Morice Watershed-based Fish Sustainability Plan

A Plan to Conserve and Protect Morice Watershed Fish Populations

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Chad Croft of Gartner Lee Ltd. wrote the previous version of the Fisheries Resources section (Section 3.0) of this report (Tamblyn and Croft 2003). The version in this report expands on his work.

EXECUTIVE SUMMARY

Purpose of the Watershed Plan

The purpose of the Morice Watershed-based Fish Sustainability Plan is to sustain robust fish populations and fully functioning aquatic ecosystems in the Morice River watershed. The goals of the plan are to:

- Maintain and protect existing fish habitat;
- Rehabilitate impacted habitat where identified as a priority; and
- Optimize quantity and quality of fish production while maintaining a natural species balance.

More detailed objectives of the plan are to:

- Provide background information and summarize the current state of knowledge of the fishery resources of the Morice watershed;
- Identify watershed issues including knowledge and data gaps;
- Identify projects to help address data gaps and other priority issues;
- Provide advice and recommendations to all parties with an interest in ensuring resource decision making conserves fish populations and aquatic ecosystems; and
- Recommend implementation and monitoring strategies.

Why Plan for the Morice Watershed?

The Fish Species

The Morice River produces significant numbers of salmon, steelhead and supports a wide array of resident fish species. The Morice watershed is one of the top three producers of non-enhanced salmon in the Skeena River system (Gottesfeld et al, 2002). For instance, one-quarter of the entire Skeena Chinook escapement spawns in the Morice watershed. Coho and pink runs are also significant. Recent escapements of steelhead, the prized sport fish in the watershed, are estimated to be between 3300 and 6750 fish. The sockeye run, about a tenth of what it was prior to the 1950s, is considered a conservation concern to the Office of the Wet’suwet’en. Resident species of fish include rainbow and cutthroat trout; char (Dolly Varden, bull trout and lake trout), kokanee, pacific lamprey, burbot, whitefish (3 species), suckers (3 species), minnows (Cyprinids) and sculpins (2 species).

A relatively good knowledge base exists for many of the fish species in the Morice watershed. Nonetheless, many information gaps remain. Basic distributions and life histories of salmon, trout and char are relatively well known, as are population trends for salmon and steelhead. However little population information exists for other species and the productive capacity of the watershed is not well understood.

The Importance of Fish

Morice fish populations are important economically, socially and ecologically. Aside from their inherent ecological value, fish are a foundation of the local and regional economy, of First Nations culture, and of the quality of life in the region. Steelhead trout and Chinook salmon are the basis of a world-renowned sport fishery in the Bulkley-Morice watershed that supports a significant tourism industry. The salmon that hatch and rear in the Morice also help maintain recreational and commercial fisheries on the northern BC and Alaskan coasts. Salmon and steelhead play important roles in First Nation culture as a food source, and for traditional and ceremonial purposes. To others, the fish runs are a reason to live in the Bulkley Valley - an amenity contributing to a rich quality of life. Finally, fish are a vital component of the food web, and of the energy and nutrient cycles within the aquatic ecosystem. These fish populations are worth conserving; planning is an initial proactive step in ensuring the sustainability of fish populations of the Morice watershed.

Previous watershed planning

The Bulkley-Morice Salmonid Preservation Group was working on a strategic plan for the Bulkley Watershed when Watershed-based Fish Sustainability Planning was introduced. The group decided to adopt the WFSP process to finish its planning. Because the Bulkley was too large for detailed planning, the watershed was divided into four planning units in Stage I of the WFSP. Of the four planning units, the Morice watershed was the one selected for detailed planning in Stage II of the WFSP due to its superior fisheries values, the relative abundance of available information, and the potential opportunities to protect quality habitat.

Activities Affecting Morice Fish Populations:

Fishing and land use are the two broad categories of human activities currently affecting Morice fish populations. Commercial, and in some cases, in-river fisheries have the greatest direct influence on anadromous fish populations within the Morice. Angling has also affected some populations of resident fish.

Wide-scale industrial land use is relatively young in the Morice, with forestry dominating development within the watershed since the early 1970s. Although, human impacts on the Morice watershed as a whole are relatively limited compared with more developed areas, logging activity has noticeably impacted some basins. In the future, cumulative effects associated with progressive forest road building, timber harvesting activities and other land use development could have significant future impacts on Morice watershed fish habitat and its productive capacity. Imminent extensive logging to salvage trees killed by mountain pine beetle poses additional risks to the aquatic environments of the watershed.

Generally though, fish populations and their habitat are in relatively good condition, providing opportunities to take proactive steps to mitigate impacts of resource harvest and development.

Plan Implementation

The Action Plan is the heart of this document. It identifies objectives and outlines 47 priority projects designed to help address knowledge gaps, significant issues, or risks in the watershed. Projects cover a range of activities including research, monitoring, stock assessment, modeling, planning, and best management practices.

The action plan is divided into three sections: land use management, habitat rehabilitation and fisheries management. The land use section identifies 22 projects separated into six categories covering issues related to lakes and rivers including water quality, water temperature, sediment loading and hydrologic integrity. The habitat rehabilitation section concentrates on developing a fish habitat rehabilitation plan, while the fisheries management section recommends 24 projects related to nine fish species.

Implementation of this plan will require volunteer collaboration among those organizations with a direct or indirect interest in managing aquatic resources, including WFSP participants and their organizations. To facilitate implementation, both contacts (project champions) and organizations with an interest or the mandate to conduct or oversee projects have been identified for each project.

Recommendations

Project Contacts and Implementing Organizations:

- Review the WFSP Action Plan regularly to help ensure that projects associated with your organization are brought forward during work planning or when a relevant funding source is found. Organizations with the responsibility for managing relevant aspects of the aquatic environment, or whose activities potentially impact waterbodies, will determine how each project fits into their regional and/or annual priorities;
- Collaborate with participants involved with related planning processes including the Innovative Forest Practices Agreement and the Morice Land and Resource Management Plan to encourage synergistic relationships;
- Work through existing research-based organizations like universities and the Bulkley Valley Centre for Natural Resources Research and Management to implement projects;
- Design projects to work effectively in an active adaptive management framework; and
- Consult with The Office of the Wet'suwet'en regarding projects initiated and conducted within the Morice watershed.

The Morice WFSP Technical Committee:

- Create a permanent group to implement the plan and meet at least annually to review and update the plan, to monitor plan implementation, and to address challenges and barriers associated with plan implementation;
- Incorporate the *Framework for Effective Watershed Monitoring* (Wilford and Lalonde 2004) developed by the Bulkley Aquatic Resources Board and the *Babine Watershed Monitoring Framework* (Price and Daust 2005) when developing a refined monitoring strategy for the plan;
- Work with project contacts and implementing organizations to integrate effectiveness monitoring into general operations in order to encourage long-term monitoring;
- Develop an agreement with the Northwest Data Sharing Network to incorporate data and results from completed projects;
- Create an extension plan to ensure knowledge gained from ongoing and completed projects reaches other interested parties;
- Work through organizations and funding sources to secure funding to coordinate the technical committee and the implementation of the WFSP

Fisheries and Oceans Canada and Province of BC

- Clarify policies and support for WFSPs and determine your role as plan custodians. WFSPs will require long-term funding and/ or coordinating support if they are to succeed.

Resource Managers:

- Adopt precautionary management approaches when uncertainty and / or high risks exist regarding potential direct and cumulative impacts of resource management activities on aquatic environments and fish populations.

Other

- Consultants, community groups, First Nations, forest licencees, government agencies interested in conducting a particular project should communicate with the project contact.

Next steps

The final stage of the WFSP process (Stage IV) puts the plan into action. This involves finding the funding and human resources to conduct the projects in the action plan. As the plan is implemented, opportunities exist to modify the plan as projects and priorities evolve, as new projects are identified, and as monitoring provides feedback.

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AT	Alpine Tundra
BEC	Biogeoclimatic Ecosystem Classification
BMP	Best Management Practice
BMSPG	Bulkley Morice Salmonid Preservation Group
BT	Bull Trout
CFDC	Community Futures Development Corporation
CWD	Coarse Woody Debris
CWHws	Coastal Western Hemlock wet submaritime
DFO	Fisheries and Oceans Canada
ESSF	Englemann Spruce-Subalpine Fir
FERIC	Forest Engineering Research Institute of Canada
FIA	Forest Investment Account
FISS	Fish Information Summary System
FRPA	Forest and Range Practices Act
GD	Gallons per Day
HCTF	Habitat Conservation Trust Fund
IFPA	Innovative Forest Practices Agreement
LRMP	Land and Resource Management Plan
LWD	Large Woody Debris
LWBC	Land and Water British Columbia Incorporated
LT	Lake Trout
MELP	Ministry of Environment, Lands and Parks
MHmm	Mountain Hemlock moist maritime
MOF	Ministry of Forests
MSRM	Ministry of Sustainable Resource Management
N/A	Not Applicable
PSARC	Pacific Science Advice Review Committee
SBS	Sub-Boreal Spruce
SFMP	Sustainable Forest Management Plan
TSA	Timber Supply Area
UBC	University of British Columbia
WFSP	Watershed-based Fish Sustainability Planning
WLAP	Ministry of Water, Land and Air Protection
WRP	Watershed Restoration Program

1.0 INTRODUCTION

1.1 What is Watershed-based Fish Sustainability Planning?

Watershed-based Fish Sustainability Planning (WFSP) is a planning process focused on fish populations and aquatic habitat. "Its overall goal is to ensure effective long-term conservation of fish and fish habitat" (MELP & DFO 2001). The process, introduced in 2001, is described in a guidebook developed by provincial and federal government agencies responsible for managing fish in British Columbia. This guidebook outlines a four-stage planning sequence that can be used by interested First Nations, stewardship groups, industries and government agencies to assemble plans that identify and help conserve valuable fish populations and their habitats:

Stage I: Establishes regional priorities for conservation of significant fish populations and habitats based on a broad profile of a large watershed or sub-basin. The stage concludes with the selection of one or more candidate watershed planning units for more detailed planning.

Stage II: Establishes priorities and an action plan framework for key planning units identified in Stage I based on a detailed watershed profile and social, economic and political considerations. In this stage, strategic direction (goals), management objectives and strategies are established.

Stage III: Develops an action plan detailing how the plan will be implemented and monitored, and by whom.

Stage IV: Implements, monitors and modifies the plan.

1.2 Rationale for adopting a WFSP approach

The Bulkley - Morice watershed is a significant producer of salmon and steelhead within the Skeena River system. These anadromous fish populations, along with the resident fish within watershed, are a foundation to the local and regional economy, to First Nation food supply, to the local of quality of life, and are a vital component of the ecosystem. Steelhead trout and Chinook salmon are the basis of a world-renowned sport fishery in the Bulkley-Morice watershed that supports a significant tourism industry. Salmon and steelhead play important roles in First Nation culture as a food source, and for traditional and ceremonial purposes. To others, the fish runs are a reason to live and stay in the Bulkley Valley - an amenity contributing to a rich quality of life. Finally, fish are a vital component of the food web and energy and nutrient cycles within the aquatic ecosystem. These fish populations are worth conserving; planning is an initial proactive step in ensuring the sustainability of fish stocks of the Bulkley-Morice.

The Bulkley-Morice Salmonid Preservation Group (BMSPG) adopted Watershed-based Fish Sustainability Planning in 2001 with the goal of completing strategic planning initiated by the group under Fisheries Renewal BC in late 2000. The BMSPG, the regional delivery group for Fisheries Renewal BC, had initiated watershed planning to help focus its activities. The group, consisting of representatives from First Nations and community organizations concerned about fish stocks and watershed health, completed its first stage of watershed planning in mid-2001. The resulting document entitled *Healthy Watersheds, Healthy Communities: Bulkley-Morice Salmonid Preservation Group Draft Strategic Plan – Phase 1* (Tamblyn and Donas 2001) identified eight priority watershed issues and listed draft goals, objectives and strategies to address each issue. However, to maximize the plan's effectiveness, the group required more detailed planning to clarify priorities and to develop an implementation and monitoring strategy. The BMSPG[1], lead by Community Futures Development Corporation of Nadina (CFDC Nadina), made the decision to continue planning for the Bulkley watershed under the umbrella of the WFSP process. They felt that integrating the existing draft plan into a government endorsed WFSP process would create greater acceptance of the plan and help promote consistency among watershed plans throughout the province.

1.3 The Morice Watershed-based Fish Sustainability Plan

1.3.1 Stage I – The Bulkley WFSP

CFDC Nadina, with support from Fisheries and Oceans Canada, initiated WFSP for the Bulkley watershed soon after the completion of Phase I of the BMSPG plan. Stage I of the WFSP was launched in late 2001 with the establishment of a planning committee (Appendix A). As an initial step, the planning committee divided the Bulkley watershed into four planning units: the Morice watershed, and the upper, middle and lower Bulkley watersheds (figure 1). After gathering feedback via questionnaires from the public, First Nations, and government regarding the fisheries values of each planning unit, the committee selected the Morice River watershed as the priority planning unit for more detailed Stage II planning (figure 2).

Around the same time, an independent Skeena Stage I WFSP process, led by the Skeena Fisheries Commission, selected the Morice watershed as one of the three most important watersheds in the Skeena from a salmon production perspective (Gottesfeld et al. 2002). The Skeena process therefore provided supporting evidence to continue with Stage II planning in the Morice watershed.

1.3.2 Stage II – The Morice WFSP

Stage II began in January 2002 with the formation of the Morice WFSP technical committee (Appendix A). The planning and technical committees mapped out Stage II of the planning process with the help of the WFSP guidebook and developed guiding principles (Appendix B) for its terms of reference. The technical committee's first task was to guide the creation of the Morice biophysical watershed profile: *Conserving Morice Watershed Fish Populations and their Habitat* (Bustard and Schell 2002). This document summarized available information on the fish stocks in the watershed including life histories, population status and trends, distributions and key habitats, and probable limiting factors to fish production. The report also commented on knowledge gaps and provided suggestions to fill those gaps. To aid the WFSP process further, Croft and Bahr (2002) developed a problem analysis to attempt to link fish and fish habitat trends with resource management practices. In addition, Croft conducted a GIS-based land use analysis using Geographic Data BC data to provide a baseline for future analysis and monitoring (see Section 4.2 and Appendix C).

[1] The BMSPG dissolved in 2002 due to cuts in project funding.

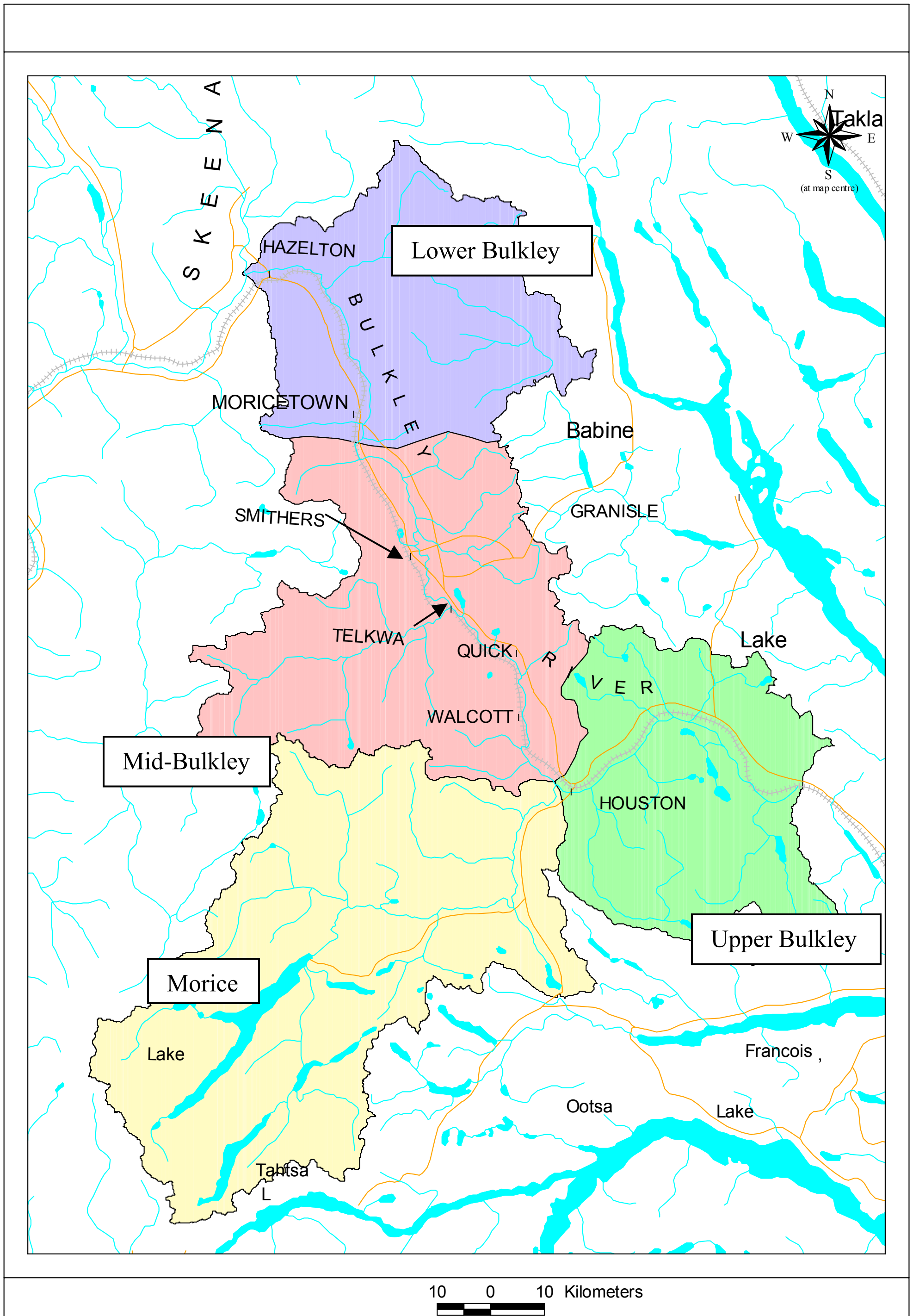

Figure 1: Bulkley Watershed sub-planning units for Stage I of the Bulkley WFSP.

Ministry of Sustainable Resource Management
Skeena Region
May 14, 2003

British Columbia

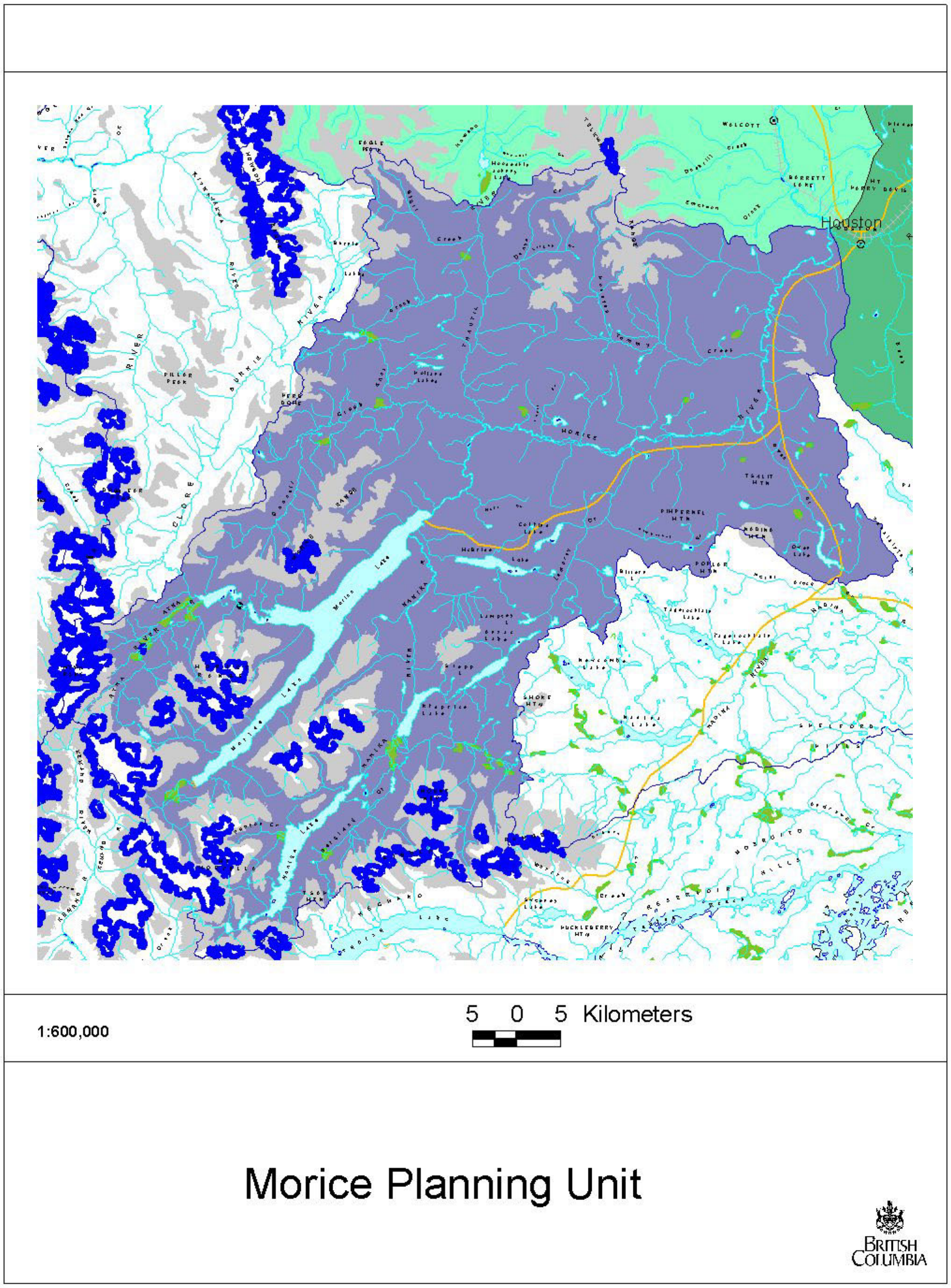

Figure 2: The Morice watershed.

The technical committee then categorized issues[2] and concerns identified by the public, Bustard and Schell (2002) and the committee itself. General aquatic ecosystem / watershed issues are summarized in Appendix D. A brief discussion of the issues can be found in Section 5.2.

1.3.3 Public Participation

Direct participation in the Morice WFSP process by community interest groups remained lower than anticipated throughout the process. In an attempt to attract the public to the WFSP process, CFDC Nadina invited BMSPG[3] members, promoted the process at local tradeshows, and provided presentations and / or occasional updates to the 45+ members of the public belonging to the Fish and Fish Habitat sector of the Morice Land and Resource Management planning process (LRMP). Anecdotal evidence suggested that burnout associated with multiple ongoing planning processes contributed to the limited public involvement.

Fortunately, CFDC Nadina was able to introduce public concerns and interests into the Morice WFSP process through its involvement in two key multi-stakeholder groups concerned with fish and fish habitat – the BMSPG and the Morice LRMP Fish and Fish Habitat Sector. CFDC Nadina advanced issues expressed in the BMSPG draft strategic plan and in compiled lists from LRMP process at WFSP meetings.

1.3.4 Purpose of the Plan

The purpose of the Morice Watershed-based Fish Sustainability Plan is to take proactive steps to sustain fish populations and fully functioning natural aquatic ecosystems in the Morice River watershed. The goals of the plan are to:

- Maintain and protect existing fish habitat;
- Rehabilitate impacted habitat where identified as a priority; and
- Optimize quantity and quality of fish production while maintaining a natural species balance.

More detailed objectives of the plan are to:

- Provide background information and summarize the current state of knowledge of the fishery resources of the Morice watershed;
- Identify watershed issues including knowledge and data gaps;
- Identify projects to help address data gaps and other priority issues;
- Provide advice and recommendations to all parties with an interest in ensuring resource decision making conserves fish populations and aquatic ecosystems; and
- Recommend implementation and monitoring strategies.

[2] Issues are defined broadly in this document to mean risks, uncertainties, problems, concerns, desires or opportunities.

[3] The BMSPG dissolved in 2002 following the conclusion of Fisheries Renewal BC.

Healthy, functioning ecosystems and optimized fish production will provide the basis from which to meet general socio-economic goals to:

- Maintain or improve quality of life for communities in the Bulkley and Skeena watersheds through ensuring clean water supplies and providing world class recreational angling opportunities; and
- Provide long-term economic opportunities for commercial and First Nation fishers and the local tourism industry by maintaining or increasing fish populations and fish habitat.

1.3.5 Time frame for the Morice WFSP

The Morice WFSP is intended to be updated regularly based on implementation and effectiveness monitoring, and society's changing priorities. While the technical committee should review the plan annually, significant updating and revision is expected every five to ten years.

1.3.6 Links to other Planning Processes

The Morice WFSP process relates to two concurrent land use planning processes: the Morice Land and Resource Management Plan (LRMP) and the Morice-Lakes Innovative Forest Practices Agreement (IFPA). The LRMP is a provincial government lead public process that sets strategic land and resource use direction for the Morice Timber Supply Area (TSA). The IFPA is a forest industry lead initiative that is now closely linked to forest licencee Sustainable Forest Management Plans (SFMPs).

WFSP and LRMP

The Morice LRMP, currently in the form of a recommendation package (MSRM 2004), is closely linked with the Morice WFSP. Geographic and participant overlap[4] enabled a synergistic relationship between the two processes. For instance, the WFSP, as a more fish-focused exercise, produced detailed information on fish species and fish distribution for the Morice watershed that proved immensely helpful to negotiators at the LRMP table. At the same time, CFDC Nadina, through participating in both processes made an effort to introduce interests and issues expressed by the LRMP Fish and Fish Habitat Sector into the WFSP process, thus facilitating a greater public voice at the WFSP.

Over the next few years, opportunities exist to simultaneously implement related components of two plans. A sustained partnership between the WFSP technical committee, the Ministry of Sustainable Resource Management (responsible for coordinating the implementation of the LRMP), and other provincial agencies involved with implementing the LRMP will help foster combined efforts that should benefit both processes. For instance, the existing WFSP technical committee could assist in implementing or monitoring common elements of the LRMP and WFSP. Another option would be for the WFSP technical committee to form the nucleus of the Watershed Advisory Committee, which is to be formed under the LRMP to assist with monitoring and implementing the aquatic portions of the LRMP.

[4] The Morice LRMP, encompassed the Morice River watershed and parts of five other watersheds to cover an area of approximately 1.5 million ha, an area about three times the size of the Morice watershed.

WFSP and IFPA

Sustainable Forest Management Plans (SFMP), a product of t he IFPA, provide a framework for developing, implementing and monitoring forestry-based management plans. These plans blend long-term strategic goals with short-term, specific strategies to meet objectives.

Members of the IFPA and WFSP have worked collaboratively to the benefit of both processes. The WFSP helps fill aquatic management and monitoring knowledge gaps in SFMPs and the IFPA provides a possible avenue for monitoring and implementing projects contained in the WFSP. Together, these processes will link sustainable fish habitat and populations to sustainable land use management.

2.0 WATERSHED PROFILE

2.1 PHYSIOGRAPHY

The Morice watershed, located southwest of Houston, B.C. (figure 2), is the largest tributary to the Bulkley River, with a catchment area of 4,349 km^2. This basin drains both the interior plateau south of Houston, and parts of the Coast Mountains to the west. The Morice River, headed by Morice Lake, flows northeast for approximately 80 km before entering the Bulkley River four kilometres west of Houston. The Bulkley then proceeds approximately 150 km northwest to join the Skeena River at Hazelton.

The predominant biogeoclimatic zone covering most of the lowland coniferous forests in the watershed is the Sub-Boreal Spruce (SBS) zone with dry cool (dk), moist cold (mc), and wet cool (wk) subzones. The SBS zone meets the Englemann Spruce-Subalpine Fir (ESSF) zone at upper elevations ranging from 900 to 1300 m. The ESSF is dominated by continuous forests stretching into subalpine meadows at upper elevations and is characterized by moist cold (mc), moist cool (mk) and moist, very cold (mv) subzones. Additional biogeoclimatic zones and subzones include the Alpine Tundra (AT) at the highest elevations, Coastal Western Hemlock, wet submaritime subzone (CWHws), flanking the shores of the large lakes in the southwestern portion of the watershed, and Mountain Hemlock, moist maritime subzone (MHmm), in the southern-most headwaters.

2.2 HYDROLOGY

The Morice River hydrograph is primarily influenced by snowmelt, with peak flows occurring from late May through July. Historically, June experiences the highest average monthly flows, which can approach 500 m^3 /second. In some years, rain on snow events produce peak flows in October and early November (Bustard and Schell 2002).

Two of the largest tributaries within the Morice River watershed are the Nanika (895 km^2) and Atna (300 km^2) rivers, which empty into Morice Lake. The Thautil River and Gosnell Creek combine to form the largest tributary (535 km^2) downstream of Morice Lake. Hydrologically, this is one of the most important systems in the Morice watershed as it influences peak flows and contributes significant bedload and sediment to the Morice River mainstem (Bustard and Schell 2002).

Due to slow glacier melt, abundant lake storage and fall rains, the mainstem Morice and Nanika rivers, as well as the larger tributaries such as the Thautil, Gosnell and Houston Tommy, maintain relatively high flows throughout the year until freeze up, typically in November. The lowest stream flows in both the mainstem rivers and smaller tributaries occur during the late winter usually from March to the middle of April at the higher elevations. Smaller, lower elevation streams draining the Interior Plateau, such as McBride, Lamprey, and Owen creeks often experience low summer flows (Bustard and Schell 2002).

2.3 WATER QUALITY

Morice River water quality is considered excellent, with a typically clear water column, a near neutral pH level, a mean alkalinity of 23 mg/l, and a mean conductivity of 53 μohms/cm (Remington 1996; Gottesfeld et al. 2002; Bustard and Schell 2002). Nutrient levels in some parts of the watershed are very low, including Morice Lake and Morice River, which are considered oligotrophic.

Impacts to water quality in the Morice have been linked to both forestry and mining activities. Bustard (1996) considered increased suspended sediments associated with road construction and inadequate road maintenance to be the greatest logging related impact on Morice watershed streams. Remington (1996) identified the Silver Queen Mine on the eastern shore of Owen Lake as a source of elevated zinc (Zn) and copper (Cu) levels in the Owen watershed.

2.4 LAND AND WATER USE

Industrial land use in the Morice watershed is dominated by forest management activities, an expansive road network, and past mineral exploration. Other land use activities include recreation (including hunting and fishing), tourism, trapping, fish guiding and guide outfitting, cattle grazing.

2.4.1 Forest Management

Large-scale forest management activities in the Morice watershed date back to the early 1970s. Forest development has generally involved progressive road development and well-distributed timber harvesting, typically characterized by clear-cut silviculture systems. However, over the past five years, activities have been increasingly focused on small-scale harvesting of stands, often using temporary roads, to control the mountain pine beetle infestation. By the summer of 2004, mountain pine beetle populations had reached epidemic proportions in parts of the Morice (McCormack, pers. comm.) and adjacent watersheds to the east and south. Sub basins in the Morice watershed with a high proportion of pine will face a significant increase in development activities to salvage this wood before it deteriorates (McCormack, pers. comm.). Increased rate of development combined with the death of large tracts of mature pine trees present a potentially significant risk to the integrity of the aquatic ecosystems of the watershed.

2.4.2 Mineral Resource Development

Much of the Morice watershed is classified as having high or extreme metallic mineral potential (Horn and Tamblyn 2000). The mining industry has a long history in the area, having undertaken extensive mineral exploration. However, of five developed prospects within the watershed, only one has reached the mining stage. The Silver Queen Mine, located on the eastern shore of Owen Lake, produced silver, gold, cadmium, copper, lead, and zinc in 1972 and 1973 (Horn and Tamblyn 2000).

2.4.3 Transportation and Utility Corridors

Progressive construction by the forest industry has resulted in a network of roads throughout most of the valley bottoms and onto the majority of the upland plateaus. This road network is primarily utilized by the forest industry, recreationalists, trappers, guide-outfitters and the mining industry. Since 1996, Huckleberry Mine, located 120 km southwest of Houston, has used the Morice-Owen Road to haul ore. A BC hydro line servicing Huckleberry Mine closely follows the road right of way (Gottesfeld et al. 2002).

2.4.4 Agriculture

Agriculture is currently limited to cattle range tenures and small areas of forage production. Range tenures exist near Houston, to the east of Owen Lake, and to the east of Tagetochlain Lake (Horn and Tamblyn 2000). Currently, there is only one agriculture lease in the watershed. However, the Morice LRMP proposes agricultural expansion of up to 200 ha per year to a total of 2000 ha in the northern and western portion of the watershed (MSRM 2004). Such expansion would occur through the permitting of agricultural lease applications. With an agricultural lease, a minimum of 25% of the leased land must be cleared and cultivated. The leaseholder also has the option of purchasing the land.

2.4.5 Other Land Use

The Morice watershed is used extensively for recreational activities such as hunting, fishing, hiking, camping, canoeing and snowmobiling. Guide outfitting, trapping and tourism also occur in the watershed.

2.4.6 Water Use

In 2003, fourteen water licences authorized use of water from Morice River tributaries for domestic, stock watering, waterworks, and “enterprise.” The total allowable consumption approved under the fourteen water licences is 35,200 gallons per day (GD) with 7000 GD for domestic, 10,700 GD for stock watering, 7,000 GD for waterworks, and 10,500 GD for enterprise (Land and Water BC Inc. 2003).

2.4.7 Settlements

Permanent settlement in the Morice watershed is currently limited to less than 20 people (Gottesfeld et al. 2002). No municipalities exist within the watershed boundaries. The District of Houston, located four kilometres east of the confluence of the Morice and Bulkley rivers, is the closest town. Its population as of 2001 was 3600 (Stats. Canada 2003). Houston has experienced a decline in population, losing 9.1% of its residents between 1996 and 2001 (Stats. Canada 2003). Neighbouring communities utilizing the Morice watershed for work or recreation include Smithers, Telkwa, Topley, and Burns Lake.

The entire Morice watershed is located within Wet’suwet’en traditional territory. Wet’suwet’en people resided in various village sites in the watershed until the early 1950s (Gottesfeld et al. 2002). The watershed is still used for traditional purposes.

2.4.8 Employment and Income

The District of Houston and nearby communities rely heavily on natural resources for employment. In 1996, half the jobs in the communities of Morice Timber Supply Area (including Houston, Granisle and Topley) were in the forest industry (Table 1). Other important employers were the public sector, tourism, construction, agriculture and mining. These statistics are aging and under estimate current numbers for the mining industry, and over estimate the size of the public sector. Significant cutbacks in 2002 and 2003 reduced the provincial government work force. Average wages for employees in the District of Houston are summarized in Table 2.

Table 1. Basic sector employment estimates as a percentage of total jobs for the Morice Timber Supply Area (including Indian Reserves), 1996.

Sector	**% Basic Employment**
Forestry	50%
Mining[5]	3%
Public sector	22%
Tourism	9%
Agriculture	6%
Construction	7%
Other[b]	2.1%

a. Note, the percentages shown above reflect each sector's share of an area's total employment, including direct and indirect employment.
b. The "other" category includes several sectors, including transportation, fishing, trapping, and high technology
c. Basic income flows into the community from outside of the area. Non-basic employment refers to local income that occurs due to the spending of basic income in the local area (e.g., local goods and services)

(Source: Horn and Tamblyn 2000)

Table 2. Number of people employed in Houston and average earnings, 2001

Characteristics	Numbers and earnings
# persons with earnings	2090
Average earnings	$34,338
# persons working full time	980
Average earnings for full time workers	$48,862

(Stats. Can. 2003).

[5] The figures for basic mining employment and after-tax income related to mining do not include the Huckleberry mine, which opened in 1997, a year after these statistics were derived.

3.0 FISHERIES RESOURCES

The Morice watershed is well known for its high fisheries values. It is an important producer of all Pacific salmon species except chum (*Oncorhynchus keta*). The watershed forms an integral part of the salmon production in the Skeena drainage, and is therefore important to First Nations groups, as well as commercial and recreational fisheries. The Bulkley-Morice watershed also supports an internationally celebrated steelhead (*O. mykiss)* sport fishery.

In addition to producing salmon, the Morice watershed sustains many resident fish species including rainbow trout (*O. mykiss*), cutthroat trout (*O. clarki*), bull trout (*Salvelinus confluentus*), Dolly Varden (*S. malma*), lake trout (*S. namaycush*), kokanee (*O. nerka*), mountain whitefish (*Prosopium williamsoni*), burbot (*Lota lota*), lake (*Conesius plumbeus*) and peamouth (*Mylocheilus caurinus*) chub, longnose suckers (*Catostomus catostomus*), largescale suckers (*C. macrocheilus*), white suckers (*C. commersoni*), redside shiners (*Richardsonius balteatus*), longnose dace (*Rhinichthys cataractae*), prickly sculpins (*Cottus asper*), pacific lamprey (*Lampetra tridentata*) and northern pike minnow (*Ptycheilus oregonensis*).

In this section of the report, population status and trends, and natural limiting factors to production are summarized for many of the fish species in the Morice. Habitat and risks to habitat / habitat protection are also briefly mentioned for some species. The discussion focuses on natural conditions within the Morice watershed. Factors outside the watershed such as ocean survival or migration mortality (including fishing) may be mentioned if they significantly affect anadromous species or fish that migrate out of the watershed. Generalized human activities affecting fish populations and aquatic ecosystems are summarized in Section 4.0.

Although the following discussion has been divided by species, many species share common high value habitat. For example, lake outlets are particularly important for spawning and early rearing because the lakes moderate flows and provide relatively warmer temperature for incubation and rearing. These areas tend to be heavily utilized by both anadromous and resident species.

The following information on fisheries resources was adapted from Bustard and Schell (2002). For more detailed descriptions of each fish species including distribution and life cycle / life history information (e.g. timing and locations of spawning and rearing), see *Conserving Morice Watershed Fish Populations and their Habitat* (Bustard and Schell 2002).

3.1 SOCKEYE SALMON

3.1.1 Population Status and Trends

The Morice watershed has a relatively small, but culturally important sockeye population. The Morice Lake - Nanika River stock is the dominant run, with a minor beach spawning deme[6] in Atna Lake. Although the Morice-Nanika Sockeye comprises only 1-2% of the Skeena watershed escapement on average, this stock provides a significant traditional food fishery for the Wet'suwet'en First Nation at the Moricetown canyon.

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6 A deme is a locally interbreeding group within a geographic population. Individuals from the lake deme and the Nanika River deme may spawn together, thus exchanging genetic information between the two demes.

The Morice-Nanika sockeye stocks are considered to be a conservation concern by the Office of the Wet'suwet'en. Following escapements over 50,000 fish prior to the mid-1950s, returns plunged suddenly to less than 4000 fish until the 1990s, when stocks improved to 22,000-41,000 fish. Since 1998, numbers have dropped again (Bustard and Schell 2002), fluctuating between approximately 3000 and 15,000 fish per year.

3.1.2 Limiting Factors to Production

The main factors influencing sockeye production of in the Morice watershed include the extremely low nutrient levels within Morice Lake, low spawner recruitment, predation and possibly the availability of quality spawning habitat during high escapement years (Bustard and Schell 2002). Commercial fishing operations targeting the huge enhanced Babine stock, comprising approximately 90% of the Skeena escapement, exposes the Morice-Nanika stock to risk of over-harvest (Bustard and Schell 2002).

3.1.3 Habitat and Habitat Protection

Critical sockeye habitat in the Morice is limited to a few locations in the upper portion of the watershed. Rearing occurs exclusively in Morice and Atna lakes. The vast majority of spawning occurs in a short stretch of the upper Nanika River, with minor numbers of remaining fish spawning in Morice and Atna lakes. The spawning grounds in the Nanika River are relatively deep and subject to stable warm water flows from Kidprice Lake. Egg survival is thought to be good in these spawning sites due to a lack of ice, flooding and sediment inputs. Secondary spawning locations downstream of Glacier Creek may be subject to changing hydrological flows, increase sediment inputs and severe ice conditions during some years (Bustard and Schell 2002). Misplaced or poorly designed development could dramatically impact Morice-Nanika stocks due to the limited spawning habitat. The value of the Nanika sockeye has been recognized in the Morice LRMP Final Land Use Recommendation package. A 500 m buffer has been proposed along the Nanika River and objectives dealing with infrastructure and road development, water flows and sediment regimes have been developed (MSRM 2004).

3.2 CHINOOK SALMON

3.2.1 Population Status and Trends

The Morice River is one of the most important producers of Chinook salmon within the Skeena watershed, averaging 25% of the entire Skeena run since 1950. From the early 1950s to 1985, Chinook escapements averaged less than 5,000 spawners; however, since the mid-1980s, numbers have reached near record levels, with returns up to 15,000 fish. This rebound in escapement levels was reflected in the Skeena as a whole where escapements were low through the sixties to early eighties, followed by increased numbers in past two decades (Bustard and Schell 2002).

The Morice River Chinook population is vital to First Nation and sport fisheries in the Skeena drainage. The run forms an integral part of the Moricetown food fishery. Wet'suwet'en catch records originating from 1930 indicate an average annual Chinook catch at Moricetown of 2,000 to 5,000 fish (Bustard and Schell 2002). Chinook are prized by sports anglers for their size and attract many local and non-resident anglers.

3.2.2 Limiting Factors to Production

Chinook production in the Morice system is probably limited by factors associated with spawning and rearing (Bustard and Schell 2002). Limitations may include the effects associated with major floods, low winter flows, dewatering, extreme cold, competition, redd superimposition and spawning gravel quality and quantity. For example, a combination of high fall flows that push spawners to the river edge and low late winter incubation flows is thought to lead to poor Chinook egg-to-fry survival in some years (Bustard and Schell 2002). In other cases, the potential for Chinook redd superimposition is high because Chinook spawners tend to concentrate in a small area and spawn over a period of roughly one month (Bustard and Schell 2002).

3.2.3 Habitat and Habitat Protection

Prime Chinook habitat within the watershed is found in the mainstem (spawning) and side channels (rearing) of the Morice River. Of critical importance is the four kilometres stretch of river downstream of the mouth of Morice Lake, with additional key areas downstream to the Lamprey Creek confluence. These habitats provide 97% of Chinook spawning habitat in watershed (Bustard and Schell 2002). Suitable gravel recruitment into these primary spawning areas is probably limited, effectively determining how much spawning habitat is available. Generally, spawning site exposure to sediment events is expected to be rare because the Morice River is lake headed. However, land use practices in the small watersheds flowing directly into key Chinook spawning areas have the potential to introduce sediments and reduce the suitability of these sites (Bustard and Schell 2002).

3.3 COHO SALMON

3.3.1 Population Status and Trends

Coho escapements to the Morice watershed have ranged from 0 to 23% of the Skeena run since 1950 (Bustard and Schell 2002). Between 1950 and 1960, returns exceeded 5000 fish with a maximum of almost 20,000 in 1956. In the 1960s and 1970s escapements dropped to an average of 1,971. Returns fell in the 1980s and 1990s, leading to the upper Skeena “coho crisis” of the late 1990s. Implementation of drastic conservation measures, including closing the commercial and sport fisheries, has resulted in the population rebounding to levels not seen since the 1950s (Bustard and Schell 2002). As the populations have increased, the fisheries have been reopened.

Wet’suwet’en Fisheries has actively participated in conserving coho stocks. It has been involved with a stock assessment program at Moricetown canyon since the late 1990s. Retention of coho has also fallen from approximately 1500 fish per year prior to 1997, to less than 100 coho annually since then in the dip-net-fishery at Moricetown (Walter Joseph in Bustard and Schell 2002).

3.3.2 Limiting Factors of Production

Factors outside the Morice watershed affecting spawner recruitment appear to have had a significant negative influence on past coho production within the Morice watershed. Poor ocean survival combined with high exploitation rates led to severely depressed populations for 30 years. The recent increased escapements indicate the high capability of the Morice watershed to support juvenile coho. Efforts to sustain coho populations in the Morice are dependent on ensuring strong escapements (Bustard and Schell 2002).

Within the Morice watershed, coho production is also influenced by natural factors, including weather. Coho spawn in both mainstems and small streams, depending on accessibility to natal streams. High water events in late October and early November help determine extent of upstream migration in many tributary streams. The high flows help coho navigate past beaver dams and other potential barriers to reach some of the best potential spawning and rearing habitat in the watershed, including habitat in Owen, Lamprey, McBride and Gosnell creeks (Bustard and Schell 2002). When flows remain low during the fall (as occurs quite regularly) coho spawner distribution is constrained and potential production is reduced due to lack of access to rearing areas.

Coho rely on small tributaries and off-channel habitat for rearing. Weather conditions in both early and late summer help determine juvenile coho distribution within these habitats, with water flows and temperatures directly affecting habitat suitability (Bustard and Schell 2002). For example, when stream flows are low, access to habitat and available rearing habitat is reduced, and stream temperatures and oxygen levels can become unfavourable for rearing coho.

Overwinter rearing mortalities in side channels and small tributaries are a result of poor water quality, dewatering as flows decline during late winter, and predation as ice cover on the channels melts during the spring (Bustard and Schell 2002).

3.3.3 Habitat and Habitat Protection

Coho are widespread throughout the Morice watershed, primarily using small streams and off-channel habitat. Therefore, habitat protection is an important issue for this species.

Habitat protection begins with accurate identification of fish distribution and key habitats. Much of the existing knowledge of coho distribution comes from inventories conducted during years of depressed coho abundance, when fish densities were low and ranges were likely limited. As a result, full extent of habitat use by coho is not known (Bustard and Schell 2002).

The redistribution of newly emerged coho fry and yearlings into non-spawning streams and off-channel ponds is greatly influenced by roads. For instance, juvenile coho have limited ability to move upstream through road culverts (Bustard and Schell 2002).

The reliance of coho on smaller tributaries and off-channel ponds makes riparian management in and around these areas crucial. The maintenance of suitable water temperatures and flows as well as the reliable recruitment of debris for cover are important factors for coho rearing.

3.4 Pink Salmon

3.4.1 Population Status and Trends

Pink salmon were unable to reach the Morice River until the early 1950s, when fish ladders were built at Moricetown canyon. Observed escapements to the Morice remained low until the 1970s, when moderate returns of up to 50,000 fish were noted. After several significant runs in the late 1980s and early 1990s (maximum 806,400 fish in 1991), pink runs have fluctuated between 5000 and 175,000 fish (Bustard and Schell 2002). Over the past two decades, Morice pinks have accounted for approximately 9% of the Skeena pink escapement.

3.4.2 Limiting Factors on Production

Primary factors affecting freshwater survival of pinks in the Morice are dissolved oxygen concentrations, stability of spawning beds, freezing of redds, and predation (Bustard and Schell 2002). Redd sites with no surface flows tend to have low dissolved oxygen levels. In mid-winter, discharge levels decline in the Morice, resulting in reduced subsurface dissolved oxygen levels, as groundwater inputs comprise a larger portion of the discharge (Bustard and Schell 2002).

Weather conditions such as winter severity and discharge levels can greatly influence pink salmon survival. Low discharge during the early winter can lead to direct freezing of redds in some key spawning habitats in Morice side channels in years with very cold temperatures and low snow cover. At the other extreme, rain on snow events can lead to extreme freshets after the pink spawning period, which can cause gravel shifting resulting in poor survival (Bustard and Schell 2002).

Predation of emerging pink fry by birds, coho smolts and resident char can be a significant factor in pink survival in the Morice watershed (Bustard and Schell 2002).

3.4.3 Habitat and Habitat Protection

Increased forest development within the Thautil and Gosnell watersheds which empty into the main pink salmon spawning area of the Morice mainstem could lead to increased sediment loading and reduced egg survival. As such, limited forest harvest rates and appropriate riparian management strategies in these areas are essential in order to protect critical downstream habitat.

3.5 STEELHEAD

3.5.1 Population Status and Trends

The Bulkley-Morice drainage is the most important producer of steelhead in the Skeena watershed. While the Morice is estimated to have only about ¼ of the production capacity of the Bulkley River, it still accounts for approximately 8% (6000 fish) of the capacity of the Skeena according to Tautz et al. in Bustard and Schell (2002). Mark-recapture surveys have estimated recent Morice steelhead escapements to be between 3300 and 6750 fish (Lough 1995 and Mitchell 2001 in Bustard and Schell 2002).

A catch and release regulation has applied to the steelhead sport fishery in the Morice since the early 1990s. The Wet'suwet'en food fishery records at Moricetown indicate an annual catch of about 500 fish per year since the early 1980s (Bustard and Schell 2002).

3.5.2 Limiting Factors for Production

The Alaskan and Canadian mixed-stock commercial fishery, First Nation fisheries, and hooking mortalities from both marine and freshwater sport fisheries affect steelhead spawner recruitment into the Skeena watershed. These factors can account for an estimated exploitation rate as high as 60% (Ward et al. 1995 in Bustard and Schell 2002). Recent observations also suggest that changes in ocean habitats have affected survival rates of steelhead (Bustard and Schell 2002).

Given adequate spawners, the limiting factor for steelhead production in the Morice watershed is juvenile rearing habitat. Steelhead populations in the Morice are influenced by density control factors in some tributaries, as well as environmental extremes such as severe ice, low winter flows and freshets (Bustard and Schell 2002). The availability of steelhead rearing areas is restricted by low summer flows in Lamprey and Owen creeks, which may have a large influence on potential production of juveniles. Water temperature in these systems is also critical. Small increases in water temperature are expected to favour species other than steelhead, resulting in increased competition for similar habitats in these streams (Bustard and Schell 2002). Rearing steelhead can be significantly impacted during severe winter conditions. As flows decline during the winter and the wetted area of the channels is reduced, standing water is created, water quality deteriorates, and predation by birds results in poor survival of steelhead parr. During the spring and fall, steelhead are subjected to high flows in the Morice watershed during the snowmelt freshet. These conditions are thought to result in the displacement of steelhead fry and small yearlings unable to find suitable refuge (Bustard and Schell 2002).

3.5.3 Habitat and Habitat Protection

Some of the key steelhead habitats in the Morice watershed are subject to low summer flows, potentially high temperatures and high erosion potential. These conditions make steelhead habitats sensitive to land use development activities. Poor logging and road building practices in the Owen and Lamprey watersheds in the past has resulted in significant sediment inputs into these systems including the headwater areas of core steelhead-producing tributaries such as Pimpernel Creek. Ongoing chronic sediment input from high-traffic main haul roads is also a concern (Tom Pendray, pers. comm.). Protecting the riparian areas and maintaining water temperatures in these systems is critical as well. A minor increase in water temperatures in both Lamprey and Owen could make these systems unsuitable for juvenile steelhead (Bustard and Schell 2002).

3.6 Rainbow Trout

3.6.1 Population Status and Trends

The status of rainbow trout in the Morice watershed is largely unknown. Creel survey data from October 1979 indicated rainbow trout were the most common sport fish captured in Morice Lake (Envirocon 1984 in Bustard and Schell), comprising 58% of the catch. Based on an additional tagging study, Envirocon (1984) estimated the rainbow trout population (individuals larger than 25cm fork length) in Morice Lake to be 4000-7000 fish. However, this estimate is expected to be high since it assumed no spawning moralities (Bustard and Schell 2002). No reliable estimates of the rainbow populations in Nanika and Kidprice lakes are available.

3.6.2 Limiting Factors of Production

Limiting factors to rainbow trout, although not well understood, may include unproductive rearing habitat, competition, limited spawning habitats, dewatering and freezing of side channel habitat in the Nanika River and angling (Bustard and Schell 2002). Perhaps the most significant restricting force on rainbow trout populations is low natural productivity, limiting food availability. Oligotrophic, cold conditions in Morice Lake result in slow-growing and late maturing fish. Absence of lakes, and scarcity of feed are likely to result in the small adults (approximately 20cm) found in Houston Tommy and Fenton watersheds (Bustard and Schell 2002).

Rainbow trout can be susceptible to angling when they congregate on salmon spawning grounds in the upper part of the Morice River. Regulating agencies should consider this vulnerability should pressure mount to re-open salmon fishing in this area.

3.6.3 Habitat and Habitat Protection

Rainbow trout populations in the Morice are primarily found in lakes, streams, smaller rivers, and in the Morice River mainstem. Spawning tends to occur in a limited number of areas, with the lower and upper Nanika River being very important to the Morice and Nanika / Kidprice populations. Due to importance of a few rivers and streams, the rainbow trout populations are at risk to impacts from land use development.

3.7 CUTTHROAT TROUT

3.7.1 Population Status and Trends

Recent inventory work has helped clarify the distribution of cutthroat trout in the Morice watershed; however, the population status remains unknown. Cutthroat are abundant in some lakes though, and probably face low angling pressure. Nonetheless, cutthroat trout are blue-listed provincially, meaning this species is of special concern in British Columbia because of characteristics that make them particularly sensitive to human activities and natural events.

3.7.2 Habitat and Habitat Protection

Cutthroat trout tend to utilize small streams and lake tributaries throughout the Morice watershed, and as such, are particularly susceptible to the impacts of forest development. Habitat issues for Morice watershed cutthroat trout are primarily linked to roads and forest management. Poorly installed road and stream crossing structures can prevent upstream movements by juveniles, while poor riparian and upland management practices can lead to changes in hydrological flow and increased sedimentation and stream temperatures (Bustard and Schell 2002). As a result, road development and access management around smaller lakes, streams and ponds should be an important consideration in future resource decision-making.

3.8 BULL TROUT

3.8.1 Population Status and Trends

Bull trout are designated as a blue-listed species in British Columbia, and are an endangered species in the Unities States (Bustard and Schell 2002). A recent study (Bahr 2002) has improved understanding of bull trout distribution, habitat and life history in the Morice, but current stock status remains unknown. Anecdotal information from anglers suggests that bull trout are common. However, based on redd counts and snorkel surveys in some Morice River tributaries, Bustard and Schell (2002) propose that the spawning population may consist of less than 1000 adults.

3.8.2 Limiting Factors of Production

Bull trout prefer cold streams. Distribution of Morice River bull trout populations is strongly correlated with the coldest streams in the watershed. Because bull trout are better adapted to cold water, they have a competitive advantage over other species in these conditions. Conversely, bull trout are less effective competitors in warmer stream reaches.

The stability of redd sites is an issue in systems which are naturally unstable (e.g. “Crystal” and “Glacier” creeks). Late fall freshets in bull trout spawning areas can lead to poor egg and fry survival.

Fry displacement as a result of late freshets is also a concern. Side channel locations buffered from the full freshet flows are expected to be important refuge areas for bull trout fry (Bustard and Schell 2002).

Morice bull trout adults are at risk to over-harvest from angling due to their aggressive behaviour and practice of schooling in defined staging areas. In addition, bull trout, like other char species, tend to grow slowly, mature late, and live for long periods of time, increasing their susceptibility to overexploitation and long-term population effects (McPhail and Baxter 1996 in Haas and Porter 2001). Studies in other rivers with good angler access indicate that sport fishing can have a major influence on bull trout populations[7] (Bustard and Schell 2002). In the Morice watershed, the Thautil-Gosnell confluence and the Nanika falls are thought to be particularly vulnerable to increased angler pressure (Bahr 2002; Bustard and Schell 2002).

3.8.3 Habitat and Habitat Protection

Bull trout habitat protection issues are primarily linked to the impacts associated with forest development activities in the Morice watershed. Increased temperature, decreased groundwater flows and reduced channel stability and complexity are primary concerns. Data in Bahr (2002), as reported in Bustard and Schell (2002), indicates that bull trout in the Morice watershed spawn in water temperatures below 10°C, while juveniles favour rearing temperatures less than 12°C. Loss of riparian vegetation in small headwater streams and potentially in wet ecosystems adjacent to streams can lead to increased stream temperatures in bull trout habitats due to reduced shading. The interception of groundwater and small seepage flows by roads can affect bull trout spawning areas by warming water (if it flows through ditches exposed to the sun) and by reducing zones of groundwater inflow, which are thought to be associated with some bull trout spawning areas. In addition, channel stability in bull trout spawning streams can be greatly influenced by road stream crossings and changes to stream hydraulics.

Although more of a land use issue, improved access to key bull trout habitats can greatly increase the risk of both legal and illegal angler harvest of bull trout (Bustard and Schell 2002).

3.9 Dolly Varden

3.9.1 Population Status and Trends

The status of the Morice watershed Dolly Varden population is unknown. No enumeration has been done. Bustard and Schell (2002) suggest that Dolly Varden can be found in relatively low densities in most stream systems, and feel that the population is not threatened or declining in the Morice watershed. However, like bull trout and cutthroat trout, Dolly Varden are blue-listed in BC and are a species of special concern as they are particularly sensitive to impacts resulting from land use development.

[7] Many of these studies have occurred on rivers where bull trout are the primary target species for anglers. In the Morice River, salmon and steelhead tend to be preferred species, so the effects of angling on bull trout populations **may** be somewhat different and need to be better understood.

3.9.2 Habitat and Habitat Protection

Dolly Varden in the Morice watershed appear to prefer smaller headwater streams with gradients less than 8%. Spawning is often associated with groundwater seepage areas (Bustard and Schell 2002). Their inclination to small streams can lead to habitat protection issues that are linked to land use development activities in headwaters.

To protect Dolly Varden habitat, land use management practices aimed at protecting upstream sites from sediment, hydrological changes (surface and groundwater), and increased water temperatures is important. The proper design and installation of road stream crossing structures on these streams is important in order to ensure fish passage (Bustard and Schell 2002).

3.10 LAKE TROUT

Four lakes within the Morice watershed are known to contain lake trout: Morice, Owen, McBride and Atna lakes (Bustard and Schell 2002). The Ministry of Water, Land and Air Protection assessed lake trout populations in Owen and McBride lakes in 2004. Both lakes showed signs of over-harvest (Paul Giroux, pers. comm., unpublished report). The Owen Lake population was determined to be in an early stage of degradation, while the McBride population was classed as degraded. The status of Atna and Morice lake trout populations remains unknown; however the prevalence of small lake trout caught in lake inventories conducted in the 1970s and early 1980s raises concerns about population status (Bustard and Schell 2002). WLAP suspects that current angling pressure and fishing mortality is low in these two lakes.

3.11 KOKANEE

Kokanee in the Morice watershed have been recorded in only Morice and Shea lakes and the status of populations is unknown. Based on a 1979 creel survey, Kokanee numbers are low in Morice Lake and make up 1% of the total angler catch (Envirocon 1984 in Bustard and Schell 2002).

3.12 OTHER SPECIES

No population data is available for the remaining species of fish in the Morice watershed.

3.12.1 Burbot

Burbot have been recorded in McBride, Morice and Owen lakes. WLAP conducted a preliminary burbot assessment on McBride and Owen lakes in conjunction with its lake trout assessment project in 2004. However, greater trapping effort over the next few years will be required to assess population status (Jeff Lough, pers. comm.). Currently no life history, stock status or additional distribution information is available for burbot (Applied Ecosystem Management Ltd. 2001 in Bustard and Schell 2002).

3.12.2 Whitefish

Three species of whitefish are present in the Morice watershed (Applied Ecosystem Management Ltd. 2001 in Bustard and Schell 2002). Pygmy whitefish are reported in Owen and Morice lakes, and lake whitefish have been sampled in McBride and Morice lakes. Mountain whitefish is the most widely distributed and abundant whitefish species in the Morice watershed, occurring in several lakes and in the Morice River. Stock status of all three species is unknown (Bustard and Schell 2002).

3.12.3 Chub

Lake chub and peamouth chub are found in the Morice. Lake chub have been recorded in the Gosnell, Thautil, Lamprey and Owen creeks, and in Morice and Owen lakes (Applied Ecosystem Management Ltd. 2001 in Bustard and Schell). The Ministry of Water Land and Air Protection (WLAP) recognizes lake chub as a regionally important species within the Morice Timber Supply Area (TSA). Peamouth chub have been seen in several lakes and in Gosnell Creek (FISS 2005).

3.12.4 Suckers

Largescale, longnose, and white suckers inhabit the Morice drainage. Largescale suckers are common throughout the mainstem of both the Bulkley and Morice rivers. Suckers are thought to overwinter in these river mainstems. Aerial counts have reported large numbers between Owen and Gosnell creeks (Bustard and Schell 2002). Largescale suckers have also been found in Collins, McBride, Morice and Owen lakes (Applied Ecosystem Management Ltd. 2001 in Bustard and Schell 2002). Longnose suckers are present in McBride, Tagit, Owen and Lamprey creeks and their associated lakes. They are also present throughout the Nanika-Kidprice lakes system (Bustard and Schell 2002). White suckers have been reported in Morice Lake and Tagit Creek, according to the FISS database (FISS 2005). White suckers are present in Owen Lake at what appears to be low densities (Giroux, unpublished data).

3.12.5 Redside Shiners

Redside shiners have been identified in Tagit creek and Owen, Collins, McBride and Morice lakes (Applied Ecosystem Management Ltd. 2001 in Bustard and Schell 2002).

3.12.6 Longnose Dace

This species is abundant throughout the mainstem Morice River and Lamprey, Owen and McBride creeks. In 1979, longnose dace comprised 9% of the mainstem Morice River sample; however in subsequent years, this percentage decreased (Envirocon 1984 in Bustard and Schell 2002). Dace are also found in the Nanika watershed.

3.12.7 Sculpins

The Morice watershed supports two species of sculpins. The prickly sculpin is present in Morice and Nanika rivers, lower McBride and Lamprey creeks and in Owen and Gosnell creeks (Bustard and Schell 2002). Triton (2000 in Bustard and Schell 2002) reports the presence of coast range sculpins in a reconnaissance level inventory.

3.12.8 Pacific Lamprey

Pacific lamprey are generally thought to be abundant and widespread in the Morice watershed. Large numbers of pacific lamprey have been observed spawning in Owen and Lamprey creeks during June and July, and in the Morice River mainstem during late July (Bustard and Schell 2002). However, Wet'suwet'en Fisheries is concerned that Pacific lamprey populations might be declining in the Bulkley / Morice watershed based on recent observations in the Moricetown canyon (Walter Joseph, pers. comm.).

3.12.9 Northern Pike Minnow

The northern pike minnow (formerly known as the northern squawfish) is thought to be widespread in some areas of the Morice watershed.

4.0 ACTIVITIES AFFECTING MORICE FISH POPULATIONS

Fishing and land use are the two broad categories of human activities currently influencing the fish populations within the Morice watershed. Salmon farming, if established on the North Coast, will pose addition risks.

4.1 FISHING

4.1.1 Commercial and In-river Fisheries

Based on existing information and population trends for Morice fish stocks, it is clear that commercial interceptions, and in some years, the in-river fisheries, have had a severe impact on salmon and steelhead populations in the Morice (Bustard and Schell 2002). Management strategies aimed at curtailing the commercial fishery over the past decade have allowed increased spawner recruitment and provided evidence of the impressive habitat capabilities of the Morice watershed to produce native fish stocks. Recent escapement numbers for Morice coho, Chinook and steelhead provide a clear insight into these potential production levels (Bustard and Schell 2002).

4.1.2 Lake Fisheries

Lake angling, targeting resident sport fish, can radically influence fish populations – both age and size classes and numbers of fish. Lake trout and other long-lived, slow growing fish are particularly susceptible to over-harvest. Regular monitoring, when possible, helps track population trends and provides an early warning sign of population declines.

4.2 LAND USE ACTIVITIES

Present land use in the Morice watershed is dominated by forest management activities. Recreation, tourism, grazing, trapping, guiding, and mining related activities occur, but on a much smaller scale. Forest development in most valleys has included progressive road expansion and timber harvesting utilizing the clear-cut silviculture system.

The effects of land use vary within sub-watersheds of the Morice. Although, human impacts on the Morice watershed as a whole are relatively limited compared with more developed watersheds, logging activity has noticeably impacted some basins, with site level impacts on fish habitat documented by Saimoto (1994); Michell et al. (1996), and Mackay (1999). In the future, cumulative effects associated with progressive forest road building, timber harvesting activities and other land use development could have significant future impacts on Morice watershed fish habitat and its productive capacity. Possible extensive logging to salvage trees killed by mountain pine beetle poses additional risks to the aquatic environments of the Morice watershed.

4.2.1 General influences of Forestry on Watersheds

Forest harvesting and related activities (particularly road building) are known to have the following general impacts on watersheds:

1) Changes to surface and groundwater hydrologic patterns including altered timing, frequency, duration and magnitude of flows including higher peak flows, and lower low flows. The extent of change is generally related to the total amount of harvesting in a watershed.

2) Increases in natural rates of sediment introduction into watercourses. This ranges from fine sediment remaining in suspension to coarse sediment, which becomes part of the stream bed and can change stream channel stability. Elevated sediment levels can be the result of increased extent or incidence of mass wasting (slides or erosion of slopes), bank erosion due to changes in peak flows or loss of roots holding banks together, or erosion of fines from road surfaces and ditches.

3) Reduction in riparian vegetation. Loss of streamside vegetation can affect streams in numerous ways including reducing large woody debris in streams (potentially leading to lower habitat complexity and decreased channel stability), altering water temperatures (warmer in summer and colder in winter), increasing surface and bank erosion, and increasing primary production (growth of algae).

All potential impacts are normally related to the overall extent and intensity of forest harvesting activities as well as "forest practices".

Section 6.0 provides more explanation on some of the effects of forest harvesting. For a more thorough discussion, see Meehan (1991).

4.2.2 Land Use Analysis for the Morice Watershed

Chad Croft of Gartner Lee Ltd. conducted a "baseline" analysis to determine relative levels of land use influence in the sub basins of the Morice watershed (Appendix C). Relative degrees of land use were noted as low, medium and high for each sub watershed[8] based on a scoring matrix with included indicators such "road density", "number of stream crossings per kilometer of stream" and "percent of watershed logged". Indicators including those for urban areas, agriculture, grazing, recreation and mining development had no bearing on total scores and were deleted from the matrix.

According to the analysis, the most heavily developed sub-watersheds, **as of the mid- to late-1990s**, were located in the lower and mid-parts of the watershed (figure 3). Owen, McBride, Lamprey, and an unnamed watershed immediately east of Lamprey Creek (460-600600-32800 or Unnamed 26), showed the highest degree of forest development (Appendix C). The Morice mainstem (including first and second order tributaries) and Gold and Knapper watersheds had moderate levels of development relative other sub-basins within the Morice. The relative levels of development help indicate which watersheds had the highest risks for land use related impacts as of 1995-1998.

A follow-up analysis of the matrix data by sub basins revealed that small areas of intense development could be masked when watersheds are grouped into large units (Freshwater Resources 2004). For example, although the Nanika and Thautil watersheds as a whole sustained relatively low levels of development in the mid-1990s, several tributary basins

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[8] Minimum third order watersheds (based on 1:50000 NTS maps) as determined by British Columbia's Watershed Atlas (Spatial Visual Consulting 1996).

contained concentrated forest development. These "scale effects" could cause potential impacts to individual small watershed to be overlooked.

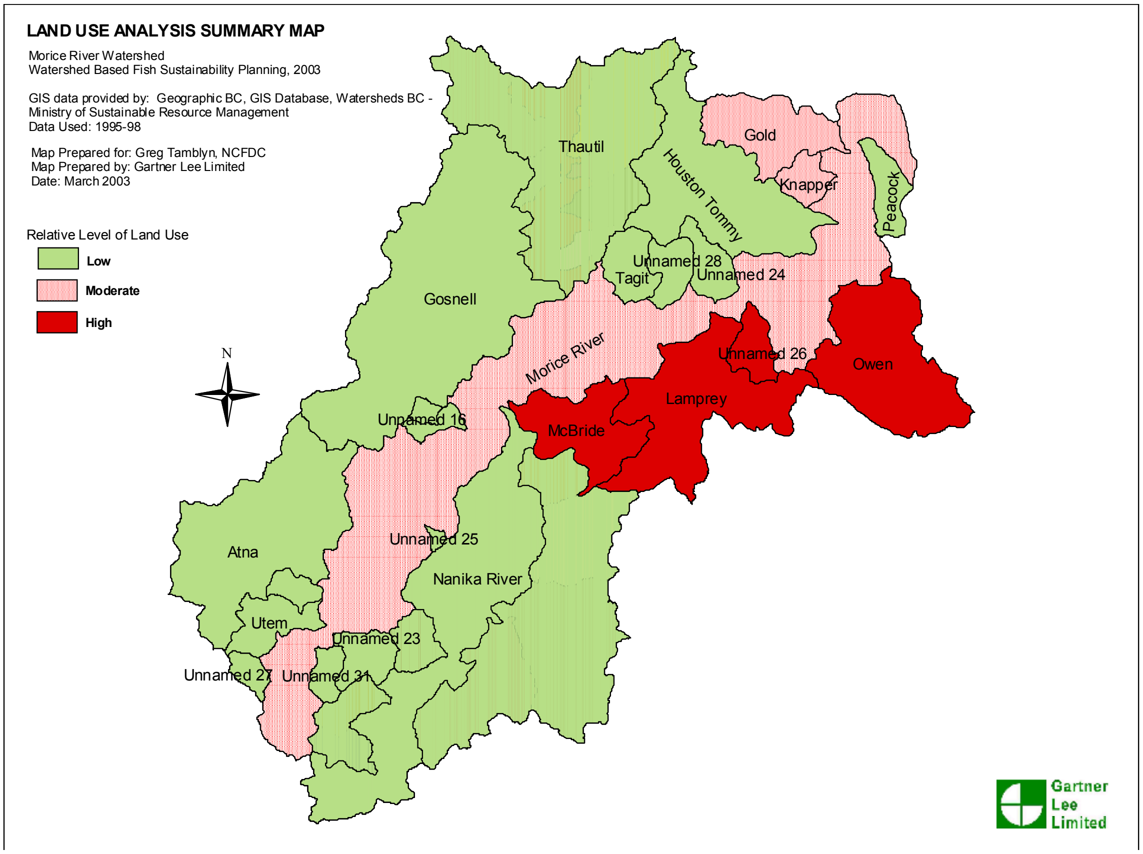

Figure 3: Relative levels of land use within the Morice River watershed

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4.3 Fish Farms

Recent initiatives to establish open-netcage fish farms on the north coast need to be closely examined in light of potential impacts to native North Coast salmonids including those of the Morice. As outlined in Gottesfeld et al. (2002), the introduction of a foreign species such as Atlantic salmon into the Skeena watershed or adjacent marine waters could threaten the integrity of native steelhead and salmon stocks. Concerns include disease and parasite transfer from farmed to wild fish, and competition from Atlantic salmon in freshwater habitats should they successfully reproduce.

5.0 PRIORITY ISSUES

5.1 MORICE WATERSHED ISSUES

Issues can be defined as problems, concerns, risks, desires or opportunities. For the purpose of the Morice WFSP, aquatic related resource issues were collated from several sources:

1. Local summary reports produced for WFSP:
   - *Conserving Morice Watershed Fish Populations and Their Habitat* (Bustard and Schell 2002);
   - *Conserving Skeena Fish Populations and Their Habitat* (Gottesfeld et al. 2002); and
   - *Phase II Watershed-based Fish Sustainability Planning: Synopsis of key fisheries resource issues* (Croft and Bahr 2002).
2. The BMSPG watershed plan:
   - *Healthy Watersheds, Healthy Communities: Bulkley Morice Salmonid Preservation Group Draft Strategic Plan – Phase 1* (Tamblyn and Donas 2001).
3. The WFSP technical committee.
4. The public via the Morice LRMP Fish and Fish Habitat Sector.

Issues were organized into three categories:

- Fisheries management;
- Habitat (includes instream, riparian, upland and hydrological issues); and
- Data gaps.

5.2 RANKING THE SIGNIFICANCE OF ISSUES

Issues were ranked as a high, medium or low priority subjectively by the technical committee based on their knowledge and experience in the watershed, and considering costs, perceived risks, and the perceived ability of the WFSP process to influence the issue. Issues over which the WFSP process had little influence (e.g. climate change), were ranked low.

General or broad "issues" affecting fish or the aquatic ecosystem are listed in Appendix D. As the WFSP process was an open process and included input from a wide variety of sources (public, government, First Nations), some issues identified in Appendix D may be based on perceptions or future possible risks. Some of the projects listed below in the Action Plan will help fill in knowledge gaps and determine the validity of the "issues." When this WFSP is revised, the technical committee may want to consider reviewing the "issues" and classifying them based on uncertainty and risk.

6.0 ACTION PLAN

The following section of the plan identifies projects designed to help address significant issues identified through the planning process. This action plan is divided into three sections: land use management, habitat rehabilitation, and fisheries management. The land use management and habitat rehabilitation sections contain objectives and projects associated with broad watershed issues affecting many fish species or aquatic ecosystems. The fisheries management section outlines objectives and projects specific to a fish species. Where relevant, objectives from the Morice LRMP (MSRM 2004) are listed to clarify links between the two plans.

Implementation of the Morice WFSP will require volunteer collaboration among participating organizations. Government, First Nations, CFDC Nadina, stewardship groups, forest licencees, consultants, participants in other planning processes such as the Morice LRMP and the Morice-Lakes IFPA will all need to play a role in implementation (Section 8.0). A contact person and potential implementing organization, or organization with the appropriate legal mandate, has been identified for each project. The year the project is proposed to begin is also listed for each project as a guide to "implementing" organizations. Many projects with the start year of 2005 are awaiting funding decisions. Only those projects noted as "underway" are currently funded. "Ongoing" projects are multi-year projects and have a high likelihood of funding, at least in 2005.

All projects are deemed to be priorities for the Morice watershed unless specified. ***The project contact is responsible for ranking the priority of the project relative to his or her organization's other projects and programs, and for integrating the projects, where possible, into his or her organization's work plans or business plans.*** For some organizations, the fact that the Morice was identified as one of the top three most important salmon producing watersheds in the Skeena River basin (Gottesfeld et al, 2002) may assist in determining priorities among watersheds.

Concerns exist that an extensive period of time will pass prior to some project results becoming integrated into day-to-day resource management operations. ***The Technical Committee would like to stress that in the absence of adequate information about potential direct and cumulative impacts of resource management activities on the aquatic environment, precautionary management approaches should be adopted***. Due to the complexity of natural systems, cumulative impacts may remain unnoticed in the absence of extensive detailed monitoring until a threshold is reached - at which time impacts become obvious, but potentially too substantial to easily reverse. As experience has shown, rehabilitation efforts are expensive (direct costs and opportunity costs of lost fisheries) and, in many cases, may not be effective.

The Morice watershed is contained within the traditional territories of the Office of the Wet'suwet'en. The Office of the Wet'suwet'en expects to be meaningfully consulted regarding projects initiated and conducted within its traditional territories.

6.1 Land Use Management

Goal: To protect and maintain existing fish habitat.

Wide-scale industrial land use development in the Morice River watershed is relatively young compared with development in much of British Columbia. Forestry is the dominant activity, fueled by the construction of two sawmills in Houston in the early 1970s. Although past land use activities have caused localized degradation of fish habitat, the expanding industrial footprint and associated access issues present broader scale risks to the aquatic ecosystem of the Morice watershed. However, precautionary management strategies combined with research-based adaptive management provide opportunities to conserve and protect these lake and river ecosystems.

6.1.1 Lakes

The lakes of the Morice watershed are tremendously varied. Large, deep oligotrophic lakes dominate the headwaters of the Morice and Nanika rivers, while several small to moderately sized, productive lakes head the eastern tributaries of the watershed including McBride, Lamprey and Owen creeks. Small lakes are scattered through the mountain drainages of the rest of the watershed.

These lakes contain a wide array of ecological values and play important hydrological roles. Many of the lakes are also important cultural features and / or provide recreational and tourism opportunities. A concerted effort is required to protect the values of lakes that are sensitive to development or lakes with valuable fish populations. The technical committee has proposed two levels of planning to help direct resource management decisions in and around lakes: lakeshore and lake basin management strategies. A lakeshore management strategy, recommended for completion in the Morice LRMP by 2006 (MSRM 2004), will classify lakes based on size and resource values. For some high value lakes, planning may need to extend to the entire lake basin to ensure land use practices are appropriate to safeguard the values of the lake. Lake access also needs to be considered as an important variable that influences the intensity of utilization of the lake’s fishery resources.

Objective: Maintain the ecological values of the lakes of the Morice River watershed

> *Related LRMP objective:* Maintain the functional integrity of lakeshore management areas.

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Implementing Organization
L1	2005 [9]	Develop a lakeshore management strategy[10] (MSRM 2004)	Planning, LRMP Implemt'n	Create partnership between MSRM, MOF and WFSP technical committee.	Design process [11]	Identify values associated with each lake[12]; classify lakes; collect baseline information [13].	Recommend zones and best management practices for developing or operating with those zones.	$50K	Geoff Recknell (MSRM) / MOF	MSRM / MOF **Funding:** MSRM
L2	2006-07	Develop lake basin management plans[14] for specific high value lakes[15].	Planning	Determine priority lakes for lake basin planning.	Review similar processes and design planning process.	Develop protocol to collect baseline information[1].	Integrate access into lake basin management plans.	Ongoing as development progresses.	Greg Tamblyn, CFDC Nadina	CFDC Nadina / MSRM / WLAP / MOF.

6.1.2 Streams / Rivers

The streams and rivers of the Morice watershed are as diverse as the geographic features that shape them. From raging headwater streams sourced in the glaciers of the Howson and Telkwa ranges, to gentler streams fed by snowmelt in the eastern plateau region of the watershed, each stream plays a role in the aquatic ecosystems of the basin. Lake-headed systems tend to contain clear and often relatively warm water, providing valuable spawning and rearing habitats for some fish species. Steeper, cold headwater streams offer unique habitats preferred by bull trout.

As the industrial footprint expands within the watershed, risks to aquatic habitats escalate. Small tributaries and headwater streams are the most likely to be impacted by land use activities due to their ubiquitous nature, their perceived low value as habitat, and their lack of buffering ability. As such, these smaller systems are of particular concern. Larger streams and rivers, although often better protected by operational practices than smaller streams, face direct effects from land use as well as cumulative impacts of upstream activities due to the downstream transfer of materials and energy. Thus, the impacts in a given place in a watershed are determined by the events in the entire upstream drainage area.

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[9] Pending final approval of Morice LRMP.

[10] Nested into lake basin plans?

[11] Review similar processes, FRPA regulations, LRMP outline for lakeshore management strategy

[12] Shoreline spawning areas and inshore ecological values should be identified.

[13] All lake basins where forest development is likely to occur have already experienced some land use activity (McCormack, pers. comm.).

[14] Lake basin plans are beyond the mandate of forest licencees to lead, but they will likely participate.

[15] Lakes containing lake trout and sockeye may be of particular interest.

The aquatic / terrestrial interface, or riparian zone, plays a vital role in maintaining structure and function of aquatic habitats. Riparian management strategies, including riparian reserve design (e.g. width) are most often based on expert opinion, limited empirical evidence (Richardson 2004) and compromise (habitat vs. timber objectives). As such, management regimes to protect riparian habitats are inconsistent across jurisdictions, varying widely by country, state or province. Management practices evolve over time, often without scientific evidence; little research exists to confirm whether reserve design is meetings its environmental objectives – especially over the long-term. A number of the proposed projects within this plan are related to improving understanding of the effects of management practices on lotic environments in order to improve practices and protect habitats over the longer term.

A watershed approach is important to minimize habitat fragmentation and cumulative effects downstream (Richardson 2004).

Objective: Increase the extent of aquatic related research conducted in the Morice watershed by 100% by 2006.

Proposed Project:

Proj #	**Start Year**	**Project Description**	**Project type**	**Steps**				**Estimated Cost**	**Project Contact**	**Implementing Organization**
LU1	Underway	Determine feasibility of developing a research watershed.	Feasibility study.	Determine interest from local and provincial research community[16].	Develop funding proposals.	Conduct feasibility study including determining the strengths, weaknesses, opportunities and threats.	Write report.	$5K	Greg Tamblyn	CFDC Nadina **Funding:** DFO

Research watersheds are vital to improving the understanding of the effects of land use activities on ecosystems. When applied, results from experiments and research can incrementally improve management practices and decisions so as to better protect habitats. For example, rigorous research at Carnation Creek since 1970 has created significant knowledge of the effects of land use on aquatic ecosystems in coastal BC - knowledge that has been incorporated into guidelines for forest practices and other land use development. Extensive hydrological and ecological studies are also currently underway in the Malcolm Knapp Research Forest near Maple Ridge by a group of UBC scientists. Knowledge gained form these research projects, while extremely valuable, is most relevant to coastal forests. Fortunately, recent fish / forestry / hydrology research in the Stuart-Takla and Prince George areas has been instrumental in building the knowledge-base in interior, sub-boreal watersheds. Nonetheless, cause and effect relationships between land use development and impacts are still not well understood, and reliable, practical indicators alerting resource managers to the early signs of deteriorating watersheds are not easily developed. Expanded long-term research efforts are required to further fill gaps in aquatic ecology and applied forest hydrology and geomorphology in order to minimize the future impacts of expanding development on aquatic ecosystems.

[16] Universities, Forest Sciences Program, WLAP, Bulkley Valley Centre for Natural Resources Research and Management

Comprehensive field monitoring to determine the effectiveness of land use plan objectives and changing resource management practices is also fundamental to assessing risks, decreasing uncertainty and determining trends in the physical, chemical and biological parameters of aquatic ecosystems. Without base-line information and well designed long-term monitoring programs built into an adaptive management framework, we will not know if or how the environment is being altered and will lack the data required to further refine management practices. A research watershed within the Morice system will help provide the focus required to conduct monitoring and research projects over the long-term.

6.1.2.1 Water Quality

Water quality is the physical, chemical and biological characteristics of water that affect its suitability for use. Land use activities may alter water quality to a point at which organisms are harmed or biological communities are modified. In an attempt to ensure water remains within acceptable standards, water quality guidelines have been established in British Columbia for a range of parameters, making water quality a relatively easily measured indicator of stream health. The Ministry of Water, Land and Air Protection in the Skeena Region is currently directing research on the use of benthic (bottom-dwelling) stream invertebrates as indicators of the biological integrity of stream channels.

Long-term monitoring (at least ten years) is required to determine trends and cumulative effects of land use on water quality. Once monitoring is underway, it should be linked with land use decision-making and permitting. For instance, should development be proposed in a certain area, data collected from an analogue site with similar land use could be used to better define conditions of a permit.

Objective: Develop a water quality monitoring program for the Morice Watershed.

Related Morice LRMP Objectives:

- Maintain water quality to support healthy aquatic ecosystems.
- Maintain water quality (surface, subsurface and ground water) to support First Nations, domestic, industrial, agriculture and recreational uses.

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Implementing Organization
WQ1	Underway	Integrate Reference Condition Approach with ongoing Benthic Index of Biological Integrity research	Research	Confirm partnerships and funding arrangement	Develop sampling protocol to integrate the 2 sampling approaches.	Conduct sampling	Develop a hybrid multivariate and multimetric tool.	$60K in each of 2 years.	Ian Sharpe	WLAP – Environmental Protection
WQ2	2005	Develop a multi-scale water quality monitoring	Monitoring / LRMP Implement'n	Compile information on the watershed and review	Assemble local experts to conduct watershed	Develop monitoring program - identify suitable	Develop a common database and input system to ensure	$15-25K depending on availability of existing	Greg Tamblyn / Ian Sharpe / Dave	CFDC Nadina / WLAP – Environmental Protection / **Funding:**

		program for priority sites / watersheds.		process used by the Bulkley Aquatic Resources Board (Wilford & Lalonde 2004)	wide review / landscape level analysis and rank watersheds[17]	parameters / appropriate spatial scale. Determine funding sources and partnerships.	monitoring results are captured in a central, accessible location.	database.	Wilford	Forest Investment Account, MSRM

6.1.2.2 Water temperature

Water temperature (and its seasonal and daily variation) is a primary determining factor shaping aquatic communities. Lakes or stream reaches can be categorized into thermal regimes, such as cold, cool and warm, derived from mean and maximum temperatures. A thermal regime reflects the climate, water source, shading and hydrological patterns of a watershed. Shifts in thermal regimes or temperature changes exceeding natural ranges can dramatically affect ecosystems at the species (physiological and behavioural), population and community level (Oliver and Fidler 2001), potentially leading to lower fitness levels, disease and death. Even minor changes in temperature can alter insect production, egg incubation periods, smolt migration timing, competition, and predator-prey relationships (Macdonald et al. 2003; Oliver and Fidler 2001). Lower water temperatures in winter can lead to the formation of anchor ice or decreased fish habitat (Hicks et al. 1991 in Oliver and Fidler 2001).

To avoid cumulative impacts of temperature changes, managing land use activities in and around waterbodies and where channels are coupled with adjacent wet ecosystems is vital. The technical committee is interested in seeing operational research trials in and adjacent to the Morice watershed to determine the effects of various riparian harvesting treatments on small streams. To date, draft best management practices for riparian reserve design and road construction and maintenance have been developed for Houston Forests Products based on preliminary research. These practices are currently being tested.

Objective: Maintain natural temperature regimes in watersheds across the landscape.

Related Morice LRMP Objective:

- Maintain water temperature within critical limits for salmonid species in all water bodies.

[17] Need to consider risk, activity (what is proposed or happening in the area) and value (what are we trying to protect).

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Implementing Organization
T1a (linked to T4 and H6)	2005	Determine effects of forestry practices on subsurface water temperatures of wet forested ecosystems.	Research	Resubmit letter of intent re proposal to the Forest Sciences Program (FSP)	Gather letters of support that include in-kind donations (members of the WFSP group)	Submit Letter of interest to FSP.	Submit proposal	$60 K for each of 3 yrs.	Dave Wilford / Patrick Hudson / Dan Moore (UBC) / Melissa Todd	MOF – Forest Sciences a/ UBC. / forest licencees. **Funding:** Forest Investment Account
T1b	2006 – included in proposal with T1a	Continue monitoring S-4 stream temperatures to determine effects of forest harvesting techniques.	Research	Conduct detailed monitoring of temperature at specific sites.	Enhance forestry operational research trials	Calibrate existing model used by Dan Moore and include a soil-warming component.	Conduct forestry operational research trials to validate models	Part of funding for T1a	Patrick Hudson / Dave Wilford	MOF - Forest Sciences / forest licencees **Funding:** Forest Investment Account
T2 (linked to T1)	2006	Develop a classification system for water temperature / thermal regimes in stream reaches.[18]	Management tool / research	Create a draft classification system, field test and develop an extension plan.	Hold a classification workshop with the aim of refining and improving the draft classification.	Field test the classification system (with workshop participants doing the same in their areas)	Revise and publish the classification. Undertake extension to ensure use of the system.	$15K /yr for 4 years.	Patrick Hudson / Dave Wilford	MOF - Forest Sciences Business Plan
T3	2005	Confirm and complete Morice LRMP list of temperature sensitive / critical streams[19].	Planning / LRMP Implement'n	Integrate temperature data from available sources – DFO, First Nations, provincial government, Alcan.	Determine sites	Determine data storage – location and custodian	Interpret data and determine future sites	$10K,	Geoff Recknell / Troy Larden – WLAP Sensitive Watershed group / Greg Tamblyn	WLAP **Funding:** MSRM
T4 (linked to T1a and H6)	2007	Research the effects of mechanical site preparation of wet sites adjacent to streams on water temperatures.	Research	Develop proposal with forest licencee(s) and submit for funding.	Conduct study.	Develop BMPs for operating in wet forested ecosystems.			Patrick Hudson / Dave Wilford / Melissa Todd.	Forest Sciences / Forest Licencees **Funding:** FIA / Forest Engineering Research Institute of Canada.

[18] This includes streams near threshold temperatures for fish as well as streams with significant warming responses post-harvest. Includes component to predict sensitivity of watershed to climate change.

[19] The Ministry of Water, Land and Air Protection is developing criteria for the designation of Fish Sensitive Watersheds and Temperature Sensitive Watersheds under the Forest and Range Practices Act. As of November 2004, an internal draft has been written. Date for release of final documents is undetermined.

6.1.2.3 Sediment loading

Water bodies naturally contain solid matter in suspension. Such matter can be mineral or organic, and results from physical, chemical or biological processes. Suspended sediment concentrations vary with weather events, typically peaking during spring runoff and storm events in the Morice watershed. Soil erosion is the largest source of sediment. Fine soils and soils with high soil pore water content (hygric and subhydric ecosystems) are the most highly erodible.

Land use activities can result in unusually high sediment loads to aquatic environments. Sources include roads, road crossings of streams, overland runoff, ditches, placer mining, draining of impoundments, landslides and accelerated bank erosion due to changes in water flows (DFO 2000).

Aquatic organisms are adapted to natural variations in sediment loading, but elevated levels of sediment, either suspended or deposited, can be harmful. Direct sub-lethal effects include decreased primary productivity, displacement from habitat, difficulty in locating food, and compromised immune systems and reproductive success. Lethal consequences include abrasion of gills, difficulty avoiding predators, and smothering of eggs, alevins and benthic invertebrates. Severity of effects is influenced by temperature, sediment load, particle angularity and size, ammonia concentration and duration of exposure (DFO 2000). See DFO (2000) for an exhaustive list of the effects of sediment on fish and fish habitat.

Objective: Prevent additions of sediments into waterbodies from all phases of development.

Related LRMP Objective: none specific to sediment

Recommended management practices:

- Use the Fish Stream Crossing Guidebook for design and installation of all stream crossings.
- Review and possibly use the stream crossing assessment process being used in the Bulkley Timber Supply Area.
- Improve road surfacing and consider paving or sealcoating roads on both sides of stream crossings.
- Improve road surfacing and consider paving or sealcoating high-traffic haul roads such as the Morice River and Morice Owen forest service roads (especially those utilized in all weather conditions for ore hauling).

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Implementing Organization
S1 Linked to R1 and H1	2005	Assess permitted / status road stream crossings and ditches for sedimentation, channel integrity, and	Assessment / SFMP implement'n	Review stream crossing assessment methodologies, and develop standardized approach.	Develop a stratified sampling design for assessments[20]	Assess stream crossings. Compile and organize existing road and crossing inventory	Link to rehabilitation plan.	$50K / yr	Melissa Todd / Jim McCormack	Forest Licencee work plans **Funding:** FIA via IFPA[21]

[20] Recognizing that it is impractical to do all crossings (use a risk assessment approach).

[21] Refer to version 3 of IFPA sustainable forest management plan.

		fish passage.				data into 1 format.				
S2	2005	Develop locally calibrated best management practices for road and ditch maintenance.	BMP	Review sedimentation issues and existing best management practices.	Identify sensitive areas[22] based on risk of sediment delivery to a fish bearing streams.	Take guidelines to companies. Develop a systematic sampling program for ditch lines and streams.	Train maintenance crews with respect to new practices (separate funding).	$20K	Tom Pendray / Ian Sharpe (discuss funding sources).	DFO WLAP **Funding:** Government staff wages or FIA
S3 Linked to R1and H1	2006	Assess non-permitted / non-status road stream crossings and ditches for sedimentation, channel integrity, and fish passage.[23]	Assessment	Review stream crossing assessment methodologies, and develop standardized approach (see S1).	Develop proposal to determine and assess priority stream crossings.	Assess priority stream crossings. Compile and organize existing road and crossing inventory data into 1 format.	Link to rehabilitation plan.	$50 - $70K	Dave Wilford / Jeff Lough (for past WRP fish passage work).	MOF Business Plan.
S4a	2006	Identify and map alluvial and colluvial fans[24] and lacustrine soils (could be combined with S4c)	Inventory / planning	Determine opportunity to identify fans and lacustrine soils as a base inventory for the Morice TSA (e.g. surficial geology or bioterrain mapping).	Develop funding proposal to develop inventory or conduct assessments.	Map fans and lacustrine soils.[25]	Include as a GIS layer for road and silvicultural planning.	$200K	Dave Wilford	MOF **Funding:** FIA
S4b	2006	Monitor success of management actions on fans and erodible soils[26]	Assessment / monitoring / adaptive management	Develop site-specific prescriptions for roads and harvesting on fans and highly erodible soils.	Embed prescriptions into standard operating procedures and site planning.	Incorporate monitoring into SFMPs.	Monitor the effectiveness of prescriptions - use results to improve future management.	$10K / yr	Each forest licensee	Each forest licencee - operational.
S4c	2006	Complete sediment source surveys.	Assessment /planning	Map sediments and textures.	Assess erosion potential prior to designing blocks or building roads			$50K / yr for 3 years. $150K total.	Ministry of Forest – Forest Sciences Program.	Ministry of Forests.

[22] Sensitive areas - problem areas on roads where sediments end up in waterways. Need to consider fish habitat and areas of high potential sediment input – E.g. Morice Owen Forest Service Road

[23] Rehabilitation plan project (R1) will summarize assessments to date.

[24] The majority of road problems occur on fans.

[25] Using surficial geology and bioterrain mapping.

[26] Determine if fans were properly identified and if prescriptions were appropriate.

6.1.2.4 Hydrologic Integrity

Hydrological integrity is the degree to which a watershed retains its structure, composition and processes associated with water flow. Land clearing, roads, water extraction, and dams can affect hydrological integrity by changing the magnitude, timing, duration, frequency and rate of change of water flows. For example, roads re-route water through ditches, reduce groundwater storage and increase water velocity at poorly functioning water crossings.

Objective 1: Maintain or restore the hydrological integrity of all watersheds in the plan area.

Objective 2: Maintain natural drainage patterns.

Related LRMP Objectives:

- Maintain or restore the hydrological integrity of all watersheds in the plan area.
- Minimize negative effects of water withdrawals on flow regimes and the aquatic ecosystem.

Recommended Management Practice: Minimize ground disturbance during burning and site preparation, especially in wet forested ecosystems (hygric and subhydric sites) that are coupled to streams.

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Implementing Organization
H1 (incorp. into S1 and S3)	2005	Assess stream crossings and ditches for channel integrity.	Assessment	See Sediment Projects S1 and S3.				See S1 and S3	Melissa Todd / Jim McCormack / Dave Wilford	IFPA, Forest Licencee work plans
H2 (reliant on T1)	2007	Develop and implement BMPs for road construction and drainage on wet sites.	BMPs, monitoring	Conduct research outlined in T1.	Develop draft BMPs.	Develop study design to investigate impacts of road construction techniques on a range of hydrologic variables.			Patrick Hudson / Melissa Todd	Forest Licencees **Funding:** FIA or FERIC
H3	2005	Determine how to manage large woody debris in small streams to maintain hydrologic integrity.	Research, BMPs	Develop and field-test a draft geomorphic classification scheme that incorporates woody debris[27].	Organize a workshop to review and revise classification system (primarily invited participants).	Apply the revised classification in the field - locally and in other areas. Evaluate the effectiveness of the classification.	Publish the classification, and undertake extension; Develop BMPs for streams in the Morice.	$20K / yr for 3 yrs	Dave Wilford / Dan Hogan (Provincial program looking at LWD in a range of BEC zones) Melissa Todd (CWD strategy)	Forest Sciences Program Work plan / UBC / WLAP/ Forest Licencees **Funding:** FIA

[27] Includes developing a geomorphic inventory of headwater streams to determine the level of sediment and bedload storage resulting from large woody debris (LWD).

H4	2005	Develop proposal to track climate change & effects on hydrologic integrity[28] & water temperature patterns.	Research	Further scope project idea.	Look into possible funding opportunities[29]	Develop and submit proposal idea.	Comment: Licencees would like to differentiate whether water flow issues are related to their practices or climate change.	To be determined	Patrick Hudson.	Patrick Hudson
H5	2006	Establish long-term pre- and post channel descriptions (probably a 25 year study.)	Monitoring	Determine similar work being done in other areas of the province.	Establish benchmarks.	Look at twinning study with vegetation resource inventory.	Develop signage for long term monitoring sites and register the project with MOF.	To be determined	Dave Wilford / (Jim Schwab / Dan Hogan)	Forest Sciences Work plan / UBC
H6 (Linked with T1a and T4)	2007	Research the effects of mechanical site preparation on hydrologic regimes.	Research, BMPs	Develop proposal with forest licencee(s) and submit for funding.	Conduct study.	Develop BMPs for operating in wet forested ecosystems.		See T1	Patrick Hudson / Dave Wilford / Melissa Todd.	Forest Sciences / Forest Licencees **Funding:** FIA, FERIC

6.2 Habitat Rehabilitation

Goal: To rehabilitate fish habitat impacted by land use activities.

Previous work completed under British Columbia's Watershed Restoration Program (WRP) between 1994 and 2002 began to address impacted watersheds within the Morice drainage, but left gaps in the following areas:

a) Tenures and jurisdictions not eligible for WRP funding (private land and impacts due to non-forestry activities such as agriculture and mining);

b) Impacts that occurred after the implementation of the *Forest Practices Code of BC Act*;

c) Pre-1995 impacts that were not assessed prior to the end of the WRP program including chart areas for the former Small Business Program;

d) Areas that were not completely assessed by the WRP; and

e) Fish passage assessments outside of active forest operating areas (Freshwater Resources 2004).

In addition, many of the proposed restoration works recommended in WRP assessments were never implemented or never monitored. Eight to ten years after the assessments, the continued relevance of these proposed projects is unknown.

[28] Atmospheric Environment Service did a study in the south coast to determine possible trends due to climate change. Earo Karanko – DFO has also done some regional work on this topic. Examine how autumn hydrograph would change with a shift to more rain on snow events.

[29] Climate change and beetle management related funding.

Extensive land use development, primarily forestry, has occurred in the Morice watershed since the mid-1990s when WRP began and the Forest Practices Code was implemented. The assumption has been that the application of the "Code" guidelines would mitigate environmental impacts. However, local monitoring programs and assessments were rarely conducted to verify that practices were not directly or cumulatively impacting streams and lakes.

Objective: Develop an updated rehabilitation plan for the Morice watershed.

A rehabilitation plan is required to provide a framework for the assessment, prioritization and cost effective implementation of watershed rehabilitation works.

Related LRMP Objectives:

- Rehabilitate high value fish habitat where degraded by land use activities.
- Restore fish access to habitat that is impeded by road or land use development.

Proposed Project:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Implementing Organization
R1	2005	Develop a Fish Habitat Rehabilitation Plan.	Planning	Secure funding by writing proposals.	Review existing assessments / assess extent of land use in sub-watersheds / map studied areas vs. high value habitat[30]	Identify gaps in assessments in high value fish habitats and conduct limited field program to confirm past assessments.	Create the plan - set priorities for assessments, effectiveness evaluations and rehabilitation projects.	$50K	Greg Tamblyn / Patrick Hudson	CFDC Nadina

6.3 FISHERIES MANAGEMENT

Goal: To optimize quality and quantity of fish production while maintaining a natural species balance.

Fully functioning habitat is only one requirement to sustain fish populations. Fisheries managers must also ensure fish are not over-harvested, a challenging task considering the resource is mobile and hidden. Managing anadromous fish is particularly difficult because of the many variables affecting fish populations including ocean conditions, fresh water and estuarine habitat availability, and various fisheries including international commercial fisheries. Determining escapement targets for anadromous fish is a balancing act maximizing economic and social objectives, while allowing the appropriate number of spawners to enter natal streams to sustain populations. Today's highly efficient commercial fish harvesting techniques can significantly impact fish populations in short order, particularly if fishery openings or fishing regulations are based on inaccurate estimates. Resident fish populations are also often vulnerable to capture by

[30] Off channel habitat on the Morice River could be investigated. Would instream works improve habitat in these areas?

both regulated and unregulated anglers. Population collapse is a risk if fish are inadvertently over-harvested.

Improving the understanding of trends in fish populations and the productive capacity of the Morice watershed will help improve the knowledge base from which fisheries management decisions are made. Unfortunately, long-term stock assessment programs are expensive and require the assurance of continuing funding. Nonetheless, better information will help managers respond more quickly to declines in populations, potentially avoiding fishery closures of the scale implemented to protect Skeena coho in the late 1990s.

The following section of the plan identifies species-specific projects meant to fill data gaps and allow more informed fisheries management decisions[31]. While it is understood that fisheries managers have large geographic areas to administer with limited staff and financial resources, it is anticipated that the following priority projects will be strongly considered by responsible organizations and / or their partners in annual work plans. ***Organizations with the legal responsibility for managing relevant aspects of the aquatic environment will determine how each project fits into their regional and/or annual priorities.***

The Morice WFSP technical committee would like to encourage government agencies, community groups, First Nations and industries to continue to work collaboratively when designing and conducting assessment and monitoring programs. Synergies will allow greater collection of data per unit of funding.

6.3.1 Angling Management

The Morice River provides world class angling opportunities for steelhead trout and Chinook salmon. An updated angling management plan is strongly desired by members of the local angling community to maintain quality angling experiences on the river[32]. Key issues include crowding, illegal guiding and ensuring maximum benefits of the fishery accrue to local communities.

Objective: Maintain or improve angling experiences on the Morice River.

> *Morice LRMP Recommended Policy Change*: "Develop area specific angling use plans that allocate a range of tourism and recreational based fishing opportunities" (MSRM 2004).

Proposed Project:

Proj #	Start Year	Project Description	Project type	Steps	Estimated Cost	Project Contact	Responsible Organization*
FM1	2006	Develop an angling management plan for the Morice River	Planning	Steps determined by Quality Waters Strategy (Anon 2004)	$70K	WLAP Fisheries Section Head	WLAP **Funding:** HCTF / Quality Waters Initiative

* Organizations with the legal responsibility for managing relevant aspects of the aquatic environment will determine how this and other projects fit into their regional and/or annual priorities.

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[31] Note: additional potential projects are identified for each fish species in Bustard and Schell (2002).

[32] The need for an updated angling management / angling use plan was one most often voiced desires of many of the members of the Morice LRMP fish sector, which represented individuals and community groups with an interest in conserving fish and fish habitat at the Morice LRMP.

In 2004, a the Ministry of Water, Land and Air Protection administered a River Guardian Program to conduct a creel survey on the Morice River in an effort to collect information on number of anglers, method of angling, targeted species, and by-catch. Similar creel surveys (or Guardian Programs) are recommended every two to five years to monitor use of the river until a monitoring program is established within the proposed Angling Management Plan.

6.3.2 Sockeye Salmon

Sockeye is a priority species for monitoring and research within the Morice watershed. Management of Morice-Nanika sockeye has implications to both First Nations and commercial fisheries. As a result of relatively low escapements over the past 50 years, the Office of the Wet'suwet'en has voluntarily suspended its traditional sockeye fishery due to conservation concerns, affecting traditional food and ceremonial practices. The commercial Skeena sockeye fishery is managed to minimize by-catch of Morice-Nanika sockeye; should Morice-Nanika sockeye returns decline further, management decisions to conserve this run may negatively impact the commercial fishery, which targets the economically huge Babine sockeye run.

The connection of Maxan Lake / upper (little) Bulkley sockeye to Morice sockeye is not fully understood, although the fish appear to be quite distinct. The upper Bulkley sockeye "may in fact be a river-type stock that is barely hanging on." (Steve Cox-Rogers, pers. comm.)

Because nutrient levels in Morice Lake are a limiting factor for smolt production, nutrient enrichment is a potential topic of ongoing research. Enrichment experiments were last initiated in 1980 (Bustard and Schell 2002). Should further lake fertilization be proposed, nutrient addition trials should be conducted using a comprehensive experimental design to test multiple ecological hypotheses including determining changes to fish populations, water quality, primary and secondary productivity, and the aquatic ecosystem in general. The effects of nutrient addition on angling experiences should also be incorporated into the study.

Objective 1: Maintain or increase sockeye populations to the natural productive capacity of the watershed.

The Morice LRMP recommendation package identifies impacts to water quality, including nutrient loading, on fish and aquatic ecosystems as an important issue.

> *Related LRMP goal:* "Maintenance of the ecological integrity of the full range of…aquatic ecosystems" (MSRM 2004).

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps			Estimated Cost[33]	Project Contact	Responsible Organization(s)
SK1	Ongoing	Determine Nanika sockeye escapements.	Stock assess.	Identify current efforts and review current monitoring techniques[34].	Standardize stock assessment techniques.	Determine if fisheries management decisions are generating the appropriate responses in Nanika sockeye through continued monitoring	$90K / yr	DFO/ Walter Joseph (Office of the Wet'suwet'en)	DFO / Office of the Wet'suwet'en
SK2	Ongoing	Estimate number of beach spawners in Morice and Atna lakes.	Stock assess.	Review methodologies to estimate # of beach spawners. (Utilize current tagging at Moricetown).	Establish various sampling procedures for adult and juvenile sockeye.	Conduct fieldwork annually or biannually.	This project is currently part of integrated stock assessment work for several species. Costs could run $50K if it were done separately.	Barry Finnegan / Walter Joseph	DFO / Office of the Wet'suwet'en
SK3	Underway	Evaluate options for enhancing sockeye production in the Morice.	Assess.	Collect and summarize existing information on enhancing sockeye populations.	Determine options and list pros and cons of each option.	Consult with public over options.	$26K	Walter Joseph	Office of the Wet'suwet'en **Funding:** Pacific Salmon Commission
SK4	2005	Conduct fall fry surveys on Morice Lake.	Stock Assess.	Develop local capacity to conduct and interpret data from fall fry surveys in sockeye lakes within the Skeena drainage.	Purchase equipment.	Conduct surveys annually or biannually.	$7-10K / yr for Morice Lake for surveys.	DFO / Allen Gottesfeld / Walter Joseph	DFO / Skeena Fisheries Commission/ Office of the Wet'suwet'en

[33] For ongoing and proposed projects, costs are difficult to estimate because many projects are integrated to save costs (e.g. sockeye and coho tagging are done at the same time in Moricetown Canyon and helicopter flights are often shared among numerous projects).

[34] Fisheries and Oceans Canada currently estimates Nanika sockeye escapements based on snorkel counts in the Nanika and mark-recapture studies conducted at Moricetown Canyon by the Office of the Wet'suwet'en.

SK5	Dependent on interest to move ahead with fertilization	Morice Lake Fertilization impact study	Impact Assess. / monitoring	Design comprehensive BACI monitoring program.[35]	Include a socio-economic impact assessment.	Monitor Morice Lake and Morice River prior to fertilization.	Initial study $50-100K; $25 - 50K / yr monitoring (integrated with existing assessment work).	DFO / Walter Joseph	DFO / Office of the Wet'suwet'en
SK6	**Low priority**[36]	Long-term sockeye Smolt outmigration study.	Stock assess.	Design monitoring strategy.	Find long-term funding	Correlate smolt numbers with adult escapements to estimate productive capacity of the watershed	$140K / yr + capital expenses	DFO / Walter Joseph	DFO / Office of the Wet'suwet'en

The Office of the Wet'suwet'en has expressed interest in determining the current and historical marine derived nutrient shadow[37] within the Morice watershed. It is also interested in determining the risks of contamination of the Morice watershed by heavy metals and organic pollutants released from body tissues when salmon decompose (Stefan Schug, pers. comm.).

6.3.3 Chinook salmon

Morice watershed Chinook populations were intensely studied in the late 1970s and early 1980s in association with the Kemano Completion project (Bustard and Schell 2002). Since this time, Chinook escapements have increased significantly and appear relatively stable. However, there has been little research into how these higher escapements have affected overcrowding on spawning grounds and distribution of both adults and juveniles.

Objective: Determine productive capacity of the Morice watershed for Chinook salmon.

[35] Consider including water quality, nutrient circulation in lake, size and age of sockeye smolts, fry distribution, fish populations and condition factors (esp. for rainbow, lake and bull trout), primary and secondary productivity and plankton and periphyton communities.

[36] This project is technically difficult and very expensive. DFO favours fry assessments to help assess stock status. To determine productive capacity of Morice Lake, DFO currently uses photosynthetic rate models.

[37] The marine derived nutrient shadow refers to the terrestrial and aquatic areas influenced by nitrogen and phosphorus delivered to watersheds from anadromous fish returning to freshwater to spawn.

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Responsible Organization
CH1	2005	Verify escapement numbers estimated during flights.	Stock assessment	Determine preferred methodology.[38]	Secure funding.	Assess population.	Compare and calibrate with flight counts.	Depends on methodology. $25-$100K	DFO	DFO
CH2	2006	Determine productive capacity (spawning and rearing) of the Morice River.	Stock monitoring and assessment	Establish systematic index sites and monitor over the long-term.	Link escapement data with rearing densities found at the index sites.	Determine spawning densities and degree of redd superimposition.	Utilize information in setting escapement levels.	$50K / yr for mainstem in conjunction with steelhead.	DFO	DFO
CH3	2006	Determine survival rates of Chinook from smolt to adult spawner.	Stock assessment	Release hatchery raised Chinook into Morice tributaries.	Link to project CH2 to capture returning adults.	Analyze fish for DNA.			DFO	DFO

6.3.4 Coho Salmon

Fisheries and Oceans Canada has improved adult and juvenile indices for coho over the past decade. Juvenile sampling at index sites is conducted annually within the Morice watershed and adult escapement estimates are now more reliable than in the past. Even so, coho use of secondary and smaller streams during higher returns is not well delineated and good long-term indices of coho stocks in the Morice are limited. Such long-term indices are vital to recognizing the kind of stock declines that resulted in the 1990s closures of First Nations, recreational and commercial fisheries to protect failing coho stocks (Bustard and Schell 2002).

Objective 1: Maintain or increase coho populations to the natural productive capacity of the Morice Watershed.

Objective 2: Develop reliable long-term indices for coho stocks.

[38] High resolution photographs, mark-recapture program are a couple options.

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Responsible Organization
CO1	Ongoing	Coho mark-recapture program at Moricetown	Stock assess.	Secure funding	Review and refine project from previous year.	Determine what concurrent studies can benefit from the tagging program (e.g. tagging sockeye and steelhead).		Costs are integrated with the sockeye tagging program[39].	Barry Finnegan / Walter Joseph	DFO / Office of the Wet'suwet'en
CO2	2006	Winter habitat survey. Determine if sites identified as coho juvenile habitat in late summer support fish over winter. Attempt to identify critical habitat.	Habitat / stock assess.	Review past work on coho over-wintering (e.g. upper Bulkley 3-yr study)	Undertake rapid low cost survey of juvenile index sites over – winter. Determine water depth, O_2 levels fish presence absence.	Undertake detailed over-wintering survey focused on 1 system or more representative systems to determine where over-wintering occurs.	If necessary, conduct a detailed survey of fish movements prior to the onset of winter and/or spring.	$15K – rapid survey $50-100K – detailed survey $150K for fish movement study (lower priority at this point).	Barry Finnegan / Tom Pendray	DFO
CO3	2006	Review current juvenile index site monitoring program.	Stock assess.	Convene a group of stock assess. biologists to review existing program.	Determine whether expansion of current program will improve understanding of coho population trends and distribution and be cost effective.	Determine whether current methodologies are providing accurate assessments of juvenile production	If deemed valuable, expand index monitoring program.	Small cost to review. Cost to expand program depends on extent.	DFO	DFO

The intensive coho stock assessment program on Toboggan Creek is currently used as a surrogate to estimate carrying capacity for coho in the Morice River watershed. In addition,

[39] Currently, coho tagging is being reduced as the emphasis moves to sockeye. However, the Office of the Wet'suwet'en is interested in reinstating the full coho tagging program.

habitat and habitat changes are estimated in Morice tributaries during annual juvenile stock assessment work. However, it is arguable that knowledge of productive capacity in key tributaries to the Morice is not well understood and that further monitoring and research would be useful in determining escapements needed to fully seed these tributaries. This work would be expensive, and currently DFO feels that available funding is better allocated on current assessment work (Barry Finnegan, pers. comm.). The following project should be considered should stock assessment budgets be significantly increased in the future.

Proposed Project:

Proj #	Start Year	Project Description	Project type	Steps			Estimated Cost	Project Contact	Responsible Organization
CO4	**Low priority** due to low feasibility and high cost.	Establish index site for coho in an upper Morice tributary (e.g. Gosnell).	Stock Assessment	Measure juvenile populations in the late summer.	Measure adult escapements to the tributary.	Measure eventual smolt output over a range of escapements	$400K	DFO	DFO

Outplanting fry above beaver dams is an option to ensure habitat is utilized. Hatchery raised coho were released into Owen Lake in 1999 and 2000 with apparently positive results (Bustard and Schell 2002).

6.3.5 Steelhead

> *"The implications of modifying the commercial fisheries to accommodate steelhead spawner recruitment combined with what has become an internationally significant and growing sport fishery for Bulkley and Morice steelhead makes it imperative that a solid adult and juvenile database be developed for the management of this stock.*" (Bustard and Schell 2002)

Assessing steelhead stocks in the Skeena watershed, however, is often fraught with technical difficulties and financial limitations that need to be overcome to provide accurate data. The limiting factors for steelhead smolt production within the Morice watershed remain largely unknown despite periodic studies on steelhead juveniles (Bustard and Schell 2002).

Objective 1: Maintain or increase steelhead populations to the natural productive capacity of the Morice Watershed.

Objective 2: Create an index of carrying capacity of major steelhead tributaries within the Morice watershed.

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Responsible Organization
ST1	2005	Refine productive capacity model for Skeena.	Modelling	Locate qualified person to develop model.	Review current model in PSARC. Determine information required to improve model.	Develop and revise model and collect data to plug into model.	Monitor stock to confirm escapement meets targets recommended by model.	$20-50K	WLAP Fish and Wildlife Section Head	WLAP **Funding** HCTF
ST2	2006	Continue with systematic long-term monitoring of juvenile index sites.	Stock Assess.	Review current monitoring methods and revise if necessary[40].	Secure long-term funding commitments for monitoring.	Establish index sites (combine with coho and Chinook sampling to maximize efficiencies where possible).	Standardize sampling methods. Implement methods.	Approx. $50K, - highly variable depending on methods and sites.	WLAP Fish and Wildlife Section Head	WLAP
ST3	2006	Link (revised) juvenile indices to long-term data.	Data analysis	Correlate data.	Report on trends.				WLAP Fish and Wildlife Section Head	WLAP

A genetic study is underway by Terry Beacham of the Pacific Biological Station (DFO) to identify stocks and to determine the population structure of Skeena River steelhead (Beacham 2004). This information can be used to determine stock composition of summer run steelhead in mixed-stock fisheries. As of autumn 2004, the research team had sampled 111 steelhead from the Morice watershed. A sample of 200 fish is required to provide 95% accuracy when determining the stock to which a sampled fish belongs.

[40] This may be driven by the productive capacity model for the Skeena.

Proposed Project:

Proj #	Start Year	Project Description	Project type	Steps			Estimated Cost	Project Contact	Responsible Organization
ST4	2005	Complete microsatellite DNA analysis for the Skeena summer run steelhead (Morice included).	Research	Collect and preserve samples from each major steelhead stock in the Skeena to a total of 200 fish per stock (approximately 90 additional steelhead required from the Morice).	Send samples to Terry Beacham	Analyze and report results	$70K for Skeena tribs (approx $6000 for Morice)	WLAP Fish and Wildlife Section Head	WLAP **Funding:** HCTF + others.

6.3.6 Rainbow Trout

Very little information exists for rainbow trout populations in the Morice watershed. The most significant stock is probably the Morice Lake population (Bustard and Schell 2002). Bustard and Schell (2002) suspect that angling associated with the salmon fishery in the upper reach of the river in the past has negatively impacted the rainbow trout population. Future decisions regarding the resumption of salmon fishing in this area need to consider the issue of by-catch of this slow growing rainbow trout. Collecting additional life history information would be useful in managing this species. Such studies could be linked to sockeye work.

Objective 1: Improve life history knowledge of rainbow trout in the Morice watershed.

Objective 2: Maintain or increase populations of rainbow trout to the natural productive capacity of the Morice watershed.

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Responsible Organization
RB1	2005/06	Gather life history information for fluvial and lacustrine rainbow populations.	Research	Review existing information with WLAP experts.	Develop methods / sampling design	Write proposal to HCTF Apply to HCTF in November	Letters of support – money or in-kind for implemen-tation	$40K	WLAP Fish and Wildlife Section Head	WLAP
RB2	2006	Assess regulations to determine if they adequately protect upper Morice rainbow trout populations.	Management	Analyze harvest data collected by the 2004 Morice River Guardian program and collate existing information.	Review genetics data; review regulations in other areas	Submit recommend-ations to managers.	Consult public regarding proposed regulation changes.	N/A.	WLAP Fish and Wildlife Section Head	WLAP

6.3.7 Bull Trout

A recent bull trout study (Bahr and Shrimpton 2004; Bahr 2002) has vastly improved the knowledge of bull trout within the Morice watershed. However, the current population and trends in population remain unknown (Bustard and Schell 2002). Bull trout are susceptible to over-fishing in systems with good access and are vulnerable to habitat alteration, particularly increased temperature. Future work is required to assess the effectiveness of current regulations in conserving Morice bull trout populations and to determine and assess the status of bull trout populations over time.

Bull trout tend to be larger in the Nanika watershed than in the rest of the Morice drainage. This evidence suggests that the Nanika River "population" may be unique in the drainage. Because bull trout located directly below the falls at the outlet of Kidprice Lake are vulnerable to angling, these potentially unique fish may not be adequately protected. Opportunities might exist to link bull trout assessment in the Nanika with assessment of sockeye salmon and rainbow trout.

Objective 1: Maintain or increase bull trout populations to the productive capacity of the watershed.

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Responsible Organization
BT1	2005/06	Assess regulations to determine if they adequately protect upper Morice and Nanika BT.	Management	Analyze data on bull trout harvest collected by the Morice River Guardian program in 2004 and collate existing information.	Review genetics data; review regulations in other areas	Submit recommend-ations to managers.	Consult public regarding proposed regulation changes.	Staff time	WLAP Fish and Wildlife Section Head	WLAP
BT2	2005/06	Establish a systematic long-term stock assessment program.	Stock Assess.	Develop sampling methodology[41] including sites.	Write proposal and apply for funding	Determine possibilities for periodic long-term monitoring.		Highly variable depending on methods and sites.	WLAP Fish and Wildlife Section Head	WLAP

6.3.8 Lake Trout

Lake trout are limited to four lakes in the Morice watershed. Populations in Owen and McBride lakes showed signs of over-harvest when assessed in 2004 (Paul Giroux, pers. comm.). The status of Atna and Morice lake trout populations remains unknown.

[41] Some base-line data is available (Dave Bustard, pers. omm.). Consider redd counts in the upper Gosnell (key area), Denys and upper Starr creeks on an annual basis; conduct snorkel counts in the Nanika and other key tributaries. Creel surveys should include size and age of fish harvested and catches per unit effort.

Lake trout are particularly vulnerable to over-fishing and populations are slow to recover. Without periodic monitoring, stocks can decline prior to implementation of corrective management actions. Prior to the lake trout stock assessments conducted in 2004, fish inventories on lakes containing lake trout last occurred 20 to 30 years ago, raising concerns about the monitoring frequency of lake fish populations in the Morice watershed. Surveys every five to ten years would provide improved population trend data on which to base management decisions to conserve fish populations.

The Ministry of Water, Land and Air Protection is currently developing a "Provincial Lake Trout Conservation Strategy" to help manage the province's lake trout populations. The strategy will identify biological reference points for species management, will determine sampling frequencies and methodologies, and will recommend recreational angler regulations to help maintain and restore degraded fish populations.

Objective: Increase lake trout populations to the natural productive capacity of the lakes they inhabit.

Proposed Projects:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Responsible Organization
LT1	2005	Implement anticipated new regulations to conserve lake trout populations in appropriate lakes.	Fisheries Management	Generate sustainable yield curves for lake trout in British Columbia.	Examine current regulations and lake trout populations to determine if regulation changes are necessary.	Develop local extension program to educate public about any changes to lake trout management changes.		N/A	WLAP Fisheries Section Head	WLAP
LT2	2006	Assess Morice LT population. Monitor adult LT populations in Owen, McBride, Atna and Morice lakes.	Stock Assess.	Assessment of abundance and exploitation level completed for Owen and McBride in 2004.	Apply provincial Lake Trout Conservation Strategy across the Skeena Region including the lakes in the Morice.	Assess Atna and Morice lakes.	Reassess lakes every 5 to 10 years to determine population trends.	15K - Morice Lake 8-10K Atna Lake	WLAP Fisheries Section Head	WLAP
LT3	2006	Implement a creel program for lakes containing lake trout.[42]	Stock Assess. / monitoring	Explore partnerships with First Nations or non-government organizations and secure funding.	Conduct roving creel survey for Morice, Owen and McBride lakes for all species.	Measure fork lengths and take samples for aging for lake trout and rainbow trout (& other species)	Determine catch per unit effort and link to population trends.	$30K for 3 lakes.	WLAP Fisheries Section Head	WLAP

[42] Creel surveys are an important part of the program and would fall in second priority only to field based assessments, except for Morice Lake where a creel survey may be the most effective technique.

6.3.9 Dolly Varden and Cutthroat Trout

Provincially, both Dolly Varden char and cutthroat trout are blue-listed species. Although populations of both species have not been formally assessed in the Morice watershed, angling pressure is low and populations are thought to be relatively stable (Bustard and Schell 2002). Cutthroat are found in smaller tributaries with lake or pond habitat, while Dolly Varden are widely distributed in lakes and are found at low densities in most tributaries to the Morice River, including many headwater streams (Bustard and Schell 2002). Loss of habitat is the largest risk to both species.

Objective: Determine population status and trends of Dolly Varden and cutthroat trout.

Proposed Project:

Proj #	Start Year	Project Description	Project type	Steps				Estimated Cost	Project Contact	Responsible Organization
DV/CT1	2005/06	Develop juvenile monitoring programs[43] for DV & CT.	Stock Assess. / monitoring	Determine best methodologies and number of sites.	Apply for funding	Establish juvenile index sites for long-term monitoring.	Report on population estimates.	Highly variable depending on number of sites	WLAP Fisheries Section Head	WLAP

7.0 MONITORING

WFSP participants will need to monitor both the progress in implementing the plan and the plan's effectiveness in meeting its objectives. To monitor plan implementation, the technical committee should meet at least once each year to determine the status of each project and to address challenges and barriers involved with project execution. Feedback will allow the plan to be adjusted as circumstances change or knowledge is gained.

Field monitoring should occur at multiple scales to determine if plan objectives are being met. Spatially, both watershed level and site-specific (for critical habitats) sites are required. Reference sites should be established as control sites. Temporally, baseline (pre-development) and post-development monitoring integrated into an adaptive management framework (figure 4) is required to determine the impacts or "results" of land use practices and adjust practices appropriately to minimize future impacts.

Most projects listed in the plan include a monitoring component or establish a monitoring program. The development of a water quality-monitoring program (project WQ2) will be a significant step toward determining the effectiveness of the land-use portion of the plan. Projects listed under the Fisheries Management section will refine and expand current monitoring of fish stocks to help determine trends in fish populations and help establish or enhance productive capacity estimates.

Two recently developed local monitoring frameworks will be useful developing an effectiveness monitoring program for the Morice WFSP. The first is the *Babine Watershed Monitoring Framework* (Price and Daust 2005), a priority setting tool that uses risk and uncertainty to

[43] Combine juvenile monitoring of these species with monitoring of other species where possible to gain efficiencies

identify where monitoring efforts are best allocated. The second is *A Framework for Effective Watershed Monitoring* (Wilford and Lalonde 2004) developed by the Bulkley Aquatic Resources Board. This framework is based on a series of questions that will help determine what aquatic parameters are most effective to monitor and where. Using these two existing frameworks will help promote consistency in monitoring adjacent watersheds.

Monitoring is required over long-periods of time to establish trends, determine cumulative impacts and separate out natural fluctuations. A challenge to any monitoring program is to secure long-term funding. Locally, an effective way to encourage long-term monitoring is to integrate monitoring into the operations of forest licencees and government agencies so that base funding helps cover costs.

Additional background information on monitoring, including a list of monitoring tools, can be found in Appendix E.

Data Management and Extension

An effective monitoring program requires that collected data and results be accessible to the organizations responsible for implementing and reviewing the plan. WFSP participants should work with the Ministry of Water, Land and Air Protection to track water quality information. In addition, an agreement needs to be developed with the Ministry of Sustainable Resource Management and / or Morice-Lake IFPA to ensure data and results collected through projects associated with the WFSP are accessible through the Northwest Data Sharing Agreement.

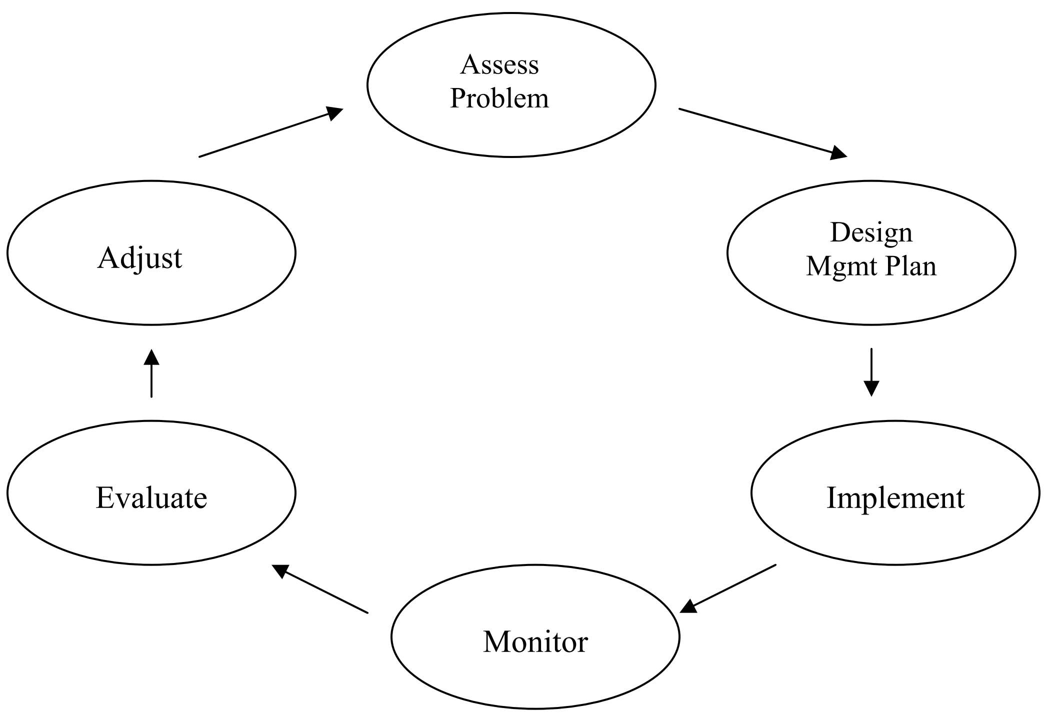

Figure 4: Adaptive Management Framework (from Taylor 2000)

An extension strategy should be created for each project to spread data and results, and to raise the profile of the WFSP. For instance, knowledge gained from ongoing and completed projects could be presented at seminars and workshops, or distributed via publications like *Streamline*.

Another option is to utilize the Upper Skeena Atlas website as a depository for summarized information – reports, implementation committee meeting summaries, etc. The GIS portion of the website could be used to display monitoring locations, collected data and information about each sampling site. This website is part of the Community Mapping Network and the Sensitive Habitat Inventory Mapping project (http://www.shim.bc.ca/), run with the help of Brad Mason of Fisheries and Oceans Canada. The site integrates data from many sources including government fisheries and watershed databases and makes it accessible through a user-friendly mapping system that anyone can access with minimal training.

8.0 IMPLEMENTATION

WFSP participants and their organizations will play a significant role in implementing this plan. Federal and provincial government agencies, First Nations, forest licencees, consultants and non-profit community groups will contribute. In some cases, projects will be implemented through, or integrated into, established processes such as the Morice-Lakes IFPA, forest licencee Sustainable Forest Management Plans and the Morice LRMP. The WFSP Technical Committee could also expand its role to help implement aspects of the Morice LRMP.

Implementation is integrated into the projects outlined in Section 6.0. Project contacts or "champions" and organizations with an interest, mandate and / or regulatory authority to conduct or oversee projects have been identified for each project. The project contact is encouraged to review the WFSP Action Plan regularly to help ensure that projects associated with his or her organization are brought forward during work planning, or when a relevant funding source is found. Any consultant or community group interested in conducting or participating in a project should communicate with the project contact. A proposed starting year has been listed for each project to act both as a guide for annual work plans and as an implementation monitoring target. Groups potentially involved in implementing aspects of the Morice WFSP include:

- Bulkley Valley Centre for Natural Resources Research and Management;
- CFDC Nadina, and other community / interest groups or individuals;
- Consultants;
- Fisheries and Oceans Canada – various branches;
- Forest licencees: Houston Forest Products, Canfor, BC Timber Sales branch of the Ministry of Forests;
- Ministry of Forests – various branches, particularly the Forest Sciences Program;
- Ministry of Sustainable Resource Management: Planning Section; Information Section;
- Ministry of Water, Land and Air Protection: Ecosystems Section, Fish and Wildlife Science and Allocation Section, Environmental Quality Section;
- New industrial developers to the area;
- Office of the Wet'suwet'en;
- Skeena Fisheries Commission;

- University professors and students; and
- Other interested parties.

Plans through which aspects of the Morice WFSP may be implemented:

- Morice LRMP (MSRM / Watershed Advisory Committee);
- Morice-Lakes Innovative Forest Practices Agreement (IFPA); and
- Sustainable Forest Management Plans arising from the IFPA.

Steps are already underway to implement parts of the Morice WFSP. For instance, over the past year, CFDC Nadina, the Office of the Wet'suwet'en and the Ministry of Forests submitted proposals for various projects listed in the plan. In other cases, forest licencees have looked for projects in the WFSP that help them meet objectives in their sustainable forest management plans. WLAP has used recommendations from the Morice WFSP technical committee to assist in decision-making in recreational fishing negotiations and to expand its lake trout assessment program. Finally, the Ministry of Sustainable Resource Management is interested in working with the Morice WFSP technical committee to help complete projects with common components in both plans.

Connections between the WFSP, resource management organizations, other planning processes and legislation is shown in figure 5.

9.0 NEXT STEPS

The final stage of the WFSP process (Stage IV) puts the plan into action. As the plan is implemented, opportunities exist to modify the plan as projects evolve, as new projects are identified, as priorities evolve, and as monitoring provides feedback. The WFSP technical committee is encouraged to become a permanent group, perhaps in the form of the proposed watershed advisory committee for the Morice LRMP or as a distinct watershed round table. The group should meet at least annually to review and update the plan, and to monitor plan implementation.

Fisheries and Oceans Canada and the Province of BC need to clarify their support for, and policies regarding, WFSPs. With no committed funding to coordinate Stage IV of the planning process, implementation and monitoring may become *ad hoc* and at the mercy of the ability of the technical committee to self-organize and for project contacts to promote their projects. To be successful over the long-term, WFSP requires official recognition by government agencies as a relevant and useful planning process that fits into the established planning hierarchy. Government agencies must also clarify their roles as custodians for WFSPs and take responsibility in assisting with plan implementation, thus protecting their investment in the planning process.

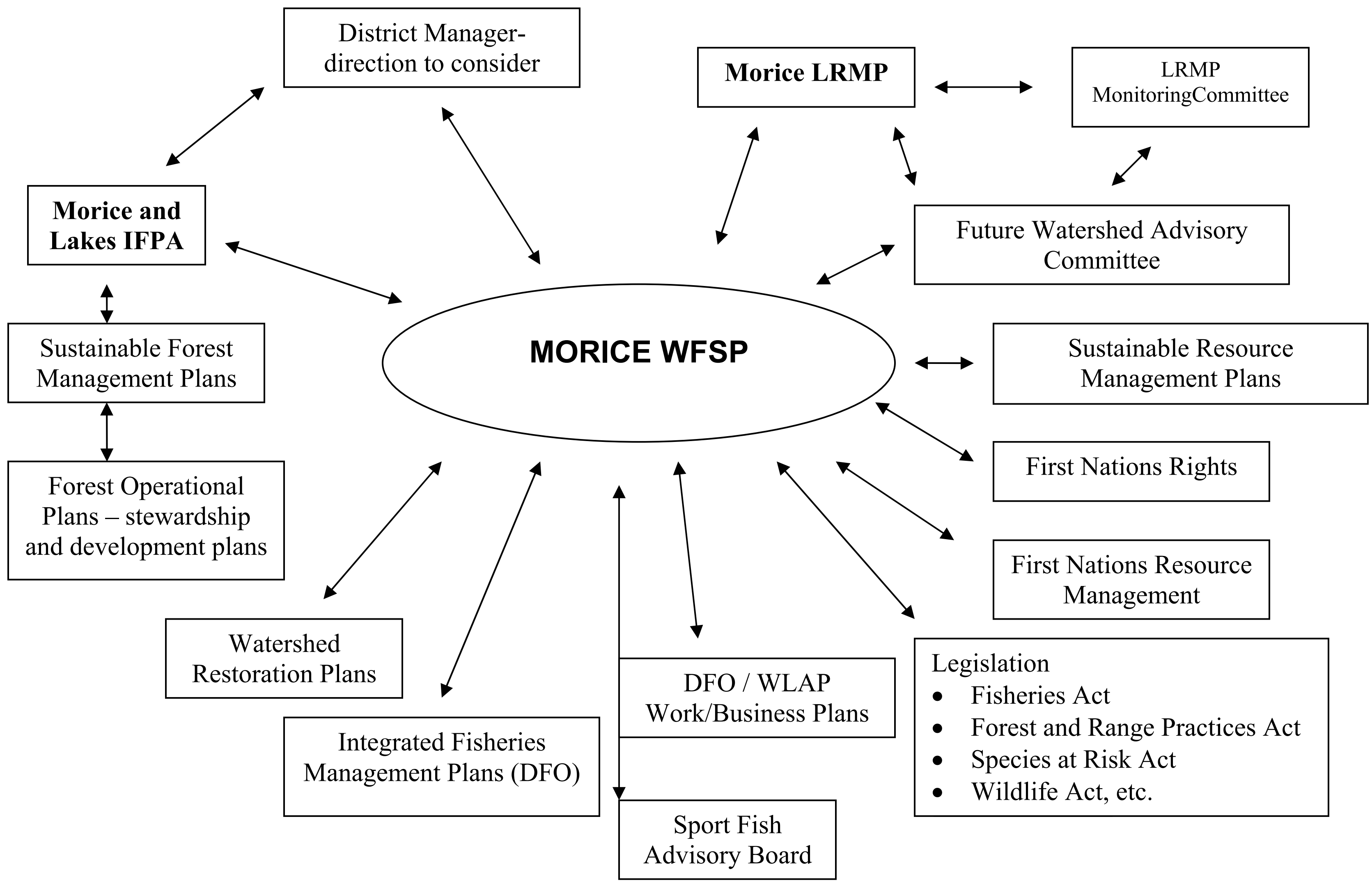

Figure 5. Current and future links of Morice WFSP to legislation, resource management organizations, and land and resource use plans.

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APPENDIX A. MEMBERS OF THE MORICE WFSP PLANNING AND TECHNICAL COMMITTEES.

Project Coordinator: Greg Tamblyn (2002-2004); Mary Swendson (2001-2002)

Planning Team (2001-2002)

- Dana Atagi, WLAP (initial participation)
- Brenda Donas, DFO
- Martin Forbes / Dale Gueret, Fisheries and Oceans Canada (DFO)
- Allen Gottesfeld, Skeena Fisheries Commission
- Walter Joseph, Wet'suwet'en Fisheries
- Sharon Robertson, BC Federation of Fly Fishers / CFDC Nadina
- Greg Tamblyn, CFDC Nadina

Technical Team (2002-2003)

- Gary Baptiste, Wet'suwet'en Fisheries
- Dave Bustard, Fisheries Biologist
- Matt Jessop, Ministry of Sustainable Resource Management (early 2002)/ Ministry of Water, Land and Air Protection (2002 - March 2003)
- Vesna Konic, DFO (2002)
- Allen Gottesfeld, Skeena Fisheries Commission
- Tom Pendray, DFO
- Stefan Schug, Office of the Wet'suwet'en
- Melissa Todd, Houston Forest Products / IFPA
- Laurence Turney, IFPA (2002)
- Carl Vandermark, Canfor / IFPA (2002 / 2003)

Combined Planning and Technical Committee (2004)

- Dave Bustard, consulting fisheries biologist
- Barry Finnegan, DFO
- Dale Gueret, DFO
- Jeff Lough, Ministry of Water, Land and Air Protection
- Patrick Hudson, consulting fluvial geomorphologist
- Walter Joseph, Wet'suwet'en Fisheries
- Jim McCormack, Canfor / IFPA
- Tom Pendray, DFO
- Stefan Schug, Office of the Wet'suwet'en
- Ian Sharpe, Ministry of Water, Land and Air Protection
- Melissa Todd, Houston Forest Products / IFPA
- Dave Wilford, Ministry of Forests

APPENDIX B: GUIDING PRINCIPLES

Eleven guiding principles provide the framework for the Morice WFSP. The process will:

i. Focus on the sustainability of wild fish stocks and their genetic diversity, with attention to anadromous, resident, commercial, and non-commercial species;

ii. Focus on watersheds, including their processes and their interconnections, both instream and upland;

iii. Take a "fish first" approach, emphasizing the needs of fish;

iv. Identify priorities for the protection, conservation and restoration of fish stocks and habitat;

v. Build on existing and concurrent land use planning initiatives including the Morice Land and Resource Management Plan (LRMP) and the Morice-Lakes Innovative Forest Practices Agreement (IFPA).

vi. Use the best information currently available, including scientific data, traditional ecological knowledge and wisdom, land and resource development trends, and community values;

vii. Identify data gaps and provide recommendations on priorities and means of filling those gaps;

viii. Use "adaptive management"; that is, an approach that incorporates ongoing monitoring and assessment to create a living plan that can be continually modified;

ix. Be inclusive, with those interested in participating welcome to attend meetings or provide feedback;

x. Be consensus-based; if consensus is not reached, options will be recommended; and

xi. Focus on activities or factors within the Morice River watershed, while recognizing that factors outside the area are influencing the watershed's fish populations.

APPENDIX C. RELATIVE LAND USE ANALYSIS

The following description has been adapted from the methodology submitted by Chad Croft, Gartner Lee Ltd. following the development of the analysis table.

The following matrix is a quantitative index used to determine the relative influence of land use on sub basins of the Morice watershed as of 1995-1998. Unfortunately, newer data was not readily available at the time of the analysis (2003). To develop the matrix, land use indicators and associated data from the Watersheds BC database (Geographic Data BC GIS database) were selected from a wide range of possible metrics. Indicators initially chosen included % watershed area logged in the last twenty years, % total stream length logged to the bank, total stream crossing density (total # of stream crossings/total stream length), total road length density, total road length density within 100m of a stream, % watershed area utilized as urban, % watershed area utilized as agriculture, % watershed area utilized as range, % watershed area utilized by recreation and % watershed area utilized by mining. All land use indicators or attributes are reported as a direct measurement of area, length, percentage or density, which allows for a meaningful comparison between watersheds of different sizes.

Data were then summarized for 3rd order watersheds in the Morice and Lakes timber supply areas. Once the upper and lower limits were identified for each indicator, the range of each attribute (except % watershed area logged and % stream length logged) was divided into eleven equal range categories. Each range category was then assigned an index value from 0-10 (0 = no influence, 10 = highest influence). The index value assigned to "percent watershed area logged" and "percent stream length logged" attributes was equivalent to the absolute percentage reported for each. This was done to accurately represent the level of influence associated with these two attributes. Indicators with no effect on relative land use scores within the matrix were deleted, leaving six indicators.

Morice WFSP Relative Land Use (as of 1995-1998)

Watershed Code	NAME	Area	Road Length	Road Density	**Index Score**	Str length logged to bank	% Str Length Logged	**Index Score**	Rd Length w/in 100m	Rd Length Density	**Index Score**	Area Logged w/in 30m (ha)	% Log w/in 30m of stream	**Index Score**	Area Logged	% watershed Logged	**Index Score**	# stream X-ings	Stream Length	# X-ings/ km of Stream	**Index Score**	**Total Score**	**Relative Landuse**
460-600600	**Morice River**	92070	309.84	0.38		99.903	6.8		93.037	0.11		642	0.8		9397	10.2		174	1466.54				
				0.38	**3**		**6.8**	**3**		**0.11**	**2**		**0.8**	**5**		**10.2**	**4**	**174**		**0.12**	**3**	**20**	Moderate
460-600600-50800	**Thautil River**	12172	7.05	0.06		2.255	0.8		2.727	0.02		15	0.1		518	4.3		8	268.16				
460-600600-50800-17400	Unnamed 1	1952	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	35.14				
460-600600-50800-38100	Hagman	4191	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	119.59				
460-600600-50800-48000	Gabriel	1818	0.00	0.00		6.571	13.4		0.000	0.00		42	2.3		370	20.4		0	48.89				
460-600600-50800-51300	Unnamed 2	949	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	24.40				
460-600600-50800-58400	Denys	11968	6.89	0.06		0.000	0.0		3.027	0.03		0	0.0		0	0.0		5	316.03				
460-600600-50800-72200	Starr	9260	0.00	0.00		0.043	0.0		0.000	0.00		0	0.0		30	0.3		0	274.90				
		42310	**13.93**	**0.02**	**1**	**9**	**0.8**	**1**	**5.8**	**0.41**	**8**	**57**	**0.1**	**1**	**918**	**2.2**	**1**	**13**	**1087.10**	**0.01**	**1**	**13**	Low
460-600600-50800-00500	**Gosnell Creek**	53489	3.50	0.01		4.993	0.4		2.914	0.01		31	0.1		578	1.1		2	1263.47				
		53489	**3.50**	**0.01**	**1**		**0.4**	**1**		**0.01**	**1**		**0.1**	**1**		**1.1**	**1**	**2**		**0.00**	**1**	**6**	Low
460-600600-17000	**Houston Tommy**	15196	9.33	0.06		3.362	1.1		1.355	0.01		24	0.2		686	4.5		3	316.44				
460-600600-17000-27400	Unnamed 3	1047	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	20.96				
460-600600-17000-35200	Unnamed 4	3414	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	80.75				
460-600600-17000-50600	Unnamed 5	2930	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	46.99				
460-600600-17000-63400	Unnamed 6	781	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	23.97				
460-600600-17000-67900	Unnamed 7	444	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	11.08				
460-600600-17000-80100	Unnamed 8	943	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	25.00				
		24755	**9.33**	**0.04**	**1**	**3**	**0.6**	**1**	**1.4**	**0.15**	**3**	**24**	**0.1**	**1**	**686**	**2.8**	**1**	**3**	**525.18**	**0.01**	**1**	**8**	Low
460-600600-36400	**Lamprey**	16243	107.41	0.69		59.579	25.4		40.134	0.26		350	2.2		4141	26.5		80	234.93				
460-600600-36400-39700	Pimpernell	6781	16.45	0.25		13.543	13.2		5.360	0.08		86	1.3		975	14.6		12	102.57				
		23024	**123.86**	**0.54**	**5**	**73**	**21.7**	**9**	**45.5**	**0.37**	**8**	**436**	**1.9**	**10**	**5116**	**22.2**	**7**	**92**	**337.49**	**0.27**	**6**	**45**	High
460-600600-73500	**Atna**	12887	0.00	0.00		0.000	0.0		0.000	0.00		0.0	0.0		0.0	0.0		0	225.63				
460-600600-73500-20700	Unnamed 9	1518	0.00	0.00		0.000	0.0		0.000	0.00		0.0	0.0		0.0	0.0		0	45.86				
460-600600-73500-22600	Unnamed 10	1882	0.00	0.00		0.000	0.0		0.000	0.00		0.0	0.0		0.0	0.0		0	57.05				
460-600600-73500-27600	Unnamed 11	4142	0.00	0.00		0.000	0.0		0.000	0.00		0.0	0.0		0.0	0.0		0	82.34				
460-600600-73500-50000	Unnamed 12	4426	0.00	0.00		0.000	0.0		0.000	0.00		0.0	0.0		0.0	0.0		0	54.06				
460-600600-73500-69400	Unnamed 13	1619	0.00	0.00		0.000	0.0		0.000	0.00		0.0	0.0		0.0	0.0		0	35.70				
460-600600-73500-79700	Unnamed 14	2612	0.00	0.00		0.000	0.0		0.000	0.00		0.0	0.0		0.0	0.0		0	31.38				
460-600600-73500-82700	Unnamed 15	901	0.00	0.00		0.000	0.0		0.000	0.00		0.0	0.0		0.0	0.0		0	16.12				
		29987	**0.00**	**0.00**	**1**	**0**	**0.00**	**1**	**0.0**	**0.0**	**1**		**0.0**	**1**		**0.0**	**1**	**0**	**548.15**	**0.00**	**1**	**6**	Low
460-600600-67600	Unnamed 16	1396	0.00	0.00		0.000	0.0		0.000	0.00			0.0		0.0	0.0		0	36.56				
460-600600-67600-46100	Unnamed 17	803	0.00	0.00		0.000	0.0		0.000	0.00			0.0		0.0	0.0		0	24.10				
		2199	**0.00**	**0.00**	**1**	**0**	**0.00**	**1**	**0.00**	**0.00**	**1**		**0.0**	**1**		**0.0**	**1**	**0**	**60.66**	**0.00**	**1**	**6**	Low
460-600600-64400	**Nanika**	37248	30.38	0.09		8.703	1.1		9.509	0.03		53	0.2		477	1.4		23	808.90				
460-600600-64400-11700	Unnamed 18	3707	14.26	0.38		11.508	15.8		4.274	0.12		71	1.9		744	20.1		10	72.71				
460-600600-64400-37000	Stepp	9360	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	259.62				
460-600600-64400-43500	Unnamed 19	17927	27.36	0.15		0.000	0.0		20.317	0.11		0	0.0		0	0.0		64	550.63				
460-600600-64400-48600	Bergeland	12416	3.02	0.02		0.000	0.0		1.026	0.01		0	0.0		0	0.0		3	239.22				
460-600600-64400-59100	Unnamed 20	3178	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	66.32				
460-600600-64400-70400	Fenton	3056	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	54.08				
460-600600-64400-84100	Unnamed 21	2640	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	58.58				
		89532	**75.02**	**0.08**	**1**	**20**	**1.0**	**1**	**35.13**	**0.5**	**10**	**124**	**0.1**	**1**	**1221**	**1.4**	**1**	**100**	**2110.07**	**0.05**	**2**	**16**	Low
460-600600-07100	**Peacock**	3696	3.77	0.10		2.112	3.4		0.255	0.01		14	0.4		213	5.8		1	61.87				
		3696	**3.77**	**0.10**	**1**		**3.4**	**2**		**0.01**	**1**		**0.4**	**3**		**5.8**	**2**	**1**		**0.02**	**1**	**10**	Low
460-600600-86100	Utem	4837	0.00	0.00			0.0			0.00			0.0			0.0		0	109.34				
460-600600-86100-31000	Unnamed 22	1835	0.00	0.00			0.0			0.00			0.0			0.0		0	40.41				
		6672	**0.00**	**0.00**	**1**		**0.0**	**1**		**0.00**	**1**		**0.0**	**1**		**0.0**	**1**	**0**	**149.75**	**0.00**	**1**	**6**	Low
460-600600-86900	Unnamed 23	3658	0.00	0.00			0.0			0.00			0.0			0.0		0	79.88				
				0.00	**1**		**0.0**	**1**		**0.00**	**1**		**0.0**	**1**		**0.0**	**1**			**0.00**	**1**	**6**	Low

Watershed Code	NAME	Area	Road Length	Road Density	**Index Score**	Str length logged to bank	% Str Length Logged	**Index Score**	Rd Length w/in 100m	Rd Length Density	**Index Score**	Area Logged w/in 30m (ha)	% Log w/in 30m of stream	**Index Score**	Area Logged	% watershed Logged	**Index Score**	# stream X-ings	Stream Length	# X-ings/ km of Stream	**Index Score**	**Total Score**	**Relative Landuse**
460-600600-44500	**Tagit**	4220	0.00	0.00		2.503	3.5			0.00		16	0.4		238	5.8		0	71.99				
				0.00	**1**		**3.5**	**2**		**0.00**	**1**		**0.4**	**3**		**5.8**	**2**			**0.00**	**1**	**10**	Low
460-600600-35600	Unnamed 24	3534	0.00	0.00		1.012	1.8			0.00		6	0.2		95	2.7		0	55.47				
				0.00	**1**		**1.8**	**1**		**0.00**	**1**		**0.2**	**2**		**2.7**	**1**			**0.00**	**1**	**7**	Low
460-600600-75800	Unnamed 25	390	0.00	0.00			0.0			0.00			0.0			0.0		0	13.52				
				0.00	**1**		**0.0**	**1**		**0.00**	**1**		**0.0**	**1**		**0.0**	**1**			**0.00**	**1**	**6**	Low
460-600600-32800	Unnamed 26	3351	26.13	0.78		6.783	16.1		4.543	0.14		45	1.3		1080	32.2		11	42.04				
				0.78	**7**		**16.1**	**7**		**0.14**	**3**		**1.3**	**7**		**32.2**	**10**	**11**		**0.26**	**6**	**40**	High
460-600600-93600	Unnamed 27	1613	0.00	0.00			0.0			0.00			0.0			0.0		0	19.86				
				0.00	**1**		**0.0**	**1**		**0.00**	**1**		**0.0**	**1**		**0.0**	**1**	**0**		**0.00**	**1**	**6**	Low
460-600600-23900	**Owen**	21302	140.92	0.68		31.405	12.0		33.646	0.16		205	1.0		3540	17.0		67	261.46				
				0.68	**6**		**12.0**	**5**		**0.16**	**3**		**1.0**	**6**		**17.0**	**6**	**67**		**0.26**	**6**	**32**	Moderate/High
460-600600-63200	**McBride**	10994	128.86	1.27		28.109	24.7		29.358	0.29		139	1.4		3428	33.7		56	113.95				
				1.27	**10**		**24.7**	**10**		**0.29**	**5**		**1.4**	**8**		**33.7**	**10**	**56**		**0.49**	**10**	**53**	High
460-600600-40700	Unnamed 28	3279	0.00	0.00		0.359	0.8			0.00		3	0.1		94	2.9		0	43.14				
				0.00	**1**		**0.8**	**1**		**0.00**	**1**		**0.1**	**1**		**2.9**	**1**	**0**		**0.00**	**1**	**6**	Low
460-600600-11800	**Knapper**	2704	5.70	0.21		2.606	6.3		1.656	0.06		17	0.6		238	8.9		5	41.50				
				0.21	**2**		**6.3**	**3**		**0.06**	**2**		**0.6**	**4**		**8.9**	**3**	**5**		**0.12**	**3**	**17**	Low/Moderate
460-600600-08200	**Gold**	5647	10.47	0.10		2.531	1.3		3.859	0.04		17	0.2		638	6.8		11	135.63				
460-600600-08200-35500	Unnamed 29	1436	0.00	0.00		0.000	0.0		0.000	0.00		0	0.0		0	0.0		0	34.46				
460-600600-08200-47200	Unnamed 30	3059	0.74	0.02		0.673	0.9		0.456	0.01		4	0.1		46	1.5		2	77.82				
		10142	**11.21**	**0.11**	**1**	**3**	**1.3**	**1**	**4.3**	**0.38**	**8**	**21**	**0.2**	**2**	**684**	**6.7**	**2**	**11**	**247.91**	**0.08**	**2**	**16**	Low/Moderate
460-600600-88400	Unnamed 31	1974	0.00	0.00			0.0			0.00			0.0			0.0		0	45.85				
				0.0	**1**		**0.0**	**1**		**0.00**	**1**		**0.0**	**1**		**0.0**	**1**			**0.00**	**1**	**6**	Low
				0.1																			
Low					**0.00**		**0.0**			**0.00**			**0.0**			**0.0**				**0.00**		**6**	
High					**1.27**		**24.7**			**0.50**			**1.9**			**33.7**				**0.49**		**53**	

All measurements in km unless otherwise stated

APPENDIX D: RELATIVE SIGNIFICANCE OF GENERALIZED ISSUES WITHIN THE MORICE WATERSHED - HIGH (H), MODERATE (M), LOW (L)

FISHERIES MANAGEMENT	HABITAT	DATA GAPS

• Over-harvesting *of anadromous and resident species (Gottesfeld et al. 2002; Bustard and Schell 2002).*
  ◦ ***Inside area*** **– H –** *regulatory realm (species-specific)*
  ◦ *Outside area* – **M** (less ability to influence)
• High angling pressure – Loss of quality angling experience *(social experience)* (Public) – **H.**
• Genetic diversity of native fish species by sub-species and by watershed (Public) **M** – *more important for some species than others*
• Aquaculture/Farming of Atlantic Salmon potentially impacting wild fish populations (Public; Gottesfeld et al. 2002). – **M** – *low ability to influence*.
• Increased angler access to sensitive fish habitats (public) **– M**. ***H*** *for Bull Trout.*
• Shifts in natural native fish species composition in watershed (Public). **– L –** *this is actually an issue of high significance, but it can be dealt with under species-specific issues***.**
	• Population declines due to habitat degradation (public). **- H**
	• Loss of critical spawning *and rearing* areas in lakes, rivers and streams for all fish species (public). **- H**
	• Reduced riparian function and integrity, especially along small tributary streams associated with forestry and range practices (Bustard and Schell 2002; Public). – **H**
	• Increased water temperatures (Bustard & Schell) – *changes from natural regimes.* – **H**
	• Road crossings as barriers to fish migration (Public and Bustard and Schell 2002)– **H**
	• Loss of channel stability associated with road stream crossing (Bustard & Schell 2002) **H**
	• Increased sedimentation affecting water quality, spawning, rearing, and over-wintering habitats (Bustard and Schell 2002). **- H**
	• Timber harvest rates and road building impacts on the hydrological processes of watersheds (i.e.: groundwater and small stream flow interception, snow accumulation and melt, "flashy water flows" Gottesfeld et al. 2002; Bustard and Schell 2002). **- H**
	  ◦ Floods can lead to redd scour, substrate movement that crushes eggs, poor survival of juveniles, stranding of juveniles, or forcing spawning in marginal habitats.
	  ◦ High flows during migration can, however, improve access to spawning grounds.
	  ◦ Low flows in winter can result in dewatering of redds, freezing.
	  ◦ Low flows in summer and fall can lead to migration barriers and reduced fish fecundity and survival.
	• Altered wetland integrity and function due to adjacent forest harvesting. **– M** – *related to hydrology and temperature.*
	• Water contamination due to mining activities (Gottesfeld et al. 2002; public) – Currently **L**, potential of **H** should a new mine be developed.
	• Beaver dams **- M**
	• Potential agricultural impacts **–** Currently **L.** ***M-H should agriculture expand in the Morice L*** – *looked after under riparian and water quality.*
	• Large volume water utilization associated with proposed industrial projects (Public). **– L**
	• Changes in stream and river morphology (public) – **L** – *already covered*.
	• Changes in ocean conditions affecting survival rates of anadromous species. **– L –** *important issue, but we have no influence in the WFSP*
	• Global warming / climate change warming water and reducing summer and autumn water flows (public) – *dealt with under temperatures.*
		a) Productive capacity of the watershed for all fish species.
		b) Linkage between escapement estimates conducted in the field and long-term indices established for the Skeena.
		c) Definition of the natural variability of stream temperatures and the impacts of specific riparian management regimes.
		d) Information on the impacts of forest harvesting on wetland integrity, function associated water quality.
		e) Information on snowmelt rates, hydrological recovery after logging or any other land use activity, runoff rates, measures of stream channel form and rates of change and climatic changes.
		f) Information on sedimentation levels (natural vs. introduced). What levels indicate reason for concern?
		g) Number and location of road crossing barriers to fish passage.
		h) Baseline data on the current genetic diversity within the watershed.
		i) Definition of cumulative effects on water quality.

APPENDIX E - MONITORING BACKGROUNDER

What is Monitoring?

Monitoring is regular or ongoing systematic testing, sampling or tracking of specific parameters in order to collect information or to determine trends. A number of monitoring approached can be implemented through a strategic plan including baseline, implementation, effectiveness, project and compliance monitoring.

Why is Monitoring Important?

Monitoring is a vital component of any plan or project. It is required to determine the effectiveness of strategies and actions in meeting the objectives of the plan. In the case of the Morice WFSP, monitoring will be used to determine the progress made toward mitigating impacts on fish populations, fish habitat and the aquatic ecosystem as a whole.

Monitoring is also integral to improving a plan through adaptive management. Adaptive management uses well-designed monitoring programs to inform management decisions and allow adjustments as circumstances change or knowledge is gained.

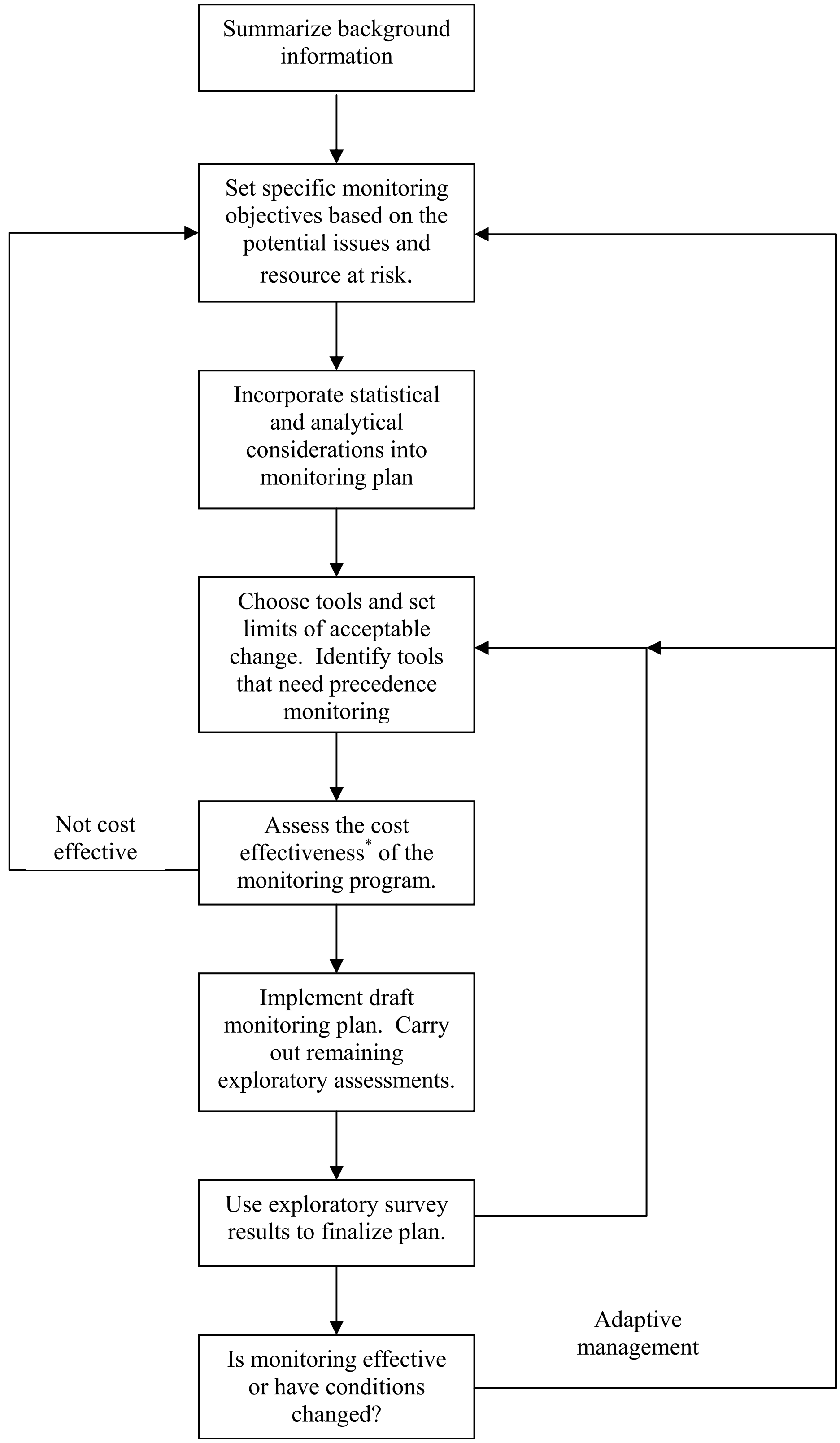
Measuring the effectiveness of a plan in meeting its objects has three stages according to Mackay (1998):

1. Baseline evaluation: Collating existing information for areas of concern, identifying data gaps and determining what potential impacts may arise from different land use and fisheries management decisions. This has been done to a large extent by Bustard and Schell (2002) and in some specific watersheds by Ecofor (2001).
2. Site Design: Selection of control and monitoring sites considering indicators and the types of information that will be required to determine if objectives are being met. Careful site selection to consider control or reference sites is vital to adaptive management.
3. Measurements:
    - Precedence measurements: Measurements to fill data gaps or measurements prior to land use development or prior to the implementation of a strategy outlined in the plan.
    - Condition measurements: Measurements taken following land use or strategy implementation (i.e. results monitoring).

A well-designed effectiveness monitoring plan should include (Mackay 1998):

- The monitoring objectives;
- Statistical considerations;
- What parameters to measure and the limits of acceptable change for each parameter;
- The benefits and advantages of monitoring selected parameters;
- Where monitoring will occur and why;
- How this plan can complement current monitoring activities;
- How frequently measurements are made;
- How the introduction of error and bias can be minimized (quality assurance and control);
- How the program's cost effectiveness can be maximized;
- How results are to be analyzed; interpreted and reported; and
- How long monitoring should continue in the absence of any exceeded limit of acceptable change.

Figure E-1 shows a set of steps that could be taken to develop a monitoring plan.



*Defined by the trade-off between cost, requirements to meet objectives and the need for statistical confidence

Figure E-1: Possible steps to develop a monitoring plan. Source Mackay (1998) with minor modifications.

The Monitoring Toolbox

In monitoring, as in a mechanic's shop, there is no magic tool. A number of tools or indicators is required to evaluate the integrity of an aquatic ecosystem and the impacts of various resource management developments and decisions. The challenge is to find the most cost-effective set of tools to fill data gaps while gaining maximum feedback.

Many options exist to monitor potential impacts of land use development on aquatic ecosystem integrity (Table E-1).

Table E-1: Possible tools for monitoring forest development (adapted from Mackay 1998)

Impact issue	Tools	Reconnaissance assessment tool	Detailed assessment tool
Sedimentation	turbidity - meters	X	X
	Total suspended sediments	X	X
	Substrate cores		X
	Sediment traps		X
	Conductivity	X	
	Cobble embeddedness	X	
	Flights	X	
Channel Morphology	Pebble count	X	X
	Bank stability	X	
	Large woody debris	X	
	% pools	X	X
	Channel aggradation / degradation	X	
	Bankfull width and depth	X	
	Time series air photos	X	
	Flights	X	
Water Quality	Temperature	X	X
	Fecal pathogens	X	
	Sulphate		X
	Dissolved oxygen	X	X
	Pesticides / Herbicides		X
	Benthic Invertebrates		
Water Quantity / Timing	Bankfull width and depth	X	X
	Peak flows		X
	Low flows		X
	Timing to peak flows		X
	General discharge curves	X	
	Groundwater flows		X
Stream productivity	Nutrients	X	
	Alkalinity	X	
	Chlorophyll a	X	
	Algal biomass	X	
	Periphyton	X	
	Benthic invertebrates	X	X
	Fish	X	X

Monitoring the effects of fisheries management decisions is another component of the plan. Historically, stock assessment (fish enumeration, combined, in some cases, with weight, size and age measurements) has been the dominant tool:

- Adult counting fences;
- Redd counts;
- Juvenile index sites – trapping / electroshocking;
- Catch per unit effort;
- Aerial, instream, stream shore counts for spawning adults;
- Mark / recapture;
- Inter and intraspecific competition studies; and
- Creel surveys.

However, additional measurements providing greater insight into the health of fish could also be tracked:

- Fecundity;
- Genetic diversity;
- Disease proneness; and
- Toxin levels.

Finally, an assessment of the social and economic value associated with fisheries management decisions could be used as an index.