Effectiveness of Streambank Stabilization Projects

Streambank erosion is a significant cause of reservoir sedimentation in Kansas. To combat this problem over 250 streambank stabilization (SBS) projects have been completed along rivers draining into major federal reservoirs. **The effectiveness of SBS needs to be studied to determine (1) whether SBS accomplishes the goal of reducing total sediment loads entering Kansas reservoirs, and (2) whether it resolves the underlying causes of streambank erosion, a stream out of equilibrium, and does not shift erosion upstream or downstream of the SBS site.** Baseline data and post-construction monitoring are essential to assess the **long-term** effectiveness of SBS projects.

Proposed Activities and Timeline

To assess long-term effectiveness, a 5-year study was proposed. Measurements of stream channel dimensions, profiles, and sediment characteristics will be collected at each study location in several phases: (1) baseline data prior to SBS construction (2018-2020), (2) immediately following construction (2020-2021), and (3) annually during the project period (2018-2023). Data collection methods include (1) topographic surveys with unmanned aerial vehicles (drones) and a total station, (2) assessment of historic satellite and aerial imagery to determine historic rates of erosion, and (3) geotechnical analyses to investigate the composition of streambank material and localized bank erosion processes. Data collected for each phase will be compared in order to assess changes to the stream channel and streambanks over time.

FY21 Activities

- Year 3 of drone flight surveys at (1) two proposed SBS sites (C102 and C112), and (2) 14 constructed SBS sites (C2, C3, C4, C5, C7, C9, C10, C11, C12, C13, C14, C15, C18, C62) (completed).
- Calculate volumes eroded at each SBS site between 2nd and 3rd flight surveys (completed).
- Repeat pre-construction total station surveys at sites C102 and C112 (summer 2021).
- Geotechnical analyses of samples from sites C102 and C112 (ongoing).
- Model streambank erosion with HEC-RAS using geotechnical data for C102 and C112 (ongoing).
- Investigate site-to-site variability for constructed sites (ongoing).
- Perform post-construction total station and drone surveys at C102 and C112 (summer/fall 2021).[1]
- Assess historic imagery to determine meander migration rates (summer/fall 2021).

Results to date

A variety of different datasets were used to determine volumes of sediment eroded at each SBS site over time. Pre-construction erosion volumes were determined from historic aerial imagery (NAIP, Lidar, and NG911 imagery) for the period 1992-2015. Post-construction volumes were determined from both as-built survey data as well as repeat drone flight surveys (Figure 1).

[1] C102 was not selected for construction this fiscal year. Refer to page 5 for additional detail and discussion of modifications in research activities and deliverables.

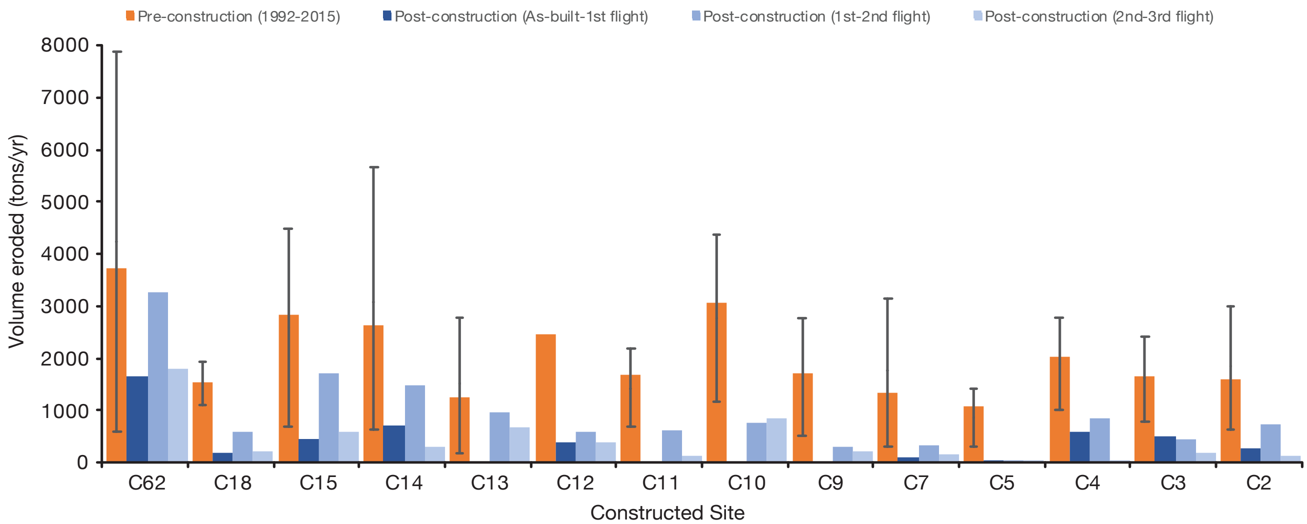

Figure 1. Pre- and post-construction volume of sediment eroded annually (tons/yr) at each SBS site. Pre-construction values are averaged values for the period 1992-2015. Error bars show the range of volumes eroded for different pre-construction periods analyzed (see Figure 2).

Significant variability was observed in the pre-construction volumes eroded per year calculated from historical aerial imagery (Figure 2).

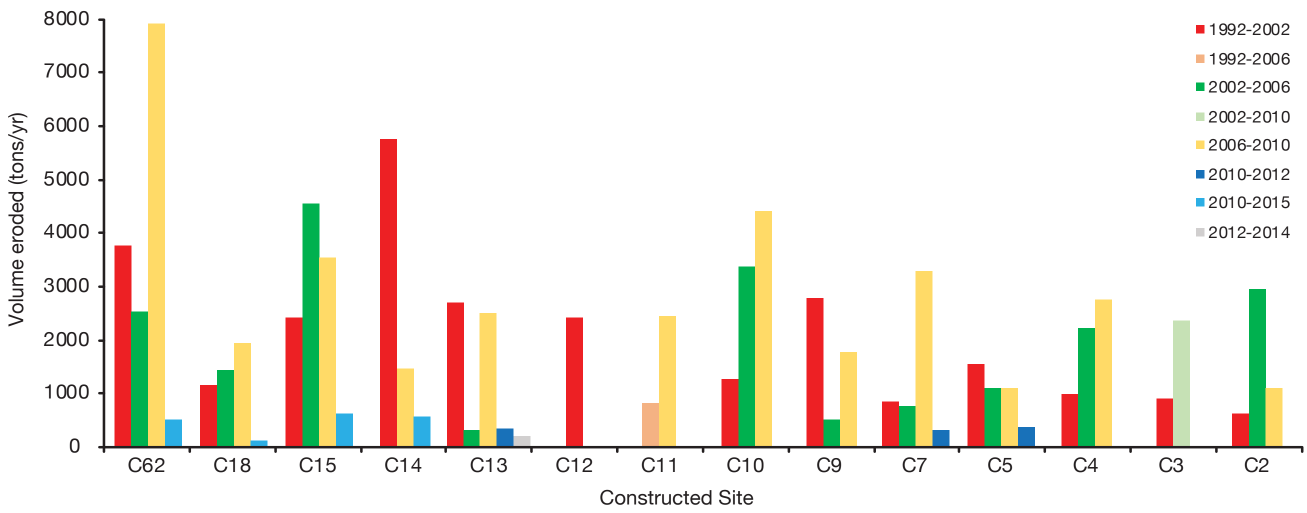

Figure 2. Pre-construction volume of sediment eroded annually (tons/yr) at each SBS site between different sets of historic aerial imagery.

Using site C62 as an example, the average annual volume of sediment eroded between the periods 2006-2010 and 2010-2015 is significantly different (over 7000 tons/yr). This variability is due in part to inaccuracies in the historical aerial imagery as well as the fact that these two periods differ hydrologically. This observation highlights the need for accurate and representative baseline data with which to compare post-construction volumes eroded.

Given that each period analyzed is different hydrologically (i.e., in terms of the magnitude and frequency of flood events) and that each SBS site is different in terms of the length of streambank stabilized, volumes eroded over time were normalized for (1) length (Figure 3) and (2) both length and the total volume of water (i.e., stream discharge) for each period (Figure 4).

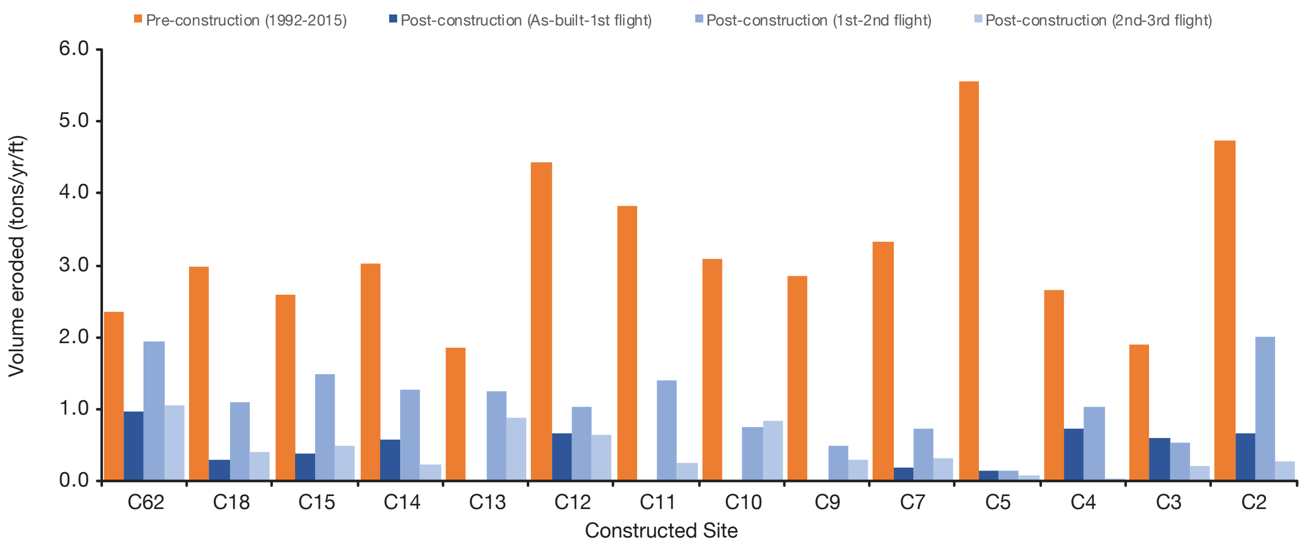

Figure 3. Pre- and post-construction volume of sediment eroded annually per foot of streambank (tons/yr/ft) at each SBS site. Pre-construction values are averaged values for the period 1992-2015.

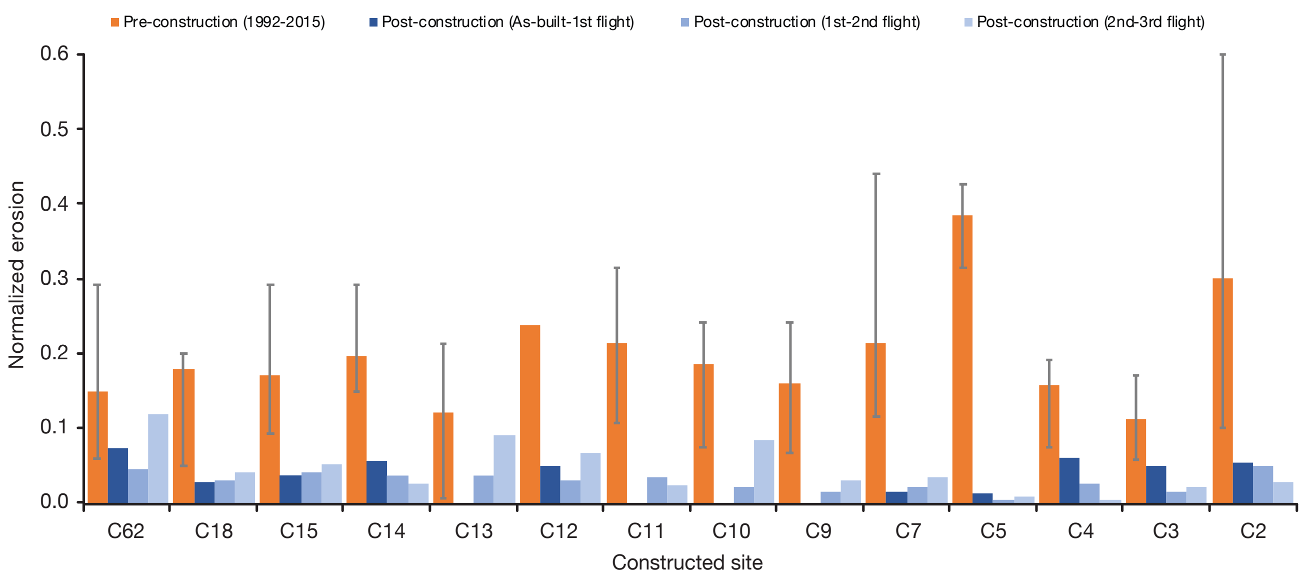

Figure 4. Pre- and post-construction volume of sediment eroded normalized for length (ft) and stream discharge (cfs) over the period of record at each site. Pre-construction values are averaged values for the period 1992-2015. Error bars show the range of normalized volumes eroded using different pre-construction periods.

Using normalized erosion data, the percent reduction in volumes of sediment eroded at each SBS site were calculated (Figure 5). Average reduction in volumes eroded ranges between 51% and 98%. However, significant uncertainty in percent reduction exists due to observed variability in erosion volumes from pre-construction datasets.

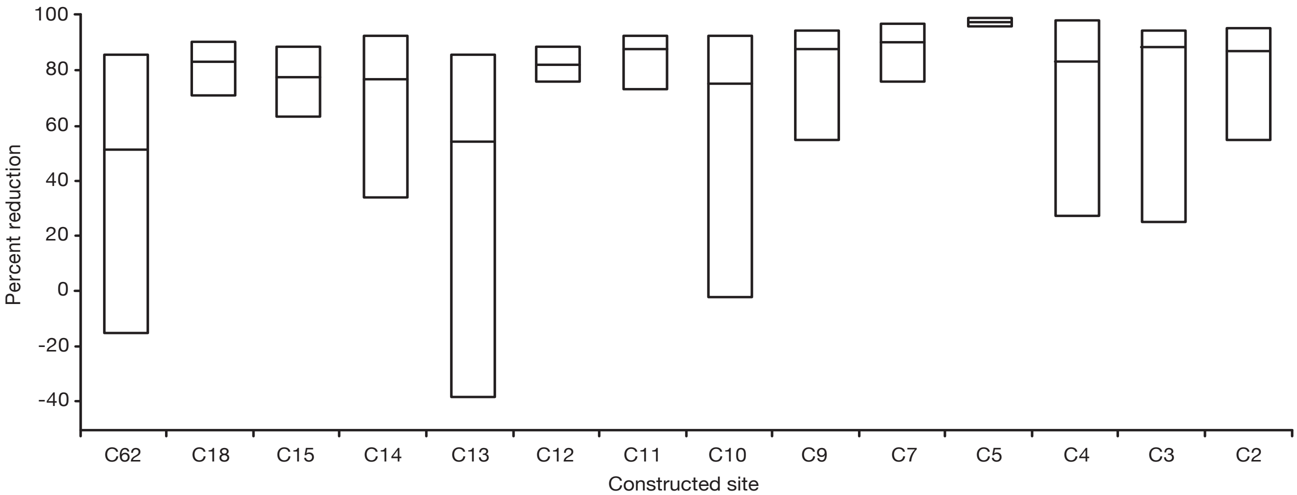

Figure 5. Percent reduction in volumes of sediment eroded for each site using normalized erosion data. Box plots show average reduction (average pre-construction/average post-construction) as well as the range (maximum pre-construction/minimum post-construction; minimum pre-construction/maximum post-construction).

Due to observed inaccuracies in some of the historic aerial imagery, volumes of sediment eroded between flight surveys were also calculated at eight unmodified reaches, including two proposed SBS sites (C102 and C112) for comparison (Figure 6). These results support the conclusion that SBS projects are effective in reducing erosion at the site.

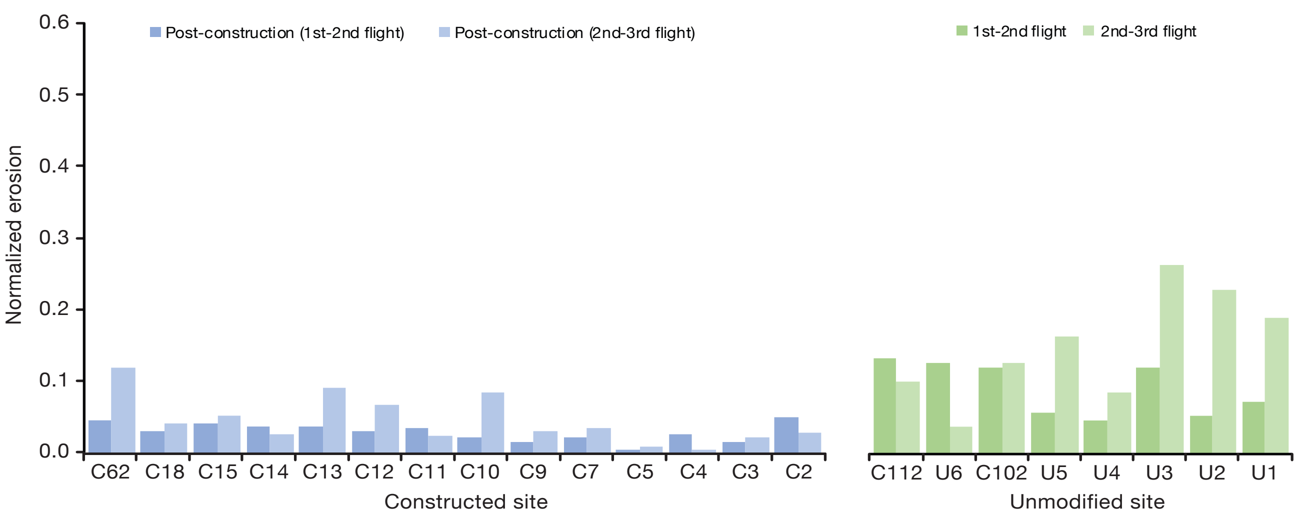

Figure 6. Post-construction volume of sediment eroded normalized for length (ft) and stream discharge (cfs) for SBS sites and unmodified sites between flight surveys.

However, the effectiveness of SBS projects at the reach scale, or on overall sediment budgets, cannot be adequately deduced from this analysis as geomorphic responses immediately upstream and downstream of SBS projects are still unknown.

Conclusions

Results to date indicate that **SBS projects significantly reduce erosion locally at the stabilized site**. Average reduction in volumes of material eroded at each SBS site range between 51% and 98%. However, significant uncertainty in percent reductions remains due to variability in pre-construction datasets. Precise quantification of sediment reduction and percent efficiency is only possible with accurate and representative baseline data. Such baseline data have been collected for proposed sites C102 and C112. Site C112 is currently scheduled for construction this fiscal year (2021).

Future work will focus on assessing the effectiveness of newly installed SBS projects, including (1) post-construction monitoring of newly constructed sites, (2) evaluation of upstream and downstream effects of SBS construction, (3) unsteady 2D modeling of streambanks, and (4) development of a site selection tool to inform future SBS site selection.

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[1] Site C102 was not selected for construction this fiscal year. We are working with the Interagency Streambank Team to determine appropriate modifications to this year's scope of work. Options for modifications include:

- **Option 1**: Resurvey the C102 reach to obtain another year of pre-construction data.
  - *Why*: Another year of survey data will enhance our assessment of baseline conditions and ultimately improve the evaluation of post-construction effectiveness.
  - *Expectation from State*: Site C102 will need to be installed eventually for this option to be worth the time/cost.
- **Option 2**: Begin pre-construction surveys on 3-4 new reaches that match the study design requirements
  - *Why*: Additional reaches will improve our understanding of the range of variability in post-construction erosion as well as better assess potential upstream and downstream impacts. Depending on when new reaches are constructed, it is likely that only 1-2 years of baseline data would be collected.
  - *Expectation from State*: Proposed SBS sites will need to be installed eventually (ideally in FY22-23) for this option to be viable.