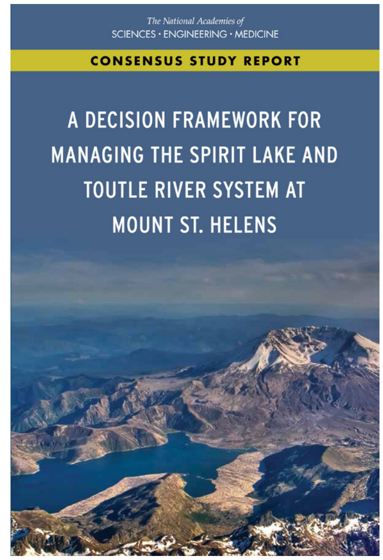
Consensus Study Report
HIGHLIGHTS

December 2017

A Decision Framework for Managing the Spirit Lake and Toutle River System at Mount St. Helens



Changes to the Spirit Lake and the Toutle River system from the 1980 eruption of Mount St. Helens put the region at ongoing risk of moderate and potentially catastrophic flooding. Engineering measures put in place in the 1980s to reduce flooding risks are in need of costly repairs or modification, presenting an opportunity to re-evaluate risk management strategies. At the request of the U.S. Forest Service (USFS), the National Academies of Sciences, Engineering, and Medicine convened a committee to propose a decision framework to support long-term management of risks in light of the different economic, cultural, and social priorities of regional stakeholders and the respective roles of federal, tribal, state, and local authorities, and other groups in the region.

The 1980 eruption of Mount St. Helens in southwest Washington State radically changed the physical and socioeconomic landscapes of the region. The eruption destroyed the summit of the volcano, sending a large amount of sediment and debris into the North Fork Toutle River and blocking the sole means of drainage from Spirit Lake, located four miles north of Mount St. Helens. Rising lake levels could cause failure of the debris blockage, putting the downstream population of approximately 50,000 at risk of catastrophic flooding and mud flows. In addition, continued transport of volcanic debris in the river impedes flow in downstream river channels, leaving the population vulnerable to chronic flooding.

Engineering measures were implemented in the 1980s to manage both catastrophic and chronic flooding risks. A 1.56-mile tunnel at Spirit Lake was constructed to drain the lake and control lake levels, and a sediment retention structure was built on the North Fork Toutle River approximately eight miles downstream of Spirit Lake to reduce sediment flowing into the river. Other flood risk management measures include levee upgrades in the Lower Cowlitz River valley and regular dredging of the region's rivers to maintain navigation.

Engineering measures now in place, however, do not represent long-term solutions to the region's risk management challenges. The Spirit Lake outflow tunnel serves as the only drainage for Spirit Lake, and disruption of tunnel operations leaves the debris blockage vulnerable to breaching. The tunnel has required major repairs and is not operating optimally. Additional expensive repairs are necessary, and, as for any constructed facility, continued costly maintenance will be needed. Downstream, the SRS is close to reaching its sediment trapping capacity and plans to increase that capacity by raising the SRS spillway provide only short-term solution to the sediment transport problem.

THE EVOLVING DECISION LANDSCAPE

Following the 1980 eruption, two principal considerations influenced management decisions: (1) the costs of possible management actions and (2) their impacts on the safety of downstream communities. Decades past the initial response, values such as those related to ecological conditions and recreational benefits have gained currency in stakeholder perceptions. For example, prior to the eruption, the North Fork Toutle River valley was an important recreation area for fishers, hunters, and other users.

Decision making in the region to date has tended to be linear: a responsible agency formulated a specific problem within its authority, analyzed options, and made a decision. Engagement with interested and affected parties consisted largely of public meetings held by the agency at certain points in the decision process to receive public comments. Although this process accomplishes some goals, it typically limits opportunities to explore the values and management ideas of other interested and affected parties, misses opportunities to identify joint gains, and can lead to a lack of trust in decisions made by those in authority.

DATA AND ANALYTICAL NEEDS

Since 1980, natural and engineered processes have changed the Spirit Lake and Toutle River system. Engineering practice has evolved, as have concerns among interested and affected parties. However, many data collection activities such as groundwater monitoring within the debris blockage and most measurements of sediment sources and transport stopped in the 1980s or 1990s, and few new data have been collected in response to changing priorities, such as those related to groundwater hydrology. The information available to correctly inform long-term management of the region is sometimes outdated or incomplete.

Decisions related to the long-term management of Spirit Lake water levels need to be informed by a current characterization of the debris blockage damming the lake, the location and behavior of groundwater in the blockage, current meteorological trends, a quantified characterization of risks posed by volcanic activity on Spirit Lake water levels and on the response of the blockage, the SRS, and other key system elements to local and regional seismic events.

NEED FOR A DECISION FRAMEWORK

Given the complexity and uncertainties associated with flooding risks as well as the uncertainty arising from incomplete information, an analytic decision process that establishes risk management as an organizing principle is needed. The process also needs to promote communication and trust among agencies and the public in light of the competing values of interested and affected parties in the region, the lack of agreement on planning timeframes, the overlapping but sometimes competing management responsibilities and authorities in the region, and the limited budgets of those authorities.

A decision framework is a tool to guide the systematic decision making process. The "PrOACT" framework (Keeney, 1988) is one such model that includes the following steps: (1) clarify the decision Problem, (2) identify decision Objectives and ways to measure them, (3) create a diverse set of Alternatives, (4) identify the Consequences, and (5) clarify the Tradeoffs. Although originally intended for use by a single decision maker, the PrOACT framework has been modified for decisions made by multiple decision makers and applied successfully to other water management decisions of significant complexity. Use of this modified PrOACT framework is recommended.

Step 1: Clarifying the Decision Problem in a Participatory Setting

A decision problem is that issue or set of issues about which management decisions need to be made. Broadly stated, the decision problem in this case is to determine a long-term solution for managing water and sediment transport in the Spirit Lake and Toutle River system. An overall goal of the recommended decision framework is to search for and identify mutually supportable, effective, and defensible management alternatives. The process requires agreeing on the following elements:

- **Who leads the process?** No single agency in the region has unilateral authority to make choices and funding decisions about management across the system. A framework implementer—a lead—needs to be identified that is responsible for understanding and applying the collaborative analytic decision-making process.
- **Who is involved, and what are their roles?** Early in the decision process, the full range of interested and affected parties needs to be engaged at a depth sufficient for management decisions to be adequately informed by their concerns and values.
- **What is the geographic scope under consideration?** While the post-1980 eruption efforts addressed flood mitigation and related sediment control options, these individual solutions to system-wide problems were considered separately, and rarely in consideration of other issues. System-wide thinking is needed in making decisions about management objectives, approaches, and alternatives.

- **What time frame is being considered?** Management timeframes need to be reconsidered in light of short- and long-term risk, the finite engineering design life of infrastructure, unanticipated events or conditions, and in terms of the financial burdens left to future generations

Step 2: Identifying Decision Objectives

Once interested and affected parties are identified, the decision participant group is selected, and the team of experts that provides neutral support is in place, a set of decision-specific objectives can be clarified and structured. Decision objectives are the goals that matter to the participants. They are always phrased as verbs—for example, to maximize economic well-being, or to minimize adverse environmental impacts.

Identifying objectives requires developing a common understanding of the underlying interests of decision participants. For example, an often-stated objective is to restore the "naturalness" of the system, but "naturalness" means different things to different people. Objectives related to that goal could be more specifically placed into categories such as increasing fish passage through the SRS and into Spirit Lake, increasing the "pristineness" of the area, or pursuing solutions that require little human intervention.

Performance metrics will need to be established to give decision participants a means to measure the predicted progress toward a desired objective outcome. Some metrics may directly measure the consequences of interest in their own terms (e.g. maintenance cost can be measured in dollars). Other metrics are best stated as proxies for the consequences of an alternative (e.g., acres or hectares of accessible fish spawning habitat can be a proxy for fish abundance).

Step 3: Identifying and Managing Alternatives

The third step of the decision process addresses alternatives. The goal is to craft multiple and diverse sets of management alternatives that would address the collaboratively generated list of management objectives. These should represent region-wide strategies and could include combinations of actions throughout the system related to engineered infrastructure (for example, the tunnel, SRS, or other capital works), management activities such as dredging, and non-structural solutions (for example, related to emergency response, land use and planning, and environmental restoration). The predicted performance of these alternatives can be quantitatively modeled using the metrics identified when identifying objectives in the previous step.

Box 1. Report Recommendations

- Responsible agencies and other interested and affected parties should develop a common understanding of the Spirit Lake and Toutle River system, its features, hazards, and management alternatives.
- Agencies engaged in risk management in the Spirit Lake and Toutle River region should develop a coordinated and targeted monitoring system to track changes in factors that affect risk. Data and analyses should be shared and available to all.
- Alternatives for managing the Spirit Lake and Toutle River system should be judged over both short and long timeframes to ensure consideration of the range of the concerns of interested and affected parties.
- Operational risk should be explicitly considered when evaluating alternatives for management.
- Adopt a deliberative and participatory decision-making process that includes technical considerations, balances competing safety, environmental, ecological, and other objectives of participants, appropriately treats risk and uncertainty, and is informed by and responsive to public concerns. Dialog among interested and affected parties and technical experts should be iterative, begin with the formulation of the problem, and continue throughout the decision process.
- Create a system-level entity or consortium of agencies to lead a collaborative multi-agency, multi-jurisdictional effort that can plan, program, create incentives, and seek funding to implement management solutions focused on the entire Spirit Lake and Toutle River system. This effort should also be open and accountable to interested and affected parties involved in management decisions.
- Broaden and deepen the participatory decision-making process from its earliest stages to include and assimilate the knowledge and interests of affected groups and parties whose safety, livelihoods, and quality of life are affected by management decisions.
- Engage in system-wide thinking when making decisions about management objectives, approaches, and alternatives for the Spirit Lake and Toutle River system. Depending on the issues being considered, the system may also include the Cowlitz River or extend beyond it.

A skilled facilitator and decision analyst may help decision participants navigate through the objectives to avoid a stalling of deliberations. This process may use tools such as strategy tables, described in the report, to create mental models for comparing individual actions within a strategy.

Step 4: Identifying Consequences

In the vocabulary of the decision framework, consequences are the estimated impacts over time—both good and bad—of the various sets of alternatives identified in the previous step. This includes a comparison of how the sets of alternatives perform using the performance metrics defined during the identification of objectives. This part of the process allows decision makers to understand how well their objectives are being met in different parts of the system over time. Capturing the range of uncertainties associated with performance predictions is important and identifying the parameters that drive uncertainty and sensitivity of the alternatives to it will give decision makers more confidence in their ability to understand the compromises they will need to make in the next step.

Step 5: Identifying the Tradeoffs

Identifying and closely considering tradeoffs (i.e., compromises) is the last step of the decision process. Getting to this step may require an iterative revisiting of previous steps. The overall purpose of the decision process is not to find some objectively defined optimal solution, but rather to find a good solution that is supportable at some level by all of the decision participants. In most cases, this support hinges on participants' awareness and acceptance of various tradeoffs. Some anticipated tradeoffs could revolve around downstream sedimentation versus a more "natural" drainage system; cost versus catastrophic flood risk; sediment retention versus anadromous fish recovery; fish populations downstream versus fish populations upstream of the SRS; and short-term versus long-term actions and consequences.

COMMITTEE ON LONG-TERM MANAGEMENT OF THE SPIRIT LAKE/TOUTLE RIVER SYSTEM IN SOUTHWEST WASHINGTON

Gregory B. Baecher (*NAE*), (*Chair*), University of Maryland, College Park; **John Boland**, Johns Hopkins University, Baltimore, Maryland; **Thomas Dunne** (*NAS*), University of California, Santa Barbara; **Youssef Hashash**, University of Illinois at Urbana-Champaign; **John Kupfer**, University of South Carolina, Columbia; **Ning Lu**, Colorado School of Mines, Golden; **Basil Stumborg**, BC Hydro, Vancouver, British Columbia, Canada; **Kathleen Tierney**, University of Colorado Boulder; **Desiree Tullos**, Oregon State University, Corvallis; **Greg A. Valentine**, University at Buffalo, The State University of New York; **Leonard Shabman**, Resources for the Future, Washington, DC (*Unpaid Consultant*); **Sammantha Magsino** (*Senior Program Officer*), **Paul Stern** (*Scholar**), **Edmond Dunne** (*Program Officer**), **Courtney DeVane** (*Administrative Coordinator*), **Nicholas Rogers** (*Financial and Research Associate*), National Academies of Sciences, Engineering, and Medicine

* Until June 2017

For More Information . . . This Consensus Study Report Highlights was prepared by the Committee on Geological and Geotechnical Engineering, Board on Earth Sciences and Resources, Water Science and Technology Board, Division on Earth and Life Studies, Board on Environmental Change and Society, and Division on Behavioral and Social Sciences and Education, based on the Consensus Study Report *A Decision Framework for Managing the Spirit Lake and Toutle River System at Mount St. Helens* (2017). The study was sponsored by the U.S. Department of Agriculture's U.S. Forest Service. Any opinions, findings, conclusions, or recommendations expressed in this publication do not necessarily reflect the views of any organization or agency that provided support for the project. Copies of the Consensus Study Report are available from the National Academies Press, (800) 624-6242; http://www.nap.edu or via the Board on Earth Sciences and Resources web page at http://www.nationalacademies.org.

Division on Earth and Life Studies

The National Academies of
SCIENCES · ENGINEERING · MEDICINE

The nation turns to the National Academies of Sciences, Engineering, and Medicine for independent, objective advice on issues that affect people's lives worldwide.
www.national-academies.org