Improving Flood Hazard Identification & Flood Risk Communication: Lessons Learned from Dam Failures in South Carolina

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Dam Failure Incidents in South Carolina

SC Dam Failures as of 10/22/2015
- 31 State regulated
- 1 Federal
- Many unregulated dams

*Update: a total of 47 dam failures have now been identified as a result of this incident
DAM*-The term 'dam'-

- Means any artificial barrier that has the ability to impound water, wastewater, or any liquid-borne material, for the purpose of storage or control of water, that is **25 feet** or more in height or **has an impounding capacity for maximum storage elevation of 50 acre-feet** or more; but does **not** include a levee; or a barrier that is **6 feet** or less in height or **has a storage capacity at the maximum water storage elevation that is 15 acre-feet** or less

*Definition from National Dam Safety Act. Definition may be different in state and federal dam safety programs.

<table>
<thead>
<tr>
<th>Hazard Potential Classification</th>
<th>Loss of Human Life</th>
<th>Economic, Environmental, Lifeline Losses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>None Expected</td>
<td>Low and generally limited to owner</td>
</tr>
<tr>
<td>Significant</td>
<td>None Expected</td>
<td>Yes</td>
</tr>
<tr>
<td>High</td>
<td>Probable, one or more expected</td>
<td>Yes (but not necessary for this classification)</td>
</tr>
</tbody>
</table>
Classification of South Carolina Dam Failures

<table>
<thead>
<tr>
<th>Hazard</th>
<th># Failed</th>
</tr>
</thead>
<tbody>
<tr>
<td>High/C1</td>
<td>7</td>
</tr>
<tr>
<td>Significant/C2</td>
<td>17</td>
</tr>
<tr>
<td>Low/C3</td>
<td>7</td>
</tr>
</tbody>
</table>
Mitigation Dam Task Force at the SC JFO

- Five member team deployed to JFO starting October 19, 2015
  - 2 from headquarters and 3 from Region IV
- Produced White Paper on Dam Risk to provide general comments and strategic recommendations to improve dam coordination, resilience, and communication for reducing future risks relating to dams and dam failure
  - Assessed failed state regulated dams and briefed out on recommendations to the JFO leadership, key South Carolina agencies, and FEMA Region IV Mitigation leadership
  - Twenty-two recommendations provided in areas of Further Study, Flood Mapping, Regulatory, Coordination, and Training, Awareness, and Exercises

White Paper on Dam Risk Management: https://www.fema.gov/media-library/assets/documents/112356
Overview of Comments and Recommendations from White Paper:
- Flood Insurance Studies
- Mitigation
- Preparedness
- Response
- Recovery
- Risk Communication

Breached Cary’s Lake Dam (FEMA)
### General Comment 5: FIS limited Dam References

- 9 Counties with failed dams

<table>
<thead>
<tr>
<th>County</th>
<th># High &amp; Significant Dams in FIS by name</th>
<th># High &amp; Significant Hazard Dams in NID</th>
<th>Percentage of C1+C2 Dams in FIS and NID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aiken</td>
<td>0</td>
<td>39</td>
<td>0 %</td>
</tr>
<tr>
<td>Clarendon</td>
<td>0</td>
<td>3</td>
<td>0 %</td>
</tr>
<tr>
<td>Darlington</td>
<td>1</td>
<td>14</td>
<td>7 %</td>
</tr>
<tr>
<td>Kershaw</td>
<td>1</td>
<td>16</td>
<td>6 %</td>
</tr>
<tr>
<td>Lee</td>
<td>0</td>
<td>4</td>
<td>0 %</td>
</tr>
<tr>
<td>Lexington</td>
<td>12</td>
<td>30</td>
<td>40 %</td>
</tr>
<tr>
<td>Orangeburg</td>
<td>0</td>
<td>38</td>
<td>0 %</td>
</tr>
<tr>
<td>Richland</td>
<td>16</td>
<td>67</td>
<td>24%</td>
</tr>
<tr>
<td>Sumter</td>
<td>2</td>
<td>11</td>
<td>18%</td>
</tr>
</tbody>
</table>

Cary’s Lake Dam shown by name on profile in FIS
General Comment 6: Limited Dam References on FIRM’s

- 31 Failed Dams

<table>
<thead>
<tr>
<th>Not Shown on FIRM</th>
<th>Shown on FIRM as ‘Culvert’</th>
<th>Shown on FIRM as ‘Dam’</th>
<th>Shown on FIRM by Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>1</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>
General Comment 8: FEMA Flood Mapping/Modeling Policies and Procedures for Dams

- FEMA currently has minimal policies and procedures in place to address how dams should be mapped and modeled in flood studies. Without this documentation, dams are accounted for inconsistently across the entire nation.

General Comment 9: Risk MAP Non-Regulatory Products

- Risk MAP (Mapping, Assessment and Planning) delivers technical products to help communicate risk based on the hydrologic and hydraulic studies used in creating the FIRM and Flood Insurance Study. These products, such as depth and velocity grids, seem to be currently underutilized when analyzing dam risk.

General Recommendation #2: Incorporate Dam-Related Flood Risk into FEMA Risk MAP Guidance

- FEMA HQ Mitigation involved with Risk MAP, in conjunction with Regional Risk Analysis engineers, should perform a comprehensive review and update of existing FEMA Flood Project modeling, mapping and documentation policies and procedures, and develop guidelines for incorporating dam flood risk in FEMA flood studies. This update should address modeling assumptions and standard practices, mapping guidance for FIRMs and required inclusion in the FIS documentation.
General Comment 22: FIS / NID Stream Name Differences

- There are a number of dams that have a discrepancy in stream names when comparing the FIRM/FIS and the NID data.
  - SCNONAME 38036 (Cleveland Street) Dam: The stream for this dam is listed as Big Poplar Creek. The National Inventory of Dams lists the stream for this dam as Browning Branch.

General Recommendation #3: Flood Insurance Study (FIS) – National Inventory of Dams (NID) Stream Name Consistency

- FEMA Region IV and SCDNR should meet with the state dam safety program to determine their familiarity with the FIS reports, FIS profiles, and Risk MAP products. This should include discussing the benefit of using consistent information in the NID which would facilitate researcher’s abilities to more efficiently cross reference.
General Comment 12: State, Local, and Multi-Jurisdictional Mitigation Plans

- Dam failure was eliminated as a hazard to analyze in the State Mitigation Plan. The local and multi-jurisdictional mitigation plans for the areas with failed dams reference dams and dam failure but contain no in-depth analysis of the risks associated with dam operation or dam failure.

General Recommendation #13: Include Dams More Comprehensively in State and Local Mitigation Plans

- The state mitigation planners (SCEMD) should coordinate with other state agencies internally (SCDHEC, SCDNR, etc.) to identify and analyze the risks relating to dams and dam failure and the opportunities for mitigation in the state mitigation plan. The FEMA Region IV Dam Safety Program and the FEMA Region IV Mitigation Planning team are available to assist in coordination, training, and technical assistance at the state’s request. The state also should coordinate with local mitigation planners to better identify and analyze the flood risk relating to dams for the area of the local mitigation plan.
General Comment 15: Dam Watershed Management Operations

- Multiple dams that were in series failed in the Twelve Mile Creek Watershed and in the Gills Creek Watershed. This may be a result of the cascading dam failures. It is not evident that a water management plan exists for either watershed to guide and coordinate the timing and quantity for dam water releases through the system.
General Recommendation #16: Develop Watershed Management Plans

- Develop watershed management plans for watersheds having interconnected lakes with dams in series. Dam owners, operators, and key agencies (Federal, State, and local) should work together to share information and develop information sharing and procedures for lowering dam reservoir levels in preparation for major future potential flood events.

*Open gate at Lake Elizabeth (SCDHEC/Long)
General Comment #4: Land Use Planning Downstream of Dams

- Hazard creep results in changes of hazard classification for dams when there is construction in the dam breach inundation zone downstream of a dam. The extent of land use planning within the downstream breach inundation areas is unknown.

General Comment #10: Dam Inundation Maps; Older Operating Dams

- Many of the C1 and C2 dams do not have inundation maps. According to state regulations, C1 and C2 dams are required to provide inundation maps through the permit application process. However, this process is triggered for new construction, repair, alteration, and removal. Many of these dams were completed long before these requirements. There may be a loophole in the regulations as to the applicability of this requirement for many operating dams.
General Recommendation #8: Develop Dam Inundation Mapping

- SCDHEC should consider coordinating with dam owners for development of inundation maps for C1 and C2 dams. These maps should be shared with local Emergency Management Agencies (EMA’s) to develop evacuation plans. The dam breach inundation maps should also be shared with local planners and decision makers for inclusion in land use planning and zoning for the potentially impacted areas.

*Sample Inundation Map from FEMA P-946*
General Comment 21: Dam Owner Coordination with State/Local Governments/EMA’s

- Emergency Notification and Actions Plans are required to be developed by dam owners and submitted to SCDHEC. It is unclear to what degree coordination and interaction actually occurs between the dam owner and state and local governments/EMA’s regarding the development of these plans.

General Recommendation #9: SCDHEC – Local EMA Dam EAP Coordination

- SCDHEC should consider coordinating more fully with local EMA’s and SCEMD in ensuring the local EMA’s receive EAP’s from dam owners on state regulated High (C1) and Significant (C2) Hazard dams.
General Comment #25: Dam Exercises for State Regulated Dams
• Currently, state regulations do not require the exercise of state regulated dams. Therefore, exercises generally are not performed by owners, SCDHEC or local EMA’s on state regulated dams.

General Recommendation #19: Include Dams in SCDHEC – SCEMD Exercises
• SCDHEC and SCEMD should consider coordinating and developing exercise scenarios to include dam incidents and failures for tabletop exercises with all impacted stakeholders for key dams regulated by SCDHEC.
General Comment #17: National Dam Safety Program Technical Assistance during Disaster Operations

- One of the Objectives of the National Dam Safety Program is to, “develop mechanisms with which to provide Federal technical assistance for dam safety to the non-Federal sector.” An established mechanism to enable the ICODS member agencies to provide subject matter expertise support to States and locals for data collection, emergency inspections, performance analysis, and post disaster assessments of dam infrastructure and dam risk management effectiveness does not currently exists.

General Recommendation #21: Develop a Standard Operating Procedure

- The appropriate state agency should develop a Standard Operating Procedure (SOP) to facilitate dam flood risk information sharing and training across state agencies and establish a protocol for utilizing regional and national dam safety expertise during a disaster. This should include developing a process for requesting assistance through the Emergency Management Assistance Compact (EMAC), where applicable.
White Paper on Dam Risk Management - Response

- **General Comment #18: SCDHEC SEOC Operations**
  - In discussions with SCDHEC dam safety personnel, they normally do not operate at the State Emergency Operations Center (SEOC) and were invited by SCEMD for this event. SCDHEC dam safety does not have an emergency manual from which to reference for emergency and disaster operations at the SEOC.

- **General Recommendation #14: SCDHEC Incorporation into State Emergency Operations Center (SEOC)**
  - SCEMD and SCDHEC should consider greater inclusion of SCDHEC dam subject matter experts during operations for flood events. A routine presence will strengthen dam awareness at the SEOC and improve response information flow across agencies.
General Comment #20: Dam Coordination at the JFO
- There were many different organizations, groups, and teams at the Joint Field Office (JFO) with a mission involving these failed dams, including Public Assistance (PA), Mitigation, Operations, DHS IP, USACE, FDRC and others, with limited coordination.

General Recommendation #11: Develop a JFO Dam Risk Management Framework for the Future
- A framework should be developed to enable a unified dams risk management team be stood up at JFOs. This unified task force would include personnel from all relevant organizations and agencies. The Framework should address the lifecycle of response actions and be managed by a single FEMA project manager. A pre-designated point of contact tasked with coordinating response and recovery efforts across multiple agencies will minimize duplicative efforts and ensure a more efficient and effective operation. Currently, such a framework does not exist.
General Comment 24: Limited Awareness of Risk Information Relating to Dams and Dam Failure

- Generally, there appears to be a limited awareness of dam-related risk information at the state and local levels of government as well as by residential and non-residential property owners.

General Recommendation #18: Improve Dam Safety Awareness

- Appropriate SCEMD staff should consider collaborating with SCDHEC, SCDNR, and FEMA Region IV Dam Safety in improving education and awareness of dam-related risk to state and local governments, property owners, and other impacted stakeholders.
Risk Communication for Dam Safety

National Inventory of Dams (NID) 2013

- ~87,359 dams
- Maintained by the USACE
- Information from State and Federal dam safety programs
- 92% of Dams 50 ft high or less
- States have permitting, inspection, and enforcement authority for 77% of dams in NID
Risk Communication for Dam Safety

- National Dam Safety Program (NDSP) Factsheet: [https://www.fema.gov/media-library/assets/documents/5865](https://www.fema.gov/media-library/assets/documents/5865)
Risk Communication for Dam Safety
