ENGINEERS INTERNATIONAL, INC.

98 E. NAPERVILLE ROAD, WESTMONT, ILLINOIS 60559 312/963-3460

WM-10 11,16

20 January 1983
Ref. No. 1085-003-19

WMUR..... C.....
WM T.S.

PDR
LPDR (B,N,S)

High Level Waste Technical Development Branch
Division of Waste Management
U. S. Nuclear Regulatory Commission
7915 Eastern Avenue
Mail Stop 623-SS
Silver Spring, MD 20910

Attention: Mr. Trueman Seamans

Subject: Final Letter Report on Site Characterization Report (SCR) Comments

Dear Mr. Seamans:

Enclosed is one (1) copy of the above mentioned report incorporating your comments of January 6, 1983. If you have any questions, please call me.

Sincerely,

ENGINEERS INTERNATIONAL, INC.

V. Rajaram
Project Manager

VR/ja

Enclosure

FLR
1085C

6.0 Design of Facilities

6.1 General Discussion

6.1.1 Subsurface Facilities

The subsurface facilities occupy an area of 766 acres and consist of 20 panels of 38.3 acres each. Thermal loading from nuclear waste is kept at 56 kilowatts per acre. Five shafts, located within a central shaft pillar, provide access to the subsurface facilities. From the shaft pillar, main access wcys are driven to the storage panels, a contact waste panel, and an experimental panel.

The basic repository concept is to store canisterized waste packages in 200-foot long, 27 inch diameter horizontal holes drilled perpendicular to 20 ft wide by 10 ft high storage rooms. The modular concept of operation is used, that is mining development and waste storage will be concurrent but will have separate ventilation systems. Facilities include waste handling, mining, waste rock transport to the surface, backfill transport, and necessary support systems.

6.1.2 Waste Handling System

Upon arriving at the site, waste packages will be inspected and sealed in an overpack and inspected again before transport underground. A series of cranes and hoists handle the canisters. Once underground the canisters are placed on a rubber tired vehicle transporter which takes the canister to its storage hole. All operations are performed by specialized and shielded equipment. The repository is provided with appropriate radiation and fire detection devices. The storage hole is suitably plugged to prevent radiation leaks.

6.1.3 Storage Room Fill

When all the horizontal holes in a storage room are filled, the room is backfilled with a basalt and bentonite material that is prepared on the surface and brought underground. The storage and reaming rooms (rooms necessary for horizontal hole development) are backfilled in lifts to half the drift height, and the remainder by low profile equipment. The annulus between the waste emplacement holes and the canister is also backfilled with bentonite.

6.1.4 Shaft Seals

The seal system design is based on a combination of waste package performance, the regulatory criteria (EPA and NRC), and site specific conditions. Two controls on radionuclide release from the engineered system are considered, the waste package release rates and the near field solubility controls. Performance is apportioned between the site and the seal system to determine maximum flow rates and minimum travel times through the seal system. Schematic seal designs developed under the generic National Waste Terminal Storage (Smith, et al., 1980) are being evaluated by the BWIP for suitability to the basalt host rock.

6.2 Design Details

6.2.1 Description

The repository is locat‹ l 3,700 feet below the surface and is designed to receive 17,500 canisters of 10-year old spent fuel (BWR and PWR, equivalent to 23,700 metric tons of heavy metal), and 10,400 canisters of 10-year old commercial high level waste (23,700 metric tons). In addition, 32,000 drums (55 gallons) of commercial low-level transuranic waste will be handled. Provision will be made to retrieve the waste for a period up to 50 years after waste emplacement. Upon decommissioning waste emplaced holes, storage rooms, access ways and shafts are backfilled with an engineered backfill.

The 15-inch diameter waste canisters are placed in 27-inch diameter storage holes leaving a 6-inch annulus for backfilling at a later time. Canisters are placed on support rails extending the hole length, and six canisters are placed in a hole. Canisters are of carbon steel, following the simple waste package design. Storage rooms are 20 feet across and 10 feet high, to accommodate the 2:1

horizontal to vertical stress ratio. Reaming rooms are 10 feet wide and 10 feet high. Storage rooms are placed perpendicular to the main ventilation and access entries. A contact waste panel is provided for the drums of transuranic waste.

6.2.2 Design of Subsurface Openings

The main access ways are oriented parallel to the direction of the maximum horizontal stress, and the storage rooms are parallel to the direction of the minimum horizontal stress. The waste emplacement holes are perpendicular to the storage rooms and have the same orientation as the main access ways. The ratio of maximum horizontal stress to vertical stress is taken as 2.0.

The conceptual repository design is based on analysis utilizing linear elastic theory and an empirical rock mass strength relationship derived from laboratory testing results. This rock mass strength relationship has not utilized the fracture data gathered from boreholes, and is the main drawback of the design. A thermal loading criteria of 56 kw per acre was utilized, and pitch (spacing) of waste canisters was selected to yield temperature and stress conditions that will maintain the stability of the openings. Since the rock mass failure criterion is yet to be determined, the pitch of the waste emplacement holes as given in the SCR should be thoroughly analyzed after this criterion is obtained from the Phase I and Phase II in-situ testing program.

6.2.3 Design of the Ventilation System

The repository is on an exhaust ventilation scheme with mining and storage having their own separate ventilation systems. Full storage rooms are bulkheaded to reduce the ventilation load. The main airflow is through two development supply and exhaust shafts, and two confinement supply and exhaust shafts. Booster fans will be used as needed, and pre-cooling with heat exchangers will be used during retrieval or when necessary.

6.2.4 Design of the Backfill System

Backfill will be prepared on the surface and transported underground via skips. A train of mine cars will haul the material to the storage panels. Shuttle cars will transport the backfill to the storage rooms where it will be compacted by bull dozers in 8-inch lifts. The material is 75 per cent crushed basalt (from mined rock) and 25 per cent bentonite clay. The backfill is moistened upon emplacement and temporarily retained with a wall for stability during the backfilling operation. The top half of entries (about 5 feet high) will be backfilled by special low profile equipment.

6.3 General Statement of Issues

6.3.1 Stable Openings

This is an important issue in repository design and is required in 10CFR60.132, and 60.141. In addition to the consideration of excavation induced stress, coupled thermomechanical and thermohydrological stresses have to be considered and adequately designed for. An important first step in designing for stable openings is a knowledge of the rock mass failure criterion. This criterion coupled with a determination of the in-situ stress and thermomechanical and thermohydrological stresses (resulting from waste emplacement) will enable the resolution of this issue.

6.3.2 Retrievability

This issue is raised to satisfy the requirements in 10CFR60.132. Anticipating storage room conditons is one primary concern to retrievability. Bulkhead design, storage hole conditions, room stability, and environmental conditions in the rooms are of concern. Presence of high pressure steam in the backfill must be discerned, as well as protection of personnel and equipment from heat and radionuclide exposure. Retrieval can impact local areas or the full repository, depending on the reasons for retrieval. Many retrieval scenarios are possible, each having its own difficulties and design impacts. These have to be fully considered and provided for in the repository design so that the retrieval requirement in 10CFR60 can be satisfied.

6.3.3 Shaft Sealing

This issue is central to the concept of geologic repositories for nuclear waste storage and provides the assurance that radionuclides can be isolated from the accessible environment. Decommissioning of a nuclear waste repository is complete only when confirmation is obtained that shaft seals are effective. Seals have to be designed to be compatible with the host rock physical and chemical properties. They have to be stable over long periods of time and provide sufficient retardation to radionuclide travel so that the travel time criteria in EPA and NRC regulations are satisfied.

6.4 Discussion of Key Issues

6.4.1 Stable Openings

The primary purpose of stable openings is to insure isolation of the waste, and should also be considered after decommissioning. Stability under coupled thermal and mechanical stresses, and under the presence of groundwater, have to be modeled. The rock mass strength, the blast damage zone around openings (if TBM is not feasible), rock mass thermal properties, and groundwater conditions present in the repository horizon should be carefully assessed to produce reliable results from the modeling effort. The spatial variability of these parameters in the reference repository location (RRL) should also be established with a large level of confidence.

The site characterization program should have specific goals aimed at refining the above mentioned parameters, and detailed plans should be laid out as to how the refined parameters will be utilized in improving the conceptual design described in the SCR.

6.4.2 Retrievability

A number of questions must be resolved when discussing retrievability. The circumstances requiring the retrieval option, that is, leaking canisters, geologic problems at the repository site, or political reasons must be carefully considered in planning for retrieval. Retrieval can be local to a part of one storage room, or it can be full scale throughout the repository. Interactions of operations must be understood. The retrieval environment is important since the same equipment used for emplacement may not be appropriate for retrieval. Conditions of heat and rock stability must be known to adequately define retrievability impacts. Detailed specifications for backfilling storage rooms are needed to assess impact on retrieval. The waste package design must be understood as this is the first radionuclide barrier and its performance affects retrievability plans. Other aspects of repository design affect retrievability, in that horizontal storage virtually eliminates the option of over coring should a canister be stuck in place. Storage hole elements such as hole plug design or the need for hole liners must be determined if retrievability is to be a viable option.

6.4.3 Shaft Sealing

Shaft sealing is one of the primary mechanisms to ensure that radionuclides do not travel to the accessible environment. Shaft sealing is an important issue and is unique to the design of nuclear waste repositories since there is no precedence which establishes the effectiveness of sealing materials over long periods of time. Sealing materials must be developed which have at least the following characteristics:

- Stable under high ambient temperature
- Compatible with the physical and chemical characteristics of the host rock
- Prevent the development of preferential pathways for the transport of radionuclides from the repository to the accessible environment

The ability of shaft seals to complement the geologic isolation provided by the host rock should be ascertained. The seals should be field tested in the exploratory shaft (Phase I and II) to obtain data on their performance characteristics. Modeling efforts should be undertaken to estimate their long-term ability to prevent the transport of radionuclides. The model should use realistic input data obtained from field testing.

Section 3 - Geology

- Contour interval is too large and isopachs are too general in RRL — better definition to ± 5 ft should be provided

- Need clarification as to the extent to which flow type criteria have been used to predict fracturing characteristics. Type II flows (middle Sentinel Bluffs) are extensively fractured vertically in colonnade and entablature, and it is doubtful that this fracturing can be represented in a vertical borehole. Type III flows (Umtanum) do not exhibit repetitive entablature/colonnade sequencing which suggests greater vertical nonhomogeneity than Type II flows. Also, the colonnade - entablature contact is sharp and distinct — a significant break from hydrogeological and geomechanical standpoints. Thus Sentinel Bluffs flows may not be as massive as the Umtanum and thus less effective at geological isolation.

- Fracture characteristics described in section 3.5.4.1.4 do not state the expected spacing of fractures and mineralogy of infilling material.

- The expected variability in flow top thickness in Umtanum is apparently a detrimental factor. No comparison between

Umtanum and middle Sentinel Bluffs flows, that would indicate preferential designation for a repository is made in Chapter 3, and the criteria for such a comparison are vague and qualitative.

- Projection of 10,000 - year geomorphological and rock formation scenarios are mostly qualitative.

- Regarding heat flow interpretations for regional analysis, "localized" anomalies are not that "local," and specific testing in the RRL should be done.

- Interpretation of geophysical borehole logging to provide control on rock mass properties is incomplete. Incomplete log interpretation (variability in equipment and methods) for control on rock mass property assessments is indicative of a lack of sensitivity to geotechnical variability in determining repository performance more than it is indicative of unavoidable technical difficulty.

- Surface geophysical analysis seems generally complete.

- Many cores have exhibited "small" faults a few cm. to 1 in. in width. The occurrence of these faults is not assessed quantitatively.

- Jointing assessment (Section 3.7.2.5) addresses only tectonic joints. No mention is made of joint data as seen in drill core. Non-tectonic fracturing not addressed in this section may have a greater effect on stability.

- Need clarification as to the nature of the earthquake swarm at Wooded Island (Figure 3-56), and assess the likelihood of further earthquakes elsewhere along the Cold Creek Syncline axis. Emphasis is given to the Frenchman Hills occurrences because they are larger, however, they are also not on a trend projecting into the RRL area and are more distant. The likelihood of damage to the underground repository from earthquakes of these magnitudes is low.

Chapter 4 Geoengineering

The following comments relate to the resolution of Issue R.1.B and R.1.C, as shown in Table 17-1 (Pages 17.1-2 and -3):

- The scatter of results from uniaxial compression tests are reported (page 4.1-7). Some of this could be due to spatial variation of strength. This aspect should be analyzed in the exploratory shaft.

- Test results from tension tests and dynamic velocity measurements need to be addressed. Dynamic velocity data from the laboratory and geophysical logs usually can be related to static values, and an estimate of the in-situ elastic modulus obtained.

- In Section 4.2, test results of the Goodman jack and the modified Goodman jack are reported. Both yield lower values than that of single-slot flat jack in the jointed block at the NSTF. Can any correlation be established between borehole jack tests and flat jack tests? If not, what is the purpose of using them again at the repository horizon as mentioned in Page 4.2-11.

- On Page 4.3-2, it is stated that core logging have revealed that most of the joints are filled with secondary minerals and are less than 0.5mm thick. Have the effects of secondary minerals on the frictional properties of joints been thoroughly analyzed?

- The temperature-dependency of several thermal properties was investigated (Page 4.4-3). However, the influence of confining pressure and jointing on thermal properties remains unclear, and will be further studied. In addition, the effect of moisture on the thermal properties must be studied.

- In Section 4.5, the ongoing heater tests reveal the poor performance of some state-of-the-art instruments at high temperatures. Much effort must be placed in improving the instruments before conducting tests in the exploratory shaft.

- The potential for rock burst, thermal degradation and slabbing are examined and discussed (Page 4.7-1). Preliminary results indicate that the possibility of rock burst seems remote, and that basalt in general seems to offer more resistance to thermal degredation than most other rocks. However, the coupled effect of the stress redistribution due to excavation and the thermal impact are not elaborated upon. The rate of application of the thermal shock, and its impact on spalling, should be considered.

Chapter 10 Comments

Repository Design:

10.4-5

- ". . . largest horizontal hole compatible with constructability." How were these dimensions determined? What case histories show success of these dimensions?

- Report later admits cuttings will be difficult to remove. (page 10.6-2), but no solution is given.

10.3-7

- Will location of the repository in the Sentinel Bluffs which is about 500 ft above the Umtamum make that much difference in the heat and hence the ventilation? The difference will only amount to about 10°F in Rock temperature.

Figure 10-11

- Why arent't the reaming rooms sized with a 2:1 horizontal to vertical ratio since they are also subjected to the tectonic and thermal stress fields?

- How will rooms be "sealed off" after they have received their full complements of waste?

10.4.3

- How and where will the spacers be placed which maintain the six-inch radial clearance between the waste packages and the hole perimeter? Of what material(s) are they constructed?

10.2.2

- What kind of control system is used on the transport operation dolly to place canisters in their proper positions in the storage hole? How is the dolly powered?

10.2-13

- Fire protection is addressed as required by 10CFR60, however fire resistant hydraulic oil should be mentioned for use in all equipment.

Backfilling and Retrievability

10.7.2.1

- The filling sequence appears to have been taken from RHO-BWI-C-116 where the room heights are greater than the current 10 ft. For example, it is stated that "This sequence continues, using large equipment until the fill height reaches half the height of the room. Low profile equipment will then be used to complete the lift to within 1.8 meters (6 feet) of the roof." It should be noted that half the height of the room is 5 ft whereas 6 ft from the roof is 4 ft. Thus lower profile equipment will be used for 1 ft. It is also stated that a "yet-to-be developed piece of equipment" will be used to backfill the remaining six ft of space.

Why not consider pneumatic filling? If dust is a problem water can, if necessary, be added at the nozzle.

- Because backfill will be moistened when emplaced, for stability reasons, this may turn into high pressure steam that will hamper retrieval. This needs to be discussed.

- Backfill material is engineered at the surface, lowered underground and stored in hoppers. Rail and rubber tire haulage systems transfer the material to the work site.

- Following the flow of the engineered backfill shows that the graded material is transferred 7 times before being spread in place. This many transfers will help to segregate material. Engineered backfill in place is what is important!

- The ventilation system provides for "mass retrieval" which presumably would cause storage operations to cease. What about local retrieval which would not necessitate shutting down all repository operations? There does not appear to be any provision for this.

10.2.3.10

- Wouldn't it be better to treat contaminated water underground in holding ponds and then hoisting or pumping the treated product?

10.7.3

- Retrieval as discussed is full retrieval which would terminate use of the repository. What about local retrieval due to (for example) geologic unsuitability of one room or panel which doesn't affect the suitability of the repository overall?

- It is implied that in 5 years enough information will be available to decide whether it will likely ever be necessary to retrieve. Is this realistic? (one of the criteria for deciding to backfill is "a consideration of the degree of confidence in the necessity for future retrieval.")

-

- The report does not discuss, but implies that the same equipment will be used for retrieval as for emplacement. This may not be realistic, depending on environmental conditions during retrieval.

- Design related work elements should include potential retrievability difficulties, as this is a prime concern of 10CFR60.

- Horizontal storage greatly complicates the overcoring option. Case histories of such overcoring operations should be provided.

- RHO-BWI-CD-35, page 266 referred to a carbon steel hole liner grouted in place. This was to aid retrievability (outlined later on page 318). Why was the hole liner concept withdrawn. Installation may be difficult but no more than using the proposed rail support concept.

- There is no discussion here of the simple waste package design.

- Sealing of rooms needs to be specified as this effects retrievability.

- It is stated that "If backfilling did start at an earlier date, it would still be feasible to retrieve waste. The backfill would have to be cooled, removed, and replaced at a later date." This seems to imply that backfill can be cooled before it can be removed. How will this be accomplished? Similarly what procedure has been developed for removing the backfill and is it technically feasible? Figure 10-14 seems to imply that there is some doubt whereas the quotation above indicates the latter.

Stable Openings:

10.5.3

- How will the grouted bolts react to the elevated temperature? They will also be subject to differential thermal expansion.

10.5

- A rock stress of 186 MPa together with a rock strength of 200 MPa provides a safety factor of only 1.08. How is this justified? Has consideration been given to the fact that the fractured zone may have a considerably smaller strength than 200MPa.

- The thermal conductivity of 2.3 W/m°k is considerably greater than values reported previously for BWIP. How was this value obtained?

- The assumption of uniform stress around the hole perimeter assumes strictly elastic analysis and doesn't account for blast damage which weakens the rock.

10.5.1.2

- Where did the 3:1 stress ratio come from? Can case studies be provided to show that 3 to 1 stress fields exist?

Chapter 14 Comments

This chapter concentrates on future issues that are important, but are not appropriate, at this time, to the goals of the SCR. Site suitability is of primary concern, and related issues are clouded among the many topics discussed.

R.1.48

- Prediction of Rock bursts is at an early stage in development
- Heavily jointed rock would not normally be burst-prone

R.1.2.A

- The rate of release of strain energy has been found to be a good indicator of burst potential. However, the only known relationship between energy release rate and the probability of rock bursting is for South African gold mines. Bursting is unlikely to occur in closely jointed rock. Bursts have been associated with dykes and sills of resistant material such as diabase.

R.1.6.1

- Is it practical to try to develop a support system for a 50 to 80 year life? Wouldn't it be better to assume that rehabilitation of openings will be required to some degree?

R.1.31

- Analysis of the dose rates from waste packages is an important item for retrieval as it is necessary to know how much shielding is required. Similarly, it must be confirmed that dosages conform to regulations. Several scenarios should be examined in this regard.

R.1.65

- What about ventilation for local retrieval - retrieval of individual canisters, one room or one panel? This type of retrieval needn't result in shut down of storage operations provided sufficient ventilation capacity is available to allow both operations.

R.1.3.9

- Radionuclide alarm system sensitivity must be established for correct system design, as this issue is vaguely addressed.

Chapter 17 SITE CHARACTERIZATION

- Throughout Chapter 17, primary issues concerning geomechanics and hydrology are discussed. In an effort to resolve these issues, an extensive in-situ testing program is proposed. The descriptions of the actual tests to be performed, however, are very general. More over, the reasons for performing the tests are not clearly stated.

- In the third paragraph on page 17.2-4 the decision analysis used to identify the repository horizons is discussed. The analysis is to be based on data obtained from three characterization boreholes. The types of field and laboratory testing are not described. Nor is the level of redundancy. It is, therefore, difficult to assess whether or not three boreholes can generate sufficient information for identifying the most desirable horizon.

- In the following paragraph (on page 17.2-4), flooding is identified as a potential problem, and construction of the exploratory shaft is intended to show that such flooding can be controlled. No evidence is cited, however, that indicates that significant water is available within the substrate. Test boreholes have been placed, and three additional boreholes are planned, but there is no indication that piezometers have been or will be installed. Also, there is no indication that packer tests or pump tests have been or will be conducted. Given this level of information, one must question the assumptions regarding flooding and rock mass permeability.

- On page 17.2-24 it is stated that a significant amount of test data was obtained from the Pomona Basalt because of its similarity to the candidate horizons. However, back up data needed to confirm such a statement is neither presented or referenced. It may be possible to use the Pomona Basalt data, but sufficient data must be produced which shows that the behavior of the Middle Sentinel Bluffs Basalt and the Umtamum Basalt is indeed similar to the Pomona.

- The Phase II geomechanical tests are discussed in section 17.2.7.1 (Page 17.2-26). However, the testing program description is very general. Extensometers are proposed for determination of excavation closure rates. No other specific information is given. Hydrofracturing and overcoring performed during Phase I will be compared with Phase II "additional rock mechanics tests." Rock-mass strength tests may or may not be conducted, and no specific criteria is presented concerning how the go/no-go decision will be made. Vertical hydraulic conductivity will be assessed by conducting "port-hole tests", and thermal properties will be obtained from "core testing." Additional details are required about the tests to determine if they will resolve the issues raised.

- Section 17.2.7.3 discusses plans for a small-scale heater test to augment NSTF data. Such testing will be useful. However, there does not appear to be any attempt to quantify the combined effect of in-situ stress and elevated temperatures. In other words, geomechanic tests are proposed to assess mechanical rock properties and the heater test is proposed to assess rock mass thermal properties, but how will the coupled effect of excavation induced and thermal stresses on rock mass mechanical properties be determined. This question does not appear to have been addressed.

- The important question of rock mass strength determination mentioned as a high priority in Chapter 10.0, Repository Design, has not been discussed. Tests to determine in-situ modulus, in-situ shear strength, and rock mass consitutive relations must be conducted in Phases I and II.

- In general, a summary table or matrix listing the desired physical properties versus the available (state-of-the-art) tests would be helpful in determining what can conceivably be accomplished during each project phase. Having the project goals clearly defined before field work begins is imperative. In addition, the manner in which the data from Phase I and Phase II will be utilized in the design process should be clearly spelled out.