Streambank Stabilization: Why, How, and Is It Working?

Kari Bingham, PE and Tony Layzell, PhD (KGS)

August 25, 2020
Why Mitigate Streambank Erosion?

• Streambank erosion is a:
  • Natural process of streams
  • Essential component of river ecosystems
Accelerated Streambank Erosion

- An effect of ‘channel instability’
- Caused by some change within the watershed and/or stream corridor
Channel Instability

• Examples of Change:
  • Converting Prairie to Ag Land or City
  • Channelization
  • Dams
  • Removal of Riparian Vegetation
  • Sand/Gravel Dredging
  • Many others....
Why We Mitigate Accelerated* Streambank Erosion in Kansas

- Protect reservoirs
- Protect land
- Improve river ecosystems & water quality
How are we addressing unstable streams?

- Physically changing the stream to more stable form
Basics of a Meandering River

- Thalweg – Deepest/fastest part of river
- Cut Bank
- Shallow, Fast Riffle
- Point Bar
- Deep, Shallow Pool
- Helical flow through meander bend
- A
Streambank Stabilization Techniques Used in Kansas

- Flow deflectors
- Additional bank protection
- Vegetation plantings
Streambank Stabilization

• A single technique or system of techniques that maximize localized streambank shear strength and/or minimize the forces acting on a streambank with the intent of halting or slowing lateral retreat

• Make sure streambed is stable or failure likely imminent.
Streambank Erosion

• Driven by:
  • Streambank characteristics (shear strength)
    • Soil physical properties and layers
    • Streambank height and angle
    • Vegetation cover and root depth
  • Gravitational and hydraulic forces (applied shear stress)
    • Gravitational force – weight of the streambank
    • Hydraulic force – the force applied by the flowing water; dependent on density of water, channel dimensions, and profile
Streambank Stabilization

- Lots of techniques available:
  - Rigid structure
  - Spurs (Impermeable or permeable)
  - Bendway weirs
  - Rock vanes
  - Iowa vanes
  - Tree revetments
  - Toe rock
  - Bank shaping
  - Bankfull bench
  - Vegetation/Bioengineering
How do you select technique(s)?

<table>
<thead>
<tr>
<th>Streambank Stabilization Approach</th>
<th>Shear Strength Addition</th>
<th>Gravitational Force Reduction</th>
<th>Hydraulic Force Reduction</th>
<th>Habitat Improvement</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spurs</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>$$$</td>
</tr>
<tr>
<td>Bendway Weir</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>$$</td>
</tr>
<tr>
<td>Rock Vane</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>$$</td>
</tr>
<tr>
<td>Iowa Vane</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>$$</td>
</tr>
<tr>
<td>Tree Revetment</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>$</td>
</tr>
<tr>
<td>Toe Protection</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>$$</td>
</tr>
<tr>
<td>Rigid Structure</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>$$$$</td>
</tr>
<tr>
<td>Bank Shaping</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>$$</td>
</tr>
<tr>
<td>Bankfull Bench</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>$$</td>
</tr>
<tr>
<td>Vegetation</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>$</td>
</tr>
</tbody>
</table>
## Techniques Used in Kansas Today

<table>
<thead>
<tr>
<th>Streambank Stabilization Approach</th>
<th>Shear Strength Addition</th>
<th>Gravitational Force Reduction</th>
<th>Hydraulic Force Reduction</th>
<th>Habitat Improvement</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spurs</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>$$$</td>
</tr>
<tr>
<td>Bendway Weir</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>$$</td>
</tr>
<tr>
<td>Rock Vane</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>$$</td>
</tr>
<tr>
<td>Iowa Vane</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>$</td>
</tr>
<tr>
<td>Tree Revetment</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toe Protection</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>$$</td>
</tr>
<tr>
<td>Rigid Structure</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>$$$</td>
</tr>
<tr>
<td>Bank Shaping</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>$$</td>
</tr>
<tr>
<td>Bankfull Bench</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$$</td>
</tr>
<tr>
<td>Vegetation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$</td>
</tr>
</tbody>
</table>

Methods employed depend on site conditions and project objectives.
Techniques Used in Kansas Today
Monitoring...
Assessing the Effectiveness of Streambank Stabilization Projects

Tony Layzell, Kansas Geological Survey
Kansas Water Office, Aug 25th, 2020
Unmanned Aircraft Systems (UAS)
3D model of streambanks
Photogrammetry
- Structure from motion
- Ground control points
August 9, 2018

November 1, 2018

19,000 ft³ of material eroded from streambank

37,000 ft³ of material deposited on bar
April 24, 2019

July 2, 2019

129,319 ft³ eroded
26,551 ft³ stored on bank toe
Cottonwood River
- 14 SBS sites
- 8 unmodified sites
As built – April 2015

Post flood – October 2015

Photos courtesy of Brock Emmert
Pre-construction imagery
<table>
<thead>
<tr>
<th>Site C62</th>
<th></th>
<th>Volume eroded</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time period</td>
<td>No. days</td>
</tr>
<tr>
<td>Pre</td>
<td>7/7/06-12/15/10</td>
<td>1622</td>
</tr>
<tr>
<td></td>
<td>12/15/10-4/7/15</td>
<td>1562</td>
</tr>
<tr>
<td>Site C62</td>
<td>Volume eroded</td>
<td></td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>----------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Time period</td>
<td>No. days</td>
<td>No. years</td>
</tr>
<tr>
<td>Pre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7/7/06-12/15/10</td>
<td>1622</td>
<td>4.4</td>
</tr>
<tr>
<td>12/15/10-4/7/15</td>
<td>1562</td>
<td>4.3</td>
</tr>
<tr>
<td>Post</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4/7/15-3/1/19</td>
<td>1424</td>
<td>3.9</td>
</tr>
<tr>
<td>3/1/19-10/16/19</td>
<td>229</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Is this SBS project effective?
Discharge (cfs)

C62 constructed

7/7/06-12/15/10  12/15/10-3/26/15  4/7/15-3/1/19  3/1/19-10/16/19

5.0  0.3  1.0  1.9 tons/yr/ft
Discharge (cfs)

- 7/7/06-12/15/10: 0.29
- 12/15/10-3/26/15: 0.05
- 4/7/15-3/1/19: 0.07
- 3/1/19-10/16/19: 0.04

Vol flux
Concerns with accuracy of pre-construction imagery

Are average pre-construction values representative?
Highlights importance of obtaining accurate and representative baseline data
Normalized for total volume of water (kcfs) for each time period.

Average 75% efficiency in reducing sediment
### Worst case scenario - Max erosion

<table>
<thead>
<tr>
<th>Length (ft)</th>
<th>Total eroded (ton/yr)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>21549</td>
<td><strong>61765</strong></td>
<td>Assuming no SBS (using av. natural rate)</td>
</tr>
<tr>
<td>8281</td>
<td>6795</td>
<td>At SBS sites (using av. stabilized rate)</td>
</tr>
<tr>
<td>13268</td>
<td><strong>38030</strong></td>
<td>Natural reaches (using av. natural rate)</td>
</tr>
</tbody>
</table>

#### Total saved (ton/yr)

- **16941**
- **27.4%**

**Price / ft**

- **71.5 $/ft SBS cost**

**Total ($)**

- **592,080 $ (est. cost for C15-C2)**
- **34.95 $/ton/yr**
Take home points

• Utility of using UAS to monitor streambank erosion
• Stabilized streambanks are effective in reducing streambank erosion
• Importance of accurate baseline data (C102 & C112)
• Site to site variability
• Upstream/downstream effects being investigated