INFO NEEDS ITEM AE-21
ER SECTION 4.2.1.5/ 4.3.2

1. Overview
   Provide a knowledgeable expert to discuss the dewatering of the power block area (ER Page 4-25) and other areas (ER Page 4-14).

2. References
   - Sargent & Lundy report "Construction Dewatering Design Bell Bend Nuclear Power Plant Unistar Nuclear Energy", Report No. SL-009655, Revision 1, dated December 17, 2008.

3. Response

The following information is obtained from Sargent & Lundy report "Construction Dewatering Design Bell Bend Nuclear Power Plant Unistar Nuclear Energy", Report No. SL-009655, Revision 1, dated December 17, 2008. This report is based on the analyses performed by Weaver Boos as documented in:

- Weaver Boos Consultants North Central, LLC, "Evaluation of Temporary Construction Dewatering Strategies Proposed Bell Bend Nuclear Power Plant Berwick, Pennsylvania", Dated September 8, 2008.
- Weaver Boos Consultants North Central, LLC, "Supplemental Evaluation No. 1, Construction Dewatering Evaluation", Dated December 1, 2008.

Need for Dewatering

For structural and seismic design considerations, the Nuclear Island structures will be supported on engineered fill (concrete or granular) extending from the bearing elevation down to the top of competent rock. This construction detail and the site geologic setting require excavation depths of up to 60 feet, with approximately 50 feet of water-bearing sands and gravels (upper glacial aquifer) in the strata to be excavated. The Mahantango Shale underlies the sand and gravel deposits. Proper placement of the backfill requires the work be performed in a dry condition. As such, an active construction dewatering system will be implemented prior to construction to maintain dry conditions and it will continue until the subgrade portions for these structures are completed and the excavation is backfilled. The dewatering system will be decommissioned as the structures are completed and the backfill is placed to establish the final grade. Evaluation of groundwater flow was undertaken utilizing a three-layered conceptual model implemented using Visual MODFLOW Version 4.3, by Schlumberger Water Services. This software is a widely used implementation of the USGS's globally-recognized MODFLOW program. Dewatering and excavation using a slurry wall, diaphragm wall, or other type of subsurface flow barrier to mitigate potential off-site water level drawdown and subsequent impact to potentially sensitive areas was considered in the evaluation.

Prior to initiating dewatering activities, preparations must be made to receive the water discharged from the excavation. Effluent from the dewatering system will be routed through Storm Water Pond No. 1 (SWP-1), which will be used during plant operation as the detention pond for the plant storm runoff. Given the layout of the areas for the Nuclear Island (NI) and the Essential Service Water Emergency Makeup System (ESWEMS), a common dewatering system consisting of deep wells surrounding the excavations is conceptually designed to facilitate both excavation areas. These excavations can proceed as the dewatering takes place provided the dewatering system maintains the groundwater level below that of the excavations. As the excavation advances a series of groundwater monitoring wells will be monitored to verify the effectiveness of the dewatering system in reducing the groundwater level.

Groundwater Considerations

The flow system was defined based on review of the 7.5-minute series USGS topographic map of the Berwick Quadrangle and a review of the site and nearby geology. The available information indicates that the BBNPP site may be viewed as located within a small groundwater basin that stores water mostly in the overburden aquifer. The basin is defined to the north by the ridge formed in till-draped sandstone of the Trimmers Formation, to the east by a bedrock ridge and groundwater flow divide corresponding approximately to the route of Confers Lane, to the south by a bedrock ridge forming in the knolls, and to the west by a bedrock ridge forming in the uplands west of Walker Run.

Three potential sources of groundwater input in this basin are identified. The first is groundwater recharge from infiltration of precipitation across the site. The second is groundwater exchange with Walker Run that flows along the west side of the site. The third is groundwater inflow originating on the ridge that rises to elevations as high as 1,100 ft. directly north of the site.

Potential discharges of groundwater originating beneath the site include discharge to Walker Run, and subsurface outflow to the south, much of which likely occurs beneath Walker Run, and eventual discharge to the Susquehanna River.

The modeling performed using a flow barrier indicates that installation of the flow barrier, such as a soil-bentonite slurry wall, around the NI and ESWEMS substantially reduces steady state outflow from the dewatering system. Considering a representative design value of hydraulic conductivity of the bedrock aquifer (1.77×10^{-5} cm/s), the suggested rate of dewatering to achieve the project objectives is about 110 gpm (0.2 cfs) as compared with 1,700 gpm (3.8 cfs) without the barrier. Walker Run may in this scenario remain a losing stream near the site, but the loss is reduced from approximately 1.4 cfs to a net of about 1.2 cfs. It must be recognized that this calculated loss is based on total consumptive use of the water from the dewatering wells. Later sections of this report indicate that there will be some recharge of the aquifer, which will reduce the losses from Walker Run. However to present a conservative model, this recharge has not been considered. Total aquifer throughput in this scenario is 3.1 cfs.

The initial report was based on using the overly conservative upper bound value of hydraulic conductivity (1.64×10^{-4} cm/s determined by pump tests) of the bedrock aquifer, and estimated rate of dewatering of 640 gpm (1.4 cfs). As discussed above in this report (Section 6.2.2), the higher rate of dewatering (640 gpm) is considered not to be representative of the bedrock condition and thus not appropriate for the design of the dewatering system. Therefore a more representative flow value of 110 gpm is used and is considered to be a more appropriate, realistic, and conservative value for the flow rate.

With a flow barrier, the groundwater levels throughout the basin are not affected to the degree of dewatering without a barrier. Attachment E of the S&L report depicts the projected groundwater levels once dewatering achieves a steady state condition.

Cutoff Wall

The final slurry wall design should reflect the following guidelines:

- The slurry wall will be a minimum of three feet thick, and will be at least ½-foot-thick for each 10 feet of hydraulic head across the wall.
- The slurry wall will be keyed into competent shale such that the flow underneath the wall through the shale is less than or equal to the flow directly through the soil-bentonite slurry wall. The minimum depth of penetration of the slurry wall key will be two feet into the shale below any permeable lenses or weathered shale zones.
- The slurry will consist of 4 to 7 percent bentonite in water, and the backfill will contain bentonite at a rate of 3 percent.
- The slurry walls will have a designed in-situ permeability less than or equal to 1×10^{-7} cm/s. Some plastic fines may need to be imported to meet this criterion.
- Slurry walls will have a minimum of a five-foot overlap at corners.
- Slurry wall will be constructed vertically.
- Slurry levels will be maintained at least seven feet above the ground water table during construction. This will require the construction of a berm to raise the ground level at several locations along the specified alignment.
- Extensive quality control measures should be taken to assure that the S-B slurry wall is constructed without gaps or windows.

Well Requirements

Assuming the use of the flow barrier, dewatering wells may be located as shown on Attachment G of the S&L report. A total of approximately 30 dewatering wells appear to be appropriate when the flow barrier is utilized. Given the number of wells required and potentially very large initial flows that such a system might develop, individual pumps should be sized for no more than approximately 30 to 150 gpm each. Included in Appendix D as referenced in the S&L report is the calculation of the time expected to drain the groundwater stored within the conceptual flow barrier. As shown therein, it is assumed that the dewatering system inside the flow barrier is pumped at a rate of about 1,800 gpm (4.0 cfs). This rate is selected so that the flow through the receiving body, assumed to be Walker Run, will not exceed its greatest measured rate of about 8 cfs. At this flow rate approximately 500 acre-ft. of water will be removed over a period of 65 days. To reduce the flow rates in Walker Run, the days to drain the water from storage could be increased to the extent the construction schedule will allow, subsequently the flow rate would be reduced. Digital flow modeling of this dewatering strategy suggests that interior dewatering might require a steady state flow on the order of 110 gpm (0.2 cfs). The majority of this water is expected to flow upward through the shale, but the actual flow may be less, since the impermeable zones were not incorporated into the model. Numerous packer tests conducted in the shale during the site investigation indicate hydraulic conductivity values much lower than considered in the model, and in approximately one-half of the tests, the hydraulic conductivity was effectively zero.

Given more complete water table depression within the excavation with the benefit of the flow barrier, a final stage of the dewatering conceptual design includes the excavation of trench drains and sumps approximately 5 ft. in front of the toe of the slope at the base of the excavation. Such trenches might be dug 3 to 5 ft. wide, and 2 to 3 ft. deep, and sloped to sumps as suggested in Attachment G of the S&L report. Groundwater flow from the bedrock is expected to vary over a wide range, and additional trenches or sumps might be needed at locations to be determined.

Attachment E of the S&L report illustrates the drawdown effect with the use of a flow barrier. The anticipated drawdown and radius of influence is considerably less than without the flow barrier.

Attachment H of the S&L report provides a typical cross section through the excavation utilizing the flow barrier. Attachment I of the S&L report provides a typical schematic for the dewatering well that would be used for dewatering the excavation. Attachment J of the S&L report provides a typical schematic for a monitoring well (piezometer).

In addition to dewatering within the boundary of the flow barrier, it is noted that placement of the barrier might cause heads to increase along the upgradient (north and east) sides owing to the cutoff of the natural southwesterly groundwater flow path. This effect is illustrated as negative drawdown as shown on Attachment E of the S&L report. This potential will be mitigated by the placement of wells or drains, as needed, along the outward northern and eastern boundaries of the flow barrier.

Operation of this conceptual dewatering system should be less sensitive to brief interruptions in electrical power because the flow barrier will retard inflows to the excavation and should eliminate the need for vacuum well point systems. However, provisions for convenient maintenance should still be included for all system elements as needed for a project duration approaching three years.

Disposal of Groundwater

As stated above, the steady state discharge from a dewatering system without the use of a seepage cutoff wall would be approximately 1700 gpm (approximately 2.5 million gallons per day [mgd]). Considering the use of a seepage cutoff wall, the discharge will be reduced. This reduced quantity is estimated to be 110 gpm (0.16 mgd) with approximately 13 gpm of this attributed to seepage through the flow barrier. For this report, an average value of 110 gpm (0.16 mgd) will be considered as the average daily quantity of water that will be discharged with the installation of a competent seepage cutoff wall.

There are several options for the disposal of the groundwater pumped from the excavation. They include:

- Used for various construction activities, such as dust control, water for compaction control, and concrete mixing.
- Direct surface inflow into the wetlands.
- Temporary storage in the on-site detention ponds prior to release into the wetlands.
- Treatment for human consumption.
- Injection into the glacial overburden (away from the excavation) to replenish the drawdown in groundwater levels.

A beneficial use of the groundwater pumped from the excavation would be its reuse as a source of non-potable water for construction use. This would include dust control on the construction roads and water to be used for moisture control during the placement and compaction of the backfill around the NI as well as the general site grading activities.

Even with the installation of the seepage cutoff around the excavation, there will be some drawdown of the water within the wetlands south of the NI. The use of the pumped water to restore the groundwater level in this wetlands area would be beneficial. The surface water present in the wetlands in the southwest corner of the site is hydraulically connected to the groundwater. Therefore, the water chemistry is very similar. The various water quality components tested from the shallow bedrock wells also indicated similar values for these components. Thus, the direct discharge of any groundwater pumped from the excavation would not have any detrimental chemical effect on the water in the wetlands. However, direct discharge would require permits, a sedimentation basin, a suitable area with erosion protection measures, and a controlled outlet. If the discharge water is pumped directly into the detention pond to be constructed on the west side of the NI, then the outlet facilities of the pond would provide the necessary controlled outlet and erosion protection. Since the in situ soils are granular and permeable, the water pumped from the excavation would naturally infiltrate through the bottom of the pond and replenish the wetlands naturally. Additionally, waters discharged from SWP-1 into Walker Run will aid in the recharge of the wetlands since Walker Run has a granular bottom. It is important to construct this detention pond as one of the first construction activities for this project.

In summary, the most prudent approach for the disposal of the water pumped from the excavation would be to pump it directly into the detention pond on the west side of the NI. This detention pond was designed to retain the 100-year, 24-hour rainfall within the limits of the NI and has a holding capacity of approximately 51 acre-feet. This drainage area is approximately the area within the seepage cutoff limits, and thus would be capable of detaining the water pumped from the excavation, after the initial dewatering of the soils within the flow barrier. With proper construction, the pond could act as a natural recharge facility to the wetlands on the south side of the NI. The pond would also act as a natural storage facility for any water to be used for dust control, compaction of fill materials, and possibly concrete mixing with proper management and testing.

Conclusions and Recommendations

The following conclusions are based on this evaluation of the conceptual dewatering system for the construction of the BBNPP:

a. A dewatering system will be required to lower the groundwater for the excavation to allow for construction of the foundations for the NI and ESWEMS structures to be performed under dry conditions. The dewatering system will consist of deep wells penetrating the glacial overburden soils down to the top of the bedrock.
b. No dewatering system will be required to excavate the area where the two cooling towers are to be located. Extensive excavation of both overburden soils and bedrock will be required to lower the area down to final grade. Some groundwater is present in the glacial overburden soils north of the cooling towers; however, trenches and ditches at the soil/rock interface can be designed to reroute any groundwater around the cooling tower excavation to the planned surface drainage system that will direct the runoff during plant operation to the storm water ponds. Additional ditches will be required at the bottom of the excavation in the bedrock. Any water that seeps into the excavation can be routed to the perimeter ditches, which will flow into the stormwater detention ponds.
c. No dewatering system will be required to excavate the area for the Combine Wastewater Treatment Pond (CWTP). The bottom of the pond is higher that the reported groundwater in the area of the pond. Therefore, excavation under dry conditions can be performed with no extensive dewatering system. Ditches will be required around the excavation to prevent surface flow due to precipitation from entering the excavation.
d. The radius of influence of dewatering wells for the NI and the ESWEMS would extend out some 3300 feet with anticipated drawdown of 20 ft. to 30 ft. being experienced some distance away from the wells if no flow barrier is utilized. This would incur a large impact on the nearby wetlands, flow in Walker Run, and potentially affect (and possibly dry up) any nearby domestic or commercial water wells within the radius of influence of the dewatering activity. Some of the nearby wetlands would most likely dry up as well.
e. The use of a flow barrier, such as a soil-bentonite slurry wall, around the NI and ESWEMS excavation would greatly reduce the drawdown effect of the dewatering wells since the wells would be located within the limits of the flow barrier.

f. There is the potential for some water seepage through the bedrock in the bottom of the excavation. Trenches and ditches will most likely be required in the bottom of the excavation to direct any upward flow through the rock away from the center of the excavation to the perimeter ditches. Sumps and pumps will be utilized to remove this water from the excavation.
g. With a competent flow barrier, inflow into the excavation through the flow barrier and up through the bedrock is anticipated to be 110 gpm. The initial flow rate, to remove the groundwater from within the flow barrier, will be contingent upon the time period allowed. If 65 days are scheduled to remove the water from within the flow barrier, a flow rate of about 1,800 gpm (4.0 cfs) would be required.
h. The use of a detention/sedimentation pond and the use of Best Management Practices to reduce the total solids in the runoff will most likely be required.
i. The water removed from the excavation should be suitable for reuse as dust control, soil compaction, and concrete mixing based on the available water quality information. Some testing of the water will be required if it is to be used for concrete mixing.

The following recommendations for a dewatering system are based on this evaluation of the conceptual dewatering system for the construction of the BBNPP:

a. A flow barrier, such a soil-bentonite slurry wall should be installed around the NI and the ESWEMS excavation. One continuous wall is recommended. The flow barrier would be installed by keying it into the underlying bedrock as shown on Attachment G. The minimum design permeability of the flow barrier is 1×10^{-7} cm/s with an approximate thickness of three feet.
b. A total of 30 dewatering wells, as shown on Attachment G of the S&L report, will be required to create and maintain a dry condition at the bottom of the excavation. These wells should have a capacity of up to 150 gpm. If a build up of groundwater occurs on the north side of the NI excavation or extreme levels of seepage are encountered, additional pumping wells can be integrated into the pumping system or stone filled drainage trenches can be constructed to reroute the groundwater flows around the flow barrier on the north and east sides.
c. Trenches will be required in the underlying bedrock in the bottom of the excavation for the NI and the ESWEMS to direct any up flow of groundwater through the rock to the perimeter ditches where it can be removed through the use of sumps and pumps.
d. Storm Pond 1 on the west side of the NI should be constructed prior to any dewatering activity. This pond can be utilized as the detention and release point for the discharge from the dewatering system.
e. The drainage ditch system in the cooling tower area should be constructed integrally with the excavation of the hillside. Sufficient ditches and trenches should be installed at the soil/rock interface to preclude groundwater from flowing into the excavation.
f. The existing monitoring wells within the NI and ESWEMS excavation limits should be utilized to monitor the effectiveness of the flow barrier. Additional monitoring wells should also be installed to provide adequate monitoring on all

four sides of the excavation. The monitoring program should include recording water levels on both the inside and outside of the flow barrier.

g. If the monitoring wells indicate an open window within the flow barrier, remedial measures, such as pressure grouting, will be required to mitigate this condition.