The Appleton Wetland;
Its Decline, Cause and Recommended Action

Report prepared by

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of the
Mississippi Valley Field Naturalists

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August 11, 2014

Acknowledgements

The work of this Research Group and the preparation of this report benefitted from the assistance of many other individuals and we would like to recognize and thank them for their contributions.

Special thanks is in order to Dr. Paul Keddy for sharing his expertise on wetland ecology with us, for encouraging us in our research on the Appleton Wetland, and for contributing a much appreciated Foreword to this report.

In January 2014, we benefitted greatly from discussion and advice at a review meeting with a number of ecological experts from the Mississippi Valley Field Naturalists. This included Jim Bendell, Ted Mosquin, Steve Miller, Tineke Kuiper, Cathy Keddy, Neil Carleton and Theresa Peluso.

An important part our work was dependent on establishing an accurate elevation reference in Appleton. To that end, Ryan MacKenzie helped by locating and unearthing a long buried geodetic benchmark in Appleton, and Ross Taggart provided the surveying expertise to accurately establish a new benchmark at the shore of Appleton Bay referenced to this geodetic benchmark.

Photographs provided a valuable part of the history of the Mississippi River and we appreciate the images provided by a number people. The collection of historic photographs compiled by Michael Dunn was especially useful, and we also thank Brent Eades for making these images publicly available on his website, along with further historical material about Almonte. Other photographs also came from Robert and Sharon Newton, Mike Caughey and Steve Fahie.

Staff from a number of agencies also provided a variety of useful information. This included;

- Shaun Thompson of MNR for details relating to the Appleton Wetland as a Provincially Significant Wetland and an Area of Natural and Scientific Interest,
- Paul Lehman, Gord Mountenay and Brian Anderson of the Mississippi Valley Conservation Authority for a range of information on the river and the wetland, and
- Scott Newton and Brian Gallagher (retired) of the Mississippi River Power Corporation for historical information.

Thanks are in order to Jim Bendell for advice on the topic of tree ring coring and for the loan of the essential tool, and to Neil Carleton for help with our tree ring coring project. Neil was also very helpful in collecting assorted information and providing commentary on various topics.

We also extend our appreciation to Debbi O'Malley for undertaking the major task of editing this report into a presentable final form.

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1 Foreword

The Appleton Swamp, an Important Alluvial Wetland

Some of the Earth's most biologically productive habitats are the great swamps that form along water courses. Known as "alluvial wetlands", they are intimately connected with rivers, providing shelter for birds, breeding grounds for fish, habitat for mammals, and generating organic matter that feeds wildlife production for many miles downstream. Some of the better known examples occur in the Amazon, the Congo, and the Mekong rivers, but every large river floodplain has alluvial wetlands. In eastern Ontario, there are alluvial wetlands along rivers including the Mississippi, Ottawa and St. Lawrence rivers. One of the finest examples along the Mississippi River is the Appleton Swamp, which has been known for decades as a favoured place for canoeing and bird watching.

For all alluvial wetlands, there is one key cause (or driving factor) that determines the area and species composition – the flood regime. The two most important components in the flood regime are the spring high and the mid-summer low. More specifically, the flood regime has four critical components: the timing and depth of the spring flood, and the timing and depth of the summer low water period. It is the alternation between highs and lows that produces the swamp. One cannot exaggerate the importance of seasonal changes in water level to alluvial wetlands; indeed, they are a textbook example of how an entire ecosystem is created by a single phenomenon. Each spring high water levels sweep through the swamp removing organic debris and depositing new layers of silt. Each summer drought allows life-giving oxygen to reach the tree roots, and allows understory plants to flower and complete their life cycle. Remove the spring flood, or prevent the summer drought, and the swamp will disappear.

The situation is even more delicate in the north than near the equator. In the Amazon alluvial forest there are hundreds if not thousands of different tree species, each with their own complex ecology; in northern swamps like the Appleton Swamp, by contrast, there is only a single common tree species, Silver Maple. This makes the alluvial ecosystems along the Mississippi River critically dependent upon the requirements of a single tree species. Indeed, without the summer dry period, the trees will die within a few years, and signs of death are already evident in the Appleton Swamp. The Appleton Swamp is older than the pyramids or Stonehenge and has, for thousands of years, created wildlife diversity along the Mississippi River. Yet, it is all now at risk because a mere few summers of high water level are sufficient to kill the trees and eliminate the swamp.

This document describes the Appleton Swamp, introduces the scientific principles of high and low water levels in alluvial wetlands, and demonstrates how changes in the low water period have been killing the trees. The swamp is now at a tipping point. Further summer flooding will kill the last trees and the thousands of years of development will be ended abruptly. The negative effects will occur not only within the boundaries of the swamp, but will cascade through fish and wildlife populations for many miles downstream. Restore the summer low water periods, and the trees will recover and continue to provide the ecological services that they have provided free for thousands of years.

Contributed by Dr. Paul A. Keddy

A Brief Biography of Dr. Paul A. Keddy

Dr. Paul A. Keddy has been a professor of ecology for 30 years, and has published over 100 scholarly papers and six books. He has been designated a Highly Cited Researcher, and in 2007 was awarded two scholarly awards, the Merit Prize by the Society of Wetland Scientists, and the National Wetlands Award for Science Research by the Environmental Law Institute. Although he has worked on many types of plant communities and a broad array of ecological questions, the focus of his work has been upon the principles that organize plant communities, with particular emphasis upon wetlands.

His teaching career started at the University of Guelph, and continued at the University of Ottawa. During this period of his life, he carried out original research on wetlands in the Great Lakes, along the Ottawa River, and in Nova Scotia. He also served science as a member of the Natural Sciences and Engineering Research Council and served conservation as a member of the Canadian Council on Ecological Areas. Dr. Keddy moved from Canada to Louisiana in 1999 to become the first holder of the Schlieder Endowed Chair for Environmental Studies at Southeastern Louisiana University. This chair provided resources that allowed him to continue research and teaching in the unique Louisiana environment with its subtropical climate, extensive cypress swamps, rich amphibian and reptile fauna, and threatened pitcher plant savannas amidst longleaf pine forests.

Dr. Keddy returned to Canada in 2007 and from his home in the forests of Lanark County he continues to work on books and scientific papers on wetland ecology, plants and vegetation.

2 Executive Summary

This report is the end result of an investigation by a Research Group of the Mississippi Valley Field Naturalists (MVFN) into the causes of a large scale die-off of soft maple trees in the Appleton Wetland (a Provincially Significant Wetland). The problem is associated with a change in water levels on the portion of the Mississippi River between Appleton and Almonte. Since 2006, the water levels on the Mississippi River have been formally regulated by the Mississippi River Water Management Plan (MRWMP), including this stretch of the river, identified in the plan as Reach 18. The generator station (GS) at the bottom of Reach 18 is operated by Enerdu Power Systems Inc., and the company appears to be operating in accord with the MRWMP terms that apply to the GS. Although it is clear that water levels in Almonte have increased since their facility operated originally as a flour mill, the exact timing of that change was not certain, nor was there any real understanding of what effect the Almonte water level changes had on water levels in the Appleton Wetland. What is known for certain is that the maple trees in the Appleton Wetland were dying massively by 2006, and there are photographs and complaints that attest to that.

The maple species involved are known to be well adapted to life in a wooded swamp such as the Appleton Wetland. They are very flood tolerant on both a seasonal basis and for longer periods. High spring floods, and elevated water levels through the late fall and winter are not a problem, and they will also tolerate continuous inundation for up to two years. What these trees must have for healthy growth is a substantial period through most summers where the water level in the adjacent river is at least 25 cm below the surface of the ground where the maples are growing.

Before this project started there were several popular opinions as to what caused the tree die-off. These included;

- onset of tree diseases or attacks by insects,
- increase in flow rates of the Mississippi River in the last decade causing a rise in water level,
- adverse effects of toxic waste that spilled from the nearby Appletex lagoon in the fall of 1989 and the spring of 1990, and
- increased summer water levels in the wetland associated with the Enerdu operations.

There was no evidence from the Ministry of Natural Resources (MNR), the Mississippi Valley Conservation Authority (MVCA), or other sources, to support the first three of those possibilities. They were dismissed by the research team as very improbable early in the investigation based on known information. That left the last item as a most probable cause, and the focus of the Research Group's work. The task of the Research Group was to eliminate any coincidental associations and to discover the real cause and effect relationships along with quantifiable evidence to support any conclusions.

The Research Group started by collecting known information that might have some bearing on river water levels at Almonte over the 1840 to 1989 period, termed the Flour Mill Era, and over the period from 1990 to the present termed the Generator Station Era.

During the Flour Mill Era there are no recorded measurements of river water levels in Almonte or Appleton that have survived. The research team has looked to other indirect evidence that may provide some indication of past water level history. This included river flow rate data, written, photographic and anecdotal records of the weir and flashboards immediately above the Flour Mill, and the observations of water levels relative to known landmarks, the submerged rock ridge and the adjacent small island just above the Almonte Fair Grounds. It was concluded that for most summers the river level at Almonte was very close to 117.2 masl, the height of the concrete weir of the former Almonte Flour Mill.

Measureable data for the Generator Station Era, particularly during the last decade, is more accessible. Photographic records show that flashboard height on the weir was increased to 117.7 masl in 2001, or possibly a few years earlier, and direct observation demonstrates that water usage is now controlled to maintain water levels between 117.7 and 117.5 masl throughout the low-flow summer period.

In 2006, the MRWMP went into effect. The water level limits in the plan set for Enerdu simply endorsed what they were already doing. Although the plan did recognize the existence of the Appleton Wetland, and clearly indicates that ecological integrity has a higher priority than power generation, it failed to appreciate that the higher water levels allowed for Enerdu would kill the trees in the wetland. In 2006 large numbers of dead trees were already clearly visible in the wetland.

Also in 2006, the MVCA started recording water level data at the Bridge Street bridge in Almonte. This provided for the first time some much needed quantitative water level data, but it was limited to Almonte with no understanding of how it would apply to levels in Appleton.

The Research Group undertook several field projects in the summer and fall of 2013 to better understand the interaction between water level, flow rate and Enerdu operations. The first requirement was to establish an elevation benchmark at the shoreline of Appleton Bay accurately calibrated to the same CGVD28 standard used for the Almonte level measurements. The task was completed on October 11, 2013, and enabled real Appleton to Almonte elevation comparison.

In the summer of 2011, MVFN undertook a “Tree Project” that simultaneously measured water levels in Almonte and relative water levels at six trees along the shoreline in the Appleton Wetland. It showed a clear association of water level changes at both ends of Reach 18. With the 2013 elevation calibration applied to the prior 2011 data, the level relationship became much clearer. With all flashboards in place on the weir, and with summer flow below 10 cms, the river was flat, with Appleton at the same level as Almonte. That is, at 117.7 masl or somewhat below. The project also led to the conclusion that the optimum summer water level in Appleton for healthy tree growth should be maintained below 117.4 masl.

From August 4 to November 17 in 2013 a series of simultaneous water level measurements were conducted at Almonte and Appleton. The results prove that the presence of flashboards at Almonte is the primary cause of high summer water levels in the wetland. River flow rate is a secondary factor and some data over a limited range of flow rates was acquired.

An investigation of the wetland was conducted in November 2013 to get a better view of interior conditions. Observations of tree health combined with ground level and water level at a number of locations were made. The conclusion was that water levels are too high and that a summer level of 117.4 masl would be needed for healthy tree growth.

A further project in the spring of 2014 made simultaneous level measurements at four locations along the river from immediately above the Almonte weir to Appleton Bay starting just before the peak of the flood, and after all flashboards had been swept away, until June 19. This data provides a set of charts with flow versus level curves for four locations, with a measured flow range from 35.5 to 244 cms for the no flashboards case. We now have some very useful data on flow versus level relationships. In particular, it is now possible to take the Flour Mill Era probable summer level in Almonte of 117.2 masl, along with the historic mean summer flow of 10 cms, and compute the corresponding level in Appleton as 117.4 masl. This is a good estimate for the previously unrecorded historic summer water level in the Appleton Wetland.

This estimate is a significant result. Two separate sets of field observations in the wetland have produced 117.4 masl as the right level for healthy tree growth, and the derived historic level has turned out to be the same level.

The research results confirm that excessive water levels resulting from Enerdu's operations, which conform to the existing MRWMP, are causing the die-off of the soft maples in the wetland. In effect, the trees are drowning. The Enerdu operational limits in the MRWMP clearly do not conform to the priorities of the plan that rank ecological integrity above power generation. Thus an amendment to the MRWMP is needed immediately.

We recommend that:

1. The MRWMP be amended immediately for Reach 18 to set the level of 117.4 masl, as measured at Appleton, as the maximum operational summer water level from May 1 to October 31.

2. The amendment provisions must include a five year test period during which the conditions in the Appleton Wetland must be monitored closely for signs of tree recovery and for evidence that 117.4 masl is a valid operational summer water level, with the option of adjusting water levels in the remainder of the test period if warranted.

3. A further amendment provision must include a thorough evaluation of results at the end of the test period to establish a final Water Management Plan for Reach 18.

4. Approval of the current upgrade plan of Enerdu must be delayed until the recommended MRWMP amendment has been resolved.

3 Introduction

This introductory section includes a variety of background information that should be understood before focusing on the details of the research findings. This includes information on the problem of maple tree mortality in the Appleton Wetland and photographic evidence, descriptive information on the immediate area around the Enerdu GS, details of the Appleton Wetland, and a description of the habitat requirements of the maples that grow in swamps such as the Appleton Wetland.

3.1 Problem Summary

The problem statement is simple. From prehistoric time the Appleton Wetland was a healthy Silver Maple Swamp. This is supported by its remarkable size, along with the richness and complex nature of its significant characteristics, which, from an ecological perspective, required stable conditions over much time to develop. This state continued through pre-colonial times when the only human inhabitants were aboriginals with a very low population density and a life style with very low impact on the environment. The early 1800s saw the arrival of early immigrants, the start of subsistence agriculture and logging, and the development of early industrialization in the form of saw mills, grist mills and textile mills in what is now Almonte. The population and industries evolved and expanded through to the late 1900s, but the combined effects on the Appleton Wetland were quite benign, and the silver maples continued to thrive.

This all changed very abruptly in the last ten years or so, and now it is estimated that 60% of the area of the Appleton Wetland is now covered with dead and seriously stressed silver maples. Some significant environmental condition has obviously changed to the detriment of the wetland trees. Since the Appleton Wetland is classed as a Provincially Significant Wetland (PSW), and is also nominated as an Area of Natural and Scientific Interest (ANSI), this major loss of tree canopy needs to be taken very seriously, and remedial action needs to be taken immediately while recovery is possible.

We will show in this report that the crux of the problem is the changes in water level management strategy on Reach 18 (the section of the Mississippi River between Appleton and Almonte) as the former Almonte Flour Mill was converted to a hydro generator station. To simplify the analysis that follows, we refer to the 1840 to 1989 period as the *Flour Mill Era* and the period from 1990 to the present as the *Generator Station Era*. Since we can see and measure many relevant conditions that presently exist, we are part of the way towards understanding what has changed since the Flour Mill Era. Unfortunately, the records from that period are limited and we have had to use indirect methods to arrive at conditions in that era, and then to identify what has changed.

There were many details to be examined in the course of our research, and fully documenting all of this requires a lengthy report. In order to simplify things for the reader, the various sections in the main body of the report contain only the essential details and conclusions pertaining to each topic. The full details of these topics are included in a set of appendices at the end of the report.

3.2 Some Photographic Evidence

Appendix O contains a collection of typical images of the wetland taken in 2006 and 2012 from the viewpoint of a kayak on the river, and from a small airplane over the river. They leave little doubt that there is a problem. A few are included below.

Figure 1 Appleton Wetland, August 8, 2006, from kayak

Note that the water level is high and the bases of all the visible trees are submerged below the water surface. In addition there are many dead branches and the surviving leaf canopy is quite sparse. A silver maple swamp that is drowning

Figure 2 Appleton Wetland, June 16, 2012, from kayak

The general appearance is similar to that in 2006 – many dead trees, and the tree canopy is quite sparse. Also note the accumulation of fallen tree trunks at the water's edge.

Figure 3 Aerial view of Appleton Wetland from 5000 ft., July 9, 2012

A view of the Appleton Wetland looking northwest along the river to Almonte in the distance. The lighter green portions indicate areas of dead and stressed trees, and the darker green portion is swamp at a slightly higher elevation that is still healthy. It is estimated that 60% of the total wetland area is now in the dead and stressed category.


Figure 4 Appleton Wetland from airplane at lower altitude, July 9, 2012

A further view from low elevation, with camera zoomed in, showing a closer view of the dead and stressed trees on the south bank of the river.

3.3 The Locale

The old Flour Mill and the associated weir are key elements in much of the detail that follows. To clarify some of the details the Google Earth image below identifies some key features. The river flows westward into Almonte and under the Bridge Street bridge. There is a staff gauge on a bridge pier at the location shown, and with binoculars from the Old Town Hall waterfront it is possible to take river level measurements manually. The reading accuracy is within about 1 cm and direct readings are accurately calibrated to metres above sea level (masl).

Downstream from the bridge is a concrete weir with a top elevation of 117.20 masl. The weir is in four sections that start on a small island near the Old Town Hall, and continue in a semi-circle to the water intake of the old Flour Mill. For convenient reference in this report the sections have been numbered as shown on the image. There is a small side channel from the river leading to the former Thoburn Mill (now a condominium building) with a spillway at the side of that building.

Figure 5 Google Earth image of the weir and surrounding area

For further orientation, the topographic map below shows the section of the Mississippi River as it flows from Appleton northwest to Almonte. The Appleton Wetland is outlined on that map, and has four components. The major one is on the northeast bank of the river starting at Appleton and extending about half way to Almonte. There are three smaller pieces on the southwest bank that start at Appleton and continue most of the way to Almonte. Conditions of dead and stressed trees are similar in all sections.

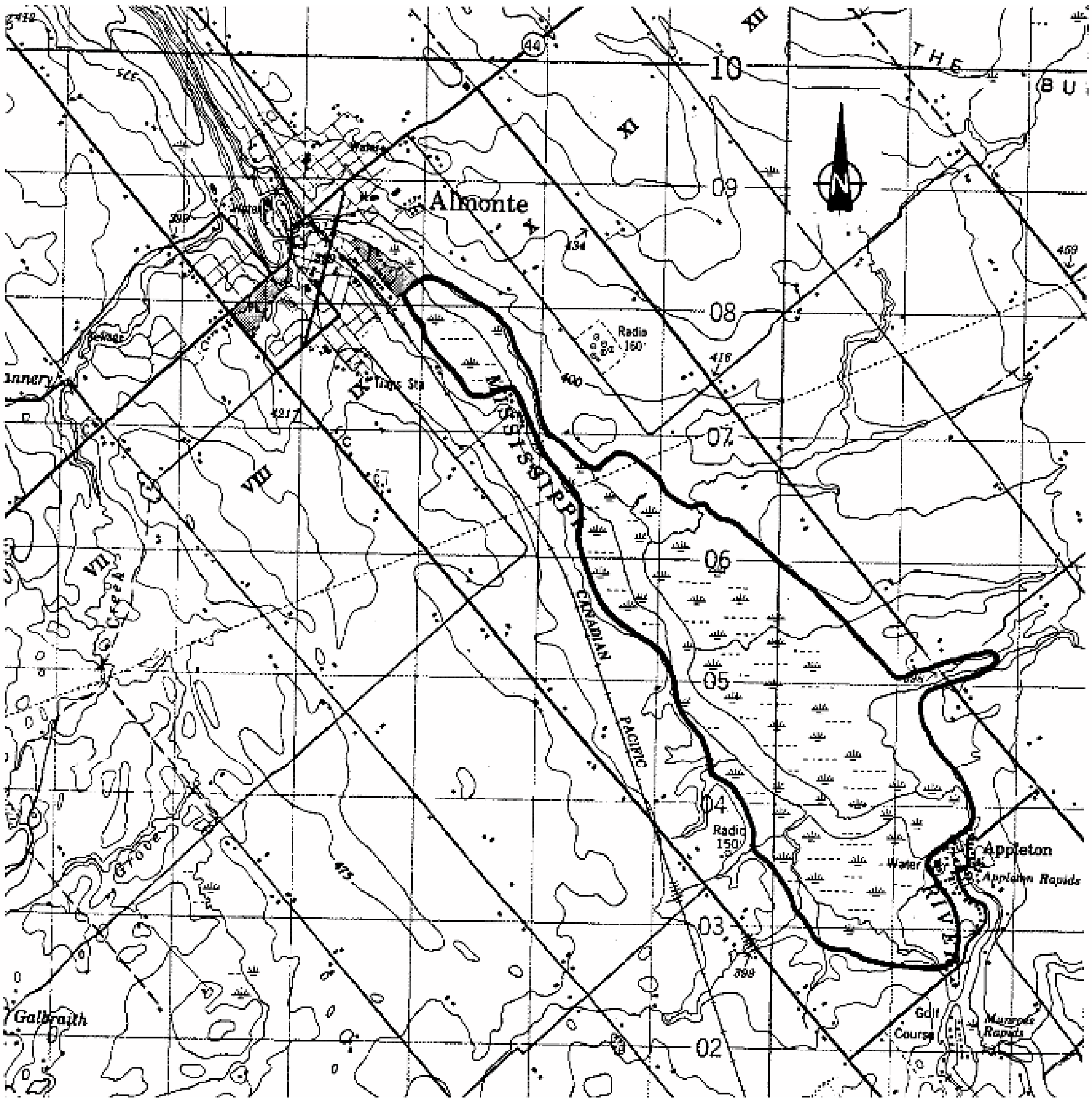

Figure 6 Topographic map of the Appleton Wetland (within dark outline)

To further illustrate the location of the Appleton Wetland, below is a satellite image from Google Earth of Reach 18. The green spaces along the river identify the four segments of the wetland. The major one is on the northeast bank of the river starting at Appleton and extending about half way to Almonte. There are three smaller pieces on the southwest bank that start at Appleton and continue most of the way to Almonte.

This satellite imagery is stated to originate from 2005 and it does show the same light green sections of stressed wetland contrasting with the dark green of healthy wetland that were observed in 2012 photographs from an airplane (see Appendix O). The beginning of the tree die-off appears to have started in or prior to 2005.

Figure 7 Google Earth image of Reach 18

Appendix N includes a summary of information on the Appleton Wetland related to its status as a Provincially Significant Wetland (PSW) and Area of Natural and Scientific Interest (ANSI).

The 628 Ha Appleton Wetland was designated as a class 2 PSW on the basis of a 1984 evaluation conducted by Bruce Brown and Jeff McNaughton of the Ministry of Natural Resources (MNR). That evaluation included a tabulation of vegetation forms with the percentage of the total area where specific forms were dominant. Significantly, form “h” (deciduous trees) was 74%, and form “dh” (dead deciduous trees) was 4%. This is in contrast with current estimates that show 60% of the wetland covered with dead and dying trees.

In 1991, the ANSI evaluation was completed by David J. White of MNR. To date, it remains with ANSI candidate status only. We have not been able to find any information on the details of the evaluation other than the summary in the Life Science Checksheet. This Checksheet does contain some noteworthy items:

- “Water levels and flows are regulated by dams at Almonte and Appleton, however, the effect on the wetland appears to be limited.”
- “The candidate is on clay plain landform (Chapman & Putnam, 1984) and offers the only provincially significant representation of riverine marsh, swamp, and upland forest on clay plain. …. This area is most similar to the riverine deciduous swamp stands on the Innisville Wetlands, however, the latter are on limestone plain and organic (peat and muck) landform (Chapman & Putnam, 1984).”

There is no reference in the 1991 evaluation to extensive tree die-off, so we conclude that what we see today started after that report.

3.4 Some Historical Background

3.4.1 <u>The Flour Mill</u>

A brief summary of historical information may be useful in understanding when events happened and how we got to the present state. The initial grist mill on this site was started by Edward Mitcheson in the 1840s and was bought by J.B. Wylie and James H. Wylie in 1854. The Wylies replaced the Mitcheson mill with the much larger present stone building and later expanded that further. It operated as the Wylie Mill and the Almonte Flour Mill for many years and was bought by Maple Leaf Mills in 1965. That continued in operation until it finally closed permanently in 1987.

The building was bought by Mike Dupuis according to the Almonte Gazette of June 8, 1988. The Gazette reported that Mr. Dupuis was applying for a zoning change on June 21, 1989, that would permit the site to operate as a hydro power plant, and on August 16, 1989, the Gazette confirmed that the rezoning was approved by the Town Council. In that article, Mr. Dupuis indicated that it would be about two years before they would start power production. On January 15, 1990, the operation was incorporated as Enerdu Power Systems Ltd. A Gazette article in 1992 confirmed that limited power production had started two years previously. A Gazette article in August 9, 1995, indicated that they were in the process of building new water intakes and a new tailrace along with upgrading the turbines and generators to produce four times more power than the old system. From the Reach 18 section in the Mississippi River Water Management Plan (MRWMP) there is confirmation that they were in operation with a capacity of 350 kilowatts in 1997.

That operation continued under the Dupuis family until ownership of Enerdu was transferred to Jeff Cavanagh on January 1, 2011. Subsequently, Enerdu announced an intention to upgrade the facility to 950 kilowatt capacity, and a Class Environmental Report for that upgrade was issued in December of 2012.

3.4.2 The Thoburn Mill

This building is located on the bank of the river across from the Enerdu building. An article published in the Millstone News on May 14, 2012, provides a good summary of the Thoburn Mill. In 1821, Daniel Shipman was granted a patent on the Thoburn site. Using the power of the upper falls, which became known as Shipman's Falls, he constructed the first water-powered sawmill and added a gristmill in 1822. Woollen manufacturing took place on the Thoburn site from 1862 under a number of different owners/occupants and, in 1880, Messrs. Sheard and Thoburn acquired the operation. Mr. Sheard disappeared mysteriously in May 1881and in April 1882 William Thoburn acquired full and sole ownership of all assets including "The uninterrupted use and flow of the water of the South Branch of the Mississippi River".

Fire destroyed the mill in 1918 but Thoburn rebuilt, still relying on the Mississippi's waterpower to continue to drive the turbines and machinery. The Mill continued to operate as a woollen manufacturer until 1956.

After its close as a woollen mill in 1956, the Thoburn building was used for a variety of commercial purposes. In 2000, a group of local entrepreneurs began the redevelopment of what is now the Thoburn Mill Condominium. The condominium was registered in 2009 and is now home to 23 apartment residences and small businesses. The condominium also retains the original water rights that were granted to William Thoburn.

3.5 Characteristics of Maple Swamps

As a starting point for examining the cause of the tree die-off in the Appleton Wetland, this section of the report summarizes the essential nature of a wooded swamp along with specific reference to the Appleton Wetland. The first requirement is a more or less level ground surface adjacent to a river that has regular seasonal variation in water level (spring flooding and summer low-water). Conditions during a sufficient portion of the total growing season must support tree growth and also allow the establishment of new seedlings. Such conditions naturally occur between the end of the spring flood and the start of a later, second flood, or near the end of the growing season. This is a demanding habitat, but some species of trees have adapted well to this variability and thrive due, in part, to the absence of competing species that are not so adapted. In the Ottawa River and the Mississippi River valleys, a few species of maples are adapted to life in a wooded swamp and are the dominant trees in our local wooded swamps.

In Reference 3 (Toner and Keddy, 1997), a model was developed that quantifies the probability of establishing a wooded swamp relative to variations in the flood regime. The model is applicable to local conditions. The key parameters are: ld, the last day of the first flood, and tsec, the day the second flood begins, with days counted from the beginning of the growing season in both cases. In the absence of a second flood, tsec is the end day of the growing season. For Lanark County, the growing season is nominally April 16 to October 26.

For Reach 18 of the Mississippi River, the end of the spring flood on average is around July 1 (ld = 77) (Figure 8) and the second flood is after the October 26 end of the growing season (tsec = 194). These dates come from the Appleton Mean Flow chart below as derived in Appendix C.

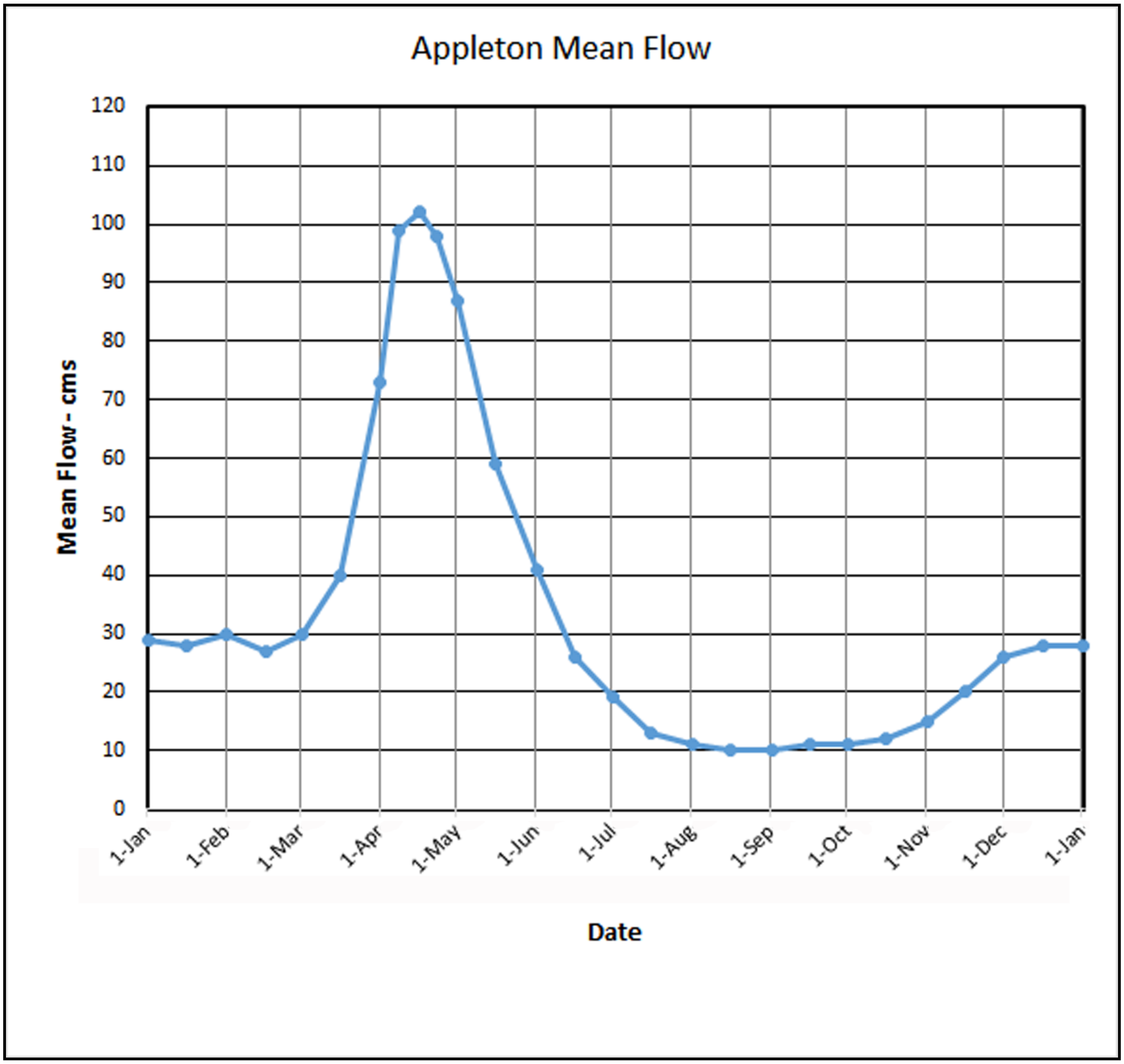

Figure 8 Mean flow as measured at Appleton, 1919 to 2012

Reproduced below (Figure 9) is Fig. 3 from the Toner and Keddy paper. With tsec greater than 140, and ld = 77, Appleton would correspond most closely to the top black box in the 140 column, indicating there is a probability of greater than 0.70 that a wooded swamp would exist here. There is little argument about that, since the Appleton Wetland has obviously been here for a long time. It is, however, quite relevant as an indicator that the wooded swamp can recover when and if the cause of the die-off is corrected.

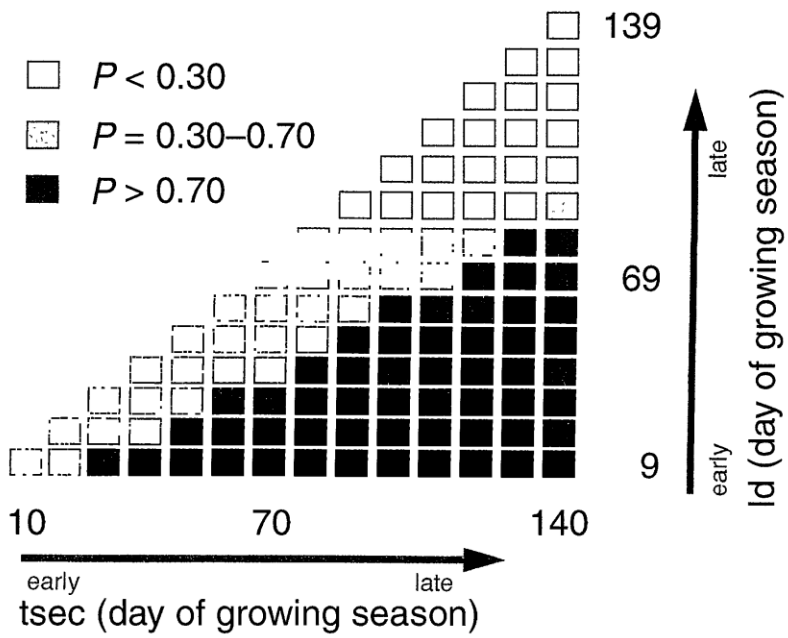

FIG. 3. The probability of occurrence of woody cover as predicted by the day of the growing season on which the first flood ends and the day on which the second flood begins. Parameters are taken from the 12-yr interval. Abbreviations: tsec, time of the second flood; ld, last day of the first flood.

Figure 9 Reproduced from Reference 3 (Toner and Keddy, 1997)

It should be noted that criteria discussed above most likely reflect limits related to the establishment and regeneration of a wooded wetland from seeds. This requires that the spring flood has subsided and the ground is above water when the trees drop their seeds early in the growing season, and that there is adequate time for the seeds to sprout into viable seedlings before the second flood. The issue of regeneration from seeds, which is a longer term process, would not account for the current problem. Instead we need to look for something that in less than a decade has killed a great number of trees and has left any survivors in a severely stressed state.

The common species in maple swamps are silver maple *(Acer saccharinum)* and red maple *(Acer rubrum)*. They are both recognized for their flood tolerance, both seasonally and longer term. They withstand yearly spring floods as well as elevated water levels through the late fall and winter as long as low water levels occur through a major portion of the growing season. They have also been found to survive continuous inundation for a period of two years, as noted in Reference 1 (Keddy, 2010) pages 67-68. On the whole, both maple species seem very capable of handling normal seasonal variations in water levels as well as intermittent extremes, as long as they get an adequate period of sufficiently low water level in the growing season that will give their upper roots a chance to breathe. There seems to be little reference material detailing what level is low enough. The question was discussed at a meeting between Dr. Keddy and some members of this research group in 2013, and his recommendation was that the summer river level should subside to at least 25 cm below the ground surface where the maples are growing. This parameter appears to be a critical factor in assessing potential causes for the Appleton Wetland die-off.

At the same meeting the question of whether it was possible for the Appleton Wetland to recover was also discussed. Indications were that recovery was certainly possible if the cause of the die-off is corrected in the future. It was also noted that if the right changes are made soon recovery will be quickest. As long as there are still viable roots in place, they will send out new shoots that will become the next generation's mature trees. If, on the other hand, corrective action is delayed until everything, including the roots, is totally dead, regeneration must come from seeds that are transported by winds or other means from live trees elsewhere, and regeneration will take much longer. Thus there is a strong incentive to take action now and get the recovery started.

In January 2014 during discussion with Brian Anderson, Advisory Services Coordinator at the Mississippi Valley Conservation Authority (MVCA) as noted in Appendix L, he indicated that red and silver maples are particularly susceptible to ice damage. If the winter water level is high, up around the root collar, and it freezes hard, the tree may be girdled when ice pressure damages growing cells at that level. This does suggest that winter water levels in the wetland are a possible contributor to the problem.

The question of exactly which species of maple may be growing in the Appleton Wetland remains to be determined. The wetland is often referred to as a silver maple swamp or a soft maple swamp but it may actually be a mix of maples.

- The inventory of plant species compiled for the Provincially Significant Wetland (PSW) survey in Appendix N contains numerous references to red maples, but no reference to silver maples. Also in Appendix N, the brief Checksheet compiled for the Area of Natural and Scientific Interest (ANSI) submission does mention black ash and cedar, but there is no reference to maples of any species.
- During the discussion noted previously with Brian Anderson, he indicated that the Appleton Wetland probably includes both silver and red maples as well as a lesser known hybrid, Freeman's maple *(Acer x freemanii)*, that is a cross between silver and red maples.
- In later discussion with Shaun Thompson, Kemptville District Ecologist, Ministry of Natural Resources (MNR) the question of why the PSW documents show only red maple and the ANSI documents show no maples was raised. He indicated that this was a common oversight and that the population probably included silver, red and Freeman's maples. He also noted that the only way to distinguish the species is to look carefully at the leaves.
- When the trees are dormant and without leaves, as they were during the excursions into the wetland as covered in Appendices K and L, tree size, shape and bark are similar among soft maples and species distinctions cannot be made. The identity of maple species can be clarified in 2014.

This species issue is mentioned only for completeness. From the point of view of correcting the cause of the die-off and restoring the trees, it is not important – all three species grow in swamp habitat, and all will benefit from corrective action.

4 Data Collection

As a first step in our research we attempted to collect any relevant information on river conditions in Reach 18 during both the Flour Mill Era and the subsequent Generator Station Era. The emphasis was on collecting reliable quantitative data in written form, but unfortunately there is a limited amount of that available. Photographic records have proven useful in some cases, but they are recognized as more qualitative in nature, and not as precise as the more quantitative forms. We have also included anecdotal records in cases where nothing better exists. These can shed a useful insight to past events.

4.1 The Flour Mill Era

Unfortunately solid quantitative data on Reach 18 conditions during the Flour Mill Era is largely non-existent. This information was probably not regarded as important at the time, and was just never measured or recorded in permanent form. In some cases there may have been useful data recorded, but through the passage of time it has become lost or destroyed. For this era it has been necessary to adopt less rigorous data with due recognition of its lower reliability.

4.1.1 River Flow Data

Detailed accurate measurements of river flow at Appleton have been recorded and maintained continuously since 1918. The Appleton Stream Gauge, now operated by the Mississippi Valley Conservation Authority (MVCA), is located just below the Mississippi Golf Club on the road into Appleton and well above the dam. All data is available publicly on the website operated by Environment Canada with the URL:

http://www.wateroffice.ec.gc.ca/index_e.html

Real time data is available for the current calendar year (2014) and the prior year (2013), recorded at one hour intervals and available on the website within a few hours of the actual recording time. For the years prior to the two years of real time data, historic records based on the real time data of each year, with editing and recalibration, are available. Note that the early part of the Flour Mill Era is not in these records. However, there is a good record for 95 years of historical data recorded from 1918 to 2012.

Appendix C contains a selection of records from that website. The records include a sample of flow rates recorded during the Flour Mill Era in the form of graphical flow charts at ten year intervals over the period 1920 to 1990. Also included is a numerical tabulation of daily flow rates for each sample chart. These tabulations provide a more accurate indication of flow rates, particularly during the summer low-flow period. The chart below is a sample from the middle of that period (1950). It is typical of the other charts in this period, showing the spring flood in April, a rapid decline in flow through May, a continuing decline through June, and an almost flat period of low-flow through July, August, September and October. A reference to the tabulated data for the summer period shows a total range of 6.29 to 9.68 cubic metres per second (cms), something that should have provided a stable low water level for the wetland trees for the majority of the growing season. The chart also includes “Max” and “Min” curves that plot the daily maximum and minimum levels throughout the 95 years of recorded data, and represent the outer bounds of natural variability.

The other sample charts for the 1920 to 1990 period are quite similar with the principal differences occurring in the height of the spring flood, and the exact timing of that flood. The year 1980 departs a bit from this pattern in that the spring flood has a double peak (March and May) and the summer flow is somewhat higher than usual with a range from 7.8 to 29.4 cms through July to October.

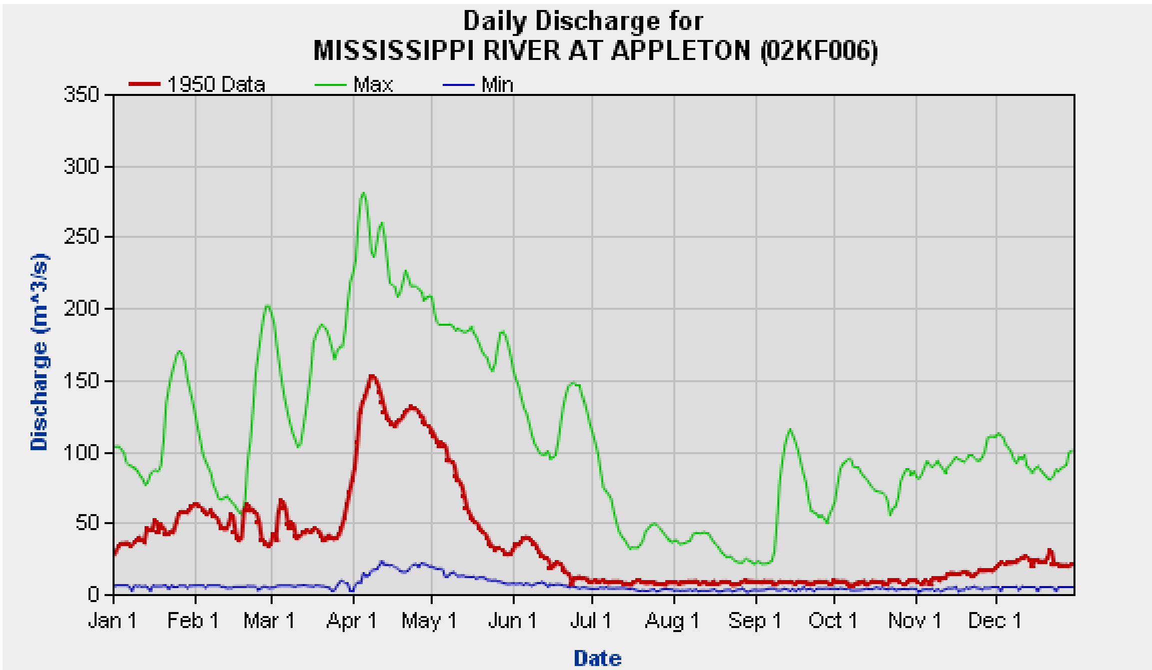

Figure 10 River flow data for 1950

While we do have pretty complete river flow records, there are no corresponding detailed records of river level in Reach 18 during the Flour Mill Era. Intuitively, when the flow increases the water level will rise, but the relationship between flow and river level had not been measured or recorded for this Reach prior to this report. The only thing that is clear is that summer flows were consistently at their lowest values, and for a free flowing river, the water level should have been at its lowest level in the summer as well.

4.1.2 Anecdotal Records - Almonte Weir

There are no detailed written records of exactly when flashboards were installed on the weir, the height of the flashboards used, and when the flashboards were broken free by the pressure of spring floods. As a result, we must fall back on some anecdotal evidence that has at least some credibility.

The video *Opposite Banks,* an independent film by Robert and Sharon Newton of Almonte in 2013, does include an excerpt from Brian Gallagher, a former manager with Almonte Hydro. A transcript of his comments in a section of the film contains the following reference to the flashboards:

> *"Those boards were in there – I know – this is not hearsay – we put these boards in for years. We bought them from Harry Barr, Stuarts, Paul Maynard. We buy 12 and 14 inch boards to go on that weir. We're talking about 4 – talking about 10 cm instead of 50. That's the difference. And those boards were there – that's part of the control system on the river "*

The same video also includes a short excerpt from Harry Barr, a lumber mill operator in Pakenham. A transcript of his comments reads:

> *"Many years ago I used to sell boards to Almonte Hydro for the dam when the water level was low in the river. The size of the boards were 1 inch x 12 inches wide by 16 feet long. That is the actual size of the boards we used to supply."*

In an unplanned meeting in the parking lot of the Almonte Old Town Hall on the morning of August 25, 2013 between Brian Gallagher and one of the members of this Research Group (Al Seaman), Mr. Gallagher reiterated quite emphatically that during the Flour Mill operation period Almonte Hydro, under contract to the Flour Mill, installed 14 inch high boards on weir sections 1 and 2, and 12 inch high boards on section 3 and 4. Subsequently, after conversion to a power generator station, he indicated that flashboard heights were changed to 50 cm for sections 1 and 2, and 40 cm for sections 3 and 4.

Note: It seems to be common practice to refer to the Flour Mill Era flashboards in English units, and those in the Generator Station Era in metric units. For comparison: 12 inch = 30.5 cm, 14 inch = 35.6 cm, 40 cm = 15.7 inch, 50 cm = 19.7 inch.

On the other hand, there are other people who have memories of the flashboards often being in a damaged or missing state with the result that in the summer low-flow period the water level was just around the level of the concrete weir (now well documented to be 117.20 masl).

4.1.3 <u>Photographic Records - Almonte Weir</u>

There are a fair number of historical photographs of Almonte, but images that show the Almonte weir, with or without flashboards, are quite rare. Rarer still are any photographs from the Flour Mill Era that are clear enough to provide an estimate of the flashboard height and state of repair, or that can be dated closely enough to identify the year or the season when they were taken. Appendix E contains a collection of pertinent images from both eras that have been analyzed in various ways. We include below some of the relevant images from the Flour Mill Era with summarized results of the analysis in Appendix E. In the commentary that follows images may be referred to in the form of Figure E-x. In all cases that refers to a specific image in Appendix E with that figure number.

Figure 11 The upper falls and weir (Figure E-3)

This image (identified as “tinted_view_of_cpr_bridge_towards_town_hall.jpg”) was selected from the Michael Dunn collection and is undated. From other evidence it was probably taken within a few years prior to 1912. There is some snow on the ground but no ice on the river suggesting that it was probably taken in November. The concrete weir section 1 can be seen across from the Old Town Hall, and the straight edge of the falls leading from the CPR bridge indicates the presence of weir section 3. There does not appear to be any sign of weir section 2 at this date. There is no indication of flashboards anywhere, and in addition there is no sign of projecting pipes for supporting flashboards. Another similar photograph from this time period (Figure E-1) shows evidence of weir sections 1 and 3 and no flashboards. There is no section 2 weir, but in that location there is a row of projecting pipes presumed to be anchored in the bedrock, and probably used to support flashboards, although not at the time of the picture.

The fact that Figures E-1 and E-3 both show weir sections 1 and 3, but neither one shows weir section 2 suggests that the operation was true Run of River at the turn of the century, and flashboards were not a means of increasing hydraulic head. Weir 1 directed flow to the Thoburn Mill, and weir 3 directed flow to the Flour Mill, and any excess flow simply went through the gap where weir 2 now sits.

Figure 12 View of weir section 3 at the time of the 1974 train wreck (Figure E-4)

This image (identified as “train_wreck_1974_no2.jpg”) was selected from the Michael Dunn collection and can be dated as very shortly after the train wreck of June 5, 1974. Environment Canada records show the river flow rate was 57 cms on June 5 declining steadily to 25 cms on June 12. The general appearance of the falls is in accord with that range of flows, and the appearance of the water going over weir section 3 suggests that flashboards were present on the weir. The water level at the junction of weir section 3 and the fourth pier of the bridge is consistent with the flashboard height being 12 inches as indicated by others as the board height used in the Flour Mill Era.

Figure 13 View of the upper falls and weirs in November 1973 (Figure E-5)

This image was provided by Al Seaman and was recovered from a forgotten set of his negatives of the Old Town Hall. The negative index was marked November 1973. The negative was scanned to convert it to the above digital image (AlScan604Nov73.jpg). There is a trace of snow on the ground, but no ice on the river suggesting that the image was taken in the second half of November. The image shows the weir sections 1 through 3. There is some question as to the state of flashboards on sections 1 and 2, but there is definitely the appearance of flashboards on weir section 3 as shown by the pipe supports and the very sharp and straight edge of the waterline along the top of the flashboards.

An enlarged portion of the junction of flashboard section 3 with the fourth bridge pier was compared to a similar modern photograph with 40 cm flashboards, and it shows that the 1973 boards were shorter than current boards and probably consistent with the 12 inch boards claimed in that era.

An enlargement of the junction of weir sections 2 and 3 indicates that the flashboards on section 3 are higher than section 2. That may be the result of missing boards or shorter boards. If the latter, it does raise a doubt about claims that section 2 had 14 inch boards while section 3 had 12 inch boards in this era.

An enlarged view of sections 1 and 2 was compared to (a) a similar view taken in the summer of 2013 when flashboards were missing from sections 1 and 2, and (b) a similar view taken in the summer of 2012 when fully intact 50 cm flashboards were installed. The 1973 image looks more like the no-boards 2013 image, although the differences in flow rate and perspective make that comparison difficult. The 2012 image certainly indicates that if there are flashboards in the 1973 image they are much lower than 50 cm in height, and also lower than the claimed 14 inches.

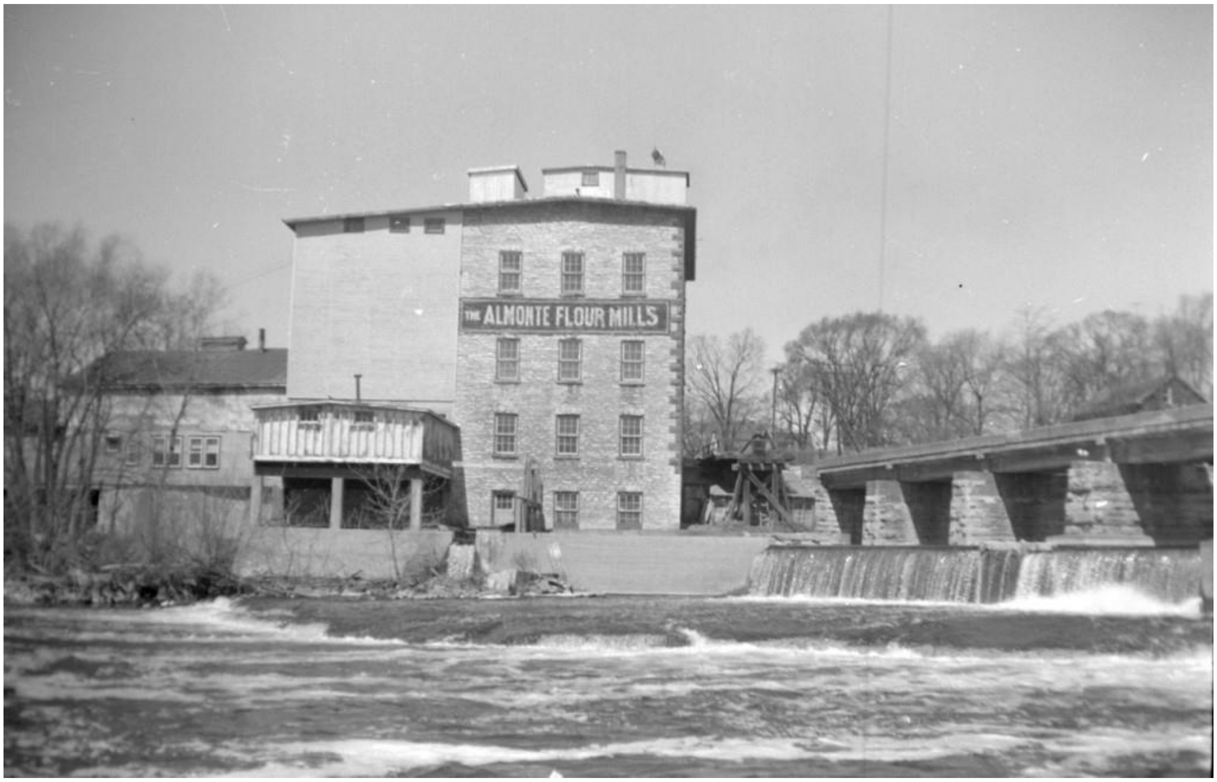

Figure 14 An undated view of the Almonte Flour Mill and weir section 4 (Figure E-9)

This image was provided by Robert Newton and is unfortunately undated. From the appearance of the trees it seems to be early May with the leaves just starting to emerge. The spring flood has passed but flow rate is still quite high. On careful inspection it can be seen that there is a short section of flashboards still on weir section 4 that was not broken off in the spring flood. As detailed in Appendix E, this provides an opportunity for close estimation of flashboard height. The results of several measurements on the images yield a board height consistently near 30 cm, equivalent to the 12 inch height claimed for the boards in this era.

4.1.3.1 Summary of Photographic Records

The historic record of the weir and flashboards in photographs is quite contradictory. There is evidence that concrete weir sections 1, 3 and 4 have been there a long time, perhaps over a hundred years. The use of flashboards is less certain. Early images such as Figures E-1 and E-3 have no flashboards, although Figure E-1 does show the pipe supports in section 2 that would anchor flashboards. Those are undated images, probably dating back to the early 1900s. More recently Figure E-4 in 1974 does appear to have flashboards on section 3 of 12 inch height. Figure E-5 in 1973 also appears to have 12 inch boards on section 3, but those on sections 1 and 2 seem to be shorter or partially missing. Figure E-9 is undated, but may be around 1950, and clearly shows a lot of missing boards on section 4 along with a short remnant that can be measured as 12 inch. There are no photographs in the Flour Mill Era that we have found that clearly show all flashboard sections in place at one time, and of a quality that permits accurate size estimation. The photographs do lend some credence to claims that flashboards were not always in place nor well maintained during the summer in that era.

4.1.4 Written Records - Flashboards

At the MRWMP Standing Advisory Committee (SAC) Meeting #7 on November 28, 2012, (see Appendix M) Scott Newton of Mississippi River Power Corporation (MRPC) made reference to having found records in the old files of Almonte Hydro indicating that there were instances of that company installing flashboards on the Flour Mill weir under contract. A short time later, Mr. Newton graciously provided the opportunity for a member of this research group (Al Seaman) to view these records. Although copies were not made at the time, the essence of the records was that on a half dozen or so instances over the period from the 1940s to the 1980s, flashboards were installed on the weir by Almonte Hydro staff for the Flour Mill. None of those records contain any information as to the dimensions of the boards installed. There was also no indication that this was a regular annual maintenance service. A couple of invoices for materials were also included. These simply showed “lumber and pipe” for flashboards with no indication of dimensions or quantities.

In summary, the written records are somewhat inconclusive. They certainly show that flashboards of unknown height were installed on occasion. Annual maintenance may have been done, but there is no written record confirming that to be the case. In view of the nature of this material it did not seem worthwhile for this Research Group to go back and get copies of those records for inclusion in this report. We also do not know of any other relevant documents at this time.

4.1.5 Memories of the Rock Ridge

A feature of the Mississippi River just above the Almonte Fair Grounds is a small island and a large, flat rock ridge that extends from it for some distance in a north-easterly direction. During the 1970s to 1980s, and probably long before, the presence of the ridge during the usual summer low-flow period was well known to the boating, canoeing and kayaking community. The water over the ridge was so shallow (10 cm more or less) that it would not permit direct passage over it without grounding, and a detour in deeper water at the north end of the ridge was necessary. Although known and remembered by many, the rock ridge has never been measured, nor has the river level that permits passage over the ridge been documented.

This provides the possibility of a more quantitative means of reconstructing what the likely summer water levels were in that period. Simply create an elevation profile of the ridge measured in masl and add 10 cm to it. To that end, on October 11, 2013, a survey by canoe of the ridge area was undertaken. Appendix I contains the full details of this survey.

The process was simple;

- paddle to a sample point,
- anchor,
- measure precise location with a GPS unit, and
- measure the depth of water at that point with a metre stick.

The GPS position was measured with a handheld Garmin eTrex Vista HCx unit, WAAS enabled, and averaged over 1.5 to 2 minutes. The GPS unit typically indicated a probable accuracy of 2 to 3 metres. The sampling did not follow a uniformly defined grid, due to the lack of close reference points and the perturbations caused by river currents and erratic breezes. In spite of that, the random points collected do provide a useful result.

The Google Earth image below shows a view of the river with the Almonte Fair Grounds at the left side of the image. The cluster of waypoints in the river shows the location of the depth sampling point. Waypoints 278 and 279 are simply reference locations on the shoreline at 222 Spring Street.

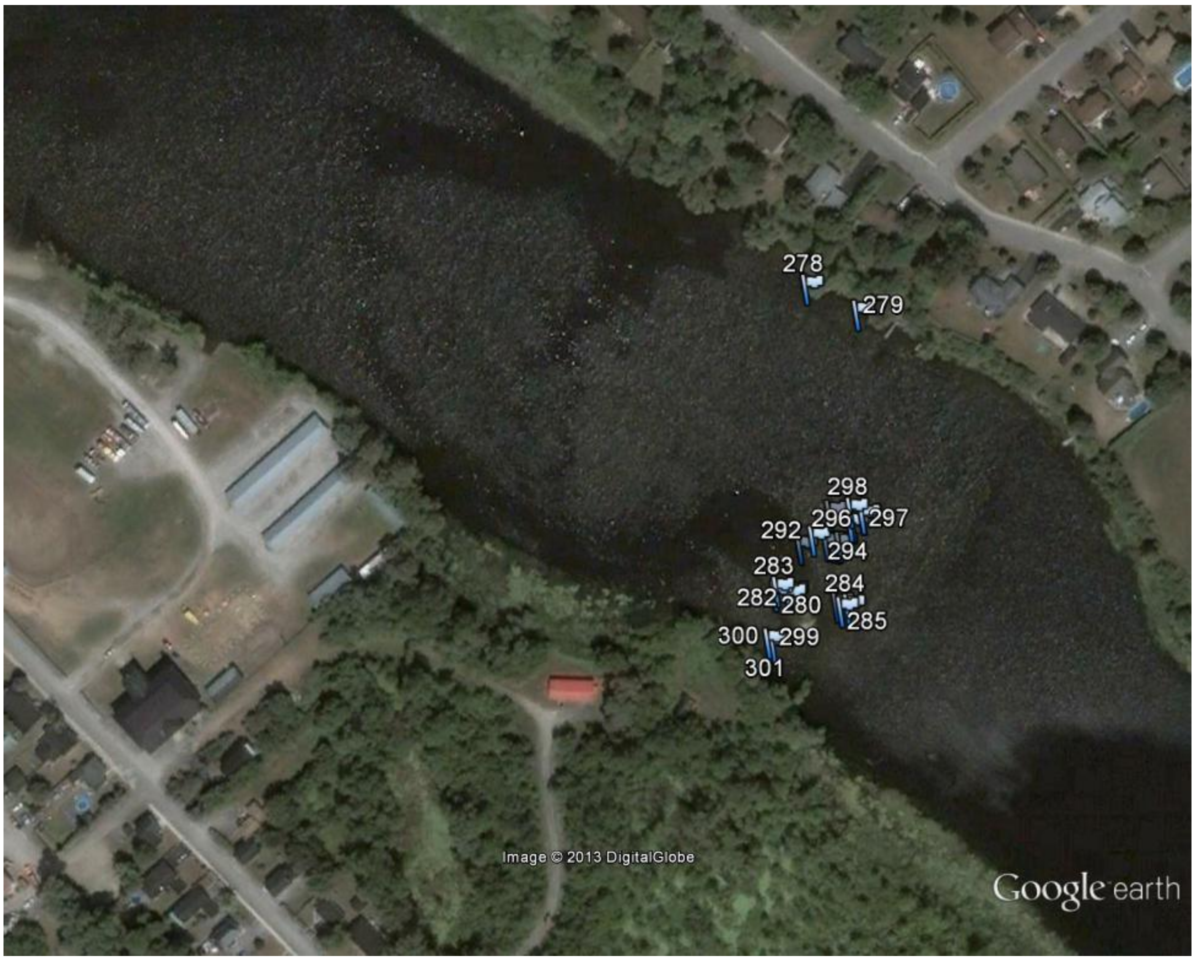

Figure 15 Google Earth image of river area with waypoints added

The chart below shows the measured elevations of the rock bottom at each sampling point. Note that there is a group of sample points that have an elevation very close to 117.10 masl, specifically waypoint numbers 285, 286, 287 289, 290 and 291. These points define part of the profile of the rock ridge.

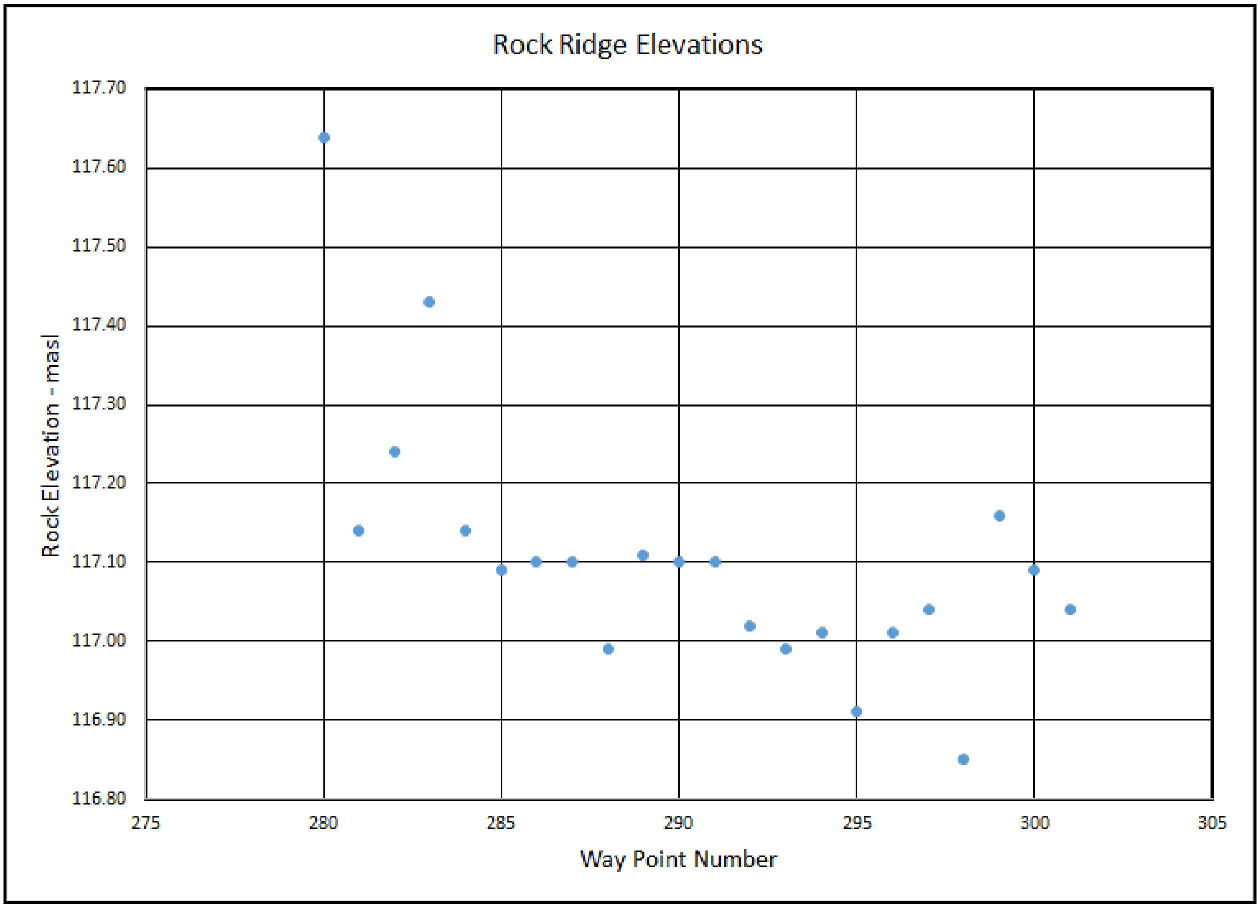

Figure 16 Rock elevation for each waypoint

Waypoints 280, 282 and 283 are fairly close to the island and show higher levels.

Waypoints 285, 286, 287, 289, 290 and 291 are all very close to 117.10 masl and define the flat top surface of the ridge.

The cluster of waypoints 293, 294, 296, 297 and 298 are closer to the buoy marking the north channel around the ridge and start to show increasing depth.

Relative positions of the waypoints are shown more accurately in the chart below that is derived from the GPS position data. The origin is arbitrary and was chosen only to optimize the view of waypoint positions. The chart gives an accurate presentation of distances between measured waypoints. In addition, from the measured levels of the ridge, the waypoints on the flat top surface at 117.10 masl have been coloured red. This provides a partial outline of the shape and location of this ridge.

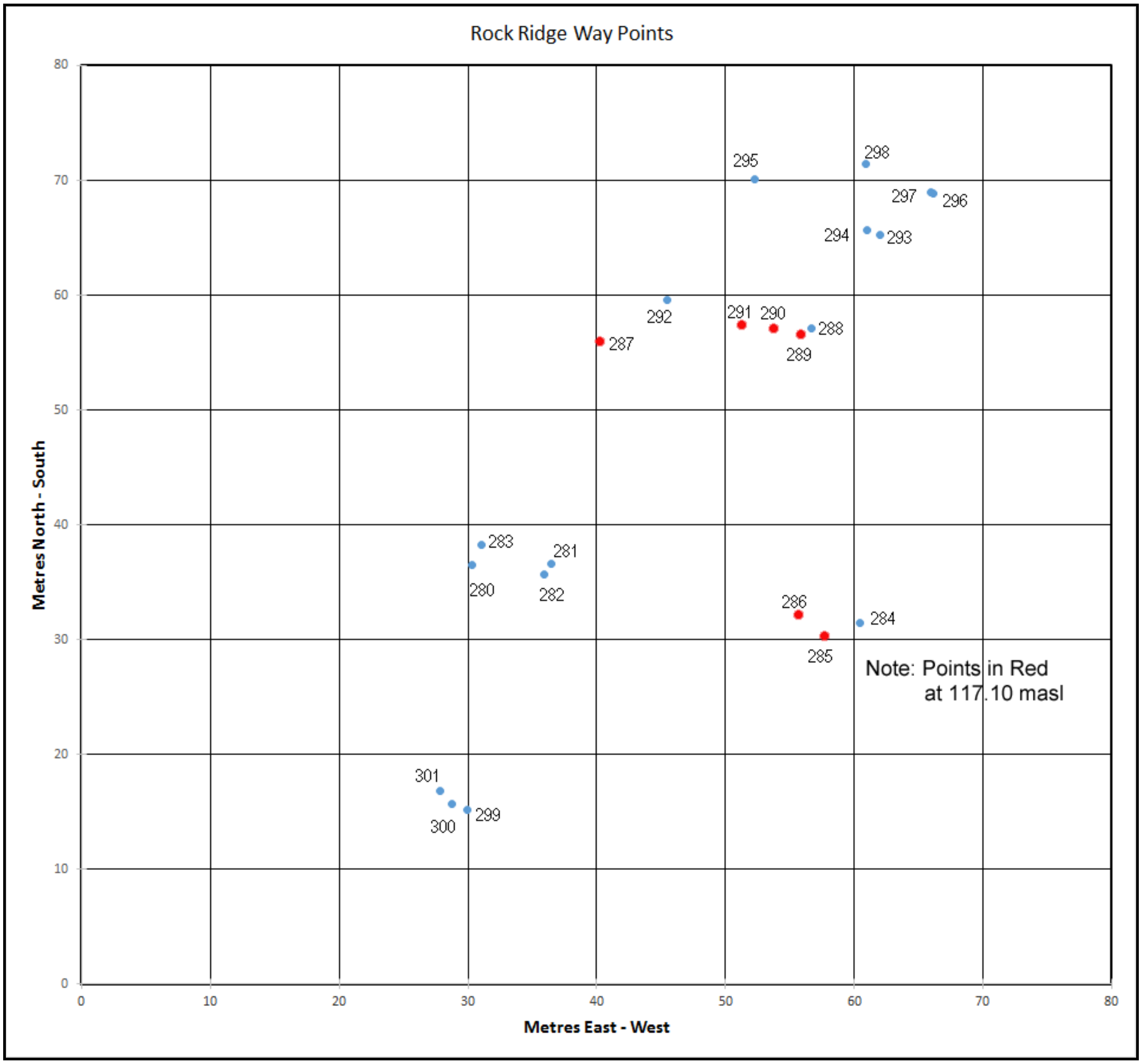

Figure 17 Waypoint positions on North-South and East-West grid

4.1.5.1 Conclusions from Rock Ridge Measurement

The measurement of the top profile of the rock ridge puts the level of that ridge at 117.10 masl. Adding the 10 cm water depth typically observed over the ridge in the 1970s and 1980s would yield a historic water level of 117.20 masl. This is the most probable number for normal summer water levels in that period. It is also the level of the concrete weir above the Flour Mill.

This suggests that the summer levels were set by the concrete weir and that flashboards were probably missing or in a state of poor repair. Alternately, water demand by the mill may have been such that all of the available water in the summer low-flow period went straight to the mill and there was no buildup of water behind the flashboards. Any records of what may have been happening at the weir have not been found.

Regardless of the cause, the evidence indicates that much of the time in the summer water levels at the weir were around 117.20 masl, and would have ensured that water levels in the Appleton Wetland were in the range for healthy tree growth.

4.1.6 Memories of the Vanishing Island

There is a strong memory, on the part of many people, of a small island just above the Fair Grounds in Almonte. This island always disappeared in the spring flood, but then later in the low-flow summer period it was usually quite visible up until around the year 2000. This was particularly noticeable while driving southeast on Martin Street South and approaching St. Paul Street where there is a clear view of the river. The small island was straight ahead down Martin Street as shown on the Google Earth image below. The yellow line projected from Martin Street does point directly at the island. A more complete summary about this island can be found in Appendix J.

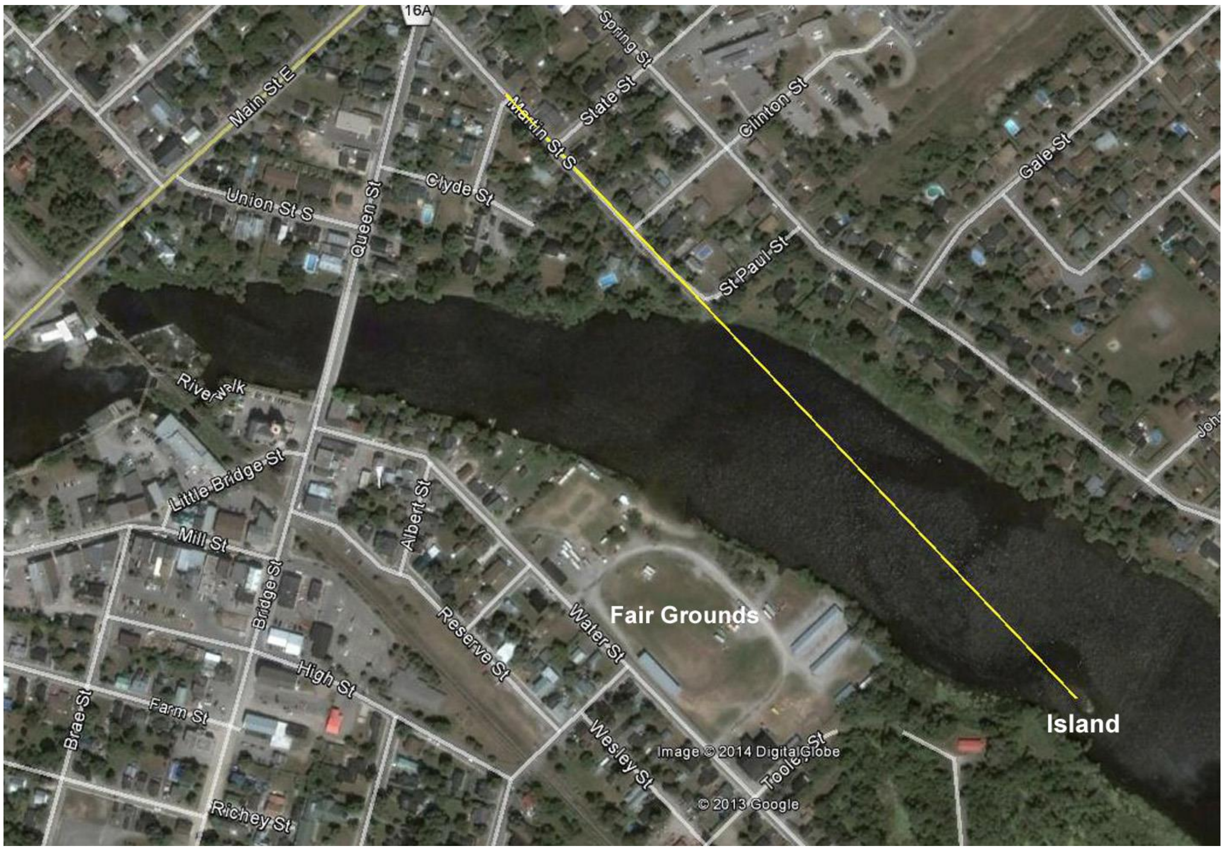

Figure 18 Google Earth image of Martin Street South and the Island

Unfortunately, there do not appear to be any pictures of the island in its summer state during the Flour Mill Era, and memories of exactly what years it was visible, or not, are vague. Without question, it was certainly there a good part of most summers in the 1970s to 1990s.

There is, however, one historical picture from around 1890 that shows Mayor John Drynan’s steamer, along with some suitably attired ladies of the period ready for some boating. That image is included below. Although the exact date of the photo is not known, from the tree foliage and the boating activity, it is clearly summer. Just above the stern of the steamer a small island with a tree is visible. For greater clarity that portion of the image has been cropped out, and an enlarged copy of the crop is pasted at the top of the original image. A close examination of the shorelines and trees in the original image suggests that the viewpoint for the photograph was on the river bank at the intersection of Martin Street South and St. Paul Street.

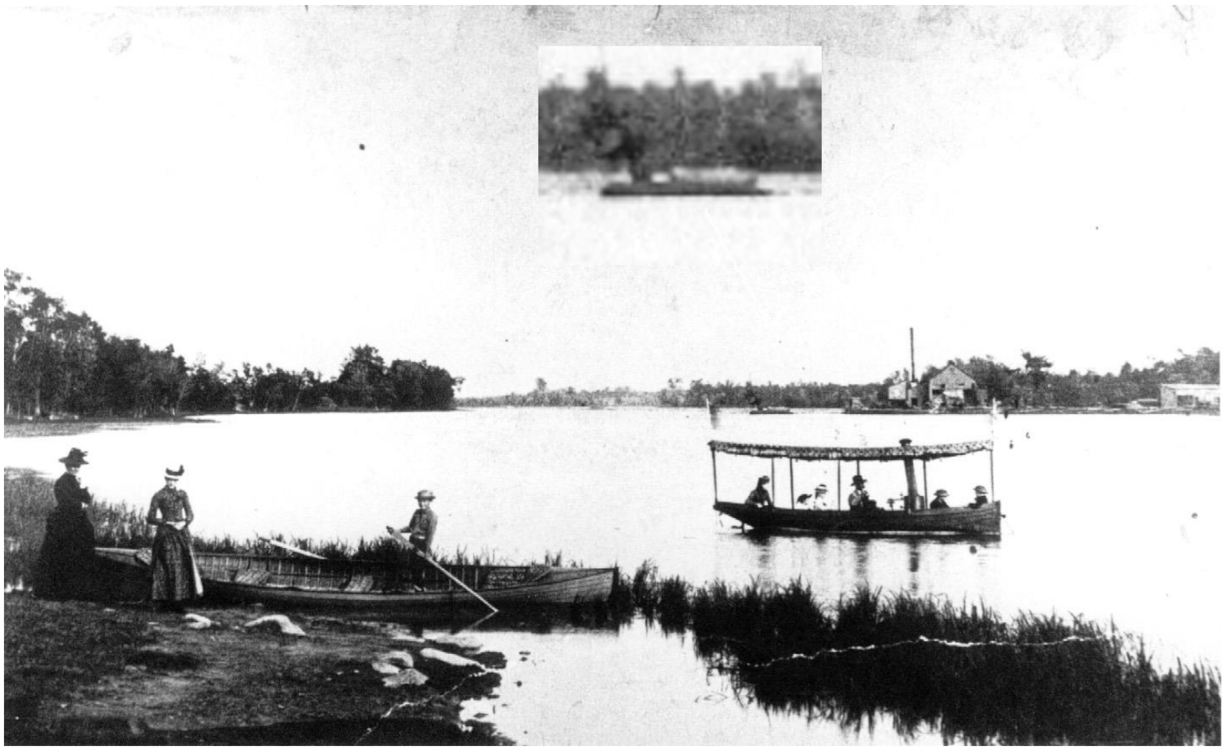

Figure 19 Mayor "John" Drynan's steamer, circa 1890

A comparison of the scene as observed in 2013 is shown in Appendix J and there is a barely visible island in the image. The difference in the images is that the 2013 image was taken with a water level of 117.58 masl while the 1890 image was probably taken with a water level of 117.20 masl or lower. The difference in level is at least 35 cm, an amount that would explain why the modern island vanishes.

During the summer of 2013 we took a series of photos of the island from the same viewpoint on the side yard of 222 Spring Street. The image below is an example from that series. It was taken on August 25, 2013, at a water level of 117.49 masl as measured at 222 Spring Street.

In this image the island is quite visible, but it is not as high as it seemed to be from recollections of earlier years in the 1970s to 1990s. The estimate is that the water would have been about 30 cm lower with the result that the island would appear another 30 cm higher.

Figure 20 The island from 222 Spring Street (IMG_0396e.jpg, 25-Aug-2013)

To illustrate the variation in island height, a composite photo was created by cropping a sample of the island from a series of seven images, taken from those available, and sorted in order as the water level varied from lowest to highest. All photos were taken from the same spot with the same camera and image zoom setting. Aside from changes in lighting and foliage, the only significant change between image samples is the water level. The composite image is below. Each of the seven components is labeled with the water level, the source image number, and the date of the original image.

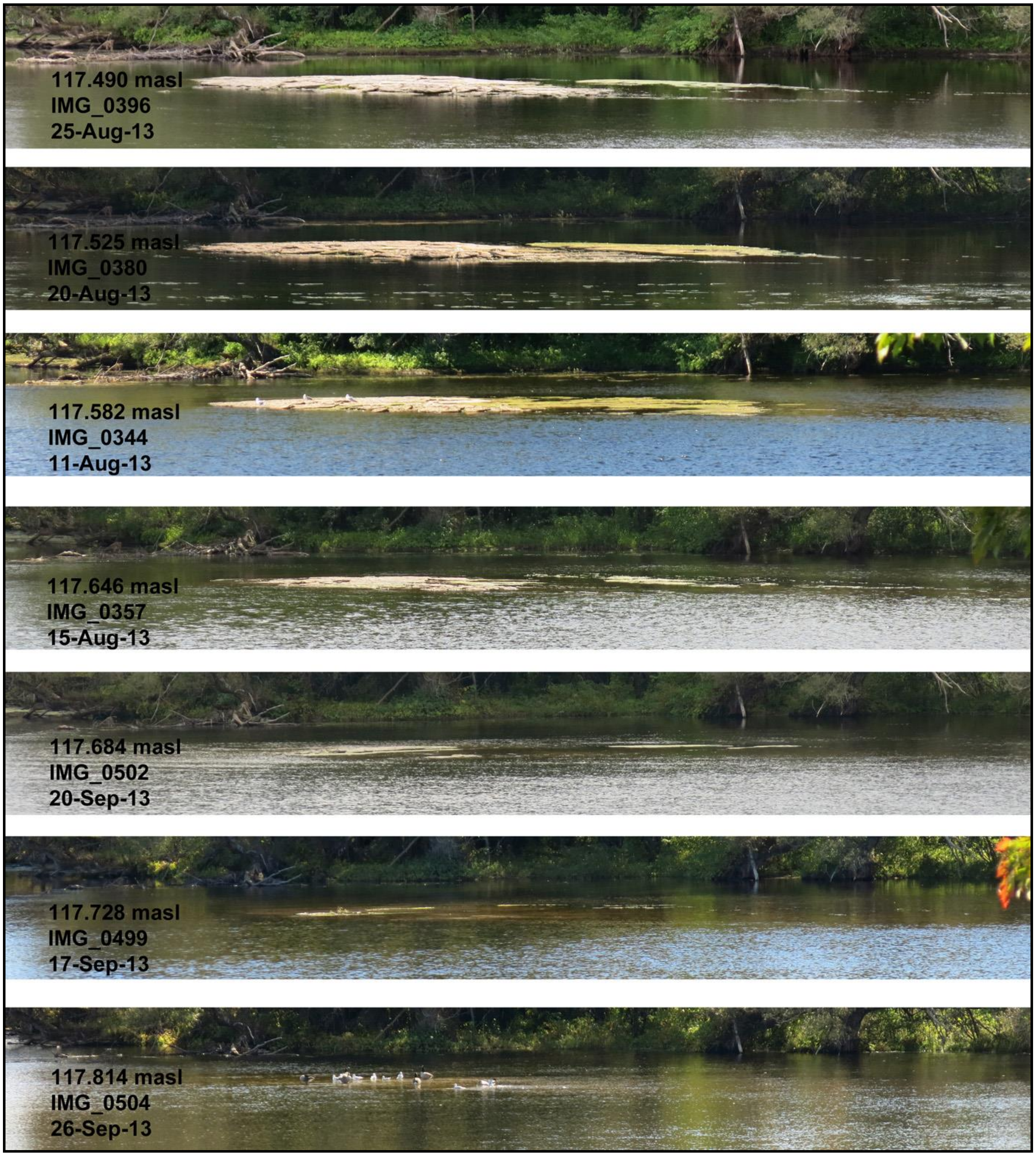

Figure 21 Composite image of the island with seven water levels

Note that while the island is quite visible at the lowest level recorded (117.49 masl) it is still considerably lower than recollections of the 1970s to 1990s. As the water rises, the island gets smaller until it is almost gone at a water level around 117.70 masl, a level that has become common in the summer since the 2000s. At 117.80 masl the island becomes a handy resting spot for birds that like to wade in the water.

The island tells us that water levels have changed significantly since the Flour Mill Era.

4.1.7 Summary for the Flour Mill Era

The previous sections of this report have provided considerable detail on river conditions during the Flour Mill Era. The information includes conflicting details, and much that is poorly documented. Taken as a whole the information, as summarized below, does provide a basis for understanding conditions that existed for over 100 years, and for determining what has changed more recently that may account for the wetland die-off.

- We do have pretty complete river flow rate records, but there are no corresponding detailed records of river level in Reach 18 during the Flour Mill Era. What is clear is that summer flows were consistently at their lowest values, and for a free flowing river, the water level should have been at its lowest level in the summer as well.
- On the basis of anecdotal information from Mr. Gallagher, during the final decades of the Flour Mill operation period, Almonte Hydro, under contract to the Flour Mill, installed 14 inch high flashboards on weir sections 1 and 2, and 12 inch high boards on section 3 and 4.
- On the other hand, there are other people who have memories of the flashboards often being in a damaged or missing state with the result that in the summer low-flow period the water level was just around the level of the concrete weir (now well documented to be 117.20 masl).
- The historic record of the weir and flashboards in photographs is quite contradictory. There is evidence that concrete weir sections 1, 3 and 4 have been there since the early 1900s. The use of flashboards is less certain. Images from the early 1900s show no flashboards. An image from 1974 does appear to have flashboards on section 3 probably of 12 inch height. An image from 1973 has evidence of 12 inch boards on section 3, but those on sections 1 and 2 seem to be shorter or partially missing. An undated image, probably from about 1950, clearly shows a lot of missing boards on section 4, along with a short remnant that can be verified as 12 inches high. There are no photographs in the Flour Mill Era that we have found that clearly show all flashboard sections in place at one time, and of a quality that permits accurate size estimation. The photographs do support the statement of Mr. Gallager, but also lend some credence to claims that flashboards were not always in place and well maintained through the summer in that era.
- The fact that images from the early 1900s show weir sections 1 and 3, but do not show weir section 2, suggests that the operation was true Run of River. The weirs were not a means of increasing hydraulic head but were simply to direct water flow. Weir 1 directed flow to the Thoburn Mill, weir 3 directed flow to the Flour Mill, and any excess flow simply went through the gap where weir 2 now sits.
- The written records of flashboards are somewhat inconclusive. They certainly show that flashboards of unknown height were installed on occasion. Annual maintenance may have been done, but there is no written record confirming that to be the case. We do not know of any other relevant documents at this time.
- The measurement of the top profile of the rock ridge just above the Almonte Fair Grounds puts the level of that ridge at 117.10 masl. Adding the 10 cm water depth typically observed over the ridge in the 70s and 80s would yield a historic water level of 117.20 masl. This is the most probable number for normal summer water levels in that period. It is also the level of the concrete weir above the former Flour Mill.
- This suggests that the summer levels were set by the concrete weir and that flashboards were probably missing or in a state of poor repair. Alternately, water demand by the Flour Mill may have been such that all of the available water in the summer low-flow

period went straight to the mill and there was no buildup of water behind the flashboards. No records of what may have been happening at the weir have been found.

- The Vanishing Island above the Almonte Fair Grounds provides further evidence of river water levels in the past. The island is visible in a photo from 1890, and there is anecdotal evidence that it was a regular summer feature through the final decades of the flour mill operation. Today the island is usually submerged or only partly visible. The island tells us that water levels were much lower in the Flour Mill Era than they are today.

4.1.7.1 Conclusion

The bottom line is that Flour Mill Era water levels were normally low through the summer growing season, probably around 117.20 masl as measured at Almonte. There is controversy as to exactly what height flashboards were, and how regularly they were replaced and maintained, but this is a secondary factor. The more important factor is the water demand of the mill relative to the average summer flow (around 10 cms). If the mill used all of the available summer flow, which seems quite likely, there would be no excess flow to build up the water level behind the flashboards, and the water level would remain low. During the period prior to 1956, when both the Flour Mill and the Thoburn Mill were sharing the flow at the upper falls, water demand would have been higher and would have contributed further to low water levels. In conclusion, it is obvious that, whatever regime for water control was being used during the Flour Mill Era, the trees in the Appleton Wetland were not affected and remained in a very healthy state.

4.2 The Generator Station Era

After the termination of operations at the Flour Mill there was a gradual conversion to the present hydro generator station as covered previously in the section on the Mill history. The evidence for many of the resulting changes is fairly easy to find, and this preliminary data is summarized below.

4.2.1 <u>Photographic Records - Almonte Weir</u>

There is no argument about the size of the currently used flashboards on the weir. It is easy to measure accurately – simply wade along the weir when the water is low and measure them with a metre stick. Those on sections 1 and 2 are 50 cm high and those on sections 3 and 4 are 40 cm high – just as stated by Mr. Gallagher in a previous section.

Unfortunately, there is no clear evidence as to just when the use of higher boards was started. Anecdotal information has suggested that the change started about 2004, but it was only after a search for photographs of the weirs that it became clear that the higher boards went into use in 2001 or just prior to that date. Appendix E contains full details of relevant photographs and the results of estimating board heights from suitable photographs with verifiable dates. Examples from the earliest date follow.

Figure 22 Crop from Image DSCF0489 of 2001

Figure 23 Reference Image 189_8924e of 2012

Figure 22 is derived from Figure E-14. It was provided by Mike Caughey and is dated May 31, 2001. Figure 23 is from Figure E-11. It was provided by Al Seaman and was taken during the summer of 2012 when these flashboards were known to be 40 cm in height.

Both images have the flashboards and the concrete weir in the same vertical plane. The pixel positions for the top of the boards, the junction of the boards and the weir, and the bottom of the weir in both digital images were measured vertically. The weir height provides the image scale for each image, the reference flashboard provides a calibration, and allows the dimension of the 2001 flashboard to be calculated by proportion. Since the measured points are in the same vertical plane, the measurements are not overly sensitive to differences in perspective or viewpoint location.

Several measurements were made on Figure E-14, and consistently the flashboard height was determined to be very close to 40 cm. This is the earliest date with a solid confirmation that higher flashboards were in use after conversion of the old mill to power production.

Subsequently, an image from 2001 that shows weir sections 1 and 2 was discovered by MNR. It is shown below along with a similar image from 2012 when the flashboards were known to be exactly 50 cm in height.

Figure 24 From Figure E-15

Figure 25 From Figure E-16

Figure E-15 (MNR “Flashboards 6”) was included in an email to the SAC by Jim Fraser of MNR and is dated on the image as November 15, 2001. The Figure E-16 (Seaman “189_8962”), taken July 12, 2012, is the closest image on hand that was taken from a similar viewpoint and suitable for comparison.

Unfortunately there are no vertical features in the same plane as the flashboards, so the technique used previously is not applicable. In addition since the viewpoints are different, the two images are not directly comparable. Alternate approaches as described in Appendix E were adopted for comparison purposes. The conclusion is that in 2001 the flashboards on weir sections 1 and 2 were the same as in 2012 – that is, 50 cm. That is consistent with the findings of MNR for this image.

During the Generator Station Era, the photographic evidence confirms that board heights of 50 cm were used on sections 1 and 2 and 40 cm boards were used on sections 3 and 4 as early as 2001. Around the beginning of this era (1990) when the GS was still using the old turbines and generators, the flashboards, if any, were probably the lower boards of the Flour Mill Era. There was a period around 1995 when the plant was idle while a new water intake and tailrace were built and the turbines and generators were replaced. Subsequently, around 1997, current operations as a GS began. It is not clear just when in the 1997 to 2001 interval that the flashboard height was increased.

4.2.2 New Weir Management Strategy

The photographs also suggest a change in purpose for the weir and flashboards in the two Eras. Early in the Flour Mill Era, the purpose seemed to be to divide the available water and direct it to the Flour Mill and the Thoburn Mill while preventing an undue amount of water from escaping over the falls. In the second era, the purpose is clearly to maximize the head for the GS and so generate more power and revenue. With an available head of only 2.8 metres between the concrete weir at 117.2 masl and the top of the MRPC dam just below the Enerdu tailrace at 114.4 masl, adding another half metre with flashboards will increase potential power production by 18%.

From observation of Enerdu GS operations it is clear that they have adopted a strategy of managing water use to ensure that water levels remain near the top of the flashboards during the summer low-flow period. With summer flows usually at rates below the 14 cms maximum generator water demand, water level above the weir will be drawn down over a period of hours. After the water level drops to about 20 to 30 cm below the top of the flashboards, the generators are turned off, allowing water level to build up to near the top of the flashboards, and then the cycle repeats. Operation of the generators is easily verified by watching the water flow in the tailrace. This change to aggressively managing water use to maintain maximum head, along with increased flashboard height, accounts for the significant water level difference between the Flour Mill Era and the Generator Station Era.

4.2.3 MRWMP - Reach 18

In the early 2000s, under direction of MNR, a program was started to develop the Mississippi River Water Management Plan (MRWMP) that defines operating strategies for all of the power producing dams and water control structures on the river in order to optimize the levels and flows throughout the year. The final MRWMP is dated June 16, 2006. We are particularly concerned with the details covering Reach 18, the portion of the river between Appleton and Almonte. Appendix B contains a number of extracts of relevant material from the plan.

In particular, the MRWMP section dealing with the Enerdu GS operating plan states;

- *the compliance range for the Enerdu GS is 116.7 to 118 .0 m,*
- *the GS is a "run-of-the-river" operation and can pass approximately 14 cms through the generating station with excess water being spilled over the weir,*
- *the target operating range for this structure is 117.20 m to 117.70 m,*
- *flashboards are added to the top of the weir to increase the head at the dam providing normal summer levels being maintained between 117.60 m and 117.70 m,*
- *flows exceeding 40 cms (25 cms if the plant is not operational) will cause levels in the community to exceed 118.0 m with flashboards in place, and the flashboards are to be removed if levels reach this elevation, and*
- *if the elevation of 118.0 m is exceeded when the flashboards are not in place and the discharge facilities have been operated when operable to provide the maximum discharge possible, the structure will not be considered to be out of compliance;*

This had the effect of officially regularizing the practices that Enerdu had put into effect just slightly before in the 1997 to 2001 interval. We are unaware of any official approvals prior to 2001 for the changes to water management that Enerdu had then adopted.

Although the MRWMP recognized the presence of the Appleton Wetland PSW and ANSI on Reach 18, it appears to have overlooked that raising water levels to the extent allowed in the Enerdu operating plan would kill the trees in the Appleton Wetland.

The Executive Summary of the MRWMP states that among the reasons for developing the Plan:

> *"Ministry of Natural Resources made amendments to the Lakes and Rivers Improvement Act that would require the production of Water Management Plans, and thereby begin*

the process of ensuring that water resources were not abused to meet potential peak hydro demands."

We believe that Enerdu's efforts to extract every possible kilowatt from Reach 18 constitutes water resource abuse resulting in tree mortality in the Appleton Wetland.

The MRWMP also clearly states the priorities for managing the water resources of the river are:

- *Water management within the Mississippi River has evolved to the point where the priorities are as follows:*
  - *flood control,*
  - *low flow augmentation,*
  - *ecological integrity,*
  - *recreation / tourism, and*
  - *hydro generation.*
- *The system is never operated to maximize hydroelectric generation to the detriment of the other priorities.*
- *As with any of the other competing interests on the system, the overall goal is to maximize the benefits of the water in the system for the people, fish and wildlife living on, or using the system.*

Since an oversight in developing the plan has resulted in serious damage to a Provincially Significant Wetland, and the priorities of the plan state that ecological integrity trumps hydro generation, there is a clear need for an amendment to the plan.

The plan also includes a mechanism for Plan Amendment that states:

- *Amendments would likely arise as a result of new scientific research and studies being conducted or other information becoming available as specified in the plan or through other data gathering exercises.*
- *If changes are of such magnitude that a change in operating regime is considered at one or more of the structures, then the Ministry of Natural Resources (MNR) will issue an order to amend the plan.*
- *The Standing Advisory Committee will be informed of all amendments and given the opportunity to provide comments.*
- *MNR, in consultation with the plan proponents, will decide the appropriate degree of public and First Nations consultation required for plan amendments.*
- *Major amendments may involve a significant geographical scale (i.e. extensive areas up and or downstream of a dam) or have significant impact on the balancing of the environmental, social and economic attributes.*

We believe that this report on the decline of the Appleton Wetland satisfies the criteria in the first bullet in the preceding paragraph and that MNR should respond by issuing an order for plan amendment.

4.2.4 River Flow and Level Data

The lack of formal water level records that was noted during the Flour Mill Era changed in July 2006 when the MVCA installed a staff gauge on one of the piers of the Bridge Street bridge in Almonte. This enabled a manual measurement of water level from the Old Town Hall waterfront using binoculars. The gauge is calibrated to read levels directly in masl, and with care under good conditions (no waves, no ice, no dirt on the gauge, good lighting) levels can be read to 1 cm accuracy or better. It is read by MVCA staff on a nominal weekly basis, but is often read more frequently during periods of interest, and at some times less frequently than weekly. All measurements from July 2006 to the current date are logged to the MVCA website and are available to the public.

In Appendix D, we have provided an extensive analysis of this Almonte water level data in combination with the flow data from the Appleton Stream Gauge as downloaded from the Environment Canada website and summarized in Appendix C. The complete analysis is available in Appendix D with charts of flow rate and water level versus date for each of the years from 2006 to 2012. From the charts it becomes evident that there are a number of distinct flow regimes through a typical year:

a. Regime A: High flow (above 17 cms) with all flashboards operational – typically late fall and up to the peak of the spring flood. Water levels will exceed 117.7 masl.
b. Regime B: High flow (above 17 cms)with all flashboards missing – typically from the peak of the spring flood until May or June when flashboards are replaced. Water levels will vary widely depending on flow rate.
c. Regime C: Low flow (less than 17 cms) with all flashboards operational.

In all cases, there is a further effect depending on whether or not the generators (with a maximum water demand of 14 cms) are on or off.

i. In regime A, the status of the generators is minor, and the water level will always be above the 117.7 masl level.
ii. In regime B, as the water flow drops to the order of 20 to 30 cms in May or June, the water level will be around 117.5 masl with the generators on. It is at this point that the flashboards are replaced, causing an immediate rise of about 25 cm and the beginning of operation in regime A.
iii. Regime C, with low flow and all flashboards in place, is an unstable operational mode.

    1. With the generators off and a natural river flow that exceeds leakage through the flashboards and Thoburn, the level will rise to slightly over the top of the flashboards, 117.7 masl.
    2. With the generators in full operation (14 cms) plus flashboard and Thoburn leakage, and a natural flow of less than 17 cms, water levels will be drawn down as stored water in the river is used to balance the deficit between in-flow and out-flow.
    3. This on - off cycle appears to happen on a daily basis, but its exact profile is dependent upon the combination of exact river flow and water demand of the generators plus leakage. Although the sampling interval used in collecting the level data is too long to record the full details of the daily level cycling, it does certainly display level fluctuations between approximately 117.4 to 117.7 masl.

For illustrative purposes a chart for 2011 is reproduced below.

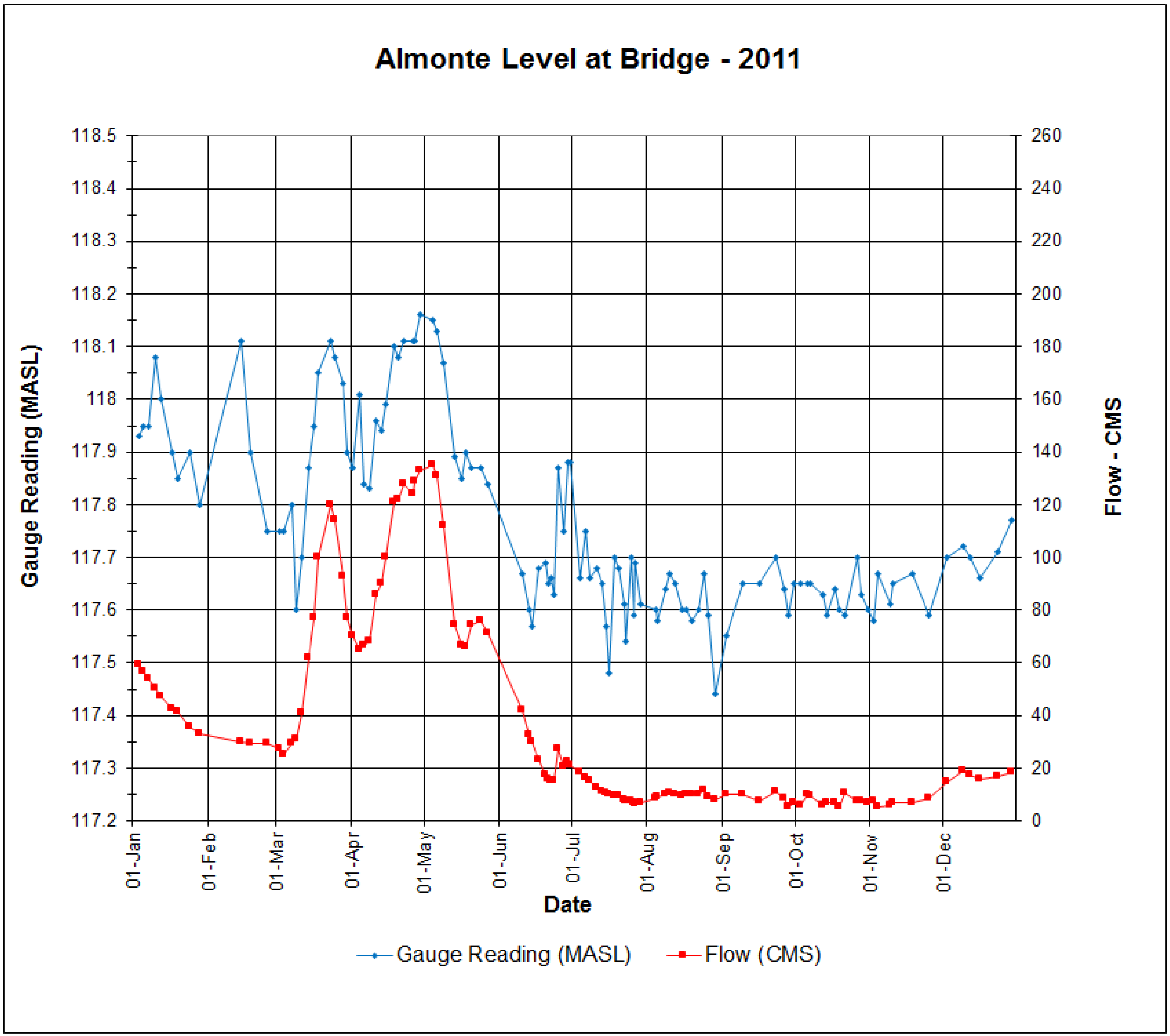

Figure 26 Water level and flow at Almonte Bridge in 2011

Comments on water level and flow at Almonte in 2011:

- The January and February level readings appear very erratic, probably due to ice conditions, and operation appears to be in regime A until the flood peak in early May.
- It is probable that flashboards were missing after the flood peak and operation was in regime B until late June.
- There is a definite rise in water level in later June that is suggestive of flashboard installation, but the picture is a bit uncertain since there is also a jump in flow rate at the same time.
- In any case, this was a summer of low water level (below 10 cms) and the period from early July to beginning of December was clearly in continuous operation in regime C – oscillations of 10 to 20 cm in level but always just below 117.7 masl.

In summary, the results of the analysis in Appendix D show three main operational regimes:

- Regime A, with high flow rates (17 cms and over) and all flashboards in place, water levels will exceed the flashboard height (117.7 masl) by an amount approximately proportional to excess flow over 17 cms. This regime can occur in the summer of years with higher than normal flow, and generally occurs in late fall, through the winter and until the peak of the spring flood.
- Regime B, with high flow rates (17 cms and over) and all flashboards removed, water levels will exceed the concrete weir height (117.2 masl) by an amount approximately proportional to excess flow over 17 cms. This regime starts around the peak of the spring flood as levels start to exceed 118.0 masl and lasts until flashboards are installed as the flow rate drops to around 25 cms, usually in June or July.
- Regime C, with low flow rates (less than 17 cms) and all flashboards in place, water levels will fluctuate between the flashboard height (117.7 masl) and a level 20 to 30 cm lower depending on cyclic operation of the generators. This regime usually starts in the summer after the flashboards are installed and can last until November.

Regime C is a particular threat to the Appleton Wetland since it causes high water levels (up to 117.7 masl) all the way to Appleton during the tree growing season, and it happens every year, including drought years. Regime A, when it happens in the summer, is even more harmful to the trees since levels will be over 117.7 masl. Regime B is not a particular problem for the trees since it occurs early in the growth season, and it duplicates the water level conditions for this period that have existed for over a hundred years. The Enerdu operations thus have two components, higher flashboards and aggressively managing generator cycling to maintain maximum head, which combine to make summer water levels much higher than normal.

4.2.5 Summary for the Generator Station Era

During the Generator Station Era, the photographic evidence confirms that board heights of 50 cm were used on sections 1 and 2, and 40 cm were used on sections 3 and 4 as early as 2001. The early part of this era started with old Flour Mill equipment that was gradually replaced and upgraded. Finally around 1997 current operations as a GS began. It is probable that at some time in the 1997 to 2001 interval the flashboard height was increased to those values.

In the second era the purpose of the flashboards is clearly to maximize the head for the GS and so generate more power and revenue. With an available head of only 2.8 metres between the concrete weir at 117.2 masl and the top of the MRPC dam just below the Enerdu tailrace at 114.4 masl, adding another half metre with flashboards will increase potential power production by 18%.

The MRWMP section dealing with the Enerdu GS operating plan indicates that:

- the target operating range is 117.20 m to 117.70 m,
- flashboards are added to the top of the weir providing normal summer levels being maintained between 117.60 m and 117.70 m, and
- flows exceeding 40 cms (25 cms if the plant is not operational) will cause levels in the community to exceed 118.0 m with flashboards in place, and the flashboards are to be removed if levels reach this elevation.

This had the effect of officially regularizing the practices that Enerdu had put into effect just slightly before in the 1997 to 2001 interval. We are unaware of any official approvals prior to 2001 for the changes to water management that Enerdu had then adopted.

Although the MRWMP recognized the presence of the Appleton Wetland PSW and ANSI on Reach 18, it appears to have overlooked that raising water levels to the extent allowed in the Enerdu operating plan would kill the trees in the Appleton Wetland. This oversight is clearly an error, and seems to be justification for amending the MRWMP to correct the error. This is especially so in view of the fact that the priorities of the MRWMP state in several places that ecological integrity has a higher priority than hydro generation and that the system is never operated to maximize hydroelectric generation to the detriment of the other priorities.

The operating regimes of Enerdu are a particular problem for the Appleton Wetland. Regime C causes high water levels (up to 117.7 masl) during the tree growing season, and it happens every year, including drought years. Regime A, when it happens in the summer, is even more harmful to the trees since levels will be over 117.7 masl. The Enerdu operations thus have two components, higher flashboards and aggressively managing generator cycling to maintain maximum head, which combine to make summer water levels much higher than normal. This happens throughout the tree growing season when the trees require, and would normally get, much lower water levels.

5 Potential Tree Mortality Causes

Although the evidence presented from the Data Collection phase of our research does strongly suggest that the cause of tree mortality in the Appleton Wetland is due to increased water levels resulting from Enerdu operations, we do need to address some other potential causes of the die-off that have been suggested by others. These alternate causes include; 1) increases in river flow rates in the last decade, 2) possible disease or insect damage, and 3) damage resulting from the chemical spill from the Appletex lagoon. The sections below deal with each of these issues.

5.1 Increasing River Flow

There has been considerable discussion of the possible role of increased water flow rates in the Mississippi River as a potential cause of the tree mortality in the Appleton Wetland. The MVCA Report 2683/12 that is contained in Appendix Q has some useful comments that are quoted below.

Streamflow rates in the Mississippi River during the fall and winter periods have exhibited a significant increase of 100% – 200% over the past 35 years and most notably in the past 5 years. Stream flows over the past five years during the late fall and winter periods have been 50 to 60 cms which would have resulted in water levels in excess of 117.8 m which would inundate some portions of the wetland for extended periods of time even with the flashboards out.

Further research would be required to determine whether these factors would have an impact on the dieback being experienced within the wetland area. MNR has indicated that they will be investigating further.

Figure 27 Extract on stream flow rates from MVCA Report 2683/12

It should be noted that the flow rate increases mentioned are in the late fall and winter. These are not likely to have a great impact on the maple trees since it is the summer growing season flow rate that is the critical factor as covered in the *Characteristics of Maple Swamps* section of this report. As a further check, Appendix C of this report includes an analysis of mean monthly flow rates over three time intervals; 1) 1920 to 1990, 2) 2000 to 2012, and 3) 1919 to 2012. A chart from that Appendix is reproduced below. It can be seen that there are differences. The April to May spring flood is moderated substantially in the second interval, and the December to March winter flow is significantly higher in the second interval, although not as much as the MVCA report implies. The flows during the July to October summer growing season are somewhat higher during the second interval, but should not result in significant degradation of tree health. A further point is that the random high flow summers that can raise the averages usually seem to be preceded and/or followed by a year of normal flow, a pattern that the maples are adapted to.

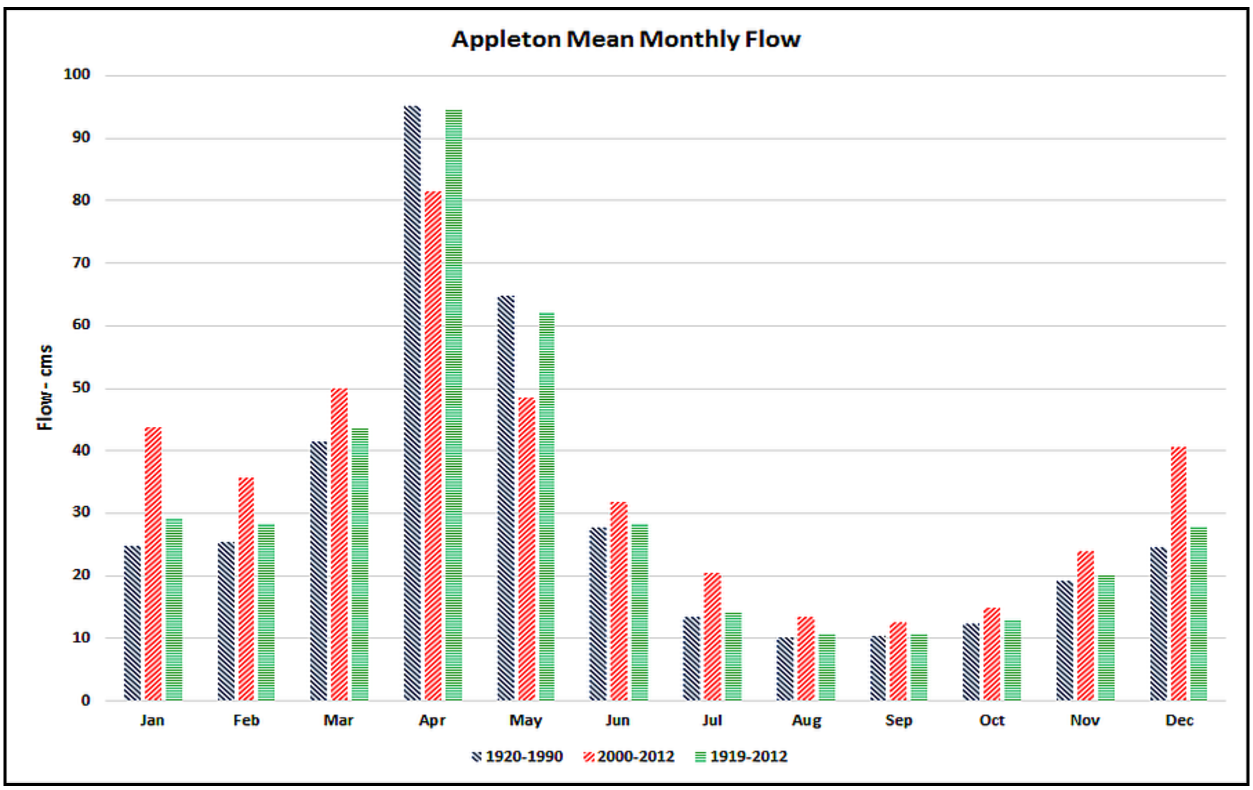

Figure 28 Appleton Mean Monthly Flow over three intervals

A further point is that there are other nearby wetlands on the Mississippi River that would share the same water flow variations that apply to Reach 18; 1) the Innisville and Mud Lake Wetlands, and 2) the Lavallee Wetland. The latter is particularly significant since it is only a few kilometres upstream from Appleton and flows would be close to identical. All three of these wetlands remain in good health as reported in Appendix G.

In summary, we conclude that increased water flow is not the cause of the die-back.

5.2 Disease or Insect Damage

Disease or insect damage are common problems, and are among the usual suspects in cases of major tree die-off. The MVCA Report 2683/12 in Appendix Q provides some clarification as quoted below.

> In response to concerns raised by a resident that the Enerdu generating station had raised water levels adjacent to the Appleton wetland causing a dieback of trees, MVC and MNR staff inspected the forested areas of the Appleton Wetland which were experiencing dieback. The MNR Forest Health Specialist did not see any evidence of insect or disease damage which could contribute to the dieback. These concerns were raised with the Steering Committee and the Standing Advisory Committee in January 2011 and again discussed at the Steering Committee in April 2011.

Figure 29 Extract on Disease and Insects from MVCA Report 2683/12

Outbreaks of tree disease or insect damage usually cover fairly widespread areas, but the Innisville, Mud Lake, and Lavallee Wetlands have not been damaged. In addition, the Appleton Wetland damage follows lower elevation contours, but the higher levels are untouched. If the cause was disease or insect damage, the higher parts would be affected too.

We conclude that neither disease nor insects are the cause of the die-back.

5.3 Chemical Spill from Appletex Lagoon

Appletex was a former textile mill in Appleton that, in its operating period, stored toxic mill effluent in a lagoon above the portion of the wetland on the south shore of the Mississippi River. There were breaches of the lagoon in the fall of 1989 and the spring of 1990 that resulted in the effluent discharging into a nearby wetland and subsequently finding its way down a creek that emptied into the Mississippi River. The image below shows the area as viewed from an airplane with the discharge path marked.

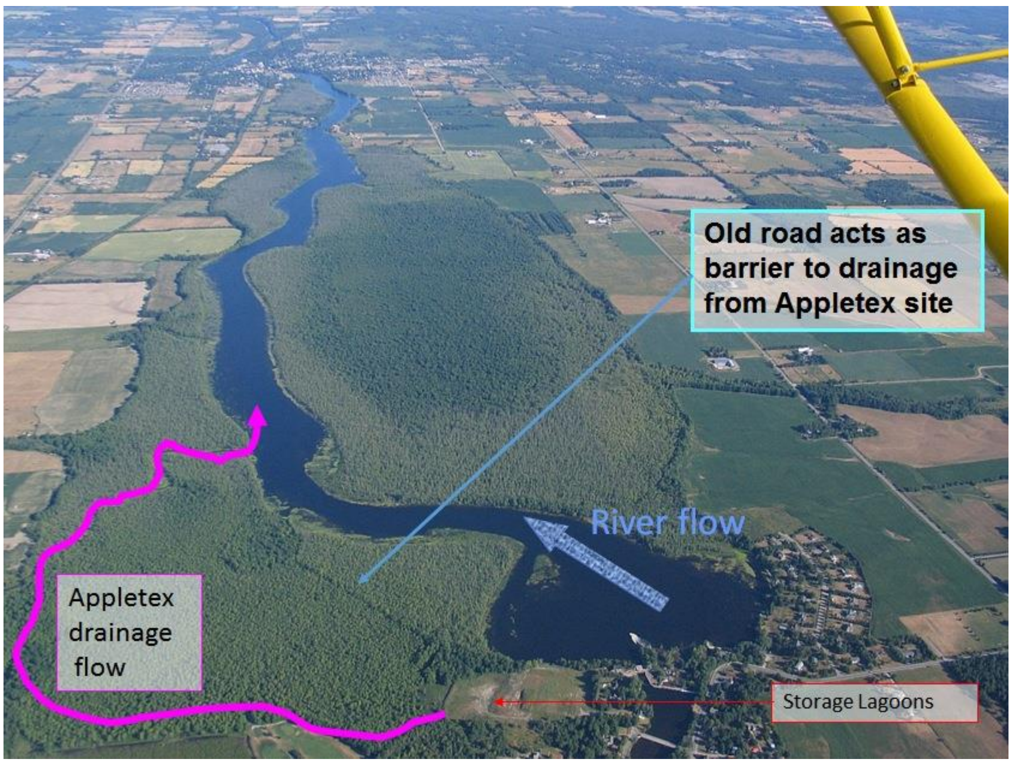

Figure 30 Aerial image showing Appletex effluent discharge path

The wetland tree mortality does not correlate with the discharge path of the effluent;

- trees along the drainage path were not affected by the spill, so it is unlikely that it was really toxic to plant life,
- trees upriver from the creek entrance show die-back, but the chemical spill could not have reached them against the river flow, and
- there is a causeway across the wetland that would have prevented any effluent from going directly northward into the wetland.

We conclude that the Appletex spill is not the cause of the tree mortality.

5.4 Increased Water Level Due to Weir Management Changes

The most likely remaining suspect in the case of tree death in the Appleton Wetland remains the changes to flashboard height and water flow management at the Enerdu facility that occurred within a few years prior to 2001.

- During the Flour Mill Era the Appleton Wetland was healthy, and a variety of evidence indicates that water levels were lower than they are presently.
- Higher flashboards and flow management strategies to maximize head for increased power output were adopted in the Generator Station Era, and MVCA water level measurements that started in 2006 verify that levels in Almonte were abnormally high during the summer period.
- Tree damage along the entire length of the Appleton Wetland was very visible in 2006.

These points suggest a probable cause of the wetland problem, and the task of the Research Group was to eliminate any coincidental associations and to discover the real cause and effect relationships along with quantifiable evidence to support any conclusions.

6 Wetland Research Group Investigations

In order to understand what was happening in the Appleton Wetland that could account for the dramatic tree die-back, a number of field investigations were undertaken by the Research Group. The sections that follow summarize the results of these projects. In all cases, more complete details of each project are included in the Appendices that are part of this report. The field work was carried out in good faith by citizen scientists in accordance with available volunteer time and resources, and in consultation with professionals

6.1 The 2011 Tree Project Analysis

The 2011 Tree Project, undertaken by Mississippi Valley Field Naturalists (MVFN) at the request of MVCA, occurred two years prior to the formation of this Research Group. Although not a part of the current work, it is a valuable prelude to our research, and it is included here for the record. A more complete record of this project can be found in Appendix G.

The project was intended to measure water level in the wetland at six sampling points and compare that to the water levels as measured at the staff gauge on the Bridge Street bridge in Almonte over a segment of the tree growing season from a high-water stage to a low-water stage later in the summer. The sample stations were large trees that were located at the water's edge for easy canoe access, with ground level well below the initial water level.

On the starting day, May 31, 2011, wide, red plastic ribbons were wrapped around the designated trees with the bottom of the ribbon aligned exactly with the level of the water. The ribbons were firmly attached with staples in the tree bark, and large numbers 1 through 6 were spray painted on the respective trunks to aid in finding them later in the project.

The trees were revisited three times through the summer and the distance from the bottom of the ribbon to the water surface was measured. The dates for these observations included June 30, July 28 and August 16.

Coinciding with each step from the initial setup on May 31 through to the final observations on August 16, the water level at the Almonte bridge staff gauge was recorded along with notes on the status of the flashboards on the weir. Any other noteworthy items at Appleton and Almonte were also recorded. In addition, the water flow rate as recorded at the Appleton Stream Gauge, and as reported on the Environment Canada website, was also noted for each observation set.

From the raw observations it was clear that there is a relationship between Appleton water levels and the level observed in Almonte. Unfortunately in 2011 there was no elevation reference in Appleton, accurately calibrated to the CGVD28 standard, which would make it possible to compare the Appleton measurements to those at Almonte. As reported in Section 6.2 below, the work in 2013 provided that calibrated level reference for Appleton, and that calibration has now been applied to the 2011 measurements. In particular, the bottom of the tree ribbons is at 118.00 masl, and with that the former relative levels can be converted to absolute levels in masl. The table below summarizes those results.

Tree Project Data Summary							
Date 2011	**Appleton Flow cms**	**Relative Tree Water Levels cm**	**Tree Water Levels masl**	**Appleton Change cm**	**Almonte Level masl**	**Almonte Change cm**	**Appleton to Almonte Difference cm**
May 31	75.8	Ribbon	118.00	-	117.82	-	18
June 30	21.2	Ribbon - 20	117.80	20	117.76	6	4
July 28	7.15	Ribbon - 30	117.70	10	117.70	6	0
Aug 16	9.54	Ribbon - 38	117.62	8	117.62	8	0

The diagram below will help in visualizing the water level changes between Appleton and Almonte on the four dates of the project.

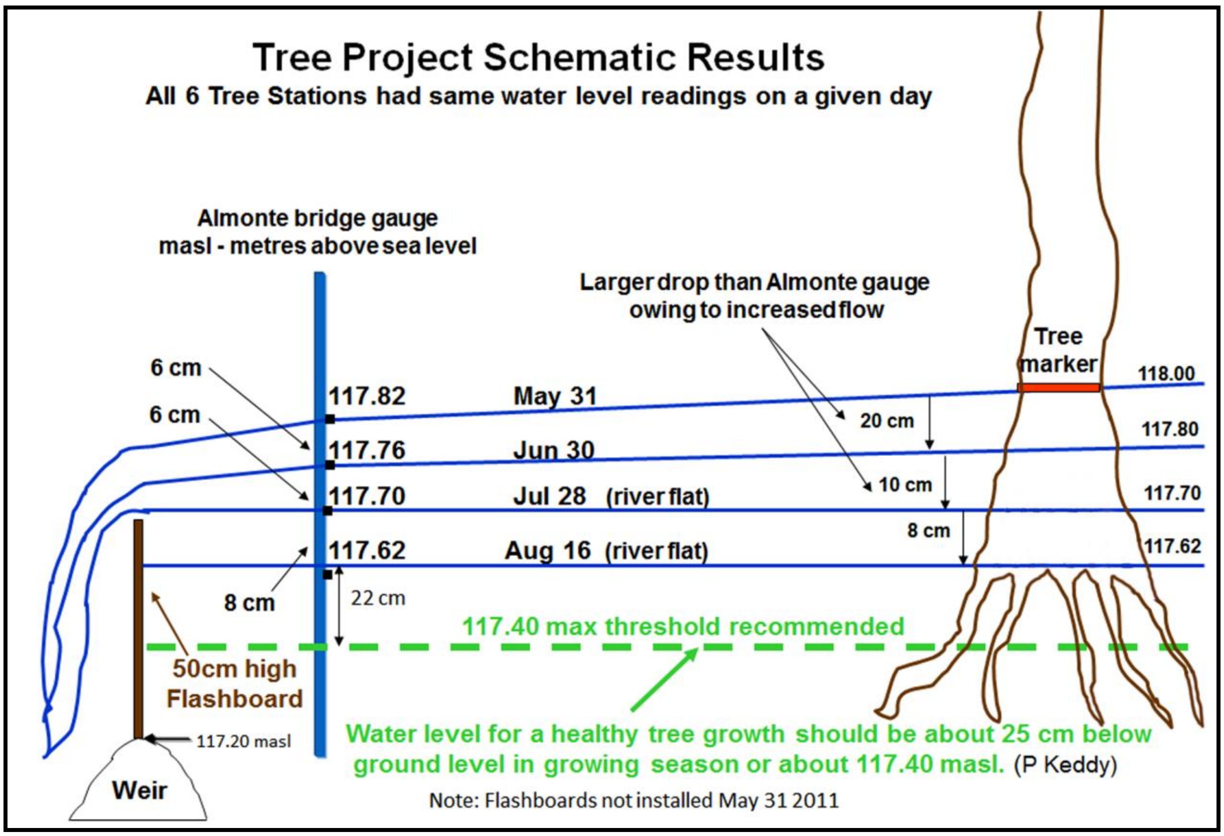

Figure 31 Schematic diagram of Tree Project results

Some general observations indicate that:

- In May during the tail end of the spring flood, the level is high in Almonte even without flashboards, and it is significantly higher in Appleton.
- In June with all flashboards in place and flow over 20 cms, the Almonte level is 6 cm over the flashboards, and a further 4 cm higher in Appleton.

- In July and August with river flows less than 10 cms, Almonte levels are set by Enerdu generator off/on cycles and will be at the top of the flashboards or somewhat less. Under these conditions the river is flat with the same levels at Almonte and Appleton.
- The May levels, without flashboards, are typical natural levels during the end of the spring flood. The June, July and August levels are unnaturally high, and are a direct result of adding the flashboards.

As detailed in Section 3.5 of this report, *Characteristics of Maple Swamps*, the maple species involved require low water levels for a significant part of the growing season for healthy growth. In particular, the water level should be at least 25 cm below the ground level where the trees are growing, and should stay at that level continuously for approximately 80 days in the summer. From observing the water levels around the tree stations, and the associated ground levels during the 2011 Tree Project, it was concluded that after the spring flood subsides, water levels in the Appleton Wetland should be maintained at or below 117.40 masl through the summer growing season.

6.2 Appleton Water Level Calibration

It became evident early in this project that we must be able to measure water levels in the river at the Appleton Wetland in a form that could be compared accurately to levels in Almonte. The Almonte levels have been measured since July 2006 with a staff gauge on a pier of the Bridge Street bridge that is accurately calibrated to give direct readings in masl using the CGVD28 vertical datum. The details of establishing a similarly calibrated reference in Appleton can be found in Appendix F.

A benchmark established by Geodetic Survey of Canada and calibrated to the CGVD28 standard was known to exist on the property of the North Lanark Museum identified with the number 70U8888. Unfortunately it was buried under new landscaping years ago and its exact location was not known. We did get some help from an experienced treasure hunter with the right equipment, and the benchmark was unearthed on September 29, 2013. With a good and relatively close geodetic benchmark identified, the next step was to do a level survey from the geodetic benchmark to the waterfront of Appleton Bay at 521 River Road and establish accurately the level for a new benchmark installed there.

We were fortunate in getting the volunteer services of Ross Taggart, a retired former professional surveyor, to do the necessary survey work, with the assistance of some Research Group members. The survey was undertaken on October 11, 2013, and included a double set of observations;

a) from benchmark 70U8888 to the new benchmark, and
b) from the new benchmark back to benchmark 70U888.

An analysis of the survey results showed the end-to-end results of both runs agreed to within 2 mm, and intermediate variances are limited to maximums of ± 5 mm. We are confident that the new benchmark has an elevation of 119.222 masl to an accuracy of better than ± 1 cm. This level reference has been used for all of our water level work in Appleton.

A further step was to transfer this level reference to Tree 1 of the MVFN 2011 Tree Project. Appendix F provides these details. The results establish the level of the bottom of the red tree ribbon as 117.998 masl, or rounded to 118.00 masl. This provided a calibration for the 2011

Tree Project, and made it possible to express the results from that project in accurate masl terms.

6.3 Coordinated Water Level Measurements

To better understand how water levels relate between Appleton and Almonte under a variety of flow rates, and in the presence or absence of flashboards, a series of water level measurements was done using nearly simultaneous samples at three sites (the Almonte bridge, 222 Spring Street in Almonte, and 521 River Road in Appleton) over a period of several months in 2013. The results confirmed that the primary driver of Appleton water levels was the operation of the Enerdu facility in Almonte. Full details of these coordinated water level measurements can be found in Appendix H.

The nearly simultaneous samples involved taking measurements at;

- the staff gauge on the Almonte bridge using binoculars, then
- driving to 222 Spring Street and measuring the depth of water over the designated point on the river bed rock shelf, and then
- driving to 521 River Road in Appleton and measuring the water level at the shore line of Appleton Bay relative to our newly placed benchmark.

The total measurement cycle took about a half an hour – not quite simultaneous, but in view of the very slow rate of level changes it was close enough for the purpose.

Samples were taken at random times over the period from August 5 to November 14, 2013. In addition to the level data, notes were taken of the status of the Enerdu flashboards and generator operation. Real time flow data from the Appleton Stream Gauge as reported on the Environment Canada website was also recorded for the time of each measurement. All data was tabulated in a spreadsheet and used to generate charts showing water levels and flow rates over the measurement period. These charts are reproduced below with commentary keyed to events on the charts denoted by letters of the alphabet.

Chart A

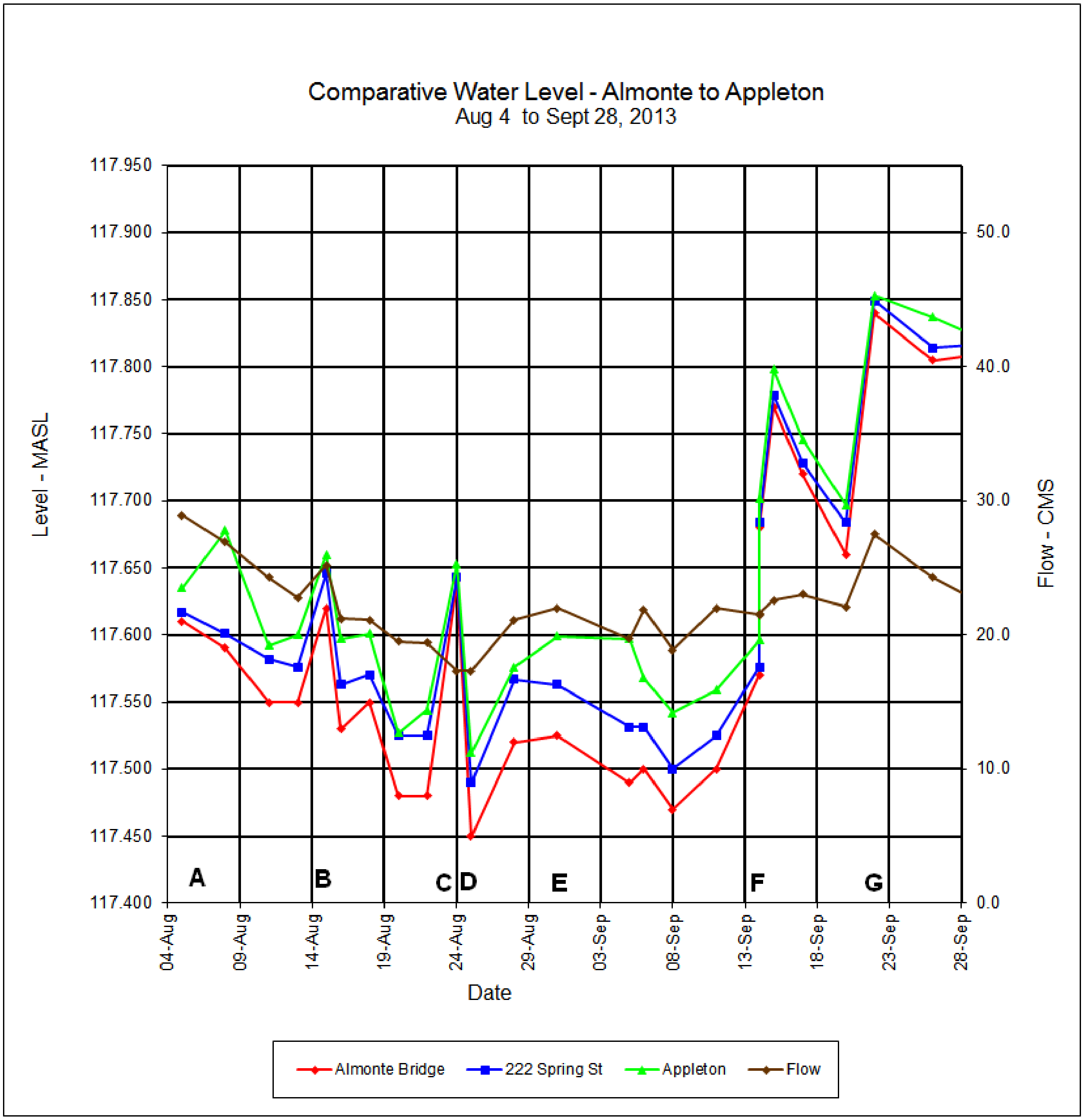

Figure 32 Chart A, comparative Water Level, Almonte to Appleton, Aug 4 to Sept 28, 2013

Notes:

A. On June 8 after the spring flood, flashboard sections 3 and 4 were installed, but not sections 1 and 2. That status continued to the start of this chart on August 5. The generators were operational and probably taking their rated water flow of 14 cms, leaving about 15 cms to flow over weir sections 1 and 2.

B. There is an upward spike in the level at all three sites on August 15. This correlates with an upward spike in river flow rate and turning off the generators. Both factors would be expected to cause a rise in level, but the proportion of the rise attributable to each cause is unknown at this time. On August 18, there is also a small rise in levels at all sites which corresponds to an instance of generators off while flow remained flat.

C. From the start of the chart to August 22, flow rate continued a steady decline, and water levels at all three sites also declined proportionally. Also note that Appleton levels tend to be about 5 cm higher than Almonte levels, with Spring Street between the two levels. Then on August 24, there is an abrupt spike in levels at all three sites. In the early morning hours around 6:00 to 7:00 AM on that day, the flashboards on sections 1 and 2 were installed, causing an immediate rise in water level. The level measurements around 3:00 PM probably had not yet reached a maximum at the top of the flashboards.
D. Overnight on August 24-25, vandals removed the new flashboards on sections 1 and 2 causing an immediate drop in all levels to values appropriate to the flow rate minimum of 17.3 cms that occurred on August 24-25.
E. In the interval from August 25 to September 11, levels at all sites followed more or less the same pattern of changes as the flow rate. Again the Appleton level was 5 to 7 cm higher than that in Almonte, similar to the differential in Note C.
F. On September 14 around 7:00 AM, replacement of the missing flashboards on sections 1 and 2 was completed and water rose to 117.57 masl around 9:00 AM, with a further rise to 117.70 masl around 3:00 PM. Levels finally peaked around 117.77 at noon the next day.
G. On September 22, there is a sharp spike in levels at all sites, and this corresponds to both a peak in flow rate and a period with generators off. Again the degree of level rise attributable to each of these factors is not known.

It should be noted that the level difference between Almonte and Appleton on September 22 is just over 1 cm, compared to the 5 to 7 cm difference recorded around the end of August. The cause of the smaller differential (or flatter level profile) is due to the 30 cm increase in water level at Almonte between the end of August and September 22, the result of the added flashboard sections 1 and 2, and the flow rate peak. As water level rises, the river cross sectional area increases proportionately, and for a constant flow volume (cms) the river velocity (metres/sec) will decrease along with decreased frictional/viscosity losses, and the water level will show a flatter profile.

Chart B

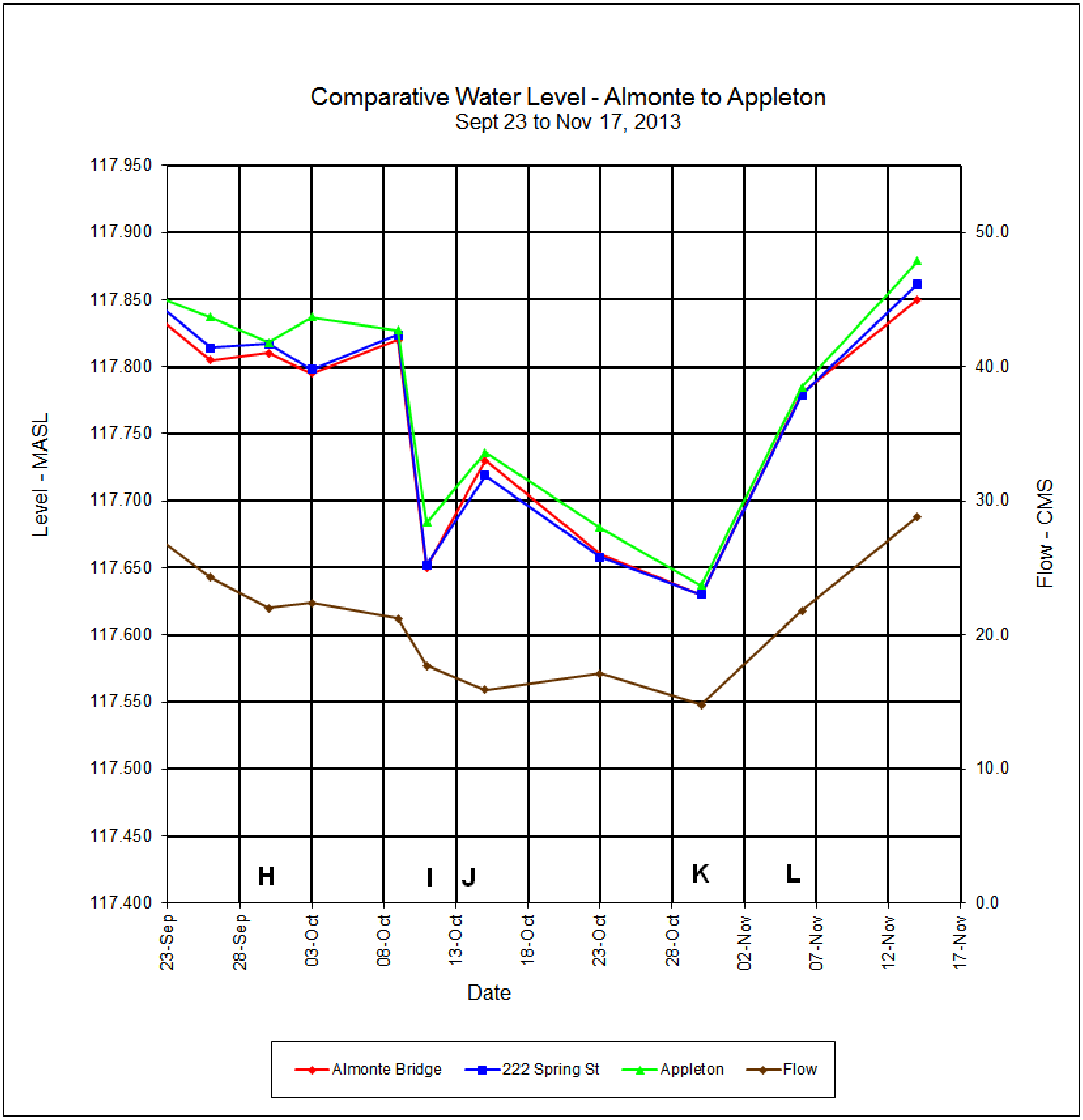

Figure 33 Chart B, comparative Water Level, Almonte to Appleton, Sept 23 to Nov 17, 2013

Notes:

H. In the time interval around September 30 flow rates are around 22 cms or more, and this is well in excess of the combined flow (17 cms estimated) through the generators, flashboard leakage and flow over the Thoburn weir, resulting in a level at Almonte about 10 cm over the flashboard tops.

I. On October 11, flow rate dropped to 17 cms, and into the unstable region where combined out-flows (Enerdu, leakage and Thoburn) exceed the river in-flow, and water level dropped below the crest of the weir by 5 cm.

J. Although river flow at the October 15 sample was still below 17 cms, water levels peaked a few cm above the weir crest. This is probably the result of generators being turned off just prior to the October 15 measurements, allowing the river to recharge to a level above the weir crest.
K. River flow remained at 17 cms or less from October 15 through October 30 with operation in the unstable region. Levels at Almonte remained below the weir crest by up to 7 cm. There were probably on/off cycles of the generators during this period, but at the observed sample times we recorded only generators on.
L. On November 4 and beyond, river flow exceeded 20 cms, and water levels increased to over the weir crest by approximately 15 cm. Again, in this period with high water levels, the river is quite flat with only a differential of a few cm at most between Almonte and Appleton.

6.3.1 Conclusions

This series of coordinated water level measurements on Reach 18 demonstrate very clearly a number of important points. These include:

1. The presence and operation of the weir in Almonte is the primary control mechanism for water levels in Reach 18, and in particular it has a direct influence on the water levels in the Appleton Wetland. This is very evident in the cases where the missing sections 1 and 2 flashboards are installed, then removed and finally reinstalled.
2. With all flashboards installed levels are higher (typically 117.70 masl or greater), and the river becomes quite flat (Appleton only a few cm higher than Almonte).
3. With sections 1 and 2 missing, levels are lower (typically 117.50 masl at 20 cms), and the river has more slope (Appleton 5 to 7 cm above Almonte).
4. There is no data for summer flows of 10 cms or less with flashboard sections 1 and 2 missing, but it is expected that the level at Almonte would be less than 117.40 masl, and the slope of the river would be greater than 10 cm. Whether or not the generators are operating would also play a significant role on final water level.
5. Although the August 5 to September 13 period had flows much higher than for a typical summer in this period, the water levels were actually lower than typical for the 2006 to 2012 summers. That is, in 2013 through August and early September, flow ranged from 29 to 17 cms while Almonte levels ranged from 117.61 to 117.48 masl. For the same August and September period during 2006 to 2012, flows were typically 10 cms or less, with some summers having flows of 20 cms or greater. For flows over 17 cms, the levels were typically 117.70 to 117.80 masl. For flows less than 17 cms, levels were 117.70 masl with short unstable dips as low as 117.50 masl.
6. If the generators are operated continuously when the flow is 17 cms or less, the level at Almonte can be reduced to 117.20 masl or less regardless of flashboard height.

7. There is an interesting point to be observed in comparing water levels as flashboard status varies. The table below summarizes the details.

Flow - cms	Flashboard Status	Level - masl	Source
30	All sections in	117.85	Chart B
30	Section 1 and 2 missing	117.60	Chart A
30	No boards	117.60	Appendix D
21.2	All sections in	117.82	Chart A
21.2	Section 1 and 2 missing	117.52	Chart A
21.5	No boards	117.50	Appendix D

This data indicates that with flows in the range of 20 to 30 cms, flashboard sections 1 and 2 play a dominant role in regulating water level, and with those two sections missing levels are very close to the levels with all boards missing. The effect probably extends to a wider flow range, but we have no empirical data to support that at this time.

6.4 Inland Observations of Wetland

Prior observations of the Appleton Wetland had been largely based on what could be seen from a boat on the water or from an airplane. Late in the 2013 season (November 6, 2013) an interior exploration of the wetland was made. Full details of these inland observations can be found in Appendix K.

The paths followed in the exploration were documented by handheld GPS readings taken at observation points along the way. The paths showing waypoints 304 to 316 are displayed on the Google Earth image below. The starting point, WP304, was actually the position of Tree 1 of the MVFN 2011 Tree Project. Our initial intent was to cover a more or less straight line due north for 200 metres to a point at the northern boundary of the wetland. That projected target is defined by WP305. The reality was that it was extremely difficult to travel through the wetland due to the very rough surface, and the presence of water, sometimes very deep, in every hollow. The result was the reduction of the planned route to a smaller circle ending back at the starting point – waypoints 304, 306, 307, 308, 309 and back to 304.

We then moved westward along the shore by boat and started another circuit from waypoint 310 through waypoints 311, 312, 313, 314 and back to 310. Subsequently, waypoint 305 was accessed overland from the fields to the north to take several pictures. Two further points, waypoints 315 and 316 were located approximately 100 metres west and east of waypoint 305, and further photographs taken.

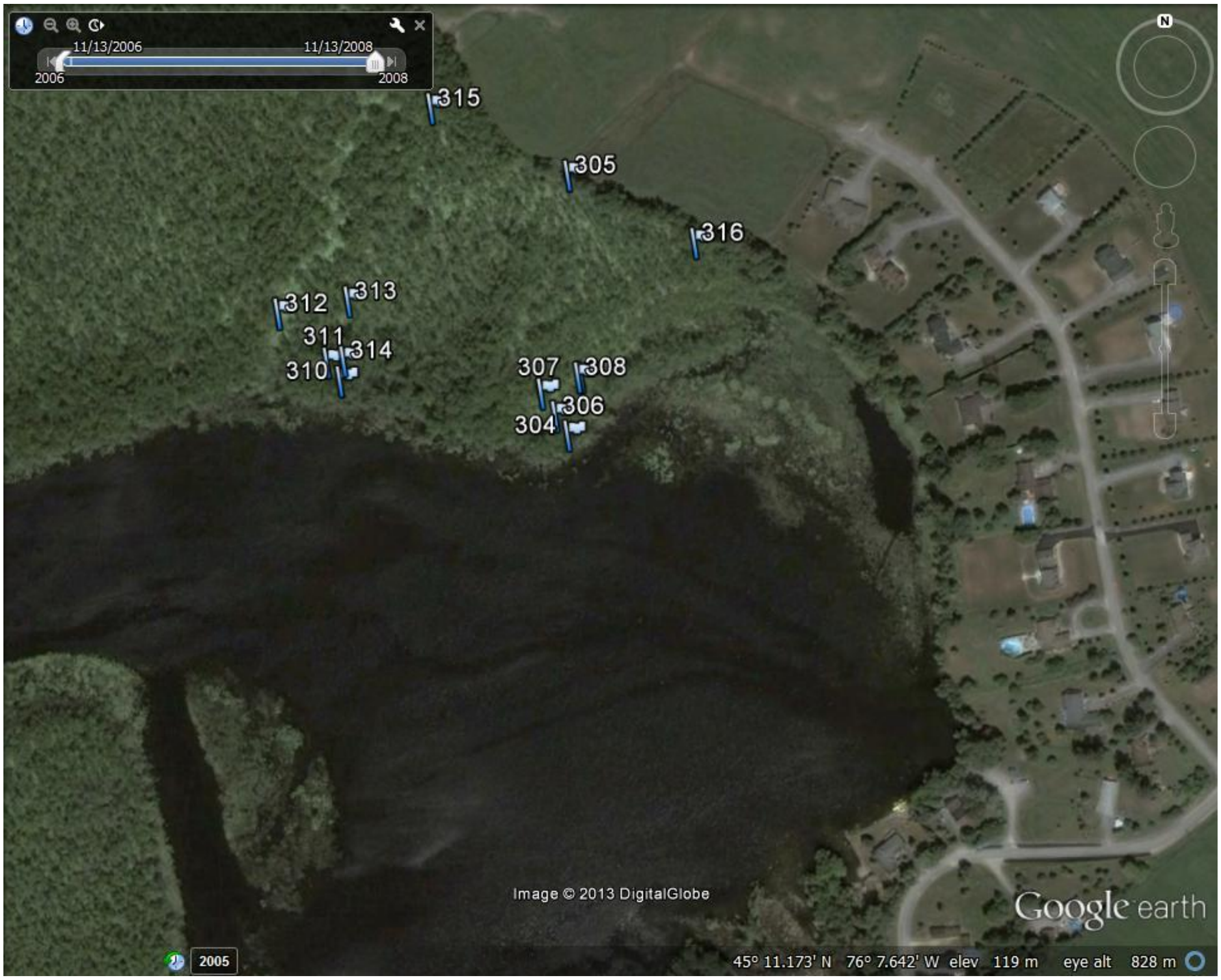

Figure 34 Google Earth image of wetland with waypoints added

The recorded water level before and after the excursion was measured as 117.80 masl. At each waypoint we typically found a very small hummock rising slightly above the water with a few trees on it. The trees were usually a mix of dead and stressed trees. Although this was late fall with all the leaves gone from the trees, the individual tree health was obvious; the tops of very dead trees had broken off, recently dead ones were missing the fine tips of the remaining branches, and the stressed trees had abnormally small crowns with branches still ending in fine tips. At each waypoint photographs were taken of the trees, and measurements of ground level and water level were recorded. The images below illustrate typical trees. More photographs can be found in Appendix K.


Figure 35 Large hummock at WP313


Figure 36 Tree crowns at WP313 – dead on left, stressed on right

All locations followed the same pattern of terrain.

- There were many fairly widely separated small hummocks where the last surviving trees remain fighting for life. The hummocks were typically 20 to 50 metres apart and were somewhat above the prevailing water level of 117.80 masl.
- The hummocks showed a pattern of clumps of two to five trees, with one or two dead or dying, and one or two struggling to survive. The crowns on the survivors had only a few short branches. Although this was November and the leaves had all fallen, the fine tips of the viable branches distinguished them from dead branches.
- Where trees had died there was considerable evidence of regrowth of new shoots from still viable root systems. It is suspected that the rate of shoot growth is considerably restricted by the high water levels.
- Between the hummocks the ground is much lower (20 - 60 cm), and these areas were filled with water.
- Under the water was a layer of water-logged dead tree trunks in a crisscrossed random pattern. While wading from mound to mound through the water filled hollows the smell of hydrogen sulphide was evident, the result of disturbing anaerobic decay on the bottom.
- There is a heavy growth of assorted long grasses on the hummocks and adjacent areas above the water line, the result of the loss of tree canopy and an increase of light at ground level. This is in contrast to the almost bare ground between trees in the Lavallee Wetland.

Due to the rough, hummocky terrain, it is difficult to estimate what an average ground level would be in the traversed portion of the wetland. As a first approximation, it seems reasonable to take an average of the level difference from tree base to the water, and from the water to the ground level at the edge of the hummock as recorded for each of the way points. The diagram below illustrates the result.

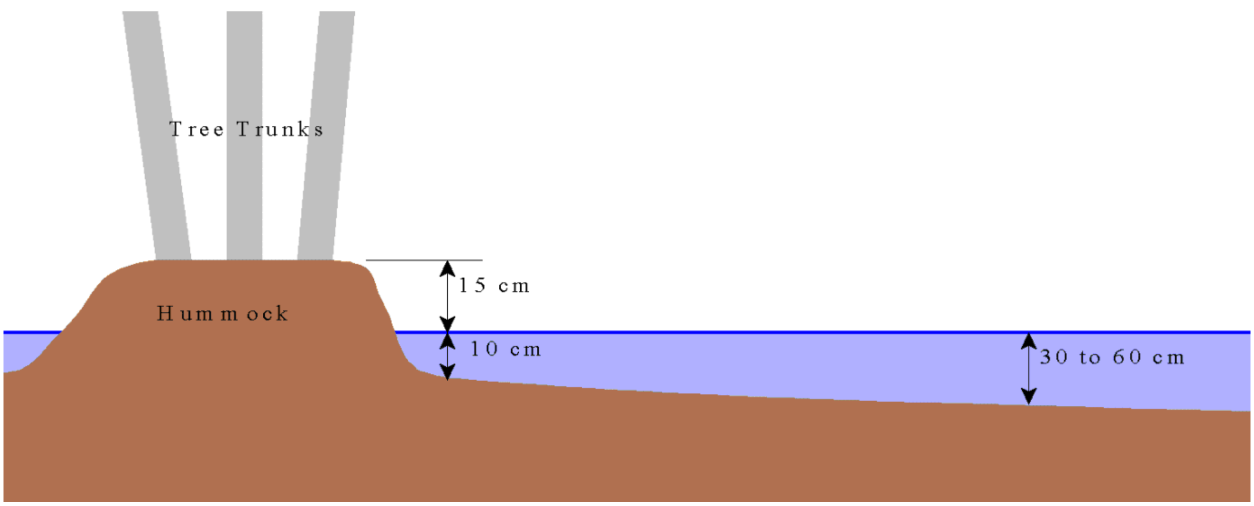

Figure 37 Sketch of typical hummock profile and water level

Faced with the irregular ground profile at the hummock, the question is just what should be considered as “ground level”? Certainly, from the point of view of the tree root system, the narrow top of the hummock is not the right place. It seems rather that it should be at the bottom of the steep sided hummock where the ground changes to the gently sloping pond bottom between hummocks – that is, about 10 cm below the water level at the time of 117.80 masl.

Based on discussion with Dr. Paul Keddy, for healthy tree growth, water level should be at least 25 cm below ground level. (See Section Section 3.5 of this report, *Characteristics of Maple Swamps*) Applying that to the above measurements would give a desirable water level of 117.45 masl or less. We recommend rounding that number to the level of 117.40 masl as measured at the wetland to ensure the restoration of tree growth in the Appleton Wetland.

6.5 Tree Ring Coring in the Wetland

Some of the MVFN biology and naturalist experts suggested that tree ring coring might be a means of dating when tree growth in the Appleton Wetland was healthy or otherwise, and thus identify when water levels were favourable or excessive. As detailed in Appendix L, we were able to borrow a suitable tree ring corer and a proof of concept trial was mounted on January 13, 2014. The site chosen was accessed overland via the new subdivision on the northeast side of Appleton. At the end of that road snow shoes were used to access the north side of the wetland near to the previously established waypoint 315 (see Figure 34 above)

Cores were taken from two healthy trees located on the northern margin of the wetland above the current summer high water levels. Further cores were taken from trees lower down in the wetland where stressed and dead trees predominate. Two samples were collected from stressed trees, and two from dead trees. The images below show the first sample point on a healthy tree, with a view of the tree crown above.

Figure 38 Tree group at first sample point

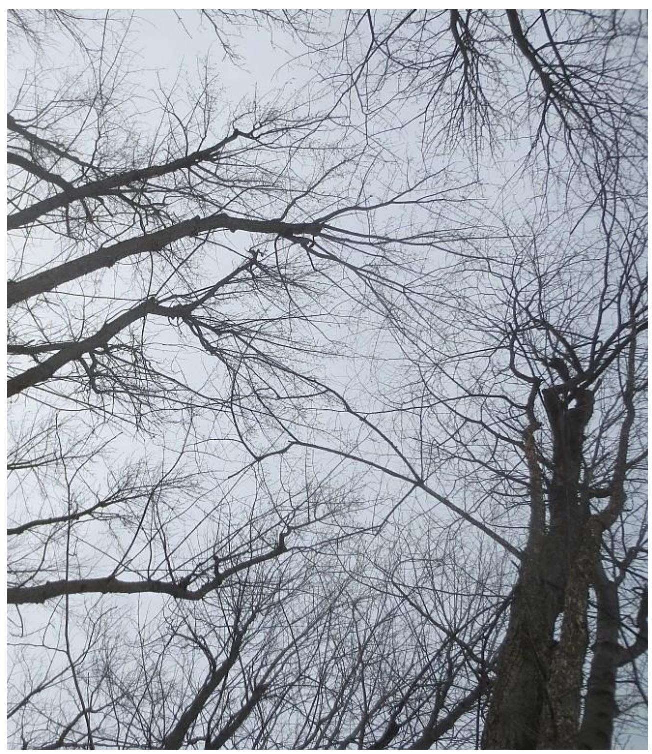

Figure 39 Tree crowns at first sample point

A total of seven cores were taken and numbered as follows:

1. From a healthy tree, core length 4.5 inch
2. From a healthy tree, but hit a hollow spot and got only a short 3 inch core
3. From a healthy tree, core length 4.5 inch
4. From a dead tree, core length 3.5 inch (interior too soft to get more)
5. From stressed tree, core length 2 inch (interior too soft to get more)
6. From stressed tree, core length 3 inch (interior too soft to get more)
7. From a dead tree, core length 4.5 inch

Subsequently the samples were glued to grooved backing boards and then the front face of the sample was sanded to create a flat face, and then polished with progressively finer sand paper to reveal the core structure. The image below shows the mounted cores.

Figure 40 The seven cores as mounted

The above image does not have sufficient resolution to see the ring structure in the samples, but they do provide some indication of the sample quality. It is evident from the samples that healthy trees (cores 1 and 3) produce useful cores, but that the stressed trees (cores 5 and 6) produce marginal to poor samples, and the dead trees (Cores 4 and 7) yield very poor samples due to the early stages of decay. It is interesting that although the two healthy tree samples (1 and 3) came from similar trees only a short distance apart, the ring detail is only roughly similar. There is certainly no detailed year-to-year correlation between the two samples. There is also a very wide variation in ring width in individual samples as viewed with at least a 10X magnifier. The widest rings approach a quarter of an inch, while the smallest are a few hundredths of an inch wide.

A general conclusion is that tree coring will give an immediate confirmation that a tree is healthy, but for stressed or dead trees the core quality is so poor that dating a tree's prior history is impossible. This initial test was very limited, and that conclusion may be premature. As time permits, more test samples will be taken.

6.6 Reach 18 Flow and Level Relationship

A deficiency in our data was the lack of measurements that detailed the relationship between water flow rates and river water levels. The spring of 2014 was a timely opportunity to get this data for the *no flashboards* case by making a series of coordinated measurements, similar to those in section 6.3, from the point in the spring flood where all flashboards had broken, through the receding flow, and to the point where the flashboards were reinstalled. Full details of the recorded flow and level data and its analysis can be found in Appendix P.

The observations of level and flow data started on April 9, 2014 and continued to June 19, 2014. The analysis and documentation of the data were stopped at June 19 prior to the desired time of installing new flashboards in order to meet deadlines for completion of this report. Data recordings have continued, and analysis of that data will be the subject of a later addendum

Level data above the weir was recorded at four places. The italic headings below are the same identifiers used in the results that follow later.

a) *Rail-A:* Measured at mid-span on the River Walk bridge between the Old Town Hall and the small island by measuring the water level down from the bridge railing. The railing had previously been established as being at a level of 120.09 masl.
b) *Gauge:* Measured at the staff gauge on the pier of the Bridge Street bridge. This is direct reading in masl.
c) *SpringSt:* Measured at a flat rock shelf in the river bed behind 222 Spring Street. The level of this rock shelf had been previously established as 117.36 masl.
d) *Appleton:* Measured at the shoreline at 521 River Road in Appleton using the previously established benchmark, at 119.222 masl, as a reference.

The raw data measurements were entered into a spreadsheet, and flow measurements in cms from the Appleton Stream Gauge as reported on the Environment Canada website were also added to the spreadsheet. In order to complete the lower end of the flow vs level curves, a final theoretical point was added to the data series for the four sites above the weir. That is, for a flow of zero cms, the river becomes a flat lake with its level established by the weir at 117.20 masl. It would be desirable to have more measured results in the flow interval between 35.5 and zero cms, but thanks to the heavy rains that we have had through much of June, lower levels did not occur until later in July. In the meantime the arbitrary zero flow point serves as a means of interpolating the lower end of the data.

The above data set was then used to generate a chart of level versus flow for the four sites above the weir. This is shown below.

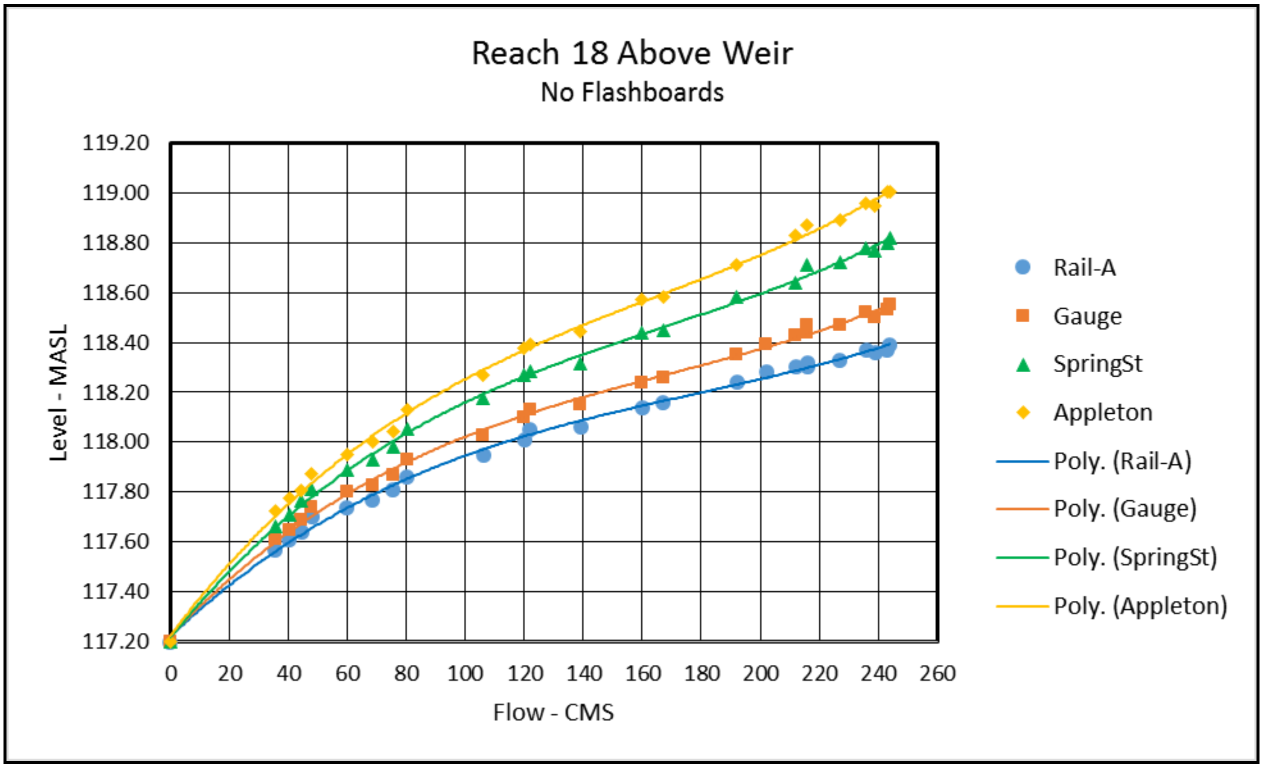

Figure 41 Chart of Level vs Flow for four locations on Reach 18

For the above chart, computed trendlines were added using a third order polynomial. The trendlines do produce a quite plausible set of curves. They do show clearly the increasing slope of the river as the flow rate increases. It is interesting that there is more slope in the short distance between *Rail-A* and *SpringSt* than there is in the nearly 9 km distance between *SpringSt* and *Appleton*. This does demonstrate the effect of the relatively narrow and shallow channel in the first interval compared to wider and deeper channel in the second interval.

Since the most important curve is that for Appleton, it is reproduced below at full scale without the clutter of the three additional curves. In addition, the computed trendline equation for that curve is added to the chart. In the equation, y represents the value of water level in masl, and x represents the value of stream flow in cms. This equation is a useful component for some further analysis.

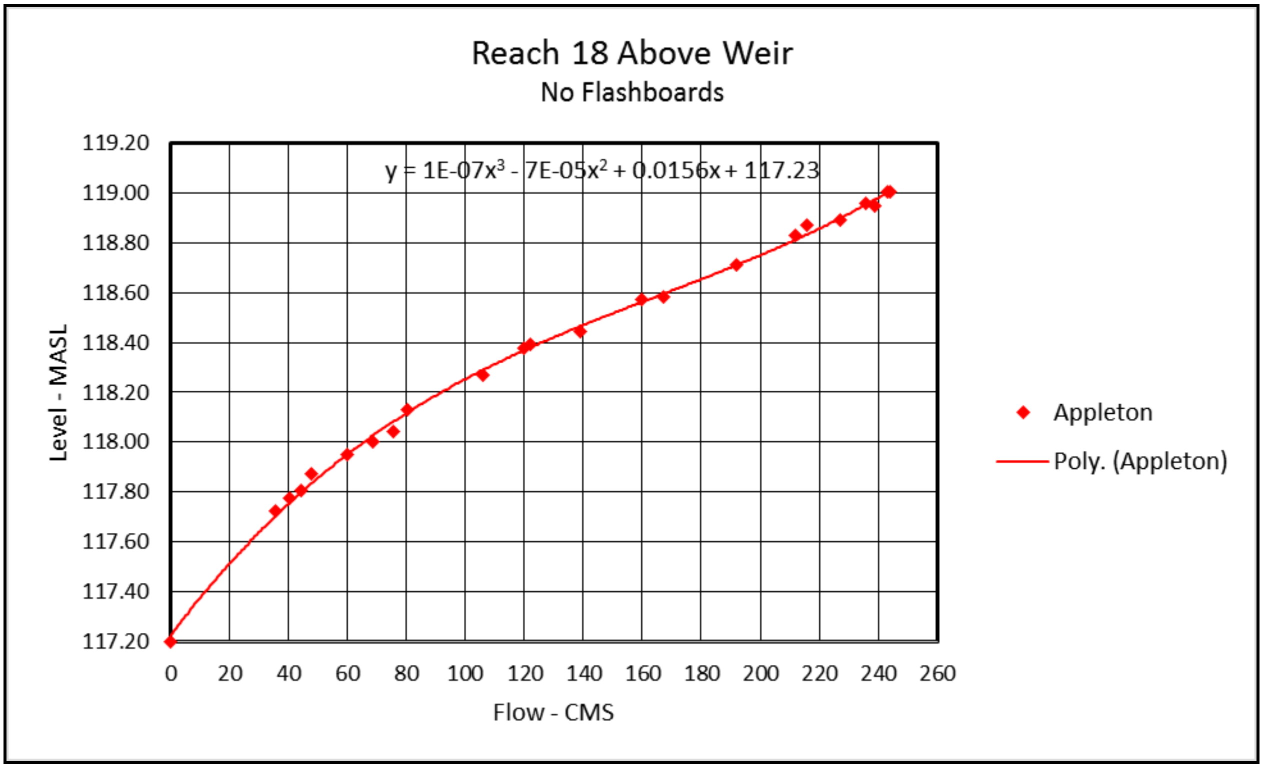

Figure 42 Chart of Appleton Level vs Flow showing the trendline equation

A further step was combining the above trendline equation with the records of mean daily flow over the 95 year history of the Appleton Stream Gauge, as covered in Appendix C. This enabled the generation of a chart of average water level in the Appleton Wetland over a full year period for the *no flashboards* case. That chart is reproduced below.

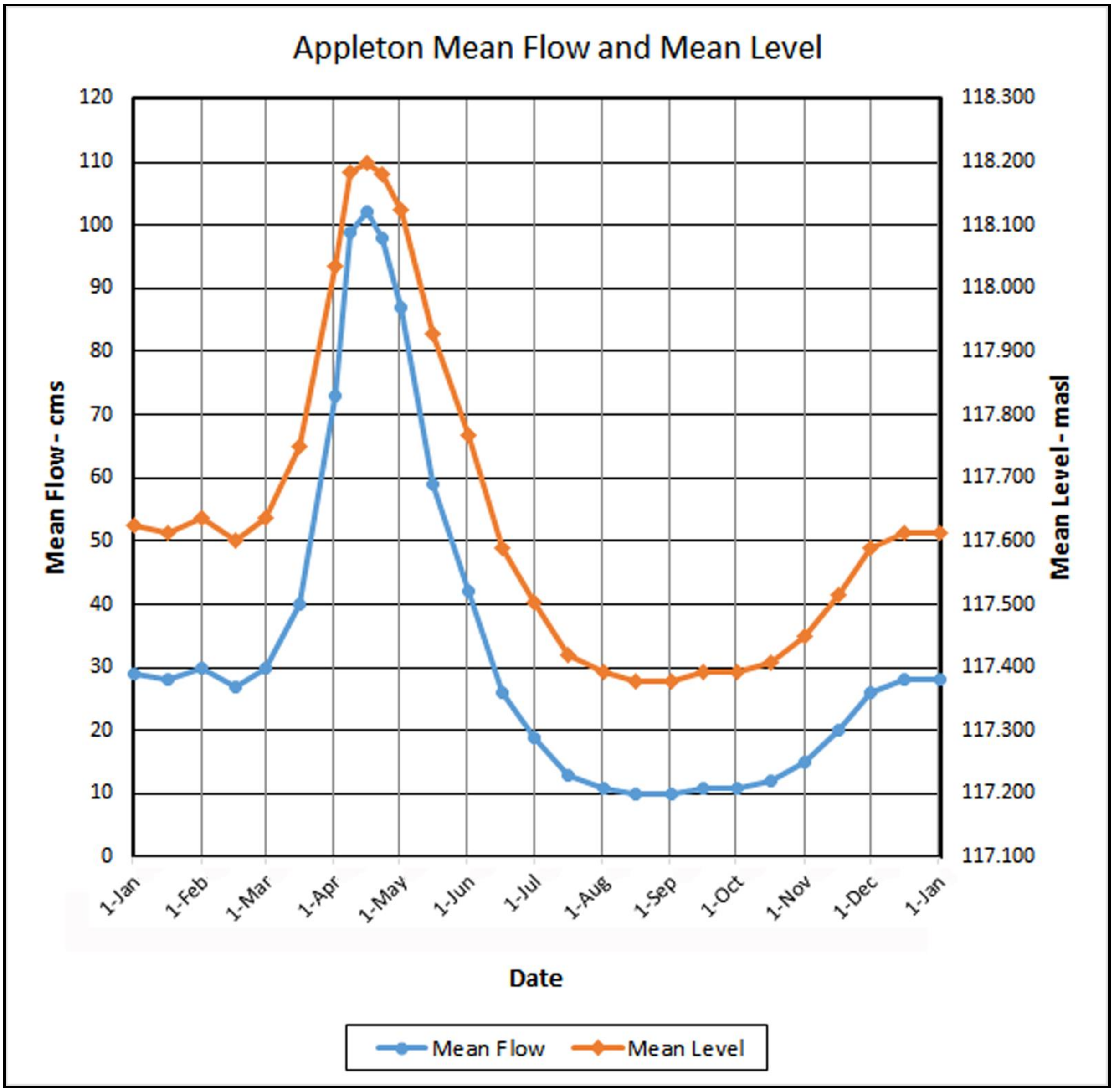

Figure 43 Chart of Mean Flow rate and Mean Water Level in Appleton with no flashboards

As we have shown in the analysis of conditions during the Flour Mill Era, the most probable water level at the bridge in Almonte through a major portion of the summer growing season was 117.2 masl. That is, the equivalent of the height of the concrete weir without flashboards. From the chart, the mean flow through much of the summer and early fall is very flat and at the 10 cms level. For that period the chart shows that the corresponding level in the Appleton Wetland would be 117.4 masl. This provides a solid estimate of what the historic water level in the wetland was during the period when the trees were healthy and thriving.

7 Results Summary

We believe that the results of our work lead to a clear answer to the cause of tree mortality in the Appleton Wetland and that is summarized in Section 7.1 below. In addition, there are some other issues that have come to light that are not directly related to the problem, but which need to be considered as part of the justification for making the needed changes to correct the problem. These items are included in Section 7.2 below.

7.1 Cause of Tree Mortality

The habitat requirements of soft maples growing in a wetland are detailed in Section 3.5 of this report. These maple species seem very capable of handling normal seasonal variations in water levels as well as intermittent extremes, as long as they get an adequate period of sufficiently low water level in the growing season that will give their upper roots a chance to breathe. The recommended water level in the adjacent river should remain consistently at least 25 cm below the ground surface for a major portion of the summer growing season. This parameter is a critical factor in assessing potential causes for the Appleton Wetland die-off.

Two separate studies of the wetland trees in 2011 (Section 6.1) and in 2013 (Section 6.4) have concluded that based on observed trees and ground levels that the maximum water level through the summer growing season should be 117.40 masl.

From all the information that was available to us, it is our conclusion that in the Flour Mill Era the industrial use of the Mississippi River in Almonte at the upper falls was quite benign, and operations were classical Run of River in nature. Our research indicates that the summer water levels during that period at the bridge in Almonte were around 117.2 masl much of the time (Section 4.1.7). This is equivalent to the height of the concrete weir without flashboards. Combining the historical record of average summer water flow of 10 cms in Reach 18 with the new water level versus flow rate model for Appleton (Section 6.6), we can now calculate that when the water level in Almonte is 117.2 masl, it will be 117.40 masl in Appleton. More concisely, the average summer water levels in Appleton in the Flour Mill Era matched the requirements of the maples based on the above tree and ground level measurements.

With the change to operations of the Generator Station Era, there has been a definite increase in water levels, the result of using higher flashboards in combination with a water usage strategy that maintains water levels near the top of the flashboards (Section 4.2.5).

Figure 26 in Section 4.2.4, showing river flow and water level at the bridge in Almonte during 2011, is a good example that illustrates the much higher levels resulting from that combination of factors. From mid-July to late November the flow rate hovered around 10 cms, equal to the long term average summer flow rate. Over the same period, water levels at the Almonte bridge fluctuated over the range of 117.6 to 117.7 masl. These short term dips in water level are of little benefit to the maples since the soil around the tree roots remains saturated over those short periods (Section 3.4). The effective water level at Almonte was thus 117.7 masl from mid-July to the end of the summer growing season. For a 10 cms flow rate with all flashboards installed, the water level in Appleton would have been the same as Almonte, or slightly higher, or some 30 cm over the desired healthy growth level of 117.4 masl.

Appendix D has further examples of summer water levels at Almonte under various actual flow rates. The summer of 2012 was a drought period and flow rates were of the order of 5 cms for the whole summer as shown on Figure D-7. In spite of that very low flow rate, the effective water level in Almonte remained at 117.7 masl for the entire period. Figure D-2 for 2007 shows similar low flow rates, and similar high water levels.

In cases where summer flow rates exceeded 17 cms, water levels always exceeded 117.7 masl. Examples include Figure D-3 for 2008, where summer flows were above 20 cms for most of the summer and water levels were 117.8 masl or higher over that period, and Figure D-5 for 2010, with summer peak flows around 20 cms and corresponding peak levels around 117.8 masl.

The above examples illustrate our conclusion that high water levels in the Appleton Wetland during the summer growing season are caused directly by the Enerdu use of higher flashboards in combination with a water usage strategy that maintains water levels near the top of the flashboards. These higher summer water levels exceed the normal threshold for healthy growth of the maples, and are the direct cause of tree mortality. Reducing summer water levels is essential for recovery of the wetland trees.

We should also note as covered in Section 3.5, that wetland maples are susceptible to ice damage. If the winter water level is high, and it freezes hard, the trees may be girdled when ice pressure damages the tree bark. In our observations of the wetland we did not notice any obvious signs of tree bark damage at the base of trees, and ice girdling is unlikely to be a significant cause of tree mortality. However, this does suggest that in addition to reducing summer water levels, it may be prudent to monitor winter water levels and reduce them if appropriate.

7.2 Other Issues

In addition to the direct issue of the cause of the tree mortality in the Appleton Wetland, there are several secondary issues that need to be recognized as part of the total picture. The sections that follow address some of those items.

7.2.1 The Impact on Upstream Power Generation

The theoretical total power that can be extracted from the Mississippi River between the water intake of the Appleton dam and the Enerdu tail race is a fixed quantity proportional to the flow rate at a given time multiplied by the total water level drop. With no flashboards in place at Enerdu, each GS gets a share of that total available energy, the shares being proportional to the individual natural heads at each dam. If Enerdu adds 50 cm flashboards, that increases their head and gives them a bigger slice of the available pie. At the same time, the tail race level at Appleton rises a similar amount and reduces the Appleton GS head, and also their share of the same pie. The net effect of the Enerdu head increase is close to zero power increase as a total for both GS locations.

This effect has been reported by the operator of the Appleton GS as noted in the following quote from the MVCA Report 2683/12 in Appendix Q.

Discussions with the former operator of the Appleton Generating Station revealed that in his opinion the water levels increased about 30 cm (1 foot) when the flashboards were installed. It was also indicated that their installation had a detrimental effect on Appleton's hydro generation capacity however as the boards were being installed when flows were low, the plant was not generating near full capacity which limited the impact on production.

Figure 44 Extract from MVCA Report 2683/12

The qualification in the above extract that there was limited impact on production when flows were low ignores the fact that the flashboards remain in place through the late fall and winter up to the peak of the spring flood, a long period when flows and production are high. Increasing water level in Almonte with flashboards during these high flow periods will still cause an increase in tail race level in Appleton and a production loss for the Appleton GS.

We recognize that reducing water levels at Appleton to restore healthy maple growing conditions in the Appleton Wetland will entail a loss of power production by Enerdu. However, it must also be recognized that it will result in a rebalancing of power production at both facilities in proportion to their natural heads, with little net change in total production, and will provide the benefit of wetland tree recovery. This change is also in accordance with the stated goals of the MRWMP that ecological integrity has a higher priority than hydro power production, and “the system is never operated to maximize hydroelectric generation to the detriment of the other priorities”.

7.2.2 Effect of Tree Canopy Loss on Bird Life

Prior to the beginning of the new millennium, Appleton Wetland was a lush area of several hundred acres of soft maple and willow trees, reaching a height of fifteen to twenty metres. Much wildlife was to be found in this swamp including otter, muskrat, beaver and many different species of high canopy and forest floor nesting birds.

Today (2014), the dying and dead trees have drastically altered the habitat of these animals and birds. During the five years of the 2nd Ontario Breeding Bird Atlas (2000-2005, Cadman et al), the Appleton Swamp was part of the atlas square surveyed by the Mississippi Valley Field Naturalists. Many species of birds nesting in the swamp at that time are no longer to be found.

The largest factor for the disappearance of these birds in the Appleton Wetland can be attributed to the loss of tree canopy because the trees are either dead or severely stressed. The resulting opening or removal of the canopy causes these birds to be vulnerable to predation by hawks. Also, nestlings are deprived of protection from the sun's heat when there are no leaves. When this happens, birds abandon their preferred nesting sites and either move on to other suitable habitat or fail to reproduce. (Ref 8 – Baicich and Harrison)

The following bird species, known and potential, are no longer present in the Appleton Wetland.

High Canopy Birds:

> Cooper's and sharp-shinned hawk, red-shouldered hawk (on species-at-risk list), least flycatcher, American crow, wood thrush, gray catbird, warbling vireo, scarlet tanager.

Forest Floor Birds:

> Winter wren, veery, hermit thrush, palm warbler, black and white warbler, ovenbird, Northern waterthrush, Canada warbler.

Other Forest Dwellers:

> Black-billed cuckoo, olive-sided flycatcher, Eastern wood pewee, yellow-bellied flycatcher, Swainson's thrush, Acadian flycatcher, alder flycatcher, blue jay, wood thrush, blue-headed vireo, red-eyed vireo, mourning warbler.

A reduction in water levels for Reach 18 of the Mississippi River to the point that would allow the tree cover to regenerate is needed urgently, and this would encourage the return of many of these bird species.

7.2.3 Effects on Biodiversity

Arguments have been raised that one marsh is much like another and suggestions were made that continuous flooding will simply take the Appleton Wetland to another stage, devoid of tree growth, but still, in essence, it would be a wetland. Typical is this statement from a letter dated March 12, 2014 to the Mississippi Mills Council from David Orazietti, then Minister of Natural Resources: “It was noted that the wetland is healthy. However the soft maples are dying and – because of this – the ecology of the wetland may shift, causing different species to form new communities.”

Aside from the potential losses of rare canopy birds described in the previous section, and losses of tree associated small mammal habitat, there is a fallacy associated with this type of thinking. The more complex wetlands are, the greater diversity of wildlife and wildlife habitat they will support. Lose the complexity and you reduce the biodiversity of these dynamic systems. Lose the complexity and you reduce a wetland's abilities for water purification. Reverse biodiversity and Reach 18's ability to function as an ecological corridor will be lessened. Bio-losses will accrue from plankton to aquatic invertebrates and to fish, dabbling and diving ducks which depend on the smaller species. Reptiles and especially amphibians, already stressed, will be even more affected.

Given their limitations of time and resources the authors of this research were unable to embark on a more all encompassing study which would have treated and explained Reach 18 and its contiguous wetlands as a riparian ecosystem. Such a study is there for others to take up to better understand the dynamics of the Appleton Wetland before irrevocable decisions are made.

The uniqueness of the contiguous Appleton Wetland along Reach 18 was recognized for a reason, hence its provincial designation as a PSW and nomination as an ANSI. To accept significant potential changes to the Appleton Wetland without fully understanding its inherent functions, richness and aesthetic appeal, educational and bio-values is disrespectful to those who saw these values and chose to designate this wetland as a PSW for the benefit of future generations. It is not too late to correct the excessive river water levels and to allow the wetland to begin recovery to its former state.

7.2.4 The Wetland and Climate Change

After an extended period of scientific study and debate, it is now widely accepted that human activity is a major driver of climate change and global warming. The changes are attributed to significant increases in the proportion of greenhouse gasses, carbon dioxide (CO_2) and methane (CH_4), in the atmosphere. Wetlands do play a role in the interchange of these gasses with the atmosphere, and human induced alteration of wetlands can lead to changing of the interchange balance.

It is recognized that methane has a greater influence on greenhouse effects than carbon dioxide – methane having an effect 23 times greater than an equal volume of carbon dioxide. It is also noted that methane production by an herbaceous marsh is approximately three times greater than for a wooded swamp of equal size. (Ref 1 – Keddy, page 309). Both swamps and marshes play a role in extracting carbon dioxide from the atmosphere and sequestering the carbon in various forms of vegetation. The vegetation in both forms of wetland are subject to continuous cycles of growth, maturity, death and decay, and the latter parts of the cycle do release CO_2 and CH_4 back into the atmosphere. Intuitively, the cycle in a temperate zone marsh will be a shorter, more or less annual cycle. A swamp is more complex, with the biomass in the tree leaves on an annual cycle, but with the biomass in the wood of the trees on a cycle lasting 60 to 100 years depending on species. In a mature and undisturbed wooded swamp regeneration of new trees offsets the death and decay of old trees so that the amount a sequestered carbon in the tree wood is constant over long periods.

The situation is quite different in the case of a wooded swamp that is disturbed by permanent and continuous flooding. The trees die and the wetland converts to an herbaceous marsh. All of the dead trees begin to decay in unison and the net result is a sudden surge of CO_2 and CH_4 into the atmosphere for a decade or so as the sequestered carbon in all of the wood is released. In addition, the marsh wetland will continue to produce three times the amount of more harmful CH_4 than the former swamp produced. On balance, causing a swamp to convert to a marsh contributes to our current problem of climate change.

The Appleton Wetland is an example of a swamp disturbed by flooding that is on the road to becoming a marsh. It is clearly in the best interests of our climate to stop the flooding, to allow the swamp to recover and to get back to its job of sequestering carbon in a healthy stand of trees.

8 Recommendations

We recommend that:

1. The MRWMP be amended immediately for Reach 18 to set the level of 117.4 masl, as measured at Appleton, as the maximum operational water level from May 1 to October 31.

   In previous sections of this report the level of 117.4 masl has been identified as the most probable historic water level of the Flour Mill Era, and during that period the Appleton Wetland continued to thrive in coexistence with the early industrialization of Reach 18. Restoration of those conditions is essential for recovery of the maple trees in the wetland. There is an urgent need to make this amendment soon while there are still live, but severely stressed, trees present, and there is still viable root stock present. As noted in Section 3.5 of this report, that is the condition that will allow the most rapid recovery of the wetland maples. Also as noted in Appendix K, there is certainly evidence of the roots of damaged trees now sending out new shoots in an attempt at survival. We believe that prompt action will ensure the survival and regeneration of the Appleton Wetland as a healthy maple swamp.

2. The amendment provisions must include a five year test period during which the conditions in the Appleton Wetland must be monitored closely for signs of tree recovery and for evidence that 117.4 masl is a valid operational summer water level, with the option of adjusting water levels in the remainder of the test period if warranted.

   We believe that a test period with close monitoring by experts of MNR and MVCA with possible assistance from professors and graduate students at the University of Ottawa and/or Carleton University, in addition to the involvement of MVFN citizen scientists, is essential for proper evaluation of the effects of a water level change. Since nature tends to respond slowly to changes it is likely to take at least five years for solid evidence that recovery has started. We would also note that with water levels so high during the past decade it has been very difficult to measure root structure levels that are submerged in high water. With the recommended lower operational water levels, root structure will be easier to study and may lead to revised levels that can achieve the balance between ecological integrity and power production that is the goal of the MRWMP.

3. A further amendment provision must include a thorough evaluation of results at the end of the test period to establish a final Water Management Plan for Reach 18.

   We appreciate that the hydro power industry needs to have clear long term rules about acceptable water level limits in order to guide their investment in generator station upgrades. The test period should provide the data that will permit the establishment of optimum water levels, but in doing this, it must be recognized that the MRWMP places a higher priority on ecological integrity than on power production.

4. Approval of the current upgrade plan of Enerdu must be delayed until the recommended MRWMP amendment has been resolved.

   This may at first appear to be an issue that is not related to the recommended change in summer water levels. Our concern is that if Enerdu makes a significant investment in their current upgrade plans before the amendment is resolved, they will then use the argument that reduced water levels will make that investment non-viable, and will insist that current excessive levels be retained. The fairest approach is to withhold upgrade approvals until such time as the MRWMP amendment is resolved. Enerdu can then reassess their upgrade design based on any revised water levels, and invest appropriately. For example, we see no need to replace the current modest concrete weir if the recommended water levels are adopted. It has been adequate for managing the historic water levels for the past century, and can be used indefinitely into the future if that level is restored.

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