Taming Stoltz Bluff: Long-term Fine Sediment Management on the Cowichan River

Craig Wightman, Marc Gaboury, and Dave Murray

In the summer of 2006, the BC Conservation Foundation (BCCF) and partners undertook an ambitious project that combined construction know-how, and innovation in the fields of fish biology, geomorphology, and engineering. The objective was to control sediment transport from a massive silt bluff upstream of Stoltz Pool that had been negatively affecting the Cowichan River. For years, fine sediment washed into the river from the base of the bluff resulting in reduced salmon egg-to-fry survival rates in the downstream river reaches. To remedy this situation, a project was proposed to construct a berm and terrace complete with a series of bendway weirs and bioengineering treatments to move river flows away from the base of the bluff and prevent further bank erosion.

The project team faced significant challenges: divert 1 km of the Cowichan River; dry out the channel; move over 40 000 m^3 of river sediment and 30 000 fish; and bypass over 3000 river recreationalists during the summer. Early results from project monitoring are encouraging and show a substantial reduction in sediment loading.

This article outlines the history and background of the project, describes its design and construction, discusses some of the lessons learned, and outlines ongoing work being carried out to monitor the effectiveness of the project.

Background

The Cowichan River (Figure 1) flows through an important Vancouver Island watershed with significant anadromous and resident fish resources conservatively valued at \$5–6 million annually (Burt and Wightman 1997). The Cowichan watershed is the ancestral home of the Cowichan Tribes, whose people have traditionally relied on the river's fish and other resources for food, social, and ceremonial purposes, and who are currently negotiating with the federal and provincial governments for a final agreement under the BC Treaty process.

The Cowichan River provides exceptional habitat for coho, chum, and chinook salmon as well as steelhead, brown, and rainbow trout.

In addition to being a major fish producer, the Cowichan River supports the local economy by providing water for industrial, commercial, and domestic purposes, and offers growing recreational use year-round. The Cowichan River's natural capital and economic values, as well as its historical importance to First Nations, have been recognized in its designation as a BC and Canadian Heritage River.

Catalyst Paper Corp. owns and operates a low-head weir at the outlet of Cowichan Lake in support of their water licence for Crofton pulp mill operations. The weir typically goes "on control" in April or early May to capture 1 m of snowmelt runoff as additional storage on the lake. Consequently, from spring to early fall (i.e., April to late September), flows in the Cowichan River are regulated to maintain a licensed volume (target is 7 m^3/s) in support of downstream water use and ecological requirements. Over the winter, the weir's gates are fully opened and the river and lake levels return to the natural regime.

The Cowichan River provides exceptional habitat for coho, chum, and chinook salmon as well as steelhead, brown, and rainbow trout. Cowichan fall chinook and coho stocks are listed priorities under the Canada–U.S. Pacific Salmon Treaty. Cowichan chinook are also an "indicator" stock for species abundance in the Georgia Basin, and were listed as the "number one priority species" for rebuilding in the Cowichan Recovery Plan (CRP) (LGL 2005). Cowichan winter steelhead are listed as a high priority for increased conservation efforts by the BC Ministry of Environment under the Greater Georgia Basin Steelhead Recovery Action Plan (Lill 2002).

Besides its obvious importance for fish and other aquatic species, the Cowichan River is an important resource for the local community, including traditional cultural values, municipal and industrial water supply, and recreational opportunities. Observations by local anglers, fisheries professionals, and geomorphologists indicate that the Cowichan River's lower reaches have been subject to increased bank instability, erosion, bedload movement, and sedimentation in recent years (LGL 2005; KWL 2006).

Stoltz Bluff is located on the left bank of the river, 27 km upstream of Cowichan Bay, within the Cowichan

Source: Cowichan Valley Regional District

Figure 1. Map of the Cowichan River showing major landmarks.

River Provincial Park Reserve. The bluff is adjacent to the outside of a meander bend where an 800 m long, 50–60 m high deposit of glacial sediment is actively eroding (Figure 2). The bluff consists of multiple layers of fine glaciolacustrine deposits interbedded with glacial outwash material. Nine major strata of distinct sediment texture were identified, ranging from sand and gravel with some cobble, to fine sand, silt, and clay.

After instabilities of the bluffs in the 1970s, early attempts at remediation were limited to willow planting in exposed soils. The bluff was generally stable for about two decades until the early 1990s, when major rain-on-snow events led to significant toe erosion and gully failures. This prompted a series of studies in the mid-1990s that provided options for stabilizing the bluff and reducing its impacts on downstream fish habitats (NHC 1996; Newbury Hydraulics 1997) and coincidentally on the Catalyst pulp mill's water supply. Yet, none of the designs in these reports was implemented, largely due to funding limitations and conflicting views on the risk of channel change in response to hard river engineering measures.

In 2004/05, field assessments by Fisheries and Oceans Canada determined that salmon egg-to-fry survival rates in the lower river reaches were dramatically lower than those in the upper river reaches. Test incubators installed in the upper and lower mainstem (over ~40 km) found a mean egg-to-fry survival rate of 86% at the uppermost site near Cowichan Lake (Greendale Road), compared with mean survivals ranging from 0.7 to 6.8% at three sample sites in the lower river (Burt *et al.* 2005). From a provincial fisheries perspective, fine sediment from Stoltz Bluff was first identified as a potential habitat problem in the late 1960s (G.D. Taylor and F.N. Axford, pers. comm.). This reduction in egg-to-fry survival between the upper and lower reaches of the river appeared to correlate with an increase concentration of fine sediment in suspension and in the spawning gravels. Therefore, further sediment analysis was carried out to quantify these observed increases.

In 2004, the Cowichan Stewardship Roundtable (CSRT), a multi-stakeholder committee consisting of Cowichan Tribes, government, industry, and community representatives, used recommendations from the CRP to attract outside funds for undertaking a quantitative analysis of sediment contributions to the river, as a basis for rationalizing a comprehensive remediation plan. A sediment source study in 2004 identified Stoltz Bluff as the primary source of fine sediment to the river below Skutz Falls, and a 1990 channel avulsion at Block 51 as the major source upstream of the falls (LGL and KWL 2005). The report indicated that Stoltz Bluff appeared to have contributed about 10 000–28 000 m^3/yr of fine sediment from 1993 to 2004. Moreover, the report found significantly higher levels of sand, silt and clay in streambed gravel samples taken about 9 km downstream of Stoltz, compared with two other sampling locations upstream of Stoltz and farther downstream near Duncan.

Based on the findings of the egg-to-fry survival and sediment sampling, as well as the priority of sediment management as a goal in the CRP, Stoltz Bluff became a top priority in the framework for overall watershed sediment management (BCCF 2007).

Project Design and Construction

Preliminary Concept

The overall strategy developed to tackle Stoltz Bluff was three-pronged approach. Phase 1 consisted of river-based works to stabilize the toe of the bluff (KWL 2006); Phase 2 would focus on slope stabilization; and Phase 3 would consider gully and upslope bioengineering/stabilization techniques. As of September 2007, Phase 1 has been completed. Plans are to secure funding to begin Phases 2 and 3 in 2009.

The objective of the Phase 1 works was to limit lateral erosion and undercutting of Stoltz Bluff by the river. The concept design for Phase 1 included:

- a permanent access road for construction equipment, beginning at the upstream end of the Stoltz Pool provincial campground and proceeding along the left bank of the river (looking downstream) and along the toe of Stoltz Bluff. The access

Continued on page 32

Continued from page 31

road also functions over the long term to stabilize the toe of smaller gullies on the bluff;

- a berm running parallel to the bluff toe (constructed primarily of gravels and cobbles excavated from the mainstem channel) to prevent ongoing toe erosion at the base of the bluff;
- 11 bendway weirs to reduce streamflow velocities and scour along the toe of the constructed berm while allowing for streambank planting between weirs;
- large riprap to protect the berm, and bioengineering between weirs (i.e., soil wraps with willow cuttings);
- a terrace between the berm and the toe of the bluff to store sediments resulting from surface erosion of the bluffs;
- a new mainstem channel on the inside of the meander curve; and
- bed-level rock sills at the upstream and downstream ends of the berm and terrace to provide grade control for the river channel.

BC Ministry of Environment

Figure 2. Stoltz Bluff (circa late 1990s), showing effects of toe erosion and upper slope runoff on sediment delivery to the Cowichan River.

The challenge in developing the design criteria was determining what design flood would govern. Could overtopping of the terrace be permitted and occasional terrace damage be tolerated? Initially, designing to a 20-year return period was considered, but when topographic surveys revealed that substantial quantities of river sediments needed to be relocated, it became possible to raise the berm and protect the river works to the 200-year flood level, plus appropriate freeboard.

Hydraulic Modelling

To set the berm design levels, a river cross-section was surveyed upstream and downstream of the site and a MIKE 11 hydraulic model (KWL 2006) was developed to model the streamflow distribution between the mainstem and side channel. The hydraulic model was then used to determine water levels before and after the proposed design for the 2-year and 200-year design floods, estimated to have peak discharges of 235 m^3/s and 490 m^3/s, respectively. The proposed design lowered the flood levels primarily due to the wider channel and removal of the centre sediment bar adjacent to Stoltz Bluff.

Terrace and Berm

The Phase 1 rehabilitation works were constructed in the summer of 2006 (Figure 3). The berm was designed as a training berm with side slopes of 2 horizontal to 1 vertical. The 5 m wide berm crest (2–3 m above the mean bed level) was designed to be higher at the upstream end of the terrace to reduce the risk of overtopping. The upper end of the berm was protected with riprap and tied into the existing slope to guard against the river scouring behind the berm and eroding the newly constructed terrace.

The berm elevation was set with standard 0.6-m freeboard above the 200-year flood level while the constructed terrace was set at the 2-year flood elevation to match the natural floodplain terrace across the river. The lower elevation on the terrace maximized the volume of sediments that could naturally accumulate on the terrace from the bluffs. During future phases of the work, sediment collected on the terrace will be reworked to construct toe buttresses and containment berms. These future structures, constructed to the natural angle of repose of the material, will stabilize the toe of the bluffs to allow the upper slopes to naturally stabilize over time.

Bank Protection and Bendway Weirs

While the thought initially was to construct standard riprap along the outbound slope of the berm, it was desirable to provide as natural a system as possible in the provincial park. This presented an opportunity to be innovative and showcase bioengineering techniques and deflective weir approaches used in other jurisdictions. The goal was to eventually allow the riverbank to naturalize over time. By using bendway weirs and a flatter berm slope, some bioengineering techniques could be used between the weirs where velocities were slower. After reviewing the available research and the pros and cons on upstream pointing weirs versus downstream pointing guidebank weirs, the upstream approach was taken, primarily to reduce material needs and resulting project costs. The weirs were designed to protrude from the new channel bottom between 30 and 50% of the 2-year flow depth (approx. 0.7 m), extend about 12 m into the channel, and angle upstream at about 20° from the flow perpendicular.

Bioengineering

A soil wrap (or vegetated geogrid) was used between the bendway weirs to strengthen the bank while maximizing natural vegetation on the riverbank. This wrap consisted of biodegradable coir geogrid and geofabrics interlaced with willow brush layers and willow live staking (Figure 4). Given that on-site soil consisted of mainly sands and gravels, using this technique was a concern in case the treatment dried out during hot, dry summers. To counter this, the brush layering was limited to the lower part of the bank where willows could reach moisture from subsurface channel flow. An irrigation program was also undertaken during the 2007 summer season. Installation difficulties and timing were a challenge and resulted in mixed success. Where installed properly, the technique has performed well; however, where willow materials were not handled properly, some plant mortality resulted.

Importance of Geomorphology

No major intervention to a river can be done without some upstream and downstream adjustment. A major concern of the partners, approval agencies, and the downstream community was the effects the Stoltz Bluff project may have elsewhere on the river due to energy transfer. The design considered geomorphic processes by incorporating the following steps to minimize the potential for downstream impacts:

- maintaining a channel bankfull width based on reference reaches upstream and downstream of the site;
- matching the radius of curvature to reference reaches;
- maintaining a channel gradient similar to the existing longitudinal slope; and
- maximizing the roughness of the river channel being constructed.

Even with these design features it is anticipated that some widening and erosion of the channel will occur into the opposite natural river terrace, and some channel degradation may occur until the river again armours itself with larger cobble material.

Figure 3. Stoltz Bluff berm, terrace, and bendway weirs in summer of 2007, one year after construction.

Environmental Protection during Construction

LGL prepared and obtained required approvals and permits under the *Water Act, Park Act*, and *Fisheries Act* (Houwers and Gaboury 2006). The selection of an experienced and innovative contractor (Johel Brothers Contracting Ltd.) and the cooperation of environmental agencies (particularly BC Parks and Fisheries and Oceans Canada) enabled implementation of measures that minimized harmful effects to the flora and fauna of the Cowichan River and its riparian corridor. These included the following:

1. Instream construction occurred during the recommended fisheries work window (July 10 to September 15, 2006), when flows were expected to be low (approx. 7 m^3/s). This construction window protected fall spawning salmon and also newly hatched steelhead, rainbow, and brown trout fry. The construction footprint was minimized by restricting machinery traffic to a single narrow corridor in the park and along the river floodplain. An Environmental Monitor was on site for any environmentally sensitive work.
2. A bulk bag dam of 1 × 1 m woven bags filled with river gravels and cobble was constructed across the mainstem to divert all river flows through an existing floodplain side channel. This allowed the in-channel rehabilitation works to be constructed in isolation of river flows. River flows of 4–8 m^3/s during the construction period were easily conveyed by the side channel, providing a safe route for recreational users in watercraft to bypass the construction area.
3. At the time of the flow diversion to the side channel, an estimated 25 000–30 000 fish were salvaged and transferred into the mainstem below the construction worksite.
4. Sediment control works were implemented to minimize the input of suspended sediments to the Cowichan River below Stoltz Bluff throughout the construction phase. Sediment barriers constructed near the downstream end of the project site from geotextile filter fabric were regularly cleaned or replaced to ensure high water quality. Sediment was controlled by pumping silt-laden water from the main sedimentation pond onto vegetated floodplains. In addition, the bulk bag dam was removed over a three-day period (September 6–8) to minimize the suspended sediment load generated from the re-watered mainstem channel.

Upon completion of construction and re-wetting of the mainstem, side channel habitats and flow were re-established through the construction of a low elevation riffle at the inlet. Five large woody debris structures were placed in the side channel to provide instream cover in fish-rearing pools.

Lessons Learned and Value Added

One primary lesson learned on this project was how effective the contractor-project management team relationship can be when a spirit of trust and co-operation is present. A

Continued on page 34

Continued from page 33

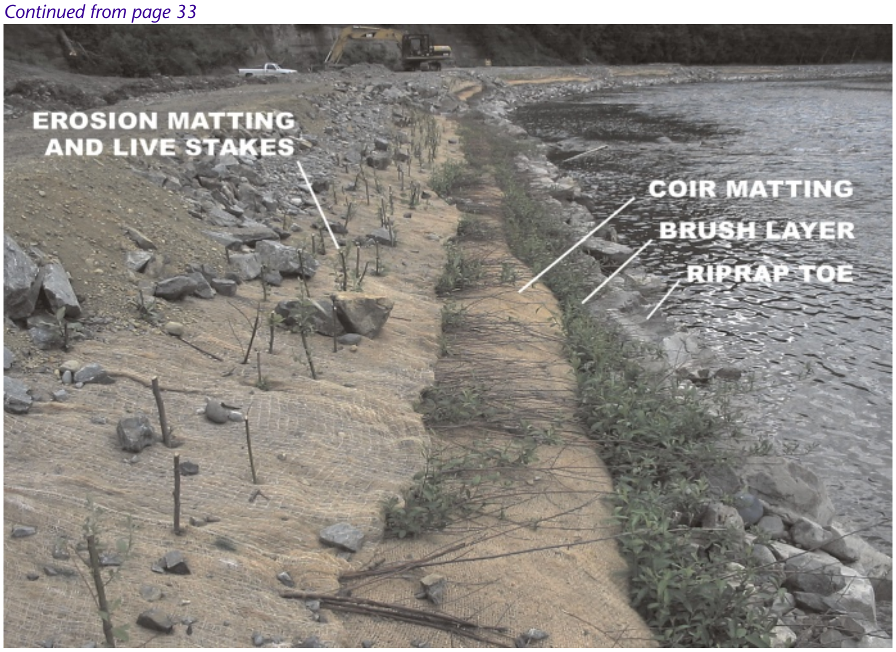

Figure 4. Bioengineering bank stabilization treatments showing soil wrap, brush layering, live staking, and erosion control matting.

time and materials approach was used to share the risk with the contractor. Weekly cost control reports allowed the BCCF to make critical decisions if required and defer non-critical items. This, coupled with a well-seasoned contractor supervisor, resulted in an estimated savings to the project of $300,000 below a fully tendered contract price.

While the project has been very successful to date, it was not without its challenges. The available materials on site did not allow for the access road to be constructed up to the estimated 200-year water level as desired. It was not until a donation of fill from Island Timberlands Limited Partnership and TimberWest Forest Corp. the following spring (April 2007) that the road was raised.

The river works were completed on time and within budget even though the TimberWest rock quarry was shut down more than once, due to forest fire concerns, and riprap supplies dwindled. During these times, the BC Ministry of Transportation kindly provided rock from its quarry. Both of these donations show the importance of broad partnerships and community involvement in the success of such large-scale projects.

With the sudden onset of winter and the high river levels from November to March, completing the bioengineering works proved to be a challenge. Works were suspended due to the extremely high flows that precluded installation until late spring, which was outside of the planting dormancy window. The lack of fine-grained soils in the berm also made installation difficult. An irrigation system, installed to avoid hand watering, proved to be too problematic and prone to vandalism and was therefore discarded in favour of a regular hand-watering program. Although the results of the bioengineering treatments were mixed, with success rates for the brush layering and live staking about 50% and 80%, respectively, the project team is pleased with the success and more treatments are planned.

A valuable side-benefit of the project to date has been the observed recreational use of the access road by park visitors and recreational anglers. Visitors have commented on the scale of the construction works and viewing opportunities of the impressive bluff formation. Sport fishers have benefited by the creation of excellent adult steelhead holding water off the ends of the bendway weirs. There has been a noticeable increase in angling effort and catch in this short reach of the Cowichan River.

The Importance of Monitoring

An apparent trend in the restoration industry is to focus on the construction of capital works without committing enough resources to long-term monitoring of a project's effectiveness. How do we determine that constructed projects are effective? Projects like the Stoltz Bluff require a well-designed monitoring program that involves water quality sampling, hydraulic sampling of spawning redds, benthic sampling, sediment sampling in spawning gravel areas, and ongoing bathymetric, orthophoto, and (or) photopoint monitoring. By monitoring effectiveness, it can be fully determined whether the $1 million spent for construction in 2006 and 2007 has been the best use of limited resources.

Limited pre- and post-construction monitoring in the river upstream and downstream of Stoltz Bluff (winter of 2006/07) has found that suspended sediment concentrations downstream of the bluff were much lower than before the project was constructed. Fishing guides have also reported improved water clarity in the Stoltz Bluff and downstream areas. These results are considered anecdotal and will be improved through a more rigorous monitoring program in future

Funding limitations in 2008 will likely restrict monitoring to topographic surveys and photographic evidence of the volume of new sediment "captured" on the constructed terrace during the winter of 2007/08. This was initially done in the summer of 2007 when it was determined that nearly 6800 m^3 of sediment was retained on the terrace in the winter of 2006/07. Plans are underway to seek funding for a more intensive monitoring program in 2009. With support, the hope is that the river will be monitored over several years to fully determine the level of success of the project and refine plans for future project phases.

Additional Information:

A two-part video that follows the planning and construction phases of the project is available at:

Part 1:
http://www.waterbucket.ca/wcp/sites/wbcwcp/documents/media/35.wmv

Part 2:
http://www.waterbucket.ca/wcp/sites/wbcwcp/documents/media/52.wmv

For further Information, contact:

Craig Wightman
BC Ministry of Environment
3-1200 Princess Royal Avenue
Nanaimo, BC V9S 3Z7
Email: Craig.Wightman@gov.bc.ca

Marc Gaboury
LGL Ltd. Environmental Research Associates (LGL)
2459 Holyrood Drive
Nanaimo, BC V9S 4K7
Email: mgaboury@lgl.com

Dave Murray
Kerr Wood Leidal Associates Ltd. Consulting Engineers (KWL)
201-3045 Douglas Street
Victoria, BC V8T 4N2
Email: dmurray@kwl.ca

Acknowledgements

James Craig, BC Conservation Foundation

John Walker, Black Label Consulting

Jas Sandu, Johel Bros. Contracting Ltd.

Mel Sheng and Brian Tutty, Fisheries and Oceans Canada

Don Closson, BC Parks

Ernie Elliott, Cowichan Tribes

Kate Miller, Cowichan Valley Regional District

Cowichan Stewardship Roundtable

Stefan Joyce, Craig Sutherland, Erica Ellis, and Nigel Skermer, Kerr Wood Leidal

References

BC Conservation Foundation (BCCF). 2007. An enhanced business plan for the Georgia Basin Living Rivers Program. Prepared for the Living Rivers Trust Fund Advisory Group. 70 p.

Burt, D.W. and J.C. Wightman. 1997. The fish resources of the Cowichan River and their economic value. Prepared for the B.C. Ministry of Environment, Lands and Parks, Nanaimo, B.C. 38 p.

Burt, D.W., M. Wright, and M. Sheng. 2005. Cowichan River Chinook salmon incubation assessment, 2004–2005. Prepared for the Pacific Salmon Commission, Vancouver, B.C. 28 p.

Houwers, C. and M. Gaboury. 2006. Rare plant assessment and active raptor nest search, Stoltz Bluff stabilization river erosion protection plan – Cowichan River Provincial Park. Prepared for BC Parks, Nanaimo, B.C.

Kerr Wood Leidal Associates Ltd. (KWL). 2006. Cowichan River Stoltz Bluff stabilization river erosion protection works – design brief. Prepared for BC Conservation Foundation, Nanaimo, B.C.

Kerr Wood Leidal Associates Ltd. and LGL Ltd (KWL and LGL). 2005. Cowichan River sediment management. Final report prepared for Cowichan Treaty Office, Duncan, B.C.

Lill, A.F. 2002. Greater Georgia Basin steelhead recovery action plan. Prepared for the Pacific Salmon Foundation. 107 p.

LGL Ltd. 2005. Cowichan recovery plan. Draft prepared for Cowichan Tribes Treaty Office, Duncan, B.C. 170 p. + appendices.

LGL Ltd. and Kerr Wood Leidal Associates Ltd. (LGL and KWL). 2005. Preliminary sediment management review – Stoltz Slide and Block 51. Prepared for the BC Conservation Foundation, Nanaimo, B.C. 26 p.

Newbury Hydraulics. 1997. Report on assessment and stabilization of the Cowichan River Stoltz slide reach. Prepared for the B.C. Ministry of Environment, Lands and Parks, Nanaimo, B.C.

Northwest Hydraulic Consultants Ltd. (NHC). 1996. Cowichan River Stoltz Slide. Prepared for the BC Conservation Foundation, Surrey, B.C. 14 p.

2007 Watershed Management Information Needs Assessments Published

The FORREX Watershed Management Extension Program has recently conducted Watershed Management Information Needs Assessments for the Southern and Northern Interior regions of BC. The assessments were conducted through key-informant interviews with a range of parties involved in water-related issues in the respective regions. Reports based on both information needs assessments (Redding and Nickurak 2008, Redding *et al.* 2008) are now available on the FORREX Web site. While there was considerable overlap between information needs in both regions, some differences were apparent. Important themes requiring research and extension that emerged from these surveys include:

- reducing uncertainty around potential climate change impacts on water;
- quantifying the effects of forest disturbance (especially the mountain pine beetle infestation and harvesting) on water quantity and quality;
- increasing hydrologic knowledge and education for professional, the public, and First Nations;
- evaluating operational tools for predicting the effects of forest disturbance on water resources;
- increasing understanding of groundwater resources (inventory) and protection (legislation);
- developing water resource monitoring capacity.

To access the reports, please see the below links:

Redding, T. and K. Nickurak. 2008. 2007 Northern Interior needs assessment for watershed management. FORREX Forest Research and Extension Partnership, Kamloops, B.C. File Report No. 08–01.

URL: ***http://www.forrex.org/publications/other/FileReports/fr08-01.pdf***

Redding, T., S. Lepsoe, and M. Laurie. 2008. 2007 Southern Interior needs assessment for watershed management. FORREX Forest Research and Extension Partnership, Kamloops, B.C. File Report No. 08–02.

URL: ***http://www.forrex.org/publications/other/FileReports/fr08-02.pdf***