A HISTORICAL PERSPECTIVE OF ICE JAMS ON THE LOWER MOHAWK RIVER

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Ice jams are an annual occurrence on the Mohawk River. As a northern temperate river, ice jams are expected, but it is clear from the occurrence and relative frequency of ice jams, that the Mohawk is particularly vulnerable to ice jams and the hazards associated with them. Here we briefly review the history of significant ice jams, we highlight research on reconstructing ice jams, and then we propose an active monitoring system that could be used by emergency personnel to better respond to active jams during breakup.

Ice jams occur when the frozen river breaks up during events that result in rapid increase in discharge. Ice out and ice jams always occur on the rising limb of the hydrograph, when the floodwaters are building. When flow starts to rise it is not uncommon for unimpeded ice runs to develop, but invariably the ice gets blocked or impeded along the way by constrictions in the river, especially where the flood plain is reduced in size.

In a survey of the past ice jamming episodes, we have come to the conclusion that any restriction or narrowing of the flood plain and constriction of the channel is a possible jam point (Johnston and Garver, 2001). An important point worth keeping in mind is that deep sections of rivers move more slowly than shallow ones, and therefore surface flow and therefore ice movement is reduced. So, a transition from a shallow to deep channel may generate a point where ice can backs may occur up, regardless of floodplain geometry.

The lower part of the Mohawk River has chronic ice jam problems and the historic record indicates that the section between the Stockade and the Rexford Knolls is the most jam-prone in the entire watershed (Figure 1). As such the empirical evidence of ice jam locations are relatively well known to local emergency management authorities. However, there is a general lack of information as to the significance of individual jam points, and how often jams occur in different areas. In addition, many jam sites are inferred based on little or no data.

Commonly, ice jams will build to sufficient thickness to dam the river and this can result in spectacularly rapid rates of water rise behind the dam. In March 1964, the USGS Cohoes Monitoring Station recorded the greatest hourly flow ever recorded on the Mohawk River when discharge peaked at 143 k cfs (1000 cubic feet per second), although the mean discharge for the day was only about half this level. In comparison to other floods on the Mohawk River this was not a big event, but the ice jam that formed resulted in very high water levels for a short time: the high discharge was due to an ice jam that formed and subsequently burst forming an ice-jam-release wave that surged downstream (Jesek, 1999). News reports from this event suggest that the elevation of the backed up water was about 25 feet, although as far as we know this is unverified.

History. One of the worst ice jams in Schenectady history occurred on 13 February 1886 when a spectacular ice gorge formed and lodged in and around the islands near Schenectady. In this event, one-foot-diameter trees on the flood plain were reportedly snapped in half, and when the water receded, the remaining ice was piled 30 to 40 feet high (see Scheller et al., 2002).

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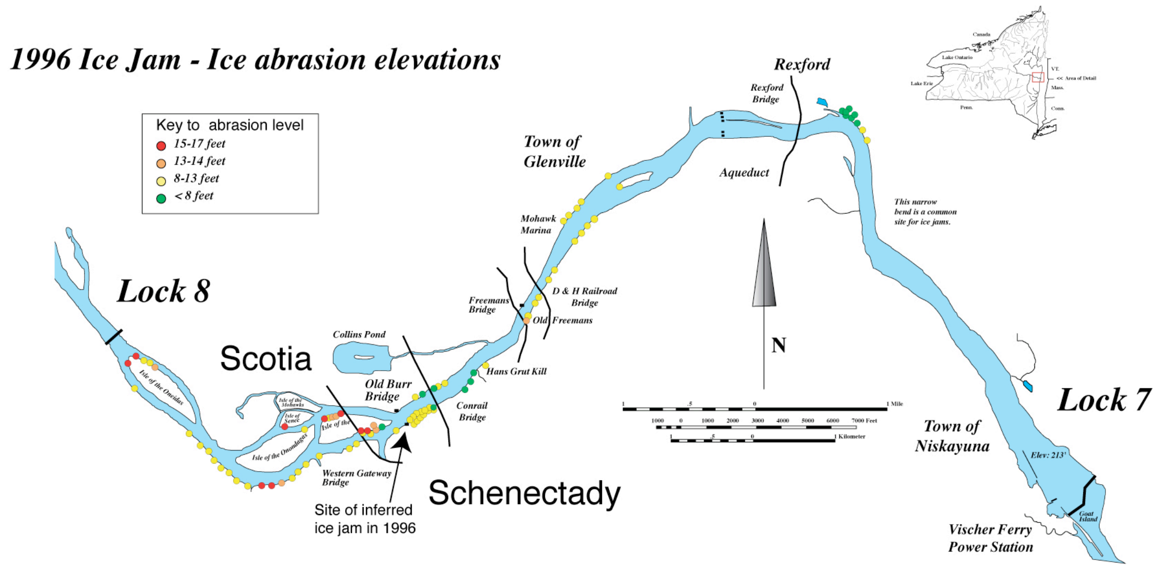

Figure 1: Map showing the elevation of measured ice scars on bank-lining trees along the Mohawk River in the Schenectady area. Scars on trees indicate the elevation of a slow-moving jam that caused damage along the riverbanks. The highest levels of tree scarring occur upstream from the Rexford Bridge and upstream of the Burr Bridge abutments. This area has chronic ice jams (from Lederer and Garver, 2000).

During this event, ice jammed at the Scotia Bridge, which linked downtown Schenectady with the Village of Scotia. Our analysis of the historic records indicates that this is a chronic jam point (same as the Burr Bridge abutments at the end of Washington St.).

The January 1996 flood is the worst recent flood and it is fairly well documented. This mid-winter thaw event (19-20 January 1996) resulted in the breakup of the Mohawk River and significant flooding, especially on the Schoharie Creek. As recorded at the USGS station at Cohoes, the event resulted in a mean discharge for the day on the Mohawk of 92 k cfs with a peak discharge of 132 k cfs resulting in extensive flooding of the Stockade area in Schenectady. Elevation of ice scars on trees lining the river banks (Figure 2) allow reconstruction of ice elevations and from these data (Smith and Reynolds, 1983), jam points may be inferred (Lederer and Garver, 2001). In the 1996 event, the highest ice-scar elevations occur between Lock 8 and the Stockade area in Schenectady, and almost no abrasion occurs below the Rexford Bridge. Two possible jam points are inferred from the data based on abrupt downstream elevation changes of the highest ice damage on bank-lining trees. One sharp elevation increase occurs between the Freeman's Bridge and the D&H railroad bridge where ice scar elevation increases from ~224 feet to ~226 feet (Figure 1).

Another sharp elevation drop occurs upstream of the still-standing abutments of the old Burr Bridge (a.k.a. "Scotia Bridge" after reconstruction) where maximum ice-scar elevations increases from ~226 feet to ~230 feet. We infer that the ice dam at the old Burr Bridge broke shortly before flood crest based on the maximum elevation of ice scaring just downstream in the Schenectady Stockade (228.4 feet), which falls just short of height of the river at crest (229.5 feet). Both jam points occur where abutments and berms (i.e. those associated with bridges) have dramatically restricted the flood plain thereby causing a severe restriction in flow.

Figure 2: The tree-lined park in Schenectady's Stockade still bears ice scars from the 1996 ice jam. Here the scar is about 14-15 feet above river level. Photo taken in the Summer of 2000, five growing seasons after the event, so it is well on its way to healing itself (Photo: J.R. Lederer).

The 15 March 2007 flooding in the Stockade was entirely related to ice jamming downstream from the city of Schenectady (Figure 3). During this event, discharge in the Schenectady reach of the Mohawk River never surpassed 45 to 50 k cfs, which makes this an insignificant event with respect to expected high water. However, the formation of the ice jam and the resulting backup of water was entirely responsible for the inundation that occurred in the Stockade. This reinforces earlier findings that the key component in these events is the evolution of stage elevation, which is not directly related to discharge. Back up of water behind the 15 March 2007 ice jam resulted in a ~13 feet elevation change. Breakage of the ice dam at about 6:45 PM resulted in a downstream rush of water referred to as an ice jam release wave that was recorded at the USGS station at Cohoes. Peak discharge at Cohoes occurred at 8:00 PM and then total discharge was 51.6 k cfs. It is possible that that was an ice jam release wave, but the measurements are too coarse (every 15 minutes) to determine this with certainty.

Figure 3: Flooding in the Stockade that resulted from the 2007 Ice jam on the lower Mohawk River. Picture taken in the late afternoon (~18:00) at nearly peak stage elevation. Peak discharge during this event was c. 50k cfs, but ice jamming resulted in back up of water that caused flooding (Photo: J.I. Garver).

The 2009 Ice Jam was, by historical standards, an insignificant event. The ice out event that occurred between 8 Mar and 10 March 2009 resulted in bank full conditions, and an ice jam occurred, but there was not significant flooding during this event. During this event, we collected data on the elevation of the river using two strategically placed pressure transducers during ice out which provides unique insight into how ice movement progresses (Figure 4).

Following a relatively cold winter with heavy precipitation, a moderate thaw accompanied by moderate rainfall increased runoff and subsequent breakup of river ice. At about 10:40 AM 8 March the water level rose rapidly in the Stockade of Schenectady. At about noon the R.A.C.E.S notes indicated that the ice had jammed and stopped in place. The toe of the ice jam was situated between the Stockade and the Freeman's Bridge (in, essentially, Schenectady). The ice floe that was jammed in place extended from the toe to a point slightly upstream from Lock 8, so it was about 4-4.5 miles long (~7 km).

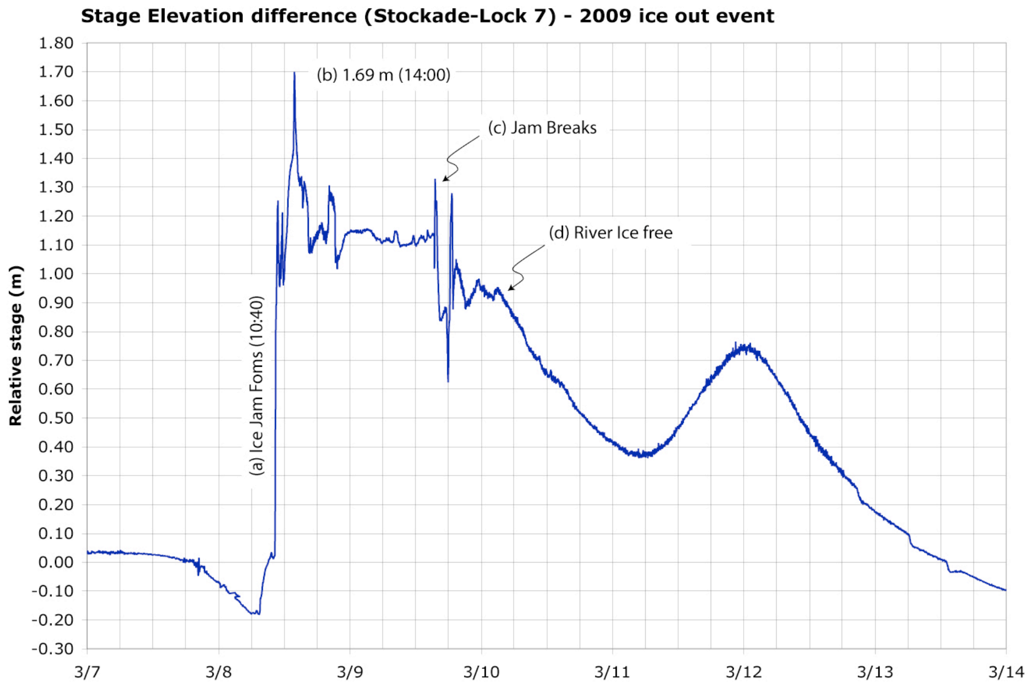

Figure 4: Difference in river elevation between the Stockade and Lock 7 measured by pressure transducers at 300 s intervals for the March 2009 ice out event. In this graph in situ measurements were made as a ~7 km ice jam lodged and then worked through the narrow channel in Schenectady. This plot shows the differential between the Stockade where water backs up due to ice jamming. High values in this plot indicate that the Stockade water level is higher than downstream sections of the river, and this backup is inferred to be cause by ice damming. The effect of a surge from breakup appears minor in this event (i.e. Jasek, 1999). (All times Daylight Savings time).

Downstream the peak flow at the Cohoes gage was recorded at 13:00 of that same afternoon (8 March) when 27.4 k cfs was recorded (all times are Daylight Savings Time). Historically, this is relatively low flow for an ice out event. At the highest point the differential between the Stockade and the Lock 7 occurred at 2:00 PM (14:00) when the difference was recorded as being 1.69 m. This means that a 1.69 m rise occurred in 200 minutes (3.3 hr) or a rise of about 0.5 m per hour during this interval. The jam stayed in place with little apparent movement, until the next afternoon, 9 March, when the ice floe became dislodged and worked its way downstream at about 16:20. Ice continued to pass through the system through that evening and the river was ice-free soon after.

Ice Jamming in Schenectady. Our analysis of the historical records suggests that the Rexford knolls, a bedrock-incised part of the Mohawk channel, is a distinct and chronic jam point for ice floes. This is because it is narrow, confined and there is no floodplain that allows the water and ice to spread out. Our research shows that over the several hundred years, it is typical for ice jams to form on the Mohawk between the Old Burr Bridge abutments and the Rexford Knolls - the most common jam points on this entire stretch of the Mohawk (between Schenectady and Lock 7).

As such, these ice jams pose a unique and serious hazard for the city of Schenectady (and to a lesser extent Scotia). We'd note that this part of the river channel is unique because it lacks a floodplain and because it is bedrock-bound.

This part of the Mohawk is relatively young having captured the main flow from the Paleo-

Mohawk at about 10 Ka (see Wall, 1995; Toney et al., 2003). Prior to this time, it is inferred that the Mohawk flowed north up the Alplaus channel and through what is now an abandoned channel occupied by Ballston Lake and adjacent lowlands in the paleo-channel. Although this is ancient history in the evolution of a river, it is relevant here because it provides a framework as to why this part of the Mohawk River has such a special hazard.

Since capture and readjustment of the course of the Mohawk, the river has had to rapidly incise into the bedrock high that now forms the Rexford Knolls. Even since settlement, this stretch of the river has been treacherous, and today we see that large ice floes have trouble getting through this narrow incised part of the channel. This is a natural feature, and the reduction in the effective width of the floodplain by abutments and berms – the Burr/Scotia Bridge being a major one – has exacerbated the hazard.

We suggest that the best mitigation strategy for this situation is a real-time monitoring network of pressure transducers that can provide fast reliable data on the condition of the ice movement through this key reach of the river (Robichaud and Hicks, 2001; White et al., 2007). These data could provide emergency personnel insight into ice dynamics (i.e. Figure 4) and a predictive tool that they have not enjoyed in the past.

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