River Denys Integrated Management Report

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Final Report

Prepared For:

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Introduction

In November 2000, the Department of Fisheries and Oceans (DFO) retained East Coast Aquatics to review the existing data, reports, air photos, and activities for the River Denys Basin watershed (see Figure 1), and develop the following Integrated Management Plan (IMP). The primary objective was to determine the measurable standard that should act as a trigger for management activities, covering as wide a range of parameters as needed to ensure the health of the ecosystem within the project area. Furthermore, a target level has been defined in order to qualify a parameter as being acceptable. Finally, a prioritized list of activities has been created to guide future resource management activities and data collection.

This IMP integrates social, economic and environmental aspects to the degree that they relate to the freshwater and estuary resources of the project area. It does not consider land based resource management that does not directly pertain to surface water resources. Although intimately linked, estuary and freshwater components have been presented separately in order to improve functionality of this report for community groups and government agencies that have greater jurisdictional interest in one component area over the other. An effort has been made to integrate the two in the prioritization of activities recommended for the project area.

IMP Summary

Potential sources of impact to the River Denys project area have been identified, and come from a wide variety of land uses and activities. Agriculture, mining, logging, shoreline development, gravel extraction, and ATV/4WD use have all had physical impact on the water resources. In order to comprehensively address this diverse array of impacts will require professional direction and strong community support. The impacts are manageable with small changes in the manner in which land uses are carried out, and a moderate degree of rehabilitation activities.

It is recommended that the IMP call on professionals in the relevant fields to confirm, based on experienced judgment and a field visit, the suggested course of priority actions identified in this report. This will allow for the initiation of rehabilitation, conservation, and protection oriented management activities to begin immediately for the 2001 field season in a manner that will begin to address the most apparent and least complex ecosystem impacts.

On the land base these activities should include establishment and planting of riparian zones, reduction in sources of fecal Coliform bacteria, and creation of mainstem river pool habitat. As these activities are completed and additional assessment fills data gaps, it is anticipated that improving fish access, reducing sediment sources, complexing stream habitat, and increasing overall watershed vegetation will become primary activities.

In the estuary, the highest priority activity is to reduce fecal Coliform sources, and these efforts should be focused initially on several potential key source areas. Shoreline development guidelines should be

created to protect the basin resources that are seeing increasing pressure from recreational and economic development activities. Any efforts to re-establish oyster habitats should only take place outside of current shellfish closure areas until re-evaluation of shellfish areas by Environment Canada determine if areas can be reopened, and ongoing sedimentation is quantified. Ongoing assessments can later be used to fine tune further IMP actions. Additional activities in the estuary will be contingent on the resulting improvements to water quality and sediment sources from all of the above noted priority activities, both on the land base and shoreline.

It is recommended that this IMP be treated as a dynamic document, which will require future updating in order to remain valuable. One of the key components of accurate evaluation is the review of current air photos. This IMP is in part based on review of 1998 photos, the most current at this date. New coverage is flow approximately every five years. Therefore, the next set should be produced in 2002 and be available in 2003. To be as current as this data source, and given outstanding data collection that could provide valuable direction, user groups should target 2003 as a year to review and update this IMP.

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1.0 Issues and Key Questions

There are six main issues that have currently been identified within the project area (see Fig. 2), through community group discussions, for which action and answers are desired. Listed below, each of these is followed by key questions that need to be answered to address the issue.

- Estuary Water quality for shellfish production and harvest, particularly oysters
    - ? With more regular water quality sampling would it be possible to obtain partial season shellfish openings?
    - ? What are the sources of fecal contamination and possible resolutions?
    - ? Can new habitat for shellfish be created?
- Drinking water quality in the Orangedale area
    - ? Is the surface water system in danger of contamination?
    - ? Can aesthetic quality be improved?
- Fresh water fish habitat quality for Atlantic Salmon and sea run trout
    - ? Are there significant habitat impacts to River Denys and its tributaries?
    - ? Are river or estuary habitats limiting populations?
- Sedimentation impacts from various land based activities and in particular the operation of a mine in the headwaters in the Glen Brook sub-basin.
    - ? Is there land based sedimentation reaching the basin, and if so, is it a past impact, current impact and / or a future risk?
- Potential of water quality impacts from privately owned dump and contaminated soil depot in the Big Brook sub-basin.
    - ? Is there direct sediment deposition to Big Brook from the dump site?
    - ? Are there any chemical leachates from the contaminated soils and dump entering the water table and Big Brook?
- Impact of Green Crab predation on oyster growth in the estuary.
    - ? Is this a local area problem?
    - ? Is the presence of Green Crab related to some environmental factor?

These are the current concerns this IMP will attempts to address. It does so by providing possible direction on how active management of the resource related issues can be carried forward. As with any management plan, the process should be dynamic. As the current issues are addressed new ones will likely arise and priorities will change. Therefore, there will be a long term need for the relationships that are currently being established and that have existed in the community to continue, and for these players to revisit integrated management planning on a regular basis in the future to ensure the objectives are being met.

2.0 Historical Conditions

At it's peak, oyster harvesting supported 90 leases in South River Denys basin. In 1995, average oyster production was 355lb/ha/yr, or approximately 12,780 lbs in the open areas of the basin (Reardon 1997).

In 1978, Chevron Standard Ltd. encountered a large pocket of high quality oil in limestone of the Windsor Group of the area. This led to the drilling of several test holes and one on Big Harbour Island in the Malagawatch area, produced potash within a large salt-dome structure. Many subsequent claims were then staked in areas around the Bras d'Or Lake that were underlain by rocks of the Windsor group (Miller and Milligan undated).

Figure 1: Provincial Location of River Denys Basin.

Marble of the George River Group was quarried on Marble Mountain in the southern River Denys watershed for some 50

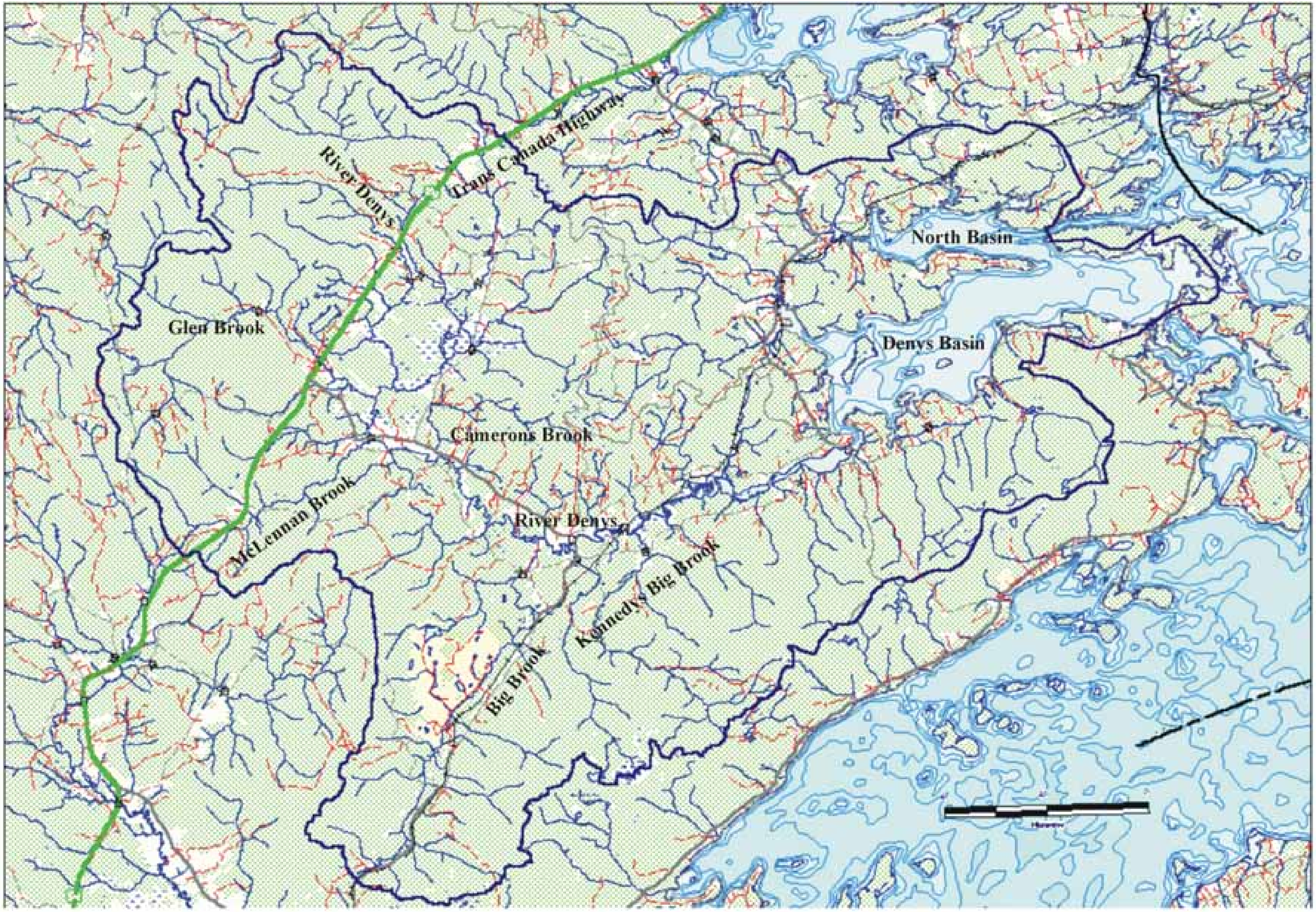

Figure 2: River Denys Basin for the purposes of Integrated Managment Planning.

years. Since 1962, gypsum has been mined in the River Denys basin, originally at the Big Brook site that is now closed and soon at a new site under development on Glen Brook near the community of Melford.

Agricultural activities have likely diminished somewhat from historical levels (B. MacLeod, 2001 pers. com.) although much of these lands remain cleared and available. Such lands are classed as ‘inactive’. Current agricultural activities are primarily hay and cattle operations, and not food crop production.

Both Atlantic Salmon and anadromous trout have sustained populations in River Denys. Caruthers Bridge has long been a favorite spot for sport fishermen.

3.0 Land Based Evaluation

This component refers to all the fresh water resources and related land based resources within the watershed. Excluded is the estuary, although many of the land based components will affect the estuary and are therefore discussed as appropriate. Five aspects of the land based project area are discussed: water quality, sediment sources, freshwater ecosystem health, riparian, and hydrology.

In order to assess the freshwater ecosystem it is valuable to identify a target species (s’). Generally, recreationally or commercially important species will be the target species for an assessment. It is appropriate that a relatively environmentally sensitive species be used as it will act as a better “indicator” of ecosystem health than a less sensitive species. Therefore, Atlantic Salmon (*Salmo salar*) and both sea run and resident Brook (*Salvelinus fontinalis*) and Brown Trout (*Salmo trutta*) will be considered target species for freshwater ecosystem in the River Denys Basin IMP.

3.1 Water Quality

Water quality concerns exist for both human uses, and for health of aquatic species within the watershed. Activities of the former may include irrigation, livestock watering, drinking water, and swimming. The latter, for land based evaluation, will focus on our target species of Atlantic salmon and anadromous trout, as their requirements are likely to address major water quality considerations for aquatic, terrestrial, and avian species that may interact with them or otherwise utilize the water resource. Sediment related water quality issues are not discussed here, but under *Section 3.2 Sediment Sources*.

3.1.1 Current Conditions

From the fall of 1996 until the spring of 1999 ADI Ltd monitored water quality at several freshwater sites around the River Denys basin and reported on the results (ADI 1999). Sites included Alder Brook, Glen Brook at several locations, Beaver Brook, North Brook, Swamp Brook, Farm Brook and River Denys near River Denys Center. These sites are all within the upper reaches of the watershed. These samples were collected and analyzed on behalf of Georgia Pacific to establish baseline environmental quality around the new gypsum mine site development in the Melford area.

All water types that ADI sampled meet the Maximum Acceptable Concentrations and for Aesthetic Objective guidelines laid out in the 1997 Canadian Water Quality Guidelines for Drinking Water for the parameters measured with the exception primarily for turbidity and color which periodically exceeded limits (ADI 1999). Sulfate was also consistently high on North Brook, a tributary to MacPhail Brook. The ADI sampling also concluded that none of the parameters sampled exceeded the 1997 Canadian Water Quality Guidelines for the Protection of Aquatic Life (ADI 1999). Total Dissolved solids on River Denys were 90-150 mg/L, nutrients were 2-5mg/L dominated by Carbon and with consistently no phosphorous. Low phosphorous is a limiting factor in primary productivity.

Stream temperatures collected by ADI in the headwater areas around Melford were few. However, they showed July and August temperatures to be in the low to mid teens on the Celsius scale. This is within the target range for salmonids, however, the fact that the water is not cooler in these headwater streams may indicate the potential for extreme temperatures lower in the watershed. ADI felt that North Brook and Alder Brook could be susceptible to elevated water temperatures and run-off as they pass through open areas near the Trans Canada Highway (ADI 1999).

Additional water quality sampling is currently being carried out by the Eskasoni Fish and Wildlife Commission (EF&W) in partnership with Environment Canada and the Department of Fisheries and Oceans in the lower reaches of River Denys, Mac Intyre Brook, Big Brook, and near Eden and Blues Mountain Brook (see map of sample sites in Appendix G). This is part of a 'Enhanced Water Quality Sampling Program' begun in fall 2000 that covers most of Denys basin. Results will help identify any harmful level of fecal contamination as well as temperature, silicate, phosphate, nitrite, nitrate, and ammonia. Furthermore, EF&W is completing a Sanitary Shoreline Survey in the lower reaches of River Denys to identify potential fecal coliform sources. This latter survey will complement available information for the coastline collected through Environment Canada.

Gypsum is exposed at outcrops along the valley of River Denys and several of its tributaries. This helps the system maintain a moderate pH, buffering the effects of acid rain that impacts many Atlantic rivers. This is a significant water quality component for which IMP managers do not apparently need to concern themselves. Sampling conducted by ADI during February through April in 1997-1999 showed consistent pH levels that always stayed above 7.0. As this is the time of year when rain on snow events are most likely, the impact of acid precipitation is typically greatest. That impact does not appear to be significant in the Denys Watershed.

Concern currently exists in the area for potential water quality impacts to Big Brook from a private sanitary landfill operation just off the MacCuish Road, upstream of the old mine site. The landfill is also a licensed facility for disposal of fuel contaminated soils. As terms and conditions of its permit, water sampling was carried out prior to implementation, and continues on a regular basis. Water samples are evaluated above and below the site for surface water and ground water. Both shallow and deep ground water wells are established around the perimeter of the operation. The results of this sampling are forwarded to the Nova Scotia Department of Environment and Labour (pers. comm. Marr 2000). The requirements of the permit state that at least total petroleum hydrocarbon, benzene, toluene, ethylbenzen and xylene are being assessed.

Review of 1998 air photos does not point to any significant land based activity that may be affecting the water quality of the drinking supply at Orangedale. There is a small amount of land clearing that has taken place nearby, and there are several road ways that may provide some surface runoff impact. However, as the source pond is small with no apparent significant through source volume of water, the source is likely fairly stagnant and will have the associated water quality of a body with poor oxygen and little turnover.

3.1.2 Target Levels

Table 1: Land based water quality trigger and target levels.

Parameter	Trigger Level	Target Level	Species of Limit / Source
PH	5.5	6.5-9.0	Canadian Water Quality Guideline – Protection of Aquatic Life
DO_2 – Dissolved Oxygen	early life stages 6000µg/L^{-1} other life stages 5500µg/L^{-1}	Near saturation	Canadian Water Quality Guideline – Protection of Aquatic Life
Upper Temperature Limit	<20^{0}C extended <24^{0}C short term	14^{0}C	salmonids
Turbidity - consumption		1NTU	Canadian Drinking Water Quality Guidelines
Fecal Coliform – Human consumption		0 MPN/100ml	Canadian Drinking Water Quality Guidelines
Fecal Coliform – Irrigation	100 MPN/100ml	14MPN	Canadian Water Quality Guidelines – Agricultural Uses
Fecal Coliform – Human Contact	200 MPN/100ml	14MPN	

Table 1 con't

Parameter	Trigger Level	Target Level	Species of Limit / Source
Dissolved phosphorous	1μg/L^{-1}	/ 3 μg/L^{-1} <10μg/L^{-1}	British Columbia Ministry of Environment
Nitrogen		/ 20 μg/L^{-1}	British Columbia Ministry of Environment

In Maritime fresh water systems phosphorous is usually the limiting nutrient to primary productivity. ADI Ltd. found there to be consistently no phosphorous in the water samples they analyzed from the upper watershed. As little as 0.3-0.6 μg/L^{-1} may be adequate for unicellular periphytic diatom growth and anything greater than 10 μg/L^{-1} may cause excessive blooms (Bothwell cited in Mouldey Ewing, Ashley and Wilson 1998).

3.1.3 Management Response

Some management activities are at this point limited to awaiting the results of current Enhanced Water Quality sampling. This sampling will produce results for several river locations. It is anticipated that the results will focus efforts to reduce fecal coliform inputs to high priority areas, as well as identify if shellfish closures may be modified in size or periodically opened. The results of the river samples for fecal coliform should be used to determine if irrigation and livestock watering are permissible (see Appendix C for guidelines). Summer temperature data will quantify thermal warming impacts and the need for higher priority of riparian planting.

As pH, DO_2, and suspended solids are not part of this effort, these parameters should be evaluated at all major tributaries, such as McIntyre Brook, Kennedy's Big Brook, Big Brook, McLennan and Cameron's Brooks. As well, these parameters should be measured at each the three main bridge crossings of River Denys between the mouth and the confluence with McLennan's Brook. Temperature profiles during summer low flow periods would help determine the extent of thermal warming. These activities should be undertaken or evaluated at a time when target levels are most expected to be exceeded. If targets are met in the "worst case scenario", then it is unlikely there is impact at other times of the year. For example, pH should be measured when there is high spring runoff associated with snow melt. Dissolved oxygen levels are positively correlated with water temperature, and often with presence of organics. Therefore, late summer is also a good time to measure $D0_2$ for potential negative impact on aquatic life, and in early morning before photosynthesis will cause any appreciable boost in oxygen. Suspended solids should be evaluated during spring flows or after heavy rains preceded by a period of dry weather. The completion of this type of data will help confirm whether water quality or habitat is more likely the limiting factor in freshwater fish production.

Sampling is established on Big Brook to determine if pollutants from a private landfill and contaminated soils depot are reaching the river system. This topic has been discussed by the Denys Watershed Advisory Group, which recently formed to address potential impacts in and around the estuary. Results are available through 'Freedom of Information' from NSD0E in Port Hawksbury and should be sought for the community to review and feel comfortable with the facility as it exists. The results should be compared to the Canadian Water Quality Guidelines as presented in Appendices B and C.

There is no obvious sources of impact to the Orangedale water supply and surrounding drainage from air photo review. It is likely that quality issues are a result of demand and the natural characteristics of the source body. Therefore, finding an alternative or supplementary source may be more viable than extensive treatment of the existing source to achieve desired water quality standards.

Once water quality results are confirmed activities to address individual parameters that do not meet target levels can be developed. However, determining results is key for many of the activities to be considered for the basin and therefore it remains the highest priority activity until existing information gaps related to targets are filled.

3.2 Sediment Sources

Significant sediment problems tend to be from a few core sources. They include roads and ditches, stream crossings, hill slope failures, and open areas such as cut blocks and agricultural lands. Stream bank erosion can also be a significant source but is usually an effect caused by some other activity that needs to be addressed. Sediment sources can further be classed as those that are fine particulate and suspend in the water column for a period of time and a heavier fraction that primarily moves along the bottom of a stream. Mobile species will often leave areas where there is suspended sediment for a short period of time until the event passes. The heavier fraction can significantly alter or eliminate species' habitat causing a long term or permanent avoidance of the area impacted.

In evaluating these sources we need to assess proximity of lakes and wetlands where settling and filtration may occur, erodibility of the soils, and connectivity to the stream channel. The latter refers to how directly sediment can be carried from a source to the stream channel by natural processes. For example, an eroding ditch line that dumps straight into a brook has high connectivity. In contrast a large open fill pit area on steep ground may have low connectivity if water running off the site drains into a brush and treed flat area a long distance from the open stream channel.

Target levels of in water sediment related concentrations tell us in general if sediment delivery needs to be addressed. Once sedimentation has been identified as a problem, the IMP then should try to identify and quantify the various sources of sediment, prioritizing which ones should be immediately addressed.

3.2.1 Current Conditions

The geology of the River Denys basin makes it naturally quite stable. The steeper sloped portions such as the Creignish Hills in the north and northwest, and the George River Group in the Marble Mountain area to the south are generally of low erodibility. These highlands are composed of metamorphic and igneous rocks of the Precambrian, and can be as old as 900 million years. Most of the River Denys basin lowland is underlain by soft sedimentary rocks of the Carboniferous age some 360 million years old. Glaciers deposited till over much of these lowlands and it primarily consists of a dense reddish brown clayey silt till with localized deposits of a yellowish brown, sandy silt till (ADI 1999). Both of these would be highly erodible when exposed. Finally much of the main River Denys corridor is covered by outwash sands and gravels that would be moderately erodible. So in short, steep areas are stable and erodible soils are in the moderate to low gradient areas where, unless exposed they also remain stable.

Silicate analysis in water samples from the river and estuary show River Denys produces higher than the average concentrations within Bras d'Or Lake tributaries (Dalziel et al. 1998). In this study of the Bras d'Or Lakes, River Denys Basin was one of three rivers being sampled for silicate concentrations over a four year period. It showed elevated silicate levels in the river. Similarly, samples taken by the Eskasoni Fish And Wildlife Commission show high silicate concentrations in samples from the 1m depth of the basin. High concentrations in the upper level of the water column of the basin further suggest input from the river system (Strain 2000). These studies do not tell us the source of the silicate, only that one is apparent and it is upstream. Therefore, a careful review of 1993 and 1998 air photos was conducted to try and identify any current sediment sources. Several potential sites were identified associated with a variety of land use practices.

Air photo review shows a high degree of ATV or 4WD use in the upper portion of Glen brook and large areas of exposed soils adjacent to the stream channel (see Fig 3). These sources could cause significant sediment delivery to the channel during times of heavy rain and surface runoff. Stream baseline monitoring in the upper reaches of the watershed on River Denys, Glen Brook, and other small tributaries that surround the new Georgia Pacific mine site in Melford show suspended solids to be less than 15mg/L on average over the period of 1.5 years of sampling (ADI 1999). ADI Limited reports peak concentrations in the 20-30 mg/L range within the sampled sites. These generally occurred in March and as such are less likely to affect salmonids feeding behavior during critical growing periods. Peak turbidity was recorded in the small tributaries entering MacPhail Brook south of the new mine site at 13 NTU. In addition these latter tributaries were felt to be impacted by excess sedimentation resulting from road work on the former Old Mill road (ADI 1999).

A short distance above the old Big Brook mine site, MacCuish Road crosses the stream (Figure 4). At that point it is apparent that some event or activity has destabilized the channel. There was evidence of active vehicle use along the margin of the channel in 1998.

Big Brook historically had high suspended solids associated with an old gypsum operation. Even as this source is eliminated, the impact may be long term. 1998 air photo review has shown several areas of concern still exist at the old Big Brook mine site including active stream fords, road failures adjacent to Big Brook, and large areas of exposed soils showing active erosion (Figure 5). Near the entrance road to the old mine site, the main stream crossing and a landing area on the east side of the channel both appear to have created sediment and channel impacts.

Logging impacts on upper Cameron's Brook are visible in 1993 air photos, and remained visible in the 1998 air photos with a larger area of the brook being dammed by a road crossing in the latter photo (Figure 6). Disturbance of soils adjacent to the stream, several roads near the stream, and an apparent road failure at a stream crossing are all likely producing chronic sediment inputs to Cameron's Brook.

There is significant channel destabilization and movement of stream substrates on Kennedy's Big Brook visible on 1998 air photos (Figure 7). MacLeod Road runs tightly between a gravel operation and Kennedy's Brook, and at the point where all three meet, the stream channel becomes obviously impacted. Elevated level of substrate movement is visible for over 500 meters downstream.

GIS review of 1993 road densities in the project area showed more than 420 km of paved and unpaved roadways throughout the basin. The majority of these roads are unpaved, and that means that along with ditch lines, road surface sediments are a potential source to stream sediments. More than 170 stream crossings were identified in the project area from a 1:50,000 map based on 1993 data.

3.2.2 Target Levels

Targets presented in Table 2 regarding road lengths will help confirm if roads are likely a primary source of sediments or if other sources are likely larger contributors. This will focus management activities to address the greatest sediment sources within the basin.

Table 2: Sedimentation trigger and target levels.

Parameter	Trigger Levels	Target Levels	Species of Limit / Source
Total suspended solids		<25mg/L	Salmonid feeding and growth
Turbidity - consumption		1NTU	Canadian Drinking Water Quality Guidelines
Roads within 100m of stream	>0.45 km/km^2	<0.3km/km^2	BC Ministry of Environment – Interior Watershed Assessment Procedure
No. of stream crossings	>0.9/ km^2	< 0.6/km^2	BC Ministry of Environment – Interior Watershed Assessment Procedure
Roads within basin	>2.6 km/km^2	<1.94km/km^2	BC Ministry of Environment – Interior Watershed Assessment Procedure
Stream Bank Erosion	<50% stability total length of both banks	>80% stability total length of both banks	Department of Fisheries and Oceans

3.2.3 Management Response

ADI Ltd. has measured peak total suspended solids to slightly exceed target levels in headwater streams during peak flow events. There are some 1.5 km/km^2 of road and 0.6 stream crossings/km^2 within the 286 sq kilometer watershed. Although both numbers are high, they do not exceed the target levels. Hard surface roads only make up 35 of the more than 425 kilometers of road identified in the basin area. Although this alone is not cause for concern, in combination with air photo review it is expected that sediment delivery to the freshwater system, and consequently the basin, is significant and of detriment to the ecosystem. Historical sedimentation within the river system has been identified as a problem. The degree of current sediment delivery from impacted sources is unknown, as it the long term impact from past sources. The first step in quantifying the potential problem of sediment sources has been completed by a review of aerial photos of the basin. The next step will require ground truthing of identified sources to determine if they still exist, and evaluation of long lasting impacts in areas where sedimentation has been deemed to have stopped.

The key is to first stop significant sediment sources before any rehabilitation work in the channel takes place. All sites identified on Figures 3-7, and the accompanying maps for this report should be visited to confirm current status of these sediment sources and connectivity to the stream network. The sites should be photo documented, and a description written about the current state, physical dimensions, and whether the site is beginning to recover or continuing to destabilize. Finally, a recommendation as to what stabilization activities, if any, should be undertaken. Stabilization activities should begin immediately once the site is confirmed and an appropriate method determined.

The second step is to determine the level of channel impact from current and past sediment sources. A survey of the stream substrate should be conducted to help confirm the type of sedimentation impact that exists. There are two primary types of impact. Either a fine suspended particulate, or a heavier particulate that settles into the substrates of the stream will usually be observed. The former means that stopping the source will likely improve stream conditions in a reasonable period without further intervention. Displaced stream invertebrates and other mobile species will likely recolonize the affected area through drift and active migration. If the impact has existed for a long period of time, or in a headwater area where recolonization by drift is not possible, or within an area where riparian vegetation is lacking, then a significantly longer time may be required for natural increases in productivity to occur. Given impacts from a heavier fraction, interstitial spaces may have become filled with sediments. Aquatic insects that live in the substrate can therefore no longer exist. Stream organics do not become trapped and therefore do not have the chance to provide nutrients to the system. Spawning habitat is greatly compromised, and the ability of the channel to provide complex microhabitats is all but eliminated. In an embedded system only a major flooding event will likely improve the impaired habitats, and the stream must also be relatively stable and complex to facilitate natural recovery. As River Denys is not particularly complex, has obvious areas of channel instability, and likely has ongoing sediment inputs, intervention would be the only means to achieving increases in stream productivity in the near term if the substrate is highly impacted. This portion of the evaluation will necessarily need to be done by a specialist. It should be carried out on all of the streams in Table 3, above, immediately below, and well below the sites of identified sources. As well, River Denys should be evaluated just above and below the confluence with any major tributary. If substrates are confirmed to be sediment impacted, instream rehabilitation prescriptions will need to be developed by a specialist, but could then be implemented by community.

Once sediment sources have been arrested, consideration should be given to a large scale bar stabilization program at several locations to stabilize the channel. This could be done in association with other rehabilitation activities that are designed based on the review in the preceding paragraph. Bar stabilization for smaller systems is best accomplished by a program of heavily staking exposed bars with willow, alder, or other appropriate species. Although they are not likely the desired final riparian vegetation they are the most effective in quickly stabilizing a channel and moving toward productive habitat. The relatively low cost of this type of program is appropriate given the risk of failure of any program if a heavy flood season follows the first year after implementation. This project can be done with locally sourced materials and labour. Target areas pending the results of the previously mentioned field assessments would include Glen Brook, lower MacLennan Brook, Lower Big Brook, Kennedy’s Big Brook, and some portions of River Denys.

The final recommended activity is to provide a system of monitoring and evaluation. In order to determine the degree of sedimentation currently occurring in River Denys and its tributaries, a sedimentation indicator should be established. It is recommended that a low cost effective means follow that utilized by the British Columbia Watershed Restoration Program (Larkin and Slaney 1996). This techniques uses plastic containers filled with graded gravels embedded in the permanently wetted portion of the main river and several major tributaries. After a period of time the buckets are removed and all sediments from the buckets captured and weighed to determine the volume of material being delivered by the channel. When compared to a standards table, and the other local streams, the process can highlight the magnitude of sediment loads. Furthermore, early collection of this data will allow for future comparison in order to evaluate a measurable objective established around sediment reduction. This should be implemented prior to spring freshet, as this typically is the period when highest suspended sediment loads are found. Collection and analysis of water samples for suspended solids is another viable alternative. However, it requires more active personnel participation and laboratory analysis. However, such samples should be taken at peak events to supplement and calibrate other data. Similarly, establishment of benthic invertebrate density plots would also provide a sound means of measuring habitat productivity. At this level of the food chain, clean substrates directly affect stream productivity and the resulting correlation would help determine the trend of recovery.

Table 3: Sediment evaluation activities and locations.

System	Sediment Source Confirmation	Sediment Impact Evaluation	Sediment monitoring system
River Denys	✔	✔	✔
McLennan Brook		✔	✔
Glen Brook	✔	✔	
Cameron's Brook	✔	✔	
Big Brook	✔	✔	✔
Kennedy's Big Brook	✔	✔	✔
McIntyre Brook		✔	
Blues Mountain Brook		✔	

3.3 Freshwater Ecosystem Health

It is often difficult to objectively determine the limiting factors of production of stream dwelling salmonids. However, quantitative comparison of observed physical conditions to some biostandard or conditions in undisturbed systems is one of the best methods available. Physical habitat assessment, in this case for our target species of salmonids, is most valuable when completed during low flow periods. An overview assessment of recent air photos or video will help target high priority areas for stream assessments. Most high fish value streams will contain a close ratio of riffle to pool habitats, an abundance of large woody debris within the active channel, adequate residual pool depth, and good overhead cover.

3.3.1 Current Conditions

In the higher elevation reaches of the watershed, assessment of habitat features using a quantitative methodology called Qualitative Habitat Evaluation Index was carried out at several locations. It resulted in "good to excellent" habitat for fish being scored in Glen Brook, River Denys and Alder Brook (ADI 1999). This methodology examined such things as channel morphology, riparian and bank condition, pool and riffle quality, substrate, in stream cover and gradient. Later physical habitat measures showed a near 1:1 pool riffle ratio by area for the lower portion of Glen Brook (below Graham Brook) with about 0.3:1 ratio above that point (ADI 2000). A baseline of benthic invertebrate sampling around the watershed is available, and appears to show a reasonably healthy environment (ADI Limited 1999) due to the presence of diverse species. Baseline sampling for fish presence, along with consideration of habitat quality led ADI to conclude that Glen Brook is an important nursery / growth habitat for Brook trout and Atlantic salmon (ADI 1999). This is supported by the lack of land use impacts in the upper basin of Glen Brook where the Bornish Hills Nature Reserve is located. However, 1998 air photos (Figure 3 and Figure 8) show evidence of impacts and channel instability below the reserve lands, and Glen Brook may be trending toward poor productivity and habitat.

Remnant populations of both Atlantic salmon and anadromous trout exist in the River Denys watershed. In 1999, preliminary habitat assessments for these species were conducted on parts of McIntyre Brook and River Denys, by Shayne McQuaid, DFO Habitat and Amy Weston Adopt – A – Stream program. Along with some other professional observations it appears that the lower system is generally devoid of large organic debris and primary habitat units of pools and riffles (Pers. comm. McQuaid and Rutherford 2000). This is further supported by review of 1998 air photos. They show that there are often long stretches of mainstem River Denys where significant pools are nonexistent, and large organic debris was extremely sparse. Twelve primary pools were counted from air photos on the mainstem between the bridge at River Denys and the bridge upstream at River Denys Center, and large wood was all but absent. Stretches of 500 -700 m between pools is not unusual. Regardless of the reason for these poor habitat observations the result is that nutrient cycles, hydrologic regimes, and food webs all become impaired. Such seems to be the case in the mid to lower reaches of the watershed based on current information.

Nutrient cycles are impaired as the diversity of habitats that once trapped leaf litter, organics and other biomass in deep pools and back eddies of the channel instead get flushed rapidly through the system to the estuary (Rutherfurd, Jerie and Marsh 1999). Strangely enough, this seems to be supported in River Denys in part by observations in the estuary that there are elevated ammonia levels, expected to be due to organic deposition and restricted circulation. High estuary chlorophyll values in the fall appear to indicate some new primary production at a time of year that it usually would not be expected (Strain 2000) further supporting the notion of a high presence of organics, possibly associated with leaf litter of the fall season.

Hydrologic regimes are affected by lack of channel diversity and large organics that allow rivers to thereby become more efficient conduits for water to leave the land base. As a result, during summer low flows temperatures may be higher due to the lack of deep holding pools, at peak floods there may be a higher volume of water entering the estuary over a shorter period of time, and so on. Related to this is the change in hydraulics and the lack of diverse microhabitats that are targeted by a variety of species and the resulting trend toward supporting fewer types of organisms within the channel. Whether a change in River Denys hydrology is apparent is discussed more in section *3.5 Hydrology*.

A final result of degraded channel habitat is that food webs are affected. The ability of the natural system to be as diverse as it was in historic times becomes restricted. Related largely to the previous two impacts, as organics are flushed through the system primary producers and invertebrate scraper and shredder organisms become suppressed. With a simplification of habitats through removal of in stream and riparian wood, and infilling of pools to name a few, the physical habitat of the organisms that make up the base of the food chain becomes smaller and less productive. The basis of stream nutrient cycling in Eastern Canada is largely from leaf litter and streamside organics that must be held within the river system long enough to support primary production. Nutrient levels are discussed further in section *3.1 Water Quality*. ADI Ltd. (1999) found that the diversity of macroinvertebrates became less and fine sediments increased in a downstream direction along Glen Brook. This coincides with observed impacts and instability that increase in the downstream direction (Figure 8).

Stewards of the River Denys Association completed significant data collection on habitat features in 2000. This information provides a general overview of characteristics but does not allow for prioritization of sites for rehabilitation effort. Data sheets collected some basic habitat measurements and provide site sketches.

Lastly, a quick review of the watershed roads shows there to be at least 170 stream crossings. Healthy habitat is of little use if the target species can not access it. Recent evaluation of culverted road crossings in the interior of British Columbia has shown as many as 40% of old installations are either full or partial barriers to fish (Parker pers. comm. 2000). In a system like River Denys, where large portions of habitat exist in first, second, and third order streams, the potential for significant habitat loss due to culvert barriers exists. Standard methodology (Parker 2000) allows for evaluation and prioritization of culverts for fish passage. Nearly all crossings observed in the basin are on the tributaries to the main river, with many being along the South Side River Denys Road or North Side River Denys Road. That means that the potential for eliminating large amounts of tributary type habitat exists as these roads run close to the confluence of the tributaries with River Denys. Tributaries to the south and northwest of the watershed are more likely to be high value salmonids habitat because of a moderate amount of gradient that will provide riffle habitat needed for Atlantic salmon juvenile rearing and adult spawning salmonids in general. Salmon fry have demonstrated a preference for streams, 2.5 meters wide (Scruton and Gibson 1993), and it is this same magnitude of stream that is more likely to have a culvert than a bridge at any road crossing. Maintaining fish passage for fry and young parr at culverts is difficult due to their poor swimming and jumping abilities.

The number of stream crossings per unit area of watershed for the River Denys basin is extremely high. Given a project area of approximately 290 km^2 and some 170 crossings within that area means that target levels of 0.6 crossings per km^2 are approached. Therefore, the potential for both sediment sources and fish barriers associated with crossings may be of concern.

A habitat analysis for Big brook is being completed by ADI Ltd. on behalf of Georgia Pacific. This report will cover all stream habitat from the headwaters to the confluence with River Denys and is anticipated to be completed during the spring of 2001 (Foulds pers. comm. 2000).

3.3.2 Target Levels

River systems are all so unique that it is difficult to provide general target guidelines that can consistently be applied. Therefore, the following targets deserve strong consideration but ultimately need to be applied by a habitat professional who can make the necessary judgments on application of the targets to individual systems. Four major components are highlighted here as ecosystem target levels. Large woody debris (LWD). Riffle – pool frequency. Residual pool depth. And overhead stream cover. Many more indicators exist that can be used by a professional to further diagnose degraded habitat, however, if these basic elements are not met then further intervention is necessary. More detailed explanation of parameters is presented in Appendix A.

Table 4: Summary Freshwater Ecosystem Trigger and Target Levels

Habitat Parameter	Trigger Levels	Target Quality Guideline
Pool Riffle Ratio (area)		>1:2 for channels <15m bank full width and <5% gradient
Pool Riffle Ratio (habitat unit)		~1:1 for channels <15m bank full width and <5% gradient
Residual Pool Depth	<30 cm for primary pools	/50cm for primary pools
Functional Large Woody Debris Tally		/1 piece per bank full channel width
Over stream Cover	< 10%	/10% cover within 1 meter of bank full surface area
No. of stream crossings	< 0.6/km^2	>0.90/km^2

3.3.3 Management Response

The two highest priority activities for the basin focus on reestablishing fish access. The first is to construct an adequate number of deep holding pools in the mainstem of River Denys to ensure adequate upstream passage and holding for adult Atlantic salmon and anadromous trout during summer low flows. These works should concentrate on the area between the upper limit of tide and the confluence with McLennan Brook. Pools will likely need to be created by excavation, and should be no less than 1 meter residual depth at time of construction. Ballasted in stream large woody debris should be used to provide cover in these new pools.

The second priority for establishing access is to evaluate culvert road crossings. The density of stream crossings within the basin warrants an evaluation of crossings for both fish passage and sediment sources. It is recommended that a Fish Passage Culvert Inspection procedure (Parker 2000) be followed to quantify and prioritize this potential impact. This is an activity that can largely be carried out by a fisheries technician both quickly and cost effectively. Assessment should be done on all crossings, but could target primary tributaries first, working from the various confluences with River Denys in an upstream manner. With over 170 identified crossings and major roadways running parallel to much of River Denys only a short distance from the river, the potential return is significant. In stream modifications or replacement/removal of culverts will rectify passage problems. The former can be done very cost effectively, but reduces the capacity of a culvert and must therefore ensure that the structure can still handle flood flows.

McLennan Brook has potentially high value salmonids habitat due to the large portion of that sub basin that is undisturbed. Therefore, the habitat between the Trans Canada Highway southeast to its confluence with River Denys should be assessed by a professional habitat biologist to confirm the value of this system. The lower 1km or so of habitat has been impacted by land use activities that have removed riparian vegetation. This section appears by 1998 air photo review to have some stability problems and lacks in complexity. If the upper portion of this system is confirmed as high value, this lower section would be a very high priority for rehabilitation, and the upper section a template and control system for basin tributary work.

Big Brook is another potentially high priority candidate. First, it should be evaluated for sedimentation impact based on past activities within the drainage (see section *3.2 Sediment Sources*). It is expected that the substrate of this tributary is embedded, and that activities should therefore focus on initially releasing fine materials from the bed to allow for primary production within the interstitial spaces. This work should occur from an upstream project boundary downstream such that any sediment that is released to move through the system can not impact areas already worked on. There are two sections of Big Brook that are priorities within the system. The section from McCuish Road just above the old mine site to just below the mine site is the uppermost area of importance. In 2000 some works were done on the old Georgia Pacific Mine site, including the removal of a large culvert on Big Brook. The second site of priority is the lower reach of Big Brook from South Side River Denys Road to the confluence with River Denys. This area is almost completely devoid of riparian cover (see Figure 9). This reach, given its proximity to River Denys should receive a stream assessment, and potentially in stream rehabilitation measures as little complexity was observed through air photo review. This should be coordinated with riparian rehabilitation along this reach if a field visit identifies appropriate growing sites (see section *3.4 Riparian Assessment*). Additionally some works may be undertaken on Big Brook in the near future based on a habitat review conducted by ADI during 2000 on behalf of Georgia Pacific (Foulds 2000 pers. com).

Glen Brook has been identified as an important salmon and trout rearing area within the watershed (ADI Ltd.1999). As such it should be considered for three management activities. First, it should be protected. It is much more cost effective and ecologically productive to protect an area than attempt to rehabilitate or mitigate for impacts at a later date. Secondly, it should be well assessed for water quality and physical habitat attributes as a reference and potential template for other similar systems. The former is being done through historic and ongoing monitoring by Georgia Pacific. The latter has been preliminarily assessed by ADI Ltd on behalf of Georgia Pacific, but should be completed comprehensively to standards that would allow comparison and replication. Finally, impacts are apparent (Figures 3 and 8) and should be actively addressed. This should be, in part, completed through planned activities. ADI Limited is submitting rehabilitation plans on behalf of Georgia Pacific in hope of conducting in stream works along some of a 2.7 km section of Glen Brook during 2001 dubbed the “Salmonid Management Zone”. These works fall out of a salmonid management plan developed by ADI for Georgia Pacific on Glen Brook (ADI 2000). That being said, it is apparent from background assessment by ADI Ltd. (ADI 2000) and 1998 air photo review that riparian functions are impaired and some channel functions may be trending toward instability even though they are currently quite productive. This is often the case as impacts associated with removal of riparian vegetation, as has occurred both in upper an lower portions of Glen Brook, does not always cause instability and significant habitat degradation until the rooting system of cut trees begins to rot and large wood that is in the channel rots or is displaced by floods and not replaced with new contributions from a mature riparian area. Such instability appears to occur in the area north of the Trans Canada highway, and the resulting bedload is depositing in the channel below the highway to the confluence with River Denys (see Figure 8), and is exacerbated throughout both zones by minimal riparian densities.

All tributaries greater than 2 meters bank full width that do not have a survey of primary habitat units within the length of stream that is potentially fish bearing should have a “Level 1 Fish Habitat Assessment Procedure (FHAP)” conducted. This means the careful measurement, over a representative length of channel, of the primary habitat units, LWD within each unit, and degree of overhead cover as described and recorded on the form in *Appendix A - Level 1 FHAP Form*, or some similar format. Results should then be analyzed relative to the Table 3 and the guidelines mentioned in the preceding. Comparison of primary habitat unit ratios and LWD tallies should also be done with any low or non-impact reaches within the watershed, such as upper McLennan Brook.

The Stewards of the River Denys Watershed Association was established in 1999. The group began in stream restoration of one tributary to River Denys, MacIntyre Brook, in 2000. Therefore, no further recommendations have been made regarding this system at this point in time other than to reevaluate the system and the benefit of the works conducted.

3.4 Riparian Assessment

Riparian and wetland areas serve several major functions to a stream system. These functions can usually be grouped into the following five categories: surface sediment filtration, bank and channel stability, stream shading, large woody debris recruitment, and small organic debris contribution (ie. Leaf litter, twigs, terrestrial insects). What we want to concern ourselves with is whether or not these stream side areas are carrying out each of these functions, and in which direction they are tending if not functioning properly. Those tending away from proper functioning condition are of greater concern than those areas that are recovering well and beginning to adequately recover their ability to carry out the above noted functions (Prichard, D. H. et. al. 1998).

3.4.1 Current Conditions.

Review of 1993 and 1998 air photos show there to be impaired riparian areas within the watershed. However, an overall assessment for the watershed has not been conducted. Nor, as explained above, is it known which way the individual functions are tending. The key question is are they repairing naturally, or are we still in a phase of becoming less functional. An example demonstrates that not all are apparent at first glance.

If an area of stream bank was logged 15-20 years ago, it could very well be overgrown with good size trees that are looking like they meet most functions reasonably well, and can only get better. However, a look at the stream may show that the large woody debris in the same reach is almost all gone. Either it has rotted away or washed away in floods. As the stream side vegetation is still young we will not expect any of it to naturally fall into the channel (natural recruitment) for another 50-80 years. That means LWD is trending away from proper functioning condition even though other functions currently may be improving (see Table 5). As the LWD becomes depleted the channel may loose stability, habitat value, in stream cover, substrate sorting ability, and pool formation. Therefore, it may be a key site for placing in stream LWD structures that will help carry us over until natural wood recruitment can begin again from the riparian area. To reiterate, it is not only important to determine what functions are impaired, but which way they are tending relative to their proper functioning condition.

Table 5: Potential level of riparian functioning (from Koning, C.W. Ed. 1999).

Structural Stage	LWD	SOD*	Stream Shading	Surface sediment filtering	Bank and channel stability
Initial	L	L	L	L	L
Shrub herb	L	M-H	L-M	M	L
Pole sapling	L	H	L-M	M	L
Young forest	L	H	M-H	H	L-H
Mature forest	H	H	H	H	H
Old forest	H	H	H	H	H

*Small organic debris (leaf litter, twigs, terrestrial insects)

A large portion of Glen Brook has minimal riparian cover (see Figure 8). It appears to get progressively thinner from the headwaters to the confluence with River Denys. The lower reach of Big Brook from South Side River Denys Road to the confluence with River Denys is almost completely devoid of riparian cover (see Figure 9) as is the lower portion of McLennan Brook (see Figure 10). LWD recruitment and bank stability appear to be inadequately serviced by the existing riparian zone.

The mainstem of River Denys is nearly devoid of mature riparian vegetation for the majority of its length, with only short lengths of riparian, shrub patches, or sparse riparian remaining. The most severely impacted riparian function appears to be from the confluence with Big Brook downstream to the bridge at the community of River Denys.

Within the watershed, some long stretches of stream have little to no riparian buffer on one or both sides of the larger systems. This can dramatically affect nutrient levels within the river and limit primary productivity on which all other organism growth largely depends. This is further seen in the nutrient sampling conducted by ADI Ltd. (1999) that revealed no phosphorous in streams of the upper watershed.

3.4.2 Target Levels

Currently there is no legislation protecting riparian areas on private land. As nearly all of River Denys watershed is privately owned, those regulations protecting Crown Lands are frequently not applied to private holdings both intentionally and unintentionally. However, the guidelines have been established to protect a common resource, our water bodies and without public participation, systems like River Denys will not be adequately protected. Therefore, all lands are evaluated the same for the purposes of this report and Provincial Guidelines are used to evaluate and identify resource management opportunities.

The evaluation of riparian function is difficult to quantify and the targets presented are only general guidelines. Those presented are for a watershed scale analysis, and a site evaluation is very different. Although from a watershed perspective there may not be an overall riparian problem, it is highly likely there are stream sections for which riparian functions desperately need to be addressed. Table 6 presents target levels to determine likely impairment of riparian functions within the River Denys basin, and can be completed through an air photo review using a map wheel to measure relevant distances.

Table 6: Summary Riparian Target Levels

Habitat Parameter	Trigger Level	Target Level	Source
Portion of stream riparian cleared		<0.15km/km	British Columbia Ministry of Environment
Portion of fish bearing stream riparian cleared		<0.25km/km	British Columbia Ministry of Environment
Riparian buffers - <50 cm stream width	< 5 m	No shrub, herbaceous veg removal within 20 meters	Nova Scotia Department of Natural Resources
Riparian buffers – >50cm stream width	< 10 m	<40% volume removed within 20 meters over 20 years	Nova Scotia Department of Natural Resources

3.4.3 Management Response

The first priority in riparian management of the River Denys Basin is to reestablish an effective riparian area along the full length of River Denys. The main river exhibits the least amount of riparian cover for the most continuous stream length. Therefore, much of the thermal warming of this system likely takes place along River Denys, and the lowest reaches of its' tributaries. As well, the pronounced lack of large wood is critical in the main river where much of the channel morphology historically would have been wood controlled. It is recommended that draft NSDNR guidelines be followed and a 20 meter riparian zone be created. A riparian specialist should be involved in determining species mix and planting densities. In some areas that exhibit a pole sapling growth, a silviculture prescription may be appropriate to release desired species and improve growth. Any of these lower river sections that have been cleared of vegetation to the stream bank should receive revegetation to help restore natural riparian function, and planting should begin immediately in areas between the confluence with McLennan brook downstream to the head of tide. However, a specialist would provide valuable input in helping ensure success. Too often the wrong species are planted in a site and success is poor. Furthermore, the species planted may not help address the most impaired function of the riparian area. For example, staking a bank area with willow and alder can provide quick dense cover that may address bank stability, surface filtering and small organic debris input. However, this species will not usually provide long term large woody debris, bank protection from heavy ice scour, nor stream shading to larger systems. Another common error is planting some species in open areas when they are the desired long term species. Unfortunately, such species are often not pioneer plants and can be intolerant to the direct sun and its heat, or too much water often associated with a cleared stream bank. The result is a good intentioned project that fails. Mixed planting and identification of micro sites by a specialist can often overcome these problems and protect the capital investment made.

ADI Ltd.(2000) is recommending that for Glen Brook basin the active floodplain be set aside as a minimum, arbitrary riparian zone width. This zone varies from 20-140m for the creek that has an estimated bankfull width around 10 meters. ADI Ltd. is recommending the development of a 150 meter wide riparian buffer along Glen Brook to be established through a Resource Advisory Committee (ADI 2000). This would meet the target recommended above for that portion of the watershed and is a supported priority of the IMP.

Other high priority riparian segments exist on Big Brook and McLennan Brook. Big Brook is a large and potentially productive tributary to the watershed. As such it should receive riparian rehabilitation along the lower reach (Figure 9) if a field visit identifies appropriate growing sites. This should be coordinated with a stream assessment of the same reach and potential in stream rehabilitation measures as little complexity was observed through 1998 air photo review. A program to stake the sediment bars with willow, alder or some other local species in order to stabilize this portion of channel is also recommended. Such a plan would need support of the land owner. In this case a section of well vegetated Provincial Crown land exists to the immediate west property boundary, so various options such as a land swap, or redirecting the stream into a designed and constructed new channel through young forest may prove both functionally and cost effective alternatives. Other priority sites on Big Brook exist at the old mine site. Mainstem riparian on the west side of Big Brook should be established and widened. A short section should be planted on a tributary to Big Brook as depicted in Figure 11. All active drainage network on the mine site should be planted or seeded to support the function of surface filtration.

McLennan Brook appears to be one of the least disturbed systems in the watershed. Unfortunately, the lower 1000 meters has been heavily impacted, primarily by riparian removal. This means that the full potential of this high value system is likely not being reached as the migration corridor between River Denys and the upper system is drastically impaired. Establishment of a riparian corridor, and a program to stabilize the significant sediment wedges in channel through a staking program should be top priority in this sub basin. With these efforts and some minimal in stream works, McLennan could be the highest value tributary in the basin for the near future.

3.5 Hydrology

Hydrology and hydraulics are often confused, in part due to their interrelationship. Hydrology deals with the large scale of the water cycle and how water lands on, runs off, sinks into and otherwise leaves the earth's surface. Hydraulics tends to deal more with how surface water acts as it tumbles over logs and rocks, goes through culverts, and babbles along a stream bed. The scale is smaller than that of hydrology, focusing on a localized area. Hydraulics is indirectly considered in section *3.3Freshwater Ecosystem Health.* Here we will discuss the larger scale of hydrology of the watershed and how it may have been impacted by human activity. Hydrologically unstable systems have poorly developed riparian vegetation and experience episodes of stream bank erosion and siltation , often resulting in poor quality habitat conditions (Scruton and Gibson 1993). There are two major areas of hydrological influence discussed in the IMP; vegetation removal and drainage alteration.

Removal of mature tree vegetation within a watershed can alter the snowfall accumulation, spring peak floods, summer low flows and other hydrological processes. Therefore, in order to determine if there is potentially altered hydrology within a basin due to this factor it is important to estimate the Equivalent Clear-cut Area (ECA) within the watershed. Note that this is equivalent clear-cut, not actual, and therefore includes cultivated lands, burn sites, and hydro lines as being "equivalent" to a clear cut. Furthermore, equivalent refers to the area that would be clear-cut after considering a reduction for forest regeneration within historically denuded areas.

A second factor that contributes to a change in system hydrology is drainage alteration due to road construction. The higher the density of roads, the greater the likelihood natural drainage patterns have been altered. Ditches redirect water to quickly exit a hill slope, and the road surface itself drains more quickly toward those ditches than does a heavily vegetated forest of equivalent surface area. As the water quickly drains off the land it enters the river system faster, creating greater "peak" flows. This in effect puts more water in a river than it was "designed" for by mother nature and can cause excessive erosion, greater bed load and sediment movement, and increased loss of wood from the channel than in historic times.

3.5.1 Current Condition

The ECA, density of roads, and number of stream crossings have been estimated for the project area. Approximately 420 kilometers of roads, 170 stream crossings and large tracts of cleared lands exist in the River Denys watershed. On a sub basin scale, ADI Limited did some preliminary evaluation of watershed hydrology on behalf of Georgia Pacific (ADI 1999) for Glen Brook and the surrounding area. They found that for the stream channels they investigated around the Melford mine site a natural flow regime was exhibited.

Evaluation of data presented by ADI (2000) relative to the target levels shows that within the Glen Brook sub basin, hydrology is likely unimpaired by human activity. They outline 11km of secondary graveled roads that produces a 0.46km/km^2 road density, significantly less than the target. This does not include the Trans Canada and other roads below the highway that would still technically be within the basin. As well, they identify cleared areas due to logging, agriculture, mining, and roads that would present a maximum 364 ha of cleared lands or about 15% of the basin. This is below the target of 25% and likely significantly less than stated above as no regeneration factor has been considered, and it was assumed that 100% of the mine site would be denuded.

There has historically been land clearing for agriculture and logging over most of the watershed. Recently, the corridor between River Denys Center and Seal Cove appears in 1993-1998 air photos to have the highest rate of logging. Between this current activity, past cleared lands that are held for agriculture, or wood lots that have not significantly regenerated, the equivalent to clear cut area is likely quite high.

3.5.2 Target Levels

When the ECA of a watershed is above 25% it is almost certainly affecting the system hydrology. The greater the proportion of ECA in the upper elevations of the watershed (in the upper 60% of the hydrosymetric curve) the more likely the hydrologic regime will be altered (Anonymous 1995). The second component being evaluated by this IMP in regards to hydrology is the density of roads within the watershed due to the relationship between road density and altered drainage.

Table 7: Summary Hydrology Target Levels

Habitat Parameter	Trigger level	Target Level
Equivalent Clear Cut Area (ECA)		< 25% of watershed area
Road density for entire sub basin	>3.0 km/km^2 of watershed area	<2.1km/km^2 of watershed area

3.5.3 Management Response

It is unknown what portion of the land base has been cleared within the project area. An accurate ECA for the watershed should, however, take into consideration regenerating areas as well. To better determine if there is potential hydrology alteration due to cleared lands, an ECA should be computed using GIS methods and current data. The need for this exercise is likely to be determined in conjunction with other observation of peak flow related impacts such as channel instability, quick flooding response, and flood related sediment loading. If none of the latter is identified as significant then re-vegetation may not be warranted. Regardless, by calculating an ECA, better judgment could be given to approving or considering additional land clearing activities.

The total length of roads in the basin was calculated through a GIS query based on data for 1993. More than 420 kilometers of road were found. This included paved highways, double and single lane dirt roads, and smaller roads that would be visible on air photos. Given the total project area of 286km^2, a resulting density of 0.6 km/km^2 approaches the minimum target level of 0.6 km/km^2. For the purpose of better understanding, if on average the road width in the project area is 3 meters, that would equate into a clear-cut of more than 1.2km^2 or 300 acres. This fact coupled with how quickly water runs off a road surface, how roads alter natural drainage by directing water parallel to the roadway instead of along the natural ground depressions (not necessarily stream channels), and the direct connectivity of roads to streams at the over 170 crossings identified in River Denys basin means that hydrology is likely being impacted. Therefore, it is recommended that old dirt roads be deactivated by establishing cross ditches at natural depression and drainage areas, removing culverts from streams and if possible scarifying and planting road surfaces. This activity will require working closely with landowners to identify which roads are not required and could therefore be candidates for deactivation. Deactivation can occur at several levels to provide 4WD access, only ATV access, or no access, and these options can be explored with the landowner to ensure their needs are met. If deactivation is not feasible, at a minimum, road drainage should be examined to ensure that water is returned to natural drainage basins and not carried for long distances along ditch lines and/or deposited directly into the stream network. Deactivation will also help in reducing fish passage concerns and sedimentation to streams.

In review of 1998 air photos there appears to be several basin scale drainage issues that need to be improved at the Big Brook Mine site. A management plan may exist, and Georgia Pacific should be queried on this topic prior to detail evaluation of the basin drainage. However, as Figure 11 shows (and to some extent Figure 4) natural drainage patterns are altered by roads, and settling ponds. As a result, it is expected that less flow now enters two tributaries to Big Brook and more goes directly to the main channel or into groundwater than historically occurred. The large area of the mine site has little tree regeneration initiated and surface water runoff is most probably affected. Therefore, it is recommended that a plan be developed to reestablish a more natural drainage pattern and vegetation cover within the mine site.

If large scale activities such as planting and road deactivation are undertaken to reduce the impact on overall watershed hydrology, or if land clearing on private and Crown lands is expected to continue at the current rate, a semi permanent hydrological station (Sooley et. al. 1998) should be installed on River Denys. Such a facility would provide the most accurate means of measuring watershed scale changes in hydrology.

4.0 Estuary Based Evaluation

This component covers all estuary base resources with relevance to the identified *Key Issues and Questions in Section 1*. Two components of the estuary based project area are discussed: water quality, and estuary ecosystem health.

4.1 Water Quality

There are two major water quality related issues currently identified in the 24 sq kilometer estuary portion of the project area. The first is high levels of fecal coliform contamination that has resulted in shellfish closures. Recent closure areas are shown in Figure 12. The second is the potential loss of hard bottom habitat in the estuary due to sedimentation. These two issues are the center of discussion under this section. However, other parameters are considered in brief and their relative importance could change over time.

4.1.1 Current Conditions

The most recent activities in the basin that help define current water quality began in the fall of 2000. The Department of Fisheries and Oceans and Environment Canada, in conjunction with the Eskasoni Fish And Wildlife Commission, are conducting an Enhanced Water Quality Sampling program of the estuary and lower River Denys (see Appendix G for sampling locations). This sampling is taking place within the area of the estuary that has seen shellfish harvest closures from Lewis Island and up river. There are 25 sites that are sampled twice a month. In addition they are sampled both 24 hours and 48 hours after significant rain events (Duggan 2000 pers. comm). The main goal of these works is to determine if present conditions would allow shellfish harvesting under specific environmental conditions and or seasonal periods. In fact, the sampling will further benefit the IMP by helping identify targets reduction of fecal coliform contamination in the whole project area by building on works conducted earlier by Environment Canada.

Much of the Basin area is closed for shellfish harvest based on earlier assessments conducted by Environment Canada in Shellfish Growing areas of the Bras d’Or Lakes (see Figure 12). As of 1997 approximately 28.7% of the Denys Basin shellfish areas were classified as closed. This is up from almost zero in pre 1974 times (Mennon 1997) and is due to fecal Coliform contamination. Sampling for Coliform bacteria (Craig, Young, Walter, Mennon and Dennis 1999) has shown levels to be as high as 79MNP/100ml in the North Basin portion of this project area and 1700MNP/100ml in Denys Basin.

In the North Basin, Morrison Cove is currently closed due to high counts, however, air photo review does not reveal any potential sources in this small drainage area that appears entirely undeveloped with the exception of one dirt road. Other significant sources occur at Orangedale into Blues Cove and with little development on the lands that drain into this coastal water, it is expected that nearly all fecal contamination comes from the shoreline homes.

Seal Cove was one of the first areas closed before the larger closure that still exists today was made. In Seal Cove there are several houses, although not particularly high density. However, as can be seen in Figure 13, there is a small surface drainage that runs through an active farming operation, passing very near the barns.

Another one of the first closure areas was a small site at Mahoney's Point near the mouth of River Denys. Two monitoring sites near the mouth of Denys River have the highest mean Coliform counts suggesting a large portion of the impact in the Denys Basin may originate up river. However, high density development is apparent at the mouth of River Denys on both sides of Crowdis Bridge, and a heavy algal mat was visible at the mouth of Allan's Brook that enters River Denys directly below the bridge in 1998 air photos (Figure 14).

Other significant counts are found in Effie's Cove and to the east at the mouth of MacKenzie's Brook.

The second target issue is related to the reports of significant sedimentation of historic oyster growing areas within the River Denys basin. It is generally felt that this sedimentation is the result of delivery from the River Denys to the basin area. This is supported by a study done in the basin on chemical silicate concentrations in the river (Dalziel et al. 1998). In this study of the Bars d'Or Lakes, River Denys Basin was one of three rivers being sampled over a four year period. It showed very high silicate levels in the river. Similarly, samples taken by the Eskasoni Fish and Wildlife Commission show high silicate concentrations in samples from the 1m depth of the basin. High concentrations in the upper level of the water column suggest input from the river system as well (Strain 2000). Assessment of land based sediment sources indicate a strong possibility that significant inputs in the river continue to be a problem (see section *3.2 Sediment Sources*). These sediments are likely delivered to the basin near the mouth of River Denys during peak flow events.

Another issue that may affect both anadromous fish populations entering the basin and River Denys system and shellfish in the estuary is elevated water temperatures. In Environment Canada's 1999 Re-evaluation Report for Shellfish Growing Area 7(Craig, Young, Walter, Mennon and Dennis 1999), data collected for 1993, '96 and '98 shows North Basin water temperatures reached as high as 26^{o}C at several sites and was above 20^{o}C at most sites for many days throughout August in each of the three years. Similarly, Denys Basin proper hit 27^{o}C at a few sites in 1996, and consistently showed temperatures to be above 20^{o}C for much of August in all years. Such elevated temperatures may well inhibit Atlantic Salmon and Brook Trout smolt that are moving out of the river to the estuary. Smolts will often spend some time in an estuary to allow time to adjust to changes in salinity. However, with such elevated estuary temperatures it could be possible that smolts migrate directly to the lake, which has higher salinity, in order to reach cooler water temperatures. Such a stress may affect smolt survival.

The second effect that summer peak water temperatures in the Denys Basin area likely has is to reduce competition for oysters. Blue Mussels can compete with oysters for habitat, however, they are more sensitive to elevated temperatures. The low presence of Blue mussel in the basin could be due in part to the high summer water temperatures.

The rail line at Orangedale was installed in its current location in the 1880's. It is apparent from 1998 air photo review that there are elevated levels of algae growth on the land side of this long causeway structure. It has likely significantly altered local currents associated with the outlet of several small brooks draining into Blues Cove, and may magnify impacts from fecal Coliform sources in the inner cove. The Orangedale Water Society, incorporated in 2000, has identified within its action plan the investigation of potential sewage treatment and disposal alternatives for the community (Orangedale Water Society 2000).

4.1.2 Target Levels

A review of recommended Bras d'Or Marine Environmental Quality (MEQ) guidelines for the two target species, American oyster (*Crassostrea virginica*), and Winter Flounder (*Pseudopleuronectes americanus*) provide target levels for several key parameters (see Appendices D, E, F for a comprehensive listing). The estuary target levels are established by taking the species with the greatest sensitivity to a particular parameter and using it to establish estuary target levels. The results are presented in Table 8, as are the species from which the target is derived.

Table 8: Estuary water quality target levels.

Parameter	Trigger	Target Level	Species of Limit
PH		7.0-8.7	Canadian Water Quality Guidelines
DO_2 – Dissolved Oxygen	5.0 mg/L	>8.0mg/l (early life stages >9500μg/L^{-1})	General (Canadian Water Quality Guidelines)
Lower Temperature Limit	+ or – 10% of seasonal ambient	>20 ^{o}C	American Oyster
Upper Temperature Limit	+ or – 10% of seasonal ambient	<32^{o}C	American Oyster
Sedimentation	2cm	<1.0mm with no silt fraction	American Oyster
Turbidity	>1.0 g/L	<1.0 g/l inorganic dry wt.	American Oyster
Salinity	+ or – 10% of seasonal ambient	15 to 20 ppt	American Oyster
Fecal Coliform – Oyster harvest	>88 MPN or 10% above 260MPN	< or = 14 MPN/100ml	Background Level
Fecal Coliform – Human Contact		<200MPN/100ml	Background Level

4.1.3 Management Response

Two major issues with the basin water quality are fecal Coliform levels and sedimentation. Any activity to reduce fecal sources, whether it be fencing livestock from water bodies, to eliminating direct residential sewage effluent that is feasible should be implemented immediately. Although there are likely priority sources that should be addressed, all sources should be controlled. Accurate prioritization will not be possible until the results of an Enhanced Water Quality Sampling program is known. These samples for shellfish closures will not be officially evaluated until late 2001, and the data set may still be too small to draw conclusions (Craig, C. Pers. Comm. 2001). However, the target should be to eliminate all direct sources, and therefore activities to meet this goal can begin immediately. Once priorities are identified, cost effectiveness would dictate addressing the most significant sources first.

One of four management alternatives related to bacterial contamination will be derived from current sampling.

A. **No Seasonality, but positive correlation with rain events**. Efforts should be made to identify and reduce sources that may be exposed on the surface to weather events. Sources such manure piles, dairy/beef operation effluent, grazing fields, and any residential discharge into lowland areas or surface features should be identified and corrected as quickly as possible.
B. **Seasonal and no apparent correlation with rain events.** This would support the idea that the source is primarily seasonal cottage use. The management approach should target reduction in both permanent residence and seasonal residence untreated sewage effluent reaching the basin. Both are problematic, however a critical threshold is passed with the additional inputs from seasonal residences.
C. **No seasonality or apparent correlation with rain events**. If there is no correlation with rain events, an no apparent seasonality to bacteria levels then permanent residences should be the primary target of management efforts that are directed at sewage effluent treatment. However, it would be inappropriate not to include seasonal residences in a management plan.

D. The final scenario is**, seasonal and correlation with rain events**. This would indicate the primary sources to be seasonal residence followed closely by surface sources such as farming operations. In such a case the guiding principal referred to in 6*.0 Prioritization and Recommendations* of “Best First Worst Last” would be a sound strategy. That is to say tackle the easier and less expensive sources to fix first and move along until all are addressed or acceptable water quality is achieved.

Sanitary Shoreline Surveys exist for the River Denys Basin and North Basin and are currently being completed for the lower River Denys by Eskasoni F&W. This information provides an opportunity to immediately try to reduce known fecal contamination sources. This activity should be carried out regardless of the magnitude of impact of river versus coastal sources. However, the priority for remediation is likely to be based on the identification of the greatest source.

In Blues Cove, high Coliform level is related primarily to residential homes. Given the number of residences, some form of community treatment system is required. The Orangedale Water Society, whom has identified the issue of sewage effluent from the community as key concern, should be encouraged and supported in addressing this issue.

It is recommended that a high priority be given to confirming and then addressing fecal Coliform sources in areas where the sources are few, and potential to significantly improve local water quality is great. There are such sites at Morrison Cove, the mouth of River Denys, Seal Cove, Effie’s Cove, and MacLean’s cove at the mouth of MacKenzie Brook. Conducting field sampling based on the ‘Sanitary Shoreline Survey’ completed by Environment Canada and Eskasoni Fish and Wildlife in these areas to confirm sources is the recommended activity. Additionally, examining the areas outlined in the following text on each basin is a priority activity. The latter are expected to be key sources for the individual basin areas. It is felt that, in of themselves, these potential sources could provide reasonable possibility of reopening shellfish areas if they were eliminated.

Field assessment of Morrison Cove should be undertaken to try and identify fecal sources. This cove has no apparent development other than a roadway on the land base draining into the cove, and therefore it should not exhibit elevated Coliform levels. Therefore, some exploration of the drainage must be made to try and identify anything that could cause elevated levels of Coliform bacteria. Likely a single source is responsible, and once found and corrected could possibly allow for a shellfish opening in the cove.

The area around the Marble Mountain Road Bridge crossing the mouth of River Denys was one of the first shellfish closure areas in the basin. The algal mat at the mouth of Allan’s Brook where it enters River Denys is a likely indicator of high levels of nutrients (Figure 14). There appears to be very little development in the small drainage with the possible exception of a couple houses, and the existence of what maps show as a community hall. The latter could certainly be a high source of nutrient input if community events are hosted frequently at the hall. If sewage treatment does not exist for this building, then it may be a key source to reduce through proper treatment. This in general may be a feasible strategy to addressing high volume fecal Coliform sources. Addressing treatment at public places of meeting would be a sound strategy prior to facilitating wider community sewage treatment. The high density of housing on both the North and South side of the Marble Mountain Road Bridge also lends itself to a shared treatment facility that may be more economically feasible to implement than individual systems. If sources of fecal waste are confirmed from these buildings, such a facility is recommended.

Seal Cove, like the area at the mouth of River Denys, has been a long identified, consistent area of fecal contaminated water. Air photo review shows that there are few potential sources from the land base drained by Little Blues Brook, MacKenzie Brook and MacLeans Brook, all which enter the head of Seal Cove. Therefore, fecal sources are likely to be from development on the coastline. There are two farms on the coast between MacKenzie and MacLeans Brook and approximately five homes in a small area near MacLeans Brook. In particular, one farm appears to have surface drainage running through the center of the operation and very near the barns (Figure 13), and should be carefully assessed as a key source. All of the locations should be evaluated for sources of fecal Coliform, and addressed, for it is possible that the closure at Seal Cove could be lifted if the apparently few potential sources in that location were addressed.

Immediately around Effie's Cove there are few residences. However, approximately six exist on Kennedy Brook, which enters the inner part of the cove from the east as far away as MacLean's Cove. Inland of MacLean Cove there appears to be a farm and barn only meters from Kennedy Brook. Water sampling on Kennedy Brook would help indicate the magnitude of fecal Coliform sources entering Effie's Cove from this tributary.

At the small cove into which Mackenzie's Brook enters there is a long standing shellfish closure, yet only a couple potential fecal Coliform sources are apparent. One residence exists on the cove, and one upstream on the Glen ponds. Sampling in Mackenzie's Brook would help confirm if either the coastal or upstream sources are more significant than the other. It is reasonable to expect that by addressing a limited number of sources, this small cove could be reopened for shellfish harvest.

The second issue of sedimentation needs to be addressed as to the magnitude of past and current impact. Key activities to reduce associated impact are addressed under *Section 3.2 Sediment Sources* and activities to evaluate impact and rehabilitation are discussed in *4.2 Marine Ecosystem Health*. As this is an impact currently identified with the land base, no coastal activities are recommended.

4.2 Marine Ecosystem Health

As with the fresh water evaluation, a target species (s') must be identified. Within the estuary the key desired species are the American oyster (*Crassostrea virginica*), and Winter Flounder (*Pseudopleuronectes americanus)*. A key predator species is the Green crab. Therefore, this report will evaluate estuary conditions relative to the presence and survival of those species.

4.2.1 Current Conditions

The DFO recently conducted a depth sounder survey throughout the River Denys estuary in order to map habitat types and to identify potential oyster habitat within the project area. It is felt that this will provide information for two key management considerations. One, it will allow for closer assessment of habitat quality in order to determine if any remedial action might be undertaken. Second, it will allow for estimation of the total potential oyster production of the estuary, and its associated economic benefit. Both bottom type and bathymetry were recorded by the process. The multi-beam scan of the River Denys basin in 2000 has produced a bathymetric map of the bottom contours, and a color depiction of substrates. However, until field sampling confirms which substrate types are being represented by the color separations, analysis of data to determine areas by habitat type is not possible. Such complete analysis may not be available through conventional means for one to two years (pers. com. Paul 2001)

There has been a high volume of land clearing in recent years both between MacLean Cove and MacLean Point separating the North Basin and Denys Basin, as well as from Seal Cove east to Barra Mens Cove on Denys Basins' northern boundary. Although this has resulted in the ground being exposed in areas of these sites, sediment delivery has likely been non-significant due to the flat topography and the fact that shoreline buffers were frequently left in tact.

There has been recent clear cut logging adjacent to MacKenzie Brook that enters MacLean Cove. The cutting has taken place on very steep ground and the potential exists for surface erosion to occur, and enter the brook and cove via the adjacent road ditch line and small tributary.

The appearance of Green crab in the basin is a reasonably new occurrence. This introduced species is felt to have had some significant effects on oyster, one of its prey, within the basin. A survey of Green crab in the basin has been conducted by Fisheries and Oceans, however, the data is yet to be analyzed. A series of trap sets at twelve locations in River Denys Basin in August of 1999 produced 145 Green Crab. The highest densities were found at MacLeans Point, West of Neilys Point, and Cassels Cove. Three traps were set at each location and left for approximately 5 hours.

Eskasoni Fish and Wildlife Commission completed a very comprehensive resource mapping project that included River Denys Basin in 1996. Terrestrial and aquatic species were mapped based on existing and elder knowledge of the area. Shoreline habitats and current oyster leases were also mapped.

4.2.2 Target Levels

Given the identified target species, the target level of habitat quality parameters show that there needs to be a mix of hard bottom habitats with virtually no sediment for the shellfish species and sandy to soft mud bottom for the Winter Flounder. Target levels of area that each of these habitat types cover should approximate historic levels.

Table 9: Estuary ecosystem health target levels.

Parameter	Target Level	Source
Hard bottom areas	72 hectares	Historic level estimate

4.2.3 Management Response

Oyster production in 1995 was 355lb/ha/yr in South River Denys Basin (Reardon 1997), estimates for 1984 were 625lbs/ha/yr. Back calculating it estimates the total shellfish area to be approximately 72 hectares in area. Leases that were fished in 1984 but are closed in the present day represent 43 ha of area. This figure could be compared to current multibeam results as they become available to try and estimate the total area and location of shellfish habitats that may have been eliminated by sedimentation. If significant, it would warrant consideration for rehabilitation of hard bottom habitat through addition of new substrate or fixing of the old. It is anticipated that any losses would likely have occurred only at the mouth of the River Denys, as this would be the main source, and poor water circulation within the basin would allow sediments to quickly drop out of the water column a short distance from the mouth of the river.

An information gap exists in the estuary portion of the watershed that inhibits integrated management planning. To address this need, it is recommended that a detailed habitat quality and distribution project be undertaken, with particular attention to the target species of oyster and flounder. There is documented herring spawning on both the inside and outside of Malagawatch, and determining stock status, along with that of oyster, would provide an indicator of coastal health, and relative location and priority of coastal and basin management options.

It is recommended that anecdotal evaluation of habitat types based on knowledge by resource users could be used to relate results of the multibeam data collected in 2000. This would provide a short term, reasonably accurate calculation of current hard bottom habitat volume as they may relate to oyster production. This would allow determination of the percent of useable natural habitat that is currently affected by closures, and further allow for calculation of potential economic productivity of those closed areas such that a cost benefit evolution of eliminating known fecal Coliform sources could be completed.

Leases that were fished in 1984 but are closed in the present day represent 43 ha of area and 24, 600 lbs of oysters in Denys Basin. This, in conjunction with the estimates from the 2000 multi-beam assessment, provides some cost benefit information for managers to consider by allowing the calculation of the potential economic benefit versus the cost of eliminating fecal Coliform sources and re-establishing historic shellfish areas.

It is recommended that shoreline development guidelines be created for the Denys and North Basin areas. There exist many valuable natural resources in this area. Given recent recreational and aquaculture development along with the future potential of the same, natural resources are going to increasingly come under pressure. Local residents should provide their regulating agencies with the appropriate background information in order that they can provide sound development guidelines. To facilitate development of meaningful guidelines, it is suggested that the Eskasoni Fish and Wildlife coastal resources map be further developed to include more on habitats and not just presence of species. Two initial activities are suggested.

The first, is once bathymetric map products from Fisheries and Oceans multi beam assessment are available, they be evaluated in conjunction with the Eskasoni Fish and Wildlife coastal resources map to try and correlate observed presence of species with distinct habitat features of the basin. The second is the mapping of coastal habitats. During air photo review, numerous brackish ponds, marsh areas, sand spits, dunes and other potentially sensitive habitats were observed. Given the small size of the basin, it is recommended that a coastal habitat biologist complete an air photo review and field assessment of habitats in the basin area, and that those sensitive habitats, along with bottom habitats be amalgamated with the Bras d'Or Lake Coastal Resource maps for the basin areas. These maps should then be made available to potential developers and agencies responsible for approving development and aquaculture in the project area.

Finally, the suggestion of hard bottom habitat loss due to sedimentation has been made. It is possible, although likely only near the mouth of River Denys, as poor basin circulation would likely have caused land based sediments to drop out of the water column a short distance from the river mouth. Based on potential current sediment sources observed in the watershed (section *3.2 Sediment Sources*), it is recommended that no effort be undertaken to create or rehabilitated oyster habitat in the basin until sediment sources are arrested or confirmed as being insignificant.

5.0 Watershed Condition Summary

Overall, information collected to date appears to indicate that impacts in the headwater reaches of the watershed are moderate, and both habitat and water quality are generally in acceptable condition. In the lower reaches of River Denys and its tributaries, human impacts are more apparent. Assessment will determine magnitude of the impacts, but priority issues inland of the basin are degraded water quality, chronic sedimentation, impaired riparian zones, and poor quality stream. habitats. Human impacts continue and even culminate in the basin area of this IMP project area. That makes it difficult to determine whether impacts in the estuary significant, for they are camouflaged by obvious land based impacts being delivered through the river. However, several key coastal fecal coliform sources are expected to be largely responsible for a few of the smaller shellfish closures.

The IMP presents in Table 11 activities to fill information gaps and rehabilitate impacts. Based on existing information a reduction in fecal contamination from farmland and residential sources will need to be carried out to achieve shellfish openings. Significant stream habitat and riparian improvements will need to be made in order to re-establish proper nutrient cycling and salmonids populations. Finally, sediment sources will need to be arrested in the mid to lower reach areas of the River Denys watershed to stop ongoing impact to both freshwater and estuary habitat.

Although the impacts in the project area are many, they come from a diverse array of land uses causing a cumulative impact. That means that no one group of users will need to bear the brunt of changes to improve conditions. Instead, small changes by all users will yield great returns in environmental quality and ecosystem productivity.

6.0 Prioritization and Recommendations

There are three principals that should be considered in prioritizing future management activities within the River Denys basin. They are not strict rules, but very well founded guidelines learned by other programs that should be adhered to as much as possible. They are:

- **Preservation of remaining environmental assets as the most important concept–** Australian Rehabilitation Manual.

This concept seems simple at first glance but inevitably ends up being one of the most difficult to enact. We can never duplicate through restoration an ecosystem that is undisturbed due to the intricacies of food webs, water cycles, nutrient cycles and so on. The best that we can do is also extremely expensive. Usually, inhibitively so. Even if we can satisfactorily rebuild affected watersheds and coastal areas, if a species has been extirpated or driven to extinction, our works have arrived too late. Therefore it is of utmost importance to preserve those remaining environmental assets to the best of our ability. This means protection of undisturbed or minimally disturbed areas and better management on those lands and water bodies already impacted.

- **Best First, Worst Last approach -** US Forest Service Pacific Northwest Region.

This concept is based on the notion that we often want to go and fix what is most visibly damaged. Unfortunately, that means we are often tackling the most expensive job with the greatest chance of failure due to the inherent risks that are associated with a badly degraded environmental asset. It is therefore worth considering the start of a rehabilitation effort with the easier and cheaper activities that are bound to be successful. That means a positive effect is almost immediate, unstable or high risk areas have a little more time for natural recovery, and a system in which the small issues have been addressed is more likely to accommodate the larger failure impacts. This principal may not always be appropriate to follow if for example the risk associated with not addressing the worst factors early on jeopardizes all other activities beyond an acceptable limit. However, it is another sound consideration to determining the proper course of action.

- **Start at the top and work down -** British Columbia Watershed Restoration Program.

Whether trying to improve fish habitat, water quality or some other ecosystem component it is a good general practice to work from high ground toward the lowest areas in the project location. Estuary projects to create new hard substrates for shellfish are compromised if the sediment sources in the watershed above are not fixed first. Planting riparian vegetation in the lower areas of a watershed to cool water temperatures does not work effectively if temperatures are already elevated from passing through exposed areas upstream. Fixing sources of Coliform in an estuary will not yield desired results if sources in the river that enters the basin are not eliminated first. The one exception is in strict habitat improvements for anadromous fish. The stream is like a ladder and if the lower rungs don't exist the fish still can not reach the rehabilitated habitat in the headwaters. However, extreme care must be used in this example for if upstream issues are not adequately addressed the risk of impact to downstream investments still is supported by the general rule of thumb to work from the top of the watershed down to the estuary.

There must be two levels of priority setting for future activities in the River Denys basin. The first is at the watershed level perspective and answers questions like: Should stream habitat or water quality be addressed first? These watershed level priorities are presented in Table 10. Although they are presented as 'very high – low' priority, that is a relative measure, and all issues are significantly important to warrant activity. The results are based on the three guiding principals laid out above and the ability of an action to address the key issues and questions presented in *Section 1 Key Issues and Questions*. A commentary on the justification for ranking an activity is provided so that the reader can further evaluate if all factors have been adequately considered. For details on each activity refer back to the relevant section in the preceding report.

Table 10: Summary table of watershed level priorities.

Rank	Activity	Justification
1 – Very high	**Water Quality - Freshwater**	This watershed level component receives highest ranking because it most directly addresses the largest number of Key Issues and Questions. It is ranked higher than estuary water quality because it is likely a significant contributing factor to poor estuary water quality and will therefore indirectly address that issue. Ultimately it receives highest ranking because water is the key building block for all living organisms and if water quality is compromised none of the other ecosystem component management activities will have any significant benefit. Finally, there is a strong economic argument for addressing the land based water quality due to potential gains in shellfish harvest, and recreational/food fisheries.
2 – Very high	**Sedimentation – Freshwater**	Closely related to the first watershed level component, sedimentation from the land based portion of the project area is a high priority. It addresses many of the Key Issues and Questions, but is ranked second to overall water quality due to the fact that some sedimentation within a system is natural and species and landscapes can often adapt and accommodate seasonal or temporary sediment increases. Until observed sediment sources are eliminated, efforts to rehabilitate freshwater and estuary habitat be exposed to greater risk of failure and a lower degree of ultimate success.
3 - High	**Water Quality - Estuary**	The water quality of the estuary is extremely important in addressing the key issues and questions of the IMP. Priorities 1 and 2 above are necessary to fully improve water quality in the estuary. However, localized success is likely by addressing keystone problem sources for individual coves. The huge economic potential through reopening closed shellfish areas makes estuary water quality a high priority.
	Habitat –	Only once acceptable water quality is confirmed and upslope risks are adequately

4 – High	**Fresh Water**	addressed is large scale in stream investment warranted. Access to habitat and diversity of habitat features appears impaired and are priorities that need to be addressed to increase system productivity.
5 - Moderate	**Riparian areas**	Riparian area management directly addresses only one of the Key Issues and Questions – fresh water fish habitat quality. However, the lower ranking of this component should not be interpreted to mean it is less important ecosystem component. Contrarily, the establishment of healthy riparian buffers is the long term solution to many ecosystem problems such as habitat, stream stability, water quality, sedimentation and so on. Activities undertaken in the previous steps are shorter term solutions that prevent greater ecological damage. However, the riparian areas are the insurance policy for future ecosystem health. These activities can begin as soon as any other if sufficient resources permit, and must be completed to achieve long term success.
6 – Low	**Hydrology**	This ranks low for local assessment or activity because those hydrological influences that can most be affected will likely have been reasonably addressed in higher ranked activities. However, large scale planting or drainage alignment may still be required to more fully reduce impacts to basin hydrology, and drainage alignment is necessary in some basin locations.
7 – Low	**Habitat – Estuary**	Estuary habitat is the next greatest ecological component to address. Once activities have been initiated to improve water quality and sedimentation from the land base efforts to improve the estuary health will be much more effective. It is ranked lower because habitat impacts seem to be minimal, and achieving shellfish openings through water quality improvements are of greater ecosystem value than creating new habitats. Preventing future impact from development is of greater importance. However, a high priority activity within this category is quantifying habitat quality and distribution, and determining stock status for oyster and herring.
8 - Low	**Sedimentation – Estuary**	This is lowest priority because there are currently no significant estuary based sources of sedimentation. Therefore, in order to address this estuary issue, land based sources must be reduced. This is reflected in the number 2 ranked priority Sedimentation – Freshwater.

The second level of priority setting is at the ecological parameter level, and addresses questions like: To reduce sedimentation in the basin should we fix road related sources or stream bank erosion problems first? These parameter level priorities are presented in Table 11. Details of these activities are further explained in the relevant sections of the preceding report.

Table 11: Summary Table of priority activities for River Denys project Area.

Rank	Activity	Explanation
1	**Water Quality – Freshwater**	
1-1	Evaluate Enhanced Water Quality Sampling Results	Fecal Coliform, temperature, nutrient data should be evaluated at 'worst case scenario' times to confirm if problems exist. Water quality should meet trigger levels at a minimum.
1-2	Obtain and review landfill sampling results	Local community should obtain results of surface and groundwater sampling around the Big Brook landfill site in order to assess impacts and feel comfortable with the facility. Data may provide additional information eliminating the need for collection under 1-3 on Big Brook.
1-3	Carry out activities to identify and resolve source of other water quality issues	Carry out additional water quality sampling to determine if problems exist with temperature, DO_2, or suspended solids in the main river or any of its primary tributaries.

1-4	Develop a list of activities to address water quality issues	When the three activities above are completed a list of activities can be developed to address identified issues if any arise. In the case of stream temperature, and suspended solids activities may already be implemented under other recommendations presented here, or simply require that those activities become of higher priority.
2	**Sedimentation – Freshwater**	
2-1	Ground truth identified sources of sediment	Several sources of sediment have been identified based on 1998 air photos. Those sources need to be confirmed as still being significant, and rehabilitation plans developed for those that are problems. Target areas exist on Glen Brook, Big Brook Cameron's Brook, Kennedy Big Brook, and River Denys.
2-2	Rehabilitate confirmed sediment sources	Those sites in 2-1 above that are confirmed sediment sources should immediately undergo rehabilitation.
2-3	Conduct a stream impact survey	A survey of River Denys and its major tributaries should be undertaken to determine the impact of past and current sediment sources of habitat and channel stability.
2-4	Stabilize bars in over widened stream segments	Once a program is initiated to arrest sediment sources, a large scale activity of stabilizing sediment wedges in the identified tributaries and mainstem River Denys should be implemented. Initial stabilization projects should be through willow/alder staking of selected areas.
2-1	Monitor / evaluate sediment reduction	Install plastic bucket sediment traps in River Denys and major tributaries to quantify level of sedimentation and serve as a long term means of monitoring and evaluation.
3	**Water Quality – Estuary**	
3-1	Confirm 'key' fecal Coliform sources	Potentially 'key' fecal Coliform sources have been identified for Seal Cove, Effie's Cove, MacLean's Cove, and the mouth of River Denys. These should be confirmed with field visits and sampling to allow for effective reduction of fecal sources aimed at achieving small shellfish openings.
3-2	Reduce fecal input from identified coastal sources.	Any sites confirmed in 3-1 above should immediately targeted for reduction. Key target areas that, due to small size could result in nearly immediate shellfish openings with reduction of direct input sources, include Morrison Cove, Seal Cove, Mackenzie's Brook west of MacLeans Cove, and Effies Cove.
3-3	Review Enhanced Water Quality Monitoring Data	This data, when it becomes available, should be reviewed to help target additional key fecal Coliform sources for reduction activities.
4	**Ecosystem Health – Fresh Water**	
4-1	Design and implement mainstem holding habitat.	Primary holding pools in River Denys should be enhanced/created to improve adult anadromous salmonids access to the watershed. Professional siting and design should be carried out at low flow and implemented as soon as possible.
4-2	Assess fish passage at watershed culverts	Culverted road crossings should be assessed in the watershed for passage of juvenile Atlantic salmon. A priority list of sites to restore access should be created.
4-3	Restore fish passage at culverts.	Based on the assessment in 4-2, priority culverted road crossings should be removed, replaced, or modified to ensure juvenile Atlantic salmon passage.
4-4	Document Glen Brook and McLennan Brook habitat	This is a higher priority than general stream habitat assessments as it serves the purpose of documenting productive habitat for monitoring of change and establishment of a potential template for other rehabilitation activities. This should be done prior to any in stream activities that might take place in 4-6.
4-5	Conduct a watershed level assessment of fish habitat	Determine degree of habitat quality and prioritize areas for rehabilitative work based primarily on importance to limiting habitat of target species, anticipated likelihood of success, and acceptable limits of risk and cost.

4-5	Carry out stream rehabilitation activities.	Start with establishing primary habitat units in high priority areas. Do not go into high risk areas that are unstable or extremely high energy if less risky alternatives exist. Later revisit initial projects areas to determine if greater habitat and hydraulic complexity can be achieved by additional in stream works. High priority candidates include lower McLennan Brook, Big Brook, Glen Brook, and River Denys.
5	**Riparian areas**	
5-1	Carry out mainstem /major tributary riparian planting	Areas that do not meet NSDNR guidelines for riparian buffers should be planted immediately. Planting will need cooperation of private landowners and be based on the prescription of a riparian specialist. The main target areas are the River Denys mainstem from the confluence with McLennan Brook downstream to the head of tide, lower McLennan Brook, and Big Brook at the mine site and its lowest reach.
5-2	Carry out riparian assessment of pole/sapling areas	A on site assessment of any riparian areas that currently are in a pole/sapling stage should be evaluated by a riparian specialist. There is potential that stand modification could greatly speed the stand change to the desired mature mix through activities such as releasing conifers, girdling, patch planting. These activities should be high priority for areas where all riparian functions are not currently being met, high fisheries values exist, and landowners are supportive of stand modification.
5-3	Carry out riparian modification.	Rehabilitation prescriptions from 5-2 for stand modification could be initiated immediately based on identified priorities. Prescriptions should be developed by a riparian specialist.
6	**Ecosystem Health – Estuary**	
6-1	Quantitatively assess bottom habitats	Historic oyster lease information, and new depth sounder mapping of basin morphology and substrates should be used in conjunction with anecdotal knowledge of hard bottom habitats to quantitatively estimate potential area, production and economic benefit of oyster rearing areas in the basin in areas closed to harvest due to fecal Coliform contamination.
6-2	Complete stock status assessments	Conduct a stock status assessment for oyster and herring both within the basin and around Malagawatch.
6-3	Assess other estuary habitats	Conduct a basin habitat assessment for sensitive coastline habitats and a review of recent depth sounder morphology data to identify critical and sensitive habitats in the basin area for target species, shoreline birds, and nursery / rearing / spawning habitats of other valued species.
6-4	Create shoreline and aquaculture development guidelines / recommendations	Based on the information collected in 6-1 and 6-2, shoreline and aquaculture development guidelines should be created for the basin area as greater pressures from these activities are expected to occur. Protection and proactive management of high value natural resources is much more effective than trying to rehabilitate area post development.
6-5	Carry out rehabilitation of impacted estuary habitats	The previous three activities may identify impacted coastal habitats. Rehabilitation plans could be developed for critically impacted areas. Rehabilitation /creation of oyster habitat may be appropriate if 6-1 does not reveal similar volumes of habitat to historic times AND land based sediment sources have been arrested.
7	**Hydrology**	
7-1	Carry out drainage alignment at old Big Brook mine site.	A full review of the drainage from the Big Brook mine site should be undertaken and natural networks reestablished where possible to eliminate hydrological impacts to this basin and reduce the risk of failure at sites where water is being dammed by inactive roadways.
7-2	Begin replanting and road deactivation	The importance of this activity is hard to quantify without a full hydrologic assessment. However, it can only benefit the ecosystem and the road deactivation

		with also greatly reduce the risk of long term sediment impacts, fish barriers. Therefore, converting any inactive agricultural lands and the old Big Brook mine site back to forested land, and the semi-permanent deactivation of inactive roads is recommended.
7-3	Establish a hydrometric station on River Denys	Establish a semi permanent hydrological station. This will serve two purposes. First it will allow quantification of local hydrology and evaluate if it has been significantly impacted. Second, the station will help track the effectiveness of changes that may occur due to changes in land use and rehabilitation.

Project activities to be undertaken.
Data gaps to be filled by information collection.

7.0 Current Monitoring and Evaluation

Table 12 outlines groups that are currently collecting data or carrying out projects in the River Denys project area. This table is likely not comprehensive, but lists many of the groups. Contacts have been provided where possible to allow groups to more easily coordinate activities with others in the basin, thereby not duplicating efforts and allowing shared resources when possible to increase efficiency. Most of these activities have been assessed and incorporated into the current IMP. Some of these activities, and many others, may be found in further detail on the world wide web at http://qlinks.ucs.mun.ca/brasdorstart/english.htm. This site, called PIKS or Paqtatek – Prisim Inter -active Knowledge System is " a community driven, web-based knowledge system serving citizens, governments, aboriginal groups, private sector and non-governmental organizations in their efforts to protect and enhance the ecological, social and economic integrity of the Bras D'Or Lakes Watershed, Cape Breton Island, Nova Scotia".

Table 12: Current activities and groups active in the River Denys project area.

Group or Person	Activity	Status
Dr. David Spear, Atlantic Veterinary College PEI on behalf of ADI Ltd. for Georgia Pacific– Fred Baechler, ADI Ltd. Sydney, NS.	Measuring parasite load on fish in Glen Brook as a measure ecosystem health/habitat quality. This is being done in partnership with ADI Ltd. as part of a salmonids management plan for Glen Brook on behalf of Georgia Pacific.	Initiated 2000, ongoing.
ADI Ltd. on behalf of Georgia Pacific – Fred Baechler, ADI Ltd. Sydney, NS.	Glen Brook fish habitat assessment work, and management plan.	Plan completed in 2000, works expected in 2001
ADI Ltd on behalf of Georgia Pacific– Fred Baechler, ADI Ltd. Sydney, NS.	Melford Mine site assessment area water quality analysis (six sites), including one site on River Denys. Utilized EF&W to collect data and provide First Nations background.	Completed 1999
Stewards of the River Denys – local residents in partnership with DFO Habitat Branch – Duncan McLean, River Denys or Shayne McQuaid, DFO	Dealing primarily with freshwater fish habitat issues this group has been collecting some water quality information, but primarily focused on habitat assessment and rehabilitation projects	Works and assessment carried out in 2000, ongoing.
Denys Watershed Advisory Group – local residents, EF&W, Env. Can., DFO, - Dave Duggan DFO	Dealing with estuary issues, this volunteer group is focusing on marine water quality issues, and oyster impacts as two of their major issues.	Initiated in 1997, formalized in 2000, ongoing.
Environment Canada – Chris Craig, Bedford Institute of Oceanography	Shellfish Area Assessment and Shoreline Survey – carried out every three years by Environment Canada to identify shellfish harvest areas that should be open or closed due to water quality issues, primarily fecal Coliform, and conduct a survey that	Last Assessment was in April 1999

	identifies potential sources.	
Eskasoni Fish and Wildlife – Lorraine Marshall	Sanitary Shoreline Survey – this is a continuation of the Environment Canada shoreline assessments and is taking place in the lower reaches of River Denys.	Ongoing fall 2000

Table 12 con't

Group or Person	Activity	Status
Eskasoni Fish and Wildlife	Bras d'Or Lakes Coastal Resources Mapping Project mapped terrestrial and aquatic species of flora and fauna, as well as current shoreline types and oyster leases.	1996
Nevin Gaudet, College of Geographic Sciences with DFO, Dave Duggan	Orthorectification of 1993 air photos of the River Denys Watershed and basin area for incorporation into a GIS as a background layer over which other data layers could be laid.	Completed 2000.
Orangedale Water Society – Tom Gunn	To supply and preserve the delivery of water to the residents of the community of Orangedale.	Incorporated 2000
Eskasoni Fish and Wildlife in partnership with DFO-Kara Paul, EF&W	Green Crab Study	Data collected 1999, analysis ongoing
Eskasoni Fish and Wildlife in partnership with DFO	Enhanced Water Quality Sampling Program in the basin area and lower River Denys to highlight Fecal Coliform contamination fluctuations as they may relate to shellfish harvest.	Started fall 2000, ongoing.

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9.0 Appendices

Appendix D – Marine Environmental Quality Guidelines for Winter Flounder in the Bras d’Or

Location: **Bras d'Or Lakes**

Species: Winter Flounder (Pseudopleuronectes americanus)

Specific Ecological Requirement	Egg	Trigger Levels	Larvae	Trigger Levels	Juvenile	Trigger Levels	Adult	Trigger Levels
Oxygen	no data	< 100% saturation	no data	< 100% saturation	no data	< 100% saturation	no data	< 100% saturation
pH	no data	+ or - 10% of seasonal ambient	no data	+ or - 10% of seasonal ambient	no data	+ or - 10% of seasonal ambient	no data	+ or - 10% of seasonal ambient
Salinity	15 to 35 ppt	+ or - 10% of seasonal ambient	3.5 to 27.7 ppt	+ or - 10% of seasonal ambient	4 to 30 ppt	+ or - 10% of seasonal ambient	5 to 35 ppt	+ or - 10% of seasonal ambient
Substrate	N/A	N/A	sand to sandy-silt	measurable change in ambient	sand	measurable change in ambient	soft mud and sand	measurable change in ambient
Sedimentation	N/A	N/A	pelagic	N/A	N/A	N/A	N/A	N/A
Temperature	-1.8 to 15 C	+ or - 10% of seasonal ambient	4 to 13 C	+ or - 10% of seasonal ambient	0 to 25 C	+ or - 10% of seasonal ambient	-1.5 to 28 C	+ or - 10% of seasonal ambient
Turbidity	no data	no data	no data	no data	no data	no data	no data	no data
Ambient Temperature	2 to 16 C		Ambient Turbidity	0.032 to 1.14 mg/l inorganic dry wt				
Ambient Salinity	20.96 to 24.04 ppt		N/A= Not Applicable					

Appendix E – Marine Environmental Quality Guidelines for Blue Mussels in the Bras d'Or

Location: **Bras d'Or Lakes**

Species: Blue Mussel (Mytilus edulis)

Specific Ecological Requirement	Egg	Trigger Levels	Larvae	Trigger Levels	Juvenile	Trigger Levels	Adult	Trigger Levels
Oxygen	no data	< 100% saturation	no data	< 100% saturation	no data	< 100% saturation	no data	< 100% saturation
pH	no data	+ or - 10% of seasonal ambient	no data	+ or - 10% of seasonal ambient	no data	+ or - 10% of seasonal ambient	no data	+ or - 10% of seasonal ambient
Salinity	5 to 35 ppt	+ or - 10% of seasonal ambient	15 to 35 ppt	+ or - 10% of seasonal ambient	5 to full seawater	+ or - 10% of seasonal ambient	5 to 35 ppt	+ or - 10% of seasonal ambient
Substrate	N/A pelagic	N/A	N/A	N/A	solid	measurable change in ambient	solid	measurable change in ambient
Sedimentation	N/A pelagic	N/A	N/A	N/A	0 mm silt	> 0 mm silt	0 mm silt	> 0 mm silt
Temperature	15-20 C	+ or - 10% of seasonal ambient	15 to 20 C	+ or - 10% of seasonal ambient	10 to 20 C	+ or - 10% of seasonal ambient	-1.5 to 23 C	+ or - 10% of seasonal ambient
Turbidity	no data	> 0.25 g/l inorganic dry wt	no data	< 0.75 g/l inorganic dry wt	< 225 mg/l dry wt	> 225 mg/l inorganic dry wt	< 225 mg/l dry wt	> 225 mg/l inorganic dry wt
Ambient Temperature	2 to 16 C		Ambient Turbidity	0.032 to 1.14 mg/l inorganic dry wt				
Ambient Salinity	20.96 to 24.04 ppt		N/A= Not Applicable					

Appendix F – Marine Environmental Quality Guidelines for American Oysters in the Bras d'Or

Location: **Bras d'Or Lakes**

Species: American Oyster (Crassostrea virginica)

Specific Ecological Requirement	Egg	Trigger Levels	Larvae	Trigger Levels	Juvenile	Trigger Levels	Adult	Trigger Levels
Oxygen	100% saturation	< 100% saturation	100% saturation	< 100% saturation	100% saturation	< 100% saturation	> 1 ppm (ug/g)	< 1 ppm (ug/g)
pH	6.8 to 8.8	+ or - 10% of seasonal ambient	6.8 to 8.8	+ or - 10% of seasonal ambient	6.8 to 8.8	+ or - 10% of seasonal ambient	6.8 to 8.8	+ or - 10% of seasonal ambient
Salinity	10 to 22 ppt	+ or - 10% of seasonal ambient	25 to 29 ppt	+ or - 10% of seasonal ambient	15 to 22 ppt	+ or - 10% of seasonal ambient	5 to 30 ppt	+ or - 10% of seasonal ambient
Substrate	N/A pelagic	N/A	N/A pelagic	N/A	hard and clean of silt	measurable change in ambient	hard and clean of silt	measurable change in ambient
Sedimentation	N/A pelagic	N/A	N/A pelagic	N/A	< 1.0 mm with no silt fraction	> 1.0 mm and no silt fraction	< 2 cm with no silt fraction	> 2 cm with no silt fraction
Temperature	17.5 to 32.5 C	+ or - 10% of seasonal ambient	27.5 to 32.5 C	+ or - 10% of seasonal ambient	27.5 to 32.5 C	+ or - 10% of seasonal ambient	-1.7 to 36 C	+ or - 10% of seasonal ambient
Turbidity	< 0.25 g/l dry wt	> 0.25 g/l inorganic dry wt	< 0.75 g/l dry wt	> 0.75 g/l inorganic dry wt	< 10 mg/l dry wt	> 10 mg/l inorganic dryn wt	1.0 g/l inorganic dry wt	> 1.0 g/l inorganic dry wt

Ambient Temperature	2 to 16 C	Ambient Turbidity	0.032 to 1.14 mg/l inorganic dry wt
Ambient Salinity	20.96 to 24.04 ppt	N/A = Not Applicable	