**Risk-Based Priority System**

**BACKGROUND**
- **33 US Code §467f-2(f) states:** “The Administrator, in consultation with the Board, shall develop a risk-based priority system for use in identifying eligible high hazard potential dams for which grants may be made under this section.”
- **Objective:** Develop a risk-based priority system that will provide justification on which projects are selected by states to move forward (assuming funding will not cover all projects).

**OVERALL PROCESS (PRE-APPLICATION)**

1. **Initial Screening**
   - In a state with a state dam safety program
   - High Hazard
   - Has an Emergency Action Plan
   - Fails to meet minimum state dam safety standards
   - Poses unacceptable risk (as defined by FEMA)
   
   *Note: cannot include federally sponsored dams, dams build under the authority of the Secretary of Agriculture, or licensed hydroelectric dams*

2. **Recruit eligible sponsors based on eligible dams and identify potential projects.** Potential construction projects must eliminate unacceptable risk. Potential planning projects must have the objective of eliminating unacceptable risk.

3. **Is the funding adequate to fund all projects?**

4. **Implement Projects**

5. **Assess Damages Avoided by Project and Summarize in Project Closeout documents.**

**Pre-Application Process**

**Submit Applications**

**Post-Project Implementation**

**Refer to flowchart on Risk Prioritization Process on Page 2**

**PAGE 1 OF 6**
MINIMUM CRITERIA

- Evaluates static, hydrologic, and seismic failure modes
- Evaluation of hydraulic failure mode should consider (where applicable):
  - Percentage of the required inflow design flood that the dam can pass safely through its spillways (both capacity and erosion resistance of the spillways should be considered).
- Whether or not overtopping of the dam has been reported or observed.
- Spillway redundancy
- Condition of the spillways
- Non-routine operational issues
- Evaluation of static failure mode should consider (where applicable):
  - Whether the dam meets state-required static stability criteria (or federal criteria if no state criteria exists)
  - Dam safety observations (e.g. settlement, cracking, depressions/sinkholes, slumps/sloughs)
  - Past seepage history
  - Instrumentation readings
  - Known design and/or construction issues (e.g. outdated design features, lack of filter compatibility, non-functioning elements)
  - Non-routine operational issues
- Evaluation of seismic failure mode should consider (where applicable):
  - Whether the dam meets state-required seismic stability criteria (or federal criteria if no state criteria exists)
  - Proximity of the dam to a high-risk seismic zone
  - Whether the embankment or the foundation is comprised of liquefiable materials
- Method should evaluate downstream consequences resulting from a breach event. This should consider (where applicable):
  - Estimation of population at risk (PAR) during a dam breach
  - Estimation of warning time for the nearest PAR
  - Loss of benefits associated with the dam no longer functioning (e.g. water supply dam)
  - Number of critical facilities (hospitals, fire stations, police stations, emergency operation centers, and schools) within the inundation zone
  - Extent of economic/environmental impacts that could occur due to a breach event
  - Whether the EAP is current and has been recently exercised
- Method complies with FEMA's "Federal Guidelines for Dam Safety Risk Management" (FEMA, 2015) for screening-level risk analysis as follows:
  - Identifies potential failure modes
  - Develops relative risk estimates for each dam in a way that enables the relative risk among the dams to be evaluated and priorities for further study or remediation to be established.
  - Can be quantitative or qualitative
- Method is objective and reproducible. It is noted that some subjectivity is likely to exist with any prioritization method, however this should be limited to the extent possible.
- Where calculations or numerical estimates are included as inputs into the method, the process to evaluate these estimates is consistent across the dam inventory (e.g. is computed for the same failure scenarios and estimated in the same way for each dam considered).
- Method includes documentation on all assumptions used in the process.
  *Method is screening-level, qualitative, allows for relative ranking of dams/projects.*

RISK PRIORITIZATION PROCESS

Receive funding from FEMA

Is the funding received adequate to fund all projects?

Allocate funding for selected projects

Has a prioritization of the dam inventory been previously performed that meets FEMA minimum criteria?

Using the same method used for the risk prioritization of the dams, re-evaluate the dam with the proposed project in place

Consider other project differentiators (e.g. dam is a water supply dam for a community, critical infrastructure is located in the inundation zone, etc.)

Develop project priority list to serve as justification for which projects are selected to move forward

Provide documentation to FEMA

Allocate funding for selected projects

Perform risk prioritization on the eligible dams using FEMA methodology and conforming with minimum FEMA Criteria.

Develop evaluation criteria using the “Evaluation Criteria Development and Documentation” document

Use the “Risk Prioritization Matrix” to qualitatively evaluate the dams based on the evaluation criteria and develop a priority list of dams

Recruit eligible sponsors based on eligible dams and identify potential projects. Potential construction projects must eliminate unacceptable risk. Potential planning projects must have the objective of eliminating unacceptable risk.

Implement Projects

Assess damages avoided by Project and summarize in Project Closeout documents.
SCREENING-LEVEL RISK PRIORITIZATION METHODOLOGY

- Define and document criteria and considerations
- Evaluate dams based on this criteria
- Establish “tie-breakers”: for dams that are within the same category
- Perform same process on dam projects to evaluate risk reduction and prioritize projects

**RISK PRIORITIZATION MATRIX**

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<thead>
<tr>
<th></th>
<th>Very High</th>
<th>High</th>
<th>Moderate</th>
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**APPROXIMATE/RELATIVE LIKELIHOOD OF FAILURE**

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<th></th>
<th>Low</th>
<th>Moderate</th>
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<th>Very High</th>
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**APPROXIMATE/RELATIVE CONSEQUENCES OF FAILURE**

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<th>Low</th>
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<tr>
<td>Very High</td>
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</table>

**CRITERIA DEFINITION**

- States would define criteria they would use to evaluate static, hydrologic, and seismic risk.
- Criteria should include/address static, hydrologic and seismic factors (see table).
- States would also define criteria they would use to evaluate downstream consequences.
- Criteria should include/address:
  - Population at Risk (PAR)
  - Warning Time
  - Economic Losses
  - Environmental Losses
- Criteria defined should also include any additional considerations that will be evaluated

**ADDITIONAL CONSIDERATIONS**

- Not directly used in original ranking of the dam
- May be related to knowledge that is available for only some of the dams within the inventory
- Examples may include:
  - Results of engineering studies/analyses
  - Past performance or deficiencies at the dam
  - Unique consequences associated with dam failure
- Additional considerations can be used to adjust the ranking of the dam (depending on whether these are likely to contribute to failure/increase consequences or prevent failure/decrease consequences)

<table>
<thead>
<tr>
<th></th>
<th>Static</th>
<th>Hydrologic</th>
<th>Seismic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static factors of safety (when known)</td>
<td>• Dam/Spillway Capacity</td>
<td>• Seismic factors of safety (when known)</td>
<td></td>
</tr>
<tr>
<td>Dam condition (based on recent dam safety observations and their severity)</td>
<td>• Condition of spillways</td>
<td>• Proximity to high risk seismic zones</td>
<td></td>
</tr>
<tr>
<td>Past seepage history</td>
<td>• Previous hydrologic performance</td>
<td>• Liquefaction potential (embankment and foundation)</td>
<td></td>
</tr>
<tr>
<td>Instrumentation readings (if available)</td>
<td>• Non-routine operational issues</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Known design/construction deficiencies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-routine operational issues</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
## EXAMPLE (FAILURE MODES)

### Probability of occurrence is consistent across failure modes.

<table>
<thead>
<tr>
<th>Static Failure Mode Criteria</th>
<th>Hydrologic Failure Mode Criteria</th>
<th>Seismic Failure Mode Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:10</td>
<td>Static Factor of Safety &lt; 1</td>
<td>Seismic Factor of Safety &lt; 1 for ground motions with an annual probability of exceedance of 1 in 10 years OR 2% Probability of Exceedance in 50 years peak ground acceleration (PGA) &gt; 0.6</td>
</tr>
<tr>
<td>1:10, 1:100</td>
<td>Most recent inspection indicates severe deficiencies that are likely to cause failure of the dam in the short-term (within the next 10 years)</td>
<td>Dam can pass less than a 10-year storm without overtopping (unless dam is designed to overtop)</td>
</tr>
<tr>
<td>1:100, 1:1,000</td>
<td>1.1 &gt; Stats Factor of Safety &gt; 1 OR Most recent inspection indicates one or more major deficiencies related to dam condition</td>
<td>Dam can pass between a 10-year and a 100-year storm without overtopping (unless dam is designed to overtop)</td>
</tr>
<tr>
<td>1:1,000, 1:10,000</td>
<td>1.2 &gt; Static Factor of Safety &gt; 1.1 OR Most recent inspection indicates no significant deficiencies related to dam condition</td>
<td>Dam can pass between a 100-year and 1,000-year storm without overtopping (unless dam is designed to overtop)</td>
</tr>
<tr>
<td>1:100,000, 1:10,000, 1:100,000</td>
<td>1.5 &gt; Static Factor of Safety &gt; 1.2 OR Most recent inspection indicates no significant deficiencies related to dam condition</td>
<td>Dam can pass between a 1,000-year and a PMP storm without overtopping (unless dam is designed to overtop)</td>
</tr>
<tr>
<td>Low</td>
<td>Persistent dam safety issues noted in past inspections that have not been addressed over the years, past seepage history, instrumentation readings, known design and/or construction deficiencies, and non-routine operational issues</td>
<td>Spillway redundancy, condition of the spillways, whether the dam has previously overtopped, and non-routine operational issues</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Whether the embankment and/or foundation is comprised of liquefiable materials</td>
</tr>
</tbody>
</table>

### Define other considerations that will factor into the final ranking.

### Numerical values defined

## EXAMPLE (Consequences)

### Population at Risk (PAR) and Warning Time

<table>
<thead>
<tr>
<th>Population at Risk (PAR) and Warning Time</th>
<th>Economic Losses</th>
<th>Environmental Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High PAR &gt; 100 and warning time is not sufficient to evacuate the majority of the persons from the inundation area</td>
<td>Exceed $1 Billion</td>
<td>losses would likely be severe and permanent</td>
</tr>
<tr>
<td>High PAR &gt; 100 and warning time is considered sufficient to evacuate some of the persons from the inundation area</td>
<td>$100 Million - $1 Billion</td>
<td>losses are expected to be significant and could be remediated, but would take many years</td>
</tr>
<tr>
<td>Moderate PAR 10-100 and warning time is considered sufficient to evacuate the majority of persons from the inundation area</td>
<td>$10 Million - $100 Million</td>
<td>losses could be remediate, but would take several years</td>
</tr>
<tr>
<td>Low PAR 1-10 and warning time is considered sufficient to evacuate most persons from the inundation area</td>
<td>Less than $10 Million</td>
<td>losses could be sustained as a result, but remediation is possible</td>
</tr>
</tbody>
</table>

### Additional Considerations

- Number of critical facilities (such as hospitals, fire stations, police stations, nursing homes/elderly care facilities, emergency operation centers, and schools) within the inundation zone and whether the EAP is current and has been recently exercised

### Define other considerations that will factor into the final ranking.

### Numerical values defined
States use the risk prioritization matrix in combination with the criteria to score the dams. This is performed for each failure mode (e.g. static, hydrologic, seismic). Use the most severe combination if seismic, hydrologic, and static are viewed to have relatively equal likelihoods of failure.

**EXAMPLE 1**
- Relative likelihood of failure equivalent
- Consequences are similar across each failure scenario
- Hydrologic failure is found to be most critical.

**EXAMPLE 2**
- Relative likelihood of failure not equivalent
- Consequences are found to be higher for hydrologic failure scenario
- Seismic failure initially found to be most critical (based on the combination of consequences and likelihood of failure), however probability of a seismic event is considered more remote – Static failure chosen as most critical. (Note: this should be evaluated on a case-by-case basis)

**“TIE-BREAKERS”**
- “Tie-Breakers” or “differentiators” can be used to distinguish between dams that rank equivalently on the risk prioritization matrix.
- Can include:
  - Critical infrastructure (hospitals, emergency management centers, schools, etc.) in inundation zone
  - Dam is considered a valuable asset to the community
  - Dam is multi-function (e.g. flood control and water supply)

**EXAMPLE 3**
- Dams 3 and 2 and Dams 1 and 4 have the same prioritization.
- Dam 3 is judged to be more critical than Dam 2 because there is a school in the inundation area directly downstream of the dam.
- Dam 1 is prioritized higher than Dam 4 because the population at risk is smaller, but closer to the dam.

<table>
<thead>
<tr>
<th>Dam</th>
<th>Category</th>
<th>Ranking</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam 2</td>
<td>Very High - Very High</td>
<td>1</td>
<td>School within inundation zone</td>
</tr>
<tr>
<td>Dam 3</td>
<td>Very High - Very High</td>
<td>2</td>
<td>No critical infrastructure within inundation zone</td>
</tr>
<tr>
<td>Dam 1</td>
<td>High - Very High</td>
<td>3</td>
<td>Smaller PAR than Dam 4, but considerable PAR very close to dam and has a higher failure potential</td>
</tr>
<tr>
<td>Dam 4</td>
<td>Very High - High</td>
<td>4</td>
<td>PAR is larger than Dam 1, but several miles downstream</td>
</tr>
</tbody>
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**STATE A – RISK EVALUATION**

**DAM A – RISK EVALUATION**

**DAM B – RISK EVALUATION**

**STATE A – RISK EVALUATION**
Dams are re-evaluated with proposed project in place
- Reduction in risk is used to rank projects (along with other project factors)
- Justification should be provided
- For projects that address a specific failure mode, the ranking of the dam related to that failure mode should be used to assess the risk reduction.
- To evaluate planning studies/non-capital projects, the ranking of the dam should be considered along with other project factors.

**EXAMPLE 4**
- D = Dam, P = Project
- Each dam has one project except for Dam 2, which has two projects.
- Dam 2 Project 1 involves capital improvements.
- Dam 2 Project 2 involves capital improvements in addition to purchasing a large residential area in the dam breach inundation zone

### STATE A – PROJECT EVALUATION

<table>
<thead>
<tr>
<th>Approximate/ Relative Likelihood of Failure</th>
<th>D1 P1</th>
<th>D2 P1</th>
<th>D3 P1</th>
<th>D4 P1</th>
<th>D2 P2</th>
<th>D2 P1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
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</tbody>
</table>

### Approximate/ Relative Consequences of Failure

<table>
<thead>
<tr>
<th>Project</th>
<th>Risk Reduction</th>
<th>Cost</th>
<th>Rank</th>
<th>Justification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam 3 Project 1</td>
<td>Very High – Very High to Very High – High</td>
<td>$1 M</td>
<td>1</td>
<td>Reduces risk associated with one of the “riskiest” dams for relatively low cost</td>
</tr>
<tr>
<td>Dam 2 Project 2</td>
<td>Very High – Very High to High – Low</td>
<td>$15 M</td>
<td>2</td>
<td>Dam 2 projects both provide significant risk reduction for relatively low cost. D2P2 was ranked higher because of a large reduction in downstream PAR.</td>
</tr>
<tr>
<td>Dam 2 Project 1</td>
<td>Very High – Very High to Very High – Low</td>
<td>$10 M</td>
<td>3</td>
<td>Provides a significant reduction in risk for relatively low cost</td>
</tr>
<tr>
<td>Dam 4 Project 1</td>
<td>Very High - High to High – Moderate</td>
<td>$20 M</td>
<td>4</td>
<td>Significant risk reduction, but larger cost than other projects.</td>
</tr>
<tr>
<td>Dam 1 Project 1</td>
<td>High – Very High to Low – High</td>
<td>$50 M</td>
<td>5</td>
<td>Significant risk reduction, but very large cost.</td>
</tr>
</tbody>
</table>

### OVERALL DAM RISK REDUCTION

- The projects selected for funding must address all deficiencies and bring the overall dam in compliance with state dam safety regulations
- A phased plan must be provided to show how the risk associated with other failure modes will be addressed
  - "no regret projects" - what is proposed does not have to be undone or fixed to address other known deficiencies
  - future phases could be eligible for grant funding subject to reprioritization and FEMA’s annual appropriation