High Hazard Dam Release - Floodplain Impacts Ranking Tool and Database

Floodplain Management Workshop

May 15, 2018
Goals of Discussion

• Show a Flooding Hazard related to dam operations that has been identified
• Show the High Hazard Dam Release - Floodplain Impacts Database and Ranking Tool
• Discuss next steps - Uses to reduce risk to communities, uses for additional CRS Credits
1,850 Program Dams
Hazard Classification

Based on an evaluation of consequences of dam failure absent of flooding conditions

Assumes the reservoir is at the high water line.

<table>
<thead>
<tr>
<th>Hazard Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Loss of human life is expected in the event of a failure</td>
</tr>
<tr>
<td>Significant</td>
<td>Significant damage is expected, but no loss of human life</td>
</tr>
<tr>
<td>Low</td>
<td>No significant damage and no loss of human life</td>
</tr>
<tr>
<td>No Public Hazard (NPH)</td>
<td>No loss of human life and damage only to dam owner’s property</td>
</tr>
</tbody>
</table>
Dam Safety and CRS

• CRS Coordinators Manual, Section 630/631

Because of the threat of flooding from dam failure or dam operations, the Community Rating System (CRS) credits cooperation among state dam safety officials, dam owners and operators, and local emergency managers. Credit is for state and local dam safety programs that:

• Help make the needed information available,
• Improve communications among operators of the dams and downstream communities, and
• Develop warning and response plans for dam failures.

The credit is keyed to addressing the areas at risk from the failure of a high-hazard potential dam. A “high-hazard-potential dam” is one for which failure or operational errors will probably cause loss of human life downstream. Communities must contact their state dam safety office to determine if they are affected by such a dam.
Why so large?

- Dam is fully breached in one-hour or less.
- Assumes dams below Ward Lake fail due to overtopping; cascading and cumulative flows
Normal Operation
Flood Operation - Button Rock Dam 2013
- Water surface in reservoir rising at $\frac{1}{2}$ ft per hour
- Outlets opened releasing 4,000 cfs
Neighborhoods around Addicks and Barker Reservoir
What Did We Learn?

• Colorado in 2013, Oroville and Houston in 2017 show dams operating as designed but still cause flooding downstream
• Emergency Action Plans have maps for dam failure inundation - of no use in operations release flooding scenarios
Project to highlight the Gap?

- $95,000 project, Funded by FEMA Grant ($45K) and Colorado Water Conservation Board grant ($50k)

- Created a High Hazard Dam Release - Downstream Floodplain Impacts Database and Ranking Tool
  - Dam Information
  - Spillway data
  - Outlet data
  - Population at risk
  - Compares spillway and outlet flows to FEMA 100-year flows, basin areas, etc
  - Promote and share the database and tools with Floodplain and emergency managers
Database

<table>
<thead>
<tr>
<th>Dam Name</th>
<th>Dam ID</th>
<th>NID ID</th>
<th>kmz</th>
<th>Dam Info</th>
<th>Dam ID</th>
<th>NID ID</th>
<th>kmz</th>
<th>Initial Ranking</th>
<th>Dam Not Considered</th>
<th>FEMA</th>
<th>Hydraulic Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>GREEN MOUNTAIN</td>
<td>570106</td>
<td>0001058</td>
<td>Google Earth</td>
<td>Controlled Capacity [cfs]</td>
<td>25,000</td>
<td>1530.0</td>
<td>26510.0</td>
<td>582.28</td>
<td>35</td>
<td>27</td>
<td>FEMA Profile</td>
</tr>
<tr>
<td>JOHN MARTIN</td>
<td>570215</td>
<td>0001293</td>
<td>Google Earth</td>
<td>Outlet Capacity [cfs]</td>
<td>13780.0</td>
<td>13780.0</td>
<td>18426.0</td>
<td>152</td>
<td>2</td>
<td>80</td>
<td>FEMA Profile</td>
</tr>
<tr>
<td>MAPLE GROVE</td>
<td>570219</td>
<td>0009203</td>
<td>Google Earth</td>
<td>Dam ID</td>
<td>13365</td>
<td>102.0</td>
<td>13467.0</td>
<td>19.49</td>
<td>2</td>
<td>2</td>
<td>FEMA Profile</td>
</tr>
<tr>
<td>GRANBY</td>
<td>571018</td>
<td>0001855</td>
<td>Google Earth</td>
<td>Outlet Capacity [cfs]</td>
<td>12000.0</td>
<td>12450.0</td>
<td>312.08</td>
<td>72</td>
<td>100</td>
<td>FEMA Profile</td>
<td>N/A</td>
</tr>
<tr>
<td>CHATFIELD</td>
<td>570324</td>
<td>0001281</td>
<td>Google Earth</td>
<td>Dam ID</td>
<td>8300.0</td>
<td>8300.0</td>
<td>3020.0</td>
<td>5</td>
<td>4</td>
<td>FEMA Profile</td>
<td>N/A</td>
</tr>
<tr>
<td>CHERRY CREEK</td>
<td>570116</td>
<td>0001280</td>
<td>Google Earth</td>
<td>Dam ID</td>
<td>6600.0</td>
<td>8100.0</td>
<td>8100.0</td>
<td>305.67</td>
<td>12</td>
<td>12</td>
<td>FEMA Profile</td>
</tr>
<tr>
<td>WILLIAMS FORK</td>
<td>571217</td>
<td>0001717</td>
<td>Google Earth</td>
<td>Dam ID</td>
<td>8200.0</td>
<td>8200.0</td>
<td>239.07</td>
<td>36</td>
<td>49</td>
<td>FEMA Profile</td>
<td>N/A</td>
</tr>
<tr>
<td>OLYMPUS</td>
<td>570114</td>
<td>0001826</td>
<td>Google Earth</td>
<td>Dam ID</td>
<td>5767.0</td>
<td>5767.0</td>
<td>155.29</td>
<td>46</td>
<td>72</td>
<td>FEMA Profile</td>
<td>N/A</td>
</tr>
<tr>
<td>RIO GRANDE</td>
<td>571019</td>
<td>0001829</td>
<td>Google Earth</td>
<td>Dam ID</td>
<td>5500.0</td>
<td>5500.0</td>
<td>671.86</td>
<td>10</td>
<td>10</td>
<td>FEMA Profile</td>
<td>N/A</td>
</tr>
<tr>
<td>TRINIDAD</td>
<td>570122</td>
<td>0000900</td>
<td>Google Earth</td>
<td>Dam ID</td>
<td>5000.0</td>
<td>5000.0</td>
<td>415.31</td>
<td>111</td>
<td>141</td>
<td>FEMA Profile</td>
<td>N/A</td>
</tr>
<tr>
<td>TONOPAH RESERVOIR</td>
<td>571016</td>
<td>0002700</td>
<td>Google Earth</td>
<td>Dam ID</td>
<td>5000.0</td>
<td>5000.0</td>
<td>335.17</td>
<td>18</td>
<td>44</td>
<td>FEMA Profile</td>
<td>N/A</td>
</tr>
</tbody>
</table>

- **Main Categories**
  - Dam Information, dam ID, google earth KMZ
  - Spillway Capacity
  - Outlet Capacity
  - Total Controlled outlet
  - Stream flow
  - Ranking
  - FEMA
  - Hydraulic Analysis
Warren Lake

• Facts
  • Dam Height 23 ft
  • Storage capacity 2185 cfs
  • Spillway Capacity 1045 cfs
  • Drainage Basin 0.44 sq mi
  • Outlet Capacity 74 cfs
  • 2-yr stream stat 97 cfs
  • 100-yr stream stat discharge 3610 cfs
  • Population at risk 2541
  • Ranking 306 of 416
  • FEMA no data
  • Safe channel capacity 40 cfs
# Warren Lake

## Dam Specifications
<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>dam ID</td>
<td>C00330</td>
</tr>
<tr>
<td>NID ID</td>
<td>C000852</td>
</tr>
<tr>
<td>County</td>
<td>LARIMER</td>
</tr>
<tr>
<td>Stream</td>
<td>CACHE LA PUDRE RIVER</td>
</tr>
</tbody>
</table>

## Drainage Area and Discharge
- **Dam Drainage Area, DA (m²):** 1,455
- **100-Yr Streamflow Discharge (Q_{100}) (cfs):** 3,610
- **Total Spillway Capacity, Q_{sw} (cfs):** 1,045
- **Outlet Works Capacity (Q_{ow}) (cfs):** 74
- **Total Maximum Controlled Discharge, Q_{max} (cfs):** 74

## Ranking Summary

<table>
<thead>
<tr>
<th>Rank</th>
<th>Category 1</th>
<th>Category 2</th>
<th>Category 3</th>
<th>Category 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>DA/Q_{sw}</td>
<td>195</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>Q_{100}/Q_{sw}</td>
<td>195</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R3</td>
<td>Dist. To DS Town</td>
<td>142</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R4</td>
<td>Q_{sw}/Q_{ow}</td>
<td></td>
<td></td>
<td>339</td>
</tr>
<tr>
<td>R5</td>
<td>1/Q_{sw}</td>
<td></td>
<td></td>
<td>218</td>
</tr>
<tr>
<td>R6</td>
<td>1/Q_{max}</td>
<td></td>
<td></td>
<td>261</td>
</tr>
</tbody>
</table>

**Composite Ranking:** 306 (LOW)

## Consequence Analysis
- **Population at Risk (PAR):** 2541 (LOW)
- **Social Vulnerability Index (SVI):** 9.1 (LOW)

**Estimated first impacted downstream road**
[View in Google Earth](#)

**Estimated first impacted downstream structure**
[View in Google Earth](#)
Warren Lake Inundation Map
Hydraulic Analysis Summary

<table>
<thead>
<tr>
<th>Dam Name</th>
<th>WARREN LAKE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam ID</td>
<td>030330</td>
</tr>
<tr>
<td>Safe Channel Capacity (cfs)</td>
<td>40</td>
</tr>
<tr>
<td>Safe Channel plus Total Max. Discharge Qcont (cfs)</td>
<td>Controlled 114</td>
</tr>
</tbody>
</table>

Reference Flow 1 (cfs) 98
Reference Flow 1 Frequency and Source 2-year (SS)

Hydraulic Analysis Findings

The safe channel capacity of the reach downstream of Warren Lake Dam is estimated to be 40 cfs. The maximum controlled discharge is 74 cfs. For comparison, the 2-year peak discharge estimated by StreamStats is 98 cfs. The downstream impact area is urban with high density. The first impacted road downstream of the dam is Ziegler Road. A small portion of the road may be inundated by approximately 0.5 feet at a peak discharge of approximately 40 cfs. The first impacted structures downstream of the dam are located southwest of intersection of S Timberline Road and Timberline Lane. The structure may be flooded at a peak discharge of approximately 40 cfs.
Warren Lake - Zone X
Fossil Creek

• Facts
  • Dam Height 42 ft
  • Storage capacity cfs
  • Spillway Capacity 88,100 cfs
  • Drainage Basin 29 sq mi
  • Outlet Capacity 393 cfs
  • 2-yr stream stat 516 cfs
  • 100-yr stream stat discharge 14,900 cfs
  • Population at risk
  • Ranking 74
  • FEMA no data
  • Safe channel capacity 616 cfs
FOSSIL CREEK

DAM ID: 030135
NID ID: CO01165
County: LARIMER
Stream: FOSSIL CREEK

- Dam Drainage Area, DA (mi²): 29.09
- 100-Yr StreamStats Discharge, Q100 (cfs): 14900
- Total Spillway Capacity, Q_sw (cfs): 88100
- Outlet Works Capacity (cfs): 393
- Total Maximum Controlled Discharge, Q_cont (cfs): 393

Go to Google Earth

Ranking Summary
R1: DA/Q_cont  120
R2: Q_sw/Q_cont 191
R3: Dist. To DS Town 142
R4: Q_sw/Q_cont 166
R5: 1/Q_cont 89
R6: 1/Q_sw 10

Composite Ranking: 74  HIGH

Consequence Analysis
Population at Risk (PAR)  N/A
Social Vulnerability Index (SVI)  N/A
Estimated first impacted downstream road  View in Google Earth
Estimated first impacted downstream structure  View in Google Earth
Fossil Creek Dam - Inundation Map

Limit of Study
Backwater from dam breach expected to continue upstream on the Cache La Poudre River within regulatory 100-year floodplain limits

Legend
- County Boundary
- FMI Spillway Floodplain
- FLO-2D Floodplain Cross Section
- Regulatory 100-yr Floodplain Limits
- Dam Breach Peak Flow Extents

South County Road 5
Peak Discharge = 96,719 cfs
Volume of Flood Wave = 13,899 ac-ft
Time of Peak Flood Wave = 0.17 hours

Interstate 25
Peak Discharge = 116,780 cfs
Volume of Flood Wave = 14,907 ac-ft
Time of Peak Flood Wave = 0.01 hours
## Hydraulic Analysis Summary

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam Name</td>
<td>FOSSIL CREEK</td>
</tr>
<tr>
<td>Dam ID</td>
<td>030135</td>
</tr>
<tr>
<td>Safe Channel Capacity (cfs)</td>
<td>616</td>
</tr>
<tr>
<td>Safe Channel plus Total Max. Discharge Qcont (cfs)</td>
<td>1009</td>
</tr>
<tr>
<td>Reference Flow 1 (cfs)</td>
<td>516</td>
</tr>
<tr>
<td>Reference Flow 1 Frequency and Source</td>
<td>2-year (SS)</td>
</tr>
<tr>
<td>Reference Flow 2 (cfs)</td>
<td>3450</td>
</tr>
<tr>
<td>Reference Flow 2 Frequency and Source</td>
<td>10-year (SS)</td>
</tr>
</tbody>
</table>

### Safe Channel Capacity Mapping in Google Earth

#### Hydraulic Analysis Findings

The safe channel capacity of the reach downstream of Fossil Creek Dam is estimated to be 616 cfs. The maximum controlled discharge is 393 cfs. For comparison, the 2-year peak discharge estimated by StreamStats is 516 cfs; the 10-year peak discharge estimated by StreamStats is 3450 cfs. The downstream impact area is rural. The first impacted roads downstream of the dam are South County Road 5, South County Road 3, and County Road 32 East. The roads may be overtopped at a peak discharge of approximately 616 cfs. The first impacted structure downstream of the dam is located at the end of Watson Drive. The residential house may be flooded at a peak discharge of approximately 616 cfs.
## Flood Mapping Legend

- **Safe Channel Capacity**
- **Safe Channel Capacity Plus Total Controlled Discharge**

### Reference Layers
- Safe Channel Capacity
- Safe Channel Capacity Plus Total Controlled Discharge
Larimer County
High Hazard Dam Release
High Risk Rankings (21)
Message

• We know the Risk exists
• Colorado Dam Safety has attempted to define and rank the severity of the risk
• We now have a tool for screening level ranking
• Examples demonstrate utility of detailed evaluations
Next Steps

• We are encouraging Floodplain and Emergency managers can use this screening level information to assess their risks

• Working with Floodplain and Emergency managers on where additional detailed safe channel capacity analysis should be done

• Working on finding funding to conduct detailed safe channel capacity analysis on all High Risk dams?
Front Range Flooding

“Normal has changed”

Fifth person presumed dead while authorities work to get hundreds to safety

Joe Goble drives down Hygiene Road with his father, Bob, while looking over flooding of neighboring properties Saturday and Hygiene. Resident of the town helps other residents save personal belongings from flooded homes. Craig F. Walker, The Denver Post