An Inventory of Reservoir Sedimentation in Hawaii

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Water Supply

Ecosystem

Aesthetic

Irrigation

Flood and Sediment Control

Recreation
Hawaii’s reservoirs face challenges

- **Changing agricultural landscape** → less financial and technical capacity to maintain reservoirs
- **Revisions to the Hawaii Dam Safety Program after the Kaloko Dam break in 2006** → **increased scrutiny and monitoring**
- **Aging infrastructure** in need of repairs and prone to sedimentation
- **Reservoir uses are diversifying** → new reasons to maintain
Geomorphologic stages of reservoir sedimentation

Stage 1: Continuous sediment trapping

Stage 2: Main channel, growing floodplain
Reservoir sedimentation can lead to:

- Decreased storage capacity
- Increased risk of dam failure during large storms
- Decreased ability to retain sediments and debris
- Decreased flood protection
History of Hawaii’s reservoirs

- 140 reservoirs regulated by the DLNR Dam Safety Office (2013)
- Many reservoirs were initially built to support the sugarcane industry in the 1890s and early 1900s
- Water system maintenance, including dredging of reservoirs, was a significant activity on early plantations
History of Hawaii's reservoirs

Kaloko Dam construction, 1910-1912
Courtesy of Kauai Historical Society and Carol McLennan
As of 2013, 88% of reservoirs in the database were listed as High or Proposed High risk
Research questions and Approach

We combined three different types of investigation:

1. Archival / Database Analysis
2. Semi-structured interviews
3. Remote sensing

- Is sedimentation in reservoirs reducing reservoir capacity and other ecosystem services in Hawaii?
- What are the implications for management of reservoirs?
Archival and Database Analysis:
Methods

- Collect:
  - State and county documents (including Hawaii Department of Agriculture, Land and Natural Resources)
  - Legislative reports
  - DLNR Dam Database information
  - Bathymetry and other documents from consulting companies, when possible
- Construct a database for the project’s needs that mimics the national database
- 2011-2013
### Island capacity and size

<table>
<thead>
<tr>
<th>Island</th>
<th>(Installed) Capacity (million m³)</th>
<th>Maximum Size of Reservoir (million m³)</th>
<th>Available storage?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hawaii</td>
<td>1.5</td>
<td>3.68</td>
<td>?</td>
</tr>
<tr>
<td>Kauai</td>
<td>19.1</td>
<td>33.9</td>
<td>?</td>
</tr>
<tr>
<td>Maui</td>
<td>5.4</td>
<td>8.3</td>
<td>?</td>
</tr>
<tr>
<td>Molokai</td>
<td>5.2</td>
<td>6.2</td>
<td>?</td>
</tr>
<tr>
<td>Oahu</td>
<td>13.3</td>
<td>25.7</td>
<td>?</td>
</tr>
<tr>
<td>Total</td>
<td>44.7</td>
<td>77.8</td>
<td></td>
</tr>
</tbody>
</table>
Current reservoir use

- Irrigation remains the dominant use type, with water supply having the second most capacity
- Many reservoirs (16%) have multiple documented uses
- “Uses” do not consider ecosystem services, including wildlife habitat or aesthetic value
Reservoir construction and date

- Reservoir building fastest between 1910-1920
- Only Maui and Oahu have built new reservoirs since 1980
- Reservoirs are being decommissioned at a rate of 2 per year
Availability of sediment data

- 10 reservoirs had data about reservoir sedimentation collected in the last decade
- Only 1 reservoir has enough info to add to the national database (RESSED)
- Often limited is the original capacity curves and bathymetries
Semi-structured interviews with reservoir managers
Interview methods

- **Contacted** all 42 owners, and interviewed 22 who responded; Interviews are on-going
- Interviews were conducted by **phone** or in person
- Open ended questions coded and grouped into themes for analysis

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer format</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. When was the last time your reservoir(s) was (have been) surveyed/measured?</td>
<td>Year</td>
</tr>
<tr>
<td>2. Original plans available?</td>
<td>Yes/no</td>
</tr>
<tr>
<td>3. As-built drawings available?</td>
<td>Yes/no</td>
</tr>
<tr>
<td>4. How many times has it been surveyed?</td>
<td>Number</td>
</tr>
<tr>
<td>4a. Who did the survey?</td>
<td>Name</td>
</tr>
<tr>
<td>4b. What method?</td>
<td>Acoustic, bathymetric survey, sediment sampling,</td>
</tr>
<tr>
<td>4c. How much did it cost?</td>
<td>Number</td>
</tr>
<tr>
<td>5. Why did you do it?</td>
<td>Open</td>
</tr>
<tr>
<td>6. What will you do with the results?</td>
<td>Open</td>
</tr>
<tr>
<td>7. Are you willing to share those results with us?</td>
<td>Yes/no</td>
</tr>
<tr>
<td>8. What is your level of interest in conducting new surveys/measurements in order to find out how much the reservoir has filled in with sediment? (1–5)</td>
<td>Scale (1–5)</td>
</tr>
<tr>
<td>9. Is sedimentation a significant issue in the reservoirs you manage?</td>
<td>Open</td>
</tr>
<tr>
<td>10. What mitigation efforts have you used to prevent additional sediment build-up?</td>
<td>Open</td>
</tr>
<tr>
<td>11. What are your incentives for continuing to use/maintain the reservoir?</td>
<td>Open</td>
</tr>
<tr>
<td>12. Would you like to continue to talk with us and help us gather more information on reservoir sedimentation in Hawaii?</td>
<td>Yes/No</td>
</tr>
<tr>
<td></td>
<td>Federal</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------</td>
</tr>
<tr>
<td><strong>Number of owners</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Number responded to survey</strong></td>
<td>1</td>
</tr>
<tr>
<td><strong>Mean interest level (1-5)</strong></td>
<td>5</td>
</tr>
</tbody>
</table>

**Additional info**

- We conducted site visits on Oahu, Maui and Hawaii Island to obtain documents

Punawai Reservoir, Hawaii Island 2013
Everyone:
Capacity loss is assumed, but we don’t know how much

Water Supply, Private development owners:
Reservoir lining important to prevent seepage losses

Everyone:
It is expensive to prevent sedimentation, although we try with pre-basins; Dredging is not an option

Private agricultural operators:
Our reservoirs are used in county fire prevention plans

Everyone:
We have chosen to decommission a portion of our reservoirs

Private agricultural operators, DPW:
Maintenance is often done yearly to maintain capacity

Private development
With sediments, the actual capacity is less, and so we think we are below the regulatory limit. We would like helping showing that.

Everyone:
We are keeping the reservoir(s) dry until we know how to proceed
Remote sensing to determine reservoir management

- Use World View 2, Google Earth Pro imagery, images from DLNR database, to investigate current management of reservoirs
Methods

Analyzed and compared 140 reservoirs for status
Methods

Capacity categories:

- Dry
- Intermittently wet
- <50% full
- Managed to capacity
- Partially breached

Sediment categories:

<table>
<thead>
<tr>
<th>Amount of sediments in the reservoir</th>
<th>Significant</th>
<th>Moderate</th>
<th>Minimal</th>
<th>Unknown</th>
</tr>
</thead>
</table>

Approximately 15% of the capacity of Hawaii’s reservoirs is in use, without sedimentation effects.
Results: Sediment

<table>
<thead>
<tr>
<th>Category</th>
<th>Value</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimal</td>
<td>21</td>
<td>15%</td>
</tr>
<tr>
<td>Moderate</td>
<td>19</td>
<td>14%</td>
</tr>
<tr>
<td>Significant</td>
<td>36</td>
<td>26%</td>
</tr>
<tr>
<td>Unknown</td>
<td>57</td>
<td>46%</td>
</tr>
</tbody>
</table>

- **Water Supply**
- **Irrigation**
- **Hydroelectric; Irrigation**
- **Fish and Wildlife**
- **Flood Control, Debris**
- **Other**
Many of Hawaii’s reservoir managers indicate that sedimentation is a serious concern, especially Private owners.

Visual surveys suggest that about 40% of reservoirs suffer from sedimentation.

25 reservoirs have been decommissioned since the Dam Safety program began.

17% of reservoirs are currently dry.

Only 15% of the total reservoir capacity is currently being used.
Management implications

- Sediment coring and or bathymetry surveys on reservoirs
- Hawaii’s reservoirs are important resources for drinking water, irrigation and other services

Puu Ka Ele Reservoir
Acknowledgements

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Questions? Mahalo!