

Appendix D - Toolbox for Handling Loads by Upstream Dams and Incorporating Consequences for Failure of Downstream Dams

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I. Purpose

This toolbox provides guidance to Reclamation risk analysis participants and Senior Engineers when they are trying to determine if, and how, loads from upstream dams of the dam of study should be included in any analysis of risk. Also, this toolbox provides guidance on how to incorporate consequences from downstream dam failures triggered by any failure of the dam of study. In most cases it will be necessary to use the information in this toolbox when performing risk analyses since many Reclamation structures have other dams located upstream or downstream from them. It is intended to be used by Technical Service Center staff to prepare for various risk analyses and should stimulate appropriate discussion on river systems and multiple structures. A checklist of questions is also provided to help ensure:

- Appropriate discussion takes place prior to and during the analysis.
- Analyses are comprehensive in nature.
- Undue work is not performed.

II. Issues Associated with Loads Imposed by Upstream Dams

For Reclamation risk analyses when an initial baseline risk analysis is to be performed potential loads from upstream dams should not be imposed on the dam of study. Structures upstream of the dam of study should be considered to operate according to in-place standing operating procedures and assumed to be functioning satisfactorily. However, operational and any intervening hydrologic loads upstream of the dam of study should be discussed by persons involved in an analysis to ensure that there is a thorough understanding of any factors that may effect the performance of the dam.

Loads from static or dynamic failure of dams upstream from the dam of study should not be incorporated into an initial baseline risk analysis.

Characterizing the risk associated with extreme floods is described in Appendix H of this methodology "Toolbox on Hydrologic Loads". Once an initial evaluation of the baseline risk for hydrologic loads has been completed with direct consideration of operational and intervening hydrologic loads, but without assuming failure of the upstream dam(s), judgements can be made regarding potential courses of action. There are a variety of scenarios that may result from performing the baseline risk analysis, assuming no failure of an upstream dam(s) due to hydrologic loads:

II. Issues Associated with Loads Imposed by Upstream Dams (cont.)

- No action is clearly justified, including no additional studies.
- More site specific flood information is required for the dam of study.
- Flood studies must include dam/river system studies, i.e., multiple dams.
- The dam of study has lower priority, based on urgency associated with other dams.

III. Dealing with Consequences from Failure of Downstream Dams

When analyzing risk for a given structure consequences of failure are defined as any and all lives potentially lost (in some cases consequences may be something other than potential lives lost as described elsewhere in Reclamation Methodology). This includes those jeopardized by failures of other dams located below the dam being studied. This convention applies to all loading conditions - static, hydrologic and seismic. Details for estimating potential lives lost can be found in Appendix O "Life Loss".

IV. A Key Concept to Remember

Any time judgements, conclusions, recommendations, or decisions are being made regarding a structure (no action, monitoring, consideration of non-structural or structural alternatives, etc.) dams upstream and downstream of the dam of decision should be examined in a risk context. There may be actions at the upstream or downstream dams that would more efficiently address risk issues at the dam of study, or there may be risk issues at the upstream or downstream dams that would be more efficiently addressed by actions at the dam of study. This is especially true of dam safety issues related to hydrologic loading conditions.

V. Checklist of Questions to Consider Prior to A Risk Analysis

These are questions that can be used to stimulate discussion related to handling dams upstream and downstream from a dam of study. These are questions that would be used to heighten risk analysis participants awareness of various key issues but would not necessarily need to be answered to complete a baseline risk analysis.

- A. Does an upstream dam(s) impose extreme operational loads on the dam of study?
- B. Is the dam for which risk is being analyzed part of a river system? Is it at the beginning, middle or end of the system? Has risk associated with the other dams been analyzed? What are the nature and complexities of these analyses?
- C. Have safe channel capacities and operational requirements been established for downstream

dams?

V. Checklist of Questions to Consider Prior to A Risk Analysis (cont.)

D. Do failure modes for downstream dams change, or are additional ones added, as a result of the failure of the dam of study?

E. Do downstream dams safely contain or pass operational, overtopping or breach flows that may occur from the dam of study?

F. Are there any plans to modify dams either upstream or downstream from the dam of study? If so for what? Does this mitigate in any way the risk that has been analyzed for the dam of study? Can changes in planned modifications efficiently mitigate risk associated with the dam of study?

VI. Examples

Two examples are provided which illustrate some of the concepts discussed in this toolbox. These examples are by no means comprehensive in nature, i.e., they cannot possibly represent all the scenarios that will be encountered when considering the influence of upstream and downstream dams in risk analyses.

Example 1 - Dam A is located upstream of Dam B. A baseline risk analysis is being completed for Dam B. Two possible loading scenarios might exist warranting consideration. First, during meteorological events in the area Dam A is assumed to operate appurtenant structures at full discharge capacity (penstocks and spillway). The storm is also contributing to runoff in the drainage area between the two dams. This would be hydrologic loading condition No. 1. Secondly, it may be possible that a storm could center solely above the drainage basin of Dam B, impacting operations and performance at Dam B only. This would be hydrologic loading condition No. 2. In this case, for baseline risk analysis purposes, at no time should the failure of Dam A be applied as load to Dam B. Static and seismic loading conditions and associated risk for Dam B would also be analyzed independently of Dam A.

Consequences would be evaluated for all populations at risk downstream from the Dam B. This would include populations jeopardized from downstream dam failures induced by Dam B failing, and for all appropriate loading conditions associated with Dam B.

Example 2 - Dam Y is located upstream of Dam Z. A baseline risk analysis is being completed for Dam Z. The dams are located in the Pacific Northwest where large winter storms are the most severe hydrologic loads experienced by these particular dams. These dams are located close enough

together (within 2 miles of each other) that both are likely to experience extreme flooding at the same time. While it is possible that Dam Y will experience some type of hydrologic induced failure while extreme flooding is occurring at Dam Z, for the initial baseline risk analysis of Dam Z, Dam Z should be examined independently of Dam Y. Also, Dam Y is assumed to pass any flood using the full capacity of its appurtenant structures. Persons establishing the baseline risk of Dam Z should be fully aware of all potential hydrologic issues and their impacts on both dams, but baseline risk analyses for Dam Z should not assume failure of Dam Y. Static and seismic loading conditions for Dam Z, and associated risk for these loads, would also be analyzed independently.

Consequences would be evaluated for all populations at risk downstream from the Dam Z. This would include populations jeopardized from downstream dam failures induced by Dam B failing, and for all appropriate loading conditions associated with Dam B.

If Reclamation guidelines potentially indicate the need for more studies, data, analyses or actions related to hydrologic issues the two dams may need to be examined as a river system with multiple structures.