An Analysis from Air Photographs of Historical Channel Changes of the West Branch, St. Mary's River, Guysborough County, Nova Scotia.

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EXECUTIVE SUMMARY

The West Branch of the St. Mary's River has long been thought to be the most degraded area of the river system and is the focus of a large-scale physical habitat restoration program of the St. Mary's River Association. An aerial photograph interpretation project was undertaken to identify active areas of the West Branch channel to assist hydrologists and engineers focus efforts on habitat restoration of this branch. The West Branch drains an area of approximately 470 km^2 and is 64.5 km long. Gradient throughout the length is low. Dominant land use of the West Branch has been forestry.

Air photographs of the West Branch from 1980 and 1997/1998 were analyzed to assess areas of channel activity and aggradation. The West Branch was divided into five sections and channel morphometry summarized for each section for each year of photography as well as between years. In addition to descriptive morphometry, quantities calculated included a Sinuousity Index, length of river in each of (i) intact, (ii) harvested, (iii) in agriculture, (iv) roaded, and channel widths. Seven sites were groundtruthed. Interpretation of the photographs must be done with the river discharge on the day of photography being considered. Discharge ranged between 2.46 m^3/s and 30.5 m^3/s on days of photography.
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Within Section I (Silver's Pool to Glencross Brook) there is significant lateral bar and island development. Aggradation is extensive throughout the section. Gravel accumulation appears to become greater moving downstream through the section. There is suggestion of aggradtion decreasing between 1980 and 1997/1998 but this interpretation is confounded by differing river discharge on dates of photography. Over this time period however, aggradation appears to remainproblematic between Glenelg Bridge and Silver's Pool with extensive redistribution of gravel occurring

In Section II (Glencross Brook to Lower Caledonia) significant lateral channel movement appears to have historically taken place between Lower Caledonia and Indian Man Brook, this being particularly apparent at Sutherland's Brook confluence. Islands appear to have increased in size over the period of photography. Between Lower Caledonia and Indian Man Brook are areas of large bar development, particularly near the Sutherland's Brook confluence. There is also significant increase in size of bars downstream of the Lower Caledonia bridge, but some of the apparent increase in bar size may be due to variation in flow between dates of photography. Two historically identified eroding banks are indicated in this section.

There is evidence of aggradation in Section III (Lower Caledonia to Caledonia) in the form of large point and mid-channel bars, islands and braiding channels. This aggradation is particularly prominent near Caledonia, Mitchell Brook, and Lower Caledonia. Near Barren Brook there is some evidence of channel change in the form of aggradation and new channel formation. There is little evidence of significant change in Section III over the 18 year period. Seven historically identified eroding banks are indicated in this section.

There is moderate bar development within Section IV (Caledonia Bridge to East Bryden Brook), particularly noticeable at the Beaver Brook, Chisholm Brook and Caledonia. There is significant

evidence of historical lateral channel movement in this section, suggesting that this is an active area of channel; particularly so at Beaver Brook and upstream of Caledonia where limited anastamosing (braiding) has developed. There is little evidence of significant lateral channel movement within the section apart from these two areas. Bars appear to be stable and increasing in vegetation cover over time.

Within Section V (East Bryden Brook to Trafalgar) there are no signs of major erosion or depositional features between Trafalgar and Castley Brook and only minor depositional features below Castley Brook. The lack of freshly deposited (unvegetated) material on point bars suggest that aggradation is not occurring in this area. Some bars are quite large, but they appear stable. The aggradation of sediments within this section appears to be at a sufficiently low rate to suggest that the in-river sediment transport processes are likely in equilibrium with the terrestrial sediment generation and delivery processes.

In general, the channel activity increases progressing downstream. The areas of greatest activity identified in this analysis are: (1) Beaver Brook confluence, (2) Caledonia area from Chisholm Brook to Mitchell Brook, (3) Lower Caledonia area from upstream of Barren Brook to Indian Man Brook, and (4) Section I from McLeod Lake outflow to Silver’s Pool. Section IV shows evidence of limited aggradation of materials and Section V appears stable and of low activity in terms of channel dynamics.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

1.0 INTRODUCTION

In 2008, the St. Mary's River Association embarked on a large-scale physical habitat restoration program of the West Branch St. Mary's River. This branch has long been thought to be the most degraded area of the river system, partly attributable to historical log driving activities and gravel removal for road and rail bed construction (Hart Buckland-Nicks, 1995). This has created a river that is overwidened and shallow throughout much of its length. In 2007, Rutherford evaluated the West Branch St. Mary's River from the perspective of fish habitat management. He identified, in particular, problems with the river being overwidened and shallow, and a lack of pools to allow adult Atlantic salmon resting pools during their upstream migration.

The purpose of the work reported here was to provide an overview, from interpretation of historical air photographs, of the active areas of the West Branch channel in order to assist hydrologists and engineers in focussing efforts on habitat restoration of this area. This work is intended as a cursory overview only, with detailed, focussed work following up on identified areas (see Recommendations).

2.0 STUDY AREA

The St. Mary's River, Guysborough County, is one of the largest watersheds in Nova Scotia (Davis and Browne, 1996), with a drainage area of approximately 1,350 km^2. The West Branch of the river is one of three branches, the others being the East and North branches (Figure 1). The West Branch drains an area of approximately 470 km^2 (Hart Buckland-Nicks, 1995) and flows over a distance of 64.5 km from the confluence of the Nelson and North Nelson rivers (45^{o}17'55.5"N; 62^{o}41'33.5"W) to where it joins the East Branch at Glenelg (45^{o}15'14.5"N; 62^{o}03'47.7"W). The river is low gradient (mean gradient over distance 0.2%) with a maximum gradient of 0.4% between river km 53 and 55 (Figure 2). There are an estimated 53 tributaries contributing flow along the length of the West Branch. Dominant land use of the West Branch has been forestry (Rutherford, 2007), with agriculture comprising a small amount of land on this branch. Highway 348 runs along the north side of the river to Lower Caledonia, at which point it crosses the river and then parallels the West Branch to Trafalgar. There is an extensive road network throughout the West Branch drainage of old and contemporary forestry roads.

3.0 METHODS

Air photographs of the West Branch St. Mary's River were purchased for 1980 (July 5, August 23, October 11) and 1997/1998 (June 30, 1997, June 11, June 12, 1998) to provide coverage of the West Branch (photograph numbers used by date are provided in Appendix 1). Photographs were viewed using a mirror stereoscope and the river channel analyzed and described within each year of photography, as well as being compared over the 18 year time period. Ideally, we would have compared the oldest available photographs with the most recent to extend our period of analysis, but photographs from years before 1980, while available, either (*i*) did not offer sufficient coverage of the entire river in a short time period (i.e., one or two years), or (*ii*) were

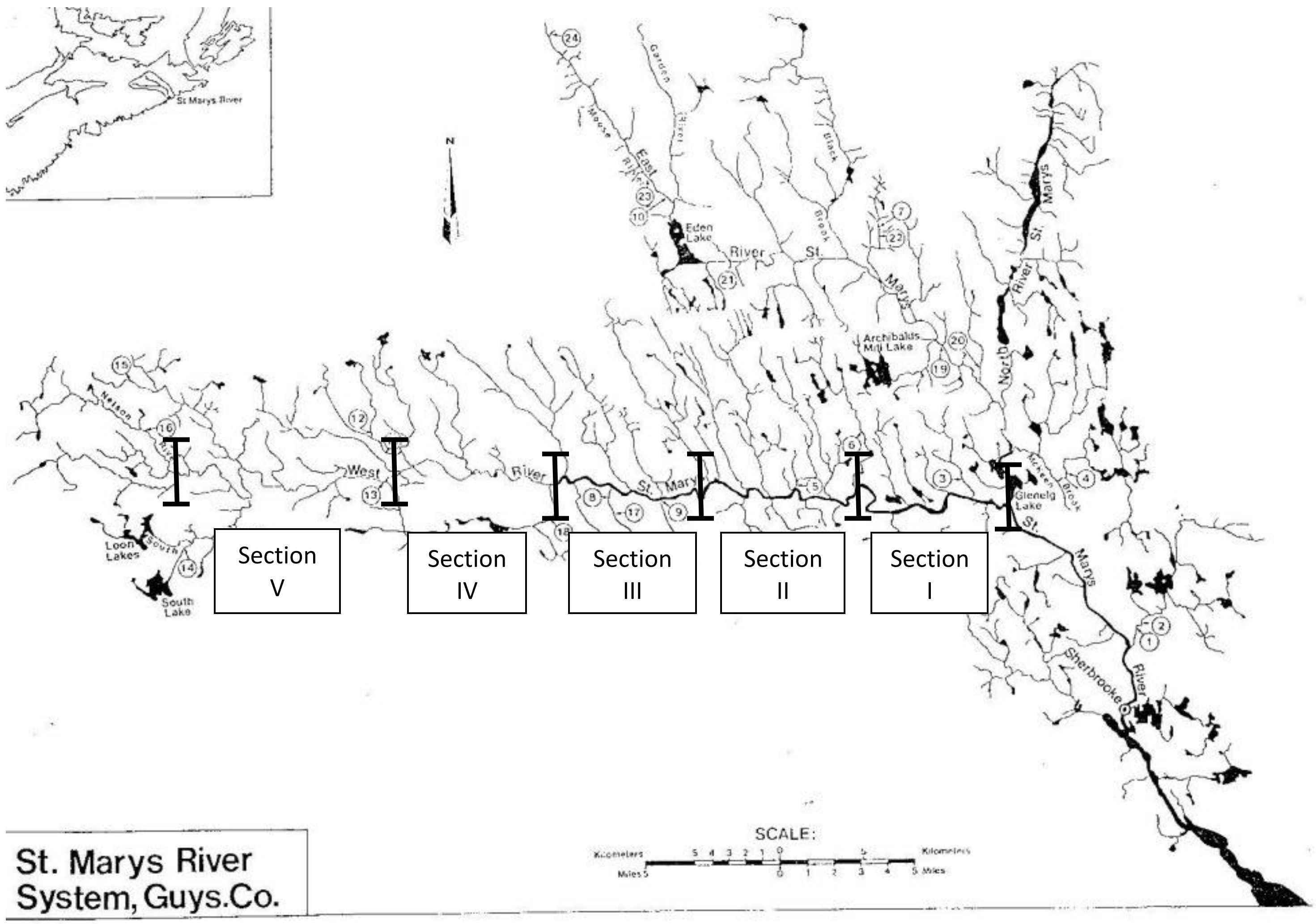

Figure 1: Study area indicating sections of West Branch St. Mary's delineated in this analysis.

sufficiently expensive as to be beyond our budget[1]. During the analysis the West Branch was divided into five sections of approximately equal length (Sections I, II, III, IV, V in Figure 1; mean length 12.9 km; SD=2.17 km) and channel morphometry summarized for each section. The sections are presented in this document in order from downstream to upstream. The degree of meandering of the river per section was quantified by a "Sinuousity Index" calculated as river length (km) divided by the straight line distance (km) between upstream and downstream ends of the section. A value of 1.0 indicates a straight channel and increasing index values indicate increasing degrees of meandering. A sinuosity index of 1-1.5 indicates a sinuous pattern, while an index of 1.5-4.0 indicates a meandering morphology (Mount, 1995).

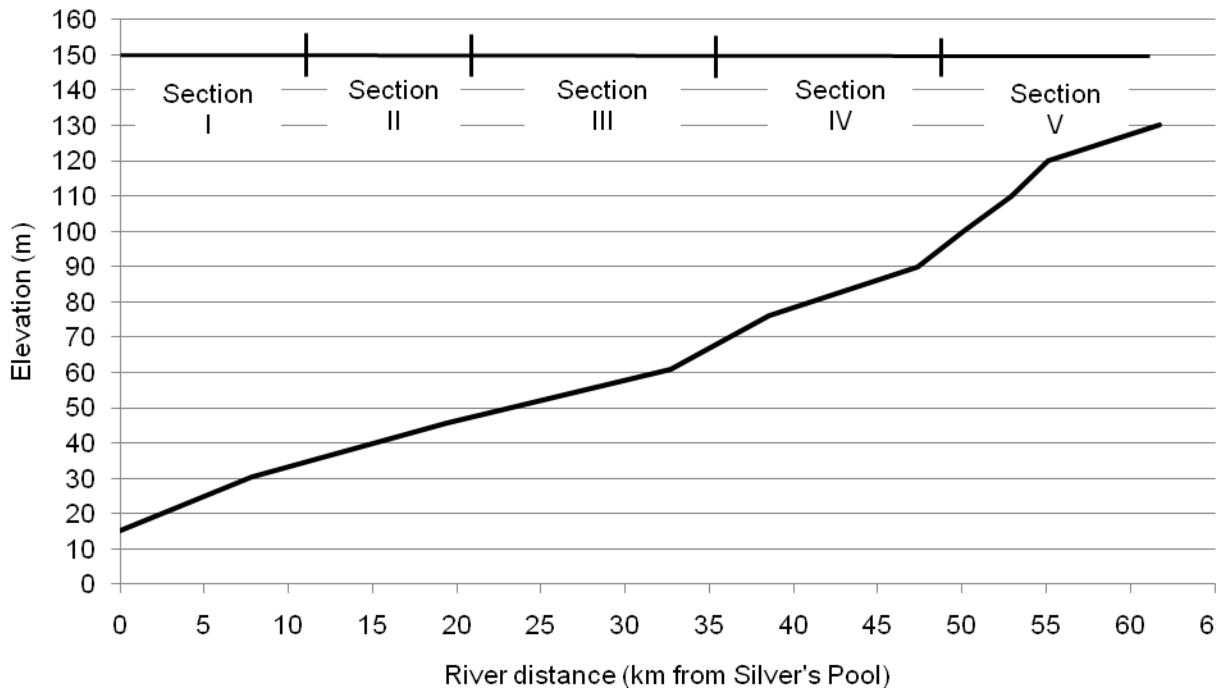

Figure 2: Longitudinal profile of West Branch St. Mary's River as derived from 1:50,000 scale NTS topographic maps 11 E/7 and 11 E/8. Sections designated for this analysis are also shown.

The extent of river length with riparian area intact, harvested, in agriculture, or with road through it (major roads or highways only) for each section was calculated from the 1997/1998 photographic series. Buffer strips were considered "intact" or "forested" if they were at least 50 m wide. Measurements of channel widths from each section were likewise made only for the 1997/1998 photographic series. Channel widths were measured from air photographs at approximately one kilometre intervals beginning at river km 0 (Silver's Pool).

[1] Photographs for the periods prior to 1970's are available through the National Air Photo Library (website http://airphotos.nrcan.gc.ca/) but the cost for a large number of these was prohibitive. Therefore, we balanced cost with going back in time as far as practical.

Seven sites were visited for groundtruthing on May 4, June 4, June 26 or June 29. An eighth site, Barren Brook confluence, was visited with Bob Rutherford and Amy Weston (Nova Scotia Salmon Association Adopt-a-Stream program) on December 1.

4.0 RESULTS & DISCUSSION

Interpretation of river and channel changes over time between 1980 and 1997/1998 is confounded by changes in river flow conditions between the dates of photography among years. The change in water level would expose bars and islands, or inundate them, dependent upon the magnitude of discharge. Therefore, interpretation of the photographs must be done with the river flow on the day of photography being considered. Hydrological data for the dates of the photographs are provided in Table 1. It may be seen that images from August 23, 1980 represent very low flow and those from October 11, 1980 high flows, with the other four dates intermediate to these.

Table 1: River discharge (m^3/s) on dates of historical air photography of the West Branch St. Mary's River. Hydrological data from Water Survey of Canada hydrometric station at Stillwater[2].

Date	Discharge	Date	Discharge
July 5, 1980	7.29	June 30, 1997	8.71
August 23, 1980	2.46	June 11,1998	19.6
October 11, 1980	30.5	June 12, 1998	22.7

SECTION I: SILVER'S POOL TO GLENCROSS BROOK CONFLUENCE
(river km 0 to 11.7; 11.7 km in length)

Section I flows through a relatively well forested landscape, though there is some agricultural activity present. The riparian area is largely intact. Approximately 4% of the river length is adjacent to harvested areas, 8% adjacent to agriculture, and the remainder well forested. Approximately 22% of the river length is adjacent (i.e., within 50 m) to main roads or highway. The channel pattern is sinuous with a sinuosity index of 1.32. Mean channel width of this section from photographs is 67.1 m (SD=12.3 m; N=12). Rutherford (2007) noted that the natural channel width from Silver's Pool to Caledonia was 30 m and at the time of his measurements reported an actual channel width of 76 m, which is similar[3] to that estimated here. In 1955, McEachern estimated the average river width between Glenelg and Lower Caledonia as 38 m, but it is unclear from his report whether he was referring to channel width or wetted width.

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[2] Stillwater Sherbrooke (station ID8205601; located at 45°8.4'N,61°58.8'W). (data available at: http://scitech.pyr.ec.gc.ca/waterweb/fullgraph.asp)

[3] The estimates are not statistically similar at □=0.05. 95 % CI on the air photo estimate are 60.10 - 74.05 m

Within this section there is significant lateral bar and island development (Figure 3). The aggradation is extensive throughout the section. Points of most extreme lateral bar formation are (1) on the bend upstream of McLeod Lake, (2) between McLeod and McCarthy lakes, (3) on bend downstream of Pommen Lake, (4) upstream of McInnis and Archibald's brooks, and (5) in the area from upstream of Glenelg Bridge to Silver's Pool. Aggradation to such a degree as to cause anastamosing channels (braiding) occurs at a point upstream of the Churn Brook confluence and also from the McLeod Lake outflow to McIntosh Brook confluence. The gravel accumulation appears to become greater as one moves down the section from Glencross Brook to Silver's Pool. There are 9 islands within this section of the river (islands defined as being surrounded by water and vegetated indicating they are stable overtime).

Historical lateral channel movement is evident at three locations. First, on the south side of the river across from McCarthy Lake are old channels and a "young" forest naturally revegetating on the floodplain indicative of relatively recent continual exposure from water. The second area is a large island on the bend downstream of Pommen Lake which splits the channel in two. The water appears to be seeking different routes. This channel could change the direction of the main channel flow from flowing north of the island to flowing along the south of the island. Lastly, for a distance extending ~1.5 km upstream of the Glenelg bridge, along the south bank, are old channels, some still with water in them, and vegetation growing in the typically meandering pattern indicating a historical channel.

Aggradation from a point upstream of McLeod Lake to the Glenelg bridge appears to be reduced in 1998 relative to 1980 (dates of photographs August 23 & October 11, 1980, and June 11 & 12, 1998). This inference is based upon reductions of island areas, reduction of bare bar material, and increased vegetation cover. This may be a suggestion of channel recovery (reduction in sediment input from upstream?) relative to historical conditions. However, this apparent reduction in bar size could be a function of higher streamflows (19.6 and 22.7 m^3/s) in 1998 compared with 1980 (2.46 m^3/s; small number of photos in this series taken on October 11 at 30.5 m^3/s). Between Glenelg Bridge and Silver's Pool, however, aggradation is problematic. There is significant movement of bars between periods of photography and bars change in size and shape (Plate 1). Gravel accumulating along both sides of the stream is changing shape. In 1980, gravel accumulation formed a mid channel bar. By 1998, more sediment had accumulated, so the mid channel bar became part of the bank. These bars do show significant vegetation growth between periods, but the obvious changes in shape and size indicate considerable re-distribution of non-vegetated material.

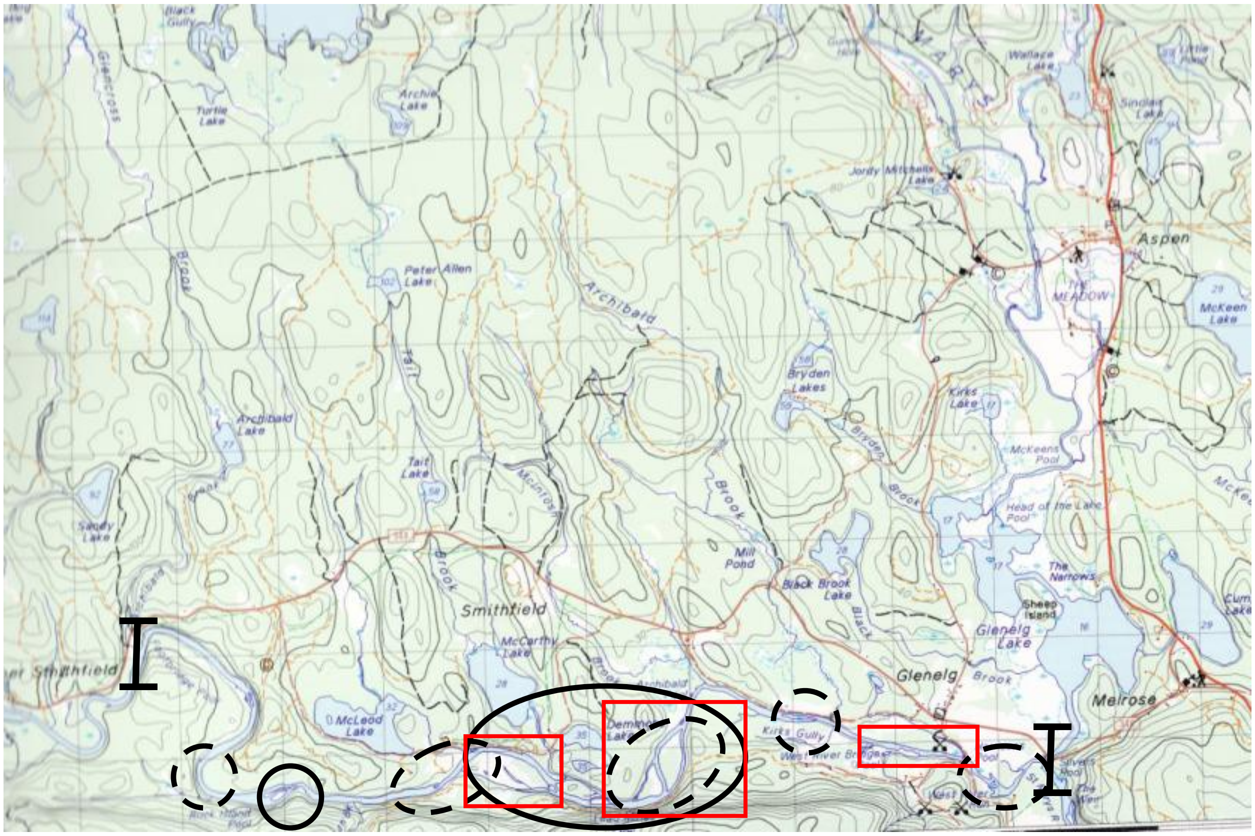

Figure 3: Section I, illustrating locations of described channel morphometric features. Lateral bar formation and island development shown in dotted ellipses, braiding (anastamosing channels) in solid ellipses, and historical lateral channel movement in red boxes.

SECTION II: GLENCROSS BROOK CONFLUENCE TO LOWER CALEDONIA BRIDGE
(river km 11.7 to 22.6; 10.9 km in length)

Similar to Section I, Section II lies within a landscape that is well forested. There are agricultural fields bordering the river, but throughout much of this section the forest is intact and fully developed. Approximately 3% of the river length is adjacent to harvested areas, 2% adjacent to agriculture, and the remainder is well forested. Approximately 12% of the river length is adjacent to main roads or highway. The channel pattern is sinuous with a sinuosity index of 1.45. Mean channel width is 45.6 m (SD=12.4 m; N=8).

Between Glencross Brook and Indian Man Brook the meander which occurs in more upstream sections (IV & V, see below) is noticeably lost, though the sinuousity here is greater than Section I. There is an island upstream of the Indian Man Brook confluence and a further two islands upstream of the Clark's Brook confluence (Figure 4). Significant lateral channel movement in the form of old channels appears to have historically taken place between Lower Caledonia and Indian Man Brook. Lateral movement is particularly apparent at Sutherland's Brook confluence with braiding of the channel (Plate 2).

All of the islands appear to have increased in size over the period of photography (dates of photography October 11, 1980 and June 11, 1998). There is also apparent aggradation along the island near Indian Man Brook which is adding to its size. In 1980 the island was about 30 m wide by 180 m long. In 1997 the island was about 55 m wide by 210 m long. Between Lower Caledonia and Indian Man Brook are areas of large bar development, particularly upstream and downstream of the Sutherland's Brook confluence. There is also significant increase in size of bars downstream of the Lower Caledonia bridge, but river discharge was two thirds in 1998 what it was in 1980. Therefore, water level was lower and so at least some of the apparent increase in bar size may be due to variation in flow between dates of photography.

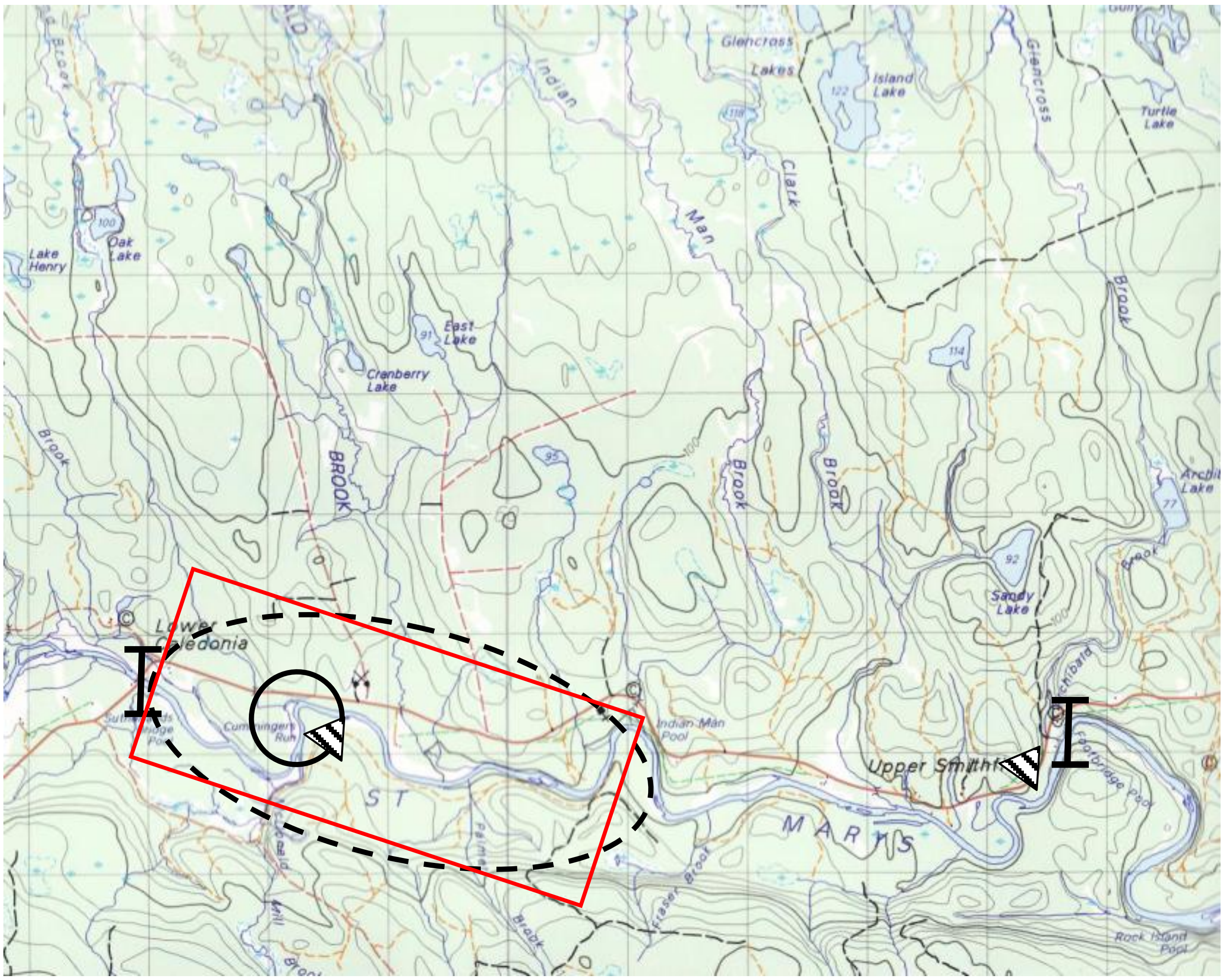

Figure 4: Section II, illustrating locations of described channel morphometric features. Lateral bar formation and island development shown in dotted ellipses, braiding (anastamosing channels) in solid ellipses, and historical lateral channel movement in red boxes. Also shown are the eroding banks (hatched triangles) from the survey of McGowan (1993).

Near the confluence of MacDonald Mill Brook one of the gravel banks has a channel cutting through it in the 1998 photos that wasn't there in 1980; this is changing the bar into a mid channel bar. As well, there is a lateral bar changing size. In 1980 the bar was only about 10 meters wide and in 1998 the bar was about 30 meters wide.

McGowan (1993) identified two large eroding banks in this section. Immidiately downstream of McDonald Mill Brook (Cumminger's Run), on the east side of the river, he identified an eroding bank ~30 m long by 10 m high with an approximate 80^{o} slope. The top of the slope is cleared of trees and has a cabin situated on it. The second site was immediately upstream of Glencross Brook on the south side of the river. This bank is also ~30 m long (height not provided) and at 70^{o} slope. Trees along the top have been removed and cottages built to the edge of the bank. McGowan (1993) considered this slope unstable.

SECTION III: LOWER CALEDONIA BRIDGE TO CALEDONIA BRIDGE
(river km 22.6 to 34.6; 12.0 km in length)

The landscape within this section contains some forest harvesting in the upriver areas and isolated areas of agriculture. Throughout much of the section, however the forest is intact and fully developed. Approximately 2% of the river length is adjacent to harvested areas, 9% adjacent to agriculture, and the remainder well forested. Approximately 6% of the river length is adjacent to main roads or highway. The channel pattern is sinuous with a sinuosity index of 1.28. Mean channel width is 39.2 m (SD=12.4 m; N=12). In 1955, McEachern estimated the average river width between Lower Caledonia and Caledonia as 30 m, but as stated before, it is unclear from his report whether he was referring to channel width or wetted width.

Within Section III there is evidence of aggradation in the form of large point and mid-channel bars, islands and braiding channels. This aggradation is particularly prominent near Caledonia (leading to braiding channels; Plate 3), near the Mitchell Brook confluence, and upstream of Lower Caledonia (Figure 5; Plate 4). Between Mitchell Brook and approximately 1 km upstream of Barren Brook there is little evidence of significant channel change; the channel remains a discrete channel, small isolated lateral bars are present, and the banks appear solid; there is little to no sign of aggradation or negative impact. There are four islands within this section of river.

There is little evidence of significant change in these areas over the 18 year period. Cross Brook appears to be a significant sediment source as there is an increase in bare sediment exposed as bar between the two periods of photography (October 11, 1980 and June 11, 1998). As with Section II, river discharge was two thirds in 1998 what it was in 1980. Therefore, water level was lower and so at least some of the apparent increase in bar size may be due to variation in flow between photography dates. Over time, the bars throughout this section appear stable; there is no significant change in size or shape and the amount of vegetative cover appears to be increasing. Further indication of a low rate of aggradation in this section is the small amount of sediment building up along the river downstream of Chisholm Brook. There are minor sediment accumulations occurring in several spots for approximately 1200 meters of the river downstream of Chisholm Brook. The most significant accumulation is seen at the tip of a mid-channel bar where approximately 10 meters of gravel is accumulating. Near Barren Brook there is some evidence of channel change (Plate 3). In 1980 the main channel ran along the south of the island, with a secondary stream running along the north of the island. In the 1998 photo it appears that the main channel is traveling mainly through the north channel. In the 1980 photo the island is about 20 meters wide and 100 meters long. In 1998 the island is 50 meters wide and 110 meters long. Differences in river flow between dates, however, confound interpretation. The area of gravel accumulating along the edge of the island was measured during a site visit on June 29, 2009. The width of the gravel was 23 meters and the length 282 meters. During this site visit it was voted that the channel is down to one and a half meters on either side of this gravel accumulation. Beyond the gravel accumulation, this channel is mainly still water. During the groundtruthing visit we (M. Myers and D. Murray) spoke with a landowner adjacent to this site who said that the gravel accumulation gets larger every winter and the new channel that is running north of the island is also getting wider every year. A second site visit to this area was conducted on December 1 with B. Rutherford and A. Weston in which the causes of this and potential restoration options were discussed. B. Rutherford suggested the changes over time may be due to an interference with the natural hydraulic pattern of the river "flipping the channel" and so resulting in new channel forming on the north side of the island, with the south side of the island having been the original channel.

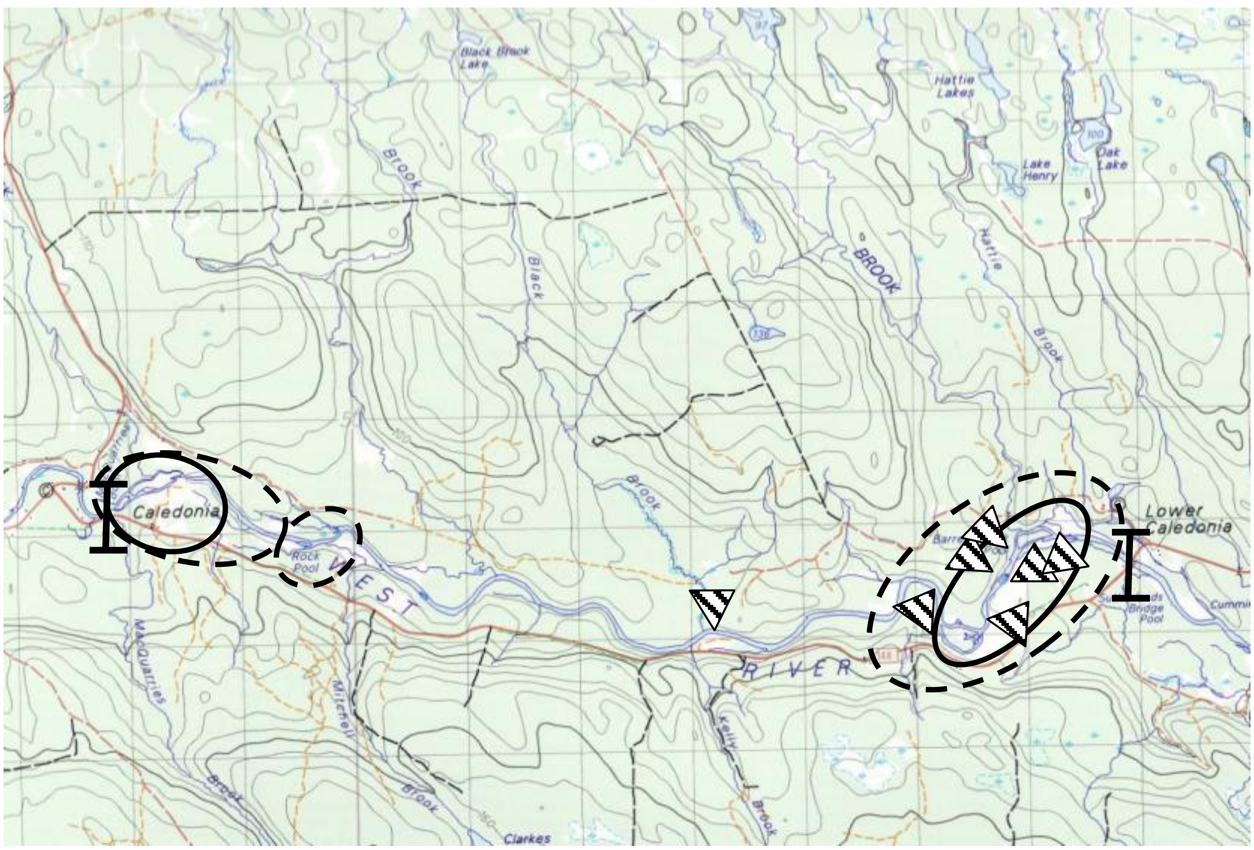

Figure 5: Section III, illustrating locations of described channel morphometric features. Lateral bar formation and island development shown in dotted ellipses, and braiding (anastamosing channels) in solid ellipses. Also shown are the eroding banks (hatched triangles) from the survey of McGowan (1993).

McGowan (1993) identified seven large eroding banks between Kelly Brook and Barren Brook. The length of eroding bank ranged from ~25m to over 100 m, but were generally on the order of 60 m and 8-10 m high. One was located on the north side of the river ~100 km downstream of Kelly Brook, the second approximately halfway between Kelly Brook and Barren Brook and numbers 3 to 7 on a stretch extending from ~1 km upstream of Barren Brook to 500 m downstream.

SECTION IV: CALEDONIA BRIDGE TO EAST BRYDEN BROOK CONFLUENCE

(river km 34.6 to 48.1; 13.5 km in length)

The river in Section IV flows through a well forested landscape. Riparian buffer strips are largely intact. Approximately 21% of the river length is adjacent to harvested areas and the remainder is well forested. There is no agriculture adjacent to the river in this section. Less than 1% of the river length is adjacent to main roads or highway. The channel pattern is meandering with a sinuousity index of 1.50. Mean channel width is 27.0 m (SD=12.5 m; N=10). Rutherford (2007) noted that the areas we have designated as Section IV and V are not as overwidened as those lower down but do still have areas of channel braiding. McEachern (1955) reported a river width in this area of 18 m.

There is moderate bar development within this section of the river, particularly noticeable at the Beaver Brook and Chisholm Brook confluences. Bar development is particularly pronounced upstream of Caledonia (Figure 6). There is significant evidence of historical lateral channel movement in this section, suggesting that this is an active area of channel (Plate 5). This is particularly so at the Beaver Brook confluence and upstream of Caledonia where limited anastamosing (braiding) has developed; there is little evidence of significant lateral channel movement within the section apart from these two areas. Chisholm Brook may have been a historically significant sediment source based on the 1980 air photos which show bar development in the brook and also gravel accumulation in the West Branch downstream of the Chisholm Brook confluence. This site was visited on June 29, 2009 and the mid channel bar was measured. The length was 30 meters and the width was 10.2 meters. The bar is covered in vegetation and the substrate is primarily large gravel and small cobble.

Near Beaver Brook three bars appear to be stable and increasing in vegetation cover over time. The amount of bare ground is diminishing between the two periods of photography. The river in the Cameron Settlement area also appears stable with bars remaining approximately the same size over 17 years. Many bars are well vegetated, including the extensive bar development upstream of Caledonia.

Gravel accumulation is occurring along the south side of the island downstream of East Bryden Brook and is contributing to the narrowing of the stream. In the 1980 photo, the river was approximately 10 meters wide and in the 1998 photo only 5 meters. At the confluence of Beaver Brook the 1980 photo shows a gravel bar along the stream bank after a meander in the river. The 1998 photos show that the bar appears stable in that it is almost completely covered in vegetation whereas there was little vegetation on the bar in 1980. This site was visited on June 26, 2009 where the bar length was measured at 92 meters and the width up to the tree line 13.8 meters.

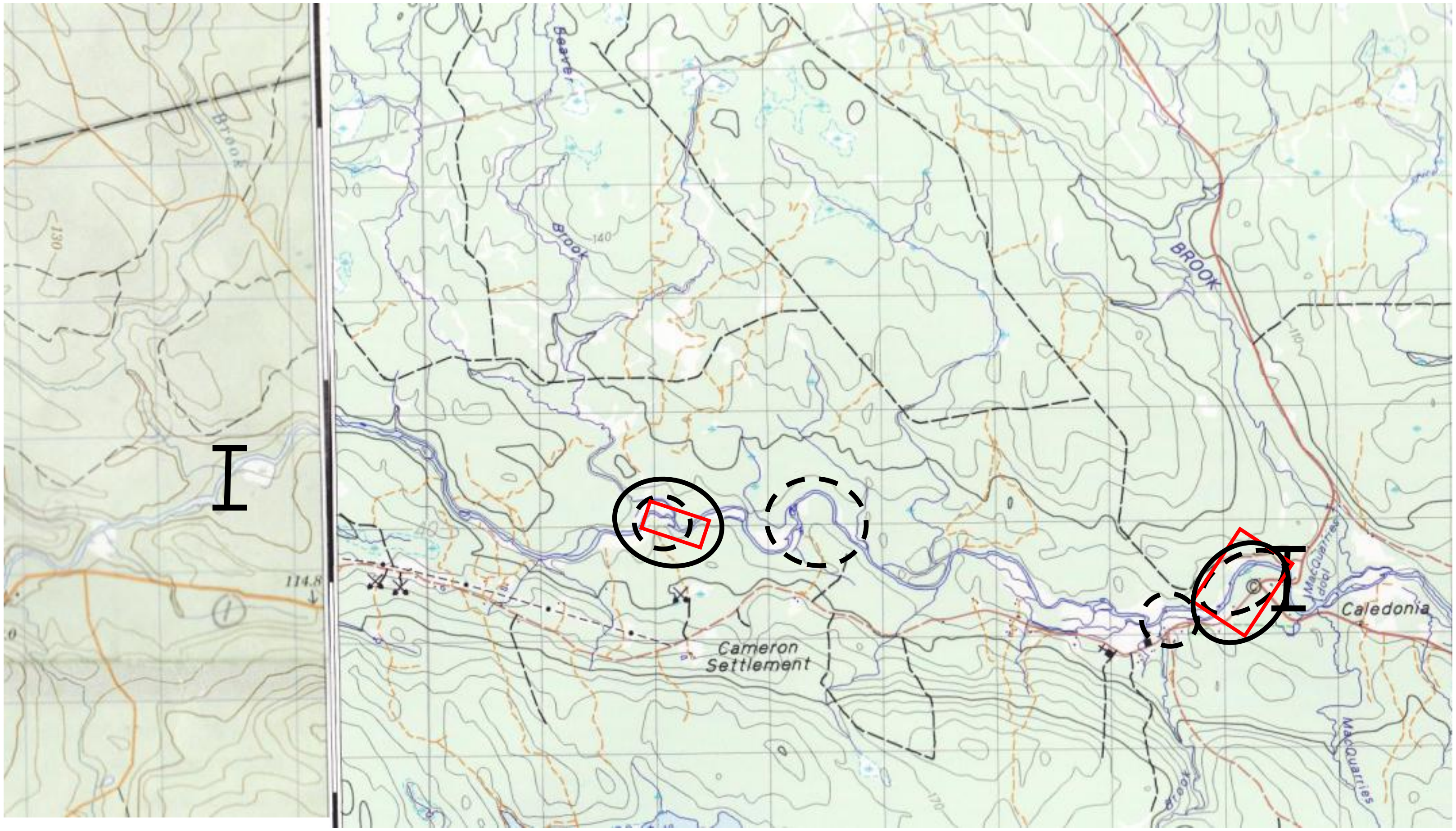

Figure 6: Section IV, illustrating locations of described channel morphometric features. Note, this section on two map sheets so figure a composite of these two maps. Lateral bar formation and island development shown in dotted ellipses, braiding (anastamosing channels) in solid ellipses, and historical lateral channel movement in red boxes.

Downstream of the Beaver Brook confluence in 1980 and 1998 photos there is evidence of the old main channel. It is more evident in the 1980 photos and there seems to be more water in the old channel (back water). In the 1998 photo it's less obvious and there is little water present. On the turn north of Cameron Settlement in 1980 photos, there is some sediment built up after a large meander in the river. In 1998 photos the build-up is continuing and the mid-channel bar is growing. There is approximately 15 meters of sediment added to the width of the bar between 1980 and 1998. This site was visited on June 4, 2009. There are large gravel bars around every meander in this general area. Not only is the gravel bar here large in terms of length (36.5 meters) and width (33.0 meters), but the height is significant compared to the other sites that were looked at (approximately 0.5-0.75 meters above the river). The substrate of the bar has a large range in size, but the majority is cobble and there is little vegetation growing on it. Finally, on the turn upstream of Chisholm Brook in the 1980 photo there is gravel accumulating after a meander in the river. There's no vegetation occurring on the gravel accumulation. In the 1998 photo there's no change in the size of the gravel accumulation, but there is a width of vegetation along the gravel bar of about 12 m greater in the later photograph than the earlier.

SECTION V: EAST BRYDEN BROOK CONFLUENCE TO TRAFALGAR
(river km 48.1 to 64.5; 16.4 km in length)

The river in this area flows through a landscape recovering from a large forest fire (the Trafalgar Fire) of 1976 which was subsequently salvage logged. Thus, the forested landscape in this area is relatively young. Riparian buffer strips remain but much of the landscape away from the river has been harvested and is in a state of regrowth. Much of this section of the river is adjacent to forestry activities from the Trafalgar Burn and subsequent salvage logging. There is no agriculture adjacent to the river in this section. Approximately 10% of the river length is adjacent to main roads or highway. The channel pattern is meandering with a sinuousity index of 1.53. Mean channel width is 17.7 m (SD=6.0 m; N=13).

There are eight islands in the channel between a point upstream of Castley Brook and the Black Brook confluence. There are no signs of major erosion or depositional features between Trafalgar and Castley Brook and only minor depositional features below Castley Brook. The lack of freshly deposited (unvegetated) material on point bars suggest that aggradation is not occurring in this area. Some bars are quite large, but they appear stable. Many are well vegetated with trees, suggesting the bars are sufficiently stable over time to allow primary succession to occur to the mature tree stage. There exist some lateral bars which lack vegetation and these are likely due to periodic inundation and slight lateral channel movement, but this does not appear to be at a rate to be problematic. The aggradation of sediments within this section appears to be at a sufficiently low rate to suggest that the in-river sediment transport processes are likely in equilibrium with the terrestrial sediment generation and delivery processes.

Between Gorman Brook and Crooked Brook, gravel is accumulating downstream of a turn in the river (Figure 7). The gravel is contributing to the widening of the mid-channel bar located after the turn. Between the 1980 photos and the 1997 photos there appears to be approximately 5 m accumulating along the side of the bar. This site was visited on May 4th, 2009. The bar was measured to be 62 meters long and 20.6 meters wide. The substrate is large gravel to small cobble in size, on average, and vegetation is covering the majority of the bar. There is evidence of primary succession.

Upstream of Doggett Brook in the 1980 and 1997 photos there are visible signs of the old channel. In the 1980 photo the old channel is more obvious then in 1997. It appears as though the new channel is creating a wider turn in the stream while the old one cuts straighter across. This site was also visited on May 4, 2009 and it was confirmed that the channel changes are taking place; the old channel has dried up although it is still receiving some backflow.

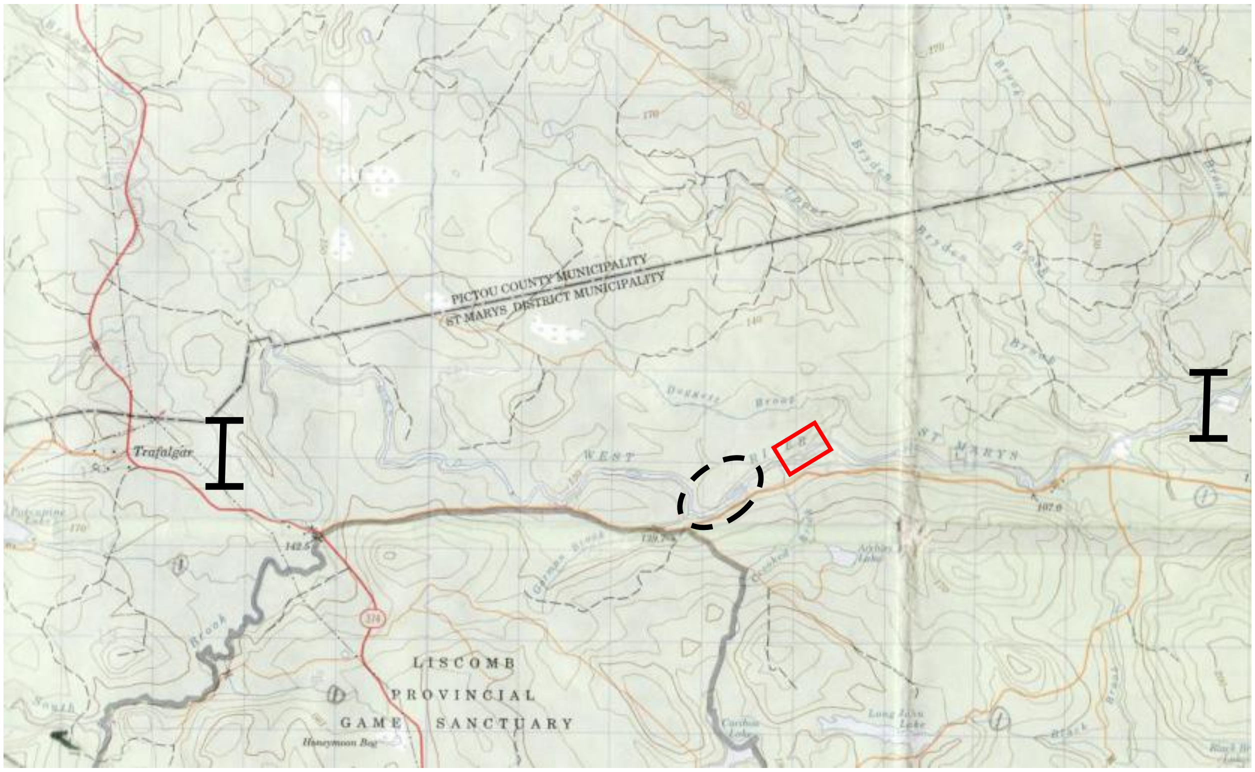

Figure 7: Section V, illustrating locations of described channel morphometric features. Lateral bar formation and island development shown in dotted ellipses and historical lateral channel movement in red boxes.

5.0 CONCLUSIONS

In general, the channel activity increases progressing downstream; from this analysis it is really only active or significant in the lower areas of the river (i.e., Sections I and II). Compared with the two more upstream sections, Section III shows increasing evidence of impact and aggradation. The bars are larger and more frequent, and there is greater evidence of historical lateral channel movement in the form of old channels. As well, there is an increase in anastomosing channels (braiding). The areas of greatest activity identified in this analysis are (proceeding upstream to downstream):

1. Beaver Brook confluence
2. Caledonia area from Chisholm Brook to Mitchell Brook
3. Lower Caledonia area from upstream of Barren Brook to Indian Man Brook
4. Section I from McLeod Lake outflow to Silver's Pool.

In general Section IV shows evidence of limited aggradation of materials. The bars appear stable and vegetating and the channel appears stable (at least on the time scale of decades; historical channels show the river does change significantly over longer time periods). Section V appears stable and of low activity in terms of channel dynamics

6.0 RECOMMENDATIONS

This analysis was a preliminary assessment aimed at identifying areas of greatest activity. Follow-up work should involve field surveys of these identified areas by qualified geomorphologists, restoration ecologists or restoration engineers to evaluate local river dynamics. Within the context of the St. Mary's River West Branch Restoration project, these areas will be the ones to consider in restoration designs. Though these areas may not be the areas on which to focus restoration efforts, upstream structures may alter conditions to an extent to affect these dynamic local areas. Professional geomorphological and engineering expertise is required to allow effective restoration structures while building within the constraints of these active areas.

7.0 LITERATURE CITED

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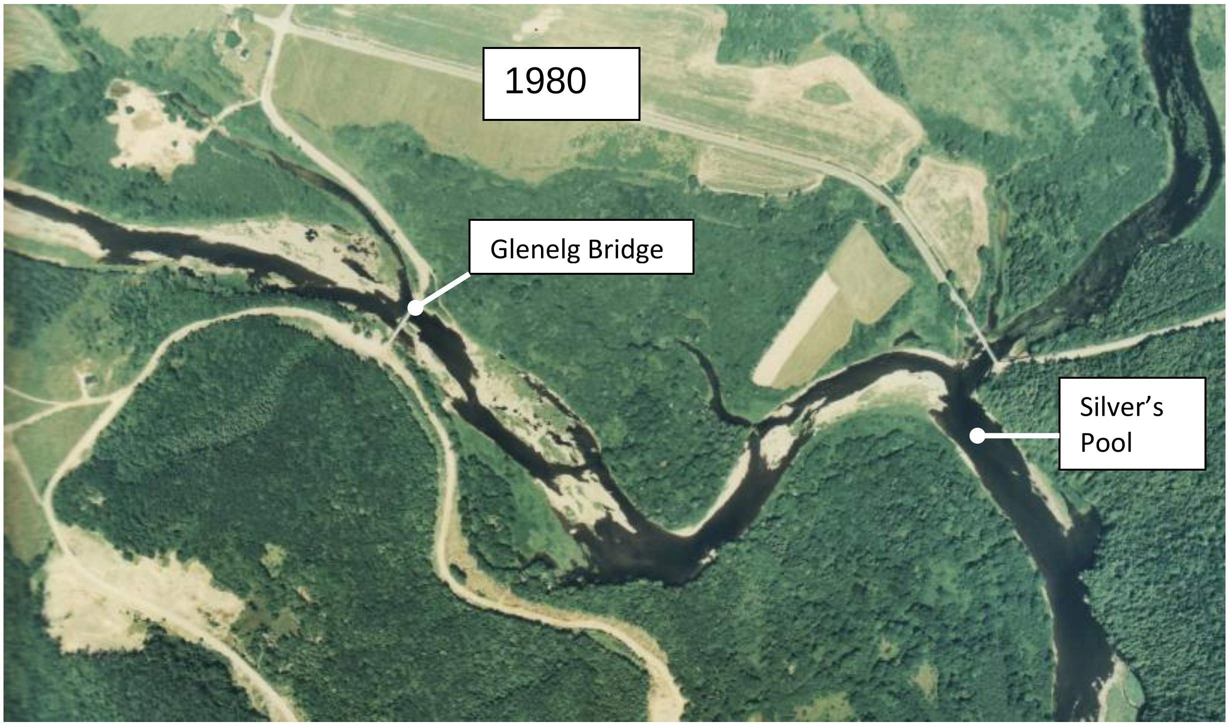


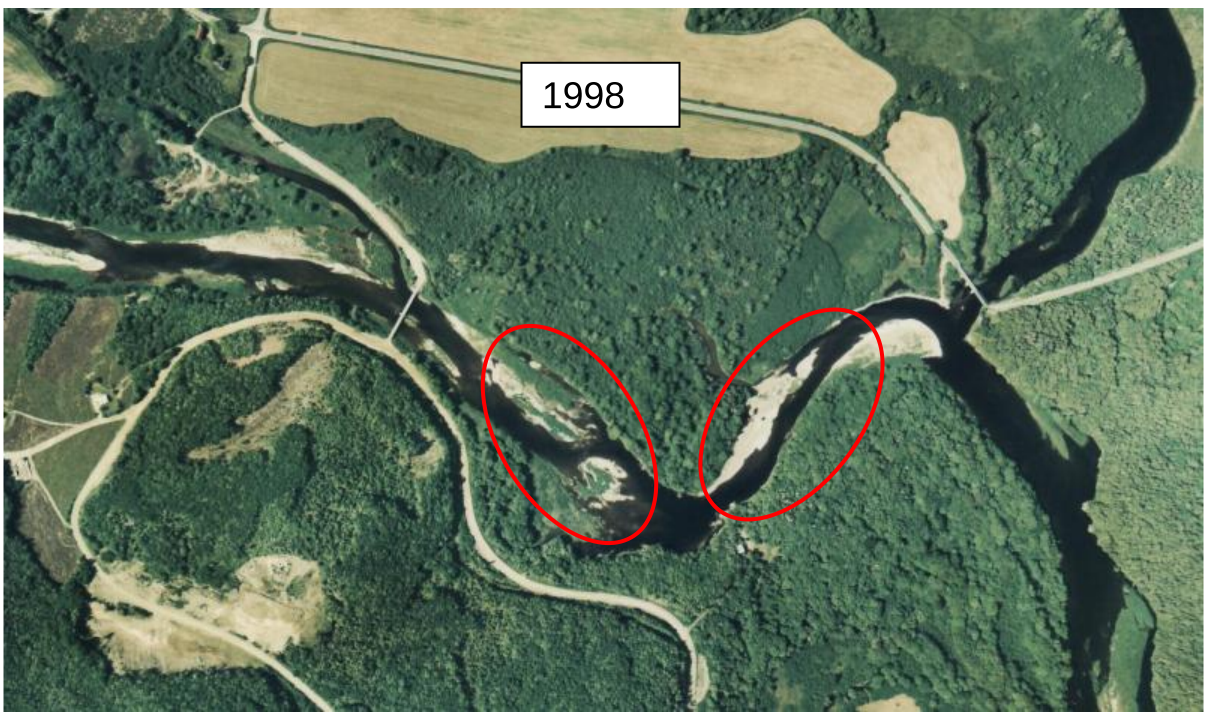


Plate 1: Air photographs of lower Section 1 from Glenelg Bridge to Silver's Pool. Note changing shapes and distributions of sediment and lateral river flow paths (highlighted in ellipses). River discharge in 1980 was very low and so this must be taken into account when comparing between these photographs.

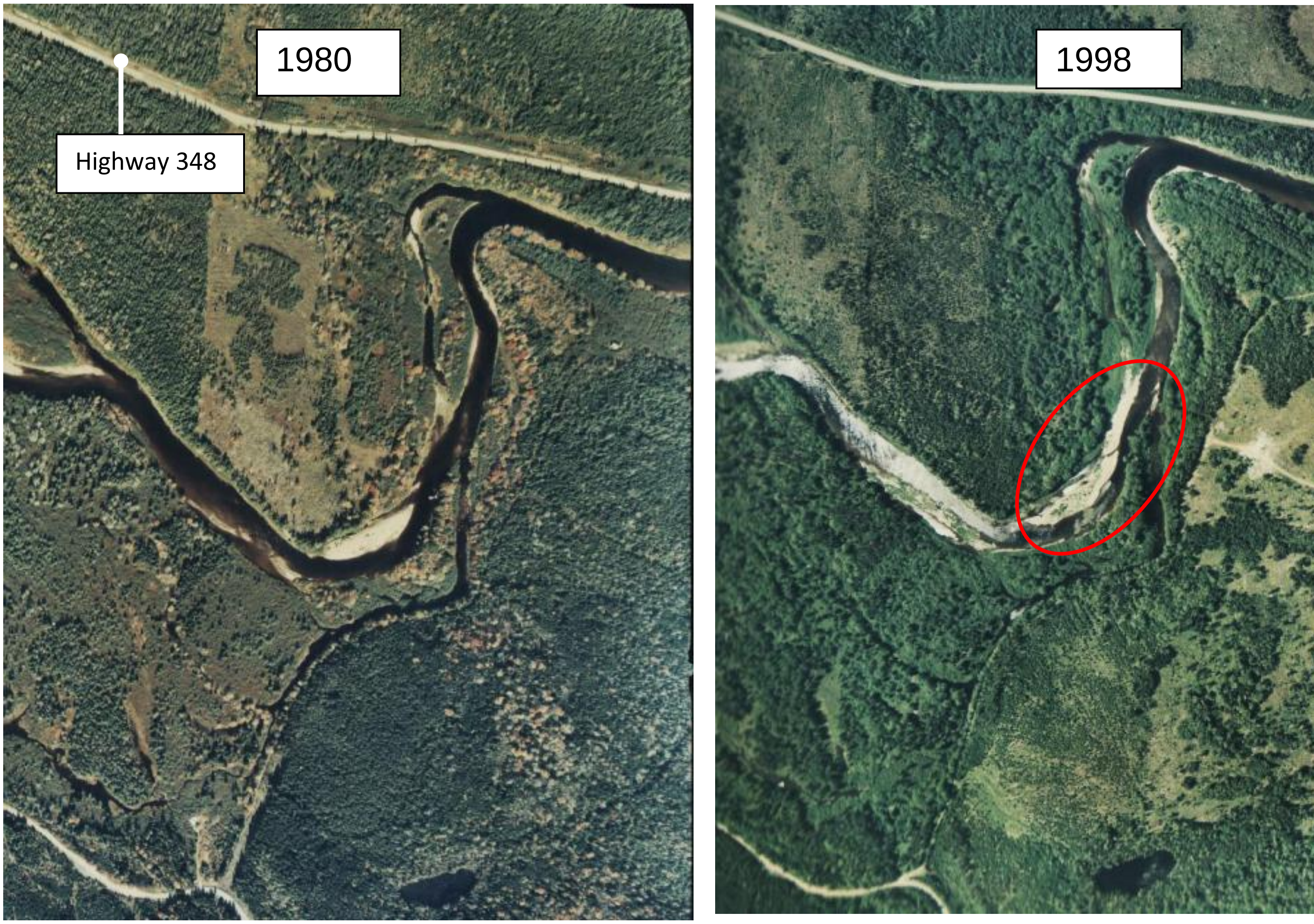


Plate 2: Air photographs of Section II at Sutherland's Brook confluence. Note lateral channel movement and braiding, as well as increased lateral bar formation (red ellipse).

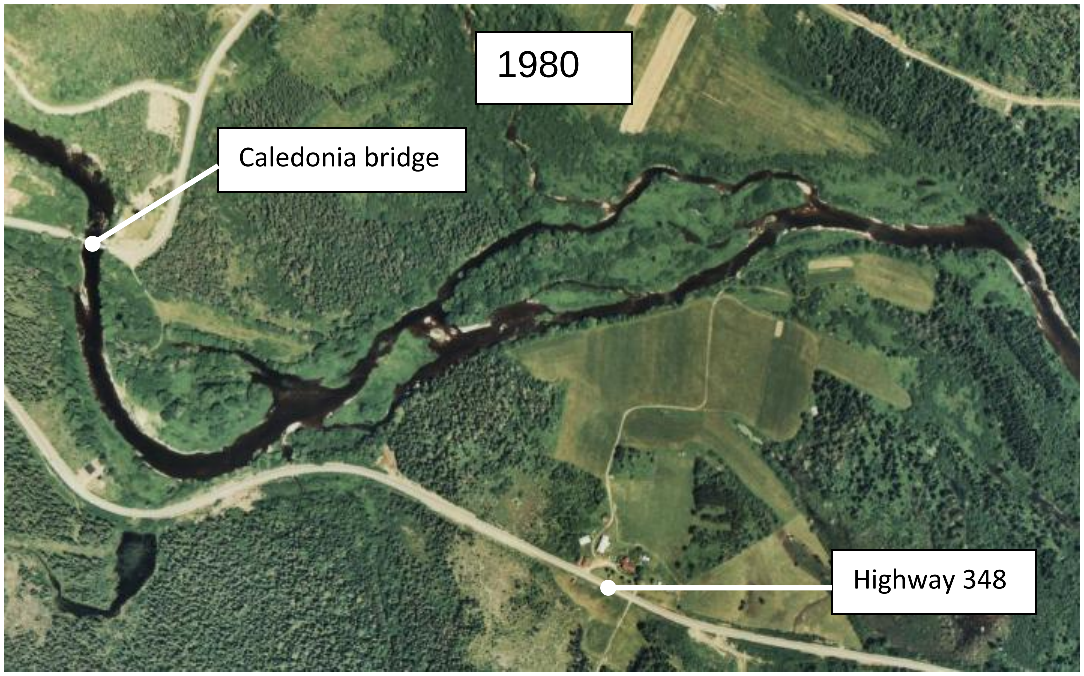
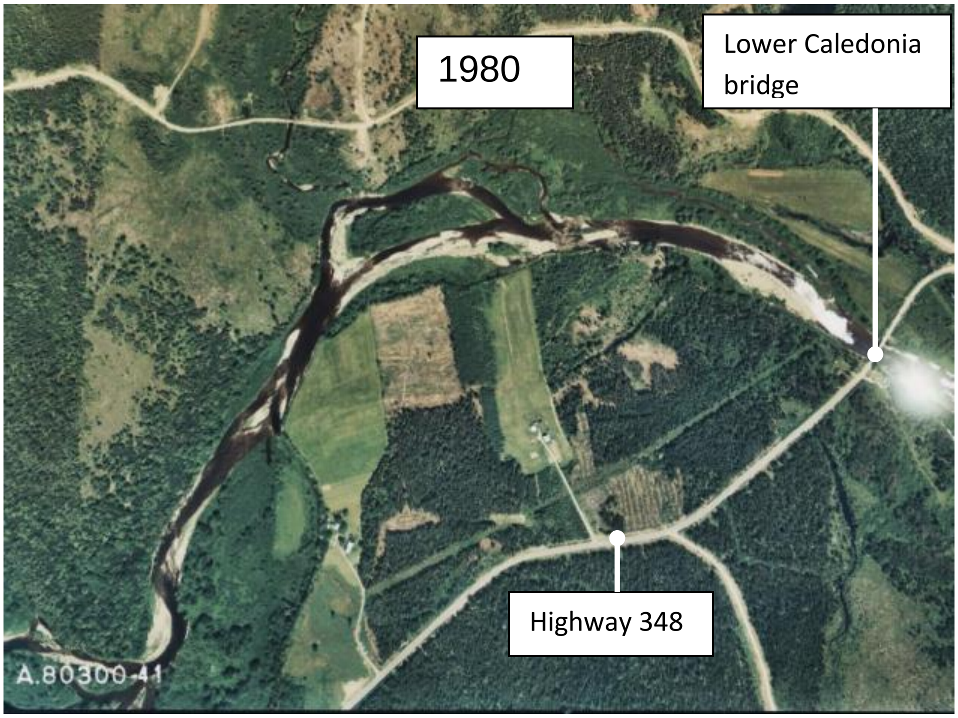


Plate 3: Air photographs of Section III downstream of Caledonia bridge. Note anastamosing channel (braiding). This appears stable over this 17 year period of record.



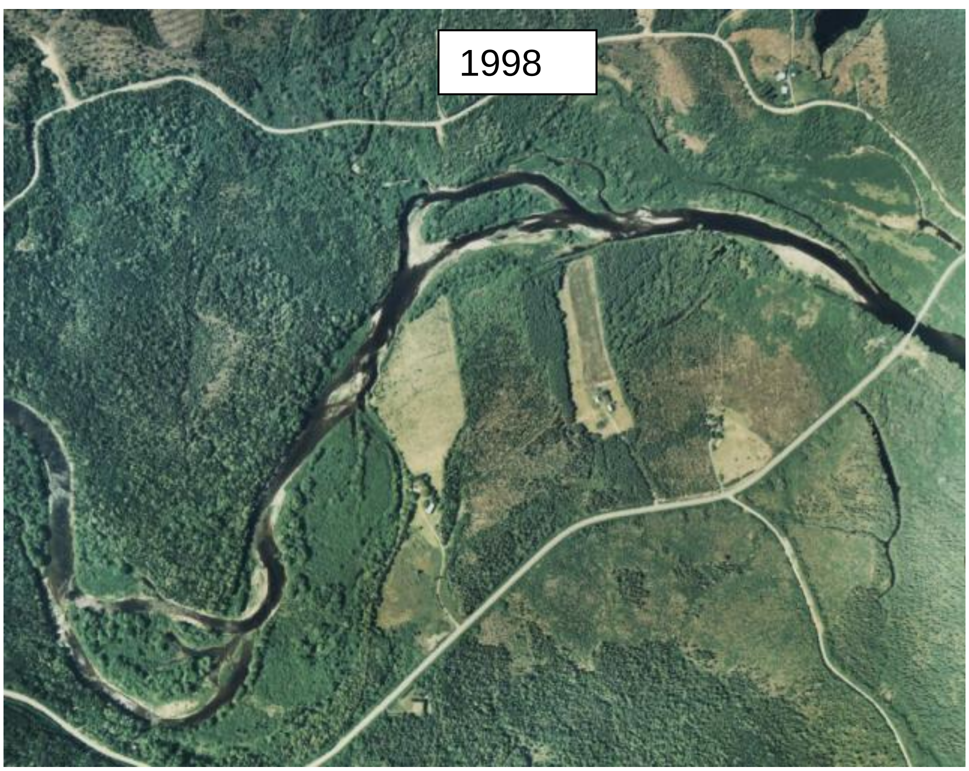
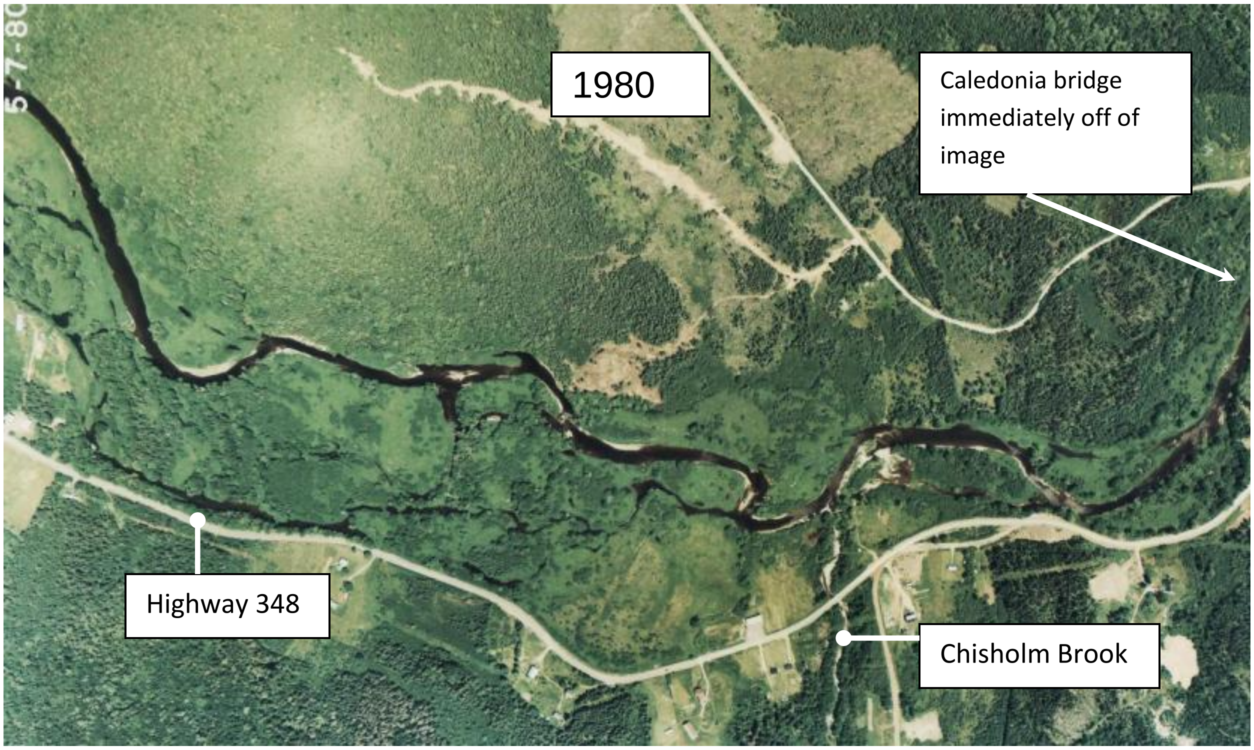


Plate 4: Air photographs of Section III upstream of Lower Caledonia bridge showing Barren Brook area. Note lateral bar presence and large island splitting river flow. Lower photograph also includes anastamosing channel upstream of Barren Brook. These features appear stable over this 17 year period of record.



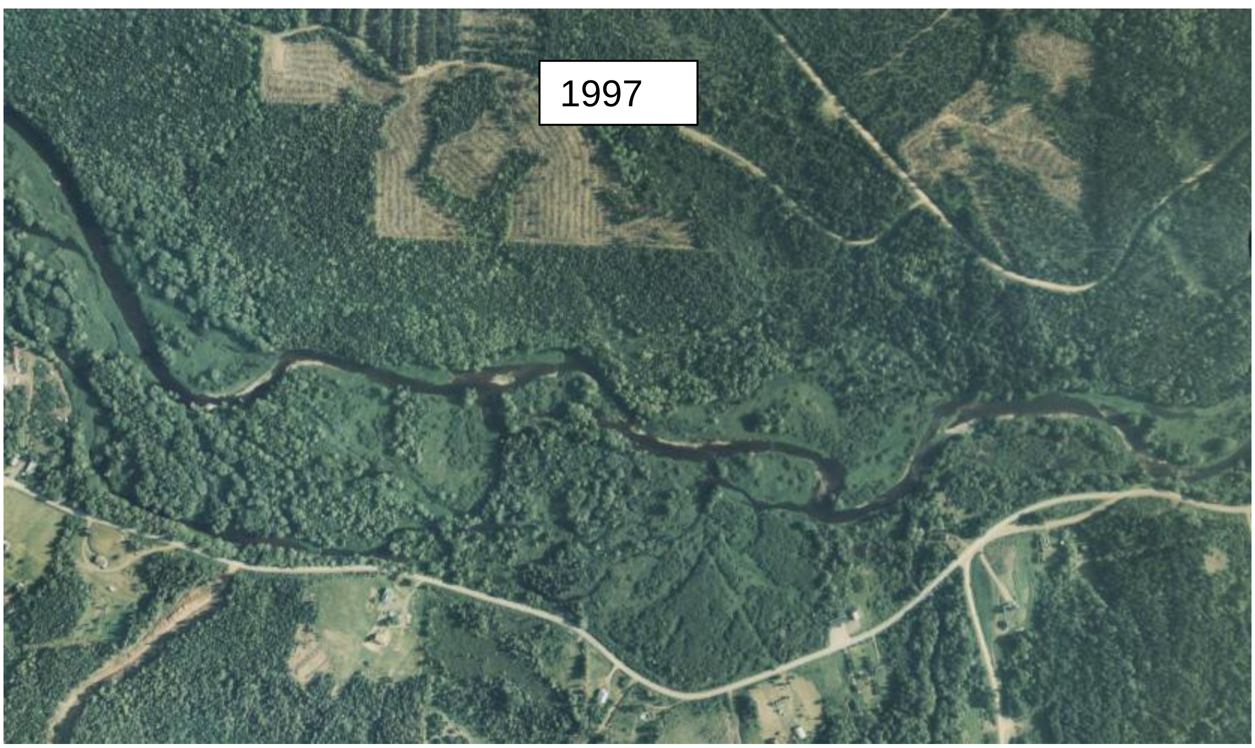


Plate 5: Air photographs of Section IV upstream of Caledonia bridge. Note evidence of historical channels.

APPENDIX 1:

Air photographs used in the analysis. First five digits indicate year (2 digits) and flight number (3 digits), followed by photograph number

Date	1980 photographs	Location in watershed
July 5, 1980	80300-8 to 80300-17	South Brook to Archie's Lake
July 5, 1980	80300-22 to 80300-27 80300-29 to 80300-30 80300-32	Upstream Beaver Brook to Lower Caledonia
August 23, 1980	80355-137 to 80355-140 80355-142 to 80355-144 80355-146	Upstream McLeod Lake to Silver's Pool
October 11, 1980	80357-199 to 80357-204	McLeod Lake to Archibald's Brook
October 11, 1980	80358-5 to 80358-9 80358-13 80358-15 to 80358-18 80358-20 to 80358-22 80358-25	Trafalger to Beaver Brook
October 11, 1980	80358-178 to 80358-182 80358-184 to 80358-185 80358-187 to 80358-188 80358-190 to 80358-194	Ross Brook to McLeod Lake

Date	1997/1998 photographs	Location in watershed
June 30, 1997	97003-09 to 97003-16 97003-19 to 97003-25 97003-28 97003-30 97003-32 to 97003-35 97003-161 to 97003-164 97003-174 to 67003-175	Trafalgar to Ross Brook
June 11, 1998	98300-33 to 98300-39	Mitchell Brook to Barren Brook
June 11, 1998	98300-43 to 98300-44 98300-46 to 98300-47 98300-49 to 98300-50	Sutherland's Brook to McLeod Lake
June 12, 1998	98302-97 to 98302-103 98302-105 to 98302-106 98302-108	Upper Smithfield to Silver's Pool