Project # Y071074- Hydrologic Indicators for Watershed Sensitivity to Peak Flow Changes in Small Watersheds

Executive Summary

Project Purpose and Management Implications: The goals for this project are to characterize the range of return periods for bankfull discharge (the discharge at which flooding begins) and effective discharge (the discharge which transports the most sediment) for small headwater streams in British Columbia, to evaluate the scaling relations for bankfull and effective discharge in small streams, and to assess the effectiveness of bankfull and effective discharge as indicators of watershed sensitivity to changes in peak flow. The project will lead to improved management of small forested watersheds through the identification of those watersheds most sensitive to hydrologic disturbance and understanding of the factors that contribute to such sensitivity.

Start Date, Project Duration and Previous Funding: The project began in April 2006 and is anticipated to continue for three years. There are no previous sources of funding. BCFSP funding for the project continues as Project # Y028074.

Overview of Methodology: Our core data set consists of small watersheds less than 100 km² with currently functioning or historic Water Survey of Canada gauges which provide a long-term record (at least 20 to 30 years of data) of peak flows within the selected watersheds. We supplement this data set with other long term gauged watersheds outside the WSC data network, such as East Creek.

The spatial distribution of WSC gauged streams within British Columbia is uneven, with the majority of gauged basins of our defined scale located in the southern portion of the province, while in the north, the gauged small watersheds are much more widely scattered. We have selected the southern watersheds for efficiency. Northern watersheds will be included if time and finances permit.

For each watershed, we will analyze the long-term flow record and fit distributions to the observed data to determine the return periods of flows of various magnitudes. At each gauge site, we will survey stream gradient, and survey cross-sectional profiles several times over the reach in which the gauging site is located, and determine the bankfull stage, bankfull width and bankfull discharge from the surveyed stream cross-sections and gradient. We will then determine the return period of the calculated bankfull discharge.

At each gauge site, we will characterize the surface and subsurface sediment grain size distributions for the gauged stream reach. The surface grain size distribution at each site will be determined using the photogrammetric analysis method (Graham, Reid and Rice, 2005) which has recently replaced the Wolman pebble count (Wolman, 1954) as the preferred technique. Subsurface sediment will be characterized by bulk sampling, sieving the coarse fraction on site and splitting the fine fraction for laboratory sieving. Once we have determined the sediment size distribution of the surface and subsurface bed material within the channel, we will be able to determine the effective discharge for the reach in which the sediment was sampled using the Shields equation (Shields, 1936) as modified by Wilcock and Kenworthy (2002) and Wilcock and Crowe (2003) and the previously determined frequency distribution of peak discharges from our CFA analysis. We will use existing sediment transport and hydrology data from long-term research watersheds (Carnation Creek, East Creek and Harris Creek) to calibrate our sediment transport equations. We have selected a subset of watersheds for the installation and monitoring of marked tracers. Data from the tracer studies will be used to evaluate the size and mobility of moving bed material, to evaluate channel stability, and to test and calibrate the outcomes of the sediment transport model in order to verify that the model is accurately modelling bedload mobility.

We will survey and count woody debris within each surveyed reach in order to account for differences in woody debris within our studied channels. Woody debris has been shown to significantly affect sediment transport in smaller watersheds (Hassan et al, 2005a) and hence must be accounted for in our analysis. Likewise, we will use our photogrammetric analysis of the channel bed to evaluate channel structural elements (Hassan et al, 2005b) in
order to account for flow resistance. Combining our analysis of the woody debris present in the bed with the presence or absence and state of the bed structural elements and channel form will allow us to develop a conceptual model of channel stability and sediment storage. The outcome of this model will be a classification system for channel stability and sediment storage which will facilitate comparison of watersheds across our scale of research by comparing streams of differing sizes but similar stabilities.

For each watershed, we will determine hypsometry, watershed elevation, overall channel slope, watershed area, and similar morphometric parameters from GIS analysis of topographic base data. We will evaluate stream order at our surveyed reach site using the mapped stream channel network at 1:20,000 scale from BC TRIM mapping. We will use Meteorological Survey of Canada (MSC) long-term climate records from adjacent climatic stations to infer watershed climatic parameters such as annual precipitation, annual temperature and ratio of snowfall to rainfall.

We will use the most recently flown aerial photography, together with historic photos and forest cover information from BC Ministry of Forests and Range and forest licensees, to evaluate not only forest cover, but also changes in forest cover, riparian vegetation, and stream morphology over the period of our gauged hydrometric record for each watershed. Since we are attempting to evaluate the potential for changes in forest cover to affect the frequency of bankfull and effective discharge, we cannot overlook the potential for such changes within our period of record. Additionally, we will use aerial photos to survey and account for major sediment sources within each watershed in order to permit comparison of existing sediment supply to our study watersheds. We will exclude watersheds where debris flow is the dominant sediment transport mechanism.

Once we have generated our database of watershed parameters, we will use analysis of variance (ANOVA) and Bayesian methods to determine the most significant parameters affecting the return periods of bankfull and effective discharge in our studied watersheds. We will evaluate the relative importance of bankfull discharge, effective discharge, and ratio of bankfull discharge to effective discharge as indicators of watershed sensitivity to disturbance. We will determine the degree to which bankfull and effective discharge can be relatively quickly estimated for small ungauged watersheds, in order to determine if our analysis will be successful in providing land managers with a rapid method of evaluating a watershed’s sensitivity to disturbance.

**Project Scope and Applicability:** The project will be applicable to all small, forested watersheds in the southern half of the province (Coast, Interior, and Columbia). Extension to Northern BC will be dependent on the availability of representative hydrologic data; small watersheds in the north with long-term data are underrepresented by the WSC sampling program.

**Interim Conclusions, Inferences or Other Information:** As of April 2007, we have completed approximately half of the field data collection and analysis for the project. It is therefore premature to offer any interim conclusions or inferences. We have developed expertise in the particular requirements of the program for photogrammetric analysis of surface sediment which we will gladly share with other researchers interested in using this technique.

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