

June 2, 2010

EES Consulting, Inc.  
570 Kirkland Way, Suite 200  
Kirkland, WA 98033

Attn: Mr. Scott E. Mahnken, P.E.

**RE: CONCEPTUAL PLANS AND PROFILES, SOUTH FORK AND UPPER  
CHEHALIS DAMS, LEWIS COUNTY, WASHINGTON**

Shannon & Wilson prepared a Geologic Reconnaissance Study dated October 27, 2009, and a Reconnaissance-level Geotechnical Report dated October 28, 2009, for the South Fork and Upper Chehalis dams. This letter provides supplemental comments related to geotechnical and engineering geologic issues at the sites based on your preliminary plans and profiles dated May 10 and 12, 2010, along with the Preliminary Information dated May 10, 2010, that you provided to us.

**UPPER CHEHALIS DAM**

The crest alignment for this structure has moved approximately 600 feet downstream and rotated about 20 degrees to the northwest from the layout included in our October 2009 reports. The downstream toe of the dam is near the extent of our geologic mapping and some of the downstream appurtenant structures are outside of our geologic mapping area.

- It appears that the uppermost portion of the right abutment and the emergency spillway will be founded in McIntosh Formation bedrock. The McIntosh Formation is a weak marine siltstone/claystone. Seepage mitigation measures may be necessary if the normal pool elevation is above the elevation of the geologic contact between the McIntosh Formation and the underlying igneous volcanic rocks.
- Our geologic mapping did not include the ravine into which the proposed emergency spillway will discharge. Landslides may be present in this area. As a first step to assessing the presence of landslides, we will review the LiDAR data for readily visible

indications of past slope instability. Geologic maps indicate bedrock in this area to be the McIntosh Formation. The weak nature of this rock makes it susceptible to erosion. Colluvium overlying bedrock is also erodible. At best, spillway flows could cause significant erosion and sedimentation of the Chehalis River channel downstream of the dam; at worst, headcutting could create a dam safety concern. Depending on the erosion potential, potential environmental impacts, and regulatory constraints, a spillway at this location may require that the discharge channel be concrete-lined or that other erosion protection measures be implemented.

- There are landslides on both the left and right banks of the river channel above the proposed valve house, powerhouse, and switchyard. Reconnaissance, explorations, study, and analyses will be required to assess the potential hazard to the proposed facilities posed by these landslides and to assess alternatives for landslide mitigation and facility construction. The Federal Energy Regulatory Commission (FERC) will likely require mitigation of landslide hazards or relocation of the facilities if in their opinion the landslides present an unacceptable risk to the facilities. As a first step to assessing the location and extent of landslides, we will review the LiDAR data to estimate where facilities might need to be relocated to.
- It appears that hydraulic control for the penstock/outlet is proposed to be located at the gate shaft near the dam crest. A permanently charged pipe below the upstream shell is a potential dam safety issue and presents maintenance challenges. Consideration should be given to including a gate at the intake structure so that the entire length of the pipe can be drained for inspection and maintenance.
- Where the outlet pipe will be buried below the dam embankment, we recommend that the pipe be designed with as few bends as possible or with long-radius bends to reduce thrust block requirements and the potential for stress concentrations that could lead to cracking of the earth embankment. For planning purposes, we recommend that the pipe be assumed to be benched into bedrock and concrete-encased for its full length where it is below the dam embankment.
- The dam does not appear to have a low-level outlet. Inability to drain the bottom 150 feet of the reservoir is a potential dam safety issue. Some means to drain the reservoir to within a few tens of feet of its upstream toe elevation should be provided.
- The single intake on the penstock will not allow reservoir water to be blended to manage environmental quality and temperature of water discharged downstream. Multiple-level outlets that allow for blending of water will likely be required. The issue of water quality and the need for a multi-level intake should be considered as the design progresses.
- Would it be worth considering re-use of the diversion tunnel as a low-level outlet? Would it be possible to use the diversion tunnel as the permanent penstock, with multi-level inlet gates and bifurcation valves downstream of the dam to direct water to the

powerhouse and to discharge directly to the stream? Maintenance of, access to, and sediment deposition around the low-level outlet intake should be considered.

- It may be possible to construct a vertical shaft on the left abutment with the diversion tunnel at the bottom and inlets at multiple elevations. Depending on the location of the shaft, a stub tower could be constructed above the shaft, if necessary. Tunneling through the abutment and tapping into the shaft is one way that multiple-level intakes might be constructed.
- The information provided to us states that an 8-foot-diameter tunnel is about the smallest practicable size constructible. We agree that an 8-foot-diameter tunnel is about the smallest practical diameter for construction using a conventional tunnel boring machine (TBM). A smaller diameter tunnel constructed using the drill-and-shoot excavation method may be feasible. Use of the drill-and-shoot method may require mitigation of blast damage for seepage control. Tunnels smaller than 8 feet in diameter could be constructed using microtunneling machines. Microtunneling is typically performed by remotely operating the TBM and jacking the machine using tunnel liner pipe that is advanced behind the machine as the tunnel is bored. One or more intermediate shafts/jacking stations and/or intermediate jacks would likely be required for microtunneling techniques to be used to bore the proposed 1,700-foot-long tunnel.
- A blanket drain and toe drain should be incorporated below the embankment shell downstream of the dam core. The blanket drain would consist of a layer of high permeability filter and drainage sand that is a foot or two thick and placed against the abutments below the embankment downstream of the dam core. The toe drain would consist of a high permeability zone of open angular rock that extends from the chimney filter/drain downstream of the core to discharge at the dam toe. This rock would be encapsulated in one or more filter-compatible soil and gravel layers.
- The channel adjacent to the powerhouse should be armored to protect the site from erosion by water exiting the diversion tunnel.
- Some thickness of existing soil should be assumed to be removed from the existing ground prior to dam embankment construction as part of the foundation preparation process. Excavation and removal of some or all of material within landslide zones that underlie the dam footprint will likely also be required to provide adequate foundation and embankment stability. Assessment of these excavation volumes would be part of later geotechnical services for the project as the design advances. These excavations will increase the volume of excavation and fill required for the project relative to the volumes that would be computed based on the current sketches.

## SOUTH FORK CHEHALIS DAM

The crest alignment for the South Fork Chehalis Dam has moved about 150 feet downstream from the layout included in our reports with minimal rotation.

- Preferred criteria (in order of importance) for an outlet pipe below an embankment dam are: (1) founded on bedrock, (2) straight, and (3) perpendicular to the crest. Obviously, all outlet conduits cannot be ideally constructed. The proposed alignment at the South Fork site is a concern for several reasons. Based on the geophysical survey by Phillip H. Duoos, the estimated top of bedrock below the alluvial terrace inside the horseshoe bend is about Elevation 435. Upstream of the proposed dam centerline, the invert of the proposed 42-inch pipe is very close to Elevation 435, so it may be difficult to achieve complete embedment in rock. The two sharp bends in the pipe may require large thrust blocks. Pipe bends concentrate stress and load and present a risk of failure. Since the pipe would be below the earth embankment, these concerns are potential dam safety issues. We understand that large radius bends and continuously welded steel pipe are being considered to partially address these issues.
- Will the 42-inch-diameter diversion pipe remain operational as a low-level outlet after dam construction or be backfilled? Inability to drain the bottom 40 feet of the reservoir may be a potential dam safety issue. Some means to drain the reservoir to an elevation lower than the intake elevation of 490 feet may be required.
- The 42-inch-diameter diversion pipe has sharp bends. As discussed above, the number of bends should be reduced to the minimum necessary. Would it be possible to shift the inlet and/or outlet locations for this diversion pipe to eliminate the bends and to align the pipe more perpendicular to the dam axis? It appears that the topography may be suitable to shift the inlet to the north and the outlet to the south. For planning purposes, the pipe should be assumed to be concrete-encased where it is below any part of the dam.
- The penstock conduit has no upstream valve control. Please refer our comment for the Upper Chehalis Dam regarding installing a permanently pressurized conduit below an earth embankment.
- Similar to the Upper Chehalis Dam, the penstock alignment on the left abutment appears to have several bends. As discussed above, the number of bends should be reduced to the minimum necessary. For planning purposes, the pipe should be assumed to be founded on bedrock and concrete-encased where it is below any part of the dam.
- See the discussion above for the Upper Chehalis Dam regarding the potential desirability of multiple levels of intake gates to blend water to meet discharge water quality and temperature requirements.

- The spillway channel will intersect a landslide between about Elevations 500 and 440. Measures to improve stability of this landslide may be required. It appears that the upper portion of the spillway channel will be in McIntosh Formation. Because of the erodibility of the McIntosh Formation and overlying colluvium, the spillway channel will need to be fully concrete-lined or other erosion protection measures implemented.
- The channel adjacent to the powerhouse should be armored to protect the site from erosion by water exiting the diversion pipe.
- As discussed for the Upper Chehalis Dam, a blanket drain and toe drain should be incorporated below the embankment shell downstream of the dam core.
- Excavation below the dam footprint to prepare the foundation and partially or fully remove landslide material should be considered in assessing areal impacts and volumes, as discussed above for the Upper Chehalis Dam.

### CONCLUSION

Several geotechnical and engineering geologic issues will influence the ultimate layout and design of the proposed dam sites. Based on the current design level and current knowledge of the sites, we see no fatal technical flaws with the general concepts for the two dams. Some aspects of the designs may need to be revised as the design progresses and to meet regulatory requirements.

We are available to discuss these comments in more detail at your convenience. We have worked with the Dam Safety Branch at the Portland Regional Office of FERC and with the Washington State Department of Ecology Dam Safety Office on several projects. In our opinion, it would be beneficial to hold an informal meeting with these regulators early in the design process so that we can address concerns they may have.

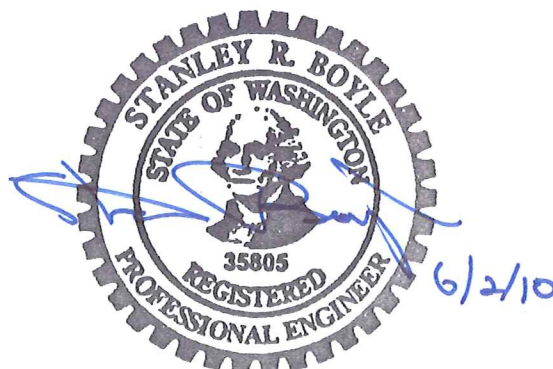
Thank you again for the opportunity to participate in the design process for these dams.

Sincerely,

SHANNON & WILSON, INC.

Stanley R. Boyle, Ph.D., P.E.  
Vice President

SRW:WTL:SRB/srw



July 22, 2010

EES Consulting, Inc.  
570 Kirkland Way, Suite 200  
Kirkland, WA 98033

Attn: Mr. Scott E. Mahnken, P.E.

**RE: OPINION OF PROBABLE UNIT CONSTRUCTION COSTS FOR SELECTED  
LINE ITEMS, CHEHALIS DAMS, LEWIS COUNTY, WASHINGTON**

At your request, Shannon & Wilson has developed an Engineer's Opinion of probable unit construction costs for selected line items for the proposed Upper Chehalis and South Fork Chehalis dams. These line items include constructing the embankments (estimated to be 7.9 million cubic yards of fill and 4.3 million cubic yards of fill, respectively), riprap erosion protection, constructing a grout curtain, and construction of an approximately 1,800-foot-long, 12-foot-diameter rock tunnel.

For the earth embankment, riprap, and foundation grouting line items, we reviewed actual bid data from several contractors for two dam construction projects in Colorado. Using the Construction Cost Indices published by The Engineering News-Record for Denver, Colorado and Seattle, Washington, we both escalated the prices to July 2010 dollars and applied a geographic adjustment to account for regional pricing differences. Costs for the tunnel are based on our experience with similar underground projects.

**EARTH EMBANKMENT**

An earth dam embankment generally contains zones of different materials. Some zones (such as the core and shells) are comprised of relatively low-cost local borrow, and others (such as filters and drains) are comprised of more expensive processed aggregates. We understand that at this stage of the project, providing a single blended unit cost for the entire embankment is preferable. To this end, we calculated and summed the extended cost of the embankment line items in the available bid abstracts (excluding riprap) and divided this total by the total embankment volume to come up with a blended unit cost.

Based on the available (escalated) bid data, we expect that the blended unit cost for embankment construction will be between \$4.00 and \$6.50 per cubic yard. This range assumes that an adequate quantity of suitable borrow material is available within a reasonable haul distance of the dam site(s). The higher end of range represents marginal soils that will require a larger quantity of processed aggregates for larger or more complex filter drains and/or transition zones. We recommend using a unit cost value of \$5.50 per cubic yard, assuming a contingency factor is applied to the opinion of overall project cost.

### **RIPRAP**

Erosion protection is often a significant cost item. We assume that the initial design will include bedded riprap on the upstream face of each dam. It is our opinion that riprap bedding can be produced from on-site materials, so it is included in the blended embankment cost above. However, in our opinion, the suitability of the on-site basalt for use as riprap is questionable, based on our field observations of its strength and durability. For this reason, we recommend that the cost of riprap be considered separately.

It is our opinion that the unit cost for imported riprap will be on the order of \$50 to \$60 per cubic yard. At this stage of design, we recommend using the high end of the cost range. We also recommend that the overall project cost contingency factor be applied to this line item.

### **GROUT CURTAIN**

For the grout curtain, we calculated and summed the extended cost of pertinent line items for the Colorado dam projects and divided this total by the total cost of embankment construction. Accordingly, the cost of the grout curtain is provided as a percentage of the embankment construction cost. Because the size of the proposed Upper Chehalis and South Fork Chehalis dams is significantly larger than the dams from which we are deriving the unit costs, and because the design area of the grout curtains is unknown, it is our opinion that referencing the cost of grouting to the cost of the embankment is appropriate for a conceptual-level opinion of probable construction cost.

In our opinion, the cost of the grout curtain will be between 25 percent and 40 percent of the cost of the embankment. We recommend using a value of 33 percent of the embankment construction cost, assuming a contingency factor is applied to the opinion of overall project cost.

## **TUNNEL**

In our opinion, the cost of mining the diversion/power conduit tunnel using a tunnel boring machine will be between \$300 and \$375 per diameter-foot, per foot of length. For a 12-foot outer diameter (O.D.) tunnel, this is between \$3,600 and \$4,500 per linear foot. The difference in cost will be largely dependent on the quality of the rock and the type of ground support that will be required. Given the limited subsurface information, we recommend using \$333 per diameter-foot (or \$4,000 per linear foot, assuming a 12-foot O.D. tunnel), and assuming a contingency factor is applied to the opinion of overall project cost.

This cost is only for the tunnel itself, and does not include a pipe or annular backfill. It also does not include the cost of a vertical shaft. The cost of sinking a shaft is considerably more expensive than driving the tunnel because the rate of production is much slower. In addition, the O.D. of a shaft is typically larger than the O.D. of the tunnel it will access. For a 12-foot O.D. tunnel, a 16- to 20-foot O.D. shaft would likely be required.

It is our opinion that the cost to sink a shaft (in rock) will be on the order of \$1,500 to \$2,000 per diameter-foot, per foot of depth, assuming a contingency factor is applied to the opinion of overall project cost.

## **CONTINGENCY**

At this stage of design, and with minimal information available about subsurface conditions, available borrow volumes, and the engineering properties of the nearby soil and rock materials, we recommend that a minimum contingency factor of 30 percent be applied to the unit costs presented above. This contingency is intended to account unforeseen conditions that may be discovered as part of the preliminary and final design process, as well as the uncertainty inherent to developing a preliminary cost opinion.

## **CLOSURE**

The costs presented herein are an opinion based on our experience with similar projects. No warranty or guarantee is offered or implied. Costs are in July 2010 dollars, indexed to western Washington state.



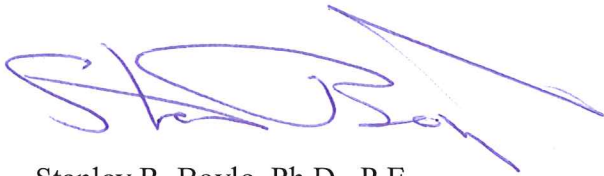
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July 22, 2010  
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SHANNON & WILSON, INC.

Thank you again for the opportunity to participate in the design process for these dams.

Sincerely,

SHANNON & WILSON, INC.

A handwritten signature in blue ink, appearing to read 'Stanley R. Boyle', with a long horizontal stroke extending to the right.

Stanley R. Boyle, Ph.D., P.E.  
Vice President

SRW:SRB/srw