MOUNT ST. HELENS LONG TERM SEDIMENT MANAGEMENT ALTERNATIVE ANALYSIS

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Abstract: Thirty-three years after the eruption of Mount St. Helens, erosion from the debris avalanche into the Toutle River continues to produce a problematic quantity of sediment for downriver communities. For the past five years the U.S. Army Corps of Engineers has been revisiting the long term sediment management strategy originally developed in 1985 to determine if there are better ways to meet flood protection goals while minimizing both harm to the environment and project costs.

Long term sediment records collected by the USGS Volcanic Observatory coupled with LiDAR and field surveys were used to create a sediment budget for the Toutle River basin. A complete sediment budget was developed from 1980 to 2007. Annual sediment loads for the period from 1999 to 2007 were stochastically sampled to create a predicted sediment record for the project life, extending out to 2035. Within these sampling years the annual sediment load from the Mount St. Helens debris avalanche ranges from 0.6 to 26 million tons. This natural variability of sediment erosion from the debris avalanche provides a reasonable representation of possible future loads to be expected in the basin. Once created, this forecasted sediment load was used as input to the modeling scheme chosen for the project.

A modeling scheme was selected to numerically represent the complexity of the Toutle River basin from the debris avalanche to the mouth of the Cowlitz River. The basin can be considered as a combination of sources and sinks placed in series. The debris avalanche represents the most significant source, the erosion of which is represented by the sediment budget. The highly braided network of streams downstream of the debris avalanche was modeled using Mike 21-C; HEC-RAS was used to develop the rating curve through the sediment retention structure (SRS). Sediment/bed interaction within the Toutle River downstream of the SRS was largely ignored as it was considered a transport reach that terminates at the Toutle River's confluence with the Cowlitz River. A mobile-bed HEC-RAS model was utilized in the lower 20 miles of the Cowlitz River to evaluate the long term sediment transport potential in this reach. Output from the upstream Mike-21C model was used for the upstream sediment load input into HEC-RAS. The water surface profiles from the RAS models were used in conjunction with HEC-FDA to compute the Level of Protection (LOP) provided by the levees located on the Lower Cowlitz Rivers. Flow- frequency and levee-fragility curves were developed to support this LOP computation.

Uncertainty/variability was incorporated into this analysis through the available period of flow records, uncertainty in levee performance, variability in bedform, and incoming the sediment load. Model uncertainty was also incorporated into the FDA model through sensitivity of key hydraulic parameters such as the roughness and contraction/expansion coefficients.

The resulting LOP estimates for each levee represent the frequency of an event that reflects a 90 percent probability of levee failure.

With the modeling scheme developed and the predicted sediment loads created for the project out years, a trend in LOP for the levees was computed for the project life. Specific authorizing language dictates that the Corps maintains LOP at a specified level. It was demonstrated that, for the "do-nothing" alternative, the LOP violates the authorization within five years. Based on this trend, a study was initiated to evaluate alternatives that would result in fulfilling the congressional authorization. Initial phases of this analysis identified the 16 measures as potential measures for evaluation. Using two rounds of screening, each measure was evaluated as to the degree to which it:

- Reduces flood risk on the Cowlitz River;
- Is low-cost based on preliminary cost estimates;
- Minimizes impacts to the environment;
- Is reliable;
- Is adaptable to changing conditions; and
- Is acceptable to the public.

After the two rounds of screening, six measures were forwarded for continued scrutiny. Of these, two were considered primary measures in that they have the potential to be employed as stand-alone measures. The rest were secondary measures that may be used to enhance the performance of the primary measures.

This short list was carried forward for further analysis during development of the long term sediment management plan, and each measure was thoroughly evaluated. The remaining four measures were grouped to form three action alternatives carried forward for further evaluation:

- Cowlitz River dredging only;
- SRS dam raise only; and
- Phased-construction (SRS spillway crest raise and GBS with as-needed dredging).

Within the model construct developed for the "do-nothing" alternative, each of the final alternatives was modeled and evaluated. Each alternative has been determined to meet the overall sediment management needs and are deemed relatively efficient, effective, complete, and they will allow for the management of the significant uncertainty in future sediment deposition.

In the evaluation of the final alternatives, it became clear that each alternative provided a specific benefit and contained unique drawbacks. For example, the dredging-only option, which involves dredging the lower 20 miles of the Cowlitz River, is highly adaptable to changing conditions, however placement of dredge material is problematic in terms of logistics and considering environmental concerns. The SRS-raise option has a high degree of certainty of trapping sediment, however, it is not adaptable to changing conditions and requires high up-front costs. The phased-construction approach combines the adaptability of the dredging only plan and the effectiveness of the SRS raise. The phased construction plan is currently the preferred alternative.

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The preferred alternative attempts to incorporate the high level of uncertainty in the basin through an adaptive management plan that only implements actions when the monitoring efforts show a need. The three components of the plan include gaining additional sediment capacity by raising the spillway crest and adding structures within the sediment plain to promote the depositional grade. The final component is emergency dredging in the Lower Cowlitz River to maintain the ability to react to unexpected extreme sediment loads. Inherent in an adaptable plan is a monitoring effort that quantifies sediment deposition in the Sediment plain and in the Lower Cowlitz.

In the case of the Toutle Basin, identification of the need is tied to the annual evaluation of the LOP. Evaluation of the LOP requires that sediment load measurements, survey data, and field observations be collected annually. A decision matrix has been put together that identifies the appropriate annual monitoring activities, decision criteria to implement a sediment control measure, and decision criteria for what type of sediment control measure is necessary. Specifics of these decision criteria will be part of the annual operation plan for the phased construction approach.