CGU HS Committee on River Ice Processes and the Environment
17th Workshop on River Ice
Edmonton, Alberta, July 21 - 24, 2013

Winter Ice Processes of the Kananaskis River, Alberta

Stefan Emmer, Jennifer Nafziger, Vincent McFarlane, Mark Loewen and Faye Hicks
Dept. Of Civil and Environmental Engineering, University of Alberta, Edmonton, AB, T6G 2W2
emmer@ualberta.ca; mrloewen@ualberta.ca

1. Introduction

The Kananaskis River (Figure 1) is a steep, gravel bed stream located in the southern Rocky Mountains of Alberta. The section of river between the Pocaterra Dam and Barrier Lake is intensely regulated for hydro-peaking operations, with the upstream dam releasing flows of 23 m^3/s for 6 hours per day during the winter months, compared to a base flow of 0.5 m^3/s (data source, TransAlta Utilities). The rapidly fluctuating water levels produced by these hydro-peaking events create a variety of interesting ice processes for study, particularly anchor ice (Andres and Van Der Vinne, 1997), ice dams and ice jams. Thus it is an ideal site to study the effects of streamflow regulation on river ice processes; anchor ice formation and morphology in particular.

2. Methodology

In order to study the ice processes of the Kananaskis River, four sites were monitored throughout the 2012-2013 winter season (Figure 1). Two major sites, located at the Fortress Bridge and Kananaskis Village Bridge, were densely instrumented. Less intensive monitoring was conducted at two additional sites, Opal and Mount Kidd RV Park, located between the two major sites. Tree mounted time-lapse cameras were installed at all sites and programmed to take photos every hour. Although most cameras were unable to monitor night-time conditions, some were equipped with a flash, allowing basic observations of water level and meteorological conditions during periods of darkness.

At each of the two major sites three water level sensors were deployed, and pairs of water temperature sensors were placed at and below the river bed in multiple locations. In addition to deploying automated equipment, frequent site visits were undertaken to observe ice conditions, take ice samples, conduct velocity measurements and take underwater photos. These field trips were primarily focused on the Kananaskis Village Bridge site, situated 36 km downstream from the dam, as it exhibited the greatest variety and frequency of ice events. This poster presents and describes these observations in detail.

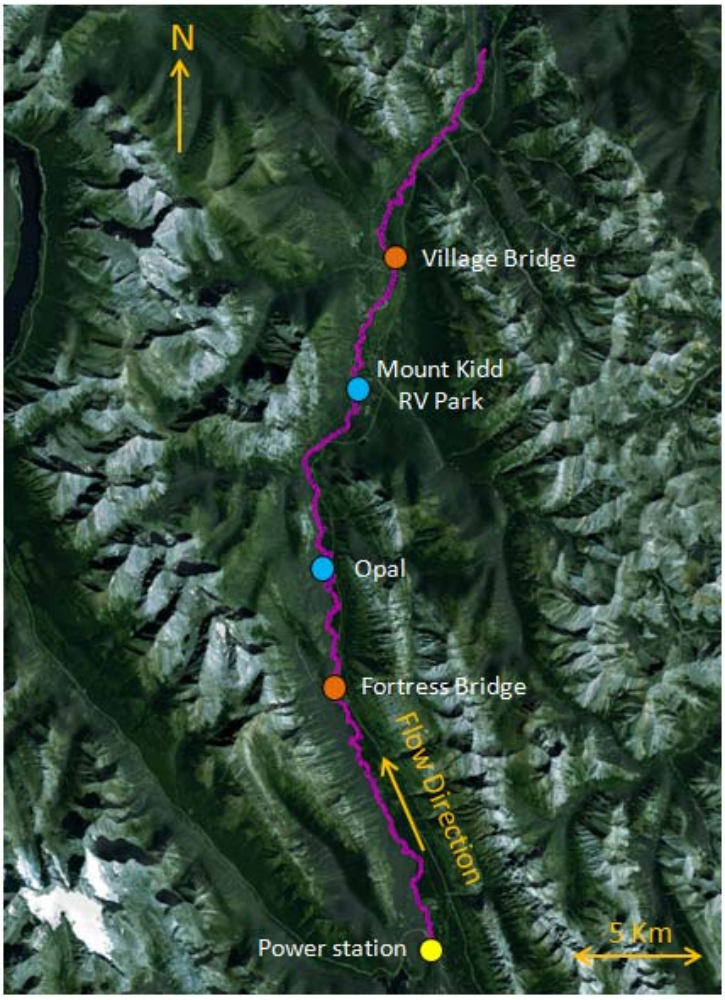

Figure 1: Kananaskis River from Pocaterra Dam power station to the Village Bridge.

highly variable water levels produced by hydro-peaking, formations of Type II anchor ice would often be left exposed to the air during the day. These frozen structures, in concert with varying water levels, created secondary ice effects such as anchor ice dams (Figure 2) and frozen slush carpets, which were seen to be strong enough to resist release through multiple hydro-peaking events.

During one of the coldest periods in mid-January, a four day period when daily average temperatures were below -14^{o}C, a unique ice process, characterized by the rapid accumulation of large quantities of frazil slush, was observed. Over a single event, 1 to

3. Ice Processes Observed

Based on their field study, Stickler and Alfredsen (2009) described two types of anchor ice, distinguishable by growth pattern, density and turbulence intensity (which was expressed using a dimensionless Reynolds number). At the Kananaskis Village Bridge site, two modalities of anchor ice formation were also observed. The first of these was a thin 1 to 5 cm layer of anchor ice that closely resembled the Type I anchor ice described by Stickler and Alfredsen (2009). It formed on top of the river substrate, filling spaces between large cobbles and boulders. This Type I ice was seen to adhere only weakly to bed substrates, and formed more stable patches in slower moving sections of the stream. The second modality of anchor ice formation observed at the Village Bridge site, was similar to the Type II anchor ice described by Stickler and Alfredsen (2009), forming on the fronts and sides of protruding bed elements. Forming more readily in faster stream sections, this anchor ice was stronger and more resistant to release than the Type I ice. Due to the

Figure 2: Local ice dam formed by exposed Type II anchor ice.

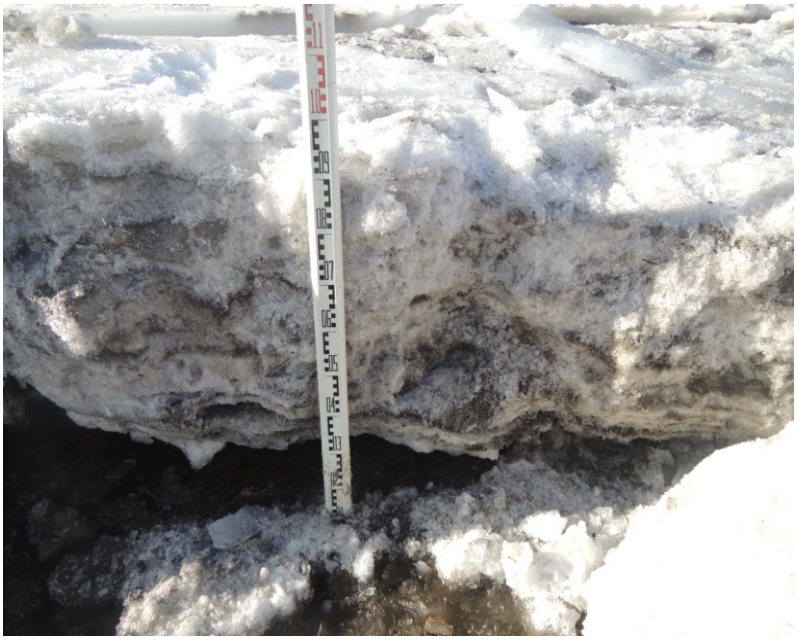

Figure 3: Example of frazil slush accumulation.

1.5 m of frazil was deposited along the left and right banks as water levels dropped (Figure 3). This deposition occurred over a series of hydro-peaking events, with each subsequent event filling more and more of the channel with frozen slush. As frazil ice filled the channel, backwater effects increased causing each subsequent hydro-peaking wave to reach a higher level than the previous. This produced layers of aufeis and frazil slush on top of previous ice formations. Due to their relatively high strength, these formations released in large chunks, ultimately creating a mid-winter ice jam immediately downstream of the study reach.

4. Summary and Future Plans

The ultimate goal of this study is to use field observations of river ice processes on the Kananaskis River, to determine whether a relationship exists between the types of processes observed, and the corresponding meteorological and hydraulic conditions. The next step in this research will be to determine the effects the observed ice processes have on river hydraulics, in particular: hydro-peaking wave propagation and shape, water levels and sediment transport.

Acknowledgements

The authors would like to thank the Natural Sciences and Engineering Research Council of Canada's (NSERC) for funding this research through the NSERC HydroNet network, research grants, and graduate scholarships. Thanks are also extended to Roger Drury and Scott Taylor at TransAlta Utilities for providing flow data as well as support in the field to aid this research.

References

Andres, D.D., Van Der Vinne, G.P., 1997. "Freeze-up processes on the Kananaskis River: Summary of the 1997-98 observations and an evaluation of the potential measures to reduce ice-related flooding." Prepared for TransAlta Utilities Ltd., Edmonton, Alberta.

Stickler, M., Alfredsen, K.T., 2009. "Anchor ice formation in streams: a field study." Journal of Hydrologic Processes 23: 2307-2315.