Taweel Project
Stream Reach Monitoring

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Keywords

Fluvial geomorphology; channel change; orthoimage; permanent reach sites; cross-sections; streamflow; biogeoclimatic ecosystem classification; Boulder Creek; Taweel.

Abstract

Under natural conditions, some very large openings occur across the landscape of the interior plateau as a result of disease or wildfire. More recently, suppression of wildfires has reduced the representation of these features in the landscape and there has been interest in developing some larger cutblocks to mimic them. The Forest and Range Practices Act requires forest licensees to assess watersheds prior to forest development, and to use the results of these assessments to provide constraints to harvesting that will sustain natural hydrologic processes. There is a general understanding that cutblocks alter watershed hydrologic processes, and concern about the possible hydrologic effects of large cutblocks has been expressed. Watershed hydrology has typically been conducted in coastal or mountainous environments and the Taweel Project is focused on a representative portion of the high elevation plateau which covers much of interior B.C. Three small catchment basins will be monitored for streamflow, channel morphology, stream temperature and snow distribution. One basin (Skwil Creek) will not have any logging and will be the control, two other catchments (Treatment East and West) will have 5 years of pre-logging and 5 years post-logging data collection.

The Stream Reach Monitoring component of the Taweel Project has established five monitoring sites within the watershed. One on each of the treatment and control catchments, one just above the Taweel FSR bridge crossing and one near the confluence of Copper and Boulder Creeks. The Boulder Creek watershed drains eastwards into Taweel Lake on the Nehalliston Plateau, which then drains through Lemieux Creek into the North Thompson River near Little Fort. The lower elevations (below approximately 1400 metres) of the watershed are within the Sub-Boreal Spruce moist mild biogeoclimatic zone while the upper elevations are within the Engelmann Spruce-Subalpine Fir dry cold zone (from 1400 m to peak of Mt. Hagen at 1850 m). A stream channel is in a state of dynamic equilibrium as hydrology and sediment supply vary and framework elements develop, erode, and migrate downstream. As forest development occurs, the amount of sediment entering the stream network increases and the natural stream framework is altered. Subsequently, the habitat for aquatic organisms is reduced in quality and diversity. Permanent cross-sections provide detailed topographic survey information which, with a complementary orthoimage, present a readily repeatable and descriptive tool to monitor channel change.
Summary of activities, results and outputs

The Taweel Project: Stream Reach Monitoring project was awarded funding in September 2002. In anticipation of proposal success, watershed similarity analysis and stream profiles had already been completed. A field review of potential sites within the main watershed and in the smaller catchments had been completed with Dr. Dan Moore from UBC in mid-June. Cross-sections were installed on June 17th in the Treatment East, Treatment West and Skwil Creeks catchments and on June 18th a site was established at the confluence of the tributary Copper Creek and Boulder Creek. All sites in the watershed, including the Main Reach Site near the Taweel Lake Forest Service Road, are located in close proximity to Dr. Moore’s streamflow data stations.

At each reach site, the channel width was measured in several locations along the proposed section and this distance was then used to mark the cross-section intervals along the thalweg of the stream. Cross-sections are aligned perpendicular to the creek thalweg at the specified interval and are located so as to provide a clear line of sight from one end to the other. Rebar posts were pounded into the ground at the ends of the eleven cross-sections, each a channel width apart, to establish a stream reach site which is 10 channel widths long. The cross-sections stretch across the active creek channel, well above high water level, and include backchannels and other floodplain features. Two benchmarks are established at each reach site, one at each end of the reach, by driving nails into the boles of mature trees. These benchmarks are located on the margins of the floodplain, higher and more protected from the main channel, and should survive any catastrophic hydrologic event.

Once funding was confirmed, measurement of the reach sites began. The Boulder Copper Reach Site cross-section was measured on October 8th. The Treatment West Site was measured October 16th, the Treatment East Site on October 16th and 17th and the Skwil Creek Site on October 17th. This measurement consisted of surveying each of the cross-sections (rebar to rebar) across the creek with an automatic level, rod and fixed tape. The initial installation of the cross-sections is excessively intricate to get as much detailed information as is possible on the channel profile; measurements include all changes in elevation, high water levels, active flow level, bars, undercutts, log jams and large boulders or other features in the channel.

Simultaneously to the auto-level survey, the total station survey, monopod photography and longitudinal profile of the reaches was carried out. The Treatment West Site was completed October 16th, the Treatment East Site was completed October 17th, and Skwil Creek Site was completed October 18th. The total station survey, monopod photography and longitudinal profile work was harnpered by short days and cold weather and so took a lot longer to complete than was expected. The Boulder-Copper Reach Site was not completed as it is located in a confined valley and the angle of the sun was too low to provide good light for a long enough duration for high quality photography. The sheltered nature of the site also meant that a discontinuous cover of snow on the ground obscured much of the stream framework elements. Future funding will be required to complete the field procedure at this site and produce the orthoimages and maps.

The total station survey requires establishment of a base datum at each reach site to which all other points can be tied, usually the downstream benchmark is used. The
survey is precise within millimetres in the vertical and horizontal, and it forms the base upon which the cross-section surveys, orthoimage and maps are created. This survey improves on the old technique involving a combination of triangulation and auto-level turning points which were then rubber sheeted from the pole photography to produce a map. Re-survey of the sites will now involve quick re-measurement of each cross-section based upon the assumption that the rebar posts remain stationary and their locations are already known.

The monopod photography involves a 35-mm SLR camera equipped with a 28-mm lens, motor drive and external shutter release. The camera is mounted on a three way, self-levelling gimbal platform attached to a post which is inserted into the top of a 10 metre telescoping pole. The pole is made up of four 2.5 metre long, tapering, hollow aluminum poles with fibreglass inserts which fit together to form the 10 metre length. High speed colour print film, usually 400 ASA, but also 200 or 800 ASA depending on light conditions (canopy density and sunlight), was used.

At each site “flight lines”, 4 to 5 metres apart and parallel to the creek and which maximized the coverage of the channel and banks were determined. At set intervals, 7 metres apart along flight lines, a “pole marker” was placed to indicate the position of the pole. Ground control points (GCP) were created where a numbered red and white card (size of a business card) was placed and surveyed in with the total station. The GCP were positioned so they would appear in the overlap area of multiple images and to obtain complete coverage of the creek, and are especially important at the channel margins where there is large topographic displacement from water level to the top of the bank. For a typical reach site 40 to 50 GCP were surveyed and used for controlling the scanned photographs in the office. At each of the pole markers a series of 7 photographs were taken parallel to the flight lines, three leaning downstream at increasing vertical angles, one vertical and three leaning upstream at decreasing vertical angles. When necessary, additional photographs were taken left and right of the flight lines to obtain coverage of significant features on the margins of the channel. This system is more organized and decreased the confusion with mosaicking photographs in the office. The resulting photographs are approximately 1:300 to 1:400 scale and cover an area of approximately 50 to 60 m$^2$ of the channel and adjacent riparian zone. The orthoimage for Skwil Creek Reach Site is attached (Figure 1), flow is to the left of the page (south).

The longitudinal profile through the cross-section site provides various easily measurable parameters, including pool and riffle spacing, volumes of stored sediment, diameter, length, age, and characteristics of large woody debris, especially in log jams. These are presented as charts of the various parameters against the distance along the creek.

When all of the collection is complete the cross-sections, orthoimage, pebble counts and longitudinal profile will provide information on:
- channel morphology, width, depth, gradient and stability;
- thalweg depth and location;
- framework element spacing (pool, riffle, cascade, glide, step, bars);
- sediment characteristics (particle size, shape, bar height and type);
- sediment sources and anelioration of effect downstream and through time;
- aggradation (sediment wedges and de-watering), degradation;
- rate and timing of movement of sediment wedges;
- reaction time to an influence (forest development in general, restoration procedure, precipitation event, snowmelt, landslide);
- large woody debris presence, orientation, amount, diameter and length;
- size, age and characteristics of log jams; and
- effect of forest development on habitat alteration, diversity and quality.

Data from the Skwil Creek Reach Site is attached as three charts: the longitudinal profile, the stored sediment and the roughness. The longitudinal profile (Figure 2) illustrates the elevation of the stream bed and the top of the water as measured along the thalweg. The vertical scale is exaggerated (11.56 times horizontal) and the stream in the field is actually has a very gentle gradient of around 4% (approximately 2 degrees). The stored sediment chart (Figure 3) illustrates the volume of sediment (cubic metres per square metre) observed along the channel. This chart can be compared to the orthoimage (Figure 1) and the available sediment can be seen upstream of the mid-channel island where the channel widens. Commonly the stored sediment chart will reflect sediment wedges forming upstream of a log jam and scouring immediately downstream. Roughness (Figure 4) is a measure of the b-axis measurement of the largest particle divided by water depth and shows where the bed material is coarsest in relation to the bankfull measurement. At the Skwil site an interval of 2 metres occurred between each measurement and this graph illustrates the relative smoothness of the section. Only two “rough” spikes are noted at around 30 and 90 metres: they both appear to indicate the presence of a large rock in the interval.

The auto-level survey data from the four sites was entered into excel spreadsheets and checked for errors and inconsistencies. This information was then added to the total station survey data and the entire data set was used to compile detailed planimetric maps. The auto-level data is also used on it’s own to plot profiles of the cross-sections and when re-measured the individual cross-sections can be compared. Areas of aggradation and degradation of the banks, bars and bed can be highlighted and volumes of sediment eroded or deposited can be obtained.

The channel images from the pole photography were scanned in colour and imported into the computer program IMAGINE OrthoBASE. The co-ordinates of each GCP from the total station survey were used to rubber sheet the images (planimetric errors include topographic displacement, e.g. bank top to water surface elevations, and radial lens distortion). The corrected individual images were then mosaicked to create a seamless orthoimage of the entire reach site. The orthoimage was then exported into a computer assisted drawing package which, with the detailed cross-section data, was used to create a detailed planimetric map of the reach site. The orthoimagery techniques enable development of accurate large scale maps on which the various features of the streams are plotted, including riparian areas, water surface, bar surface, woody debris, large boulders, stone lines, pools, riffles, cascades and log jams.

Preliminary extension of results from the Stream Reach Monitoring component of the Taweel Project were presented as part of an informal presentation and poster display at the SISCO Meeting in March, 2003.
Figure 3: Skwil Creek Stored Sediment
Figure 4: Skwil Creek Roughness
Evaluation of project outcomes

The overall objective of the stream reach monitoring component of the Taweel Project is to establish long-term monitoring sites on three small catchments in the upper Boulder Creek watershed and two downstream sites to monitor the overall change in the watershed. One reach site was established in the watershed just above the Taweel Lake FSR in 2001.

Funding for 2002-2003 was to cover site selection, cross-section installation, auto-level survey, total station survey, monopod photography, longitudinal profile, orthoimage production, planimetric map production and longitudinal profile data analysis for four sites (Table 1)

<table>
<thead>
<tr>
<th>Selection + installation</th>
<th>Auto-level survey</th>
<th>Total station survey + monopod photography</th>
<th>Orthoimage production</th>
<th>Planimetric map</th>
<th>Data analysis</th>
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</thead>
<tbody>
<tr>
<td>Boulder Copper</td>
<td>June 2002</td>
<td>incomplete</td>
<td>incomplete</td>
<td>incomplete</td>
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</tr>
</tbody>
</table>

Office preparation, field review and site installation were all finalized prior to funding approval in September 2002. Once funding was confirmed I returned to the sites to survey them with the auto-level. The consultant, Fluvial Systems Research Inc., had committed to other projects and they were delayed in coming to complete the total station survey, photography and profile until mid-October. This work was restricted by the cold weather and shortening days and took longer to complete than was expected. As a result of timing, the Boulder-Copper Reach Site survey, photography and profile were not completed as the quality of the photography would have been degraded by the poor light conditions. The requested funding was just sufficient to cover the increased costs associated with the extended field surveys, plus all of the other original commitments. Future funding will be required to complete the field procedure at this site and produce the orthoimages and maps.

For all four remaining sites the auto level data survey was entered into the computer and cross-section profiles drawn. Where the total station survey had been completed, the auto-level data was added to this data set, and the orthoimage was compiled, the planimetric map derived and the longitudinal data analysis completed. These products are available at this time and the Skwil Creek reach site orthoimage (Figure 1) and long profile data analysis (Figures 2, 3 and 4) are attached.
Assessment of the applicability of results

Natural physical science typically requires long-term research, including a significant post-logging period of observation. Immediate results are available in the form of orthoimages and planimetric maps which illustrate the reach site characteristics and from which a generalized picture of the fluvial system function in each can be formed. Reach sites in the treatment watersheds will be compared with the control watershed, before and after forest harvesting occurs. Any alterations in the streams as a result of forest development, hydrologic events, landslide occurrences, blowdown, log jam build-up or destruction, or other forcing factor the changes will be captured through re-surveying and re-photographing the reach sites.

The long-term approach of the Stream Reach Monitoring study increases certainty of the results. It is reasoned that long-term is necessary because forestry is a long-term management activity, and management decisions must be made today that affect values for decades. Long-term monitoring is also the only way to reduce uncertainty about the long-term consequences of infrequent events (e.g. damage from exceptional landslide events in the spring and early summer of 1997, or drought in summer 1998). Understanding this, Tolko has altered its forest development plan to accommodate research objectives over the 10-year study period. This means that there must be a long-term vision and commitment to the project, since a lot of money and time will be invested before results are available. Over ten years, this experiment will produce results that may lead to improved forest and watershed resource management planning throughout the snowmelt dominated watersheds of interior British Columbia. It will also add to our fundamental scientific understanding of small plateau watersheds and stream channels.

The move to a results-based forest practices code based on reliable science greatly increases the pressure on managers to understand research and use good scientific results. Easily accessible and understandable technical reports will become a necessity for forest managers. An important component of this research is getting the procedures streamlined and made available to a wide range of forest managers and resource consultants. Talks and poster presentations are planned to reach a broad spectrum of interested audiences. Researchers associated with the Ministry of Forests will continue to provide extensive support to industry in interpreting and applying these technical results.

The most direct end-user of this research will be Tolko Industries Ltd. who are the operating licensee in the Boulder Creek watershed. However, the results of the study will be applicable to all licensees operating on the high elevation plateau which covers much of interior B.C. In the southern interior many watersheds which provide valuable fish habitat, and from which community water supplies are obtained also sustain British Columbia's natural resource industry. In meeting the demands of society, forest development within these watersheds must be carefully laid out and based on sound hydrologic knowledge. This study will provide criteria and indicators of stable channel morphology and allow scientists to explore the effects of a broad range of management and environmental options. These in turn can be used to develop tools that enable foresters to develop those management strategies which allow them to find the balance between timber sustainability, community water supplies and aquatic habitat in the southern interior.
Knowledge gap and further research

In January of 2000, Tolko Industries Ltd. initiated a hydrology study in the Boulder Creek watershed on the Nehalliston Plateau. The study is in conjunction with the development of CP 848, which includes blocks ranging in size from less than 5 hectares up to about 300 hectares. Two treatment watersheds will be logged in a single pass in late summer 2005. Therefore, including the year 2000, there will be six years of pre-logging data, and five years of post-logging data available by the end of 2010.

This research was prompted by an anticipated concern regarding the potential hydrologic impact of the 300 hectare block on snow accumulation and melt patterns, and on the hydrologic regime. A review of the available relevant research literature indicates that small blocks have a larger impact on snow accumulation than large blocks, and that in large openings, substantial snow can be lost from the opening through wind scour and sublimation. The conclusion was that the effects of a single 300 ha block on snow accumulation, melt, and hydrologic regime were likely to be similar to or smaller than the effects of a series of smaller blocks with the same total area.

Historically, many of the forest ecosystems in BC have experienced frequent wildfires that ranged in size from small spot fires to conflagrations covering tens of thousands of hectares. With the movement towards forest management based on natural disturbance patterns there will be a need for large openings across the landscape of the interior plateau. Although there has been a considerable amount of research on the hydrological effects of conventional sized cutblocks (e.g. 40 hectares or less), there is a lack of research in larger blocks. Very little research has been done in conditions similar to the Nehalliston Plateau, or in blocks approaching 300 ha in size. Therefore, with the development of CP 848 there is an opportunity to conduct research to fill a knowledge gap. Accordingly, it was proposed that research over the next ten years, and possibly beyond, should be undertaken to document the hydrologic changes associated with the development of CP 848.

The multidisciplinary monitoring of the Taweel Project increases certainty for many forest values. Multidisciplinary work is needed to provide comprehensive guidance, to anticipate future issues and to reduce the uncertainty of which recommendation to apply. The Taweel Project presently covers the physical sciences of snow accumulation and melt, streamflow and channel responses to forest development, but the team is bringing in at least one researcher interested in the biological aspects of the aquatic environment. For many of the biogeoclimatic zones in the interior, the Forest Practices Code Biodiversity Guidebook recommends the 60% to 80% of a landscape unit should have openings 250 hectares to 1000 hectares in size. This desired future condition may not necessarily be achievable unless the effects on other resources, such as fish and water, are understood.

Most forest hydrology research in B.C. has focused on coastal biogeoclimatic zones and the mountainous southern interior and little research has been conducted in the more rolling upland terrain typical of the interior plateau. This research will help fill these knowledge gaps, providing a stronger scientific basis for estimating future hydrologic impacts associated with proposed harvesting, and add confidence to forest planning decisions throughout the plateau-dominated environments of central B.C.
**Impact of key operational variances**

Cold weather and decreasing daylight hours in mid October forced delay of the total station survey, monopod photography and longitudinal profile at the Boulder-Copper Reach Site. This in turn meant that the orthoimage, planimetric map and longitudinal profile statistics would be incomplete.

The impact of this is likely to be marginal, it is intended that the established site be photographed in the coming field season. In the interior the peak of the snow-dominated freshets typically last 5 to 10 days, although there are continued higher flows from mid April through June. During this very short peak flow event the majority of the sediment and woody debris movement occurs, pools fill and riffles migrate, and the dominant framework elements such as stone lines or log jams form or break up. The snowpack is below normal levels across the interior plateau and the spring freshet is unlikely to be large and will probably only cause moderate sediment and woody debris movement as a result. Leaving this for a year will decrease our long-term observations and characterizations of the reach site, but ensuring high quality photography is more important.