Initial Reservoir Evolution Following the Removal of Marmot Dam on the Sandy River, Oregon

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Digital Terrain Analysis
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Outline

- Background
- Research goals
- Study area
- Photogrammetric model construction methods
- Surface construction and volume calculation methods
- Results
- Discussion and Conclusions
Marmot Dam and its Removal

- Constructed in 1913
- 14.3 m-tall dam
- 3 km-long reservoir
- Removed October 2007
- “Blow and Go”
- Few other studies monitoring reservoir response
- 125,000 m$^3$ of sediment eroded in the 1$^{st}$ two weeks

Research Goals

- Characterize the changes in reservoir evolution in the first few days following removal
- Measure the erosional volume change in the lower reservoir and identify area of erosion
Research Objectives

1-Create 2 3D models from terrestrial post-removal photographs

2-Create a DTM from the 3D models and compare it with pre-removal LiDAR

3-Use those same DTMs identify spatial distribution of erosion

4-Compare results to a USGS survey collected 2 weeks following dam removal

Study Area

EXPLANATION
- River kilometer
- High Cascades
- West Cascades
- Willamette Valley
- Reference point

Marmot Dam
Previous Research

- Initial incision and widening rates developed using time-lapse photography

- Long-term erosion calculated through comparison of pre-removal LiDAR to post-removal data sets
Photogrammetric Methods

• Time-lapse photography
• PhotoModeler 5.2 software
  – Uses collinear equations to solve the intersection of light rays for a 3D point
  – Outputs coordinates
• Internal controls
  – Focal length, lens distortion, principal point
• External controls
• Tie points
• Point tagging

Photogrammetric Methods

Marmot Dam
Surface Creation Methods

• Imported 3D point array to ArcGIS
• Created a TIN for October 20 (A) and October 23 (B)
• Converted to raster

• Same methods for field survey, November 5

Surface Creation Methods

• 2007 LiDAR collected pre-removal
• Converted to common projection and vertical units
• All surfaces covered different spatial extents
• Re-sampled to similar cell size, clipped to coincident area (10% of 2 week erosion area), and snapped to LiDAR surface
Volume Calculation and Erosion Map

- Cut/Fill tool
- Raster Calculator

  - LiDAR to October 20 surface
  - LiDAR to October 23 surface
  - LiDAR to November 5 surface

Erosion Volume Results

<table>
<thead>
<tr>
<th>Date</th>
<th>Volume (m³)</th>
<th>Cumulative Volume (m³)</th>
<th>Percent of Total November 5 Erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 20</td>
<td>39,622</td>
<td>39,622</td>
<td>32</td>
</tr>
<tr>
<td>October 23</td>
<td>15,855</td>
<td>55,477</td>
<td>44</td>
</tr>
<tr>
<td>November 5</td>
<td>-316</td>
<td>55,161</td>
<td>44</td>
</tr>
</tbody>
</table>
Spatial Erosion Results

October 20

October 23

November 5

Are results valid?

- Field observations and other terrain analyses show rapid erosion in the early hours and days following dam breach
- October 20\textsuperscript{th} accounts 32\% of total 2 week erosion volume
- October 23 accounts for an additional 12\%
- Results are reasonable considering the distribution of the impoundment and timing of flows
Sources of Error

- Error could stem from a variety of sources
  - Coarse resolution of field-based surveys
  - Variation in river discharge
  - Deposition could be sourced from outside study area
  - Multiple stages of processing

Quality of Photogrammetry

- 3D photogrammetric models can provide sturdy foundation for addressing response
- Results are close to what should be expected
- Improvements and future work
  - Increased density of points possibly with updated software
  - More expansive camera network
  - Define geomorphic surfaces for more diverse results
Conclusions

• 1 day
  – ~40,000 m$^3$ eroded
  – Downstream portion of analysis window near the central reservoir
• 3 days
  – ~55,000 m$^3$ eroded
  – Erosion spread laterally across impoundment and longitudinally upstream
• Results are consistent with field and photo observations
• Photography can be used effectively to address response to dam removal at certain spatial and temporal scales

References
