Geomorphic Assessment and Monitoring for Stream Rehabilitation, Bayfield Peninsula, Wisconsin

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Abstract

In 2002, a watershed-scale geomorphic assessment of five tributaries to Lake Superior in Wisconsin was initiated to identify past and present geomorphic factors that affect native brook trout habitat. The tributaries included in the study are the Cranberry River, Bark River, Raspberry River, Sioux River, and Whittlesey Creek (fig. 1). Past studies indicated that sedimentation problems were caused by bank and bluff erosion in upper main stem reaches of the tributaries. As part of the geomorphic assessment, the success of streambank stabilization structures constructed in the 1960s and 1970s were evaluated in the context of flood history. Results from the geomorphic assessment are being used to identify management implications for rehabilitation alternatives for the five tributaries.

Monitoring of geomorphic conditions and hydrologic events before and after installation is necessary to adequately evaluate the success of rehabilitation techniques (North Fish Creek example, see reverse).

Study-Specific Goals

There are five study objectives: (1) identify current geomorphic conditions for five tributaries, (2) identify potential problem areas, (3) identify ground-water contributions, (4) recommend feasible and cost-effective rehabilitation alternatives, and (5) protect and rehabilitate critical brook trout reproduction sites.

Geomorphic Assessment

A thorough geomorphic assessment of the study area is necessary to assure understanding of the processes that act upon an area. This in-depth study also provides the foundation for a successful evaluation of the rehabilitation study in the future. Through the evaluation studies, improvements can be made to future rehabilitation techniques.

Keys for a Successful Geomorphic Assessment

- Conduct geomorphic assessment prior to rehabilitation using multiple spatial (upstream, downstream, watershed) and temporal scales of data
- Identify major sediment sources
- Identify current and historical human factors that potentially alter water and sediment inputs
- Put current geomorphic conditions in hydrologic context
- Develop clear goals for rehabilitation efforts

Methodology Based on Multiple Spatial and Temporal Scales of Data

Pre-field activites include reviewing available literature; characterizing watershed land coverage and geologic setting; interpreting historical air photos; constructing stream longitudinal profiles; and gathering existing streamflow and precipitation data.

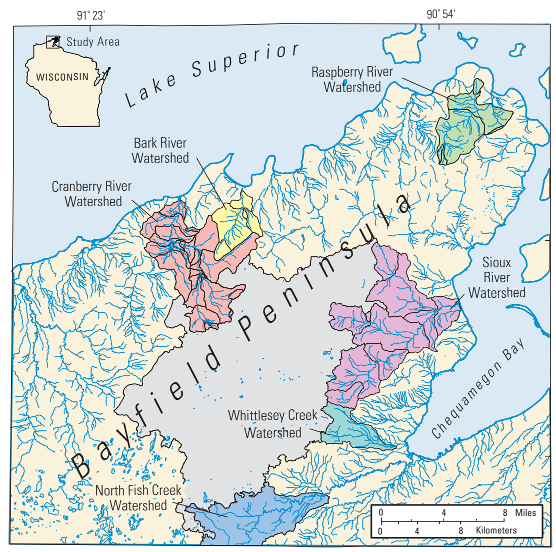

Figure 1. Location of Bayfield Peninsula, Wisconsin, and study streams.

Field activites include surveying channel cross-sections and longitudinal profiles, determining bankfull stage, conducting pebble counts; identifying channel and flood-plain erosion, sedimentation and lateral migration; surveying valley cross sections (including abandoned channels and flood plain) and coring fluvial sediment; measuring base flow; quantifying amount of woody debris and local riparian conditions; monitoring streamflow; and identifying sources of sediment.

Post-field activites include calculating bankfull discharge, stream power, and potential sediment movement; modeling rainfall/runoff and sediment transport; constructing sediment budget; determining geomorphic conditions, sensitivity to change, and causes for historical change; and determining ground-water sources.

Evaluation of Past Rehabilitation Techniques

In the mid-1950s, the Red Clay Interagency Committee identified erosion and sedimentation problems in the Bayfield tributaries. The program started after an episode of large floods in the 1940s followed by moderate floods in the early 1950s. Stream banks, roadside ditches, and gullies were identified as major sediment sources. A variety of erosion-control methods were implemented and tested. Structures were checked and maintained following episodes of flooding (fig. 2).

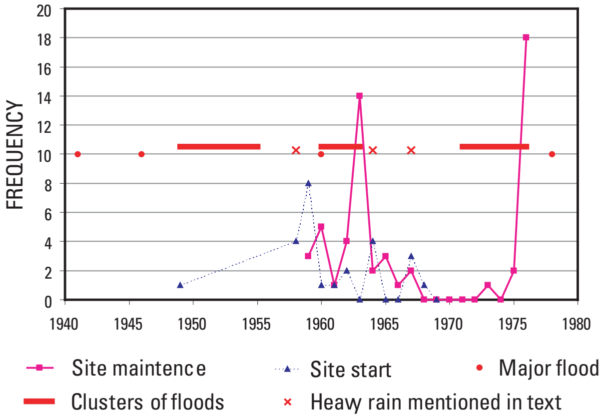

Figure 2. Graph illustrating the timing among flood events and initiation and maintenance of rehabilitation sites.

Local Versus Watershed Issues

In 1994, a local rehabilitation field trial was begun on an eroding cut bank near the mouth of Whittlesey Creek. Stream barbs, vortex weirs, and several bioengineering techniques were demonstrated.

Overall, the techniques were successful at stopping local bank erosion. However, these techniques were applied to a reach where sedimentation of the channel and flood plain has been the dominant geomorphic process for centuries. Accelerated sedimentation problems in the reach are caused by widespread gully, bluff, and bank erosion upstream. Local cut bank erosion naturally occurs at meander bends in this sinuous stretch just upstream of where the creek enters Lake Superior.

North Fish Creek in Stream Stabilization Demonstration and Monitoring

A detailed geomorphic assessment of North Fish Creek by the USGS in the late 1990s identified bluff erosion along the upper main stem as the main source of sediment and cause of sedimentation problems in the lower main stem. Submerged vanes (Odgaard type) were installed in the channel at two bluff sites on North Fish Creek in 2000 and 2001 by the University of Wisconsin-Madison Civil Engineering Department. The vanes operate by deflecting flow away from the toe of the bluff. The success of the vanes is monitored through repeated channel cross-section and bluff surveys (fig. 3).

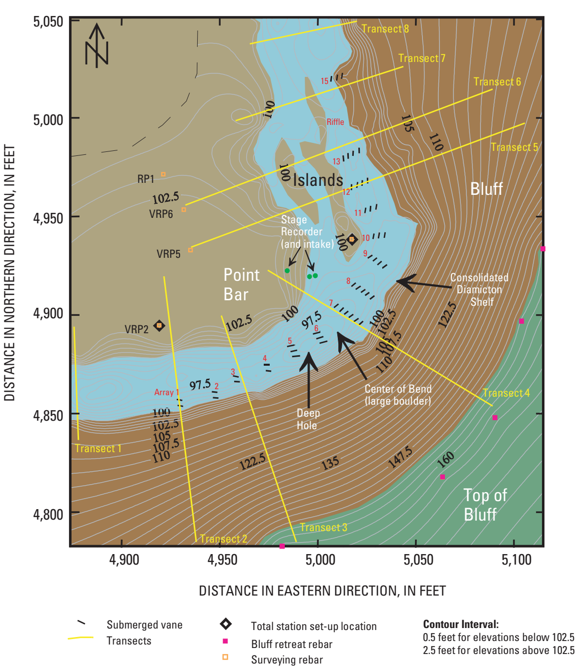

Figure 3. Site map of North Fish Creek vanes, Site 1.

A USGS streamflow gaging station records flow downstream of the vane sites on North Fish Creek. Stage recorders are located at both sites as well. The vanes survived floods in 2000 and 2001 with recurrence intervals of approximately 50-75 years. Some maintenance was required after the floods. At site 1, the vanes are successfully moving the channel away from the bluff and into the point bar (fig. 4).

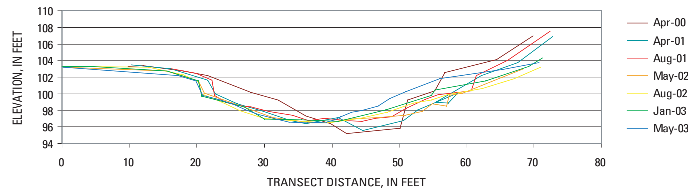

Figure 4. Change in channel cross-section, transect 4, site 1, April 2000–May 2003.

Management Implications

- Impacts from historical land cover change are still affecting geomorphic conditions in Bayfield streams today.
- A watershed-scale geomorphic assessment with a historical component is needed to select the most appropriate types and locations for rehabilitation.
- Human interest in stream rehabilitation often increases following destructive episodic flooding.
- The success of rehabilitation efforts can only be quantified with detailed, long-term monitoring that includes monitoring of channel and hydrologic conditions.
- For Bayfield streams, rehabilitation efforts need to be geared toward reducing stream power in the upper reaches. This includes a combination of upland and in-channel techniques such as land leveling of constructed ditches in abandoned farm fields, protecting and restoring forests, restoring wetlands, increasing channel and valley roughness, and constructing grade control structures.
- For Bayfield streams, wide-spread decreases in erosion and sedimentation can be achieved by reducing and slowing runoff.

References

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