RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 6, Supplemental Question 5:

Clarify the flood analysis and design calculations for the two diversion ditches to the west of the geologic repository operations area North Portal shown on the North Portal site plan (BSC 2008a)) provided in the response to Chapter 2.1.1.3, Set 3, RAI 6, RAI 2.2.1.1.3-3-006 and the Aging Pad site plan (BSC 2008b) provided as Figure 3 in the response to Chapter 2.1.1.1, Set 1, RAI 2, RAI 2.2.1.1.1-002.

1. RESPONSE

Stormwater drainage diversion ditches, sized to transport the probable maximum flood, are identified to protect the North Portal and the surface geologic repository operations area from runoff and debris flows that could potentially emanate from the eastern slopes of Exile Hill. The current location and configuration of these ditches (the north diversion ditch and the south diversion ditch) are shown in the *Geologic Repository Operations Area Aging Pad Site Plan* (BSC 2008b) and the *Geologic Repository Operations Area North Portal Site Plan* (BSC 2008a).

The two diversion ditches divert flow from the upper part of Exile Hill and route this flow into larger diversion ditches near the boundary of the geologic repository operations area. The flood analyses did not quantify the runoff carried by these ditches or include this flow in the HEC-1 analyses (i.e., BSC 2007). The ditches were added to the design after the flood analysis was completed. Given the limited drainage area above the diversion ditches on Exile Hill, the flow captured by these ditches is expected to be relatively minor. The final flood analysis and design of the two diversion ditches, including sizing and placement, will be performed as part of the detailed design.

The conceptual design of the diversion ditches is as trapezoid-shaped, open channels with sections that are unlined, lined with riprap, or constructed of concrete in areas of higher velocity flow or for increased stability, as appropriate. These ditches will be sized to transport the probable maximum flood, provided in the site drainage report (BSC 2007), per the nuclear safety design basis (SAR Section 1.9, Table 1.9-6).

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

BSC (Bechtel SAIC Company) 2007. *Yucca Mountain Project Drainage Report and Analysis*. 000-CDC-MGR0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070924.0043.

BSC 2008a. *Geologic Repository Operations Area North Portal Site Plan*. 100-C00-MGR0-00501-000-00F. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080125.0007.

BSC 2008b. *Geologic Repository Operations Area Aging Pad Site Plan*. 170-C00-AP00-00101-000-00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080129.0005.

RAI Volume 2, Chapter 2.1.1.3, Third Set, Number 6, Supplemental Question 7:

Where can the NRC staff find in the response to RAI 2.2.1.1.3-3-0076 or in the SAR information on the flood control feature's geotechnical engineering design information such as location and configuration, properties of the proposed dike material, and demonstration of the dike and ditches' capability to perform and maintain their credited safety functions during the design basis events throughout the preclosure period?

1. SUPPLEMENTAL RESPONSE

The following response provides a summary of the geotechnical design aspects of the flood control features as provided in the license application and in support documents. The detailed analysis and design of the flood control features will be provided as part of detailed design.

1.1. GEOTECHNICAL ENGINEERING ASPECTS OF FLOOD CONTROL FEATURES

The location and configuration of the flood diversion channels and dikes (i.e., more specifically, levees) are provided in repository site plans:

- *Geologic Repository Operations Area North Portal Site Plan* (BSC 2008a), provided with the response to RAI 2.2.1.1.3-3-006, and also shown in SAR Figure 1.2.1-2.

- *Geologic Repository Operations Area Aging Pad Site Plan* (BSC 2008b), provided as Figure 3 in the supplemental response to RAI 2.2.1.1.1-002 and included (schematically) in GI Figure 1-6.

The flood diversion channels are planned to be trapezoid-shaped, unlined open channels. Sections of the channels may be constructed of concrete as necessary for erosion control. As shown in SAR Figure 1.2.2-7, the excavated side slopes of the diversion channels are planned with a 3:1 (horizontal:vertical) slope, and man-made channels typically range in size from 68 to 88 ft (20.7 to 26.8 m) in width at the base. The adequacy of channel side slopes and dimensions will be confirmed during detailed design to assure stability of the slopes, and the constructed channels will be sized to transport the probable maximum flood around the North Portal pad, in accordance with the *Project Design Criteria Document* (BSC 2009, Section 6.1.9).

Levees will ensure that probable maximum flood elevations do not affect important to safety facilities (BSC 2009, Section 6.1.9). The levees will be constructed of unzoned engineered fill to achieve design requirements and typically covered in coarse stone (riprap) to protect slopes from the weather and possible scour, as appropriate. The side slopes of a levee will be no steeper than 2:1 (horizontal:vertical) and will be analyzed for slope stability. Design of these features will include flood loads on the levees and within the channels, and stability will be computed based on the maximum probable flood (BSC 2009, Section 4.2.11.3.15).

Detailed design of the open channels and associated levees will be in accordance with requirements determined from the hydraulic analyses and generally accepted engineering

standards of practice (e.g., COE 2000), utilizing guidance from Regulatory Guide 1.102 and Regulatory Guide 1.59 (BSC 2009, Section 4.2.10.2) to protect structures, systems, and components that perform safety or waste isolation functions. Flood hazard analyses have shown that the design probable maximum flood event of 55,240 ft^3/s at the location of maximum collection is a beyond Category 2 event (e.g., BSC 2008c). Accordingly, the design of levees and open channels will not consider seismic ground motions concurrent with a probable maximum flood, as this combined event is well beyond Category 2. Design of levees and channels will be based on load criteria in the *International Building Code 2000* (ICC 2003) and using site-specific seismic parameters in accordance with the *Seismic Analysis and Design Approach Document* (BSC 2007a, Chapter 9).

As noted in *Supplemental Soils Report* (BSC 2008d), engineered fill for the levees will be placed in lifts and compacted to an in-place density of at least 95% of the maximum laboratory dry density as determined by ASTM D 1557, *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))*. Engineered fill will meet design criteria for the levees (e.g., bearing capacity, settlement, stability, erosion control). In addition, riprap-lined aprons and jetties will be utilized at outlets from the flood channel to the natural surface, as necessary to control erosion at transition points. As recommended in *Soils Report for North Portal Area, Yucca Mountain Project* (BSC 2002, Section 14), the engineered fill of the levee will be keyed[1] at the base into the existing soils or rock for additional stability.

Several penetrations of the levee system will be included in the design and will be considered in geotechnical analyses. As shown in *Geologic Repository Operations Area North Portal Site Plan* (BSC 2008a), the southern portion of the levee system is penetrated by six major culverts of approximately 15 ft (4.6 m) in width. In addition, the H Road drainage structure directs flow under the developed extension of the H Road embankment southeast of the geologic repository operations area. This structure consists of eight 48-ft × 20-ft (14.6 × 6.1 m) arch culverts, as indicated in Section 6.1.6 of *Yucca Mountain Project Drainage Report and Analysis* (BSC 2007b). Further, a diversion structure may be added to control and channel the flow under the road to the aging pad, if needed.

To prevent scour and erosion where these control features penetrate the levee system, the inlet and outlet sections around pipes and culverts will be protected as necessary with riprap and concrete structures. Antiseepage devices will be included as needed to prevent piping or erosion along the outside wall of drainage pipe. The culvert and riprap designs will be developed as part of detailed design in accordance with applicable standards and engineering practice (e.g., FHWA 2005, COE 1994).

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[1] The levee is constructed with a portion of the base excavated or trenched into the existing soils or rock below the final grade on which the levee is placed.

2. COMMITMENTS TO NRC

None.

3. DESCRIPTION OF PROPOSED LA CHANGE

None.

4. REFERENCES

ASTM D 1557-02. 2003. *Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))*. West Conshohocken, Pennsylvania: American Society for Testing and Materials. TIC: 254263.

BSC (Bechtel SAIC Company) 2002. *Soils Report for North Portal Area, Yucca Mountain Project*. 100-00C-WRP0-00100-000-000. Las Vegas, Nevada: Bechtel SAIC Company. ACC: MOL.20021015.0323.

BSC 2007a. *Seismic Analysis and Design Approach Document.* 000-30R-MGR0-02000-000-001. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20071220.0029.

BSC 2007b. *Yucca Mountain Project Drainage Report and Analysis*. 000-CDC-MGR0-00100-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20070924.0043.

BSC 2008a. *Geologic Repository Operations Area North Portal Site Plan*. 100-C00-MGR0-00501-000 REV. 00F. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080125.0007.

BSC 2008b. *Geologic Repository Operations Area Aging Pad Site Plan*. 170-C00-AP00-00101-000 REV. 00C. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080129.0005.

BSC 2008c. *Flood Hazard Curve of the Surface Facility Area in the North Portal Pad and Vicinity*. 000-PSA-MGR0-01900-000-00A. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080204.0007.

BSC 2008d. *Supplemental Soils Report*. 100-S0C-CY00-00100-000-00E. Las Vegas, Nevada: Bechtel SAIC Company. ACC: ENG.20080828.0016.

BSC 2009. *Project Design Criteria Document*. 000-3DR-MGR0-00100-000-008. Las Vegas, Nevada: Bechtel SAIC Company. ACC: DOC.20090331.0010.

COE (U.S. Army Corps of Engineers) 1994. *Hydraulic Design of Flood Control Channels*. Engineer Manual, EM 1110-2-1601. Washington, D.C.: U.S. Department of the Army, U. S. Army Corps of Engineers. Accessed December 08, 2009. URL: http://140.194.76.129/publications/eng-manuals/em1110-2-1601/toc.htm

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FHWA (Federal Highway Administration) 2005. *Hydraulic Design of Highway Culverts*. Hydraulic Design Series No. 5. FHWA-NHI-01-020. Washington, D.C.: Department of Transportation, Federal Highway Administration. Accessed January 04, 2010.
URL: http://isddc.dot.gov/OLPFiles/FHWA/015808.pdf

ICC (International Code Council) 2003. *International Building Code 2000, with Errata to the 2000 International Building Code*. Falls Church, Virginia: International Code Council. TIC: 251054; 257198.

Regulatory Guide 1.59, Rev. 2. 1977. *Design Basis Floods for Nuclear Power Plants*. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 2708.

Regulatory Guide 1.102, Rev. 1. 1976. *Flood Protection for Nuclear Power Plants*. Washington, D.C.: U.S. Nuclear Regulatory Commission. TIC: 3697.