ENCLOSURE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 23, 1998

MEMORANDUM TO: N. King Stablein, Acting Chief
ENGB/DWM/NMSS

Michael J. Bell, Acting Chief
PAHL/DWM/NMSS

Budhi Sagar, Technical Director
Center for Nuclear Waste Regulatory Analyses

FROM: Philip S. Justus, Sr. Geologist, ENGB, NMSS
H. Larry McKague, Element Manager, CNWRA
Amitava Ghosh, Sr. Research Engineer, CNWRA

SUBJECT: TRIP REPORT: APPENDIX 7 MEETING IN LAS VEGAS, NEVADA, OCTOBER 15-16, 1997, ON U.S. DEPARTMENT OF ENERGY'S PLANS FOR MAPPING SUBSURFACE FACILITIES AT YUCCA MOUNTAIN

ATTENDEES

See list of attendees at Appendix 7 meeting (October 16) in Attachment 1. There is no official list of attendees at the site visit on October 15. However, P. Justus, C. Glenn, L. McKague, and A. Ghosh also participated in the site visit.

PURPOSE

To participate in Appendix 7 briefing in Las Vegas on DOE's accomplishments and plans for geologic mapping of subsurface facilities. In preparation for TSPA-VA review, obtain up-to-date information on lithology and rock discontinuities DOE considers significant and how such information will be used in TSPA-VA.

OBJECTIVES

(1) Provide NRC with status, plan, justification for proposed repository subsurface facilities mapping program;

(2) Discuss past mapping, and process leading to definition of mapping techniques selected; field visit;

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(3) Discuss how mapping information is to be incorporated into TSPA/VA assessments;

(4) Outline mapping requirements and means expected to fulfill needs meeting those requirements;

(5) Provide support material and discussion for site visit to ESF to examine subsurface structural features;

(6) Establish path forward: 1) to reach agreement on adequacy and sufficiency of current performance confirmation proposals for future mapping of underground facilities, and 2) to obtain NRC feedback on the adequacy and sufficiency (for intended use and purposes) of the proposed mapping approach.

SUMMARY

List of discussion topics was distributed by fax prior to the Appendix 7 meeting (Attachment 2). Agenda for the October 16 discussions (initially scheduled for October 15) was distributed at the Appendix 7 meeting (Attachment 3). DOE speakers (see Attachment 3) provided 'handouts' summarizing their presentations. There is no requirement for written materials to be provided at Appendix 7 meetings. However, the handouts will be made available on request to P. Justus or L. McKague up to one year from the date of this report.

October 15 Site Visit (am) included briefings by C. Lewis on current drilling and erionite protocol; M. Mapper on WT-24 status; R. Lund on fracture mapping; S. Beason on underground geologic mapping in the ESF; B. Thompson on 10 CFR Part 60.72(b) and 60.140(a)(1) mapping requirements [additional requirements discussed in a handout include: 60.32(b)(2), 60.44(b), 60.51(a)(3) and 60.133(b)] on technical mapping to obtain data for various confirmatory and documentary needs and on current levels of confidence in modeling and predictions. October 15 Site Visit (pm) included respirator training and guided geological tour of selected ESF alcoves, niches, and tunnel sites to near station 71+31.

DOE considers underground geological mapping will be needed throughout the construction and emplacement phase to confirm design assumptions about natural conditions, to record anomalous conditions, and to record as-built installed systems in relation to drift stratigraphy and geologic features.

DOE described the current geologic features and water table surface that were used to determine the location of the repository's lateral boundary and depth: a) minimum overburden of 200m; b) minimum 100m to water table; c) geometry of the Topopah Spring thermal/mechanical unit: standoff 5m from top and 10m from bottom of unit; d) Ghost Dance fault - standoff 120m from western edge, and other faults (e.g., Solitario Canyon) - standoff 60m. Additionally, the expected use of rail transportation system requires drifts and ramps with shallow slopes.

DOE's current level of confidence in knowledge of certain mappable features of importance to design or performance assessment or process modeling was stated as follows: stratigraphy -

high confidence, except in western part of repository block; faults and fault zones - moderate confidence, specific underground locations and hydrologic importance of faults are less certain; fractures/fracture zones and chemical/mineralogical and biological characteristics of fracture fillings - high confidence in ESF, lower confidence away from ESF; locations and characteristics of seeps - moderate confidence everywhere; confirmed absence of hydrocarbons and mineral resources - moderate to high confidence everywhere.

Underground geologic mapping is recorded on full-periphery maps compiled into 100m-sections and detailed line surveys. All discontinuities longer than about 1m are recorded. Over 21,000 discrete fractures have been characterized by up to 19 attributes each. Definition of fault: structure with greater than 0.1m offset; definition of shear: structure with undeterminable offset or offsets less than 0.1m. Correlation between surface and ESF fault mapping was generally very good with regard to location and orientation. DOE noted little or no mineralization along fault traces of the most notable features in the ESF: Bow Ridge fault, Imbricate fault zone, Drill Hole Wash fault zone, Sundance fault, Ghost Dance fault, Dune Wash fault, unnamed structures at stations 70+58 and 71+30.

On October 16, DOE thoroughly briefed NRC/CNWRA on its mapping efforts and plans (with justifications). These are summarized below; see Attachment 3 for names of presenters.

DOE reviewed many reasons why geologic mapping is required: (a) tabulate rock quality data to determine conditions on which to base design and location of ground support safety measures and instrumentation to monitor tunnel stability, predict excavation rates; (b) locate samples and interpret results; (c) correlate and extend understanding of geologic features predicted from surface and borehole mapping and geophysical surveys; (d) provides data for generating repository- and site-scale 2D and 3D framework for building models of the fracture-networks and hydrologic and rockmass systems.

A comprehensive overview of the performance confirmation program (see definition in 10 CFR Part 60.2) was given. DOE outlined a two-phase approach to performance confirmation: (i) site characterization/license application/pre-construction; and (ii) construction/operation/caretaker. Also outlined were concepts of subsurface and surface test facilities and support, including site, repository and waste package monitoring and testing packages (for example, geologic mapping, and seismic monitoring packages).

DOE discussed the 3D repository volume available for use as a repository based upon its `Design Model,' LYNX Model YMP.M03. No standoff distance is prescribed for non-major faults that intersect the repository drifts, such as for the Sundance fault, segments of the Drill Hole Wash and Abandoned Wash faults, or a mapped splay of the Solitario Canyon. NRC/CNWRA staff technical reviewers should note that 75% of the waste packages will be emplaced within the lower lithophysal zone, 15% in middle nonlithophysal zone, 10% in lower nonlithophysal zone of Topopah Spring Tuff.

DOE discussed `Design Drivers,' which strongly influence design of such things as repository drifts, ramps and drainage controls as follows: (1) rock characteristics, (2) seismotectonic stability, (3) waste package size/shape/weight, (4) areal thermal load, (5) rail transportation

requirements, (6) mechanical excavation methods, (7) post-closure drainage control, (8) performance confirmation requirements, and (9) retrievability option. Estimates of current repository layout include: (1) length of drifts/ESF tunnel/ performance confirmation, emplacement and peripheral drifts/subfloor exhaust drift - 157km; (2) excavation spoils - 10.3 million metric tons; (3) 105 emplacement drifts; (4) 741 acres emplacement area for 63,000 MTU at 85 MTU/acre; (5) main drifts - 7.6m diameter; (6) emplacement drifts - 5.5m diameter; (7) two vertical shafts to surface.

DOE discussed its rationale and strategy for future underground mapping at a frequency less than the 100% being done in the ESF. In general, DOE intends to map features that meet its data needs, including features most likely to impact design, such as faults (including 'minor' faults of 200-300m trace-length). DOE considered three strategies: (1) map non-emplacement drifts only; (2) map 10% of emplacement drifts; and (3) map 100% of emplacement drifts. DOE currently prefers the 10% solution. However, the preferred strategy includes mapping all non-emplacement drifts, continuous observation during excavation of each drift (currently, about 0105), detailed mapping of every tenth emplacement drift (currently a total of about 10, spaced every 200-300m). The spacing ensures that minor faults will be intersected.

DOE introduced its concept of sequential excavation of panels of drifts by a TBM that would accommodate installation of pre-cast concrete liners as it bores. There were concerns about the ability to design a TBM that could accommodate concurrent geological observations and liner-emplacement (and have the capability to allow installation of alternate ground support systems when needed). TBM design was beyond the scope of the Appendix 7, except for DOE's proposal to conduct continuous observation of actual/anomalous geologic conditions in drifts not slated to be mapped (9 of every 10).

DOE discussed briefly the use of fracture data in its TSPA-VA. Such data will be considered in unsaturated flow models at repository and site scales. DOE noted a paucity of fracture frequency data in units above and below repository level. No requirements for mapped features significant to any model that involves fracture flow were discussed.

DOE discussed in some detail the use of fracture data in the ESF and repository design and construction. In particular, DOE demonstrated the need for continuing to gather underground fracture data in order to: (1) design the repository layout, (2) confirm geology and empirical rock mass quality, (3) develop confidence in rock parameter statistics, (4) compare and assess actual mechanical stability of underground openings and constructability (TBM performance) to design assumptions, (5) define geological anomalies and 'off-normal' conditions, and (6) provide as-built geotechnical drawings.

DOE discussed the specific parameters required for determining (1) the rock quality designation (RQD), (2) rock mass quality (Q), (3) rock mass rating (RMR), (4) geological strength index (GSI), and (5) rock mass index (RMi) methods of measuring and comparing geotechnical properties of rock masses. DOE also indicated that it would likely employ and compare the following criteria to assess future behavior of the repository host-rock mass: (1) Hoek-Brown rock mass strength, (2) Mohr-Coulomb shear strength, (3) Serafim-Pereira rock mass deformation modulus, and (4) the Barton joint shear strength. Discontinuities that must be

mapped in addition to 'fractures' include (1) faults, (2) shears, (3) vapor-phase partings and (4) cooling joints.

DOE has concluded that tunnel/drift orientation has a significant effect on the size of blocks that may fall; and that joint distribution has a significant effect on both the size and number of blocks that may fall. DOE provided the status of the following data derived from mapping fractures (selected): (1) average joint spacing (lognormal distribution) for detailed line survey data - fractures 0.31m, faults and shears 7.35m, vapor-phase partings 10.87m and cooling joints 12.35m; and (2) block size from scanline joint frequency data, at 95% confidence - TCw >= 4m-cubed,TSw1 >= 10m-cubed, TSw2 >= 0.6 m-cubed. DOE indicated that the proposed alignment of emplacement drifts (WNW-ESE) is designed to minimize the size of blocks that may fall, and maximize TBM advance rate.

AGREEMENTS

DOE/NRC procedures do not enable agreements to be reached at an Appendix 7 meeting.

CONCLUSION

The objectives of the Appendix 7 meeting and site visit were met.

OBSERVATIONS OF PLANS FOR GEOLOGIC MAPPING OF UNDERGROUND FACILITIES

1) The experience of having planned, designed and constructed the ESF (and similarly, the TBM), the rail transportation, and various ground support and safety systems, has helped DOE to develop detailed specifications for collection of essential fracture data, which methods would get such data efficiently, and with what effort.

2) DOE's criteria for selecting its preferred mapping strategy considers: (1) the goal of meeting data-needs (currently unspecified by process and performance modelers); (2) cost and schedule; (3) regulatory risk; and (4) impacts on design. The need for flexibility (mapping at increased frequency) is acknowledged when anomalous or 'off-normal' conditions are encountered.

3) Most of the emplacement drifts (75%) are now planned to be excavated in the lower lithophysal member of the Topopah Spring Tuff, not the middle nonlithophysal member, as previously planned. Present plans call for 15% of drifts to be excavated in the middle nonlithophysal and 10% in the lower nonlithophysal members.

4) Current plans call for excavation of 3 levels of drifts, and 2 vertical shafts that connect the repository to the surface. The upper level contains the cross drift and performance confirmation drifts; the middle level contains the emplacement, east and west main and performance confirmation drifts; the lower level contains the exhaust main drift.

5) Consideration of features to map during future underground excavations: Preliminary observations (not conclusions) by attendees included (1) the input from repository

designers and constructors discussed at the Appendix 7 appeared to be adequate for the purpose of planning future mapping, and (2) input from other users of fracture data were not as thoroughly discussed. Therefore the attendees recommend to DOE that prior to finalization of underground mapping strategy, it should consider obtaining the specifications of features and conditions of significance to process and performance modelers required to be observed and mapped.

6) Consideration of how much to map (e.g., less than 100% of the excavated surfaces) during future underground excavations: DOE's preferred option, based on the current proposed design of repository and the current excavation plan, appeared reasonable because it had a basis in ESF experience, had reasonable and achievable goals, and was to be sufficiently flexible to increase mapping frequency as needed to understand the nature and extent of anomalous or 'off-normal' features and conditions. However, the performance confirmation and mapping needs of users other than the repository designers and constructors did not appear to be fully considered in the criteria for selecting the option. Therefore, the attendees recommend to DOE that it should consider the needs of all users prior to finalization of the plans for mapping of future underground openings.

7) Concerning DOE's plans for performance confirmation including future geologic mapping of subsurface facilities: the staff should continue to monitor DOE's developing plans to implement a required performance confirmation program in order to prepare to review DOE's program plan. The relevant Key Technical Issue teams should be aware that performance confirmation needs (such as mapping) bear on the design specifications for DOE's next-generation TBM, and that DOE's performance confirmation program includes input from many disciplines involved in waste isolation, design and performance.

Attachments: As stated

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October 16, 1997

APPENDIX 7 MEETING

UNDERGROUND MAPPING

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October 16, 1997

APPENDIX 7 MEETING

UNDERGROUND MAPPING

NAME	ORGANIZATION	TELEPHONE
Gerald Nieder-Westermann	MGDS-ESF Design	295-0327
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DOE / NRC APPENDIX 7 DISCUSSIONS

Plans for Mapping of Subsurface Facilities

October 15, 16, 1997

OBJECTIVES:

- *Provide NRC with status, plan, justification for proposed repository subsurface facilities mapping program.
- *Discuss past mapping, and process leading to definition of mapping techniques selected: field visit.
- *Discuss how mapping information is to be incorporated into TSPA/VA assessments.
- *Outline mapping requirements and means expected to fulfill needs meeting those requirements
- *Provide support material and discussion for site visit to ESF to examine subsurface structural features.
- *Establish path forward 1) to reach agreement on adequacy and sufficiency of current performance confirmation proposals for future mapping of underground facilities, and 2) to obtain NRC feedback on the adequacy and sufficiency (for intended use and purposes) of the proposed mapping approach.

Discussion Topics, Day 1, October 15, 1997

DOE Hillshire facility, 1551 Hillshire Drive, Las Vegas, NV 89134

DOE Blue Room, #302

INTRODUCTION: (20 minutes)

General overview of Performance Confirmation study current approach to development of potential future subsurface facilities and associated proposed mapping program. ISSUE: Less than 100% of the emplacement drifts will be mapped. Will this proposed approach be acceptable to NRC for licensing.

1) **Regulatory Requirements for Mapping:** (10 minutes)
   Construction Records and Performance Confirmation

2) **Previous Mapping Efforts:** (20 minutes)
   Focus on ESF; Surface , Boreholes, top level discussion only
   a) overview ESF mapping requirements (from study plan, SCP, PI input)
   b) ESF mapping techniques, products generated
   c) users for ESF mapping data
   d) mention of surface and borehole feature characterization methods, products

3) **Available Repository Volume:** (20 minutes)
   3-d model. Data input, output, model uses

4) **Current proposed subsurface facility configuration / design / test facilities and repository configuration and construction sequence** (15 minutes)

5) **Data Needs:** (15 minutes)
   Two types of data needs:
   1) Confirmatory (assumptions, design requirements, etc), and
   2) Anomalies, Document and Understand.
   For confirmation, need to locate and identify features that may be significant to performance. Focus on faults and fault characteristics to verify current predictive models used as basis for development of proposed facilities mapping program. For anomalies, ensure any anomalous condition is observed, documented, and understood.

Attachment 2

6) **Confidence in Modeling and Predictions Based on Previous (Mapping and structural studies) Work: Qualitative discussion** (10 minutes)

(We will discuss qualitatively our confidence in modeling and predictions for the data needs.)

7) **Rationale for Mapping Frequency:** (15 minutes)

Length and characteristics of known faults (based on surface mapping); a) generally longer faults have greater offsets > 200 -300 meter lengths; b) Greater offsets = greater likelihood for hydrologic significance; c) uncertainty in fault zone hydrology

8) **Strategy for Mapping:** (15 minutes)

a) Map non-emplacement drift openings; b) map every tenth emplacement drift; c) observe rock mass for anomalous conditions during construction.

9) **Open Discussion, Questions and Answers:** (30 minutes)

Lunch

10) **Uses of fracture data in ESF and repository design** (20 minutes)

The Afternoon of Wednesday, October 15, 1997: Open discussion for the afternoon on details of subsurface mapping results to date, uses of subsurface mapping data in program, including application in design, VA, TSPA, hydrology, poster displays.

DAY 2, October 16, 1997:ESF visit

Thursday, October 16, 1997: ESF visit on day 2 of Appendix 7 meeting , October 16, 1997. Examine ESF from north portal to south portal with focus on structural features. Other field activity sites could be visited, but technical support will not be extensive. Bring your own lunch. If time permits, visits to C-wells and SD-6 may be possible. Gather on ESF pad in the morning, 8AM to 8:30AM. Out of field by 3PM; return to Las Vegas.

DOE / NRC APPENDIX 7 DISCUSSIONS

Plans for Geologic Mapping of Subsurface Facilities
DOE Hillshire Office, 2nd Floor Atrium Conference Room
October 16, 1997

Agenda

8:00 – 8:20	INTRODUCTION – Brent Thomson
8:20 – 8:30	KEY TECHNICAL ISSUES – Mark Tynan
8:30 – 8:50	PREVIOUS MAPPING EFFORTS – Steve Beason
8:50 – 9:10	AVAILABLE REPOSITORY VOLUME – Bob Elayer
9:10 – 9:30	CURRENT PROPOSED SUBSURFACE FACILITY – Dan McKenzie
9:30 – 10:00	Break
10:00 – 10:05	MAPPING REQUIREMENTS – Brent Thomson
10:05 – 10:20	TECHNICAL DATA NEEDS – Brent Thomson
10:20 – 10:30	CONFIDENCE IN MODELING AND PREDICTIONS – Brent Thomson
10:30 – 10:50	RATIONALE FOR MAPPING FREQUENCY – Steve Beason
10:50 – 11:05	STRATEGY FOR MAPPING – Steve Beason
11:05 – 11:35	Open Discussion, Questions and Answers
11:35 – 1:00	Lunch
1:00 – 1:15	FRACTURE DATA USED DIRECTLY AND INDIRECTLY IN TSPA: Informal discussion – Bob Andrews
1:15 – 2:00	USES OF FRACTURE DATA IN ESF AND REPOSITORY DESIGN – John Pye, Gerald Nieder-Westermann, Dwayne Kicker
2:00 – 5:00	OPEN DISCUSSION

Attachment 3