Conserving Lakelse Fish and their Habitat

Lakelse Watershed Backgrounder

Skeena Fisheries Commission
January 2003

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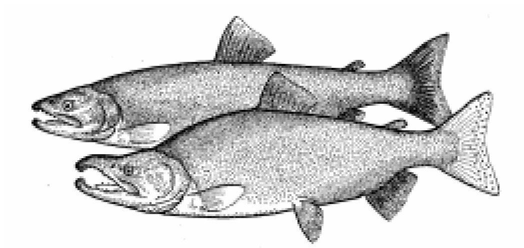
Preamble

This backgrounder has been updated for the use of the Lakelse Lake Sockeye Recovery Plan (LLSRP) planning table. It briefly presents at a watershed scale a biophysical profile, a description of the fisheries resource, and anthropogenic effects; both tangible and intangible. Social, political, and economic factors influence the status of fish and habitat in the Lakelse Watershed.



Sockeye salmon.

For example, they may influence the rate of development or forest harvesting, resulting in riparian, in-stream, or associated effects within the watershed. These factors can also affect the location, timing, and focus of fish sustainability planning. There is likely to be a high interest in rehabilitating fish populations or habitat with high social, cultural, or economic values.

Within Lakelse Watershed, there are currently other land use plans or planning processes that are inclusive or semi-inclusive of fish and fish habitat. The current forest land use plan being implemented is the Kalum Land and Resource Management Plan (LRMP). The Lakelse Lake Management Plan, which is focused on the Lake and its communities, is presently being drafted (WLAP 2003).

The Kalum Land and Resource Management Plan was initiated and led by the Ministry of Forests with approval in 2001. The plan creates three categories of management directions for the LRMP area: General Resource Management, Resource Management Zones, and Protected Areas. The Kalum LRMP integrated two earlier planning initiatives, the Kalum South Land and Resource Plan and the Thunderbird Integrated Resource Management Plan (TIRMP). The TIRMP, a landscape level forest management plan, provided broad objectives to the Lakelse River, Lakelse Lake, and the Thunderbird area.

Highlights of the Kalum LRMP involving Lakelse Watershed include establishing protected area status for the Lakelse Lake wetlands and Hai Lake on Mount Herman, as well as a Special Resource Management Zone for the Lakelse River. The General Resource Management direction applies to all other portions of the watershed. From a fish first perspective, the fish and fish habitat, and fresh water management directions provide for: Watershed Assessment Procedures (WAPs) to evaluate Williams Creek, Lakelse River, Hatchery Creek, Scully Creek, Furlong Creek, and the Coldwater Creek sub-drainages, and management plans to be developed for Lakelse, Ena, End, and Clearwater Lakes.

This sub-regional land use plan is biased towards timber development; objectives involving fresh water and fisheries are weak and vague at the site-specific and watershed level. This situation is exacerbated by inter-agency disputes, and the lack of commitment by government agencies and planners to fund their own and other programs such as the Watershed Restoration Program (WRP) or to monitor the effectiveness of the plan.

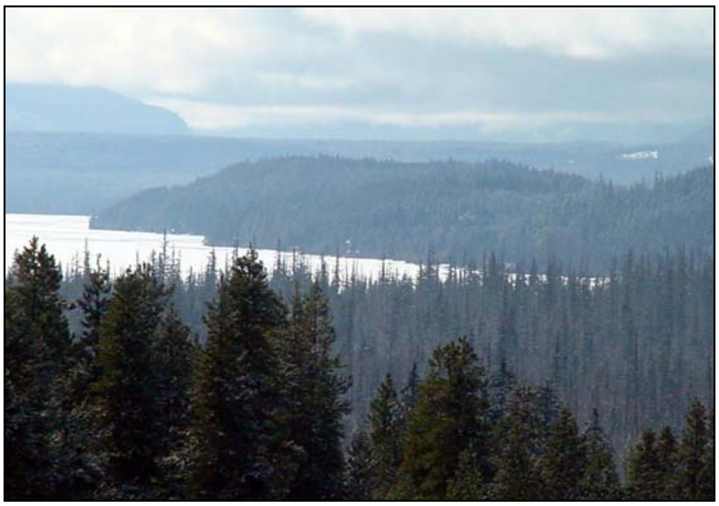
The Lakelse Lake Management Plan is presently being drafted to create strategies that will permit management of the recent *Elodea canadensis* growth and colonization of the lake's littoral zone and other priority issues (WLAP 2003). The plan is a partnership between the Ministry of Water, Land and Air Protection (WLAP), the Lakelse Watershed Society, and the Regional District of Kitimat-Stikine. The Lakelse Watershed Society (LWS), with representation from the various communities around the lake, is bearing the main responsibility for the plan. LWS's action plan identifies and clarifies concerns, and provides extensive recommendations prioritizing direction concerning *Elodea canadensis,* high fish values, forest activities, shoreline development, stream modification, and drinking water quality (WLAP 2003).

A new generation of forest planning is underway. Proposed planning for the watershed consists of three different levels: Sustainable Resource Management Plans (SRMP), Sustainable Forest Management Plans (SFMP), and Forest Stewardship Plans (FSP). SRMPs are the consolidated approach by the Ministry of Sustainable Resource Management to planning on provincial Crown lands at the landscape level. SFMPs are an output from the Land Base Investment Program, which is a component of the Forest Investment Account. These plans are expected to select, plan for, and execute cost-effective activities related to forest productivity, resource information, and sustainable utilization. SFMPs are forest licensee driven and funded according to an allocation formula based on the volume harvested during the previous three years. Forest Stewardship Plans are expected to describe licensee forest development activities within the framework directions stated in higher-level plans such as SRMPs and LRMPs.

Lakelse Watershed Environmental Setting

Location

The Lakelse Watershed is located in northwest British Columbia, 20 km south of Terrace. The watershed is bounded to the east and west by the steep mountain slopes of the Kitimat Ranges, to the north by the Skeena River floodplain, while an ancient ice contact terrace establishes the southern boundary.



Lakelse Lake, view from the northern perimeter.

Hydrology

The Lakelse River is a fifth order system that drains a watershed area of 589 km^2. Elevation ranges from approximately 62 to 1845 m. Mount Hipp, Mount Catt, and Mount Gordon in the west and mountainous country of the Kitimat Ranges to the east exert the major hydrological influences. The Lakelse River and Lakelse Lake valley bottoms are low gradient, but the watershed as a whole has a moderately high response from water input due to the steep topography of the major tributaries. Coastal weather systems have easy access to the watershed, leading to heavy snow packs and precipitation in the mid and upper elevations of the drainage.

Precipitation records based on observations between 1950-2002 show an annual average precipitation of 1322 mm per year, 70% falling as rain and 30% as snow (Environment Canada 2002). The major portion of this precipitation (66%) falls from October to February. Rainfall is greatest during October and November, while snowfall is greatest during December and January. Total annual precipitation is greater as elevation is gained.

The Lakelse River drains Lakelse Lake in a northwesterly direction for approximately 18 km to reach the Skeena River left bank, about 17 km downstream of Terrace. Cleugh *et al* (1978) estimate that the greatest discharge from Lakelse River occurs in May and June due to snowmelt. Decreased stream flow in July and August is followed by an increase in September and October. Typical fall rain on snow events often generate peak discharges.

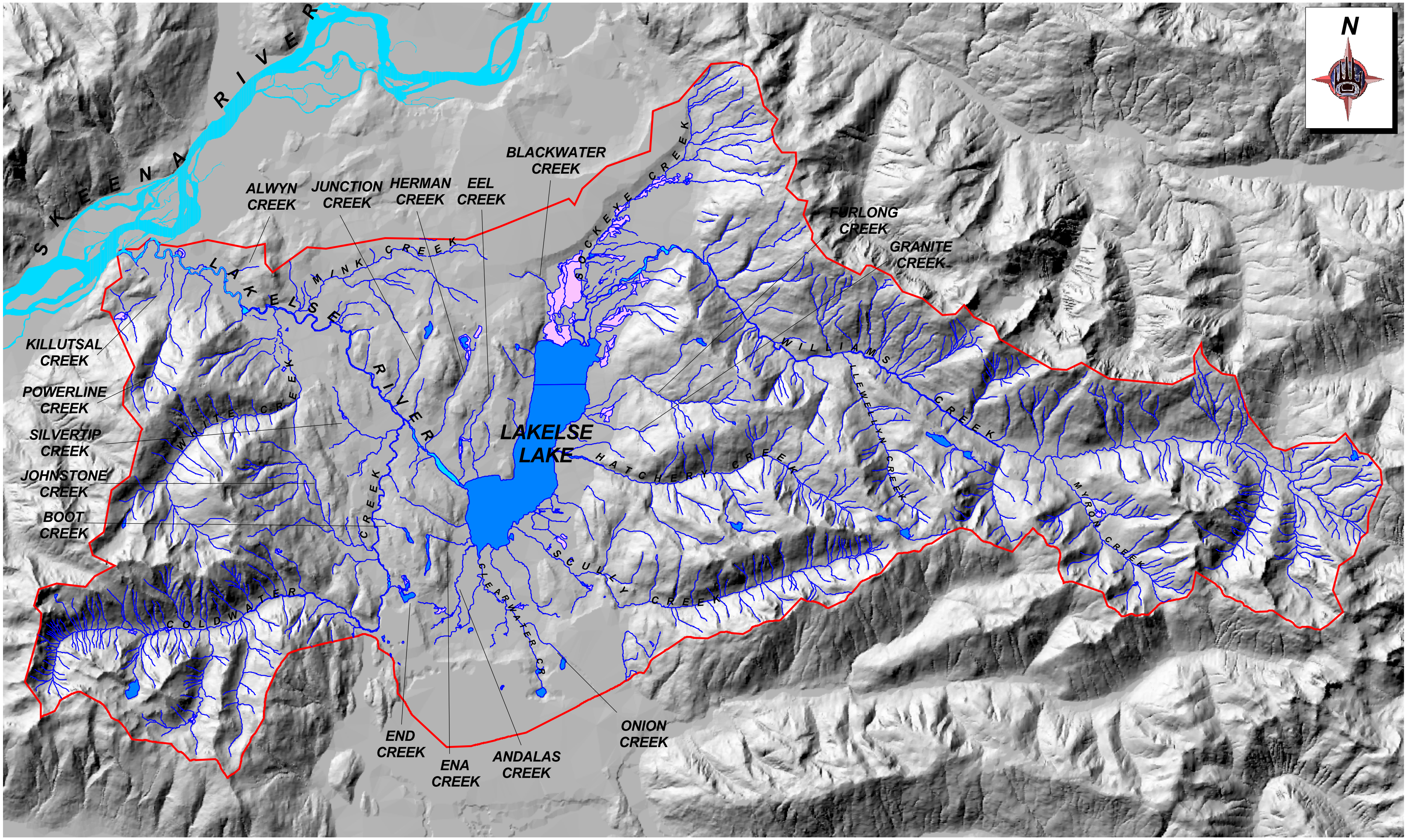
Lakelse Lake's mean annual discharge into Lakelse River is 20 m^3/second (Kerby 1984). In 1995, the provincial Water Management Branch installed a manual stage gauge on the Lakelse River; however, there is insufficient data for analysis at this time. The regulated flow of the Lakelse River is controlled by Lakelse Lake and low slope gradients along its drainage (Kerby 1984). The lake also moderates water temperatures and some water quality characteristics in the river flows.

Lakelse Lake is the predominant feature of the upper watershed. It covers an area of 14.5 km^2 (14,516 ha), with the majority of watershed tributary streams feeding directly into the lake. Lakelse Lake is approximately 8.7 km long with an average width of 1.2 km. The average flushing rate of the lake is four times during the six-month spring and summer seasons and once during the fall and winter (WLAP 2003).

Williams, Hatchery and Schulbuckhand (Scully) Creeks are major tributary streams and the biggest of the thirteen tributaries feeding Lakelse Lake. It is thought that Lakelse Lake is the warmest lake in northern BC. It has a maximum depth of 32m (at the north end opposite Furlong Bay), but a large portion (42%) of the lake is littoral. This extensive littoral zone affects temperature, dissolved oxygen, aquatic plants, and overall productivity of the lake (Cleugh *et al* 1978).

Temperature profiles indicate the absence of a stable thermocline, which is probably a consequence of relative shallowness combined with strong prevailing southwesterly winds (Abelson 1976). Due to the shallowness of the lake and large volumes of water from tributary streams, Lakelse Lake flushes on the average of every 58 days (Kerby 1984, Remington 1996). A number of hot springs with a temperature of 85^{o} C occur on the eastern shore of Lakelse Lake.

Tributary drainages are characteristically of two types: either a meandering channel at a low gradient, or a steeply graded channel within a narrow confined "V"-shaped valley, becoming braided or meandering on lower gradient fans. The majority of steeply graded creeks originates in the mountains to the east or west of Lakelse Lake, while the creeks north and south of the lake are meandering in nature. The steeply graded creeks are fed from the large area of the alpine mountain slopes, which make up approximately 19% of the total watershed area.



MAP LEGEND

- CREEKS
- RIVER POLYGONS
- LAKE POLYGONS
- SWAMP POLYGONS
- LAKELSE WATERSHED BOUNDARY

FIGURE 1:

LAKELSE WATERSHED KEY MAP

LAKELSE SOCKEYE RECOVERY PLAN

5 0 5 Kilometers

0 2000 4000 6000 8000 10000 Meters

MAP SCALE - 1:200,000

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Water Quality

Water connects the land, air, plants, and animals while flowing throughout the varied ecosystems in the watershed. Water appears as rivers, streams, lakes, ponds, wetlands, as well as underground storage. Forests, water, fisheries, wildlife, and humans are linked together by the hydrologic cycle. Water quality is defined as the natural physical, chemical, and biological characteristics of water. Water quality criteria are policy guidelines concerning the acceptable range of conditions, usually safe levels for a given water use for particular kinds or classes of water use. Setting water quality objectives involve taking the set of criteria and adapting them to a specific body of water.

For example, water quality objectives or guidelines are applied to drinking water, fish and aquatic life, agricultural and mining activities, or forest development. Province wide ambient water quality criteria include pH, substances that degrade water quality such as nutrients, algae, and particulate matter, low level toxic substances and high level toxic substances such as cyanide, PCBs, and metals respectively, and microbiological indicators of risks to humans (fecal coliforms, *Giardia*). Other common criteria include dissolved oxygen, total suspended solids, water stage, and biochemical oxygen demand (BOD).

Critical to the review and understanding of water quality is long-term data, which are essential to detect changes or trends in water quality. There are no long-term monitoring stations within the watershed, even though forest resource extraction has been intense. Known water quality studies are reported in Brett (1950), Abelson (1976), Cleugh *et al* (1978), McKean (1986), Wilkes and Lloyd (1990), and Shortreed (1998).

In 1982, MOELP Waste Management Branch initiated a 5 year monitoring program on major drainages of the Skeena River Watershed. Data was collected monthly from seven stations located on the upper Bulkley River, Morice River, Bulkley River at Quick, Telkwa River, Kispiox River, Skeena River at Usk, and Lakelse River (Wilkes and Lloyd 1990). The Lakelse River station is located near the mouth of the Lakelse River. The Lakelse River is exceptional in that it has a very low TSS (total suspended solids) as a result of being lake headed (mean = 9.1 mg/L, range = 1.79 mg/L).

Turbidity, an indicator of suspended sediments is also low. The Lakelse River is moderately coloured (mean = 16.7 TCU), which is attributable to natural organic substances and is not harmful to human health. Lakelse pH was near neutral (mean = 7.1) with a range of 6.7 to 7.6. Alkalinity is low (mean = 21.1 mg $CaCO_3$/L) and very near the water quality criterion, indicating the waterbody would be sensitive to acidic inputs. Nutrients are generally low, with metal concentrations often less than detection limits.

Water quality objectives were prepared for Lakelse Lake (McKean 1986), and the accompanying assessment stated that the impact of forestry on water quality has been a concern in the Lakelse Watershed, in particular, the siltation of spawning and rearing streams. There had, however, been no data collected to quantify the degree of siltation attributable to logging. A specific objective for turbidity was established for tributary streams to the lake to protect spawning areas possibly affected by logging. Monitoring recommendations include intensive turbidity sampling one year prior to and following a logging operation.

Lakelse Lake is considered to be oligotrophic because of its low phosphorous concentrations, the low oxygen depletion rates of its bottom waters, and low chlorophyll *a* concentrations. These attributes, together with the lake's high water quality, determine the recreational and fisheries importance of the lake. Physics (light, climate and thermo regime) and chemistry levels (nitrogen and phosphorous) suggest that increased nutrient loading would quickly increase lake productivity and phytoplankton biomass in Lakelse Lake. Further, already low Nitrogen:Phosphorous ratios indicate that increases in phosphorous loading without concomitant increases in nitrogen loading could result in the development of undesirable blue-green algal blooms or eutrophication (Remington 1996).

There are concerns regarding the protection of drinking and recreational waters, particularly associated with the rural residential developments that are served by septic systems, most of which are located in soils with moderate suitability for septic tank tile fields. McKean (1986) reported about 30% of the residential development, or 72 houses, of which 60 houses are located adjacent to the lakeshore, are located on poor landforms. Further monitoring of water quality objectives, as well as providing a biological and water quality database, entailed monthly monitoring (May to September) of drinking water intakes for fecal coliforms and turbidity. This was carried out in 1988 – 1992, with most water quality objectives being attained.

In 2000, an aquatic invasive plant, *Elodea canadensis*, was noted to be colonizing the littoral zone waters of Lakelse Lake. As this weed has the potential to severely change fish habitat, a management plan is currently being developed (Maxwell 2002). The growth of *Elodea canadensis* in the lake over the last several years has reached levels that seasonally occludes beaches and shorelines. In 2001, the Lakelse Watershed Society conducted regular shore surveys and documented the rate of *Elodea* colonization. The growth currently occupies most of the volume of several shallow bays and patches of shorelines (WLAP 2003). Water quality was monitored at Lakelse in 2002, through a partnership with WLAP, the Lakelse Watershed Society, and the Regional District of Kitimat-Stikine. This program sampled 9 shoreline sites, 1 deep station site, and one site on upper Williams Creek. The results from this project are not yet available.

In 2002, sediment core samples were obtained from the north and south basins in Lakelse Lake. Sediment cores allow the reconstruction of lake productivity levels over time. Analysis results (Cummings 2002) from the cores show that Lakelse Lake appears to have been oligotrophic to slightly mesotrophic throughout the past several hundred years. There has been little change in the diatom species over the last several hundred years, with only small increases in eutrophic species after 1957. These small changes were not large enough to change the estimated phosphorous levels. The sediment core analysis indicates that in the north basin, sediment delivery rates began to increase in the 1950s and peaked in 1991. In the south basin, loading was highest between 1967 to 1972 and 1981 to 1984 (Cummings 2002).

Significant human activities in the watershed began to occur in the 1950s and included a sawmill operation on the north end of the lake, increased logging activity, highway construction, creek diversions, and landslides. These activities may be related to the observed increase in sediment delivery. The changes in sediment input to the lake between 1950 and 1990 may have contributed to the creation of favourable habitat for *Elodea canadensis* colonization (WLAP 2003).

Stream Channels

The Lakelse River mainstem is nearly 20 km long, with a very low gradient (0-1%) and no obstructions to anadromous fish species over its entire length. Major inlet streams are Herman, Coldwater, Mink and White Creeks. Stream banks are vegetated and stable, though minor amounts of rip-rap have been placed to increase stability. Sediment loading is high at times; however, this is mostly associated with the Mink Creek earthflow. Bedload movement is minimal with stream flow levels buffered by the lake. Channel morphology in this 40-120M wide mainstem is meandering, occasionally confined with many exposed sandbars at low flows. The channel stability is rated high in this high fisheries value river.

Reach 1 of Hatchery Creek has banks that are highly unstable, while the banks of reach 2 are stable. The high degree of bedload movement, originating in reach 2 and deposited in reach 1, has caused aggradation to the point that some sections of the creek do not have surface flow during low flow stages. The source of the bedload is natural; however, construction of dikes and channelization along the creek does not allow it to be distributed in an alluvial fan (Gordon *et al* 1996). Hatchery Creek is an established Community Watershed.

Schulbuckhand Creek, flowing into the southeast end of Lakelse Lake, has received restoration works in reach 1. In reach 2, large quantities of bedload are being deposited from upstream failures and the flow is sometimes subsurface. Logging and the "Cat Fire" above the Scully Creek fan apex has exacerbated problems associated with levels of sediment and bedload mobilization (Reese-Hansen 2002). Maxwell (2003) reports that 80% of the stream flow in Scully Creek has been diverted by the gabion baskets placed at PNG's right of way. This diverted stream now flows through a constructed channel for the lowest kilometre before entering the lake.

Falls on Schulbuckhand Creek. Photo credit: Dave Gordon.

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Coldwater Creek flows northeast into the Lakelse River three kilometres downstream of Lakelse Lake and has several notable tributary streams. Reach 2 acts as a depositional area with associated bank instability, while reach 3 has moderate bedload movement resulting from high sediment contributions from its tributaries.

Mink Creek flows into the Lakelse River from the east about 8 km from Lakelse Lake. It had a massive earthflow (43 ha) of glaciomarine silt and clays in the early 1990's (Geertsema and Schwab 1995). This has led to bank instability, very-high sediment loading, and a significantly unstable channel with a sediment wedge moving down the Lakelse River.

White Creek, flowing north into the Lakelse River, 9 km below Lakelse Lake, has unstable channel changes related to three major logging related impacts in reaches 2 and 3. Powerline Creek has been extensively logged with the result of unstable banks and channel (Gordon *et al* 1996).

Swamp at the north end of Lakelse Lake. Williams Creek occupies the valley in the background. Photo credit: A. Gottesfeld

Williams Creek and its three main tributaries, Sockeye, Myron and Llewellyn Creeks, comprise approximately 25% of the total stream length in the Lakelse Watershed. The alluvial fan of Williams Creek, particularly reach 2, has a somewhat unstable channel receiving large amounts of sediments from the unconfined reach 3 and the large amounts of bank erosion in reach 4. The recent avulsion (2001) of Williams Creek into Sockeye Creek has left three km of creek bed dry at times of low flow (Culp 2002).

View of Williams Creek, reach 3, upstream portion.
J&S Outdoor Ventures, 1995.

Furlong Creek, Granite Creek, Eel Creek, Herman Creek, and Killutsal Creek have received channel disturbance, and in some cases are unstable as a result of logging and road building activities (Culp 2003). Maxwell (2003) reports that construction of the highway required diversion of the five original Furlong Creek channels into one consolidated channel and that in the recent past, major landslides have been observed in the upper reaches. Clearwater Creek, Andalas Creek, Ena Creek, North Ena Creek, Powerline Creek, Junction Creek, as well as their tributaries, have essentially undisturbed or stable channels.

Geography

The Lakelse Watershed is situated within the Kitimat-Kitsumkalum trough, a broad north-south trending depression, in the Kitimat Mountain Range, south of Terrace. The deep-seated nature of the eastern boundary fault along the Kalum-Kitimat trough is demonstrated by hot springs activity. The bedrock geology of the Lakelse Watershed is described as Late Cretaceous to Early Tertiary, consisting of plutonic rocks that form part of the Coastal Mountain Belt. At the eastern most end of the watershed the bedrock geology changes to early and middle Jurassic volcanic and local sedimentary rocks of the Hazelton Group. This group forms part of the larger Intermontane Belt (Clague 1984).

For a short period of time at the end of the last Ice Age, between 10,000 and 10,600 years ago, the Lakelse Valley was occupied by the sea (Clague 1984, Gottesfeld 1985). The maximum sea level was about 700 m. Due to postglacial erosion and burial beneath alluvium, glaciomarine sediments presently have a patchy surface distribution in the Kitsumkalum-Kitimat trough. The largest area of relic sea floor occurs between the Skeena River and Lakelse Lake. The area is bounded on the north by alluvium of the Skeena River floodplain, bordered on the east and west both by alluvium (Williams Creek and White Creek fans) and by the walls of the Kitsumkalum-Kitimat trough.

To the south, the relic sea floor is partially obscured by organic deposits but borders against the steep ice-contact face of the large deltaic platform south of Lakelse Lake. The west margin of the deltaic platform north of Lakelse Lake is a relict foreset slope built into the sea by meltwater streams. The fore slope became inactive when the glacier flowing down Skeena Valley retreated back from the arcuate ice-contact face at the northeast (proximal) edge of the delta. Shortly thereafter, rapid isostatic rebound uplifted much of the glaciomarine terrain in this area above sea level. The continuity of this large area of glaciomarine deposits is broken by drift-veneered bedrock knobs and ridges such as Mount Herman, and by a large ice-contact delta north of Lakelse Lake (Clague 1984).

Certain portions of the low-lying landscape in the Kitsumkalum-Kitimat trough are riddled with earthflow landslide scars. These landslide scars include the two slides that occurred in May and June 1962, with the failures occurring in marine clay overlain in part by alluvial fan sediments (Clague 1978). The May slide between Furlong and Granite Creeks buried 540 m of the old road and the new highway, moving over a distance of 2.4 km on very nearly level ground (Evans 1982).

The June slide buried 1.6 km of the old road and the new highway. The most significant example of unstable glaciomarine deposits occurred in December 1993 or January 1994, when 23 ha of glaciomarine sediment – located on nearly level ground - flowed and slid rapidly into Mink Creek, a tributary of the Lakelse River. Currently, instability problems are noticeable along Schulbuckhand Creek, where numerous failures are occurring along the mouth of this tributary.

The predominant biogeoclimatic zone in the Lakelse Watershed is the Coastal Western Hemlock (CWH) zone that merges into Mountain Hemlock (MH) at approximately 550-650 m. The historic, natural vegetation of the watershed was dominated by old-growth conifer stands (rainforests) of western hemlock, western red cedar, and amabilis fir. Sitka spruce is common, but never dominant, and occurs mainly on alluvial soils. Seral stands were uncommon before clearcut logging began on a major scale, except for some south facing slopes, where lodgepole pine, birch and aspen were well established. Red alder and cottonwood occur mainly on floodplains and landslide scars where disturbance exposes mineral soil (Banner *et al*, 1993). The Mountain Hemlock zone is distinguished by the presence of mountain hemlock and the lack of red cedar.

Fisheries Values and Resources

The Lakelse Watershed possesses very high fisheries values and is one of the premier watersheds of the Skeena system. It is a major producer of sockeye, coho and pink salmon as well as supporting chum, chinook, and steelhead populations. McKean (1986) noted that the Lakelse system supports about 35% of the total Skeena River commercial fishery catch for all species. Steelhead, coho, and cutthroat trout support major sport fisheries. Resident species present in the system include rainbow trout, cutthroat trout, Dolly Varden, bull trout, mountain whitefish, and the following coarse fish: prickly sculpin, largescale suckers, redside shiners, northern pikeminnow, peamouth chub, and threespine stickleback. No fish species are known to be at risk within the watershed.

The fish community contributes to the ecology, nutrient regime and structural diversity of the drainage and provides strong cultural, economic and symbolic linkages, as well as supporting aboriginal, recreational, and commercial fisheries. The presence of salmon is a strong part of cultural and community values and identity within the watershed. The very high fishery values are rooted in the outstanding spawning and rearing habitat. When the water is low and clear, the Lakelse River is an angler's paradise with easy wading, many pools and stretches of swift water.

The richest source of data on the status of salmon stocks within the watershed is the Salmon Escapement Database System (SEDS) maintained by the Department of Fisheries and Oceans (DFO 2001). This data set consists of annual spawning ground observations of census areas collected since 1950 by the DFO. Spawning area counts are made with different techniques, including aerial counts, ground counts, counts from boats, swimming counts, counting weirs, and mark and recapture experiments. Most counts are simple estimates made from one or more ground visits or aerial surveys. Because of this variety in technique and natural conditions, particularly visibility, these data vary in quality in often-unknown temporal and spatial ways. The data quality varies from observer to observer and place to place.

The SEDS database is most reliable for the larger and more consistent spawning stocks. The bulk of salmon spawning areas appears to be represented; however, very small and infrequently used spawning areas are often overlooked. For example, in years of large pink salmon runs, spawning occurs at numerous sites that are not utilized under most conditions and may even appear to be unsuitable. These sites do not consistently appear in the SEDS database. Many small streams tributary to Lakelse Lake, and specific spawning sites on the mainstem are not documented.

The SEDS records can only be utilized as indicators of general trends and at best reflect relative abundance, rather than actual values. Whatever the shortcomings, this data set is the best available and exceeds the quality of data available for steelhead, trout and other non-anadromous, freshwater species. In general, the number of stocks counted increased from 1950 to 1990 and declined after 1992. Coho, followed by chum, are probably the most poorly estimated fish.

Data for steelhead is more dispersed. Since they spawn in the spring at high water conditions direct counts are usually not possible. Catches in the Tyee test fishery give aggregate abundance indices for the whole Skeena River. In general, enough is known to infer the order of importance of spawning streams.

Although there are many salmon spawning areas represented in the SEDS database, the bulk of the salmon production is from a much smaller set of localities. These localities are not randomly distributed within the watershed but are sites of very high or high habitat quality. If these tributary streams are examined more closely, it is likely that even within the productive systems, small portions of the stream produce the bulk of the fry. In stream-rearing species such as coho and chinook, the fry may be widely dispersed from the spawning beds. Lake-rearing populations such as sockeye are dependent on the productive capacity of the associated rearing lake.

The following section reviews the habitat and status of the six Pacific salmon species and selected indigenous, freshwater fish in the Lakelse Watershed. For each species, the nature of their habitat and life history is described, major stocks and status are identified, their context within the Skeena Basin is reviewed, and the genetic structure of the population is described where information is available.

Chinook Salmon

Chinook are the largest species of salmon in the Skeena Watershed. In general they are fish of larger streams and spawn in faster moving water with coarser gravel than other salmon; chinook stocks are usually relatively small (Healey 1991). Chinook are the first salmon species to return to freshwater, resulting in the popular name, "springs." Early stocks arrive in May and June; late stocks in June and July. Late stocks tend to be more coastal and/or tend to spawn downstream of lakes.

The genetic structure of chinook stocks is discussed by Beacham *et al.* (1996), who focuses on the separation of regional stocks and defines the Vancouver Island, Fraser area, and North Coast aggregates. Chinook from Skeena tributary rivers such as the Kalum River and the Lakelse River are clearly separable. Assuming that individual spawning stocks are genetically distinct, then conservation units are narrowly drawn and concern must be placed on preservation of the smaller stocks as well as the more productive larger stocks.

Chinook originating from Oregon through Alaska are widely mixed along the Pacific coast. Coastal mixed-stock fisheries therefore intercept fish originating in many rivers, and this has been difficult to manage without serious impacts on less productive stocks. Chinook stocks have probably been in decline since 1920; with a definite decline after 1950. This led to management actions that progressively decreased the commercial and sports catches. Restrictions on the North Coast chinook commercial fisheries and on river sports fishing began in the mid 1970s (Ginetz 1976), and the 1985 Canada-U.S. Pacific Salmon Treaty, with its subsequent amendments, has also put in place provisions to help stop the decline of chinook.

It is likely that the increase in escapement from 1985 on is due to the restriction on chinook harvest in Alaska that took effect with the Pacific Salmon Treaty. It should be noted that the recent recovery of Skeena chinook escapement to 1950s levels is in the absence of a large commercial fishery in B.C. It is likely that the long-term depression in chinook production and the recent increase in stock productivity are due not only to changes in exploitation rate, but also to changes in ocean survival. Since the 1950s, a long-term population decline occurred due in part to the mixed-stock fishery and incidental interception, and a targeted sports fishery

Information on Skeena Watershed chinook stocks prior to 1950 is available only from catch data. Catches from 1899 to 1930 in the Skeena River fishery averaged over 100,000 chinook with peak catches exceeding 200,000 (Ginetz 1976, Riddell and Snyder 1989). Chinook catches declined steadily from 1930 to the 1970s. Escapement data based on some spawning ground counts has been collected since 1950. Total Skeena River escapement was about 50,000 in the 1950s, declining to about 25,000 from 1965 to 1985. Chinook escapement has been recovering in the past 15 years and is now approaching levels of fifty years ago.

The chinook salmon population is relatively low in the Lakelse Watershed. The decadal mean since 1950 is 183 chinook spawners with a range from 91 in the 1990's, to 293 in the 1970's. Chinook enter the Lakelse system in mid August through early September. Chinook spawning principally occurs below the lake outlet, with limited spawning in the Lakelse River mainstem in a patchwork of small areas (MoE 1979, Pinsent and Chudyk 1973). Historically, chinook have spawned in low numbers (20-30) in Coldwater Creek, White Creek, Sockeye Creek and Williams Creek. (Smith and Lucop 1966, DFO 2001, Koefed 2001).

Most chinook spawning occurs in August and September. Fry emerge from the gravel early in the spring. After hatching many fry move or are displaced downstream. Chinook fry are territorial and as they grow, individual territories expand and the excluded fish are displaced downstream. Chinook rearing occurs virtually throughout the high value habitat located in the watershed, with migrants for the most part migrating at age 1 downstream to the Skeena River, into the estuary, and then into saltwater. Chinook return after one to five years at sea, though most return after three seasons. Chinook with longer ocean residence times are larger as adults.

Pink Salmon

The Lakelse River is one of the major pink salmon producing areas of the Skeena River system, with pink escapement exceeding 1.5 million fish in some years. The mid-season pink run typically averages 50% of Area 4 production (DFO 1985). Pink salmon escapement and catch were comparatively high from the early 1980's through to the mid-1990's.

Pink salmon are exclusively two years old at spawning time, meaning that odd and even-year stocks are genetically separate. Pink salmon return at a smaller size than other salmon due to their short life cycle. In the ocean they grow faster than other salmon species (Heard 1991).

Pink salmon tend to stray at higher rates than other salmon. Heard (1991) summarizes mark and recapture experiments that show approximately 10% straying in pink salmon. Most straying is to nearby streams. In years of large escapement many pinks wander into previously unused spawning areas and even spawn in places that appear to be unsuitable. The genetic structure of pink salmon populations reflects this pattern of straying, though only regional patterns of stock separation have been described. Beacham *et al.* (1985) report allozyme studies that result in identification of three stock groups: Fraser River, Puget Sound and B.C. non-Fraser. In general the odd and even-year lineages of pink salmon are more different genetically than stream populations over large areas (Heard 1991).

The Lakelse pink salmon run enters the Lakelse River in late August, peaks early to mid-September, and ends mid-September to mid October. Odd-year pink salmon usually enter and spawn over a longer time period than even-year pinks. The mid 1980's saw different timing, as was characteristic of many Lakelse salmon runs. Pink salmon spawn virtually throughout the mainstem, with extremely heavy spawning taking place between Coldwater and Herman Creeks. This area often has the latest spawning timing in the Lakelse Watershed (DFO 1991).

Wisley (1919) reported that the Lakelse River, from the lake outlet to Coldwater Creek, was literally filled with a mass of spawning humpbacks. This was a common observation throughout the 1920's. The lower reaches of White Creek, Mink Creek, Coldwater Creek, Herman Creek, Scully Creek, Hatchery Creek, and Granite Creek are also occasionally utilized for spawning. Upon emerging from the gravel in spring, pink salmon fry migrate immediately to the saltwater.

Chum Salmon

Chum salmon are the least abundant of the six Pacific salmon species in the Skeena Watershed. They are much more abundant in southern BC and in Southeast Alaska where hatchery production enhances some of the stocks. In the Skeena Watershed, chum salmon live two to five years. Three year old returning fish are most abundant, but four year old fish are generally present at spawning time (Halupka et al. 2000). There is an extraordinary variability in year to year chum salmon returns. Annual escapement estimates in the SEDS have varied one hundred fold over the past fifty years (DFO 2001).

Chum salmon arrive in the Skeena Watershed from late July to early September. Their migration coincides with the much larger runs of pink salmon, and they usually spawn in places that also have, or are adjacent to spawning pink salmon. Unlike coho and sockeye, which may hold for a month or two before spawning, chums normally spawn soon after traveling up the Skeena River. Fry emerge early in the spring and migrate to the Skeena estuary immediately upon hatching. Chum salmon smolts typically remain in estuaries for one to several months, growing rapidly before dispersing in the ocean (Healey 1980). There is apparently a high degree of variability in the survival rate of chum early in their marine life.

Chum are most common in the coastal portion of the Skeena Watershed. The most important spawning area is the Ecstall River and the multi-channel reach of the Skeena River below Terrace. Other spawning areas are near the mouths of large tributary streams and in back-channels along the Skeena River from Terrace to Kispiox. There is significant spawning in the Kitwanga and Kispiox Rivers. Smaller stocks are present in the lower portions of several other Skeena River tributaries. Chum are rare in the Bulkley River and in the Skeena River above the Kispiox River confluence.

Field observations suggest chum are highly specialized in their selection of spawning sites. Several of the Skeena River spawning sites used every year are less than a few hundred meters long. Chum continue to use these patches of gravel even when channel reorganization separates them from their former source of flow.

There are no genetic studies aimed at separating stocks of chum at the river tributary level. Beacham *et al.* (1987) used electrophoretic analysis to distinguish five large-scale population assemblages in chum salmon from the Queen Charlotte Islands, the north and central coast, the west coast Vancouver Island, the south coast, and the Fraser River system. Kondzela *et al.* (1994) used similar techniques to divide Southeast Alaska and northern British Columbia stocks into six groups.

Chum salmon stocks were apparently much more abundant early in the twentieth century. The commercial catch of chum salmon in the Skeena Area between 1916 and 1928 was over 200,000 per year (Argue *et al.* 1986). This suggests an escapement about ten times larger than that of the recent past. Chum salmon escapements have been low for the last 50 years. With the exception of the spectacular high escapement in 1988, the average escapement has been declining over this period. The decline in chum salmon stocks is basin wide, suggesting that much of the problem is in the marine realm. Similar declines have taken place in the mid-coast region and non-enhanced stocks in southeast Alaska. This suggests that a major component of the decline in chum salmon is decreased ocean survival.

Skeena River chum salmon are taken as incidental catches in the sockeye and pink salmon fisheries of Area 3, 4, and 5 and to a lesser extent in the Noyes Island and Cape Fox fisheries in Alaska. Charles and Henderson (1985) calculate an overall exploitation rate of between 50% and 83% for the years between 1970 and 1982. This relatively high exploitation rate has probably also contributed to the decline of the Skeena stocks. Chum are also taken in small numbers in First Nations food fisheries.

The average overall escapement to Area 4 in the 1990s was only 10,000 to 14,000 chum salmon. The Ecstall and the West Skeena areas contain the only strong stocks, accounting for over 9, 000 of this total. In the 1990s, 29 enumerated stocks had escapements below 200, of which 26 had average escapements of below 100. In general, one can conclude that chum are probably the Skeena Watershed salmon species in the greatest danger of significant loss of spawning stocks and genetic diversity.

The chum salmon run into the Lakelse River is modest. Escapement data over the last thirty years is scant due for the most part to a lack of counts; recent escapement trends are unknown. Run timing typically starts in late August, and peaks in mid September; usually all chum are in by mid October. Hancock *et al* (1983) show patches of chum spawning grounds scattered sporadically from below Mink Creek upstream to the lake outlet. Chum have been observed spawning at 6.0 km in Coldwater Creek. Migration downstream to the saltwater begins immediately following fry emergence in the spring.

Sockeye Salmon

Sockeye are significant in the Lakelse system, which for its area supports one of the largest sockeye runs in the Skeena. Sockeye salmon are the most valuable commercial fish of the Skeena Watershed and have consequently received considerable research and management attention. Important sources of information are found in Brett 1952, Larkin and McDonald 1968, Smith *et al.* 1987, Rutherford *et al.* 1999, Shortreed 1998, and Wood *et al.* 1997. The total annual Skeena sockeye run size (i.e. before harvest) averages several million fish. The vast majority of Skeena sockeye return as 4 and 5 year old fish, although 3 year old males (jacks) are common in some years. Skeena sockeye fry typically rear in lakes; therefore, the adults usually spawn in streams either tributary to lakes or near the outlet of lakes.

Sockeye fry spend one or two years rearing in lakes. Productive sockeye stocks, such as those of Lakelse Lake and Babine Lake, spend one year as lake residents before migrating to saltwater in late May and June. Lakelse Lake is biologically productive with abundant plankton populations, the main food source for sockeye fry. Sockeye derived from colder subalpine lakes such as Onerka Lake and Sicintine Lake spend two years rearing in the lake. This unique life cycle is different from other Pacific salmon.

Babine sockeye studies and investigations began with the Fisheries Research Board of Canada in the 1940s. Construction of the Babine Lake Development Project (BLDP), an approximately 10 million dollar project, consisted of artificial spawning channels and dams to provide for water flow regulation located at Pinkut Creek and Fulton River, tributaries of Babine Lake.

Sockeye salmon production from Babine Lake increased significantly as a result of the BLDP program. At least 90% of Skeena sockeye salmon now originate from the Babine-Nilkitkwa system (McKinnell and Rutherford 1994) compared with less than 80% prior to 1970. The relative increase in Babine Lake sockeye is due to an increase in abundance of enhanced sockeye and a decrease in all other wild Skeena sockeye sub-populations. Most wild sockeye stocks have declined since the 1970s, probably in response to increased exploitation rates supported by the success of the Babine Lake enhancement.

The mixture of enhanced and wild stocks in the commercial mixed-stock fishing areas has generally depressed wild stocks – some to a greater extent than others – particularly non-Babine sockeye, coho, chinook and steelhead stocks. Management concerns regarding this situation are dual in nature: ensuring the conservation and continuity of non-Babine stocks, and maximizing the catch of enhanced Babine sockeye salmon (Wood *et al.* 1997).

The high commercial value of sockeye salmon is the motive to a high exploitation rate of Skeena River sockeye in a series of fisheries in Alaska, on the BC coast, and at the mouth of the Skeena River. The commercial fishery for Skeena sockeye began in 1877, and from 1910 to 1970, the total return (catch plus escapement) of Skeena sockeye fluctuated between 1 and 3 million fish. There was an overall decline of 50% in the catch from 1910 to 1955. Beginning in 1930, effort declined as a result of regulation and poor returns per boat, levelling off at an exploitation rate of approximately 50% (Argue *et al*, 1986).

Since 1970, after enhancement of the Babine sockeye stocks, catch of Skeena sockeye increased steadily until a large decline in 1997 that was due to disease problems in the Babine stocks. Over this period, exploitation rates have been fairly constant, averaging 61%, but since 1970 have exceeded 70% four times (Rutherford *et al.* 1999). These relatively high exploitation rates may have led to the decline of less productive wild sockeye stocks.

Research advances over the past ten years have identified genetic markers in sockeye that can separate sockeye from different spawning areas and provide a tool to help understand their population structure (Wood *et al.* 1994, Beacham and Wood 1999). This information has important conservation implications. Sockeye salmon appear to be highly specific to individual lakes, and each lake system is genetically distinct. Different spawning areas in a single lake system have sockeye that are similar genetically to one another and have modest amounts of genetic interchange between different spawning streams (Varnavskaya *et al.* 1994, Wood and Foote 1996, Withler *et al.* 2000).

Each lake complex is an evolutionary significant unit and hence an important fisheries management unit (Waples 1995). In contrast, river dwelling sockeye are relatively similar genetically (Wood 1995, Beacham and Wood 1999). This pattern is quite unlike that of coho where populations seem to vary by degree along river systems. Consequently the preservation of even small sockeye populations is important to the preservation of species diversity.

In the Skeena system overall, sockeye spawning population abundance was moderate in the 1950's, increased through the 1960's, severely declined in the 1970's, regained strength in the 1980's, and in the 1990's has been moderately depressed.

Comprehensive propagation and migrant survival studies of Lakelse sockeye were instituted as a component of the Skeena River Investigations (Brett 1952). Sockeye studies on Lakelse Lake in the early 1960's followed the loss, by fire, of the pink hatchery facilities at Kleanza Creek. This prompted construction of a hatchery, fish fence, and ancillary facilities at Schulbuckhand Creek. Fish fences, holding ponds and spawning facilities were also built on Williams Creek. Tow netting, trap netting and lake-pond studies were used in an effort to observe and better understand sockeye behaviour.

The Lakelse sockeye salmon run usually enters the system in June, holding in Lakelse Lake and starts ascending the streams in August (Sword 1904, Whitwell 1906, Bams and Coburn 1962). Spawning occurs in the lower reaches of many Lakelse Lake tributaries, including: Andalas Creek, Clearwater Creek, Hatchery Creek, Granite Creek, Sockeye Creek and Blackwater Creek. Williams Creek and Scully Creek are the two important spawning streams.

Sockeye spawning in Williams Creek. **Photo credit: Dave Gordon**

The major spawning stream, Williams Creek, has excellent beds of medium coarse gravel, while Sockeye Creek also provides good gravel. Culp (2003) notes that in 2001, Williams Creek breached a logged stream bank and diverted into Sockeye Creek. This flood event left approximately 3 km of channel dry during low stream flows. The effect of this avulsion on sockeye, coho, and possibly chinook eggs is unknown. In fall 2002, approximately 2/3 of Williams Creek stream flow was back in its original channel, though is now dry. Recent watershed assessments reviewed the Williams Creek sub-basin overall habitat components. Channel, fish habitat, riparian, hillslope, and road conditions are rated as poor (Reese-Hansen 2001).

Shortreed *et al.* (1998) examined the juvenile sockeye productivity of Lakelse Lake. They propose that littoral production might be an important component in sockeye growth. At an average size of 6 g, Lakelse fall sockeye fry were the largest in the Skeena study and among the largest found in British Columbia. Sockeye fry biomass was 51% of the PR model's prediction of maximum production, and recent escapements have averaged 15% of predicted optimum escapements. It was suggested that increased fry recruitment through enlarging escapements or fry stocking would be the best ways to enhance this population.

Coho Salmon

Coho salmon are widely dispersed throughout the Skeena Watershed and show the least amount of concentration into a few, large productive stocks. Coho usually spend one to two winters in freshwater before migration to the ocean. They typically return as two or three year olds after spending one winter in the ocean (Holtby *et al.* 1994).

Coho migrate into the Skeena River between late July and the end of September as recorded by the Tyee test fishery. The annual peak of the migration is in late August. In general the fish destined for upstream tributaries arrive first because they spawn earlier in cold-water tributaries and have longer travel times. The early arrivals pass through the various coastal fisheries along with the large sockeye run destined for Fulton River, a tributary of Babine Lake. Coho are usually the last salmon to spawn in the fall with spawning occurring from the end of September through December.

The vast majority of coho return to their natal stream. However, when compared to other species like sockeye and chinook, coho typically have a higher amount of straying, and in years of low flows may stray to other nearby streams or spawn further downstream after holding. Sandercook (1991) suggests that typical straying rates are less than 1% with most straying to nearby similar streams. The genetic structure of coho reflects this pattern of straying of adult fish, and straying rates of less than 1% are sufficient to ensure gene flow between nearby streams (Wood and Holtby 1999). Coho appear to wander freely within their spawning stream, taking advantage of fall floods to pass barriers such as beaver dams in order to occupy new upstream areas.

The coho of the Skeena and Nass Watersheds constitute a genetically distinct regional group of populations (Small *et al.* 1998). Within the Skeena Watershed, variation appears to be roughly proportional to the distance between spawning streams. Wood and Holtby (1999) suggest that the effective size of subpopulations is approximately 100 to 400 km. Important evolutionary units are then at the major tributary level of separation, suggesting that there are several functional subpopulations in the Skeena that are genetically distinct populations. The implication of this model is that decline of coho in a single stream is not an evolutionary concern if nearby streams retain healthy populations.

The decline in coho stocks is attributed to a combination of Alaskan net fisheries, the Skeena mixed-stock net fishery, and a decline due to unknown ocean survival factors. Tagging information available for Babine coho suggests that the stocks have a distinct ocean distribution off southeast Alaska. With complete closure of the Skeena commercial fishery in 1998, the estimated exploitation rate of 60% on Babine coho indicates an intense Alaskan net impact (DFO 1999).

Total exploitation rates before 1998 ranged for the most part from 60% to 80%. Few if any of the Skeena coho stocks can be expected to thrive at the upper range of this rate of exploitation. One third to one half of the total exploitation during this time period was in Alaska. Counts of coho spawners in streams are notoriously difficult and often underestimate true escapement numbers. The concern for coho individual stocks should be assayed against the generalized pattern of genetic differentiation and the ability of coho to reoccupy available habitat. Rebuilding coho in the Skeena region will require continued conservation efforts.

The low escapements of Skeena coho in the 1980s and 1990s raised concerns about coho survival, especially survival of stocks spawning upstream of Terrace. DFO responded to this management crisis by instituting substantial changes to the commercial and sports fisheries in 1998 and 1999, directed at reducing the catch to zero. Severe restrictions on commercial fishing continued through 2001. These actions have met with some success as escapements increased in 1999, 2000 and 2001, with the added benefit of better-than-average ocean survivals. Smolt to adult survival rates are a measure of ocean survival. The general pattern in the past decade in Oregon, Washington, and British Columbia is a decline in ocean survival. Mortality is highest in the first year at sea and probably in the first months. Ocean survival rates for Skeena coho are extremely variable (from 0.2% to 20%) and seem to have decreased in the 1980s through 1996.

Coho rearing typically takes place in low gradient streams, ponds, and lakes. In ponds and lakes, juveniles inhabit the near-shore littoral zone (Irvine and Johnston 1992). Riverside channels and small streams often provide preferred habitat with structural complexity that includes stones, logs, and overhanging vegetation. Coho are dependent on low gradient streams (<2%) for rearing habitat (Nass *et al.* 1995). Coho frequently occupy small upstream habitats, often moving into these small spawning streams when heavy fall rains increase water flows, allowing them to get over obstacles such as beaver dams.

Coho are fish of small streams and are often dependent on off channel habitat such as beaver ponds, back channels, and seasonally flooded areas for rearing. These small stream and flood plain habitats are highly susceptible to damage from logging. Prior to the Forest Practices Code (1994) protection of small streams was often inadequate.

Lakelse coho aggregate stock remains one of the most productive coho stocks in the Skeena drainage. Coho escapement in the 1950's annually averaged 21,000 fish, with an increase in the 1960's to 34,000 annual spawners. Coho escapement declined severely by the mid-1970's to an annual average of 8,000 fish and the decadal mean has stayed depressed at that level into the present.

Lakelse system coho enter the Lakelse River in early to mid September, through to early or mid October; by early December the run has tapered off. Most of the spawning, approximately 75%, occurs in the Lakelse River below the lake outlet. Spawning has also been noted (Hancock *et al* 1983, DFO 1991) to occur in the lower reaches of: White Creek, Coldwater Creek, Herman Creek, Ena Creek, Andalas Creek, Clearwater Creek, Scully Creek, Refuge Creek, Hatchery Creek, Granite Creek, Furlong Creek, Blackwater Creek, Williams Creek, and Sockeye Creek. Coho use has been nil in the once productive Mink Creek since the large earthflow in the early 1990's (Culp, J. 2002).

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Dams and Bustard (1996) noted that in 1995, spawning in Clearwater Creek peaked during the last week of October and the first week in November, with completion by the middle of December. The spawning peak on Sockeye Creek occurred in mid November to early December, with spawners still present in the last week of December. Coho juveniles are widespread throughout the accessible portions of the Lakelse system.

Steelhead

Summer run steelhead arrive relatively late in the Skeena along with coho salmon and continue to arrive in the lower Skeena River throughout the winter. The earliest part of the steelhead run overlaps the much larger sockeye runs with most of the steelhead arrivals taking place while pink salmon are entering the Skeena.

Overall, the Tyee Test Fishery best estimates the summer run portion of steelhead escapement to the Skeena Watershed. Total summer run escapement estimates based on the Tyee index data began in 1956. Steelhead escapement declined from about 1985 to 1992. The low escapements in these years led to changes in the timing of the Area 4 commercial fisheries to decrease the impact on steelhead, and to the beginning of mandatory catch and release in the sports fishery. The total closure of the Area 4 fishery in 1998, and improving ocean survival, contributed to the high escapement of that year. Spence and Hooton (1991) suggest a minimum escapement target of 26,500 for Skeena River summer run steelhead, assuming no upriver harvest. Allowing for aboriginal food fisheries, the minimum escapement should be set at least 28,000; however, only 9 of the last 45 years have met this criterion.

Low levels of straying are characteristic of steelhead (Quinn 1993, Heath *et al.* 2001). Where straying occurs, it is likely to streams close to the spawning stream. This pattern results in a moderate degree of genetic separation of steelhead. Heath *et al.* (2001) analysed the genetics of steelhead stocks in the Skeena and Nass Rivers and they found significant differences between stocks from the various tributary watersheds of these two rivers. Steelhead from the Morice, Babine, Kispiox, Sustut, and Zymoetz Rivers are genetically distinct, and differences increase proportional to the geographic separation of the watersheds.

Changes to steelhead populations in tributary watersheds in the Skeena are hard to identify due to a shortage of relevant information. While Catch Per Unit Effort (CPUE) applied to sports fisheries is not a solid measure of abundance, the most useful source of data is the Steelhead Harvest Analysis (Ministry of Water, Lands and Air Protection 1991). There are few good data to record steelhead escapements at individual streams. This is in large part because they spawn in spring at high water conditions when counts are usually not possible and they are typically spread out at many sites within a stream. Steelhead spawning typically occurs from March through May, coinciding with warming water temperatures and an increase in stream flows.

Steelhead fry emerge between mid-August and mid-September and are widespread throughout smaller tributaries that offer suitable refuge. It is suggested that freshwater residency time relates to the location of juvenile steelhead habitat in the system; slower growth rates are apparent when rearing in glacial fed stream systems, compared to nutrient rich lake habitat.

Information concerning Lakelse steelhead escapement and population trends is not available. Steelhead trout enter the Lakelse Watershed in three distinct runs: a spring run from March until May, a summer run of steelhead enter the river in September (Culp 2003), and typically a winter run enters from October until January. The latter run is one of a few substantial winter run steelhead populations in the Skeena River system.

Lakelse River Steelhead. **Photo credit: Mike Whelpley.**

Although steelhead do not generally overwinter in the Lakelse River or its tributaries, they have been known to do so in the lake (Tetreau 1982, Whelpley 1983, 1984). It is likely that Lakelse system steelhead overwinter in the Skeena River, both upstream and downstream of Lakelse River (Grieve and Webb 1997). Lakelse Lake is most likely the most important rearing and overwintering habitat in the watershed. There is First Nations anecdotal information that describes the under-ice, set netting of steelhead off the inlets of Andalas and Clearwater Creeks.

Critical spawning takes place in a patchwork of small areas spread throughout the Lakelse River mainstem (Pinsent and Chudyk 1973). The major spawning area is in the river section immediately downstream of the lake outlet (DFO 1991). The Lakelse River Project documented steelhead spawning at various sites in the main stream, from the lake outlet to the Skeena confluence (Whelpley 1983, 1984).

This investigation also observed steelhead spawning in the lower reach of Herman Creek, White Creek and Williams Creek. Culp (2002) considers Coldwater Creek as one of the most important steelhead spawning streams in the Lakelse system. Gordon (1996) also notes evidence of spawning in Coldwater Creek. Local anglers (Brown and Webb, *cited in* Grieve and Webb 1997), Whelpley (1984), and Culp (2003), note that summer and winter run steelhead generally use the upper and middle river to spawn, while spring run steelhead utilize the lower river. Tagging records of 347 steelhead collected over a thirty year period showed that a majority of these fish spent three years in fresh water and two or three years in saltwater. These records indicated that repeat spawners accounted for 15.6%.

Juvenile steelhead utilize the low gradient streams throughout the watershed for rearing. Rainbow trout have been observed in the lower and mid reaches of White Creek, Clearwater Creek, Junction Creek, Coldwater Creek, Johnstone Creek, Eel Creek, Ena Lake, and Williams Creek.

Indigenous Freshwater Fish

In comparison to salmon, information is sparse on resident, non-anadromous or freshwater fish in both fluvial (or river) and lacustrine (or lake) habitats of the Lakelse Watershed. Ecological and life history information that permits good conservation planning is simply not available. There are 18 known species of fish in the Lakelse Watershed; of these, 12 are freshwater species (FISS 2002).

Known freshwater species and documented populations inhabiting the Lakelse Watershed include Rainbow trout (*Oncorhynchus mykiss*), Cutthroat trout (*Oncorhynchus clarki clarki*), Bull trout (*Salvelinus confluentus*), Dolly Varden char (*Salvelinus malma*), Mountain whitefish (*Prosopium williamsoni*), Northern pikeminnow (*Ptychocheilus oregonesis*), Largescale sucker (*Catostomus macrocheilus*), River lamprey (*Lampetra ayresi*), Redside shiner (*Richardsonius balteatus*), Peamouth chub *(Mylocheilus caurinus)*, Threespine stickleback *(Gasterosteus aculeautus)*, and Prickly sculpin (*Cottus asper*).

The focus of government management efforts in the past on a narrow range of game fish has recently given way to interest in the characteristics and conservation of populations of all species. Defining conservation levels requires understanding fish values and the status of the fish resources, as well as basic habitat knowledge and values. What and where are critical areas for fish? What are the capability and constraints for production? What are the population and habitat sensitivities?

Currently, it is important to define conservation levels and to preserve biodiversity outside protected areas, as well as in conjunction with forestry and other development activity practices that potentially could impact fish abundance and habitats. Responsibility and jurisdiction for the freshwater species lies with the provincial government. The following section briefly reviews the habitat and status of selected trout and char species in the Lakelse Watershed.

Rainbow Trout

Within the Lakelse Watershed, rainbow trout have been documented in most of the tributaries and in the mainstem and are one of the most widely distributed fish. Rainbow trout have recently undergone a name change from *Salmo gairdneri* to *Oncorhynchus mykiss* (Smith and Stearly 1989), with anadromous forms being commonly referred to as steelhead, or steelhead trout. Rainbow trout are present throughout the Skeena Watershed as residents in lacustrine, resident fluvial and adfluvial life history forms and are an important, popular sport fish.

It is generally thought that Skeena Watershed populations of rainbow trout exhibit three different life history strategies, with considerable variation depending on geographic location and habitat. The different life histories are populations that live their entire lives in small streams, those that spawn in small streams and migrate to rivers to rear and mature, and those that spawn in small streams and move into lakes to rear and mature.

Rainbow are most often a lake fish, but they enter streams to spawn in the spring before ice break-up. Females construct redds in the gravel into which the eggs are deposited. Young emerge from the gravel in the summer and usually migrate in the first year to rearing areas within streams or lakes. Juveniles spend up to a year in the stream following hatching, then return to lakes to grow and mature. Normally, the fish remain in the rearing lake or river until they reach maturity in 2 to 4 years, before moving back to natal streams for spawning. Scott and Crossman (1973) reported that survival after spawning is usually low and the number of repeat spawners is often less than 10% of the total spawning population.

Rainbow trout exhibit a wide range of growth rates dependent on habitat, food type and availability, and life history strategy. Generally the growth of rainbow trout is slower in streams than in lakes and is greatest in marine environments (Carlander 1969). The fish show seasonal movement to access suitable habitat for feeding and overwintering. Generally, the type of food eaten reflects the size of rainbows and the season, with principal prey being zooplankton, benthic invertebrates, terrestrial insects, and fish. Small rainbows may eat zooplankton crustaceans and small insects, while larger trout may take leeches, larger insects, molluscs, and a variety of juvenile fish (Griffiths 1968). Griffiths documented growth and feeding habits, primarily by stomach analysis of rainbow trout in Babine Lake.

Hatchery raised rainbow trout are the predominant species used for stocking lakes in the Skeena watershed. The majority of hatchery-produced fish are put into lakes that either cannot support rainbow trout or have insufficient natural production to satisfy sport fishing demands. Current daily catch quotas allow the keeping of 5 rainbow trout.

Cutthroat Trout

Cutthroat trout comprise a popular sport fishery in limited instances in the Lakelse River drainage. Within the Lakelse Watershed, cutthroat trout distribution is documented throughout most of the system; along with rainbow trout it is one of the most abundant fish species. The cutthroat trout sport fishery is described by Bilton and Shepard (1955), Imbleau (1978), Hatlevik *et al* (1981), and de Leeuw (1991).

The species of cutthroat trout in the Skeena River watershed is the coastal cutthroat trout (*O. clarki clarki*), which is blue listed by the BC Conservation Data Centre (CDC) as a species of concern. It is not, however, an identified wildlife species under the Forest Practices Code, nor is it listed by COSEWIC (Committee on the Status of Endangered Wildlife in Canada). Lacustrine populations of cutthroat trout exist throughout the Skeena Watershed, but are rare in Skeena tributaries upstream of the Babine/Skeena confluence and are not documented in the uppermost tributaries that include Slamgeesh, Kluatantan and Sustut Rivers.

Cutthroat trout are very adaptable to their environments, resulting in considerable variation in life histories. Generally there are three life history types of cutthroat trout in the watershed. Anadromous life forms of cutthroat exist in the Skeena but are poorly studied and understood. For regulation purposes, populations upstream of Cedarvale are not considered to be anadromous. There are adfluvial populations that spawn in tributary streams and migrate to lakes to grow to maturity, and fluvial populations that move between mainstems and headwater streams, as well as resident populations that remain in headwater tributaries for their entire lives.

Cutthroat trout exhibit considerable variation in spawning time, though it normally occurs from mid-May to mid-June (Hart 1973). The fish usually spawn in small gravel substrate streams that are tributary to rivers and lakes, with redds constructed by the females. Emergent fry spend variable lengths of time in their natal streams, while migratory populations may spend as little as a few months to as long as 4 years in their original streams (Liknes and Graham 1988). Once in rearing areas, the river and tributary dwelling populations may make minor migrations to access preferred food and appropriate winter habitats. Cutthroat trout in lakes generally grow faster than those in streams; Carlander (1969) suggests the smaller the stream, the slower the growth.

Cutthroat trout are opportunistic feeders that consume a variety of freshwater invertebrates and may feed heavily on other fishes, crustaceans, and freshwater insects. Moore and Gregory (1988) studied cutthroat habitat preferences in tributary streams and found that fry abundance was proportional to the area of lateral habitat, meaning stream margins, backwaters, and isolated pools. Cutthroat living in association with other trout species generally alter their feeding behaviour to minimize competition with the other species.

Dolly Varden Char

Dolly Varden char (*Salvelinus malma*) are blue listed by the BC CDC as a species of concern, but are not listed as identified wildlife by the Forest Practices Code or by COSEWIC. Dolly Varden are common in the greater Skeena Watershed and are probably the most common freshwater fish in the Lakelse Watershed after rainbow and cutthroat trout. Small resident Dolly Varden are predominant in the upper reaches of small streams throughout the watershed. Dolly Varden char also exist in lacustrine-adfluvial populations. Beyond knowledge of distribution and general life history, Dolly Varden char have not received extensive management or biological study in the Lakelse Watershed.

Spawning takes place in streams in the autumn with maturity usually reached in the fifth year. Regular seaward migrations may take place in spring with return migrations in the fall. Hart (1973) suggests that in the Skeena Watershed most fish spend 3 years in fresh water and 2-3 years in the ocean, with males tending to stay longer at sea. Generally, food consists of fishes, including herring, sticklebacks, juvenile salmon, salmon eggs, molluscs, insects and crustaceans (Hart 1973).

Cedarvale constitutes the regulatory upper limit of Dolly Varden anadromy; the remaining populations are fluvial or adfluvial residents. Dolly Varden char are only targeted as sport fish in the lower Skeena and its coastal tributaries, due primarily to their small size in upper watershed drainages. Current daily catch quotas allow the keeping of five Dolly Varden.

Bull Trout

Bull trout (*Salvelinus confluentus*) is actually a char that are blue listed as a species of concern by the BC CDC, as well as by COSEWIC, due primarily to limited global distribution and threatened status in their southern US range. They are also listed as an *identified wildlife* species (species at risk) under the FPC. Studies on bull trout in the Skeena watershed are limited to the Morice Watershed (Bahr 2002) and the Shelagyote River (Giroux 2002). Despite differences in life history traits and morphometry, bull trout are often confused with Dolly Varden and much of the available information on distribution is suspect (Hass 1998).

Fluvial and adfluvial populations spawn in small tributary streams and over-winter in larger rivers or lakes. Maturity is generally reached at 5 years of age, though precocious males may mature by age 3 (Shepard *et al* 1984). Recent observations by (Giroux 2002, Bahr 2002) show watershed populations typically spawning in gravel and cobble pockets in streams during late summer and early fall. Usually eggs hatch before the end of January with emergence occurring in late spring. After hatching, bull trout fry rear in low velocity backwaters and side channels and avoid riffles and runs (McPhail and Murray 1979). Juveniles tend to utilize a variety of stream and lake habitats and are most abundant where water temperatures are 12^0C or less. Their intra-watershed distribution patterns indicate they are sensitive to water temperatures, preferring cold natal streams.

Bull trout are a long-lived, repeat spawning fish that can exceed 20 years of age and 10 kg in weight; however, in general terms, most bull trout char captured by anglers range between 45-60 cm in length, and are 8-17 years old. Bull trout are a popular sport fish and are frequently harvested by sport anglers as by-catch during targeted recreational fisheries for summer-run steelhead, chinook, sockeye and coho.

As adults, they are an aggressive piscivorous (fish eating) fish and vulnerable to overharvest by anglers. Limiting angler access, as well as critical habitat identification and protection, are the most significant issues for the protection of bull trout in the Skeena River drainage. Bull trout are suspected to be found throughout the Lakelse Watershed and its tributaries, though there is uncertainty whether the identified fish are bull trout or Dolly Varden. Bull trout occurrence is considered common in Skeena tributaries upstream of Cedarvale.

Whitefish

Mountain whitefish are present within the Lakelse Watershed. Mountain whitefish, also commonly called Rocky Mountain whitefish, are the most widely distributed fish species of the greater Skeena Watershed fishes, with occurrence throughout tributaries and lakes of the Skeena system (Godfrey 1955). They have been found in moderate abundance in the 20-plus sockeye rearing lakes in the system, which vary from deep, cold and opaque bodies of water to small, shallow and warm ponds (Ibid).

Mountain whitefish use a wide range of habitats for spawning and do not construct redds. Mainstream river resident and lake dwelling populations move into tributary streams to spawn; however, McPhail and Lindsey (1970) report some cases of spawning occurring within lakes. Clearly, the habitat used for spawning should be determined for local populations. Mountain whitefish are generally nocturnal spawners (McPhail and Lindsey 1970). The eggs hatch in early spring usually at the time of ice break-up. Under-yearlings leave lateral habitat generally during the summer; there appears to be relatively little specific information in regards to yearling and sub-adult feeding, migration and habitat.

Although this whitefish has attracted moderate attention from anglers, there are surprising gaps in its essential life history and biological processes. As well, there appears to be little attention given to its fishery management or the protection and conservation of its habitat. Information gaps also exist in relation to stock recognition and the impacts from forestry or other causes affecting water quality and habitat.

Fisheries

First Nations Traditional Use

First Nations traditional occupation and use of the Lakelse Watershed is extensive and conservatively estimated to be from at least 5,000 years ago. The Lakelse River Watershed is territory held by Gilutsau (Barbeau 1917), considered part of the Kitselas people. Gilutsau, also called Killutsal was an important settlement close to the southeast bank at the Lakelse-Skeena confluence (Dawson 1881). Most of the occupants of this village moved to Port Simpson prior to 1900, and the village was largely abandoned at this time.

Local First Nations territories sustained home places and resources for many thousands of years, with traditional use features covering the landscape. Subsistence activities were tightly interwoven with the social structure, the local landscapes, and the broader regional environment. Detailed knowledge and understanding of the environment, the characteristic of each resource, and the seasonal variation in abundance and availability, were necessary to the chiefs and House members for making decisions about what, where, and when different resources were to be harvested. A strong and adaptive semi-nomadic economy, pre-occupied with food gathering, was based around the summer salmon food fishery and mid-winter feasting, with dispersal into smaller family groups during the rest of the year to fish, hunt and gather on the House territories.

The Gilutsau salmon fishery formed the principal foundation of the Gilutsau economy. Hereditary House Chiefs exercised authority for management and decision-making. The principal management tools included ownership of specific sites, access allocation, control of harvest techniques and harvest timing, and harvest limitations imposed by processing capacity. All fishing sites were considered property of the House, with particular sites being more or less delegated to individual chiefs or sub-chiefs within the House. The chief typically decided who would be fishing at specific sites and at which time.

Fishing sites are treated as the property of a particular House. How that property right is exercised depends on the nature of the fishing gear used. The House owns dipnet and small basket trap sites. However, several Houses from various clans might share in the harvest distribution from productive weir and trap sites at villages, which were strategically located to access the fishery. It was and is also the responsibility of the chiefs to oversee the processing and distribution of the fish, so that all members of the House received sufficient amounts, even if they could not provide for themselves directly because of age, disability, or other circumstances.

Fundamental conservation elements were practiced; waste was forbidden. Processing capacity was limited by smokehouse infrastructure, particularly the amount of space available on the lower poles, where fish were hung in the first stages of the drying process, and by the number of fish that could be dressed in the available time. When the daily processing limit was reached, the traps were removed from the water, and the salmon were allowed to proceed upstream. The predominant use of live-capture gear enabled the people to selectively harvest desired species, with the remainder released unharmed

The Gilutsau fishery maintained an understanding of the tools and techniques that allowed management for optimal utilization and escapement on a stock-by-stock basis. These modes of management enabled the fishery system to adapt to changing natural situations and conditions, and facilitated allocation and regulation in managing the fishery, while encouraging habitat protection.

Recreational Fisheries

The Lakelse River supports a strong recreational steelhead, coho, cutthroat and rainbow trout fishery. The cutthroat trout sport fishery is described by Bilton and Shepard (1955), Imbleau (1978), Hatlevik *et al* (1981), and de Leeuw (1991). In addition, due to a substantial winter steelhead run and easy access, there is generally an easily exploitable eight months of steelhead fishing. A large and popular coho fishery takes place in September particularly on the lower half of the river. Culp (2003) reports that the river can be so crowded it can be difficult to find an area without angling pressure in this coho fishery.

Proximity to Terrace and Kitimat and high aesthetic values also contribute to this popular high value angler destination. The recreational importance, use patterns and economic values and opportunities were surveyed and documented by Sinclair (1974). The Lakelse River steelhead recreational fishery is comprehensively reviewed by Grieve and Webb (1999).

The Lakelse River is designated a Class II water with specific regulations applicable to the river and its tributaries, including use of a single barbless hook, a bait ban, and on a seasonal basis, catch and release and fly fishing only. The fall and winter fishery (October to January) is principally located from the CN Bridge crossing upstream to Herman Creek, with access from Beam Station Road. There is also fishing throughout the entire Lakelse mainstem with the easiest access points receiving most of the angling pressure, though there are favourite seasonal hot spots, as well.

Enhancement Activities

The Coldwater Creek-Lakelse River confluence was the site of the first hatchery in the Skeena system, which was constructed in 1901 and operated until 1920. Fish were trapped for the egg take at the mouth of Sockeye River (presently Williams Creek) and taken to the hatchery, which had capacity for 4,000,000 fry. Coldwater Creek was dammed for a water supply, with the dam failing on a regular basis (1902, 1903, 1904, 1905 x 3) and flooding the hatchery (Sword 1903, Whitwell 1906). Due to cold water and flooding, the hatchery moved in 1920, to Granite Creek. This hatchery operated until the fall flood of 1935, when due to flood damage and the lack of funding during the Depression, the Government closed it (FRB 1948).

Escapement of sockeye salmon to Lakelse Lake averaged 175,000 fish during operation of the hatchery (Kerby 1984). From 1960 to 1962, counting fences were operated on the lower Lakelse River, Scully Creek and Williams Creek by the Federal Government. Fish eggs from these fences were raised at an experimental hatchery operated on Scully Creek.

Since the early 1900's, remedial work has periodically been implemented on lower Williams Creek to improve fish passage by countering aggradation effects on the alluvial fan. Sockeye Creek received channel improvements as well as logging debris cleanup in the mid-sixties. Scully and Williams Creeks were the sites of hatcheries from 1962 till an unknown date, possibly 1967 (Hancock *et al* 1983). Various studies for enhancement opportunities were undertaken under the auspices of SEP, particularly reconnaissance for sites with good groundwater flow (Brown 1980). In the 1980's, a small volunteer facility at Howe Creek in Terrace, called Eby Street Hatchery, began enhancing many of the small streams flowing into the east shore of Lakelse Lake. This group consistently produced coho fry from broodstock collected on Clearwater Creek for at least eight years. In the late 1980's, Deep Creek Hatchery conducted chinook enhancement on Coldwater Creek. Presently, there is one small project for coho, on Scully Creek.

Williams Creek fence construction 1950.

Land Use and Development Activities

Principal development activities in the Lakelse Watershed are forest development, settlement and housing, and transportation and utilities.

Forest Resource Development

The conclusion of the Second World War brought a great demand for lumber, and small mills selectively logged portions of the most valuable timber stands. The Whitebottom area of the Lakelse Watershed was awarded to Columbia Cellulose (TFL #1) in 1948. In 1960, the area south of Lakelse Lake was awarded to Eurocan Pulp and Paper Co. as TFL #41.

The majority of roads in the watershed were built in the 1964 to 1972 period when logging was most active. This resulted in few patches of accessible, viably commercial mature timber being left standing. Over this period, the following areas were intensively logged: Herman Creek, along Beam Station Road, in the lower Coldwater and White Creeks drainages, and north of Lakelse Lake in Sockeye Creek and Blackwater Creek watersheds. South of Lakelse Lake, logging development occurred in the Andalas Creek area, the Ena Lake area of Coldwater Creek, the south end of the lake, parts of Clearwater Creek Watershed, and at Onion Lake Flats.

View upstream on Williams Creek to the left, Llewellyn Creek in center.
J&S Outdoor Ventures.

The Lakelse WRP Project (Triton 1996b) stated that of the 64 stream reaches rated for logging-related impacts to riparian habitats, 25% were rated as having very high impacts, 31% as having high impacts, 22% were given moderate impact ratings, 6% low impact ratings, and 16% had no riparian impacts. Results of the fisheries assessment noted a total of 63 reaches assessed, with 43 reaches being rated as very highly impacted (68%), and eight reaches as highly impacted (13%). Ten reaches were rated as moderate (16%); no reaches were rated with low impacts, while only two reaches had nil impact (3%).

In 1992, the Thunderbird Integrated Resource Management Plan was established with the recognition that future timber harvesting activities would be constrained due to past practices and the high fisheries, wildlife and recreation values in a portion of the Lakelse Watershed (Ministry of Forests 1992). This plan has since been subsumed into the higher level Kalum LRMP with specific directions related to land use in the watershed. The Lakelse River Corridor (one km width from each bank) has been designated a Special Resource Management Zone (SRMZ) with a conservation orientation to maintain the natural integrity of this highly productive and unique river (MoF 2001).

Lakelse River, Williams Creek, Hatchery Creek, Scully Creek, Furlong Creek, and Coldwater Creek are to be evaluated by the Coastal Watershed Assessment Procedure (CWAP). Lakelse Lake, Ena, End and Clearwater Lakes are to be managed for water quality, fisheries, wildlife, recreation and other uses. Hatchery Creek will be an established Community Watershed. Mount Herman and the Lakelse Lake wetlands at the south end of the lake are approved Protected Areas.

Road related slide into Williams Creek, reach 6. **J&S Outdoor Ventures.**

The Lakelse Watershed is located in and administered by Ministry of Forests, Kalum Forest District. The large-scale industrial logging of timber along many of the streams has had profound impacts on stream structures and has lowered the productive capacity of the sub-watersheds (Gordon *et al 19*96).

Mineral Resource Development

There is no known mineral resource development in the Lakelse Watershed, though there are active claims west of the Lakelse River.

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Transportation and Utilities

A network of transportation and utility systems traverses the Lakelse Watershed. Linear development includes Highway 25, a major north-south transportation route connecting Terrace and Highway 16 with Kitimat and tidewater to the south. Alongside the highway, built in 1957, are PNG's natural gas pipeline and a BC Hydro major transmission line. The transmission line forks north of Lakelse Lake with a branch transmission line heading down the south side of the Skeena River.

Secondary roads through the watershed include two main north-south and two main east-west, with many secondary roads providing access to the two Provincial Parks, forest development activities, and residential developments. Both commercial and private floatplanes utilize Lakelse Lake as a base. Known impacts from linear development within the watershed include degradation of riparian habitat, a reduction in stream channel complexity at stream crossings, channelization, bank erosion and degradation. Current activities are directed towards deactivation on recent and proposed roads and a more aware attitude to fish, fish habitat and riparian zones.

Population and Settlement

The Lakelse Watershed supports a relatively high number of seasonal and full-time residences providing a variety of rural and high quality lifestyles for a population of 360 people (RDKS 2002). Lakelse Lake is believed to be the most heavily utilized recreational lake in the region (MoE no date). Mount Layton Hotsprings Resort, a family orientated facility, operates hot and cold pools, water slides, a restaurant and a motel on the east shore of Lakelse Lake. Mount Layton Hotsprings Resort has proposed an eighteen hole golf course and a convention centre.

There are two Provincial Parks located on the east side of the lake, and at the northeast corner, which are popular stopping off points for local and non-local water-based recreation, picnics, and camping. The east and west sides of the lake have many homes. These developments, with their associated septic systems and occasional stream diversions, may have fish and fish habitat impacts.

Property owners have also expressed interest in lowering the lake outlet to facilitate property drainage during spring and fall floods. This proposal would directly threaten critical spawning habitat at the lake outlet. Fertilizer use on residential lawns and future developments may also be of concern. There is concern associated with any housing development at or near Lakelse Lake because of the contribution of phosphorus to the watershed. The lake has been described as a phosphorous limited system that is literally in danger of becoming mesotrophic, or even eutrophic (Remington 1996). Federal, Provincial and First Nation governments, as well as community organizations, each representing differing values and interpretations, are working together to effect plans and regulations regarding settlement, water quality issues, recreation facilities and other developments. The developments surrounding the lake appear to be closely monitored, and this will most likely continue for the foreseeable future.

Cumulative Effects

The decline of various salmon stocks in the watershed has resulted from the cumulative effects of land use practices, fish harvest management, enhancement practices, and natural fluctuations in environmental conditions. Because of the linear nature of river and stream ecosystems, the accrual of effects is significant along both spatial and temporal dimensions. Activities that take place in headwater streams influence the suitability of habitats in downstream reaches – for example, temperature change and sediment input – can affect the response of ecosystem components to additional stresses. Similarly, activities that have occurred in the past may influence current habitat conditions through residual effects. This appears to be occurring in Lakelse Lake with colonization of the littoral zone by *Elodea*.

Accumulation of localized or small impacts can result in cumulative watershed level changes to fisheries. Accumulations of effects, often from unrelated human activities, pose a serious threat to fisheries (Burns 1991). The effects of increased sedimentation on spawning gravels will be the same, whether the sediment resulted from logging, road building, shoreline development, or other activities. The same is true of other variables such as water temperature, dissolved oxygen, channel morphology, or quantity and distribution of instream cover (Remington 1996). Loss of habitat elements such as large woody debris can have effects lasting from 80 to 160 years (Sedell and Swanson 1984). Cumulative losses of one element of fish habitat may result in long-term problems.

Within the context of conserving and restoring fish populations and their habitats in the Lakelse Watershed, the concept of cumulative effects has two significant and important underlying premises. Fundamentally, individual actions that are by themselves relatively minor may be damaging when coupled with other actions that have occurred or may occur elsewhere in the watershed. Historical and current patterns of land use activities and practices, particularly forest development, though other factors as well, have a significant bearing on how salmonid populations will respond to further anthropogenic disturbances. Within the Lakelse Watershed, resource extraction management strategies that have been based on onsite conditions only, without regard for other activities that have or may occur within the watershed, have generally failed to protect salmonid populations against cumulative effects.

Secondly, declines in the Lakelse Watershed salmonid populations are the product of numerous incremental changes in the environment and fish populations. Recovery and conservation of salmonid populations may proceed in a similar way - through incremental improvements in habitat conditions, using alternative management strategies in relation to fish harvesting, and viewing the watershed as a connected web of land use activities and practices. This means that individuals can and must play an active role in salmonid conservation and restoration even if tangible efforts are slow to manifest.

To define cumulative impacts to fish habitats in the Lakelse Watershed, short-term and long-term datasets that measure water quality are critical. Few adequate datasets exist within the greater Skeena Watershed, except, perhaps for studies conducted in Babine Lake. Environmental parameters not usually included in water quality sampling are also important to stream health. These include measures of the integrity of riparian areas, timing and measures of snowmelt rates in non-forested areas (hydrological recovery after logging or other land disturbance), measures of runoff rates in settlement areas and on logging roads, measures of stream channel form and rates of change, and monitoring of climatic changes.

Lakelse Watershed Management Issues

The Lakelse Watershed possesses very high fisheries values and is a major producer of sockeye, coho and pink salmon, which are fished both commercially and recreationally, making it one of the premier watersheds of the Skeena system. Steelhead, coho, and cutthroat support a major sport fishery.

The very high fishery values stem from the superb spawning and rearing habitat. The Lakelse Watershed was impacted by large-scale industrial logging, particularly in the mid 1960's to mid 1980's; some of the post-logging impacts to fish and fish habitat have been mitigated by time. Other impacts continue, some in a cumulative nature.

Significant human activities in the watershed began to occur in the 1950s and included a sawmill operation on the north end of the lake, increased logging activity, highway construction, creek diversions, and landslides. These activities may be related to the observed increase in sediment delivery from 1950 to 1990 that may have contributed to the creation of favourable habitat for *Elodea canadensis* colonization (WLAP 2003). The growth of *Elodea canadensis* in the lake over the last several years has reached levels that seasonally occludes beaches and shorelines and currently occupies most of the volume of several shallow bays and patches of shorelines. This aquatic invasive plant has the potential to severely change fish habitat, particularly sockeye rearing habitat, and a management plan is currently being developed.

Lasting impacts of timber harvesting are primarily to tributary riparian zones, stream structure, and as well to increased bedload mobilization leading to channel destabilization and aggradation on steep gradient stream fans. Many tributary riparian zones have seen an expansion of beaver habitat that may provide rearing habitat, but fish access to this habitat is problematic. As immature forests stands become commercially viable, the nature and extent of logging of second growth forests will become an issue.

Recreational activities including water based activities, angling, day use picnic areas, camp grounds, resort development, and winter activities such as snowmobiling, cross-country skiing and ice fishing are now important economically in the Lakelse Watershed. These activities often increase pressure on fish and fish habitat. The high density of use by people requires increasing the availability of support services. The continued development of support facilities increases the potential for nutrient overloading of Lakelse Lake and increases the amount of conflict between alternative uses for recreation.

Transportation and utilities impacts are rated moderate to high, due to the transportation network, the railroad, power transmission lines, and natural gas pipelines. The severity of impacts related to settlement and development adjacent to and on the lakeshore, create conflict with water quality and fish conservation values, posing difficult questions that need to be addressed in a localized, detailed fashion. The priority in managing and conserving fish habitat in the Lakelse Watershed, particularly the sensitive lake habitat, is to ensure protection of the environmental quality of the lake's water and the fisheries resource. Proper land management practices must be promoted and monitored to maintain and where possible, restore the integrity of streams and the lake.

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Glossary and Acronyms

100-year floodplain: That area adjacent to the channel that has a 1 in 100 chance of being flooded in any given year.

abiotic: Something that is not living, for example, rock.

adfluvial: Migrating between spawning areas in streams and rearing areas in lakes or ponds.

aggradation: The general accumulation of unconsolidated sediments on a surface, which thereby raise its level. A large range of mechanisms can be involved, including glacial, fluvial, aeolian, marine, and slope processes. In terms of channel morphology, its means raising of the channel bed elevation due to sediment deposition.

alluvial fan: An area where large amounts of sediment are deposited by a stream as the stream gradient rapidly decreases. This is common where smaller steep streams enter wide valleys with a low gradient. The decrease in gradient as the stream enters the wide valley causes a decrease in stream power, which allows sediment to be deposited, forming an alluvial fan. At any one time, only a portion of the fan is active and actively being built up by sedimentation. As sedimentation continues and the height of the channel increases, it becomes unstable since lower areas are located on other parts of the fan. At some point, often during a major flood, the channel location will switch to a steeper gradient and the old channel will become abandoned.

alevin: Stage of development of the salmonid embryo from hatching to absorption of the yolk sac. The yolk sac is generally the sole source of energy at this stage,

anadromous fish: Fish that move from the sea to fresh water for reproduction.

annual maximum 24-hour precipitation: The largest amount of precipitation that has occurred in a 24-hour period over the course of one year.

annual minimum flows: The lowest daily flows that have occurred within a given water year.

annual peak flow: The highest stream flow or discharge recorded at t stream gage during each water year. Annual peak flows are reported on a water-year basis, defined as October 1 through September 30.

aquifer: A body of rock that can collect groundwater, and can yield water to wells and springs. A groundwater reservoir that can be either confined or unconfined.

aspect: Aspect of a slope is the direction toward which the slope faces.

avulsion: lateral displacement of a stream from its main channel into a new course, usually across its floodplain or alluvial fan. Normally this is caused by channel aggradation or channel blockage.

backwater: A pool type formed by an eddy along channel margins downstream from obstructions such as bars, rootwads, or boulders and sometimes separated from the channel by sand or gravel bars.

bank erosion: A loosening and tearing away of soil and rock by water from the edge of a stream, usually resulting in an enlargement of the stream.

baseflow: Typical flow for a given stream at a particular time of the year. The flow of water derived from the seepage of groundwater or through-flow forms only a proportion of the flow, with snowmelt, glacial melt, and rainfall representing various amounts.

bed fining: An increase in the amount of fine sediment (<2mm) in the stream channel bed.

bench: A horizontal surface or step in a slope.

benchmark: An initial context for evaluating stream or terrestrial habitat quality. Derived from reference conditions, analysis of regional survey data, and published information.

(BMP) best management practice: Structural, nonstructural, and managerial techniques recognized to be the most effective and practical means to reduce surface- and groundwater contamination while still allowing the productive use of resources.

bioengineering: The application of vegetative practices combined with structural practices to provide a stable site condition. Common structures include brush layers, cuttings, live stakes, willow wattlings, and live pole drains used unstable slopes or disturbed hillside seepage zones..

biota: Living matter.

biotic: Something that is living, or pertaining to living things.

borrow pit: An area where rock or soil is excavated from the hillside.

braiding: Branching of a stream into many channels.

broodstock: Fish collected and spawned artificially for purposes of artificial propagation or transplantation.

calving-off: The rapid movement of soil from the steep leading edge of a large landslide.

canopy cover: The overhanging vegetation over a given area.

carrying capacity (biological): The maximum average number of a given organism that a stream or section of stream can maintain under a given set of conditions and over a specified period. Carrying capacity may vary from season to season or from year to year.

channel: the preferred linear route along which surface water and groundwater flow as streams, usually in a concave-based depression.

channel complexity: A term used in describing fish habitat. A complex channel contains a mixture of habitat types that provide areas with different velocity and depth for use by different fish life stages. A simple channel contains fairly uniform flow and few habitat types.

channel confinement: Ratio of bankfull channel width to width of modern floodplain. Modern floodplain is the flood-prone area and may correspond to the 100-year floodplain. Typically, channel confinement is a description of how much a channel can move within its valley before it is stopped by a valley wall hill slope, bedrock, or terrace.

channel gradient class: Channel gradient is the slope of the channel bed along a line connecting the deepest points (thalweg) of the channel. Channel reaches are then grouped according to gradient into stream gradient classes (<1%, 1-2%, 2-4%, etc.)

(CHT) Channel Habitat Types: Groups of stream channels with similar gradient, channel pattern, and confinement. Channels within a particular group are expected to respond similarly to changes in environmental factors that influence channel conditions. In this process, CHTs are used to organize information at a scale relevant to aquatic resources, and lead to identification of restoration opportunities.

channel pattern: Description of how a stream channel looks as it flows down its valley (for example, braided channel or meandering channel).

channelization: Zones of artificially stabilized or diverted channels, usually resulting in straighter and deeper channels.

char: A close relative to trout, another salmonid. Bull trout, Dolly Varden and lake trout are species of char.

Class I and II angling waters: The *Wildlife Amendment Act*, 1989, enabled the designation of Class I and II angling waters in recognition of extremely high sport fishing values. This includes the existence of special fish, as well as a highly desirable fishing experience.

Clearcut equivalency: A measure of hydrologic recovery. As a clearcut regenerates, the impacts of cutting decrease and it becomes less of a clearcut. Such an area is assigned a clearcut equivalency percentage, which diminishes over time with increasing vegetative cover.

CMP: Corrugated metal pipe, usually round.

cohesive: When describing soil, tendency of soil particles to stick together. Examples of soils with poor cohesion include soils from volcanic ash, and those high in sand or silt.

complex pool: Portion of stream with reduced velocity, a smooth surface, and deeper water; usually with undercut banks, thick bank vegetation and/or associated with large woody debris.

conifer: Cone-bearing tree, generally evergreen (although certain exceptions occur; for example, larch is a deciduous conifer), having needle-like leaves. Examples include pine, subalpine fir or balsam, cedar, and hemlock.

connectivity: The physical connection between tributaries and the river, between surface water and groundwater, and between wetlands and these water sources.

consumptive use: The quantity of water absorbed by the crop and transpired or used directly in the building of plant tissue, together with the water evaporated from the cropped area.

contour interval: A line of equal elevation drawn on a topographic map.

counting weir: A fence constructed across a stream to enable accurate counts of fish by species, sex, sexual maturity, etc.

cover: An area of shelter in a stream that provides aquatic organisms with protection from predators and/or a place to rest and conserve energy. This is often overhanging banks, LWD, or boulders.

cross-drain culvert: A culvert that drains water which collects within the inside ditch of a road to the outside slope of the road.

crown closure: The amount of canopy cover in a given area.

cutblock: An area from which trees have been harvested, also called a block.

cut slope: The sloping excavated surface on the inside of a road.

debris flow: A type of landslide characterized by water charged, predominantly coarse-grained soil and rock fragments, and sometimes large organic material, flowing down a pre-existing channel. Sometimes referred to as channelized debris flow, debris torrent, or mudflow.

delta: At a river's mouth, the sediment deposits found between the diverging channels.

detention pond: A pond constructed to temporarily store water, thereby allowing sediment to settle out of the water. Also known as a settling pond.

DFO: Department of Fisheries and Oceans, a federal agency whose legislative mandate is management and administration of Pacific salmon.

discharge: The volume of water flowing in a given stream at a given place and within a given period of time, usually expressed as cubic meter per second (m^3/s).

disturbance: Events that can affect watersheds or stream channels, such as floods, fires, human related land use activity, or landslides. They may vary in severity from small-scale to catastrophic, and can affect entire watersheds or only local areas.

downcutting: When a stream channel deepens over time.

drainage basin: A geographic and hydrologic subunit of a watershed, often referred as a sub-basin.

ecoregion: Land areas with fairly similar geology, flora and fauna, and landscape characteristics that reflect a certain ecosystem type.

ecosystem: An ecological system or unit that includes living organisms and nonliving substances which interact to produce an exchange or cycling of materials.

elevation: The vertical reference of a site location above mean sea level, measured in meters.

embryo: For salmonid fish, the stage of development between egg fertilization and absorption of the yolk sac, at which time the emerging fry begins to seek external sources of food.

emergence: For salmonids, the time of year when fry swim up from gravels in their nesting site and begin to swim in the stream.

energy dissipation: The loss of kinetic energy of moving water due to bottom friction, pools, large rock, debris, and similar obstacles that impede flow.

ephemeral: A stream that is dry for a portion of the year and most often contains water during and immediately after a rainfall event or snowmelt. Most often there is not sufficient volumes to create well-defined channels.

epilimnion: The relatively warm, circulating and fairly turbulent surface layer of water in a lake which thermally stratifies during the summer.

estuarine: pertaining to, or in, an estuary.

estuary: Area of a river mouth where the fresh water of a river mixes with ocean water.

eutrophication: The process by which lakes and streams become biologically more productive due to increased supply of nutrients (phosphorous and nitrogen). It sufficiently large amounts of nutrients enter natural waters, negative consequences may result from the presence of excessive amounts of algae.

evaporation: As water is heated by the sun, its surface molecules become sufficiently energized to break free of the attractive force binding them together; they evaporate and rise as invisible vapor in the atmosphere.

(ET) evapotranspiration: The amount of water leaving to the atmosphere through both evaporation and transpiration.

eyed egg: The stage of embryonic development when the body shape and eyes have formed within the egg.

fecundity: General term used to describe the number of eggs produced in relation to fish. Fecundity of an individual female may vary according to species, stock, size and age.

fill slope: The outer edge of a road that extends downhill of the road surface that has been filled to help create the road subgrade.

fine sediment: Sand-sized particles that readily settle to the bottom of a stream and fill in the substrate.

fish life stage: See life stage.

flood attenuation: When flood levels are lowered by water storage in wetlands.

flood peak: The highest amount of flow that occurs during a given flood event.

floodplain: The flat area adjoining a river channel constructed by the river in the present climate, and overflowed at times of high river flow.

fluvial: pertaining to a river.

fluvial fish: Fish that rear in larger rivers and spawn in smaller river tributaries.

fluvial processes: The set of mechanisms that operate as water flows within and at times beyond its channel, bringing about erosion, transfer, and deposition of sediment.

freshet: A rapid rise in river discharge and level caused by heavy rains or melting snow.

full-bench construction: A practice of constructing a road on steeper slopes whereby excess excavated soil or rock is hauled away in trucks to a stable storage area rather than disposed of by pushing it downhill of the road or being used as part of the subgrade.

foot slope: Area located at the bottom of a hill slope.

gaining reach: Reach where groundwater is flowing into the stream channel to become surface water.

gauging station: A selected section of a stream channel usually equipped with a staff gauge, stage recorder, stage logger for measuring stream discharge.

(GIS)Geographic Information System: A computer system designed for storage, manipulation, and presentation of geographical information such as topography, elevation, geology, etc.

gradient: Channel gradient is the slope of the channel bed along a line connecting the deepest points (thalweg) of the channel. The general slope or rate of change in vertical elevation per unit of horizontal distance of the water surface of a flowing stream.

groundwater: Water stored in the earth that occupies pores, cavities, cracks, and other spaces in the crustal rocks and soil.

hazard delineation: Mapping the boundaries of areas with inherently unstable slopes and applying a risk factor to delineate the degree of hazard.

high grading: uneven-aged harvest systems where the most valuable trees or forest stands are removed, and trees or stands of lesser quality and value are left to grow.

hydraulic continuity: The connection between groundwater and surface water such that withdrawal from an underground aquifer affects the stream flow level in the channel (surface water).

hydraulic gradient (hydraulic head): Water level from a given point upstream to a given point downstream; or the height of the water surface above a subsurface point. Used in analysis of both ground- and surface-water flow, and is an expression of the relative energy between two points.

hydraulic jump: An abrupt, turbulent rise in the water level of a flowing stream, normally occurring at the transition from shallow, fast flow to deeper and slower flow.

hygric soil: A soil that is saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part.

hydrograph: A graph of runoff rate, inflow rate, or discharge rate, past a specific point over time. This can help to show stream characteristics such as base flow and precipitation runoff.

hydrologic: Refers to water in all its states, and its properties, distribution and circulation through the hydrologic cycle.

hydrologic cycle: The circulation of water around the earth, from ocean to atmosphere and back to ocean again.

(HSG) hydrologic soil group: Soil classification to describe the minimum rate of infiltration obtained for bare soil after prolonged wetting.

hydrology: The science of the behavior of water from the atmosphere into the soil.

hydrophobic soils: Soils that do not easily soak up water, and thus increase the rate of surface runoff.

hypolimnion: The relatively cold, undisturbed deep waters of a lake which thermally stratifies in the summer.

impervious surface: surface (such as pavement) that does not allow, or greatly decreases, the amount of infiltration of precipitation into the ground.

incised channel: A stream that through degradation has cut its channel into the bed of the valley.

infiltration: The rate of movement of water from the atmosphere into the soil.

lag time: In a hydrological sense, the interval between the center of mass of the storm precipitation and the peak flow of the resultant runoff. It is the delay between upstream production of flow and its arrival at a downstream location.

(LRMP) Land & Resource Management Plan: A consensus-building process involving a cross section of the public, interest groups, and government agencies to establish resource-management objectives and strategies for a sub-regional management area, usually a timber supply area (TSA).

landing: An area adjacent to a road where logs are skidded, accumulate, and are loaded onto trucks or forwarded during timber harvesting.

(LWD) large woody debris: Logs, stumps, or root wads in the stream channel, or nearby. These function to create pools and cover for fish, and to trap and sort stream gravels.

legacy activities: Past land use practices that have contributed to current watershed and stream channel conditions.

lentic riparian/wetland area: Lentic riparian areas have standing water, such as lakes, ponds, seeps, bogs, and meadows.

life stage (fish life stage): A part of a fish's life cycle, with identifiable habitat requirements associated with it; for example, summer rearing, spawning, and juvenile outmigration to ocean waters.

low flows: The minimum rate of flow for a given period of time.

ma: million years ago

machine reserve: A machine reserve is a system of selective cutting along a stream in which leaning commercial trees and immature trees are left within a specified distance of the stream bank and equipment operation is minimized in this strip.

mass wasting: (also soil mass movement): Downslope transport of soil and rocks due to gravitational stress.

meandering: When a stream channel moves laterally across its valley meandering is characterized by a clearly repeated pattern of curvature as seen from above.

mg/L: Milligrams per liter. Unit of chemical concentration that is essentially equivalent to parts per million (PPM)>

µ/L: Micrograms per liter. Unit of chemical concentration that is essentially equivalent to parts per billion (ppb).

monitoring: Actions undertaken to evaluate the efficacy and effects of any management activity on species, processes, habitats, flows, landscape and ecosystem characteristics, and outputs. Monitoring provides a feedback loop to ecosystem management experiments that addresses accountability and validity of actions.

montane: Of growing in, or inhabiting mountain areas.

morphologic features: From the Greek root meaning structure or form; in stream channels, those physical features (such as gradient and confinement) that reflect the influence of processes which operate on a landscape scale (such as geology and climate).

morphologic response: In stream channels, the response or change in the characteristics that define the channel.

morphology: A branch of science dealing with the structure and form of objects. Geomorphology as applied to stream channels refers to the nature of landforms and topographic features.

morphometry: The form or shape of a lake or stream, including the contour of the bottom.

(NTU) nephelometric turbidity unit: Turbidity is a measure of the suspended particles such as silt, clay, organic matter and microscopic organisms in water. The measure of turbidity as the amount of light detected in a sample after it is scattered 90° from the source in a nephelometer, is expressed in NTU units.

nonpoint source pollution: Variable, unpredictable, and dispersed pollution sources from agriculture, silviculture, mining, construction, saltwater intrusion, waste disposition and disposal, and pollution from urban-industrial development areas. ("Point sources" are steady, predictable, and concentrated usually through "end of pipe" discharges from manufacturing, waste, or water treatment plants.)

oligotrophic: An oligotrophic lake is low in nutrients and productivity, with large amounts of dissolved oxygen in the deepest water. Water clarity is high, as is diversity of phytoplankton, but total algal biomass is low.

order: see stream order.

orthophoto: A combined aerial photograph and planimetric map without image displacements and distortions. Orthophotos may or may not have contours indicated.

oxbow: A bow-shaped river bend.

perennial surface water: Surface water that persists all year.

pipe-arch culvert: A corrugated metal pipe that is wider than it is tall.

peak flow: The maximum instantaneous rate of flow during a storm or other period of time.

percolation: The act of surface water moving downwards, or percolating, through cracks, joints, and pores in soils and rocks.

periphyton: Various types of algae growing on submerged surfaces, firmly or loosely attached.

pH: A measure of the relative acidity or alkalinity of water.

point bar: A sediment deposit in a river that protrudes above the water surface and is located primarily on the inside of channel bends.

pool: That portion of a stream where the water is relatively deeper and slow moving, which is frequently used by fish for resting, cover, and overwintering. A plunge pool is formed by water passing over or through a complete or nearly complete channel obstruction, and dropping vertically, scouring out a basin in which the flow radiates out from the point of entry.

pool-riffle ratio: The ration of the surface length of pools to the surface length of riffles in a given stream reach, frequently expressed as the relative percentage of each category.

precipitation: The liquid equivalent (inches) of rainfall, snow, sleet, or hail collected by storage gages.

precipitation intensity: The rate at which water is delivered to the earth's surface.

raindrop splash: Erosion created when a raindrop hits a bare soil surface.

rain-on-snow (event): When snow packs are melted by warm rains, causing peak flow events. Rain-on-snow events usually occur within the transient snow zone.

rating curve: A graphed result showing the relationship between the stream stage and the discharge at the gauging station measured.

ravel, or raveling: Erosion caused by gravity, especially during rain, frost, and drying periods. Often seen on steep cutslopes immediately uphill of roads.

reach: A stream reach is a fundamental landscape unit that consists of a homogenous channel based on channel pattern, floodplain width, and flow regime.

recurrence interval(s) (return interval): Determined from historical records. The average length of time between two events (rain, flooding) of the same size or larger. Recurrence intervals are associated with a probability. (For example, a 25-year flood would have a x probability of happening in any given year.)

recruited large woody debris: A term assessing the amount or size of large trees in a riparian area that could potentially fall in (recruit) to the stream channel. Mechanisms for recruitment include small landslides, bank undercutting, wind throw during storms, individual trees dying of age or disease, and transport from upstream reaches.

recruitment: In the context of riparian function, recruitment refers to adding new LWD pieces to a stream channel. It is the physical movement of LWD into the stream channel. As used in fisheries management, recruitment refers to the addition of new individuals to a fish population resulting from reproduction of the adult stock.

redd: The salmonid gravel nest excavated into loose gravel in the stream bed.

relic channel: A channel historically occupied by a river or stream, but that currently does not convey flow.

resident fish: Non-migratory fish that remain in the same stream network their entire lives.

return flow: The portion of a diversion that returns to the river system via subsurface pathways.

riffle: A shallow, rapid section of stream where the water surface is broken into waves by obstructions wholly or partly submerged.

rilling (surface rilling): Erosion caused by water carrying off particles of surface soil.

rills: Very shallow gullies that can develop on a hill slope that is eroding.

riparian area(s): Areas bordering streams and rivers whose soils, and vegetation are influenced by the presence of pooled or channelized water.

(RCU) Riparian Condition Unit: A portion of the riparian area for which riparian vegetation type, size and density remain approximately the same.

Riparian Recruitment Situation: Groups of RCUs that have similar characteristics and that may be treated similarly for the purposes of restoration and/or enhancement.

riparian zone(s): An administratively defined distance form the water's edge that can include riparian plant communities and upland plant communities. Alternatively, an area surrounding a stream, in which ecosystem processes are within the influence of stream processes.

riparian vegetation: Vegetation growing on or near the banks of a stream or other body of water in soils that are wet during some portion of the growing season. Includes areas in and near wetlands, floodplains, and valley bottoms (from Meehan 1991).

riprap: Rock material, usually boulders or blasted fragments, placed along a stream bank to prevent erosion of the bank.

rock pit: An area where rock is excavated from a hillside and is usually processed as subgrade or riprap material.

run: A stream section of varying depth with moderate velocity and surface turbulence. Intermediate in character between a pool and a riffle.

runoff: Surface runoff is water that moves overland across the surface into creeks, ponds, lakes, and rivers that eventually take the water back to the ocean.

salmonid: Fish of the family *Salmonidae*, including salmon, trout, char, whitefish, ciscoes, and grayling. Generally, the term refers mostly to salmon, trout, and char.

scarification: The mechanical loosening of compacted soil usually using subsoilers attached to a crawler tractor.

scour: Removal of sediment from the bed or banks of a river by the energy of moving water.

screening-level assessment: An initial evaluation of information using simplified methods.

seasonal surface water: Surface water that is normally only present during a portion of the year.

sediments, fine and coarse: Fragments of rock, soil, and organic material transported and deposited into streambeds by wind, water, or gravity.

seral stage: Plant species of early, middle, and late successional communities of any plant associations, though most commonly expressed in a more limiting sense as the dominant vegetation following forest disturbance.

sheet erosion: Soil erosion caused by surface water that occurs somewhat uniformly across a slope.

side-channel: A channel that is separated from the main channel, usually by an island.

s**ingle-thread channel:** A stream channel that has no side channels, braiding, or islands.

skid trail: Trail that is planned or develops when logs are hauled by ground-based machinery to a landing.

slash: Detached tree limbs, branches, and other woody material that is left on the ground after logging is completed.

slough: A side channel within an estuary.

smolt: A seaward migrating juvenile salmonid which is silvery in color, has become thinner in body form, and is physiologically prepared for the transition from fresh- to saltwater. The term is normally applied to the migrants of species such as coho, sockeye and steelhead that rear in freshwater for a period before migrating to sea.

soil creep: When gravity moves the soil mantle downhill at rates too small to observe.

species: The smallest unit of plant or animal classification commonly used. Members of a species share certain characteristics that differ from those of other species, and they tend not to interbreed with other species.

specific heat (of water): The amount of heat required to make a 1º change in water or air temperatures.

splash damming: Historical practice where a small dam was built across a stream to impound water and logs. The dam was then removed (usually with explosives) to release the impounded logs and water, causing scour downstream.

spring snowmelt: The time when the seasonal snow pack melts out.

stadia rod: Surveying rod used for measuring changes in elevation from one point to another.

staff gauge: A measuring ruler for measuring stream stage; is often seen attached to a tree, post, bridge pier, or other easily observed site in the stream bed.

stage: the water level in a stream or lake. The height of the water surface above some arbitrary, chosen zero level.

standing wave: A turbulent condition in a stream which produces a fixed wave pattern at a specific location. Standing waves are often caused by two similar waves traveling at the same time in opposite directions.

stand-replacing fire: A fire of enough severity, at a local level, to kill the forest stand.

stereo aerial photo: Pairs of photos taken from the air that can be viewed through a stereoscope to reveal three-dimensional features of the landscape.

stereoscope: An instrument used to observe stereo aerial photographs in three dimensions.

stock: A population of one species of fish which inhabits a particular stream and tends to spawn at a place or time separate from the other stocks.

stream cleaning: The removal of large wood or fine organic matter (i.e., branches, twigs, leaves, etc) from stream channels. Historically, this practice was used to remove debris jams that were thought to block fish passage, or to remove fine organic matter that was thought to cause water quality problems such as reducing aquatic oxygen levels. Because stream cleaning was found to damage fish habitat, it is currently not a common practice.

stream density (drainage density): Total length of natural stream channels in a given area, expressed as kilometers of stream channel per square km of area.

stream order: First order channels are non-branching headwater channel segments. Second order channels are those that receive only 1st order channels. Third order channels are those where two 2nd order channels join; fourth order channels are those where two 3rd order channels join, etc. Most salmonid spawning and rearing takes place in 2nd to 4th order streams.

stream reach: A section of stream possessing similar physical features such as gradient and confinement.

stream segment: Contiguous stream reaches that possess similar stream gradient and confinement and which can be used for analysis.

substrate: Mineral or organic material that forms the bed of a stream.

surface runoff: Water that runs across the top of the land without infiltrating the soil.

surrogate measure: An indirect measure of a pollutant; for example, the use of turbidity to measure suspended sediment.

suspended sediment: Fine soil particles (e.g., silts and clays) that do not readily settle out. Compare to "fine sediment" – which is sand-sized particles that readily settle to the bottom of a stream and fill in the substrate.

tailings: Washed or milled rock that has been processed for ore removal.

talus slope: A sloping mass of rock fragments which has been dislodged from a mountain side, rock outcrop, or cliff due to the process of weathering. The rock fragments accumulate faster than the forces of erosion are able to remove them or reduce them to smaller particles.

TCU: True colour units. A measure of the dissolved coloring compounds in water. The colour of water is attributable to the presence of organic and inorganic materials; different material absorb various light frequencies. Water whose color is less than 10TCU passes unnoticed to visual inspection; water with a value of 100 resembles tea. Water from swamps and bogs may exhibit values in the 200 to 300 TCU range.

thalweg: The path of maximum depth in a river or stream. This path normally follows a meandering pattern, back and forth across the channel.

(TSA) Timber Supply Area: An area of the province designated by MOF for the purpose of analysis, planning and management of timber resources. The harvesting limits for TSAs, called allowable annual cuts (AACs) are determined by the chief forester. Many types and sizes of harvesting agreements may exist within a TSA.

(TDS) total dissolved solids: TDS is the amount of dissolved substances in water, and gives a general indication of the chemical quality. TDS is defined analytically either by total filterable residue (the portion in a sample which passed through 0.45 μm glass fiber filter and dried at 180° C) or by conductivity (specific conductance is a measure of the ability of an aqueous solution to carry an electrical current).

total nitrate: A measurement form of nitrogen in surface- and groundwater that is composed of nitrate and nitrite.

total phosphorus: A commonly used measurement of phosphorus that includes most forms of phosphorus which are biologically available (or can be readily converted to available forms) to algae and aquatic plants.

TSS: total suspended solids: TSS are particles such as silt, clay, organic matter, plankton, and microscopic organisms which are held in suspension by turbulence and Brownian movement in lakes and streams. Particulate matter can be quantified by measuring non-filterable residue (NFR).

transpiration: Loss of water to the atmosphere from living plants.

transport velocity: The velocity of flow required to maintain particles of a specific size and shape in motion along the stream bed.

TCU: True colour units. A measure of the dissolved colouring compounds in water. The colour of water is attributable to the presence of organic and inorganic materials; different material absorbs various light frequencies. Water whose colour is less than 10 TCU passes unnoticed to visual inspection; water with a value of 100 resembles tea. Water from swamps and bogs may exhibit values in the 200 to 300 TCU range.

turbidity: An optical measure of the murkiness of water. An indirect measure of the affect of suspended sediment in water.

upland vegetation: Vegetation typical for a given region, growing on drier upland soils. The same plant species may grow in both riparian and upland zones.

waterbar: A deep trough in a skid trail or road that is excavated at an angle to drain surface water from the skid trail or road to an adjacent area that is not compacted or to the ditch line.

water quality criterion: A maximum or minimum physical, chemical or biological characteristic, applicable province-wide, which must not be exceeded to prevent detrimental effects from occurring to a water use, including aquatic life. Water quality criteria are safe levels of contaminants for the protection of a given water use.

(WQO) Water Quality Objectives: Water quality objectives are environmental quality conditions set as targets for specific water bodies based on three main factors 1)the designated uses for the water 2) the water quality criteria that have been adopted for the most sensitive designated use, and 3) the local conditions, including the actual measured water quality in the area.

water quality station: A designated location on a stream at which water samples are collected.

water table: The water table marks the change in the groundwater zone between the zone of aeration, where some pores are open, and the underlying zone of saturation, in which water fills all the spaces in the soil and rocks.

water year: The water year in North America is referred to as the 12-month period beginning October 1 in one year and ending September 30 of the following year. The water year is designated by the calendar year in which it ends. For instance, the annual peak flow for water year 1996 would be the highest flow recorded from October 1, 1995, through September 30, 1996.

weir: A low dam or fence constructed across a stream or river primarily to control water levels or to divert water into another facility. A counting weir is a fence across a stream to enumerate fish.

wetland vegetation: Plants that are adapted to living in saturated or inundated conditions for at least part of the growing season.

wind throw (also blowdown): The uprooting and felling of trees by strong gusts of wind.

WRP: Watershed Restoration Program of British Columbia.

year class: The fish spawned or hatched in a given year.