CIVILIAN RADIOACTIVE WASTE MANAGEMENT SYSTEM

Management and Operating Contractor

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WASTE ISOLATION IMPACT EVALUATION

PLUGGING OF BOREHOLES UE-25 NRG 1 AND UE-25 RF 3, 3B, 5, 9, 10 and 11

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Yucca Mountain Site Characterization Project Office
U. S. Department of Energy

Date: December 15, 1992

M&O Program: Waste Isolation Impact Evaluation
Plugging of Boreholes UE-25 NRG-1 and UE-25 RF 3, 3B, 5, 9, 10, and 11

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This waste isolation impact evaluation was prepared in accordance with M&O QAP-3-5.

1. INTRODUCTION

1.1 Purpose

This waste isolation evaluation was performed in response to two letter requests (for boreholes NRG 1 and RF 3, 3B and 5) and a verbal request (for boreholes RF 9, 10 and 11) from the Yucca Mountain Site Characterization Project Office (YMPO) to assess potential waste isolation impacts of the planned plugging of these boreholes, plus a memorandum from Los Alamos National Laboratory (LANL) to evaluate the cement to be used (Ref. 1, 2 and 3). This evaluation supersedes the waste isolation attachment to an earlier response (Ref. 4).

1.2 Evaluation Approach

This is a largely qualitative evaluation based on information in the referenced documents. No new quantitative analyses were performed with the exception of quantitative comparisons of available information. A checklist (see last page) was used as guidance to ensure that no potential activities and impacts were overlooked.

1.3 Quality Assurance

The proposed activity will affect natural barriers at the Yucca Mountain site, which are listed in Appendix A of the Q-List. Accordingly, this report was prepared as a quality-affecting activity according to CRWMS M&O Quality Administrative Procedure QAP-3-5 Development of Technical Documents. Some of the referenced data may not have been approved for quality-affecting activities and the referenced analyses may not have been performed as quality-affecting activities or under software QA requirements. The extent and possible effect of non-qualified data on the evaluations, conclusions and recommendations of this report were not determined.

2. EVALUATION

2.1 Evaluation of UE-25 NRG 1

NRG-1 is located about 0.88 miles east and outside of the conceptual perimeter drift boundary (CPDB) and inside of the conceptual controlled area boundary (CCAB) (Ref. 7). The borehole is about 150 feet deep. The bottom of the hole is about 330 feet above the Topopah Spring level of the north ramp. Per Exploratory Studies Facility (ESF) Phase 1A design drawings, NRG 1 is approximately on the center line of the planned starter tunnel, about 60 feet from the headwall, near the tunnel invert crest between the up-slope from the entrance and the down-slope toward the Topopah Spring level.

Due to the distance of NRG 1 from the conceptual repository and potential repository expansion areas (Ref. 13), thermal effects of a potential repository on the borehole sealant, which could affect the sealant's stability, are expected to be negligible.

Due to the NRG 1 location and the geometry of the site, NRG-1 is unlikely to impact waste isolation. The bottom of the borehole is at a higher elevation than the conceptual repository. Thus, no radionuclides will be transported by water out of the borehole. Gaseous radionuclides would be impeded by seals in the ramp before they would reach the borehole.

The drill and blast techniques to be used in the construction of the entrance ramp could induce fractures in the sealant material which could open pathways for water from the ground surface. The borehole is located about 60 feet from the entrance to the tunnel, approximately at the peak of the tunnel invert. This could result in some water leaking down the borehole to flow toward the repository. The amounts are expected to be small, however, and impeded by future ramp seals: consequently, this water would infiltrate into the rock underlying the tunnel before it reaches the conceptual repository and potential repository expansion areas. Water leaking into the tunnel during the ESF and potential repository operational phases can be removed with other infiltrating water by sump pumps before it flows to the potential repository area.

Due to the distance of the borehole from the conceptual repository and potential repository expansion areas, and since it is downdip from the conceptual repository and potential repository expansion areas (Ref. 11 and 12), any seepage into the rock is expected to flow away from the conceptual repository and potential repository expansion areas (Ref. 8 and 9).

Concerns were recently expressed by the YMP Assessment Team with regard to some assumptions and results in two SNL reports which form the basis for conclusions on water infiltration from the surface to the conceptual repository. SNL has provided evidence, however, that the conclusions are still valid due to the high conservatism in their assumptions and as indicated by new analyses (Ref. 10).

2.2 Evaluation of UE-25 RF 3, 3B, and 5

RF 3 and RF 3B are located about 1.1 miles east and outside of the CPDB, inside of the CCAB, and along the existing road leading to the planned ESF north portal pad (Ref. 6). These boreholes are 301 and 111 feet deep, respectively. The bottoms of the holes are about 180 feet below and 130 feet above, respectively, the Topopah Spring level of the north ramp.

RF 5 is located about 0.88 miles east and outside of the CPDB, inside the CCAB (Ref. 6), and near the planned ESF topsoil and rock storage areas. It is above a potential repository expansion area (Ref. 13.) The borehole is 122 feet deep. The bottom of the hole is about 420 feet above the Topopah Spring level of the north ramp.

Due to the distance of all three boreholes from the conceptual repository, thermal effects of a potential repository on the borehole sealant, which could affect the sealant's stability, are expected to be negligible.

Due to the borehole locations and the geometry of the site, RF 3B and RF 5 are unlikely to impact waste isolation of the current conceptual repository. The bottoms of the boreholes are at higher elevations than the conceptual repository; thus, no radionuclides will be transported by water out of the hole. There is no direct path for release of gaseous radionuclides, and their release would be impeded by the mile of tuff between the CPDB and the boreholes.

Unlike the other boreholes, RF 3 extends to an elevation lower than the conceptual repository horizon. It is also geologically downdip from the conceptual repository and potential repository expansion area. Per geologic cross-sections by Scott and Bonk (Ref. 11), the bottom of RF 3 is toward the bottom of the Tiva Canyon tuff. Because this is above the Topopah Spring tuff, the potential repository horizon, water-born radionuclides are not expected to reach the borehole. For the same reasons as for RF 3B and 5 (i.e., principally the borehole's distance from the conceptual repository and potential repository expansion area) gaseous radionuclide releases from RF 3 are expected to be insignificant or nonexistent.

Raytheon Service Nevada (RSN) reports that all RF boreholes contain cast iron casings and residual polymer drilling mud which would be sealed in the boreholes (Ref. 17). The cast iron casings, if left in place, are expected to corrode and provide pathways for water.

Due to the distance of the boreholes from the conceptual repository, however, and since they are downdip of the conceptual repository (Ref. 11 and 12), any leakage of water into the boreholes and transport of foreign materials is not expected to reach the conceptual repository (Ref. 8, 9, and 10).

Due to the location of borehole RF 5 above a potential repository expansion area, this borehole could provide pathways for water from the ground surface and foreign materials from the borehole itself to a potential repository expansion horizon and for gaseous radionuclide releases from a potential repository expansion horizon to the ground surface. The stability of the sealant could be affected by repository temperatures, but this is unlikely since the bottom of the borehole is more than 400 feet above a potential repository expansion horizon.

2.3 Evaluation of UE-25 RF 9, 10, and 11

Boreholes RF 9, 10, and 11 are located about 0.94, 0.99, and 1.0 miles, respectively, east and outside of the CPDB, inside the CCAB (Ref. 6), and uphill of or above the planned ESF north portal pad. These boreholes are 106, 60, and 78 feet deep, respectively. The bottoms of the holes are about 300, 340, and 320 feet, respectively, above the Topopah Spring level of the north ramp.

These boreholes have already been sealed. Based on the same reasoning as given for borehole NRG 1, these boreholes are not expected to impact waste isolation.

2.4 Sealant Evaluations

The planned sealant for the boreholes is a neat cement slurry (i.e., without sand or aggregate) composed of type II Portland cement. However, as Licastro et al. (Ref. 14) noted, "There is considerable evidence that the adjustment of the composition of the Portland cement matrix of concrete materials to higher silica contents more closely matching the composition of the host rock is a means of generating greater stability and probable long-term durability in sealing materials" (Ref. 14). The addition of excess silica acts to consume calcium hydroxide, the weaker component of the hydrated matrix.

In their evaluation of mortar and grout formulations, Licastro et al. (Ref. 14) chose three for further study: expansive mixtures 82-22 and 82-30 and nonexpansive mixture 84-12. All three have low permeabilities (less than 10^{-8} Darcy) and are less permeable than the rock, which is expected to have permeabilities greater than 10^{-4} Darcy (Ref. 16). Mixtures 82-22 and 84-12 seem to be appropriate sealants. The first, 82-22, is the closest to the bulk composition of the nonwelded and welded tuff, and the latter, 84-12, has a similar composition. This is desirable as, "It is presumed that the closer the bulk chemistry of a material is to its emplacement environment, the lower is the potential for the modification of the material bulk chemistry. Therefore, the potential modification of its physical and mechanical properties will also be lower" (Ref. 14).

Mixture 84-12 has a reduced sulfate content and high silica, so that an intermediate pH is maintained and there is a lessened potential of the sulfate reacting as a radionuclide complexing agent. It was noted by Scheetz and Roy (Ref. 15) that aluminum substitution into the tobermorite structure increases the thermal stability of the mixture. Mixture 82-22 has the highest alumina content of the three listed above, and therefore more Al-substituted tobermorite could be formed. Also, when there is coupled alkali plus aluminum substitution in tobermorite, material is generated which has ion exchange properties favorable for radionuclide sorption.

The specific properties of the type II Portland cement proposed for the borehole plugging were not provided, only that they satisfy ASTM Standard C 150-89. The minimum compressive strength for a C 150-89 cement after seven days is 17.2 MPa. However, the experimentally measured 7-day compressive strengths for the 82-30 grout (no sand included), 82-22 mortar (with sand), and 84-12 mortar (with sand) are 99.1 MPa, 77.5 MPa, and 86.9 MPa, respectively, and are therefore significantly stronger than type II Portland cement.

3. CONCLUSIONS AND RECOMMENDATIONS

<u>Recommendation 1</u>. Due to the locations and depths of the boreholes, except borehole RF 5, they are not expected to impact waste isolation for the current conceptual repository and potential repository expansion areas. Thus, leaving the casings in place and sealing with the planned neat cement slurry is acceptable, except for borehole RF 5.

<u>Recommendation 2</u>. Because borehole RF 5 could provide a potential pathway for surface water to a potential repository expansion horizon and for gaseous radionuclide releases from that expansion horizon to the surface, removal of the borehole casing and a better sealant than the planned cement slurry should be considered. A mixture is recommended whose compressive strength is high, whose bulk chemistry is similar to that of the host tuff, and whose permeability is at least as low as the host tuff. Mixtures 84-12 and 82-22 are good candidate sealants. Pie charts and tables of the compositions, obtained from Scheetz and Roy (Ref. 15), are attached.

Recommendation 3. Analyses are recommended to determine the significance of the above pathways if borehole RF 5 will not be sealed as recommended.

Recommendation 4. During the blasting of the starter tunnel, fractures could be induced in the cement seal of borehole NRG-1. Due to the location of the borehole, this is not expected to impact waste isolation. Thus, delaying the sealing until after the excavation of the starter tunnel is not necessary.

4. REFERENCES

1. "Request for Test-to-Test Interference and Waste Isolation Evaluation for the Plugging of UE-25 NRG 1; Test Planning Package 92-1, Revision 2, Job Package 92-2," Letter from J. Russell Dyer, YMPO, to L. D. Foust, CRWMS M&O, November 10, 1992 (received November 16, 1992).

2. "List of Tracers, Fluids, Materials Assessment for UE-25 Borehole (NRG-1)," Memorandum from H. Kalia, LANL, to L. Foust, CRWMS M&O, November 24, 1992 (received November 25, 1992).

3. "Request for Test-to-Test Interference and Waste Isolation Evaluations for the Plugging of UE-25 RF 3, 3B, and 5," Letter from J. R. Dyer, YMPO, to L. D. Foust, CRWMS M&O, November 25, 1992 (received November 30, 1992).

4. "Addendum to Test Interference Evaluation Update for the Construction of North Portal Drillhole UE-25 NRG-1, etc.," Letter from L. D. Foust, CRWMS M&O, to C. P. Gertz, YMPO, November 23, 1992.

5. "Title I Design Summary Report for the Exploratory Studies Facility," YMP/CC-0019, Rev. 1, p. 0-8, October 16, 1991.

6. "YMP Existing Drillholes and Subsurface Access Drifts," EG&G Map YMP-91-025.1, June 1991.

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9. "SNL Response to Information Request of October 27, 1992," Letter from T. E. Blejwas, SNL, to R. L. Bullock, RSN, November 3, 1992.

10. "Resolution of Assessment Team (AT) Concerns Regarding SNL Input to ESF Design Package Classification Reports," Letter from L. E. Shephard, SNL, to M. B. Blanchard, YMPO, November 23, 1992.

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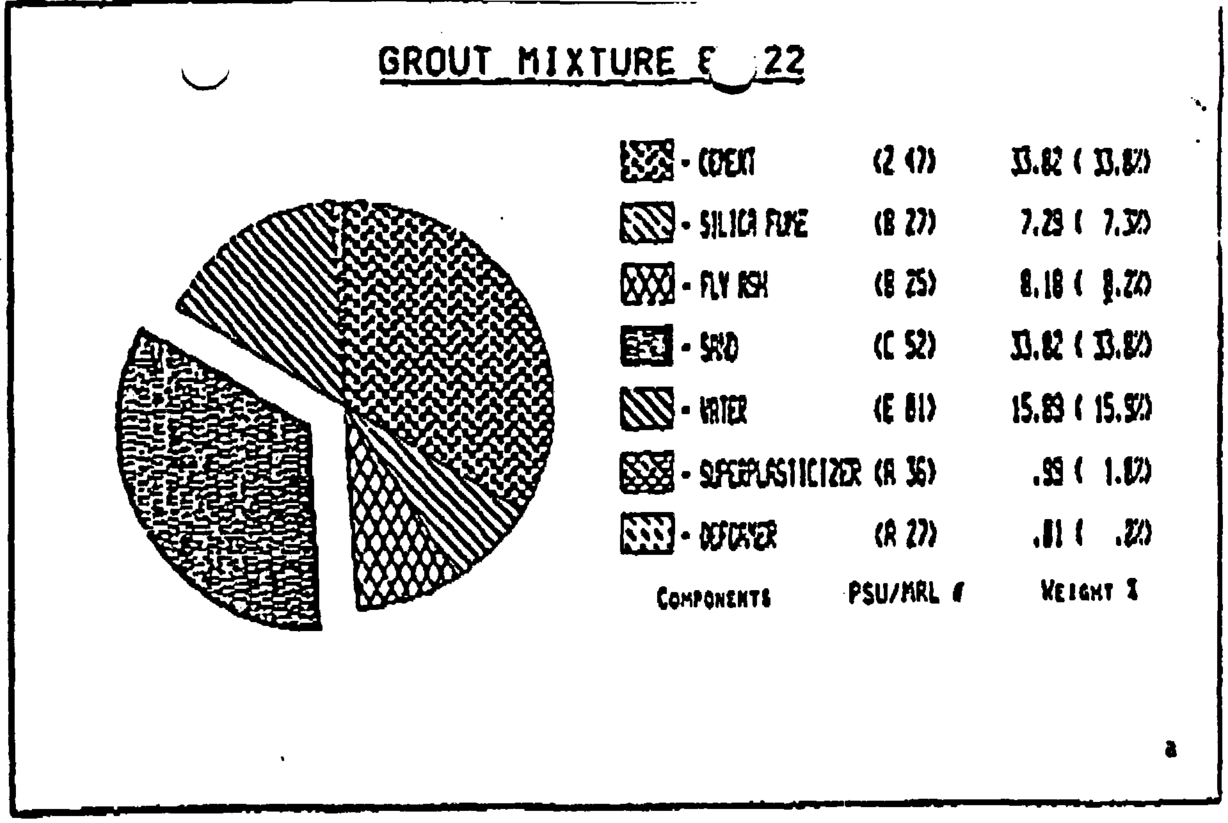
13. "Site Characterization Plan, Yucca Mountain Site, Nevada Research and Development Area, Nevada," DOE/RW-0199, Volume III, Part A, p. 6-226 and 6-228, December 1988.

14. Licastro, P. H., J. A. Fernandez, and D. M. Roy, "Preliminary Laboratory Testing of Selected Cementitious Material for the Yucca Mountain Project Repository Sealing Program," SAND86-0558, 1990.

15. Scheetz, B. E., and D. M. Roy, "Preliminary Survey of the Stability of Silica-Rich Cementitious Mortars (82-22 and 84-12) with Tuff," Los Alamos, NM: Los Alamos National Laboratories, 1986.

16. Daemen, J. J. K., et al., "Rock Mass Sealing -- Annual Report, June 1, 1982 - May 31, 1983," NUREG/CR-3473, 1983.

17. "Hole History Data, NWWSI," Fenix & Scisson, Inc., November 1986.



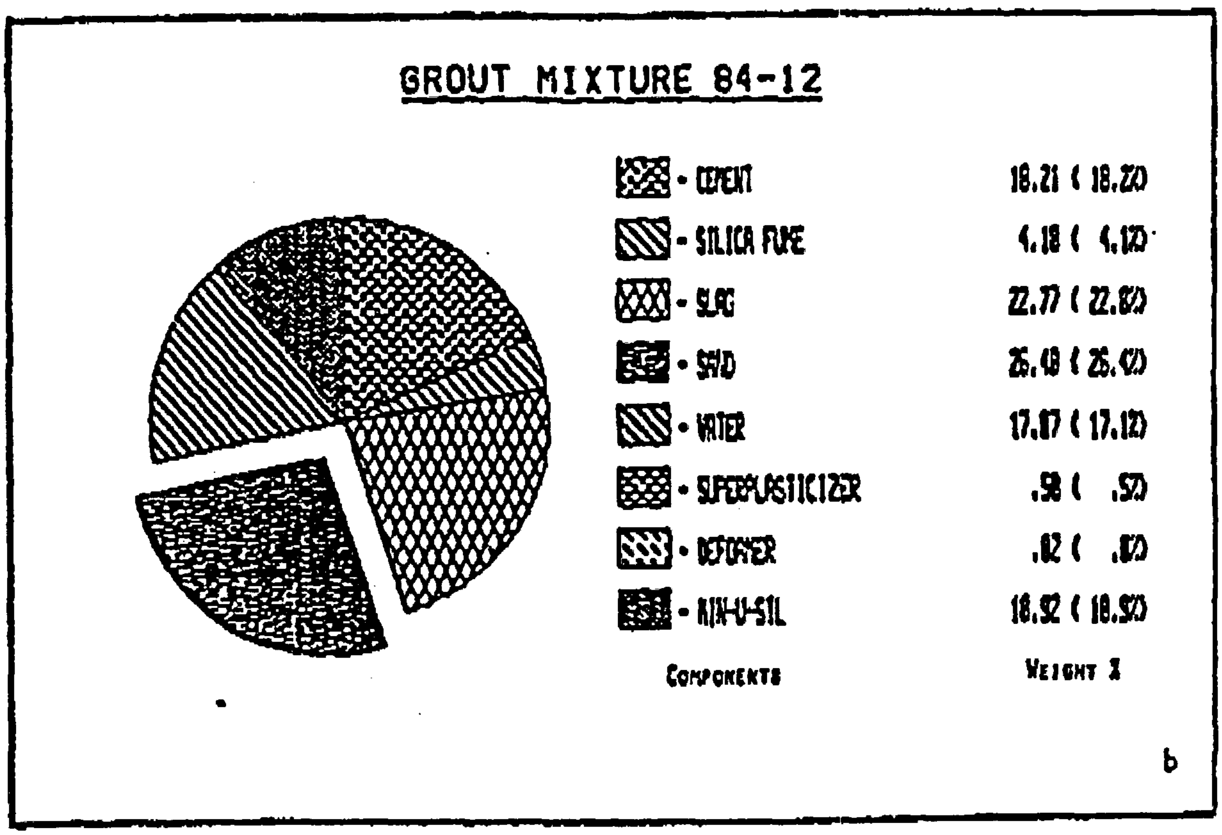


Fig. 1. Schematic representation of (a) 82-22 mortar and (b) 84-12 grout compositions

TABLE I

BULK CHEMICAL COMPOSITION OF GROUTS

Oxide	Grout (wt %) 82-22	84-12
SiO_2	64.16	61.98
Al_2O_3	4.50	4.19
Fe_2O_3	2.74	1.10
CaO	25.88	27.52
MgO	1.83	4.65
MnO	0.12	0.17
Na_2O	0.10	0.10
K_2O	0.48	0.27
P_2O_5	0.11	0.02
Total	99.92	100.00

TABLE II

BULK CHEMICAL COMPOSITIONS OF GROUTS WITHOUT SAND AGGREGATE

Oxide	Grout (wt %) 82-22	84-12
SiO_2	38.60	48.45
Al_2O_3	7.74	5.44
Fe_2O_3	4.72	1.59
CaO	44.59	37.69
MgO	3.14	6.05
MnO	0.04	0.22
Na_2O	0.15	0.13
K_2O	0.83	0.40
P_2O_5	0.18	0.04
Total	99.99	100.01

CHECKLIST OF
GENERAL CONCERNS REGARDING IMPACTS ON WASTE ISOLATION

	CONCERNS	COMMENTS
I.	**Water**	
A.	Surface Sources	
1.	Road watering for dust control	Not applicable
2.	Drill pad dust control	Not applicable
3.	Equipment washdown	Not applicable
4.	Natural surface runoff	Not applicable
5.	Accidental water spillage	Not applicable
B.	Underground	
1.	Water loss during drilling	
a)	Normal	Not applicable
b)	Fishing	Not applicable
c)	Unexpected	Not applicable
2.	Recovered or produced during drilling	
a)	Perched water	Not applicable
b)	Water table	Not applicable
II.	**Materials (other than water)**	
A.	Used in surface construction	
1.	Building materials	Not applicable
2.	Leachates from rock & muck piles	Not applicable
B.	Used in borehole construction and/or sealing	
1.	Grout for surface casings	Not applicable
2.	Drilling fluids	See section 2.2
3.	Other materials left in boreholes	See sections 2.2, 2.3 and 2.4
III.	**Other considerations**	
A.	Physical & chemical characteristics of seals	See section 2.4
B.	Seals may not achieve design objectives	See section 2.4 and recommendations
C.	Cut-and-fill for roads, pads, trenches & pits	Not applicable
D.	Blasting	See section 2.1 and recommendations