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Ice Tree Scar Evidence of Historic Ice Events on the Grasse River

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Ice tree scars provided important physical evidence on the timing and severity of historic ice jams on the Grasse River in northern New York State. Detailed mapping ice scars along a 11-mile section of the Grasse River, indicated the spatial extent and height of moving ice and ice jams during the past 40 years. The chronology of ice past events was determined from analysis of annual growth rings of ice-scarred trees. The tree scar evidence agreed with numerical model simulations of historic ice jams, a scour analysis based on the age and stratigraphy of bed material, and an ice jam hindcasting analysis based on hydro-meterorological data. Results of these related investigations are described in the "April 2004 Addendum to the Comprehensive Characterization of the Lower Grasse River" (Alcoa, 2004a, 2004b) and they also appear as separate papers in these proceedings.

1. Introduction

Tree scars can be used to estimate the presence of ice jam conditions, the elevation of breakup ice runs on rivers, and tree ring data can provide information on the years that ice jams occurred (Gerard, 1981, Uunila, 1997). Ice damage to trees along rivers ranges in severity from mild abrasion of the outer bark, removal of the bark down to the wood surface, gouging and tearing of the wood surface, to complete uprooting of the tree. The most severe tree scarring typically results from moving ice during river breakup, but minor damage is also possible from movement of sheet ice at lower stages. Maximum tree scar elevations often result from ice jams, either as the jam moves into place or as it releases, and a single tree can experience multiple ice scarring events with intervening periods of bark healing. By inspecting ice-scarred trees and counting annual growth rings, ice events can be dated, and, because the tops of ice scars coincide approximately with maximum stage reached during an ice event, dated tree scars can be used to compare the peak stages from past ice events. Tree scar height, and the degree of damage to the tree, can therefore be used to gage the relative severity of past ice jams.

The lower Grasse River is the site of an EPA Superfund contaminated sediment remediation project. A 230-m-long pilot test cap, built in 2001, experienced under-ice hydraulic scour during a large ice jam that occurred on the lower river on March 28, 2003 (McShea, et al, 2005). Based on field observations and DynaRICE computer simulations (Shen and Liu, 2000), the 2.4-km-long jam was about 5-m-thick at its toe, 2-m-thick in its mid section and caused a maximum stage rise of about 3 m. As part of the Grasse River Ice Evaluation that followed (Alcoa, 2004), tree scars were surveyed during low flow conditions in the summer and fall of 2003. The survey had three sections: a 7-mile-long flat water "lower river", extending from the mouth up to the old power canal, a steep 1-mile-long "middle river" through the village of Massena, and a 3.3-mile-long relatively flat "upper river" above the village (Fig. 1).

Fig. 1. Map of Study area.

The main objective of the tree scar survey was to estimate maximum ice jam stages and frequency and, if possible, gauge the relative severity of the 2003 ice jam in the historical context. A second objective was to use tree scar data to help define the downstream extent of historic ice jamming on the lower river. On the middle and upper rivers, it was hoped that tree scars would provide general information on the nature of ice breakup, whether or not ice jams formed upstream of the Village of Massena, and how frequently they may have occurred.

2. Approach

In the lower river, the location and maximum height of all significant tree scars were mapped. Tree species and approximate diameters were also noted. Tree scar data were separated into 2003 and older event groups. Scars with light-colored exposed inner wood and ragged margins were considered to be from the 2003 event, while scars with exposed, weathered gray wood and healed scar edges were considered to be older. At two lower river locations trees were sawed down to count annual growth rings and determine the years when the scarring occurred. A forester's increment borer was also used to date scarring events, but proved less accurate than viewing the sawed sections.

On the middle and upper rivers, tree scars were far more abundant than on the lower river making it impractical to map every ice-scarred tree. The locations and maximum elevations of representative tree scars were recorded, and approximate event years were estimated from counting annual growth rings from borings at two locations. Cutting trees along the middle and upper rivers was not possible since this land is privately owned.

3. Data Collected

Figs. 2 and 3 show maximum tree scar heights from the lower, middle and upper rivers, respectively. On the lower river, tree scars were observed at 48 locations. In addition, two sawed samples were obtained, the first from a 30-cm diameter, 40-year-old willow on the left bank just downstream of the Power Canal Dam, and the second from a 25-cm diameter, 34-year-old aspen, located about 1.3 miles downstream of the Power Canal Dam. The plots present these data, grouped by right bank or left bank (facing downstream) and whether they represent the 2003 event or earlier ones. Maximum scar heights are listed and, where possible, the minimum elevations of the scars are noted. The lower margins of the scarred areas were often obscured by grass and vegetation.

On the middle and upper rivers, tree scars were noted at 47 and 64 locations respectively. Here, tree scarring was much more frequent, more severe, and higher up the trees than on the lower river. Due the high density of scars, not all scars were recorded, so the sampling is representative rather than comprehensive as it was on the lower river. Two trees were cored on the upper river in an effort to determine event chronology, the first a 60-cm- diameter green ash located on the right bank at RM 10.3, and the second, a 30-cm diameter willow, located on the same side of the river at RM 10.5.

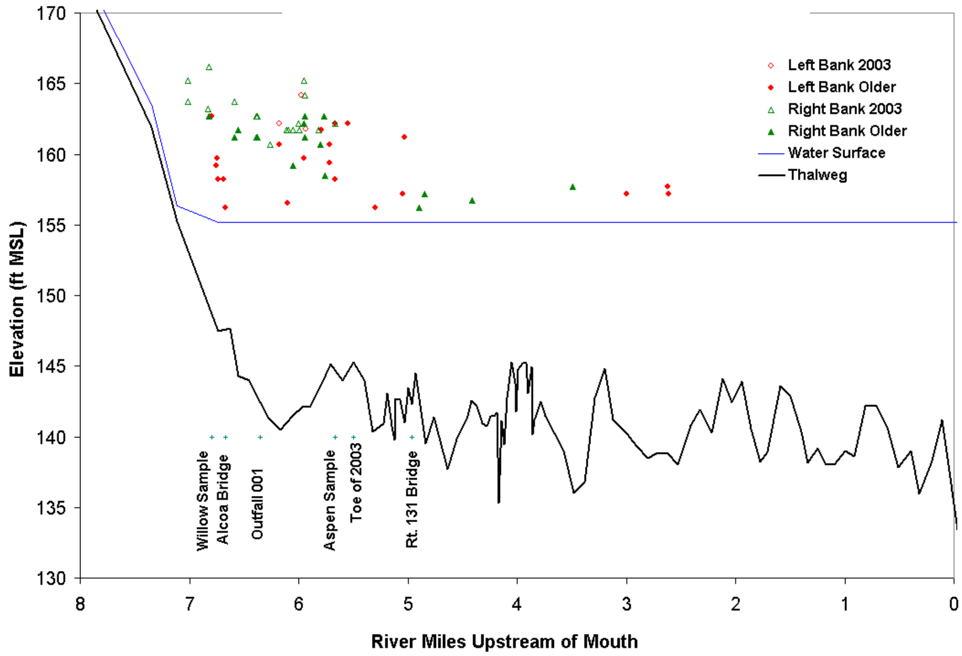

Fig. 2. Maximum tree scar heights on the lower Grasse River

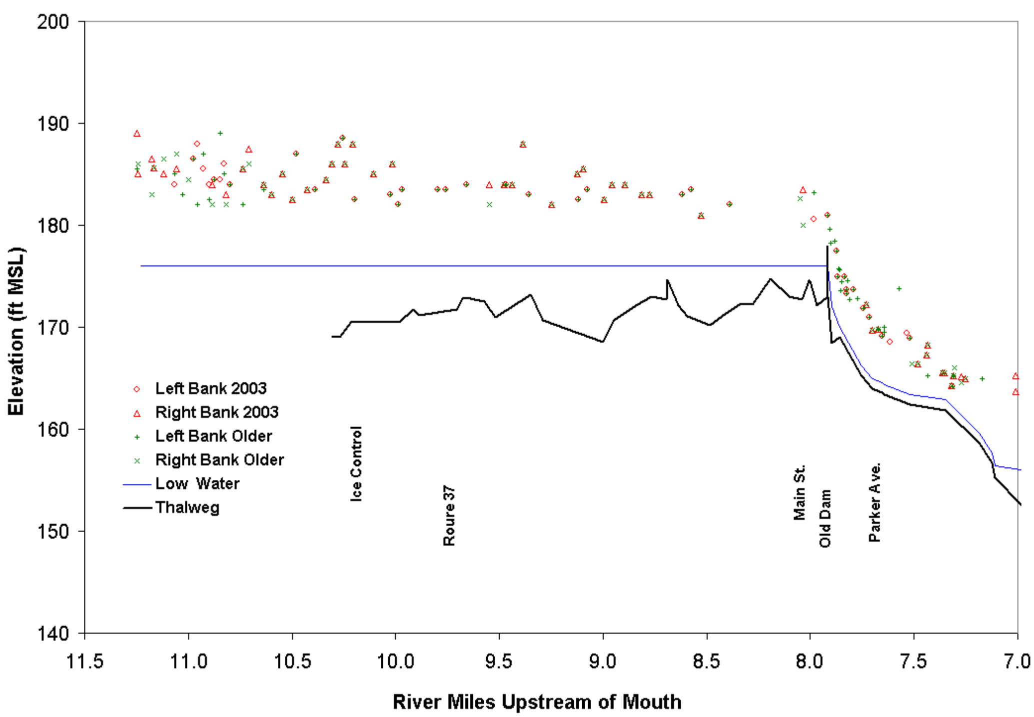

Fig. 3. Maximum tree scar heights on the middle and upper Grasse River.

4. Results

Lower River

Fig. 2 shows maximum tree scar heights from the 2003 event to be 2.7 to 3.0 m above low water, which compares well with the observed high water levels in the vicinity of Outfall 001 during the March 28, 2003 ice jam. Recent scarring at this elevation continues for about 1 mile downstream of Outfall 001, then declines sharply approaching the location of the observed toe of the 2003 jam. Compared to the 2003 scars, the maximum scar heights from previous jams show a similar but slightly lower profile. Observed tree scars downstream of the toe of the 2003 ice jam were generally within 0.6 m of the low water level. The tree scar record is limited, however, by the maximum age of the trees, which is probably no more than 40 to 50 years. Attrition of older trees and the eventual healing of scars and both limit the length of the tree scar record.

Inspection of annual growth rings of the 30-cm-diameter, 40-year-old willow near the Power Canal Dam indicates four distinct ice-scarring events in 2003, 1996, 1986 and 1978 (Figure 4). The 2003 and 1996 event dates are quite certain, while the two earlier dates are slightly less certain, probably accurate to plus or minus 1 year. The sections were cut from a portion of tree trunk about 2.4 m above the low water level, indicating that these four ice events caused stage increases of at least this height. Tree ring analysis of the 25-cm-diameter, 34-year-old aspen, 1.3 miles downstream of the Power Canal Dam shows scarring from the 1996 event up to a height of 2.1 m, and scarring from a 2001 event up to 0.9 m above the low water elevation (Figure 5). The absence of scarring from the 2003 event may result from the fact the tree was set back about 3 m from the water's edge. A 2.7-m-high recent scar, located 80 m upstream of the aspen sample, indicates that the 2003 ice levels were high in this area.

Fig. 4. Ice scarred willow limb overhanging Grasse River near old power canal (left). Sawn section from willow showing 4 distinct ice-scarring events (right).

Fig. 5. Aspen 1.3 miles downstream of Old Power Dam, scarred by the 2001 and 1996 events.

As mentioned above, downstream of the toe of the 2003 ice jam nearly all tree scars were observed to all be within 0.6 m of the low water level. This tree scarring downstream of the 2003 toe could be attributed to the movement of sheet ice, rather than ice jamming. Based on the tree scar evidence, no major ice jams have formed on the lower river at locations downstream of the 2003 ice jam location.

Middle and Upper Rivers

Tree scars are abundant and severe in the middle and upper rivers. Unlike the lower river channel, which was dredged to more that twice its original depth to accommodate outflow from the Power Canal, the middle and upper rivers retain a more natural channel morphology. The middle river is rock-bedded and steep, with a partially breached 1.5-m-high weir at RM 7.91. Upstream of the village, the river is flatter, with a sand-bedded, nearly rectangular channel, and a water depth of about 1.5 m. Adjacent floodplains are about 1.5 to 2.4 m above the low water level. The maximum tree scar heights are well above the top of bank elevation in this reach, and decrease more or less linearly from nearly 4.3 m above low water, 3 miles upstream of Massena village to 2.4 m above low water at the upstream edge of the village. The downstream decrease in scar height is gradual in the upper river in contrast to the more abrupt drop-off in the scar profile seen in the lower river near the observed toe location of the 2003 ice jam. In the upper and middle rivers, the maximum height profiles of the 2003 and older ice scars are roughly equivalent. In addition to the greater height and density of the scars on the upper river, the higher degree of damage to the trees suggests that ice runs and ice jams on the upper river have been extremely dynamic.

A likely ice jamming cause is the combined obstructing effect of the old dam, the piers of the Main Street Bridge and the bend immediately upstream. A March 15, 1977 photograph [1]of ice flows covering a park at the upstream edge of the village confirms that ice jams have occurred in

[1] Massena, NY Observer, Thursday, March 17, 1977 p. 20.

the upper river. On the other hand, a 1995 video of broken ice sheets passing the old dam (before it breached) shows that the ice floes can move from the upper to lower river without jamming, or following the release of a jam.

Tree ring data were obtained at two sites on the upper river using an increment borer. Borings from a 60-cm-diameter green ash located 900 m upstream of the Route 37 Bridge (Fig. 6) and a 30-cm-diameter willow 300 m farther upstream (Fig. 7), show evidence of two major ice events about 10 and 20 years ago, in addition to the 2003 event.

Fig. 6. Ash on upper river with scars from multiple ice events, up to 4 m above low water.

Fig. 7. Cores taken from a willow on the upper river.

5. Conclusions

In the lower river, elevated ice jam tree scars extended downriver to about RM 5.5. Based on the tree scar record, the portion of the lower Grasse River that has experienced serious ice jams lies between rivermiles 7.3 and 5.5. In the lower river, the 2003 ice jam produced the highest observed scars suggesting that this event was the most severe in the 40 to 50-year-long period of record. Tree scars from previous events were slightly lower than the 2003 scars. The profile of the highest scars suggest a relatively uniform maximum ice jam stage that declines sharply a short distance downstream of the observed 2003 ice jam toe area.

Within the RM 7.3 to RM 5.5 reach, tree ring data indicate that major ice jams have occurred in the upper end of the lower river in 2003, 2001, 1996, approximately 1986 and 1978. The 1996 jam extended nearly as far downstream as the 2003 jam, causing slightly lower stages near its downstream end. The upper river jams likely form as a result of channel obstructions such as the old weir below Main Street, the Main Street Bridge, and the bend above. Another probable cause of jams in the upper river is the high energy required for the breakup front to fracture its way through the thick sheet ice cover.

The upper river has experienced numerous dynamic ice runs and ice jams resulting in stages well above top of bank. Tree ring data indicate that at least two jams more severe than the 2003 event have occurred in the upper river in the last 20 years. Based on the tree ring data obtained to date, the severe upper river events do not correlate with the most severe jams in the lower river. It is possible that jam formation in the upper river reduces the severity of ice jams in the lower river, in that the jammed ice in the upper river has time to erode and melt before moving downstream. Also the delayed arrival of the upper river ice in the lower river may give the lower river ice more time to deteriorate, lessening the lower river ice jam potential.

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