Irish Cove Brook Restoration Project

Irish Cove, NS

2012

Plans, modifications and results

Nova Scotia Salmon Association - NSLC Adopt A Stream Program

Contents

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Site Description

Irish Cove Brook is located on the southeastern side of the Bras d'Or Lake, Cape Breton NS. The lower reaches of the stream are downstream of the #4 Trunk Highway, flowing through an old limestone pit that was reclaimed several years ago; the stream was not restored. The total instream length of the stream between the #4 Highway crossing (454849.7N 604022.1W) and Bras d'Or Lake outlet (454917.8N 604034.8W) is 1040m with a design width of 6.5m, for a total riverine habitat area of approximately 6760sqm.

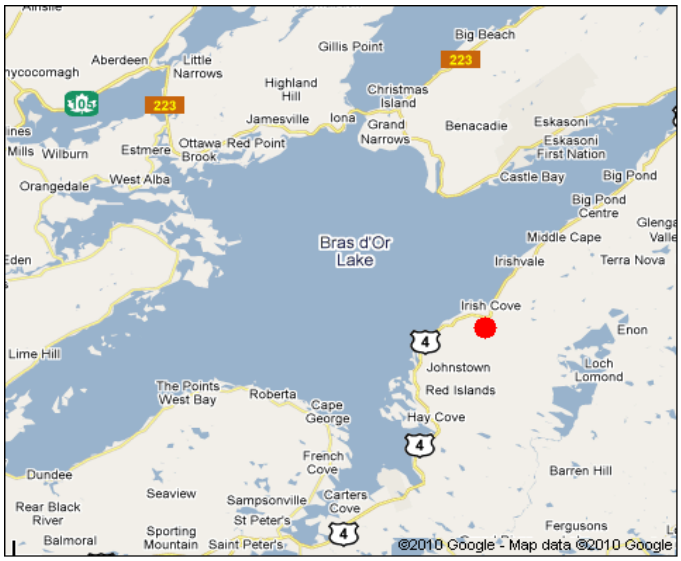

Fig. 1 Location of Irish Cove Brook, NS

The upper section has a culvert plunge pool 19m long that has been formed by scouring during high flows. This has deposited gravel and cobble in the stream channel, completely blocking a 117m section of the channel except during very high freshets. The normal flows now leave the plunge pool through a scoured out channel on the right bank, along the toe of the highway fill, lowering the water level in the pool creating fish passage problems in the culvert. Sixty meters downstream this channel rejoins the original channel in a phase shifted meander pattern. There is a small amount of seepage under the infilled channel. Both channels flowed during high flow events in the fall of 2010 and 2011.

Downstream, the brook is over-widened with sections in excess of 21m wide, three times the natural width, and in the out of phase meander pattern. This means where the original channel had a right pool and meander, the flows where building a left pool and meander. The net result is poor quality pools and over widened riffles with shallow flows that are a fish passage problem and raise the water temperature.

There are two high eroding banks on the right side (a 40m long bank at 454857.4N 604019.4W, and a 51m long bank at 454902.0N 604021.1W). These banks are eroding as a result of the over widened channel and realigned meander pattern caused by the cutting of the back channel. The original meander pattern took the brook away from these eroding banks toward the left back which is stabilized with rock.

The remaining approx. 400m is in good condition structurally but the substrate was embedded in silt and sand from the eroding banks which limited channel development and the fish habitat. This section was cleaned with the SandWand in 2010 after the observation that the toe of the eroding banks was on bed rock and erosion now was minor and due only to rain run off on the slopes and high flows that would normally deposit sand bed load out of the main channel. Sour at the toe of these banks was due to ice buildup in the over widened areas that scraped at the soft bed rock. This would not be a problem in the restored channel as with a good thalweg you don't get significant ice buildup.

The brook upstream of the highway is disturbed by the changes in hydrology created by the culvert, but there is no other development in the watershed; preliminary surveys indicate severely degraded habitat extends above the culvert for approximately 120m the culvert, excellent habitat more than one kilometer above the highway, and fair habitat beyond due to the steep stream gradient. Access to the stream is a problem above the culvert and will limit restoration work in this area, but the upstream section is not considered a limiting factor on the overall trout population at this time.

Streams in this corner of the Bars D'Or lakes do not have salmon populations. The reason is unknown but according to the Natural Resources staff this has always been the case. Salmon habitat in Irish Cove brook would be limited to the area below the highway culvert as the areas above this are very steep and limited in suitable habitat features for them.

Work and Monitoring related to SandWand

In 2010, 351m of brook was cleaned of sand and silt using the SandWand with an average width of 6.5m. Approximately 2281 sq m was restored.

This lower section of Irish Cove Brook had physical habitats degraded by sedimentation, the brook has excellent water quality and appeared to have optimum water temperature during sampling in July 2009 the temperature below this area was 17.8^0C and above was 15.9^0C air temperature was 21^0C, and the pH was 6.99.

Thermographs in the Brook in 2010 (fig 2) showed more detailed results. Water temperature at the Highway culvert pool was good throughout the late summer. Water temperatures below the over widened section fluctuated more widely and were often above Trout tolerance levels. It appears as though the temperature variation and increase disappeared as the SandWand work progressed but there are other possible explanations that might give this result including dropping air temperatures.

The wide shallow sections at the upper half of the site were not fixed with rock sills as planned. The land owner Nova Scotia Natural Resources did not want the heavy trucks carrying rock for the sills or the excavator required for installation to cross the newly restored pit floor so there was no over land access to install sills. The only access was by an old construction road near the highway culvert and that would mean bringing equipment and rock down the brook which would have been very disruptive. Delays in obtaining DNR permission to work on the site and the learning curve on how best to use the new SandWand limited the amount of work done in 2010. We also wanted to see the results of the SandWand work as there were many questions about its' effects; if it would actually increase fish production, if the substrate would remain clean of sand and silt, if habitat features would develop, the impact of insect food supply, but also many early signs of positive results from the work done in 2010 including the start of pool and thalweg development. This raised the possibility that the over-widened sections could be completely restored using the SandWand.

In the fall of 2011 we received permission from all Departments to do the proposed work at the highway culvert. The figures below show the culvert before the work.

In 2011 the remaining 689m of the Brook was SandWand and the original plunge pool channel was re-constructed to bring it in line with DFO guidelines for the design of plunge pools and to raise the water level 60cm to back flood the culvert to provide fish passage. This channel is 117m long @6.5m wide for new habitat of 760 sqm. The upper end of the channel remained closed so that it could stabilize and just be subject to flood flows.

The 2011 SandWand work was done following the proposed meander pattern and proper stream width. This left the future bar areas untouched and gravel & cobbles set in sand. This treated 689m of stream @6.5m wide for a restoration of 4479 sq m of Brook habitat restored.

Fig 2 A large 19m diameter pool has been scoured at the outlet of the Highway #4 culvert

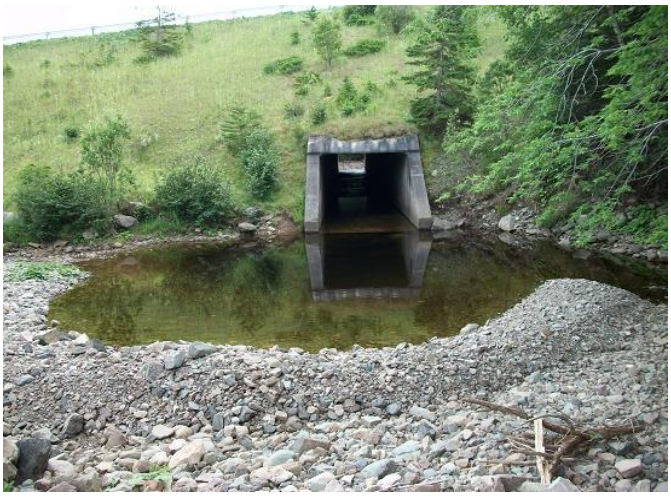

Fig 3 With the original channel blocked the flows are directed right down a 60m back channel

Fig 4 Material scoured out of the plunge pool had been deposited in the channel, blocking water flow

In 2012 the channel was repaired in a couple places and the top end opened to carry the base flows. To preserve habitat in the channel along the toe of the slope a double gabion weir was built across the channel at the edge of the pool. It was set so that a maintenance flow would remain in the channel and it would act as a flood channel while raising the pond by 60 cm resulting in no loss of habitat at the site due to the diversion as requested by DFO. Fig 5.

Trout were seen in the new channel and in the culvert the day following construction.

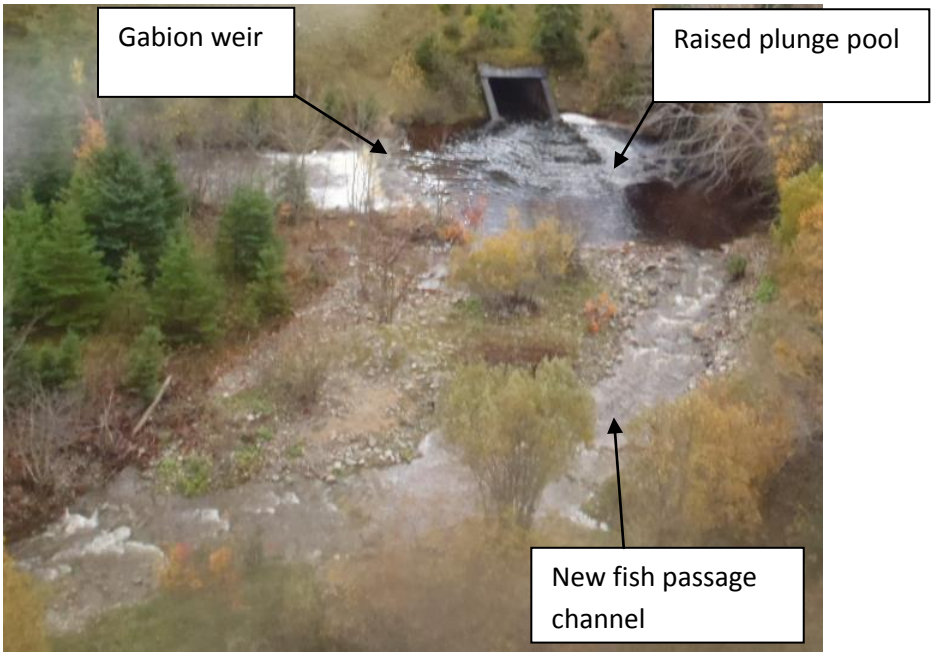

Fig 5 November 2012 photo of culvert pool and new channel under Fall flows.

Results

Habitat restored

Total square meters of habitat restored to date 2281sqm in 2010, 4479 sq m in 2011, and the culvert diversion was completed in 2012 without a loss of habitat in the flood channel for an additional 760 sqm plus fish passage in the culvert. For a total of 7520 sqm restored.

Water temperature

The 2010 upper and lower water temperatures are shown in Fig 2. Water temperature is affected by flow levels, air temperature, and stream pool/riffle/thalweg structure, and shade. The data indicated that the water temperature at the mouth of the brook followed or exceeded shade air temperature. It can be seen here that at times of low flows the daily low temperature below the degraded habitat was still higher than the daily high of the water entering the site. Also the daily fluctuation was greater at the lower site. This is due to the shallow flow between rocks in the over widened section and the lack of inter-gravel flow due to the embededness of the substrate in sand and silt. We were encouraged by the observation that water temperature at the lower site more closely followed the pattern of the upper site even with a short section SandWanded. This is likely due to increased ground water interchange and the increased thermal mass provided by the water flowing through the clean gravel. However there are other explanations for this as the weather did cool.

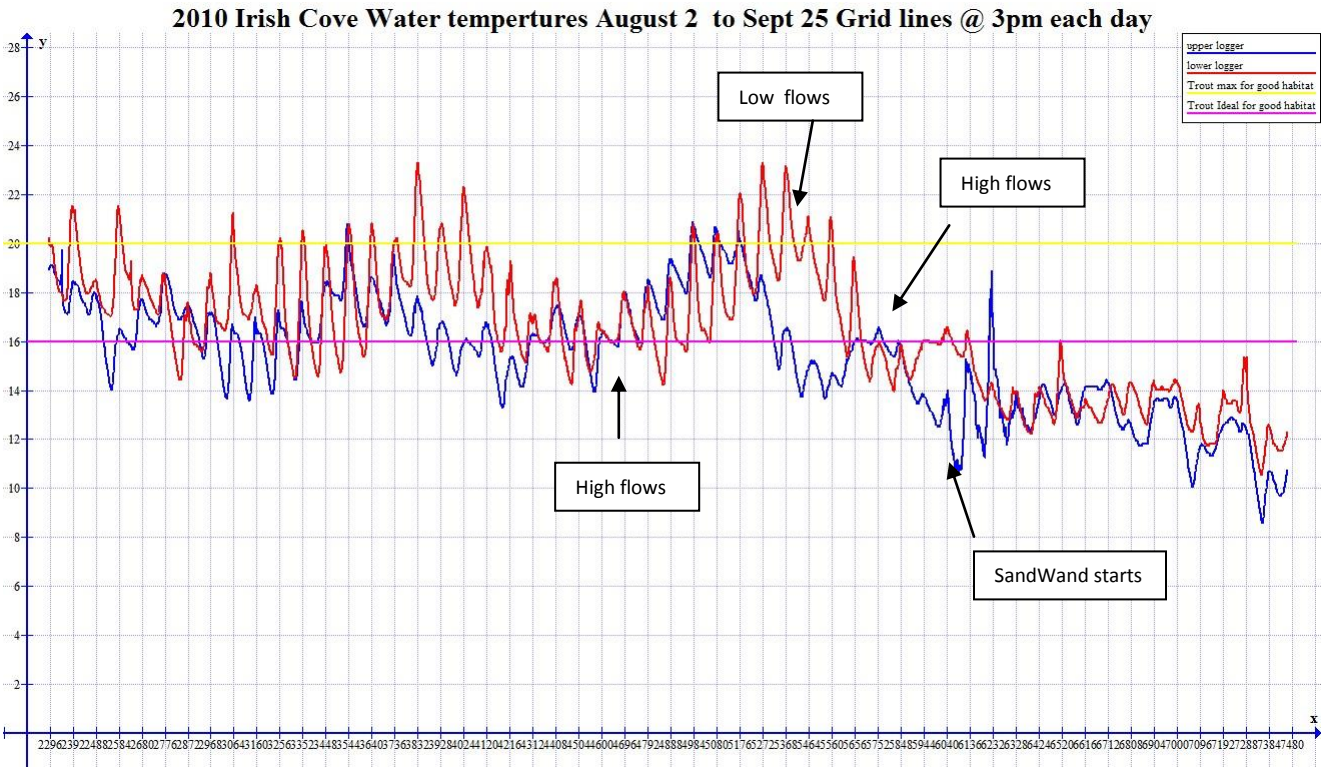

Fig 6 2010 Temperature Monitoring Results

Blue (Series 1) is the upstream thermograph just below the culvert pool.

Red (Series 2) is the downstream thermograph just upstream of the ford and just above the end of the SandWand work for 2010.

In June 2011 an air temperature logger, and water temperature loggers at three locations, just below the culvert, below the over widened section and below the SandWand section, were installed and were left in place over the summer to better define this this observation. Unfortunately they were not well enough secured and the critical central thermograph was lost.

In 2012 (Fig 3) both temperatures followed the same pattern which was an improvement but the lower water temperatures still have a greater fluctuation and maximums are now peaking at 2 to 3 degrees higher. This is especially true during the low flow periods.

Monitoring will continue in 2013 as the SandWanded sections continue to develop their thalweg.

The green line is the ideal growing temperature for Brook Trout that we would like to average throughout the growing season 16 ^{0}C. The yellow line is the maximum temperature we would like to stay below for Trout 20 ^{0}C.

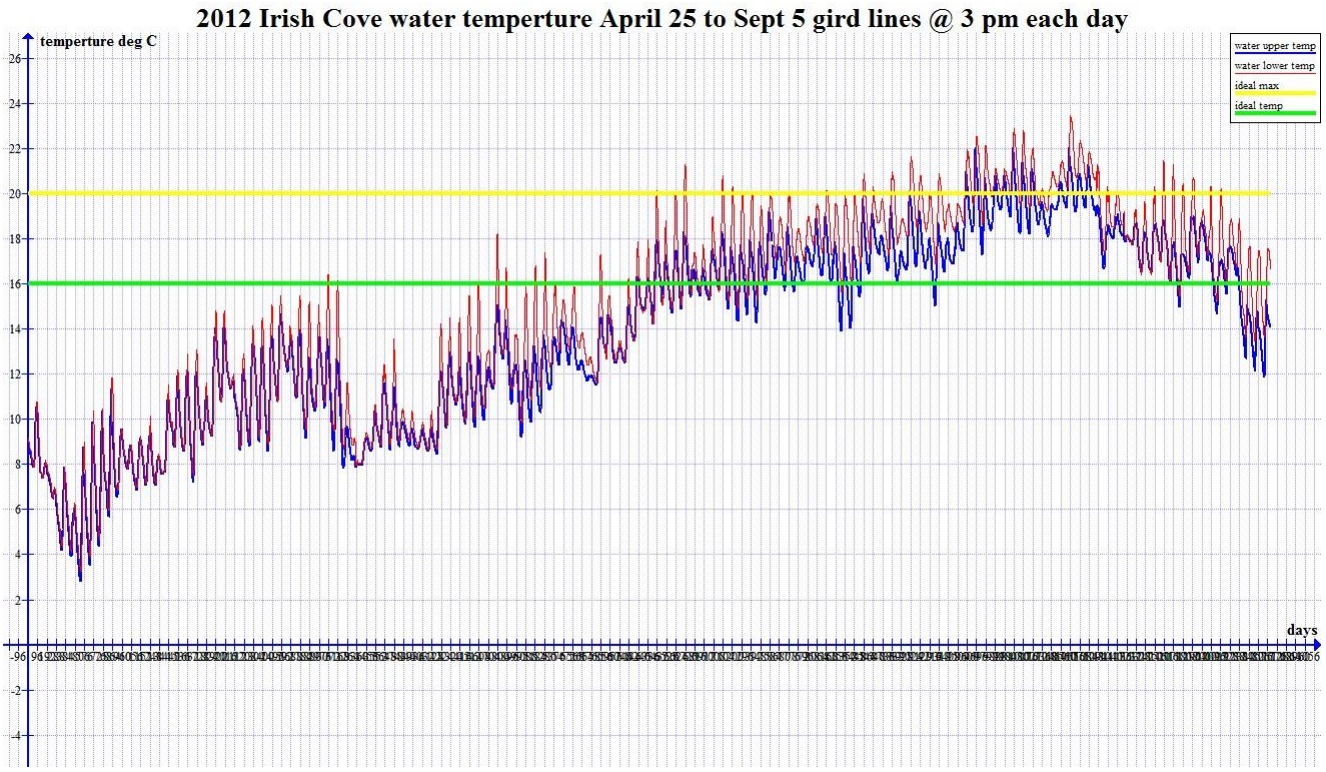

Fig 7 2012 Temperature Monitoring Results Blue (Series 1) is the upstream thermograph just below the culvert pool. Red (Series 2) is the downstream thermograph

Substrate

The SandWand removes the sand and silt from the substrate. Sand in particular degrades salmonid habitats and is a long term impact that in some heavy cobble or boulder streams will never naturally be removed from Nova Scotia streams. The sand infills the interstitial spaces eliminating the collection of riparian organics that are the major source primary productivity for the stream, greatly reduces insect habitat, impacts or eliminates successful spawning, can eliminate cover habitat for all age classes, including over wintering habitat and can severely damage the pool/ riffle /thalweg development resulting in shallow over widened streams with long runs that restrict migration.

The SandWand removes the sand and silt down to a depth of 30 cm to 40 cm.

Core samples were taken by working a steel pipe into the substrate at least 25cm and removing the contents by hand. Fig 4 below shows the before sample with sand and silt and the after sample of cleaned gravel. It is clear to see that the intestinal spaces have been cleared and the substrate un-grouted making it 5 to 10 times more mobile and able to be shaped by the stream flows into a more productive pool/ riffle/thalweg stream structure.

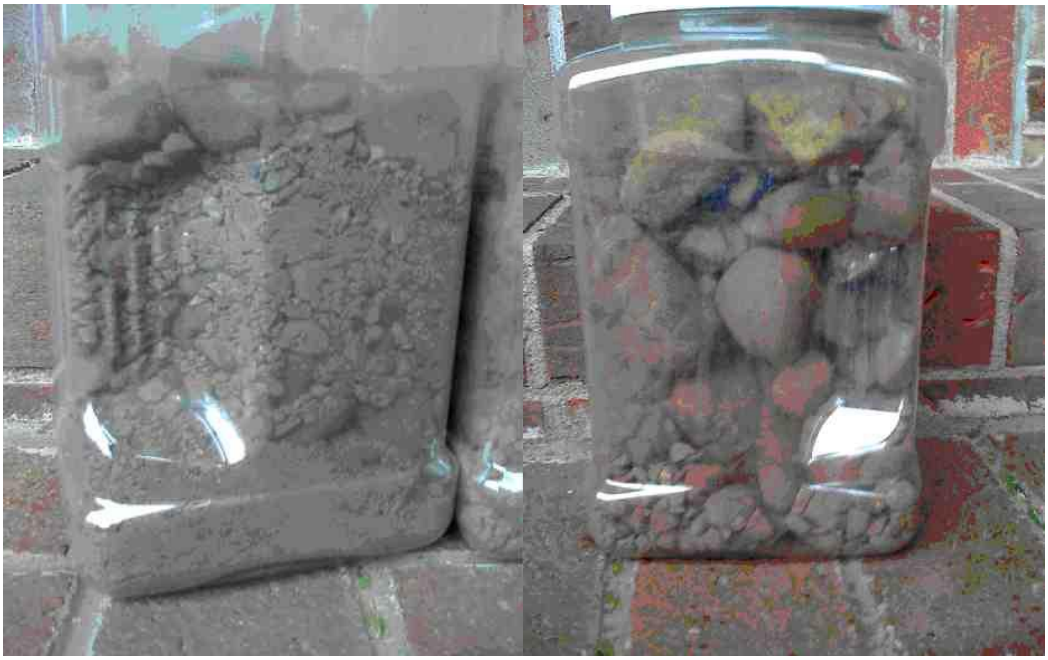

Fig 8 Gravel samples beefore cleaning and after

In fig 8 the right hand picture shows the surface view of the substrate with un-cleaned gravels at the top and cleaned bottom and the picture on the left shows the nature of the sand removed. It is very similar to beach sand. The silt content is very low with the discharge water staying under 80 mg/l and it is almost not measurable in the sample anaylysis.

Fig 9 The output is clean “beach sand” with suspended solids < 80 mg/l

Substrate samples were sieved through an Endicott 2.35mm screen to determine the dry weight of sand vs gravels and cobble. Cobble larger than 6.4 cm were removed from the sample.

Our objective was to lower the sand content in the substrate to obtain a habitat suitability index rating well into the excellent range of less than 5% fines. The graph below for riffle substrate quality and spawning sites is almost the same for rearing habitats. We met and exceeded this objective when starting with fine levels in the poor category.

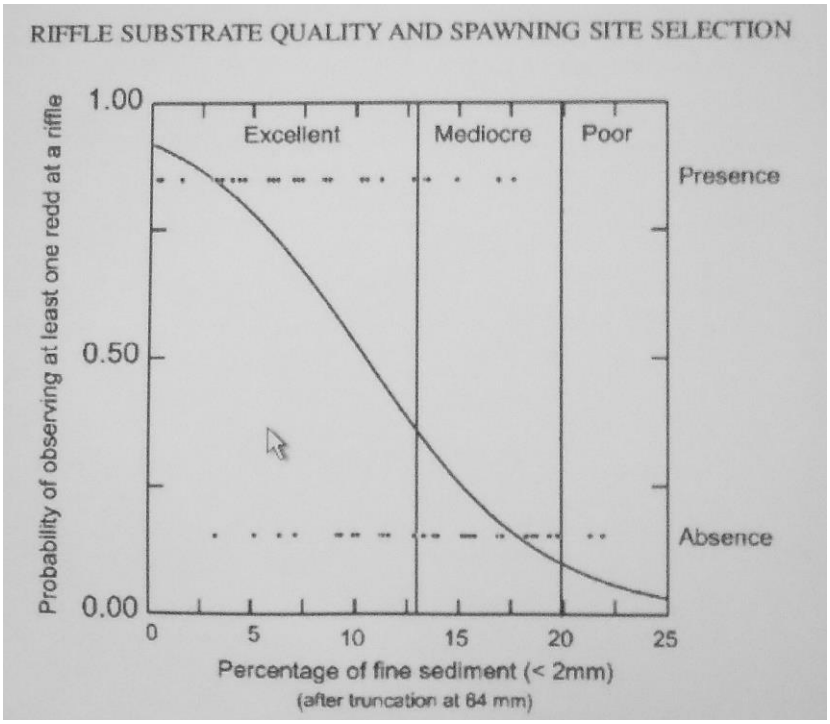

Fig 10 2004 Coulombe-Pontbrand, M ; Lapinte, M Geomorphic Controls, Riffle Substrate Quality & Spawning Site Selection in two Semi Alluvial Streams in Gaspe Peninsual Canada. River Res, Applic 20 pg 577 590

2010 test site substrate analysis

22% sand/silt by weight before treatment

2.3% sand/silt after treatment down to 40cm deep

2011 5.5% sand/silt over all but only 1% in the top 20cm and all sand in the very bottom of the sample this is likely due to the greater depth of thalweg that meant the sample was getting down below the SandWand work. Really there was no increase in sand in cleaned substrate

2012 2.89% sand/silt

At this site the fine gravels with some remaining sand that were brought to the surface by the SandWand were sorted to the point bars by 2011.

The habitat in this area had been shallow run with 12% third class pool and by 2011 it had a good thalweg and 30% second class pool

In 2012 the habitat had improved further with the channel narrowing in a run & riffle form with good thalweg and 45% first class pool

In 2011 we added a second test site upstream of the first one and near the lower end of that years work.

2011 new test site substrate analysis

20.7% sand/silt before cleaning

2.4% sand/silt after cleaning

2012 3.41% sand /silt

2011 test site habitat

Shallow run 10% third class pool

In 2012 thalweg is shifting from the far right to the left bank 15% third class pool

At this site the actual change is less than the rest of the area SandWanded in 2011likely due to the full pattern shift at this site and possibly to a windfall across the brook that had branches down into the site at the upper end.

Thalweg development on the 2010 study site

Figure 11 is the cross section in the pool area of the 2010 study site. The black line is the 2010 cross section and the red line is the 2012 cross section. The point bar has risen by approx. 10 cm and the pool has widened slightly but deepened by 30 cm resulting the exposure of several boulders that provide cover for larger age classes of trout. The blue line is the normal summer water level.

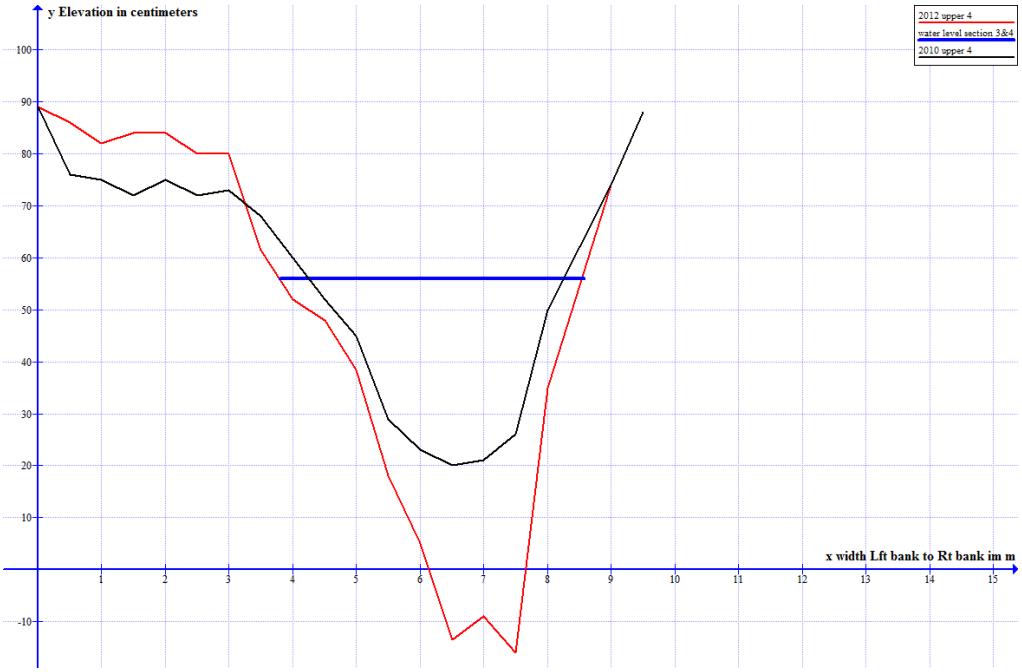

Fig 11 Pool cross sections

Figure 12 is the cross sections across the riffle area. The split channel is starting to fill in and the bar is building while the thalweg has deepened approximately 15 cm providing a single deeper riffle that was used by the young of the year trout.

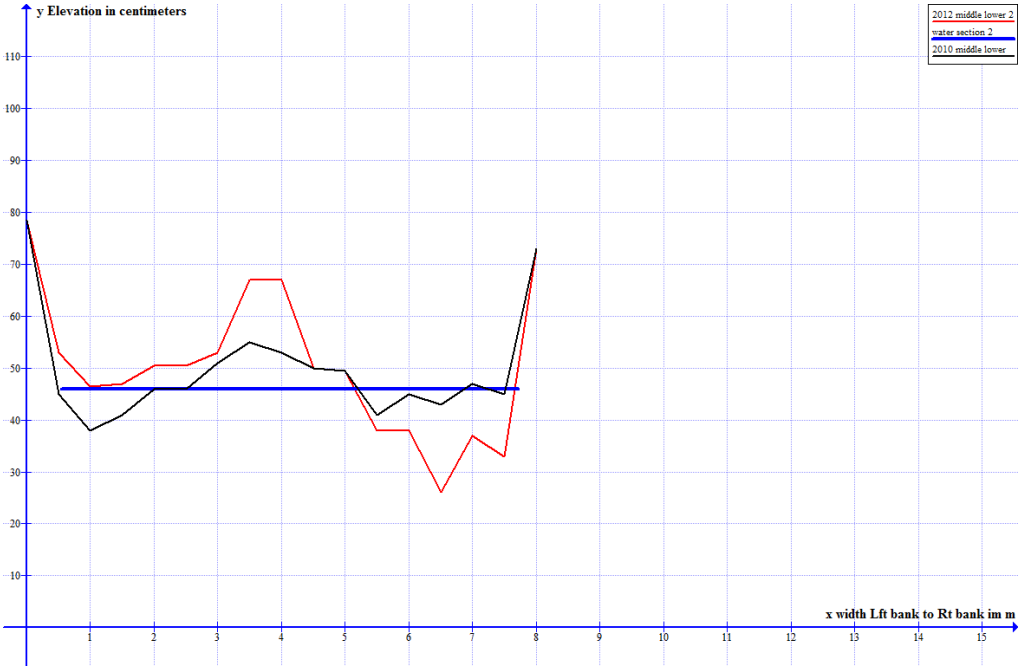

Fig 12 riffle cross sections

Generally the over widened sections have narrowed up and formed a meander pattern with pools on the bends. The un-grouted the stream gravels allows the formation of proper stream structure. In fig 13 the meander pattern has developed taken the flow way for the toe of the eroding bank. In 2011 the main channel was along the toe but the entire width had water flowing between the rocks.

Fig 13 new meander pattern at low flow

Insects

One of the concerns with this approach to stream restration was the loss of aqautic insects that could not aviod the wand and would be pumped in to the riparian area or sedimet traps. To study this we collected invertabrates using the CABIN 3-minute kick sampling technique. In 2010 there was a long delay in looking at the samples and they were not properly preserved so the data was lost. Observations at the time indicated a reduction of invertebrates but not a complete loss. Sand in the outflow was checked and there were no invertebrates or invertebrate parts found.

In 2011 the sampling was repeated on the new site and we found that:

There was a 64% loss in numbers after sampling but no insects or parts found in removed sand and pump test show the invertebrates survive the pump and live in turbid water but the sand content may destroy them during wand operation. No invertebrate parts were found in the water from actual SandWand operation.

The assessment was by 3-minute kick samples and pulling the hoses through the water likely detached most of the insects that would be sampled by this method

The invertebrate population recovered after 10 days likely by drift from areas above.

The 3 minute kick samples covering all habitat types and the species present are; Stonefly, Crane fly, Midges, Mayfly, and Caddis fly. The ratio of each species numbers stayed the same before and after sampling.

The site had 2.36 times the insect population in 2012 almost all the increase as Mayflies. There was a great increase in organics in 2012 as food for shedder insects.

Fish

The fish were sampled using a Smith-Root mark 11 electrofisher, in a three or four sweep removal that covered all habitat types present and estimates done using the Zippen method. The results were as follows:

2010 test site

In 2010

58.4 trout/ 100 sq m before SandWand 83% young of the year (YOY); 17% 1year olds

36.9 trout/ 100 sq m immediately after 100% YOY

The loss were fish chased out of site by the work no fish were caught or killed during the SandWanding

In 2011 repeat of 2010 test site

100.7 trout/100 sqm 59% YOY, 32% 1year olds; 7% 2 year olds

In 2012 repeat of 2010 test site

142.5 trout / 100 sq m 53% YOY, 24% 1year olds, 18% 2 year olds, 5 % 3 year olds

The 2011 new test site Upper site

In 2011

54 trout /100 sq m before 87% YOY, 13% 1year olds

47 trout/100 sq m immediately after SandWand 90% YOY 10% 1year old

2012 repeat of new test site

105 trout / 100 sq m: 83% YOY, 16% 1year olds, 2% 2 year olds

In order to see if the increase was due to the SandWand work and not changes in flow or water temperature at the time of sampling a control site was fished on the nearby Irish Vale Brook.

Irish Vale Brook

2010 - 43 trout/100 sq m 85% YOY, 15% 1 year olds

2011- 45 trout/110 sq m 86% YOY, 14% 1 year olds

2012- 35 trout/100 sq m 95% YOY, 5% 1 year olds.

Despite a significant drop in the numbers at the control site in 2012 due to low water conditions both of the SandWand sites increased in numbers. In the original study site the numbers have increased each year as the pool and riffle form has developed and almost all of the increase has been in the 1, 2 and 3 year olds that were poorly represented in 2010. This is giving a better age class distribution and actually providing some angling opportunity. In addition the availability of habitat that allows the fish to stay in the freshwater will increase the survival of those entering the Bras D'Or Lakes estuary. The 2011 site is following the same pattern as the physical habitat develops.

Smelt

Smelt we present in large numbers to the upper end of the SandWand work and not beyond. In 2011 they appeared to reach just the lower test site. In 2012 after the whole site had been SandWanded the smelt filled the pool up to the top of the site but not into the culvert pool. Figure 14 shows the concentration of smelt 2/3 of the way up the restored section. If the smelt can migrate up this far so can all the other resident fish so we have greatly improved migration habitat that was restricted by long shallow runs and the lack of resting pools.

Fig 14 Smelt in a upper pool

Conclusion

The technique's effects

SandWanding removes the sand and silt down to 40cm un-grouting the substrate and allowing the Brook to re-establish a natural pool riffle pattern with excellent quality pools and thalweg. This is achieved without causing new bank erosion or disruption. Every measure of habitat quality has improved although is seems to take at least 2 years and perhaps more.

Temperature seems to be moderated and will likely continue to improve as the stream form develops over the next year or two.

Substrate quality is maintained and does not fill right back in with sand and silt if the banks are relatively stable and the land use is not contributing sand. We did see an increase in the amount of silt in the substrate likely due to problems with a gravel pit and overburden disposal from highway upgrading outside of the watershed. This silt source has since been stopped. The silt accumulation was not significant enough to be measured in the sampling but was evident by turbid water if the substrate was disturbed. The eroding banks appear to be stabilizing with more vegetation than in 2010. The erosion was primarily due to water running over the face from the top. The toe of the slope is soft sandstone and high flows did not discolour the water running against these banks. Erosion of the toe is likely due to ice formation and scour in the spring break up. The better thalweg will prevent the formation of ice and eliminate this impact.

Insect populations were lowered by the pulling of hoses through the site and the disruption of the SandWanding but all species that drift quickly brought the population back up and the cleaned substrate supported a larger population in the following year.

Fish population was not negatively impacted by the SandWanding none were killed or pumped out but only moved out of the work area. Although we don't have data it is expected they quickly returned. The fish populations increased in the flowing years and the age distribution greatly improved.

The rock sill proposed to be constructed were not due to access restrictions but It is clear that in streams with a gravel cobble substrate the SandWand does an excellent job at **restoring the stream habitat structure** without requiring the physical structures in the stream. This is good because it will allow the stream to develop naturally without being restricted by hard manmade structures. Digger logs deflectors and similar techniques using timber also ultimately allow the stream to do this as they work with the flows to form the improved habitat and ultimately break down allowing the stream to function normally. Rock sills and bank rocking often do not allow this natural process to take over after recovery.

The SandWand has been accepted by DFO Maritimes as a low impact activity and is covered under the NSSA's NSE blanket watercourse alteration permit for habitat restoration.