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High Level Waste Technical
Development Branch
Division of Waste Management
U.S. Nuclear Regulatory Commission
7915 Eastern Avenue
Silver Spring, MD 20910

Attention: Dr. Jerome R. Pearring

Subject: Document Review for Waste Isolation Pilot Plant, Preliminary Design Validation Report.

Ladies and Gentlemen:

Please find enclosed the subject document review which was performed by Mr. Robert A. Cummings, as required. We hope you will find this satisfactory.

Should you have any questions or comments, please contact Bob or the undersigned.

Sincerely,

ENGINEERS INTERNATIONAL, INC.

Madan M. Singh

Madan M. Singh
Project Manager

MMS/RAC/ja

Enclosure

cc: Mr. John T. Buckley

DR/ltr
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EI DOCUMENT REVIEW

FILE NO: 1148-07-03, No. 1

DOCUMENT: "Waste Isolation Pilot Plant, Preliminary Design Validation Report", Bechtel National, Inc., Nuclear Fuel Operations, San Francisco, CA, for U. S. Department of Energy, March 30, 1983

REVIEWER: Engineers International, Inc.

DATE REVIEW COMPLETED: 24 May 1986

DATE APPROVED:

SIGNIFICANCE TO NRC WASTE MANAGEMENT PROGRAM:

The Waste Isolation Pilot Plant (WIPP), near Carlsbad, New Mexico, is to research the disposal of defense-generated high-level waste (DHLW) as well as provide for long-term TRU waste disposal. The DHLW program will include thermomechanical and mechanical bedded salt behavior experiments that are generically relevant to the repository program in salt for commercial wastes.

WIPP experimental data could be used by the DOE in salt test plan formulation, to support repository design concepts in salt, or to support assessments of waste transportation and handling, repository operations, and retrievability systems. The WIPP experience may also be of interest to the NRC when it is not referenced by the DOE, as it is one of the few subsurface construction projects in salt that address thermomechanical behavior for which extensive documentation of shaft and drift behavior and the response of the rock mass to excavation have been systematically gathered and are readily available.

Finally, the geologic studies carried out at the WIPP have been major. Certain generic aspects of these studies for example, the relationship of fluid inclusions to brine migration, methods of geologic analysis, relationships of primary and secondary permeability to rock mass hydrogeology, and relationship of clay seam occurrence and continuity to depositional environment, are of direct interest to repository siting studies in other salt strata. Many of the formation names and broad characteristics at WIPP are familiar to the Texas panhandle sites as well.

The Site and Preliminary Design Validation program (SPDV) was formally initiated in January, 1986. It consisted of subsurface development and instrumentation to validate the suitability of the site and the viability of the design for the WIPP program. The SPDV was set up to address various factors most associated with the site (earth science and cultural factors) and some associated with the design (character and behavior of subsurface openings). In 1981, the

DOE agreed to perform certain work pursuant to satisfying the State of New Mexico of the validity of the WIPP underground facilities design. This agreement modified and extended the data collection and reporting requirements. This work, including the evaluation of the design validation factors is undertaken in the Preliminary Design Validation Report.

The Preliminary Design Validation report describes the excavation and response of the WIPP underground openings to the creation of the SPDV facility. The design validation factors, which are listed and evaluated at various places in the report, include the design bases (stability, function, deformability, stability, water or gas occurrence) for the exploratory and ventilation shafts and the exploratory subsurface openings. These are many of the same construction elements that will be addressed by the NRC in licensing deliberations for the commercial waste repository.

There was a related document, Results of Site Validation Experiments Report, issued separately. The final Design Validation Report is mentioned on page 1-2 as being expected 2 - 3 years hence (1985-86).

BRIEF SUMMARY OF DOCUMENT:

This document provides background, measurements and findings, and analyses to support its assertion that the design at the WIPP is validated.

The report begins with an executive summary that provides an overview of the relevant program elements and findings and that repeats the validation factors and their assessment.

Chapter 1 is introductory and gives the preliminary design validation information elements: underground opening behavior observation, characterization of geologic conditions, confirmation of roof and floor stratigraphy, and evaluation of geomechanical instrumentation. It also lists the field activities and provides overview and schedule information.

Chapter 2 describes the development and background of the WIPP design. It gives generalized stratigraphic characterization, and design bases and their development from the site data gained to date.

Chapter 3 gives the construction history of the subsurface works: exploratory shaft, ventilation shaft, shaft stations, exploratory drifts, and panel drifts. The information is generalized and much of it is of a summary or statistical nature. There is no great detail on the construction at any particular location that could be used to correlate the complete time history of events and the exact geologic conditions at a particular location with the observations and measurements at that location. There is useful information on the plans and sections of the drifts and on the corehole logs contained in Appendix F, which are referenced in the Chapter.

Chapter 4 describes how geologic field data were obtained: observation of shaft drill cuttings, mapping of portions of the unlined shaft sections at reconnaissance and restricted detailed scales, mapping and exploratory drilling in facility level drifts, instrumentation readings, rock behavior observation measurements, water inflow measurements, and data preparation.

Chapter 5 gives the geologic results obtained in the shafts. It contains a description of the formation encountered in the non-salt sections, based largely to entirely on the examination of drill cuttings, for each of the two shafts. The Salado formation, which was not lined in either shaft, was mapped directly as well as by drill cuttings. Reconnaissance mapping in the exploratory shaft was done throughout the salt section in a strip. Detailed mapping was done in the shaft key and facility level intervals. In the ventilation shaft, the walls were obscured by salt crust below about 1180 ft depth (coming from suspended salt dust in the exhaust air), which was chipped away to support the mapping. Detailed mapping was more extensive in the vent shaft. Since the vent shaft was unlined, first hand observations of the non-salt section were possible.

Shaft geologic maps were correlated with borehole and in shaft geophysical logs.

Chapter 5 also gives a discussion of the geologic correlations and bed continuities. On a broad scale, the beds are correlatable and continuous. However, the unexpected appearance of a clay layer in the roof reduced the thickness of halite in which to position the facility from 32 ft to 27 ft, resulting in significantly thinner immediate halite roof thicknesses. Also, the marker bed top contact in the floor was found to be much more irregular than anticipated. The chapter notes the low water inflows (0.6 gpm) noted in the shafts.

Chapter 6 gives the geologic character of the horizontal openings, in particular the areal makeup of the Salado formation. Discussions are provided on stratigraphic continuity and the gently-sinusoidal structure.

Chapter 7 describes the geomechanical instrumentation program used in the shafts, shaft stations, and drifts/test rooms. The types of instruments are only briefly described, but the instrument locations are described schematically in the text and are diagrammed in Appendix F. The frequency and method of monitoring is described. The data logger used in the shaft is mentioned. (It should be noted that the data logger system has experienced many problems in the last 2 years or so and is apparently not robust for long-term operation in the exploratory (now the Construction and Salt Handling) shaft. Also, much of the instrumentation in the shaft, particularly the piezometers and convergence points, has suffered from routine shaft operations). Selected graphical data representation are presented.

Chapter 8 analyzes the geologic behavior of both the shafts. It is shown that measured water pressure buildup behind the exploratory shaft lining has been within design limits, that the exploratory shaft key salt creep stresses have not yet occurred, and that creep stresses have not yet occurred, and that the unlined sections of both shafts are apparently stable and have been converging at an acceptable rate. The design philosophy is given considerable attention, including the calculational bases. The very short duration of the data record is recognized, along with the fact that some instruments (notably the shaft lining convergence points) have been read infrequently or not at all. Ground water inflow tests are described and the results are given. The general geologic behavior of both shafts is assessed.

Chapter 9 presents similar types of information for the drifts. The finite element and empirical scoping calculations are described in order to establish the design intent. From closed-form methods, the effect of the unanticipated clay seam as well as the design basis stratigraphy from ERDA-9, are given. Using the ERDA-9 stratigraphy, parametric modeling found that increasing the coefficient of friction from zero to 0.4 reduced vertical closure at 10 years to 28 percent, and horizontal closure to 37 percent, of the zero value. Ongoing modeling efforts are mentioned, to better define the effect of the change in stratigraphy to the mapped condition, using ranges of properties. The design performance evaluation recognizes that the presence of the clay seam in the roof, together with the upward repositioning of the facility necessitated by the uneveness of the Marker Bed 139 top surface, reduced the roof beam thickness by about 7 ft, to about 3.5 ft in the exploratory shaft station and to 7 to 9 ft in the drifts. However, observations are asserted to confirm that the openings are stable and safe overall, despite some local areas of instability. Failure of resin-grouted rock bolts in the exploratory shaft station is described. (It should be noted that as these failures became more extensive, bolting practice at WIPP has changed to include expansion shell bolts and header blocks).

Chapter 10 gives the conclusions from the program. The difference and variations in the geologic character are acknowledged but are said to be of no major engineering significance. The geologic behavior, despite localized strata separations in the drifts, the rock bolt behavior problems, and minor localized spalling in the shafts, is said to be within design limits. Indeed, most of the facility drifts with less than 13 ft of head room were left unsupported. The chapter concludes with a table showing the validation of the design.

Also included in the report are a glossary, references list, and appendices A through G providing the relevant section of the Stipulated Agreement between the DOE and the State of New Mexico (A), geologic correlation (B), exploratory shaft geologic logs and maps (C), ventilation shaft geologic logs and maps (D), facility level rock coring logs (E), facility level plans, profiles and cross sections (F), and summary of geomechanical instrumentation measurements (G).

PROBLEMS, DEFICIENCIES, OR LIMITATIONS OF REPORT:

It is particularly relevant to note the effect of the appearance of the clay and anhydrite layer above the exploratory shaft station. This did not occur in ERDA-9, which is shown on Figure 3 of Appendix B as being only about 550 ft from the ventilation shaft and less than 1,000 ft from the exploratory shaft. Analyses presented in Chapter 9 suggest that this clay seam may present the capability for buckling of the exploratory shaft station roof.

The geomechanical data reported in the document are generalized. The duration of the record is short and the document at many places admits that long-term projections of behaviors such as sag or convergence should not be made on the basis of the available data. Modeled drift closure rates are highly sensitive to input clay seam properties (an over-300-percent increase if the friction coefficient is reduced to zero) but there is no definitive assessment of drift closure projection attempted. It is appreciated that this is a preliminary report only and that the final report will benefit from further data.

The discussion suggests that the stress buildup in the exploratory shaft key due to salt contact should be experienced in about 2 years after completion, or sometime late in 1984. However, the Geologic Field Data Report for the period ending 30 June, 1985, indicates that this contact had not occurred as of that time.

An examination of the GFDRS subsequent to the Preliminary Design Validation Report reveals the extent of the rock bolt problem and some reliability problems with the instruments. These complications do not show up after only a 3-4 month monitoring period. Thus the data, as recognized in the report, are useful only for near-term closure and stability assessments.

This document provides a useful, though generalized and abridged, overview of the early underground development at the WIPP. Its main purpose is to present the rationale for asserting that the WIPP underground design is validated. The design bases upon which the validity assessment is made are not particularly rigorous in light of the issues posed by a commercial HLW repository. Nonetheless, the document provides a frame of reference for considering later, more detailed accounts (GFDRS and topical reports) of the WIPP rock mass behavior that will be relevant to the civilian waste disposal program.