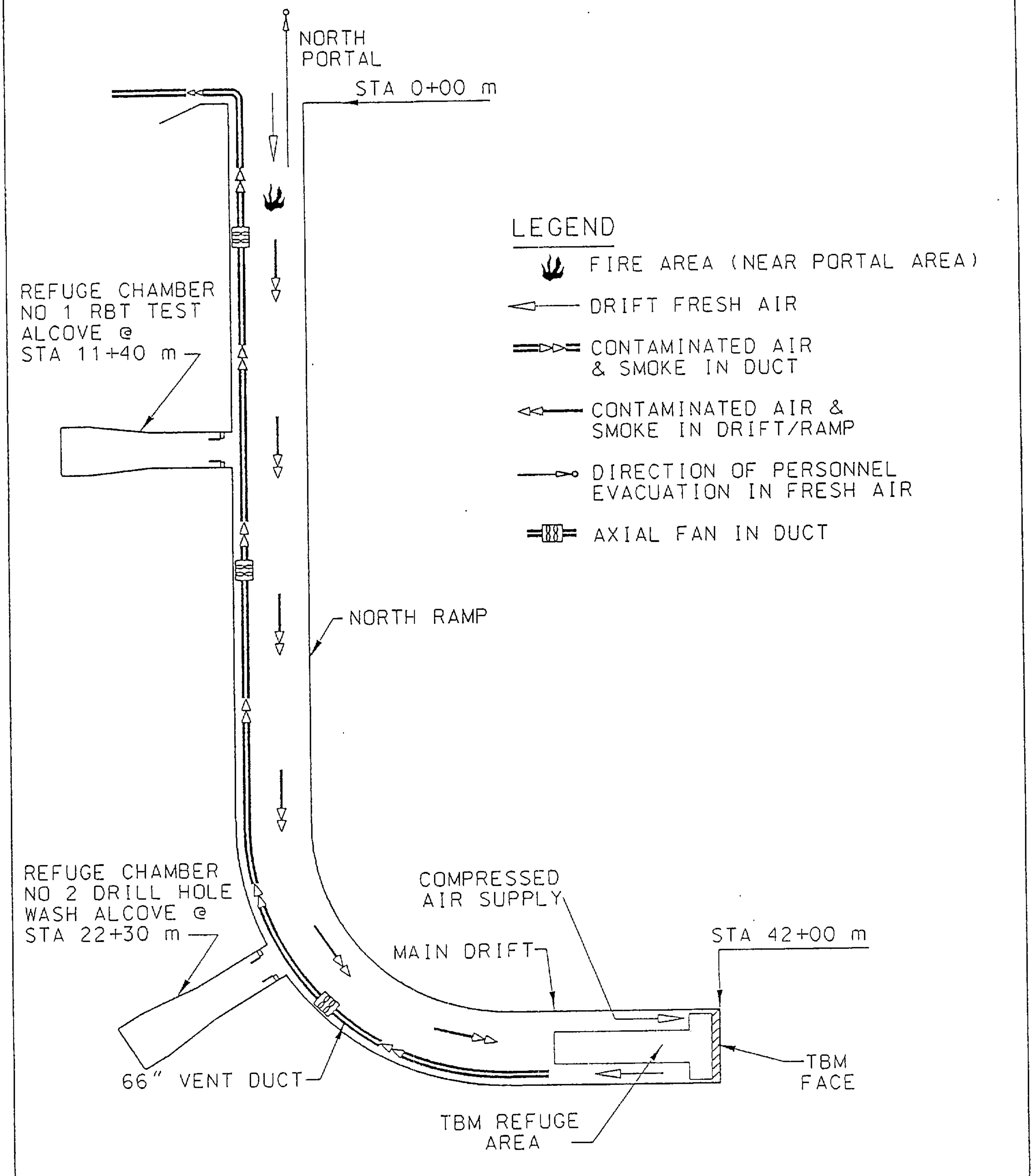

FIGURE Schematic 2A

DESIGN: R.S. JURANI

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Establishing Strategic Location of Refuge Chambers

Case 2B: TBM at TS Main Drift Station 42+00 m

Fire Area: Somewhere between the North Ramp Station 11+50 m and 20+00 m (between RBT and Drill Hole Wash alcoves).

Available Refuge Chamber:

1. RBT Alcove at Station 11+40 m (See Note)
2. Drill Hole Wash at Station 22+30 m
3. TBM Forward Area at Station 41+50 m

(Note: In this case, personnel not trapped by fire should evacuate directly to the surface bypassing any refuge chamber.)

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel: (4150-2230) = 1920 m

Average potential (midpoint) walking distance to available refuge chamber for trapped personnel: 1920/2 = 960 m

(Temporary portable inflatable refuge chamber may be deployed between Drill Hole Wash and the TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted or may reverse the ventilation to keep the fresh air to the TBM.

Refer to Schematic 2B for normal airflow and personnel **evacuation direction.**

Establishing Strategic Location of Refuge Chambers

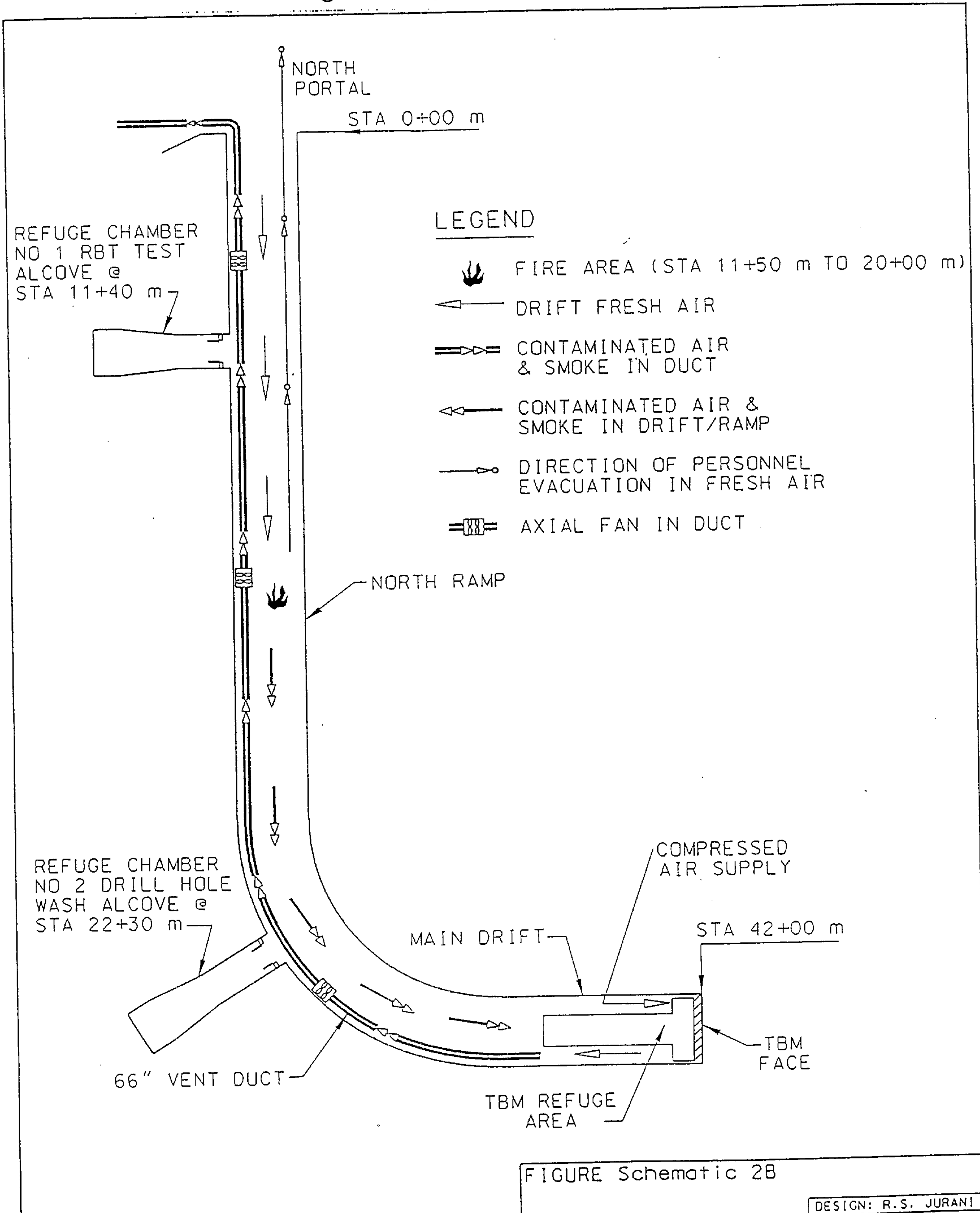

FIGURE Schematic 2B

DESIGN: R.S. JURANI

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/proj/esf_ss/mine/mosk/ss-m-sk133.dgn

Establishing Strategic Location of Refuge Chambers

Case 2C: TBM at TS Main Drift Station 42+00 m

Fire Area: TBM Area at TS Main Drift Station 41+70 m

Available Refuge Chamber

(When a fire is in the TBM area, personnel are to evacuate to the surface and bypass all refuge chambers.)

1. RBT Alcove at Station 11+40 m
2. Drill Hole Wash at Station 22+30 m

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers:	(4150-2230)	=	1920 m
Average potential (midpoint) walking distance to available refuge chamber:	1920/2	=	960 m

(Temporary portable inflatable refuge chamber may be deployed between Drill Hole Wash and the TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted.

Refer to Schematic 2C for normal airflow and personnel **evacuation direction.**

Establishing Strategic Location of Refuge Chambers

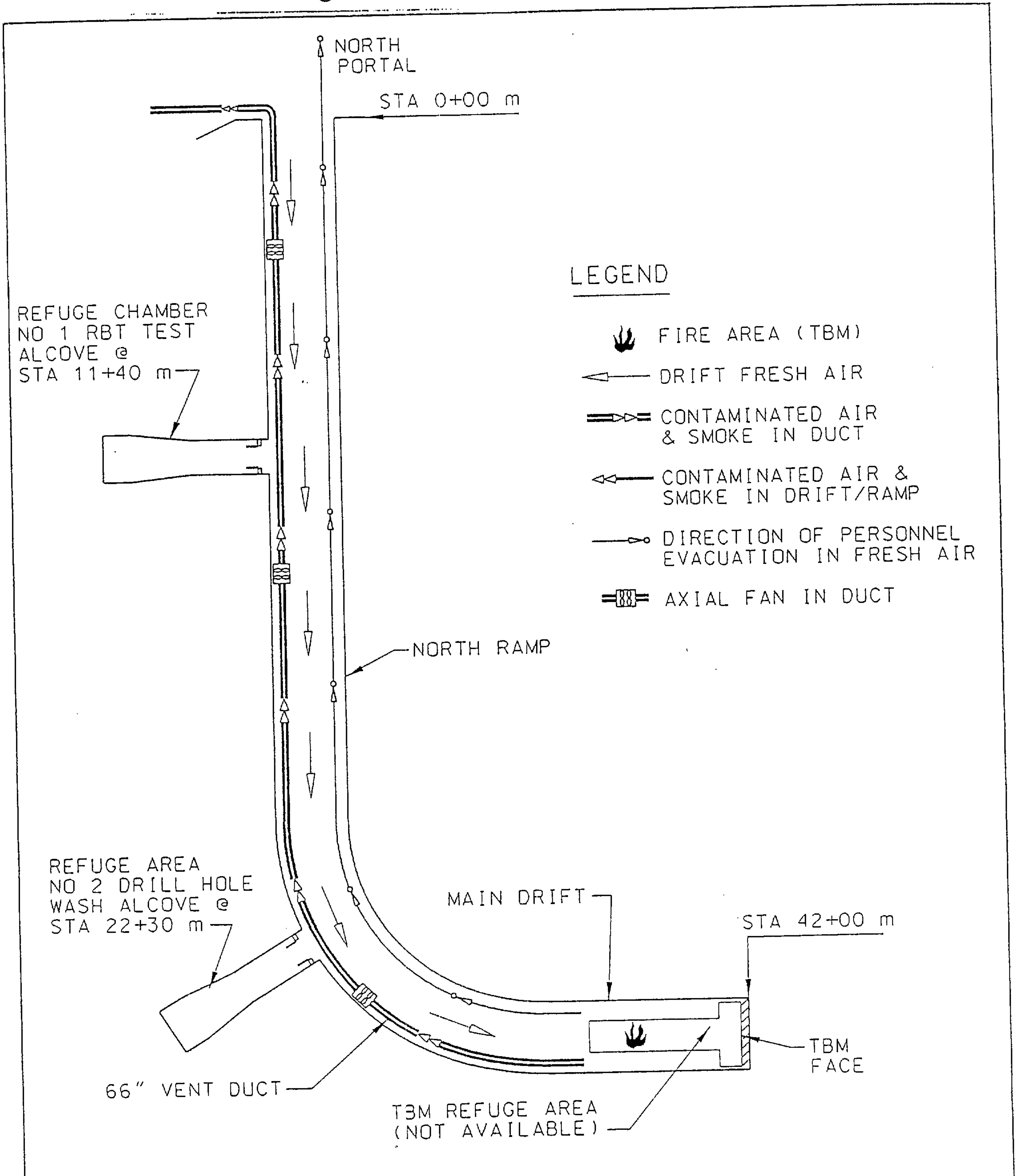

FIGURE Schematic 2C

DESIGN: R.S. JURANI

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Establishing Strategic Location of Refuge Chambers

Case 3A: TBM at TS Main Drift Station 59+00 m

Fire Area: Somewhere between the North Portal and Station 1+50 m

Available Refuge Chamber:

1. RBT Alcove at Station 11+40 m
2. Drill Hole Wash at Station 22+30 m
3. TS Ghost Dance 1 at Station 38+25 m
4. TS Ghost Dance 2 at Station 48+50 m
5. TBM Forward Area at Station 58+50 m

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel:	(3825-2230)	=	1595 m
Average potential (midpoint) walking distance to available refuge chamber for trapped personnel:	1595/2	=	798 m

(Temporary portable inflatable refuge chamber may be deployed between TS Ghost Dance 2 and the TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted or may reverse the ventilation to keep the fresh air to the TBM.

Refer to Schematic 3A for normal airflow and personnel **evacuation direction.**

Establishing Strategic Location of Refuge Chambers

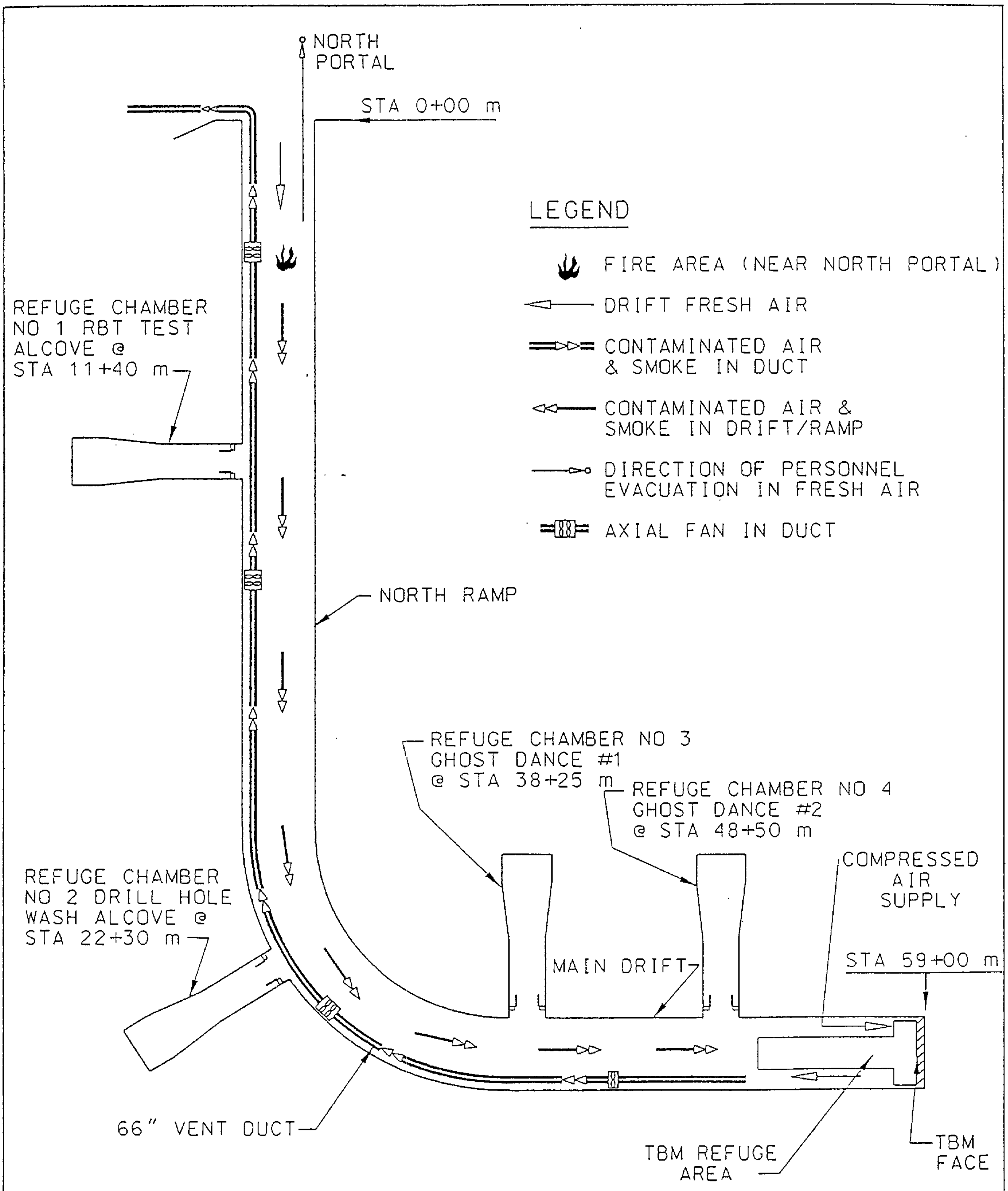

FIGURE Schematic 3A

DESIGN: R.S. JURANI

Establishing Strategic Location of Refuge Chambers

Case 3B: TBM at TS Main Drift Station 59+00 m

Fire Area: Somewhere between Station 22+50 and 37+00 m (between Drill Hole Wash and TS Ghost Dance 1 alcoves)

Available Refuge Chamber:

1. RBT Alcove at Station 11+40 m (See Note)
2. Drill Hole Wash at Station 22+30 m (See Note)
3. TS Ghost Dance 1 at Station 38+25 m
4. TS Ghost Dance 2 at Station 48+50 m
5. TBM Forward Area at Station 58+50 m

(Note: In this case, personnel not trapped by fire should evacuate directly to the surface bypassing any refuge chamber.)

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel:	(3825-2230)	=	1595 m
Average potential (midpoint) walking distance to available refuge chamber for trapped personnel:	1595/2	=	798 m

(Temporary portable inflatable refuge chamber may be deployed between TS Ghost Dance 2 and the TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted or may reverse the ventilation to keep fresh air to the TBM.

Refer to Schematic 3B for normal airflow and personnel **evacuation direction.**

Establishing Strategic Location of Refuge Chambers

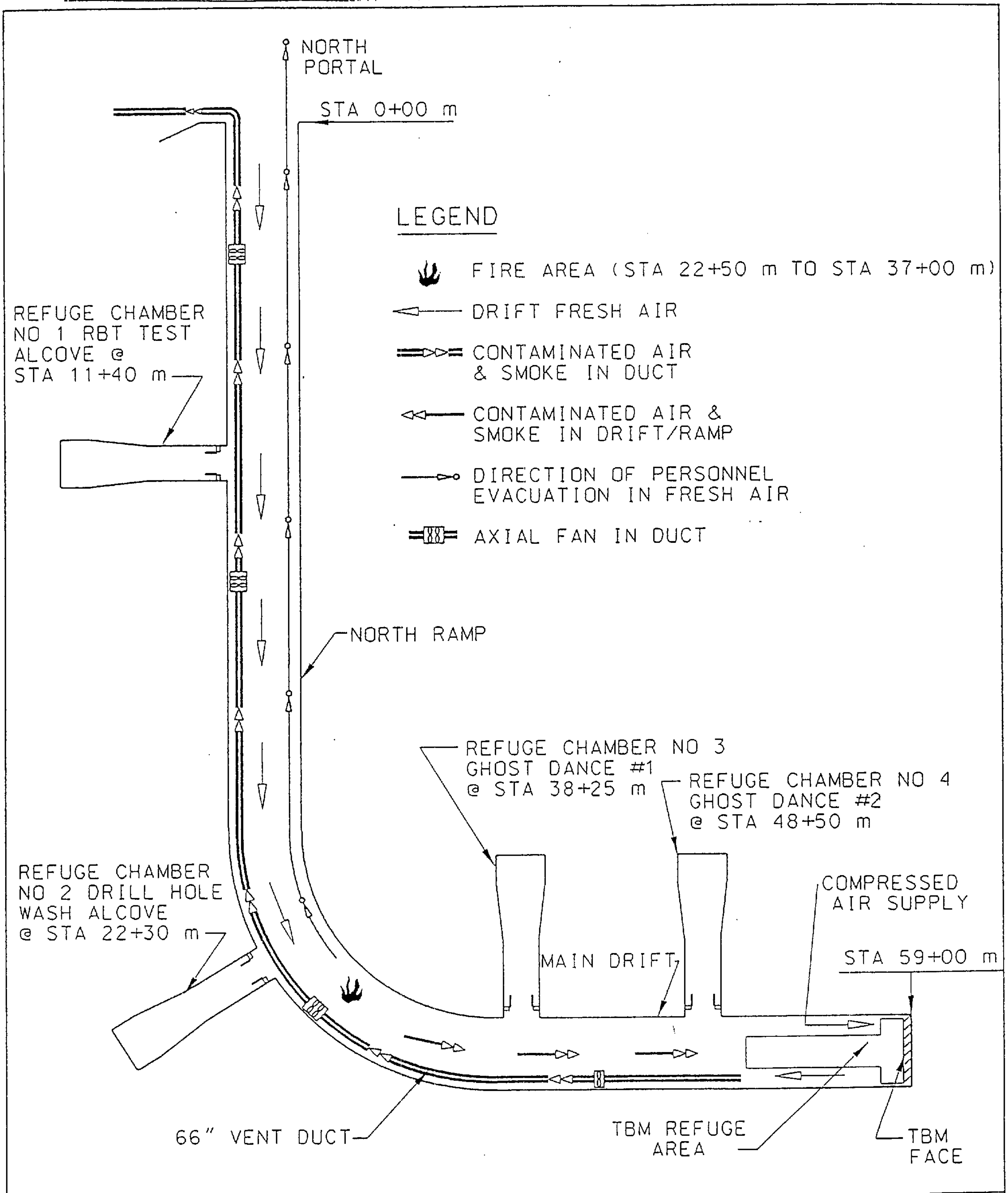

FIGURE Schematic 3B

DESIGN: R.S. JURANI

Establishing Strategic Location of Refuge Chambers

Case 3C: TBM at TS Main Drift Station 59+00 m

Fire Area: TBM Area at TS Main Drift Station 58+70 m

Available Refuge Chamber:

(When a fire is in the TBM area, personnel are to evacuate to the surface and bypass all refuge chambers.)

1. RBT Alcove at Station 11+40 m
2. Drill Hole Wash at Station 22+30 m
3. TS Ghost Dance 1 at Station 38+25 m
4. TS Ghost Dance 2 at Station 48+50 m

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers: (3825-2230) = 1595 m

Average potential (midpoint) walking distance to available refuge chamber: 1595/2 = 798 m

(Temporary portable inflatable refuge chamber may be deployed between TS Ghost Dance 2 and the TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted.

Refer to Schematic 3C for normal airflow and personnel **evacuation direction.**

Establishing Strategic Location of Refuge Chambers

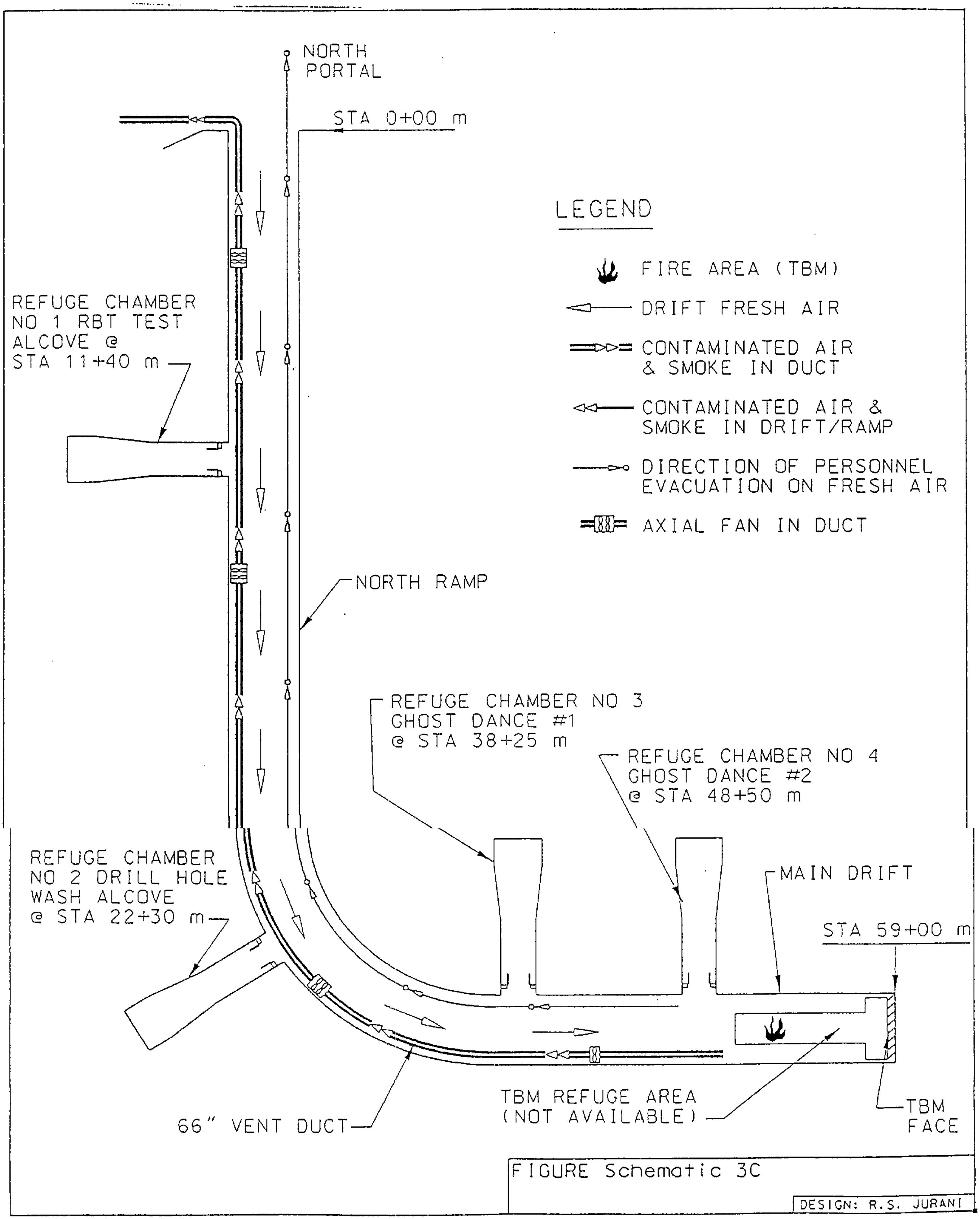

FIGURE Schematic 3C

DESIGN: R.S. JURANI

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Establishing Strategic Location of Refuge Chambers

Case 4A: TBM at TS South Ramp Station 78+50 m

Fire Area: Somewhere in between the North Portal and Station 1+50 m.

Available Refuge Chamber:

1. RBT Alcove at Station 11+40 m
2. Drill Hole Wash at Station 22+30 m
3. TS Ghost Dance 1 at Station 38+25 m
4. TS Ghost Dance 2 at Station 48+50 m
5. Abandoned Wash at Station 57+10 m
6. TBM Forward Area at Station 78+00 m

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel: (7800-5710) = 2090 m

Average potential (midpoint) walking distance to available refuge chamber for trapped personnel: 2090/2 = 1045 m

(Temporary portable inflatable refuge chamber may be deployed between Abandoned Wash and the TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted or may reverse the ventilation to keep fresh air to the TBM.

***Refer Schematic 4A for normal airflow and personnel* evacuation direction.**

Establishing Stategic Location of Refuge Chambers

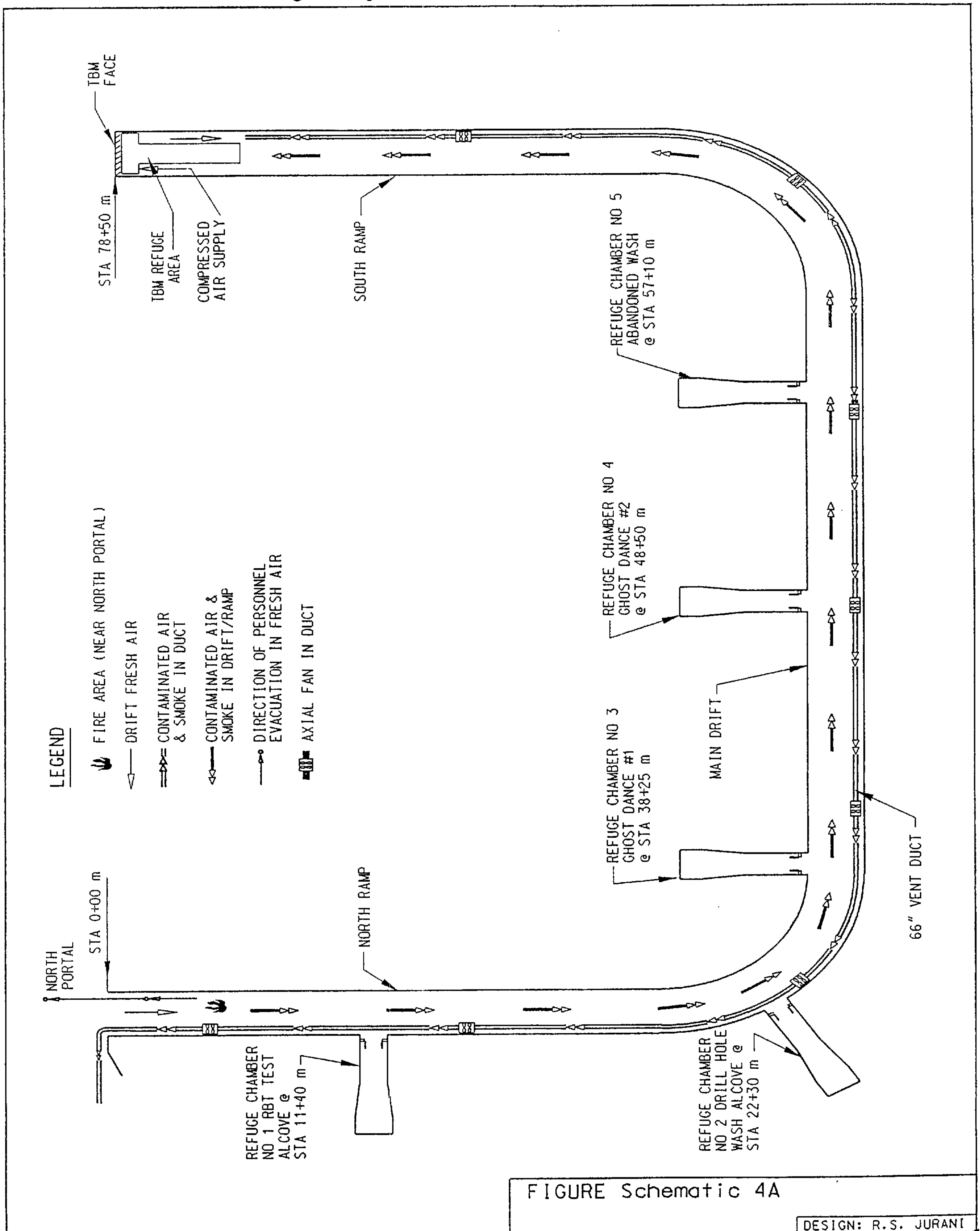


FIGURE Schematic 4A

Establishing Strategic Location of Refuge Chambers

Case 4B: TBM at TS South Ramp Station 78+50 m

Fire Area: Somewhere in between Station 38+00 m and 48+00 m (between TS Ghost Dance 1 and TS Ghost Dance 2 alcoves)

Available Refuge Chamber:

1. RBT Alcove at Station 11+40 m (See Note)
2. Drill Hole Wash at Station 22+30 m (See Note)
3. TS Ghost Dance 1 at Station 38+25 m (See Note)
4. TS Ghost Dance 2 at Station 48+50 m
5. Abandoned Wash at Station 57+10 m
6. TBM Forward Area at Station 78+00 m

(Note: In this case, personnel not trapped by fire should evacuate directly to the surface bypassing any refuge chamber.)

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel: (7800-5710) = 2090 m

Average potential (midpoint) walking distance to available refuge chamber for trapped personnel: 2090/2 = 1045 m

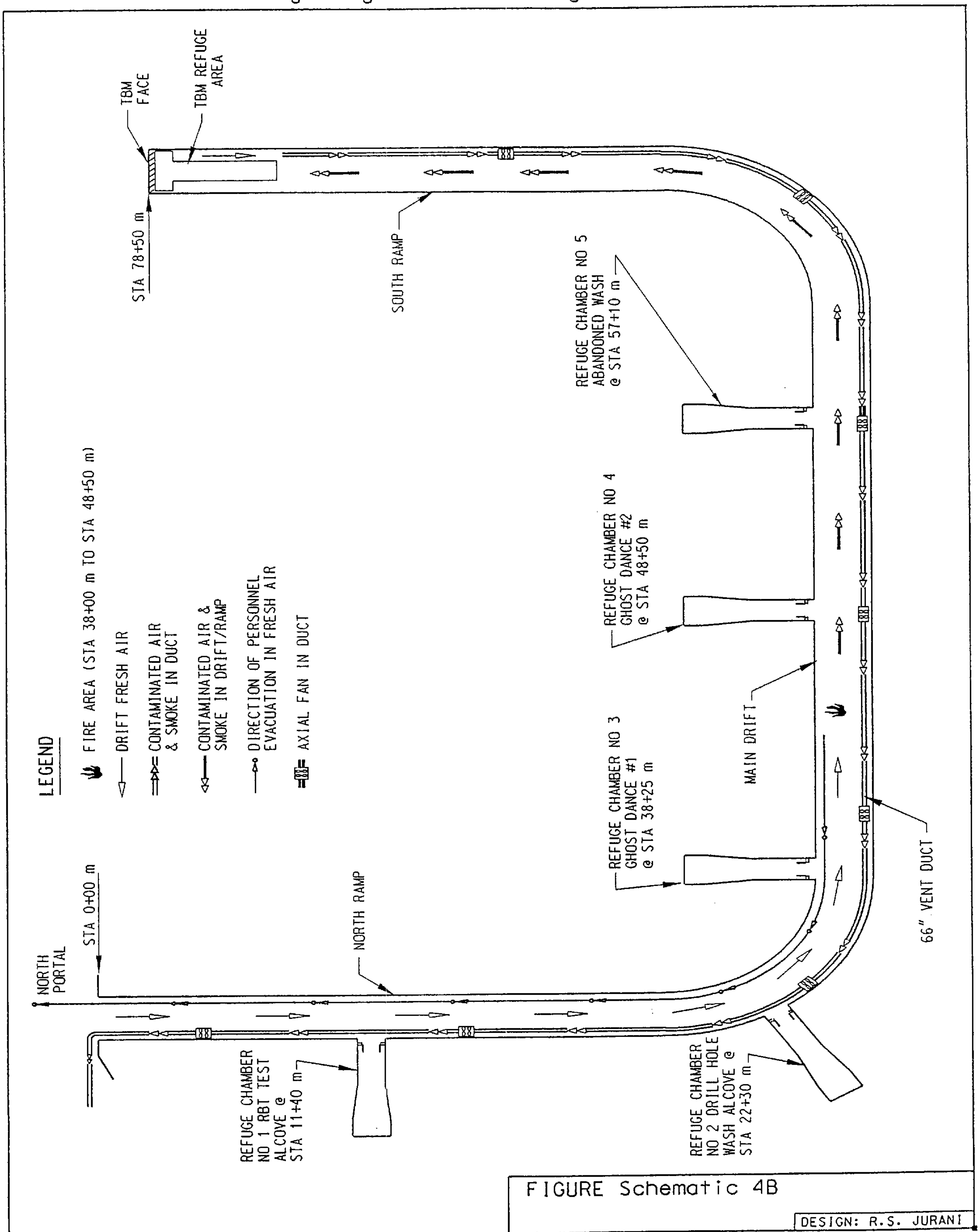
(Temporary portable inflatable refuge chamber may be deployed between Abandoned Wash and the TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted or may reverse the ventilation to keep fresh air to the TBM.

Refer to Schematic 4B for normal airflow and personnel **evacuation direction.**

Establishing Stategic Location of Refuge Chambers



Establishing Strategic Location of Refuge Chambers

Case 4C: TBM at TS South Ramp Station 78+50 m

Fire Area: TBM Area at TS South Ramp Station 78+20 m

Available Refuge Chamber:

(When a fire is in the TBM area, personnel are to evacuate to the surface and bypass all refuge chambers.)

1. RBT Alcove at Station 11+40 m
2. Drill Hole Wash at Station 22+30 m
3. TS Ghost Dance 1 at Station 38+25 m
4. TS Ghost Dance 2 at Station 48+50 m
5. Abandoned Wash at Station 57+10 m

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers:	(7800-5710)	=	2090 m
Average potential (midpoint) walking distance to available refuge chamber:	2090/2	=	1045 m

(Temporary portable inflatable refuge chamber may be deployed between Abandoned Wash and the TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted.

Refer to Schematic 4C for normal airflow and personnel **evacuation direction.**

Establishing Stategic Location of Refuge Chambers

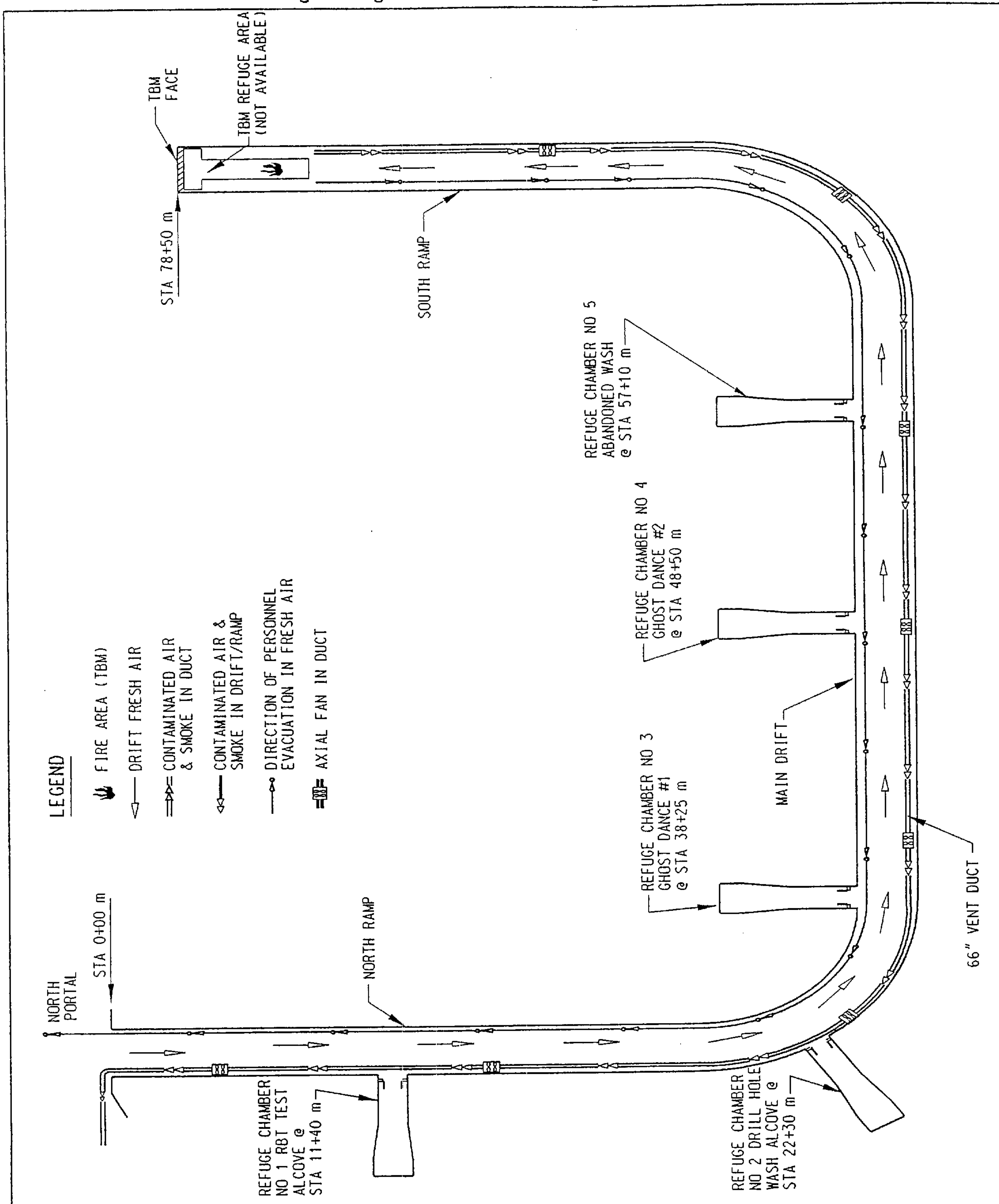


FIGURE Schematic 4C

DESIGN: R.S. JURANI

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Establishing Strategic Location of Refuge Chambers

Case 5A: First TBM at TS Main Drift Station 59+00 m and Second TBM at North Ramp Extension Station 20+50 m

Fire Area: Somewhere in between the North Portal and Station 1+50 m

Available Refuge Chamber:

1. RBT Alcove at Station 11+40 m
2. Drill Hole Wash at Station 22+30 m
3. TS Ghost Dance 1 at Station 38+25 m
4. TS Ghost Dance 2 at Station 48+50 m
5. Drill Hole Wash/North Ramp Extension at Station 11+00 m
6. First TBM Forward Area at Station 58+50 m
7. Second TBM Forward Area at North Ramp Extension Station 20+00 m

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel: (3825-2230) = 1595 m

Average potential (midpoint) walking distance to available refuge chamber for trapped personnel: 1595/2 = 798 m

(Temporary portable inflatable refuge chamber may be deployed between TS Ghost Dance 2 and the first TBM Forward Area, and between Drill Hole Wash North Extension and the second TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted.

Refer to Schematic 5A for normal airflow and personnel **evacuation direction.**

Establishing Strategic Location of Refuge Chambers

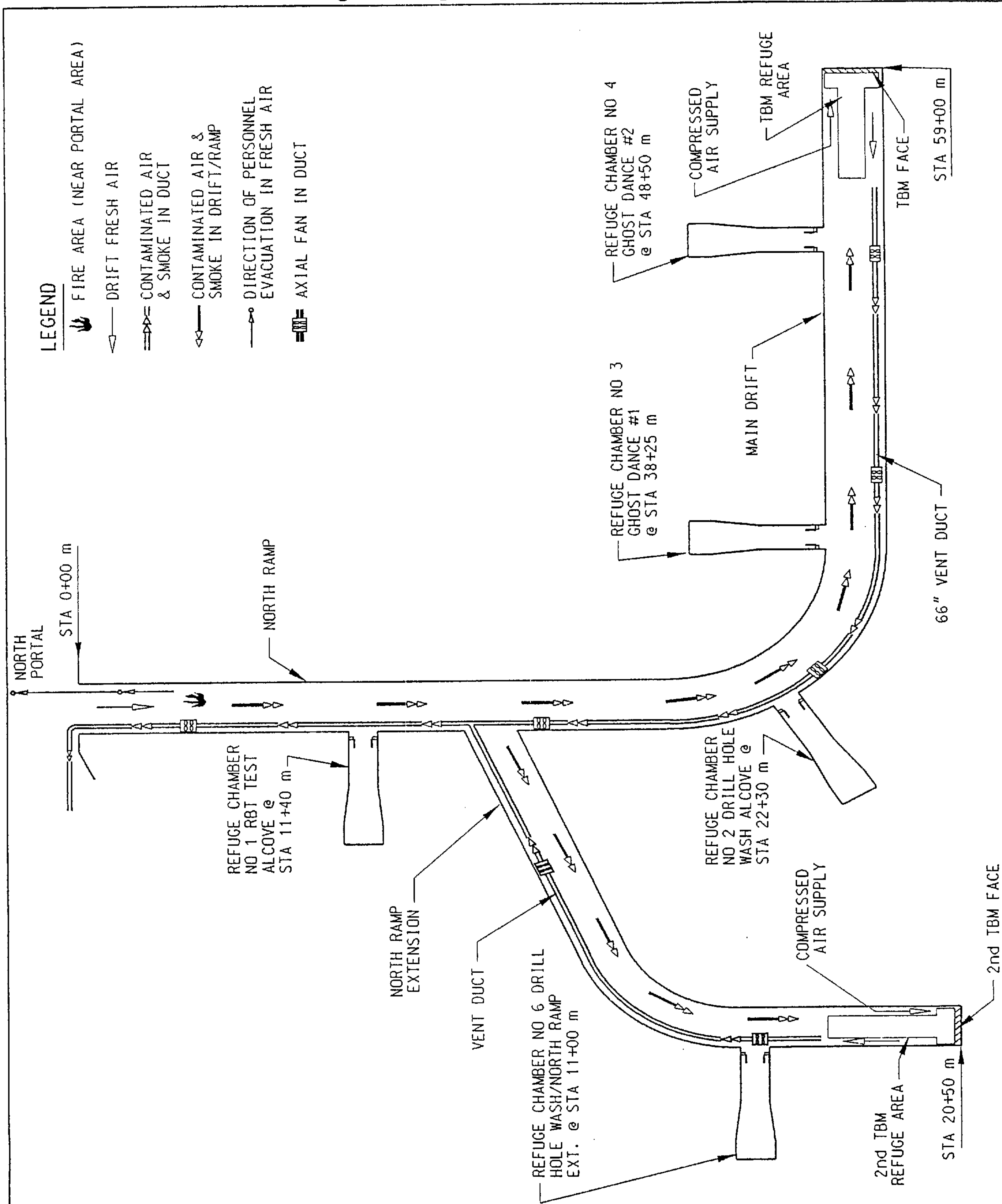


FIGURE Schematic 5A

DESIGN: R.S. JURANI

Establishing Strategic Location of Refuge Chambers

Case 5B: First TBM at TS Main Drift Station 59+00 m and Second TBM at North Ramp Extension Station 20+50 m

Fire Area: Somewhere in the North Ramp Extension between Station 00+50 m and 8+00 m

Available Refuge Chamber:

1. RBT Alcove at Station 11+40 m (See Note)
2. Drill Hole Wash at Station 22+30 m (See Note)
3. TS Ghost Dance 1 at Station 38+25 m (See Note)
4. TS Ghost Dance 2 at Station 48+50 m (See Note)
5. Drill Hole Wash/North Ramp Extension at Station 11+00 m
6. First TBM Forward Area at Station 58+50 m
7. Second TBM Forward Area at North Ramp Extension Station 20+00 m

(Note: In this case, personnel not trapped by fire should evacuate directly to the surface bypassing any refuge chamber.)

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers for trapped personnel: (3825-2230) = 1595 m

Average potential (midpoint) walking distance to available refuge chamber for trapped personnel: 1595/2 = 798 m

(Temporary portable inflatable refuge chamber may be deployed between TS Ghost Dance 2 and the first TBM Forward Area, and between Drill Hole Wash North Extension and the second TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted.

Refer to Schematic 5B for normal airflow and personnel **evacuation direction.**

Establishing Strategic Location of Refuge Chambers

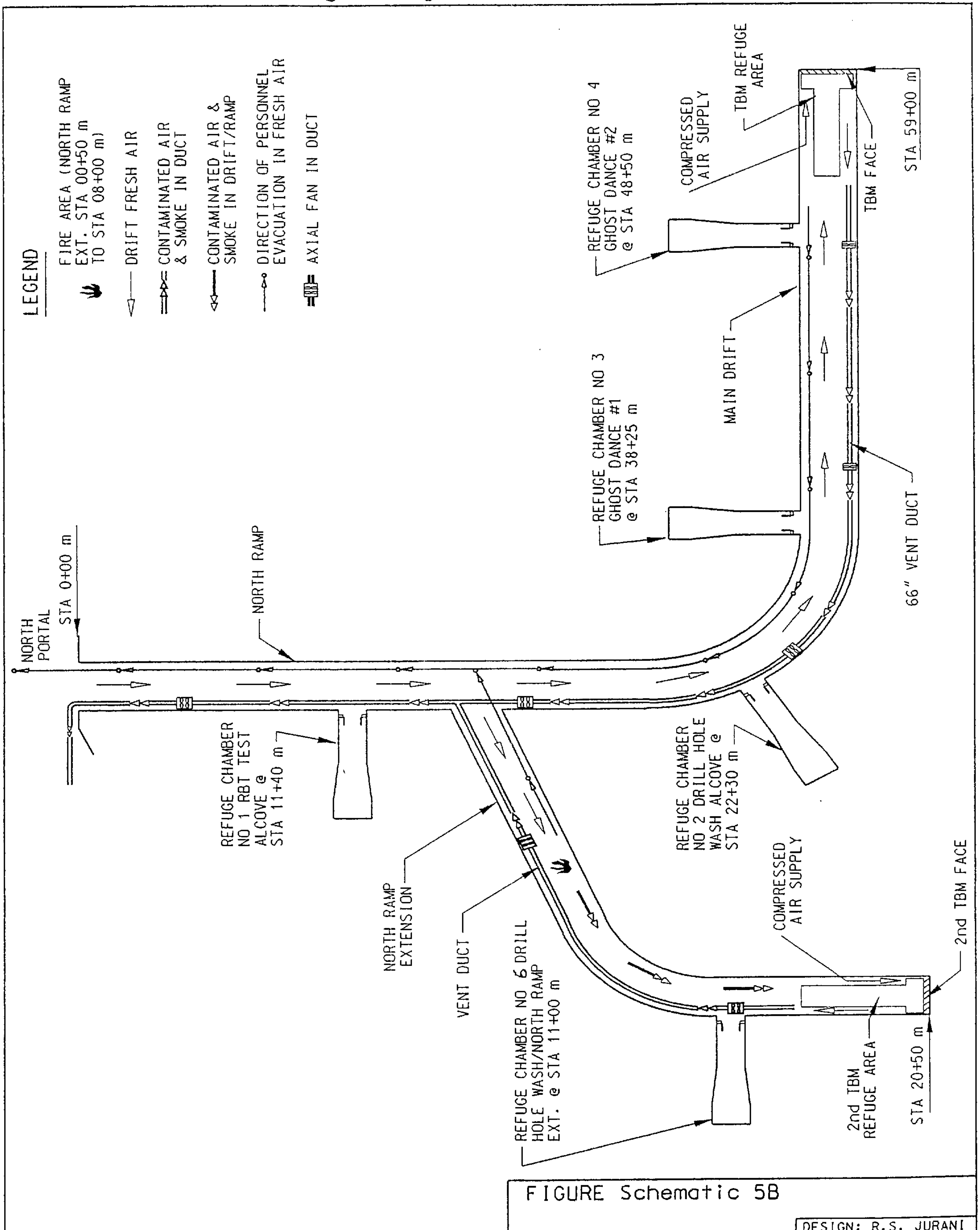


FIGURE Schematic 5B

Establishing Strategic Location of Refuge Chambers

Case 5C: First TBM at TS Main Drift Station 59+00 m and Second TBM at North Ramp Extension Station 20+50 m

Fire Area: Second TBM area at North Ramp Extension Station 20+20 m

Available Refuge Chamber:

(When a fire is in the TBM area, personnel are to evacuate to the surface and bypass all refuge chambers.)

1. RBT Alcove at Station 11+40 m
2. Drill Hole Wash at Station 22+30 m
3. TS Ghost Dance 1 at Station 38+25 m
4. TS Ghost Dance 2 at Station 48+50 m
5. Drill Hole Wash/North Ramp Extension at Station 11+00 m
6. First TBM Forward Area at Station 58+50 m

Fresh Air Base: North Portal to Station near fire

Maximum potential walking distance between available refuge chambers: (3825-2230) = 1595 m

Average potential (midpoint) walking distance to available refuge chamber: 1595/2 = 798 m

(Temporary portable inflatable refuge chamber may be deployed between TS Ghost Dance 2 and the first TBM Forward Area, and between Drill Hole Wash North Extension and the second TBM Forward Area)

Ventilation Action:

Keep normal ventilation. After careful evaluation of the case, management may decide to keep or shut off the normal ventilation until the fire is controlled or exhausted.

Refer to Schematic 5C for normal airflow and personnel **evacuation direction.**

Establishing Strategic Location of Refuge Chambers

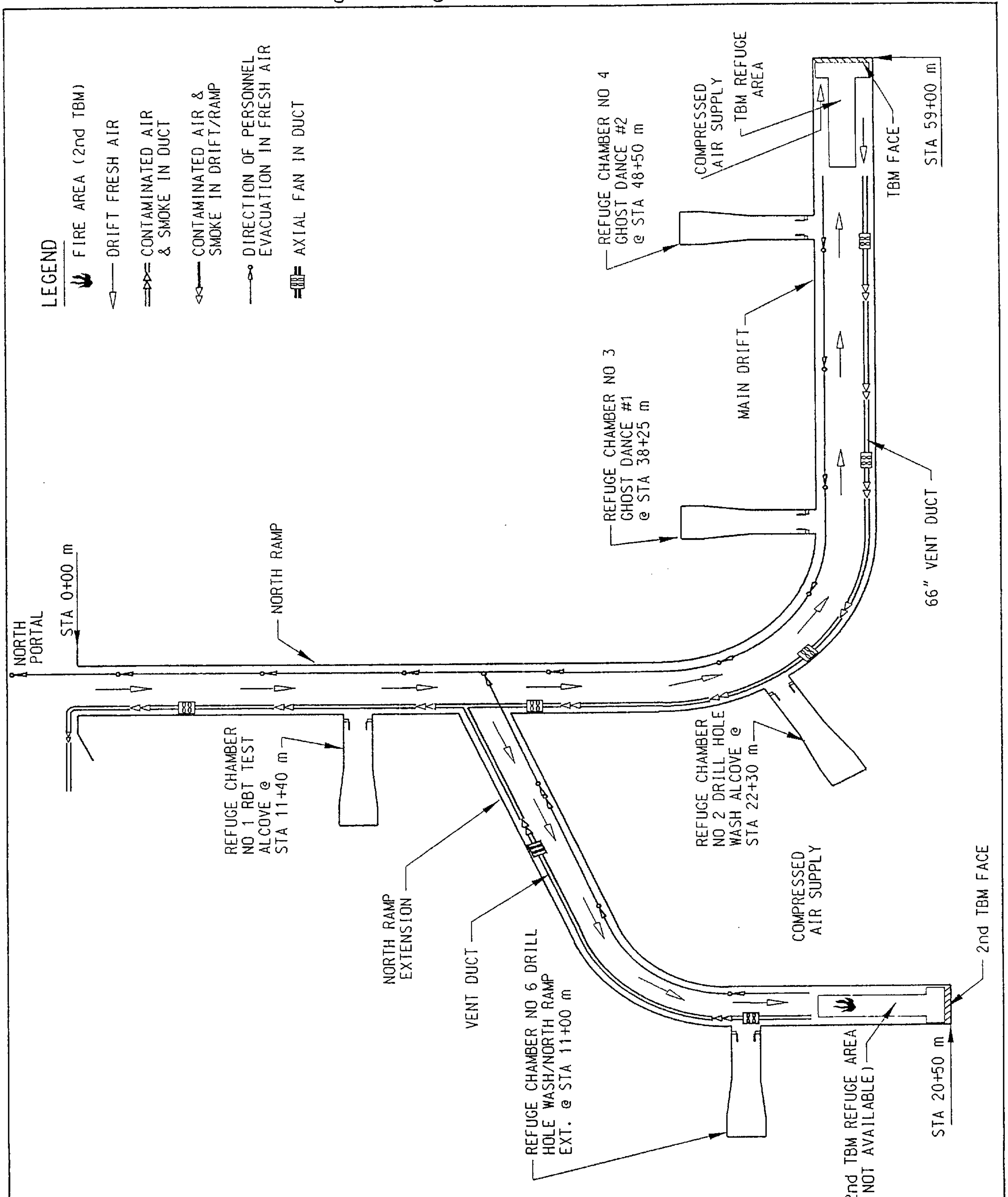
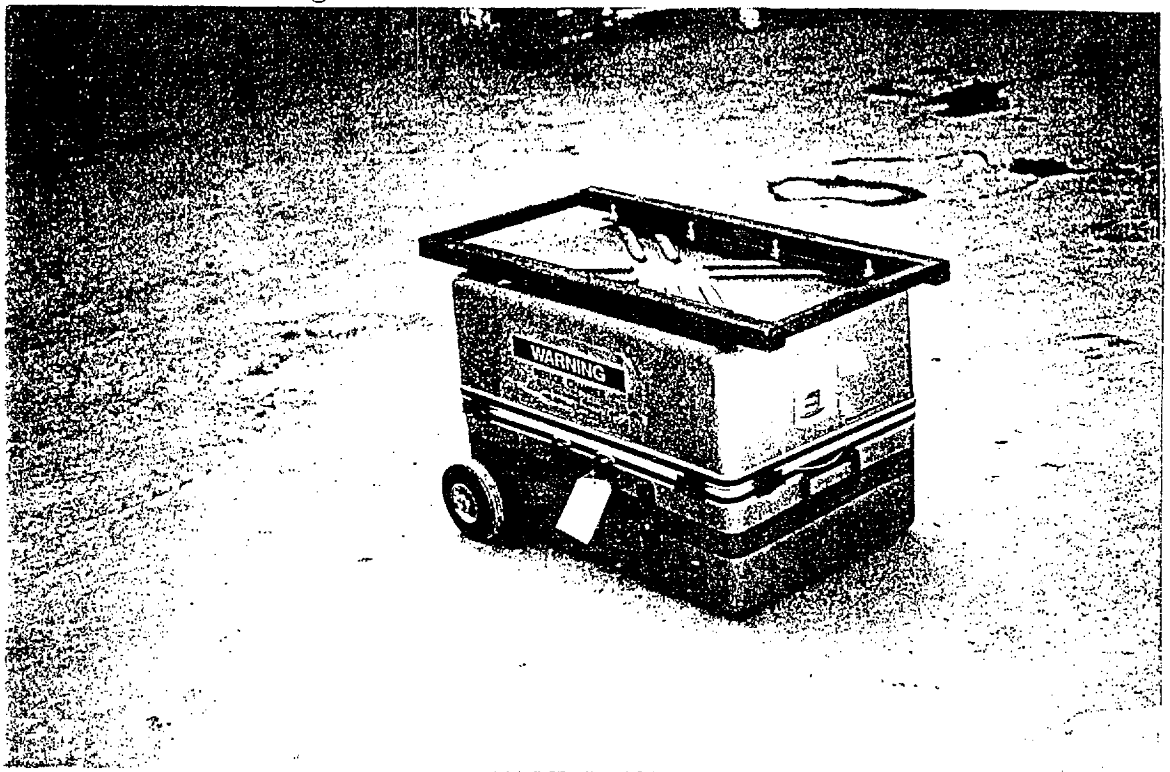


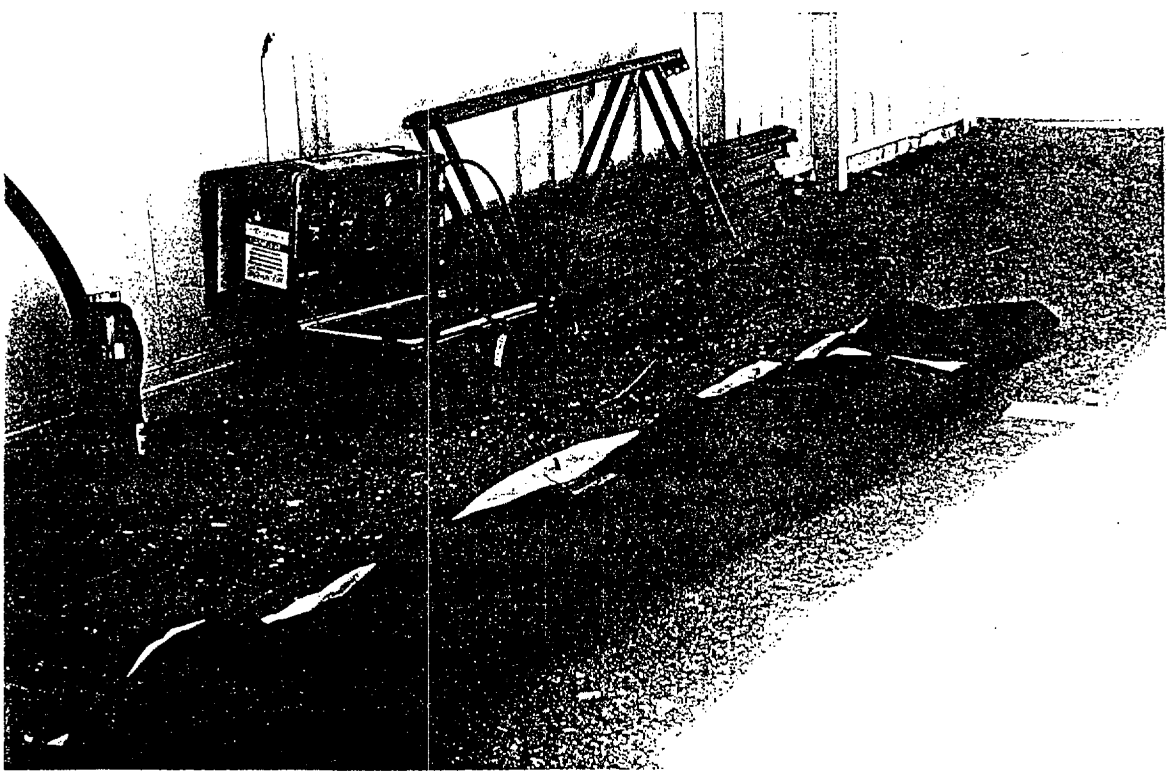
FIGURE Schematic 5C

DESIGN: R.S. JURANI

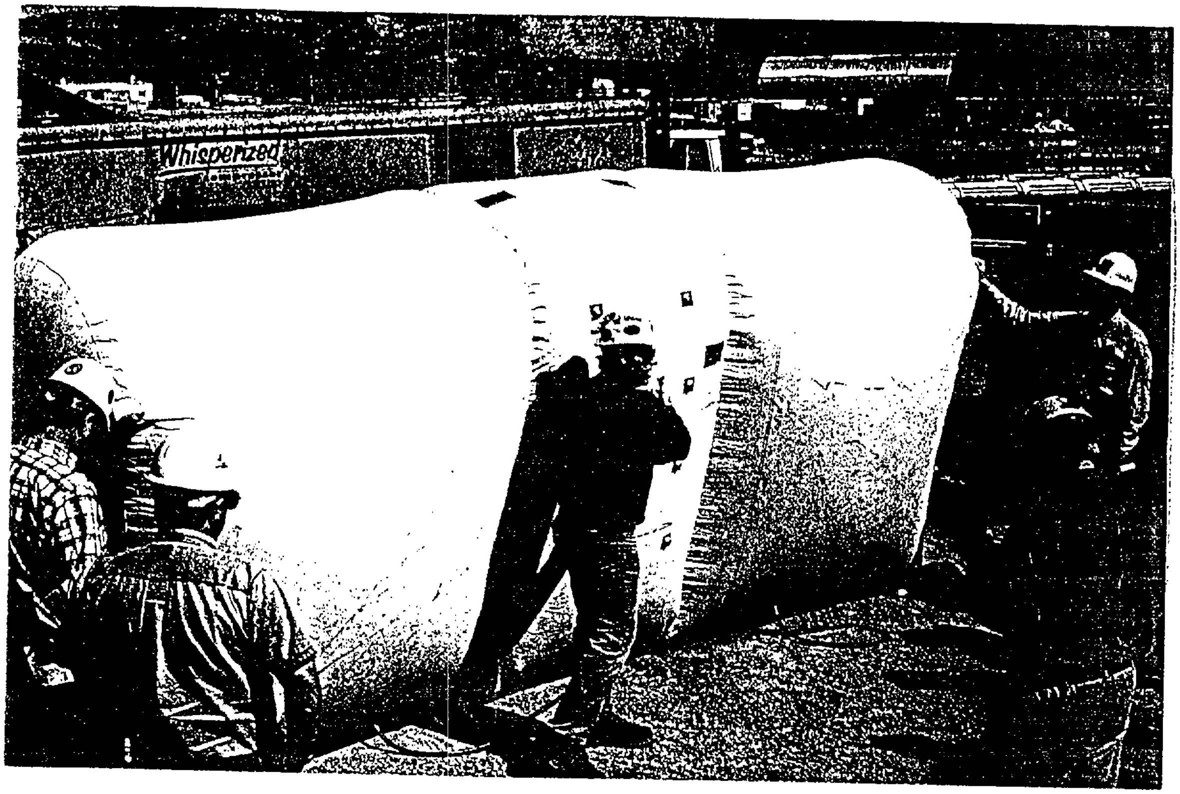
Portable Inflatable Refuge Chamber



Storage Box

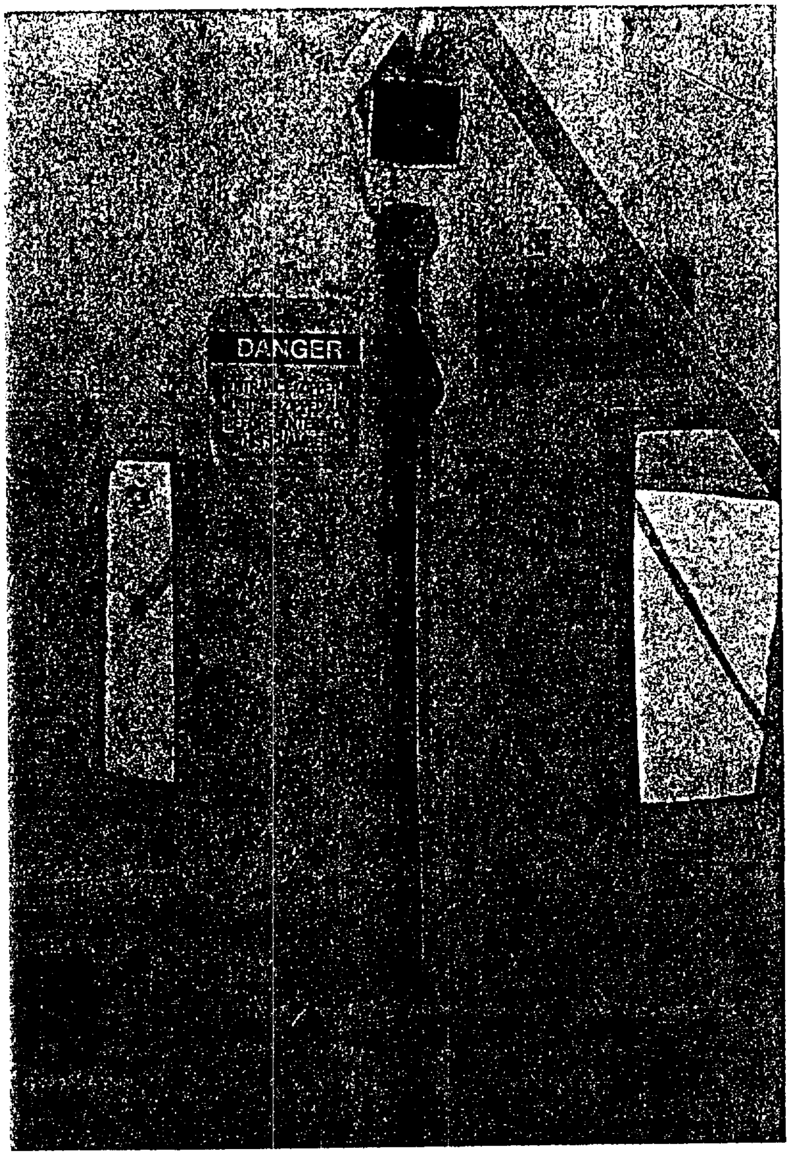


Uninflated Refuge Material



Inflated Refuge Chamber

Inflated Refuge Chamber



Inside Compartment of Refuge Chamber

Interoffice Correspondence
Civilian Radioactive Waste Management System
Management & Operating Contractor

TRW
TRW Environmental Safety Systems, Inc

Subject Portable Refuse Chamber	**Date** April 10, 1995 LV.SHPD.CCP.4/95-001	**WBS:** 1.2.13.2 **QA:** N/A **From** Carl C. Pierce, Jr.
To G. D. Milligan	**cc** R. Jurani, TES3/423 R. McDonald, M/S 717 L. E. Minnick, TES3/423 RPC	**Location/Phone** TES3/263 (702) 794-7795

To my knowledge, the only Portable Refuge Chamber that I know of is distributed by National Mine Service Company.

A demonstration on March 8, 1995, at the portal area (ESF) revealed that this chamber could be erected within 5 minutes to accommodate 8 or more persons to a safe atmosphere for breathing.

As it is a fabric, it cannot stand high heat exposure, but due to the lack of wood and other combustibles away from TBM, this type of chamber might benefit the project by providing a refuge between existing alcoves.

The light weight and compactness of the chamber has an advantage if it is positioned nearby, plus the short-time it takes to inflate and be fully erected for use in an emergency. It cannot contain supplied oxygen bottles (as that will ruin its portability). If the air line breaks in the emergency, the refuge chamber will be good only as long as the oxygen that's in the air inside the chamber lasts.

Whether this device is used, is a matter that needs careful consideration.

CCP:lm

Carl- I concur with these observations. Forward to R. Jurani if you wish. GDM

National Mine Service Company
Mining & Safety Supply Division
P.O. Box 310, Indiana, PA 15701 • (412) 349-7100 • FAX (412) 349-7352

March 23, 1995

TRW
Mr. Carl Pierce
101 Convention Center Drive
Las Vegas, NV 89109

Dear Mr. Pierce:

We, at National Mine Service Company, would like to express our appreciation for the recent opportunity of March 8, 1995 to demonstrate the Portable Inflatable Refuge Chamber (RC) to the Yucca Mountain Project staff. Our special thanks to Mr. Carl Pierce of TRW for setting up this demonstration.

In review the RC provides a refuge/rescue chamber for eight (8) people. The RC protects workers from IDLH atmospheres. The RC is made up of two (2) rescue chambers, one on each side of an air lock entry. The RC is inflated within three (3) to five (5) minutes by compressed air. Positive pressure within the chambers hold the air lock and entire structure erect. The positive pressure flow of air through a NIOSH approved Air Systems point of attachment into the chamber continually purges the chamber air. Grade "D" air is supplied through the air filtration system.

Effective, portable, lightweight, durable and easy to use the RC provides an excellent alternative at a reasonable cost of $7500.00 per unit for refuge/rescue protection of your valuable employees. If you have any questions or require any additional information, please contact me at 800-692-6672. We look forward to working with you.

Sincerely,

Randall C. Britton /la

Randall C. Britton
Manager - Tunnel Sales

RCB:la
cc: J. Lydic - NMS,IND
S. Lipe - NMS,PRI
M. Rarick - NMS,PRI