# DATABASE DESIGN AND METHODS FOR THE KLANAWA RIVER FISHERIES RESEARCH PROJECT

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## ABSTRACT

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Database design for all information collected on five creeks (Park, Blue, Moon, Ralf, and Child) on the west coast of Vancouver Island from 1988 to 1996 is presented within this report. The study objectives, site descriptions and methodology are discussed for four study areas. They include: 1) streambed composition data, 2) downstream migration of juvenile fish, 3) coho ecology, and 4) stream temperatures and water level data. This report was designed to provide a single source of the information considered essential to the initial practical study designs for future fish/forestry research.

## RÉSUMÉ

Duke, L.A., T.G. Brown, J.C. Scrivener, J.S. Macdonald, and B.C. Andersen. 1997. Database design and methods for the Klanawa River fisheries research project. Can. Manuscr. Rep. Fish. Aquat. Sci. 2437: 48 p.

Ce rapport présente la structure de la base de données sur cinq ruisseaux (Park, Blue, Moon, Ralf, Child) de la côte ouest de l'ile de Vancouver entre 1988 et 1996. On y trouve les objectifs de l'étude, une description des lieux et un exposé de la méthodologie employée, en quatre volets: 1) composition des lits fluviaux; 2) dévalaison des poissons juvéniles; 3) écologie du saumon coho; 4) température et niveau des eaux. On souhaite, avec ce rapport, regrouper en une seule source l'information jugée essentielle á la préparation des plans initiaux de recherche pratique en matière halieutique/forestière.

## INTRODUCTION

The potential impacts of forest harvesting practices on the physical and biological characteristics of coastal watersheds has been investigated since 1970 in British Columbia. Research performed at Carnation Creek, on the west coast of Vancouver Island, has indicated that subsequent to forest harvesting, there are measurable changes in radiant energy inputs, stream water temperatures, hydrological processes, water quality, volumes and compositions of large woody debris, substrate composition, bank stability, and channel morphology (Chamberlin 1988; Hartman 1982; Hartman and Scrivener 1990). Some of these physical changes have led to alterations within the salmonid populations which spawn and rear within this coastal watershed. Observable changes occurred in salmonid species composition, age structure of juvenile coho, coho growth, timing of salmonid movement, salmonid density, and survival rates at different salmonid life stages. Many of the results obtained from studies completed at Carnation Creek have been used in the design of Coastal Logging Guidelines, the Forest Practices Code of B.C., and have been incorporated into many other scientific studies. It is imperative that the observations made at Carnation Creek be substantiated for other streams, and that the hypotheses developed be tested in other coastal watersheds.

The objective of the Klanawa River fish/forestry research project was to test the repeatability and applicability of some of the findings made at Carnation Creek in a nearby coastal watershed, from the same Coastal Western Hemlock Biogeoclimatic (CWHB) Zone. An opportunity also existed to test restoration techniques in an intensely harvested tributary to the Klanawa system. This study seeks to relate the physical and biological characteristics of tributaries to the Klanawa River (or sections of their channel). Research conducted in the Klanawa watershed will generate hypotheses to be tested in future paired stream studies (Brown et al. 1987).

This study was conducted on the west coast of Vancouver Island within four tributaries, located in the lower reaches of the Klanawa River watershed: Park Creek, Blue Creek, Moon Creek, and Ralf Creek. A fifth tributary, Child Creek, located outside of the Klanawa watershed, was also examined. This report includes data from four areas of the investigation: 1) streambed composition data, 2) downstream migration of juvenile fish, 3) coho ecology, and 4) stream and air temperatures, and water levels. It also provides descriptions of the study and study areas, and an overview of the methods involved in the collection of the data. Data presented here were obtained between 1988 and 1996.

## STUDY DESIGN

Park, Blue, and Ralf creek watersheds contained significant stands of old-growth timber, which had not been harvested at the beginning of the project. The Moon Creek watershed had been extensively clear-cut harvested in the early 1980's and provided an opportunity for experiments that involved watershed restoration and coho salmon outplanting. The Child Creek watershed was harvested primarily between 1905 and 1955, and now has merchantable second growth forests. With the cooperation of the timber licence holder, MacMillian Bloedel Ltd., portions of Blue and Ralf creeks were clearcut harvested during the project in 1990 and 1994, and 1995, respectively. The Park Creek watershed is largely contained within Pacific Rim National Park and will not be harvested. Park and Child creeks act as long-term controls for the effects of harvesting in the other systems. All streams studied were chosen for their similar size and orientation.

As a result of shifting departmental priorities, the scope of the Klanawa Research Project was reduced after the second field season. Restoration activities planned for Moon Creek were not initiated, and downstream fish migration and streambed sampling ceased after 1989. Only collection of water height and temperature data, and coho salmon growth and residency experiments, continued into subsequent years.

## SITE DESCRIPTIONS

### KLANAWA RIVER

The Klanawa River is located on the west coast of Vancouver Island (48°41'59"N, 124°56'50"W, river mouth), approximately a 2-hour drive from Port Alberni (Figure 1). Originating in the Somerset Range and Hobiton Ridge regions west of Nitinat Lake, the Klanawa River flows in a southerly direction into the Pacific Ocean. The Klanawa watershed comprises an area of approximately 172.7 $km^2$, with the lower 2 km of river passing through Pacific Rim National Park. Harvesting of old growth forest has not occurred in the portion of the watershed (19%) designated as park. The remaining 81%, in Tree Farm Licence 44, has been subjected to moderate forestry activities within the last 40 years. At the time of program initiation, the majority of the northwestern side of the Klanawa Valley had been harvested, including Moon Creek. The eastern side remained primarily undisturbed old growth. Further physical watershed characteristics may be found in Brown et al. 1987 and LGL Limited 1989.

### CHILD CREEK

Child Creek is a small, multi-branched tributary to China Creek in the Alberni Valley on Vancouver Island, located ~10 km south of Port Alberni by way of the Bamfield Road (Figure 2; Table 1). The headwaters of this tributary originate in the western flanks of Patlicant Mountain and the northern flanks of Mount Underwood (LGL Limited 1989). Child Creek flows for approximately 5.8 km in a westerly direction (draining an area of 11.5 $km^2$ ) to its confluence with China Creek, and then west into Alberni Inlet through China Creek Provincial Park. Within the study areas of Child Creek, the gradient is less than 0.75%, with riffles and glides predominating. The stream bed consists primarily of gravels and cobbles (LGL Limited 1989). The watershed is roughly 77% second growth forest and 23% old growth. At the time of program initiation, the most recent timber harvesting had occurred in 1955.

The headwaters of Child Creek are comprised of two branches (north and south forks) of approximately equal size (Figure 2). Timber harvesting began in 1878 and both watersheds were extensively harvested between 1905 and 1955. Many of these early clearcuts were extremely large. Child North was harvested, predominately, during the early 1950's, while the study area on Child South was harvested in 1905. Child North is bounded by mature stands of red alder (*Alnus rubra*) and Child South has stands of second growth western hemlock (*Tsuga heterophylla*), amabilis fir (*Abies amabilis*), and Douglas fir (*Pseudotsuga menziesii*). A portion of the timber stands in some areas are nearing potential harvesting as second growth timber. Child Creek was chosen as a study site due to its similarity with the Klanawa River study watersheds, and its condition as a near mature second growth timber stand, thus allowing investigation into the recovery of previously harvested watersheds within this region.

PARK CREEK

Located primarily within Pacific Rim National Park, Park Creek flows in a southwesterly direction (~ 3.5 km ) into the tidal influenced, lowest reach, of the Klanawa River, 0.2 km upstream from the ocean (Figure 1; Table 1). Park Creek drains an area of 5.9 $km^2$, that is accessible to fish for ~900 metres. This second order stream flows within an old growth stand with no previous forestry activities. The nearest road was located 3 km from the creek, so access was by helicopter twice per year. Within the lower 0.9 km, the gradient is ~0.5 to 1.5 %, with riffles and glides predominating. The stream bed consisted of gravels and cobbles with frequent areas of exposed bedrock.

BLUE CREEK

Blue Creek is a second order stream, approximately 4.1 km in length (Figure 1). It drains an area of 12 $km^2$, including Blue Lake, with small ephemeral channels feeding into the lake from the lower slopes of Hobiton Ridge (Table 1). Blue Creek flows in a southwesterly direction, to join the Lower Klanawa River 5 km upstream of the river mouth. Within the lower reaches, the gradient is less than 1%, with riffles and glides predominating, but some pool habitat exists that is >1m in depth. The stream bed consisted of gravels with a few cobbles and a few areas of exposed bedrock (LGL Limited 1989). At the time of study initiation, the Blue Creek sub-basin was unharvested. No road access or other disturbances had occurred within the lower watershed prior to 1994. Access was gained by 1 km of trail from Moon Creek and by crossing the Klanawa River (Figure 1) by helicopter twice per year. By 1995, harvesting in the Blue Creek watershed had occurred in two locations allowing road access in close proximity to the study reaches. The first cut block (harvested in 1990) bordered the northeastern portion of Blue Lake, with a 150-metre leave strip between the lake and cut block. The second cut block (harvested in 1995) was located along the north side of the creek, commencing approximately 150 m from the mouth and terminating 875 m upstream. A 30-m wide strip of vegetation buffer was left along Blue Creek, as required by the new Coastal Logging Guidelines. Currently, more harvesting is scheduled within this watershed for 1997, south of Blue Lake. Study sites were confined to the first 750 m of the creek because fish were restricted by falls within the lower 1.2 km.

MOON CREEK

Moon Creek flows in a southeasterly direction, draining a sub-basin ~ 8.3 $km^2$ in size (Figure 1). There is a major water fall located 500 metres from the confluence of Moon Creek and the Klanawa River, preventing salmon access to the upper reaches of Moon Creek (Table 1). This watershed has been almost completely clear-cut. Approximately 70% of Moon Creek was modified by timber harvesting in the 1980's. Since that time, additional timber has been removed in the upper reaches and southern portions of the watershed. One study site was established on Moon Creek.

RALF CREEK

Ralf Creek is a multi-branched (five main tributaries) creek, flowing in a southwest direction from the steep slopes on the northwestern exposure of Hobiton Ridge to its confluence with the Lower Klanawa River ~10 km upstream of the river mouth (Figure 1; Table 1). Ralf Creek flows for approximately 6.6 km, draining an area of ~12.7 $km^2$. The gradient in the lower 400 m is less than 0.5%, with riffles and glides predominating. The stream bed in the lower reaches consists mainly of gravels and cobbles. Due to a series of impassable falls (at 550 metres) and cascades (at 0.6 to 0.63 km), salmon access to the upper reaches was restricted. Before road construction and timber harvesting occurred in 1990, study site access was by a 100-m trail and a crossing of the Klanawa River. During high water, Ralf Creek was accessible by a 500-m trail located on the south side of the Klanawa River.

The most recent timber harvesting within the Ralf Creek watershed occurred in 1994. This cut block is located on the southern banks of Ralf Creek, near the confluence with the Klanawa River. A small buffer zone of vegetation between the cut block and Ralf Creek was left from the confluence to the bridge located 550 m upstream. Timber harvesting had occurred during the 1980's, within the northeastern portions of the watershed, but this cut block only incorporated a few low gradient ephemeral channels, some distance from Ralf Creek.

## MATERIALS AND METHODS

STREAMBED SAMPLING

During the autumn of 1989, frozen gravel cores were obtained from the stream bed of four study tributaries on the Klanawa River to examine baseline gravel composition before harvesting treatments began (Table 2). Park, Blue, and Ralf Creek each contain 5 study reaches; 3 to 5 samples were taken from each reach (Table 3). Moon Creek contained only one study site, from which 6 samples were obtained. At each study site, samples were collected 1 to 3 metres apart, on both sides of the thalweg in a single riffle. A modification of Ryan's (1970) freeze-core technique was used to sample the stream bed (Figure 3a, 3b). A 5-cm diameter hollow steel probe attached to a sampling "pot" was driven 30 cm into the bed. Acetone and dry ice were added to the pot, where the super-cooled acetone froze a gravel core (20-30 cm in diameter) around the probe in ~35 min. The frozen cores, weighing 8-22 kg, were split into a top (1-15 cm), bottom (15-30 cm), and middle layer (for larger samples). Rocks that protruded >50% outside the core diameter, and that were not against the probe, were discarded. The samples were reliable representations of the stream bed as core diameters were usually >2 times the diameter of the largest particles and because excluded rocks reduced bias in the samples (Shirazi et al. 1981). Each layer was placed in a polyethylene ore bag, labeled and stored in a burlap sack. The samples were transported to the laboratory for particle size analysis.

In the laboratory, each layer was oven dried at 105°C for ~12 hours. The largest and smallest diameter of the largest rock was measured and the mean diameter calculated. Depending on the samples' weight, each layer was then split one to four times to make analysis of particle size easier. Particles too large to pass through the splitter (25 mm) were weighed and recorded in the data base. Each of the split samples was weighed and one was passed through five nested sieves (9.55, 2.36, 1.18, 0.3, and 0.074 mm) using a Ro-Tap® (model T-674) testing shaker (Figure 3c) (Scrivener and Brownlee 1982). This separated the samples into medium gravel (25-9.55 mm), pea gravel (9.55-2.36 mm), coarse sand (2.36-1.18 mm), medium sand (1.18-0.3 mm), fine sand (0.3-0.074 mm), and silt-clay components (<0.074 mm). The separated portions were then weighed to the nearest 0.5 g and the data entered into a database file on the Micro VAX 3100-40 computer cluster located at the Pacific Biological Station, Nanaimo, B.C. Data analysis performed on the gravel cores included the calculation of the geometric mean particle size (*Dg*), and the fredle index (*Fi*). Detailed descriptions of the methods used in the analysis of gravel data is available in Scrivener and Brownlee (1989). A summary is provided below:

1. Geometric mean particle size (*Dg*, Platts et al. 1979) was calculated for each layer of each core using the formula:

$$Dg = d_1^{w1} \bullet d_2^{w2} \dots \bullet d_n^{wn.}$$

where d = geometric mean dia between two adjacent sieve sizes, and w = proportion of the sample retained by the smaller sieve. The geometric mean between 25 mm and the average dia of the largest rock was the largest diameter (d) used. It was raised to the power of the proportion of sample greater than 25 mm (w) (Scrivener and Brownlee 1989).

2. The fredle index (*Fi*) (Lotspeich and Everest 1981) was calculated using the formula:

$$Fi = Dg/\mathrm{So}$$

where So = $(d_{75}/d_{25})^{1/2}$ = the sorting coefficient, $d_{75}, d_{25}$ = particle size diameter at which 75% and 25% of the sample was finer, respectively. *Fi* is a single measure of the mean particle size in a sample and the associated standard deviation of the distribution of particle sizes around the mean.

A cumulative particle size distribution of each layer was calculated as the sample percentage smaller than each size category. A least squares technique was then used to fit each distribution to an equation of the form:

$$\text{Percent} = a + b * \log_{10}\text{SIZE}$$

where Percent = the inverse probability transformation of percentage of substrate smaller than a given mesh size, a = intercept of the regression line, b = slope of the line, and SIZE = mesh size in mm (Shirazi et al. 1981). This equation was used to calculate the $d_{75}$ and $d_{25}$ for each sample. These equations could accurately predict the percent of sample finer than any mesh size, given that the average $R^2$ values for this data was 0.81.

JUVENILE FISH OUT-MIGRATION METHODOLOGY

In the spring of 1989, LGL Limited established three fences to capture juvenile fish on Blue, Moon, and Ralf creeks (Table 2, 4) (LGL Limited 1989). The fences were established to document out-migration timing and run size of fish (primarily coho) occupying the tributaries. Captured fish were anaesthetized in 2-phenoxy-ethanol and identified to species. Fork length was measured to the nearest mm and the weight to the nearest 0.2 g was recorded. The presence or absence of brandings was noted, and age or life stage determined. In addition, the physical site and weather conditions were recorded at each fence location on a daily basis.

Each fence was located as close as possible to the tributaries confluence with the Lower Klanawa River. These sites were chosen for their low gradient with well defined banks, which served to confine the stream flow and thus limited the possibility of fish loss. All three fences were of the same design, consisting of a standard V-trap (Conlin and Tutty 1979). Each fence was formed of 1 x 2.5-m panels, with wooden frames made of clear grade fir (5 cm x 10 cm) divided into three internal sections (Figure 4, 5). Each rectangular panel was covered by galvanized wire mesh screen with 1 $cm^2$ openings. This configuration allowed each 'wing' of the fence to block the current at an angle of <35 degrees from the direction of flow.

Before installation of the fence panels, each site was cleared of large rocks and/or debris. Sandbags were used to anchor each wing as the panels were positioned in the stream. Sand and gravel from the stream were used to fill the required number of sandbags necessary to ensure that the fence could withstand two months of use under variable flow conditions. Plastic sheeting was laid down on the stream bed beneath the panels to prevent fish loss and to reduce hydraulic scouring of the stream bed. The panels were installed with the smooth side of the wire mesh toward the inside of the 'V' to minimize damage to fish brushing against the panels. Strips of 1 x 4-in. fir were placed over each joint to prevent fish from injuring themselves in any of the gaps. The panels were supported by steel rebar that was driven into the substrate, with wooden back braces for added structural strength (Figure 4). Sand bags were used to anchor the mesh skirt along the entire length of each wing, with more bags placed on the downstream side. Sacrificial flood gates were built into the panels to minimize fence damage during periods of high flow. The flood gates could be opened automatically or manually if high flow conditions threatened the fence.

At the apex of the fence, a holding box was constructed to hold captured smolts. The holding box consisted of a rectangular box (2 m x 1 m x 1 m ) made of plywood sheets and braced externally by angled sheet metal (Figure 5). Internal baffles were used to reduce turbulence in the box created by inflowing water. Water exited through several screen windows located on the sides of the holding box. The holding box was connected to the apex of the fence by a semi-ridged plastic pipe (Big-O tubing 25 cm in diameter) supported within the sluice trough. This method has proved more reliable than the sluice trough alone, as illustrated in Figure 5. Adjustments for variation in flows were made by adjusting the vertical angle of the pipe as it entered the holding box. Nylon webbing over the end of the pipe prevented fish loss upstream from the holding box inlet.

In addition to the fence and holding box, each site contained a separate sampling box in which to place the fish while enumeration and sampling proceeded. A recovery box was also built to hold fish during their recovery period after sampling. These boxes were anchored to the stream bed downstream of the fence and out of the main current. Screen windows covered with nylon webbing provided adequate water circulation and protected fish from brushing against the wire mesh (LGL Limited 1989).

COHO ECOLOGY

Juvenile coho salmon were enumerated twice a year (spring and autumn) between 1989 and 1995 (Table 2). Fish were sampled at 15 sites on the lower Klanawa tributaries, and at an additional two sites on Child Creek (Table 4). Study sites were ~30 m in length and were chosen systematically. On Park Creek, 5 sites at 150-m intervals were sampled, with the last site located at the upper limits of salmonid spawning. Exposed bedrock was common from 0 to 150 m in Park Creek, thereby requiring the first site to be located at 150 m. On Ralf Creek, 4 sites were established at 100-m intervals in the main channel and an additional two sites were chosen in off-channel streams. On Blue Creek, 4 sites were chosen at 200-m intervals. The two study sites on Child Creek were locatedon the North and South forks, 300 m and 400 m upstream, respectively, of their confluence (Table 4).

Using a combination of pole seining and electro-shocking to capture juvenile fish, data on age structure, seasonal abundance, size, biomass and seasonal movement (with site characteristics) were collected and analyzed. Data collected included information necessary for fish location/population calculations and growth and movement over time estimates.

The multiple pass removal method was used to estimate population size (Zippin 1958; Platts et al. 1983). Study section access was blocked with stop nets and the section was fished, first with a pole seine and then with a Smith-Root® electro-fisher. The fish captured were combined and set aside. After 15 minutes, the sampling was repeated. The majority of coho and trout captured were anesthetized, identified as to species, measured (fork length, mm) and weighed (nearest 0.1g). All fish were counted by species and life stage. Scale samples were obtained for subsequent separation of age classes by length. At each sampling site, the length and width of each pool and riffle was measured in metres. This information was then used to calculate total study area length and the areas for each pool and riffle. This information is necessary for future fish per metre stream population calculations.

As a means of studying fish growth and movement within each study creek, fish captured at each site were marked using a cold branding technique created by Everest and Edmondson (1967) and modified by fisheries personnel (Brown 1985). Brands were unique to each fish and varied by brand symbol, brand orientation and by side of fish. Their position and orientation could be easily determined months later. A silver tipped branding iron, dry ice, and acetone were used to mark the salmonids. Each branding iron consisted of a handle and 1 $cm^2$ silver cube with raised (2 mm) 5 x 6 mm-symbol. Dry ice and acetone cooled the branding iron to -60° C and marks were applied by rolling the iron from dorsal to ventral surface of the fish.

During the spring, juvenile fry were branded to identify individual fish for growth and movement analysis. In the autumn, the removal method was again used to estimate population size, and the branded fish were re-weighed and measured. Scale analysis of samples collected during the spring and autumn enabled the age of the captured juvenile salmonids to be determined. Some trout and yearling coho were recaptured with readable marks more than a year after they were first branded.

TEMPERATURE AND STREAM LEVEL MEASUREMENTS

Stream temperatures were collected throughout the year from each of the study tributaries using Lakewood® or Unidata® data logging systems (Table 5). Stream levels were recorded (in metres) in Park, Blue, and Ralf creeks. Air temperatures were recorded on Blue, Ralf, and Child creeks, and swamp temperatures were also recorded on Blue Creek (Table 5). In Child Creek, a data logger was installed at the confluence of the two branches (~ 200 metres upstream of their confluence with China Creek) with thermisters ~5 m upstream in each fork (Table 2). Between July, 1989, and May, 1995, the Child Creek data loggers were programmed to measure stream and air temperatures. In Park Creek, physical data was collected between May, 1989, and December, 1995, (Table 2) approximately 100 m upstream of the confluence. Physical data on Blue Creek was collected between July 1988 and January 1996 (Table 2) approximately 300 m upstream of the confluence. In Ralf Creek, data collection occurred between July ,1988, and November, 1995 (Table 2) approximately 500 m above the confluence with the Klanawa River.

Each data logger recorded data every 5 seconds, calculated a 15- to 40-minute average (depending on its program), and stored this information with the date and time. A complete description of the programming details is given elsewhere (Streamline Research 1994). Data were obtained from each logger monthly during the first year, and then four times a year thereafter (Figure 6).

Initially, temperature data and stream levels from Park, Blue, Moon, Ralf, and Child creeks were recorded by the Lakewood ® data logger system. Using model number LE8110, with a memory capacity of 32K, temperature data were collected using thermisters (model number LE8396) with an operating range of -40° C to +50° C and accuracy of ± 0.1°C. Water levels were measured using a pressure transducer (model number LE8360) with an operating range of 0 to 3 metres. A detailed description of the Lakewood Data logging components is given elsewhere (Lakewood 1988, 1987). Unidata Starlog data system, model number 6003B with a 64 K memory capacity, replaced the Lakewood data logger system in the latter part of the project. The thermisters measured temperatures between -8.9°C and 35°C (model 6507A, with 15 K ohm resistors) with an accuracy of ± 0.2°C. Water levels were measured using a hydrostatic water depth probe (model 6508C) with an operating range of 0 to 2 metres. Sensor wires were connected to the loggers via a field termination strip, model 6103-1. A detailed description of the Starlogger components is given elsewhere (Unidata 1993, 1992a, 1992b, 1992c, 1989).

Loggers and termination strips were installed in weatherproof enclosures and then mounted in small plywood shelters at each recording site. Each data logger data base was edited in Microrim's R:Base software, exported as daily maximums, minimums, and averages and stored as ASCII files. Too few stream discharge measurements were made to provide correlations between discharge and water levels. As a result, water discharge estimates could not be made.

Factors involving personnel or access periodically prevented service to the loggers on a timely basis. As a result, occasional gaps occurred in the temperature and water level data bases. Extreme high or low flows could exceed the capabilities of the water height recorded, resulting in a few unreliable records. Appendix A through D indicate the available data and notes on disrupted data collection for each creek.

## RESULTS

Eight years of physical and biological data was collected during the Klanawa River Fisheries Research Project commencing in 1988. As timber harvesting was active in and around the study tributaries, the data offer a window of opportunity into furthering what is known about the impacts of forest harvesting, over time, on coastal watersheds and the impact it may have on juvenile salmonids. Due to the volume of the data collected, it has been stored in ASCII format at the Pacific Biological Station, Nanaimo, B.C.

Only one season of streambed sampling was accomplished during this project. This offers a comparison between study tributaries as to the differences between harvested and unharvested watersheds (Table 6a, 6b). Streambed composition data were collected on the four tributaries (Park, Blue, Moon, and Ralf creeks), commencing on September 23rd, 1989, and ending on September 25th, 1989.

Juvenile fish out-migration data were collected on three study tributaries (Moon, Blue, and Ralf creeks) by LGL Limited commencing on April 28th, 1989, and terminating on June 24th, 1989. At each of the juvenile fish fences, data on all juvenile fish which passed through each fence were recorded (Table 7a, 7b). The number of coho at each life stage passing through the fence was calculated (Table 8a, 8b). A listing of all other species encountered was also given (Table 9a, 9b). As a means of explaining any irregularities in data collected, the physical site conditions for each day of sampling were recorded, specifically the stream level, stream temperature, and the number of hours the fence had been operating (Table 10a, 10b).

Coho ecology data was collected on four of the study tributaries (Child, Park, Ralf, and Blue creeks) commencing in 1989 and terminating in 1995. This data was collected by Department of Fisheries and Oceans personnel twice per year, in the spring and autumn, using the multiple pass removal method described earlier. Data necessary for biomass and density calculations, such as fork length, weight, and life stage, were collected at each site (Table 11a, 11b). Area and length of study sites were also measured twice per year (Table 12a,12b).

Stream temperature and water level data were recorded on five of the study tributaries (Child North, Child South, Park, Blue, and Ralf creeks). Data was measured year round, commencing in the summer of 1989 and terminating in the winter of 1995. Data collected on Child Creek (from July, 1989 ,to May,1995) provides insight into the characteristics of a stream found within a mature second growth forest (Table 13a, 13b). As Park Creek is exempt from timber harvesting or any other disturbances, it acts as a control and provides data critical for the comparison of those watersheds which have been modified over the course of this project (May, 1989, to December, 1995) (Table 14a, 14b). The stream data collected on Blue (July,1988, to January, 1996), and Ralf (July, 1988, and November, 1995) creeks will reflect any changes in stream temperatures, stream levels, and swamp temperatures (Blue Creek), which may have occurred as timber harvesting activities progressed through pre-harvesting (Table 15a, 15b, 16a, 16b).

## SUMMARY

The primary objective of the Klanawa River Fisheries research project was to study the impacts of forest practices on coastal watersheds both physically and biologically, and to reaffirm findings and hypotheses made at Carnation Creek. The Klanawa River offered a study area consisting of both harvested and old growth watersheds. Child Creek offered researchers the opportunity to investigate the natural changes within creeks found in mature second growth timber. Opportunities also existed for watershed restoration and coho salmon outplanting experiments.

This report outlines the methods used in data collection, describes site characteristics, and provides examples of the archived data collected during the Klanawa River Fisheries Research Project. The data illustrated has yet to be analyzed in depth. The information collected during the course of this project has been organized into four areas of investigation: stream bed composition data, juvenile fish out-migration data, coho ecology, and stream temperature and level data.

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**Table 1.** Latitude and longitude of key sites on the study tributaries. Positions were determined by receiving Global Positioning System signals on a Garmin GPS receiver unit with a ground accuracy of ±15 m.

| Sites | Park Creek | Blue Creek | Moon Creek | Ralf Creek | Child Creek |
|---|---|---|---|---|---|
| Creek Confluence | N 48°42'06.4" W124°56'48.9" | N 48°43'39.7" W124°56'40.1" | N 48°44'13.8" W124°56'20.9" | N 48°45'06.7" W124°55'13.3" | N 49°09'27.1" W124°46'28.0" |
| Juvenile Fence | - | N 48°43'44.2" W124°56'34.0" | α | α | - |
| Data Logger | - | N 48°43'43.9" W124°56'22.9" | - | N 48°45'05.0" W124°54'44.5" | N 49°09'27.1" W124°46'28.0" |

αNote: Positions could not be attained by GPS due to overhead obstructions and/or lack of satellite coverage.

**Table 2.** Klanawa River research project field time line, including sites, dates of sampling and methodology. Methods employed during this study included: Gravel; streambed composition analysis, Biophysical; stream temperature and water level data, DFO enumeration; coho ecology, and LGL Fence, fish out migration studies.

| Year | Park Creek | Blue Creek | Moon Creek | Ralf Creek | Child Creek | Methods |
|---|---|---|---|---|---|---|
| | - | - | - | - | - | Gravel |
| 1988 | | start: 7/28/88 | - | start: 7/28/88 | - | Biophysical |
| | - | - | - | - | - | DFO enum. |
| | - | - | - | - | - | LGL fence |
| | September | September | September | September | - | Gravel |
| 1989 | start: 5/01/89 | continuing | - | continuing | start: 7/12/89 | Biophysical |
| | June 15 & Sept 6 | June 6 & Sept 21 | - | June 7 & Sept 8 | - | DFO enum. |
| | - | Apr 28-June 19 | May 7-June 24 | May 5-June 19 | - | LGL fence |
| | - | - | - | - | - | Gravel |
| 1990 | continuing | continuing | - | continuing | continuing | Biophysical |
| | June 15 & Sept 20 | June 14 & Sept 21 | - | June 13 & Sept 18 | June 18 & Sept 25 | DFO enum. |
| | - | - | - | - | - | LGL fence |
| | - | - | - | - | - | Gravel |
| 1991 | continuing | continuing | - | continuing | continuing | Biophysical |
| | June 3 & Sept 20 | June 4 & Sept 19 | - | June 5 & Sept 17 | May 29 & Sept 25 | DFO enum. |
| | - | - | - | - | - | LGL fence |
| | - | - | - | - | - | Gravel |
| 1992 | continuing | continuing | - | continuing | continuing | Biophysical |
| | June 2 & Sept 9 | June 3 & Sept 11 | - | June 1 & Sept 10 | May 29 & Sept 8 | DFO enum. |
| | - | - | - | - | - | LGL fence |
| | - | - | - | - | - | Gravel |
| 1993 | continuing | continuing | - | continuing | continuing | Biophysical |
| | July 7 & Oct 7 | July 8 & Oct 8 | - | June 8 & Oct 6 | June 7 & Oct 4 | DFO enum. |
| | - | - | - | - | - | LGL fence |
| | - | - | - | - | - | Gravel |
| 1994 | continuing | continuing | - | continuing | continuing | Biophysical |
| | June 22 & Oct 19 | June 23 | - | June 21 & Sept 13 | June 20 & Sept 12 | DFO enum. |
| | - | - | - | - | - | LGL fence |
| | - | - | - | - | - | Gravel |
| 1995 | end: 12/27/95 | continuing | - | end: 11/6/95 | end: 5/17/95 | Biophysical |
| | - | - | - | - | Aug 21 | DFO enum. |
| | - | - | - | - | - | LGL fence |
| | - | - | - | - | - | Gravel |
| 1996 | - | end: 1/26/96 | - | - | - | Biophysical |
| | - | - | - | - | - | DFO enum. |
| | - | - | - | - | - | LGL fence |

**Table 3.** Streambed composition study site summary. Number of samples and location of sample sites from which streambed cores were removed.

| Park | | Blue | | Moon | | Ralf | | Child North | | Child South | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Study Site* | # of Samples | Study Site* | # of Samples | Study Site* | # of Samples | Study Site* | # of Samples | Study Site* | # of Samples | Study Site* | # of Samples |
| 100 | 5 | 100 | 5 | 100 | 6 | 100 | 5 | - | - | - | - |
| 300 | 5 | 300 | 5 | - | - | 200 | 5 | - | - | - | - |
| 500 | 5 | 500 | 5 | - | - | 300 | 5 | - | - | - | - |
| 700 | 4 | 700 | 5 | - | - | 400 | 3 | - | - | - | - |
| 800 | 5 | 800 | 5 | - | - | 500 | 5 | - | - | - | - |

* Study site locations are given in metres (approximate) from the tributary mouth.

**Table 4.** Location of downstream juvenile fish fences operated by LGL Limited in the spring of 1989, and the location of Department of Fisheries and Oceans juvenile fish sampling sites (1989 to 1995). Study site locations are given in metres (approximate) from the tributary mouth.

| | Park | Blue | Moon | Ralf | Child North | Child South |
|---|---|---|---|---|---|---|
| LGL | - | 100 | 100 | 100 | - | - |
| DFO | 150 | 150 | - | 100 | 300 | 400 |
| | 350 | 350 | - | 200 | - | - |
| | 550 | 550 | - | 300 | - | - |
| | 750 | 750 | - | 400 | - | - |
| | 880 | - | - | -200 | - | - |
| | - | - | - | -350 | - | - |

**Table 5.** Physical stream attribute summary. An indication of the location of data loggers and the data collected at each study site. See Appendix A through D.

| Creek | Study Site Location* | Stream Temperature | Swamp Temperature | Air Temperature | Stream Level |
|---|---|---|---|---|---|
| Park | 100 | X | - | - | X |
| Blue | 300 | X | X | X | X |
| αMoon | - | - | - | - | - |
| Ralf | 500 | X | - | X | X |
| Child North | 5 | X | - | X | - |
| Child South | 5 | X | - | X | - |

* Study site locations are given in metres (approximate) from the tributary mouth.

**Table 6a.** Klanawa streambed composition data.

## KLANAWA RIVER
## GRAVEL DATA FIELDS

| | |
|---|---|
| 1. Date | Date samples were collected (mm/dd/yy). |
| 2. Stream | Tributary name. |
| 3. Site | Site number refers to the location of the samples taken on each tributary. Site numbers represent the distance upstream from the confluence of the tributary with the main stem of the Lower Klanawa River. |
| 4. Sample Number | The four digit number presented as a sample number has **three** definitions. Example: #1011<br>a) 1011: the first two digits represent the site number, in this case site 100.<br>b) 1011: the third number represents the sample number taken at that site, a number between 1 and 5, in this case sample #1<br>c) 1011: the fourth number indicates the level of the sample; top(#1), middle(#2) or bottom(#3).<br>In this example, #1011 represents site number 100, sample number 1, and the top of the gravel core. |
| 5. Mean Rock Size | Mean rock size is an indication of the mean diameter (in mm) of the largest rock collected within each sample. |
| 6. >25mm (g) (rocks) | Values are the combined weight in grams of that portion of the sample greater than 25 mm in diameter. |
| 7. 9.55mm Sieve (g) (gravel) | Values are the weight (in grams) of that portion of the sample greater than 9.5 mm in diameter (< 25mm). |
| 8. 2.38mm Sieve (g) (pea gravel) | Values are the weight (in grams) of that portion of the sample greater than 2.38 mm in diameter (< 9.5mm). |
| 9. 1.19mm Sieve (g) (coarse sand) | Values are the weight (in grams) of that portion of the sample greater than 1.19 mm in diameter (< 2.38mm). |
| 10. 0.3mm Sieve (g) (medium sand) | Values are the weight (in grams) of that portion of the sample greater than 0.3 mm in diameter (< 1.19 mm). |
| 11. >0.074mm (g) (fine sand) | Values are the weight (in grams) of that portion of the sample greater than 0.074 mm but < 0.3mm in diameter. |
| 12. <0.07mm (g) (silt-clay) | Values are the weight (in grams) of that portion of the sample < 0.07mm in diameter. |
| 13. *Dg* | Geometric mean particle size. |
| 14. *Fi* | Fredle index. |

**Table 6b**. Data base sample illustrating the layout with example values.

| Stream | Date | Site | Sample # | Mean Rock Size (mm) | >25mm (g) | 9.55mm Sieve (g) | 2.36 mm Sieve (g) | 1.18 mm Sieve (g) | 0.3 mm Sieve (g) | >0.074mm Sieve (g) | <0.07mm (g) | Dg | Fi |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ralf | 09/23/89 | 100 | 1011 | 67 | 3340 | 1290 | 650 | 273 | 356 | 29 | 8 | 16.84 | 8.59 |
| Ralf | 09/23/89 | 100 | 1013 | 62 | 2054 | 1154 | 1084 | 464 | 418 | 42 | 16 | 10.42 | 5.13 |
| Ralf | 09/23/89 | 100 | 1021 | 69 | 2485 | 1190 | 976 | 712 | 562 | 22 | 1 | 10.62 | 5.42 |
| Ralf | 09/23/89 | 100 | 1023 | 72 | 1779 | 746 | 1568 | 786 | 726 | 40 | 12 | 7.077 | 3.40 |
| Ralf | 09/23/89 | 100 | 1031 | 65 | 3301 | 1466 | 1094 | 586 | 744 | 34 | 6 | 11.6 | 5.83 |

**Table 7a.** Juvenile fish fence data: general specimen biological data.

GENERAL BIOLOGICAL JUVENILE
FISH FENCE DATA

| | |
|---|---|
| 1. Stream | Tributary name. |
| 2. Date | Date sample collected (mm/dd/yy). |
| 3. Fish Number | A numerical account of each fish unique to its own species. |
| 4. Species | Species of fish. |
| 5. Stage | Stage of life cycle. |
| 6. Length (cm) | Measured length of fish in centimetres. |
| 7. Weight (g) | Weight of fish in grams. |
| 8. Scale Sample | Indicates if a scale specimen was removed. |
| 9. Remarks | Indicates mortality factors. They include:<br>-dead on fence (found dead)<br>-dead in trap (found dead)<br>-killed (death due to handling)<br>-preserved (coho taken as samples)<br>Cold Brand:<br>-Left U brand - indicates fish found with previous markings on it. |

**Table 7b**. Data base sample illustrating the layout with example values.

| Stream | Date | Fish Number | Species | Stage | Length (cm) | Weight (g) | Scale Sample | Remarks |
|---|---|---|---|---|---|---|---|---|
| MOON | 05/07/89 | 1 | COHO | SMOLT | 9.60 | 8.90 | Yes | preserved |
| MOON | 05/07/89 | 2 | COHO | SMOLT | 8.70 | 6.50 | Yes | |
| MOON | 05/07/89 | 1 | C. asper | | 11.60 | | No | |
| MOON | 05/08/89 | 3 | COHO | SMOLT | 10.50 | 10.90 | Yes | dead on fence |
| MOON | 05/09/89 | 4 | COHO | SMOLT | 10.20 | 10.20 | Yes | |
| MOON | 05/09/89 | 5 | COHO | SMOLT | 9.50 | 8.10 | Yes | |
| MOON | 05/09/89 | 6 | COHO | SMOLT | 9.50 | 7.80 | Yes | preserved |
| MOON | 05/09/89 | 7 | COHO | SMOLT | 8.90 | 6.80 | Yes | |
| MOON | 05/09/89 | 1 | RBT | PARR | 7.10 | 3.30 | No | left U brand |
| MOON | 05/09/89 | 2 | RBT | PARR | 7.60 | 4.70 | No | |
| MOON | 05/09/89 | 3 | RBT | PARR | 7.40 | 4.00 | No | preserved |
| MOON | 05/09/89 | 2 | C. asper | | 9.20 | | No | |
| MOON | 05/10/89 | 1 | C. aleut | | 7.30 | | No | killed |
| MOON | 05/11/89 | 8 | COHO | SMOLT | 10.30 | 10.60 | Yes | killed |
| MOON | 05/11/89 | 9 | COHO | SMOLT | 9.90 | 9.10 | Yes | |
| MOON | 05/11/89 | 10 | COHO | SMOLT | 8.90 | 6.70 | Yes | dead in trap |
| MOON | 05/11/89 | 11 | COHO | SMOLT | 9.00 | 7.40 | Yes | |
| MOON | 05/11/89 | 2 | C. aleut | | 6.00 | | No | |

**Table 8a.** Data specific to juvenile coho salmon.

| JUVENILE COHO SALMON SPECIFIC DATA | |
|---|---|
| 1. Stream | Tributary name. |
| 2. Date | Date sample was collected (mm/dd/yy). |
| 3. Time | Time (24-hour clock) sample was collected. |
| 4. Coho Fry | Number of coho fry. |
| 5. Coho Parr | Number of coho parr. |
| 6. Coho Smolt | Number of coho smolt. |
| 7. Handling Mortality | Specimen death as a result of handling. |
| 8. Hold Mortality | Number of specimen death between time of capture and time of release. |
| 9. Other Mortality | Other factors of specimen death. |

**Table 8b**. Data base sample illustrating the layout with example values.

| Stream | Date | Time | Coho Fry | Coho Parr | Coho Smolt | Dye Mark | Mark Mortality | Hold Mortality | Other Mortality |
|---|---|---|---|---|---|---|---|---|---|
| MOON | 05/07/89 | 1430 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| MOON | 05/08/89 | 930 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| MOON | 05/09/89 | 1130 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| MOON | 05/10/89 | 1330 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/11/89 | 1150 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| MOON | 05/12/89 | 1200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/13/89 | 1200 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| MOON | 05/14/89 | 1130 | 0 | 0 | 4 | 0 | 0 | 0 | 0 |
| MOON | 05/15/89 | 1140 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| MOON | 05/16/89 | 915 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| MOON | 05/17/89 | 1000 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| MOON | 05/18/89 | 1030 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/19/89 | 1030 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/20/89 | 1300 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| MOON | 05/21/89 | 1130 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| MOON | 05/22/89 | 1120 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/23/89 | 1340 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| MOON | 05/24/89 | 1110 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| MOON | 05/25/89 | 1145 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| MOON | 05/26/89 | 1555 | 0 | 0 | 79 | 0 | 0 | 0 | 0 |

**Table 9a.** Juvenile fish fence data specific to specimens other than coho.

**FISH (FENCE) SPECIMENS**
**OTHER THAN COHO**

| | |
|---|---|
| 1. Stream | Name of tributary. |
| 2. Date | Date sample was collected (mm/dd/yy). |
| 3. Time | Time (24-hour clock) when sample was collected. |
| 4. RBT Fry | Number of Rainbow Trout fry. |
| 5. RBT Parr | Number of Rainbow Trout parr. |
| 6. RBT Smolt | Number of Rainbow Trout smolt. |
| 7. RBT Adult | Number of Rainbow Trout adult. |
| 8. RBT Kelt | Number of Rainbow Trout kelt. |
| 9. Cutt Fry | Number of Cutthroat Trout fry. |
| 10. Cutt Parr | Number of Cutthroat Trout parr. |
| 11. Cutt Smolt | Number of Cutthroat Trout smolt. |
| 12. Cutt Adult | Number of Cutthroat Trout adult. |
| 13. Cutt Kelt | Number of Cutthroat Trout kelt. |
| 14. Chum Fry | Number of Chum fry. |
| 15. C.asper | Number of Cottus asper. |
| 16. C.aleut | Number of Cottus aleuticus. |
| 17. Dolly Vard | Number of Dolly Varden. |

**Table 9b.** Data base sample illustrating the layout `with example values.

| Stream | Date | Time | RBT Fry | RBT Parr | RBT Smolt | RBT Adult | RBT Kelt | CUTT Fry | CUTT Parr | CUTT Smolt | CUTT Adult | CUTT Kelt | CHUM Fry | C. asper | C. aleut | Dolly Vard |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MOON | 05/07/89 | 1430 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| MOON | 05/08/89 | 930 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/09/89 | 1130 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| MOON | 05/10/89 | 1300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| MOON | 05/11/89 | 1150 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| MOON | 05/12/89 | 1200 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/13/89 | 1600 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/14/89 | 1130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/15/89 | 1140 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/16/89 | 1145 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 |
| MOON | 05/17/89 | 1000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| MOON | 05/18/89 | 1030 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/19/89 | 1030 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/20/89 | 1300 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/21/89 | 1130 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/22/89 | 1120 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| MOON | 05/23/89 | 1340 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/24/89 | 1110 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| MOON | 05/25/89 | 1145 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| MOON | 05/26/89 | 1555 | 0 | 26 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 2 | 0 |
| MOON | 05/27/89 | 1330 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 10a.** Juvenile fish fence biophysical data.

| FENCE BIOPHYSICAL DATA | |
|---|---|
| 1. Stream | Tributary name. |
| 2. Date | Date data was collected (mm/dd/yy). |
| 3. Time | Time (24-hour clock) data was collected. |
| 4. Fence Hours | The length of time operating. |
| 5. Water Temp | Stream temperature in degrees celsius. |
| 6. Depth G1 | Depth of stream at Gauge one in feet. |
| 7. Depth G2 | Depth of stream at Gauge 2 in centimetres. |
| 8. Rain | An arbitrary scale indicating the rain fall intensity: 0 (no rain) to 6 (torrential downpour). |
| 9. Wind Direction | Cardinal indication of wind direction (i.e. source). |
| 10. Wind Speed | Velocity of the prevailing wind measured in kilometres per hour. |
| 11. Cloud % | Percent of cloud cover. |

**Table 10b**. Data base sample illustrating the layout with example values.

| Stream | Date | Time | Fence Hours | Water Temp (C) | Depth G1 (ft) | Depth G2 (cm) | Rain | Wind Direction | Wind Speed (km/h) | Cloud (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| MOON | 05/07/89 | 1430 | 24 | 13.50 | | | 0 | SE | 10 | 0 |
| MOON | 05/08/89 | 930 | 24 | 12.50 | | 24.00 | 0 | CALM | 0 | 100 |
| MOON | 05/09/89 | 1130 | 24 | 11.80 | | 24.00 | 0 | CALM | 0 | 70 |
| MOON | 05/10/89 | 1330 | 24 | 10.50 | | 24.50 | 1 | SW | 10 | 70 |
| MOON | 05/11/89 | 1150 | 24 | 10.00 | | 24.00 | 0 | SW | 7 | 90 |
| MOON | 05/12/89 | 1200 | 24 | 9.50 | | 24.00 | 0 | SE | 7 | 10 |
| MOON | 05/13/89 | 1600 | 24 | 11.50 | | 23.50 | 0 | CALM | 0 | 70 |
| MOON | 05/14/89 | 1130 | 24 | 10.00 | | 23.50 | 0 | SE | 7 | 5 |
| MOON | 05/15/89 | 1140 | 24 | 10.50 | | 23.50 | 0 | SW | 7 | 0 |
| MOON | 05/16/89 | 915 | 24 | 11.00 | | 23.00 | 1 | SE | 7 | 100 |
| MOON | 05/17/89 | 1000 | 24 | 9.50 | | 24.50 | 3 | CALM | 0 | 100 |
| MOON | 05/18/89 | 1030 | 24 | 8.50 | | 31.00 | 0 | CALM | 0 | 70 |
| MOON | 05/19/89 | 1030 | 24 | 8.50 | | 25.00 | 0 | CALM | 0 | 40 |
| MOON | 05/20/89 | 1300 | 24 | 10.00 | | 24.00 | 0 | SW | 7 | 10 |
| MOON | 05/21/89 | 1130 | 24 | 9.00 | | 23.50 | 0 | SW | 5 | 10 |
| MOON | 05/22/89 | 1120 | 24 | 9.00 | | 23.50 | 1 | CALM | 0 | 100 |
| MOON | 05/23/89 | 1340 | 24 | 10.00 | | 26.50 | 2 | CALM | 0 | 100 |

**Table 11a.** Juvenile fish population and movement data.

**KLANAWA TRIBUTARY AND CHILD CREEK**
**BIOLOGICAL DATA**

| | |
|---|---|
| 1. River | Stream name. |
| 2. Site | Site number refers to the location of the samples taken on each tributary. Site numbers represent the distance upstream from the confluence of the tributary with the main stem of the Lower Klanawa River. |
| 3. Date | Date data were collected (mm/dd/yy). |
| 4. Method | Indicates the method of capture:<br>PS: Two-person pole seine<br>EL: Electro-shocker<br>and: (2): Number of passes or runs. |
| 5. Run | Indicates passes of equal effort used for population estimates:<br>1: pass one<br>2: pass two |
| 6. Species | Species of fish (Note: trout < 100 mm were not classified). |
| 7. Length (mm) | Measured length of fish in millimetres. |
| 8. Weight (g) | Weight of fish in grams. |
| 9. Id Brand | Identification number cold branded on fish.(first two numbers refer to year of marking) |
| 10. Age | Age of fish. |
| 11.Season | Time of year:<br>1: spring (June)<br>2: autumn (September) |
| 12. Year | Year data was collected. |

**Table 11b.** Data base sample illustrating the layout with example values.

| River | Site | Date | Method | Run | Species | Length (mm) | Weight (g) | Id Brand | Age | Season | Year |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BLUE | 750 | 06/06/89 | PS&EL(2) | 2 | TROUT | 31 | 0.24 | 89234 | 0 | 1 | 1989 |
| BLUE | 750 | 06/06/89 | PS | 2 | TROUT | 27 | 0.18 | 89543 | 0 | 1 | 1989 |
| BLUE | 750 | 06/06/89 | EL | 2 | TROUT | 98 | 2.10 | 89757 | 1 | 1 | 1989 |
| BLUE | 350 | 06/14/90 | PS&EL(2) | 1 | TROUT | 31 | 0.20 | 90233 | 0 | 1 | 1990 |
| BLUE | 750 | 06/14/90 | PS&EL(2) | 2 | TROUT | 31 | 0.20 | 90246 | 0 | 1 | 1990 |
| BLUE | 350 | 06/04/91 | PS | 1 | COHO | 31 | 0.25 | 91352 | 0 | 1 | 1991 |
| BLUE | 550 | 09/04/91 | PS&EL(2) | 1 | CUTT | 100 | 1.90 | 91573 | 1 | 2 | 1991 |
| BLUE | 550 | 09/04/91 | PS&EL(2) | 1 | CUTT | 105 | 2.05 | 91883 | 0 | 2 | 1991 |
| BLUE | 750 | 09/04/91 | EL | 1 | CUTT | 108 | 2.10 | 91848 | 0 | 2 | 1991 |
| RALF | 100 | 09/05/91 | PS | 1 | COHO | 97 | 2.00 | 91464 | 1 | 2 | 1991 |
| RALF | 400 | 09/05/91 | PS&EL(2) | 1 | TROUT | 33 | 0.20 | 91992 | 0 | 2 | 1991 |

**Table 12a.** Juvenile fish population and migration study site physical attributes.

| STUDY REACH PHYSICAL CHARACTERISTICS | |
|---|---|
| 1. River | Stream name. |
| 2. Site | Site number refers to the location of the samples taken on each tributary. Site numbers represent the distance upstream from the confluence of the tributary with the main stem. |
| 3. Date | Date data was collected (mm/dd/yy). |
| 4. Pool Area | Measured area of pool in metres squared. |
| 5. Riffle Area | Measured area of riffle in metres squared. |
| 6. Total Area | Combined area of pool and riffle per study site in metres squared. |
| 7. Total Length | Measured length of pool-riffle sequence in metres. |

**Table 12b.** Data base sample illustrating the layout with example values.

| River | Site | Date | Pool Area | Riffle Area | Total Area | Total Length |
|---|---|---|---|---|---|---|
| ChildNorth | 300 | 06/07/93 | 92.80 | 47.80 | 140.60 | 33.00 |
| ChildSouth | 400 | 06/07/93 | 76.20 | 61.75 | 137.95 | 37.00 |
| RALF | 100 | 06/08/93 | 293.80 | 78.65 | 372.45 | 52.00 |
| RALF | 200 | 06/08/93 | 29.65 | 159.60 | 189.25 | 46.50 |
| RALF | 300 | 06/08/93 | 109.75 | 6.70 | 116.45 | 18.00 |
| RALF | 400 | 06/08/93 | 278.28 | 173.52 | 451.80 | 56.00 |
| RALF | -200 | 06/09/93 | 112.95 | 0.00 | 112.95 | 35.00 |
| RALF | -350 | 06/09/93 | 61.50 | 18.80 | 80.30 | 25.00 |

**Table 13a.** Stream attribute data fields for Child Creek.

| CHILD CREEK STREAM ATTRIBUTE DATA FIELDS | |
|---|---|
| 1. Date | Date samples were collected (mm/dd/yy). |
| 2. Max South Temp | Maximum stream temperature (in Celsius) of the southern arm of Child Creek. |
| 3. Min South Temp | Minimum stream temperature (in Celsius) of the southern arm of Child Creek. |
| 4. Avg South Temp | Average stream temperature (in Celsius) of the southern arm of Child Creek. |
| 5. Max North Temp | Maximum stream temperature (in Celsius) of the northern arm of Child Creek. |
| 6. Min North Temp | Minimum stream temperature (in Celsius) of the northern arm of Child Creek. |
| 7. Avg North Temp | Average stream temperature (in Celsius) of the northern arm of Child Creek. |
| 8. Max Air Temp | Maximum recorded air temperature (in Celsius). |
| 9. Min Air Temp | Minimum recorded air temperature (in Celsius). |
| 10. Avg Air Temp | Average recorded air temperature (in Celsius). |

**Table 13b.** Data base sample illustrating the layout with example values.

| Date | Max South Temp | Min South Temp | Avg South Temp | Max North Temp | Min North Temp | Avg North Temp | Max Air Temp | Min Air Temp | Avg Air Temp |
|---|---|---|---|---|---|---|---|---|---|
| 7/13/89 | 11.80 | 11.10 | 11.43 | 12.50 | 11.90 | 12.19 | 21.80 | 14.20 | 17.28 |
| 7/14/89 | 11.80 | 11.40 | 11.61 | 12.50 | 11.70 | 12.18 | 21.60 | 10.60 | 15.88 |
| 7/15/89 | 11.60 | 11.10 | 11.32 | 12.30 | 11.90 | 12.16 | 18.80 | 10.90 | 15.31 |
| 7/16/89 | 11.60 | 10.90 | 11.38 | 12.10 | 11.90 | 12.05 | 17.50 | 13.60 | 15.10 |
| 7/17/89 | 11.80 | 11.40 | 11.57 | 12.30 | 11.90 | 12.15 | 17.20 | 13.90 | 15.54 |
| 7/18/89 | 11.80 | 11.40 | 11.58 | 12.30 | 11.90 | 12.11 | 18.30 | 13.30 | 15.51 |
| 7/19/89 | 12.00 | 11.60 | 11.73 | 12.50 | 12.10 | 12.29 | 19.10 | 13.10 | 16.14 |
| 7/20/89 | 11.60 | 11.10 | 11.33 | 12.30 | 11.70 | 11.95 | 16.90 | 10.00 | 14.05 |
| 7/21/89 | 11.60 | 11.10 | 11.32 | 12.30 | 11.70 | 12.05 | 18.80 | 12.20 | 15.44 |
| 7/22/89 | 11.60 | 10.90 | 11.20 | 12.30 | 11.50 | 11.93 | 21.80 | 9.20 | 15.26 |
| 7/23/89 | 11.60 | 11.10 | 11.37 | 12.50 | 11.90 | 12.15 | 19.90 | 11.10 | 15.55 |
| 7/24/89 | 11.60 | 10.90 | 11.28 | 12.50 | 11.70 | 12.15 | 22.70 | 9.80 | 15.92 |
| 7/25/89 | 11.80 | 11.10 | 11.45 | 12.80 | 11.90 | 12.36 | 24.30 | 10.60 | 16.85 |
| 7/26/89 | 11.80 | 11.10 | 11.54 | 12.50 | 12.30 | 12.41 | 18.80 | 11.70 | 15.50 |
| 7/27/89 | 11.80 | 11.60 | 11.70 | 12.50 | 12.30 | 12.40 | 18.00 | 14.70 | 16.13 |
| 7/28/89 | 11.80 | 11.40 | 11.60 | 12.30 | 11.90 | 12.18 | 19.60 | 10.90 | 15.37 |
| 7/29/89 | 12.00 | 11.60 | 11.73 | 12.80 | 12.30 | 12.46 | 20.50 | 13.90 | 16.89 |

**Table 14a.** Stream attribute data fields for Park Creek.

| PARK CREEK<br>STREAM ATTRIBUTE DATA FIELDS | |
|---|---|
| 1. Date | Date samples were collected (mm/dd/yy). |
| 2. Max Stream Temp | Maximum recorded daily stream temperature in degrees Celsius. |
| 3. Min Stream Temp | Minimum recorded daily stream temperature in degrees Celsius. |
| 4. Average Stream Temp | Calculated daily average stream temperature in degrees Celsius. |
| 5. Max Stream Level | Maximum recorded daily stream level in metres. |
| 6. Min Stream Level | Minimum recorded daily stream level in metres. |
| 7. Average Stream Level | Calculated daily average stream level in metres. |

**Table 14b**. Data base sample illustrating the layout with example values.

| Date | Max Stream Temp | Min Stream Temp | Avg Stream Temp | Max Stream Level | Min Stream Level | Avg Stream Level |
|---|---|---|---|---|---|---|
| 5/1/89 | 9.80 | 9.20 | 9.46 | 0.22 | 0.21 | 0.22 |
| 5/2/89 | 9.80 | 8.80 | 9.29 | 0.22 | 0.22 | 0.22 |
| 5/3/89 | 10.00 | 9.00 | 9.41 | 0.22 | 0.21 | 0.21 |
| 5/4/89 | 9.80 | 8.40 | 9.15 | 0.21 | 0.20 | 0.20 |
| 5/5/89 | 9.80 | 9.20 | 9.55 | 0.20 | 0.20 | 0.20 |
| 5/6/89 | 10.40 | 9.40 | 9.90 | 0.20 | 0.20 | 0.20 |
| 5/7/89 | 10.40 | 9.60 | 9.93 | 0.20 | 0.20 | 0.20 |
| 5/8/89 | 10.40 | 9.40 | 9.90 | 0.20 | 0.20 | 0.20 |
| 5/9/89 | 9.80 | 9.00 | 9.40 | 0.20 | 0.19 | 0.20 |
| 5/10/89 | 9.00 | 8.40 | 8.69 | 0.20 | 0.19 | 0.20 |
| 5/11/89 | 9.00 | 7.80 | 8.43 | 0.20 | 0.16 | 0.19 |
| 5/12/89 | 8.80 | 7.60 | 8.25 | 0.20 | 0.17 | 0.20 |
| 5/13/89 | 8.80 | 7.60 | 8.29 | 0.19 | 0.15 | 0.18 |
| 5/14/89 | 9.00 | 7.80 | 8.49 | 0.19 | 0.15 | 0.17 |
| 5/15/89 | 9.20 | 8.00 | 8.74 | 0.19 | 0.15 | 0.18 |
| 5/16/89 | 9.40 | 8.80 | 9.08 | 0.19 | 0.17 | 0.18 |
| 5/17/89 | 8.80 | 8.20 | 8.55 | 0.25 | 0.17 | 0.21 |
| 5/18/89 | 8.60 | 8.00 | 8.26 | 0.27 | 0.22 | 0.25 |
| 5/19/89 | 9.00 | 7.80 | 8.35 | 0.25 | 0.19 | 0.22 |
| 5/20/89 | 8.60 | 7.40 | 8.05 | 0.21 | 0.16 | 0.19 |
| 5/21/89 | 8.40 | 7.10 | 7.84 | 0.20 | 0.16 | 0.18 |
| 5/22/89 | 8.60 | 7.40 | 8.06 | 0.20 | 0.16 | 0.18 |
| 5/23/89 | 8.40 | 8.00 | 8.28 | 0.25 | 0.18 | 0.23 |
| 5/24/89 | 9.20 | 8.00 | 8.50 | 0.24 | 0.20 | 0.22 |

**Table 15a.** Stream attribute data fields for Blue Creek.

**BLUE CREEK**
**STREAM ATTRIBUTE DATA FIELDS**

| | |
|---|---|
| 1. Date | Date samples were collected (mm/dd/yy). |
| 2. Max Swamp Temp | Maximum recorded daily swamp temperature in degrees Celsius. |
| 3. Min Swamp Temp | Minimum recorded daily swamp temperature in degrees Celsius. |
| 4. Average Swamp Temp | Calculated daily average swamp temperature in degrees Celsius. |
| 5. Max Stream Temp | Maximum recorded daily stream temperature in degrees Celsius. |
| 6. Min Stream Temp | Minimum recorded daily stream temperature in degrees Celsius. |
| 7. Average Stream Temp | Calculated daily average stream temperature in degrees Celsius. |
| 8. Max Stream Level | Maximum recorded daily stream level in metres. |
| 9. Min Stream Level | Minimum recorded daily stream level in metres. |
| 10. Average Stream Level | Calculated daily average stream level in metres. |
| 11. Max Air Temp | Maximum recorded daily air temperature in degrees Celsius. |
| 12. Min Air Temp | Minimum recorded daily air temperature in degrees Celsius. |
| 13. Average Air Temp | Calculated daily average air temperature in degrees Celsius. |

**Table 15b**. Data base sample illustrating the layout with example values.

| Date | Max Swamp Temp | Min Swamp Temp | Avg Swamp Temp | Max Stream Temp | Min Stream Temp | Avg Stream Temp | Max Stream Level | Min Stream Level | Avg Stream Level | Max Air Temp | Min Air Temp | Avg Air Temp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7/29/88 | 12.67 | 12.29 | 12.40 | 14.47 | 13.32 | 13.85 | 0.13 | 0.06 | 0.09 | 18.58 | 12.43 | 15.29 |
| 7/30/88 | 12.67 | 11.96 | 12.20 | 14.00 | 12.67 | 13.33 | 0.14 | 0.06 | 0.08 | 16.42 | 8.71 | 12.51 |
| 7/31/88 | 12.25 | 11.94 | 12.07 | 13.48 | 12.65 | 12.97 | 0.14 | 0.06 | 0.08 | 15.54 | 10.11 | 12.42 |
| 8/1/88 | 12.13 | 11.34 | 11.62 | 14.02 | 11.82 | 12.60 | 0.14 | 0.06 | 0.08 | 16.94 | 7.63 | 11.96 |
| 8/2/88 | 11.70 | 10.83 | 11.15 | 13.66 | 11.17 | 12.32 | 0.14 | 0.06 | 0.09 | 21.16 | 7.12 | 13.19 |
| 8/3/88 | 11.90 | 11.43 | 11.63 | 14.06 | 11.72 | 12.72 | 0.14 | 0.05 | 0.09 | 21.93 | 9.67 | 14.67 |
| 8/4/88 | 12.14 | 11.72 | 11.90 | 14.00 | 11.53 | 12.68 | 0.14 | 0.06 | 0.09 | 20.64 | 9.15 | 14.27 |
| 8/5/88 | 12.43 | 12.15 | 12.32 | 12.75 | 11.80 | 12.24 | 0.13 | 0.05 | 0.08 | 14.48 | 11.60 | 12.52 |
| 8/6/88 | 12.48 | 12.17 | 12.31 | 12.81 | 11.53 | 12.07 | 0.14 | 0.05 | 0.08 | 15.16 | 10.86 | 12.45 |
| 8/7/88 | 12.52 | 12.04 | 12.28 | 12.93 | 11.35 | 12.16 | 0.14 | 0.05 | 0.08 | 17.05 | 9.52 | 12.84 |

**Table 16a.** Stream attribute data fields for Ralf Creek.

| | |
|---|---|
| **RALF CREEK** | |
| **STREAM ATTRIBUTE DATA FIELDS** | |
| 1. Date | Date samples were collected (mm/dd/yy). |
| 2. Max Stream Temp | Maximum recorded daily stream temperature in degrees Celsius. |
| 3. Min Stream Temp | Minimum recorded daily stream temperature in degrees Celsius. |
| 4. Average Stream Temp | Calculated daily average stream temperature in degrees Celsius. |
| 5. Max Stream Level | Maximum recorded daily stream level in metres. |
| 6. Min Stream Level | Minimum recorded daily stream level in metres. |
| 7. Average Stream Level | Calculated daily average stream level in metres. |
| 8. Max Air Temp | Maximum recorded daily air temperature in degrees Celsius. |
| 9. Min Air Temp | Minimum recorded daily air temperature in degrees Celsius. |
| 10. Average Air Temp | Calculated daily average air temperature in degrees Celsius. |

**Table 16b.** Data base sample illustrating the layout with example values.

| Date | Max Stream Temp | Min Stream Temp | Avg Stream Temp | Max Stream Level | Min Stream Level | Avg Stream Level | Max Air Temp | Min Air Temp | Avg Air Temp |
|---|---|---|---|---|---|---|---|---|---|
| 7/29/88 | 12.33 | 11.02 | 11.38 | 0.34 | 0.26 | 0.29 | 19.19 | 12.83 | 15.02 |
| 7/30/88 | 12.11 | 11.06 | 11.45 | 0.36 | 0.25 | 0.29 | 17.11 | 9.54 | 13.15 |
| 7/31/88 | 12.19 | 11.06 | 11.34 | 0.37 | 0.25 | 0.29 | 16.74 | 10.52 | 12.92 |
| 8/1/88 | 11.90 | 10.78 | 11.10 | 0.35 | 0.25 | 0.29 | 18.28 | 8.89 | 12.85 |
| 8/2/88 | 11.82 | 10.54 | 10.97 | 0.37 | 0.25 | 0.29 | 21.18 | 8.06 | 13.35 |
| 8/3/88 | 12.56 | 11.12 | 11.47 | 0.36 | 0.26 | 0.30 | 20.00 | 10.11 | 14.57 |
| 8/4/88 | 12.25 | 11.35 | 11.68 | 0.35 | 0.26 | 0.29 | 20.00 | 9.86 | 14.49 |
| 8/5/88 | 12.23 | 11.61 | 11.76 | 0.33 | 0.25 | 0.29 | 14.99 | 12.13 | 13.04 |
| 8/6/88 | 12.25 | 11.23 | 11.47 | 0.34 | 0.25 | 0.29 | 16.01 | 11.60 | 12.93 |
| 8/7/88 | 12.15 | 11.10 | 11.33 | 0.33 | 0.25 | 0.29 | 17.59 | 9.97 | 13.23 |
| 8/8/88 | 11.49 | 11.10 | 11.22 | 0.33 | 0.26 | 0.29 | 15.01 | 10.39 | 12.74 |
| 8/9/88 | 11.61 | 11.01 | 11.21 | 0.34 | 0.25 | 0.29 | 17.15 | 11.39 | 13.95 |
| 8/10/88 | 12.59 | 11.19 | 11.45 | 0.35 | 0.25 | 0.28 | 18.28 | 10.21 | 13.56 |
| 8/11/88 | 11.53 | 11.17 | 11.30 | 0.36 | 0.25 | 0.29 | 15.68 | 9.38 | 11.78 |
| 8/12/88 | 12.39 | 11.16 | 11.36 | 0.33 | 0.24 | 0.28 | 16.16 | 10.19 | 12.94 |
| 8/13/88 | 12.37 | 10.96 | 11.18 | 0.36 | 0.25 | 0.29 | 16.19 | 8.87 | 12.30 |
| 8/14/88 | 11.21 | 11.08 | 11.14 | 0.33 | 0.24 | 0.29 | 14.12 | 11.37 | 12.96 |
| 8/15/88 | 11.08 | 10.83 | 10.91 | 0.33 | 0.25 | 0.29 | 12.97 | 11.49 | 12.17 |
| 8/16/88 | 11.68 | 10.72 | 11.23 | 0.36 | 0.26 | 0.31 | 13.81 | 11.74 | 12.58 |

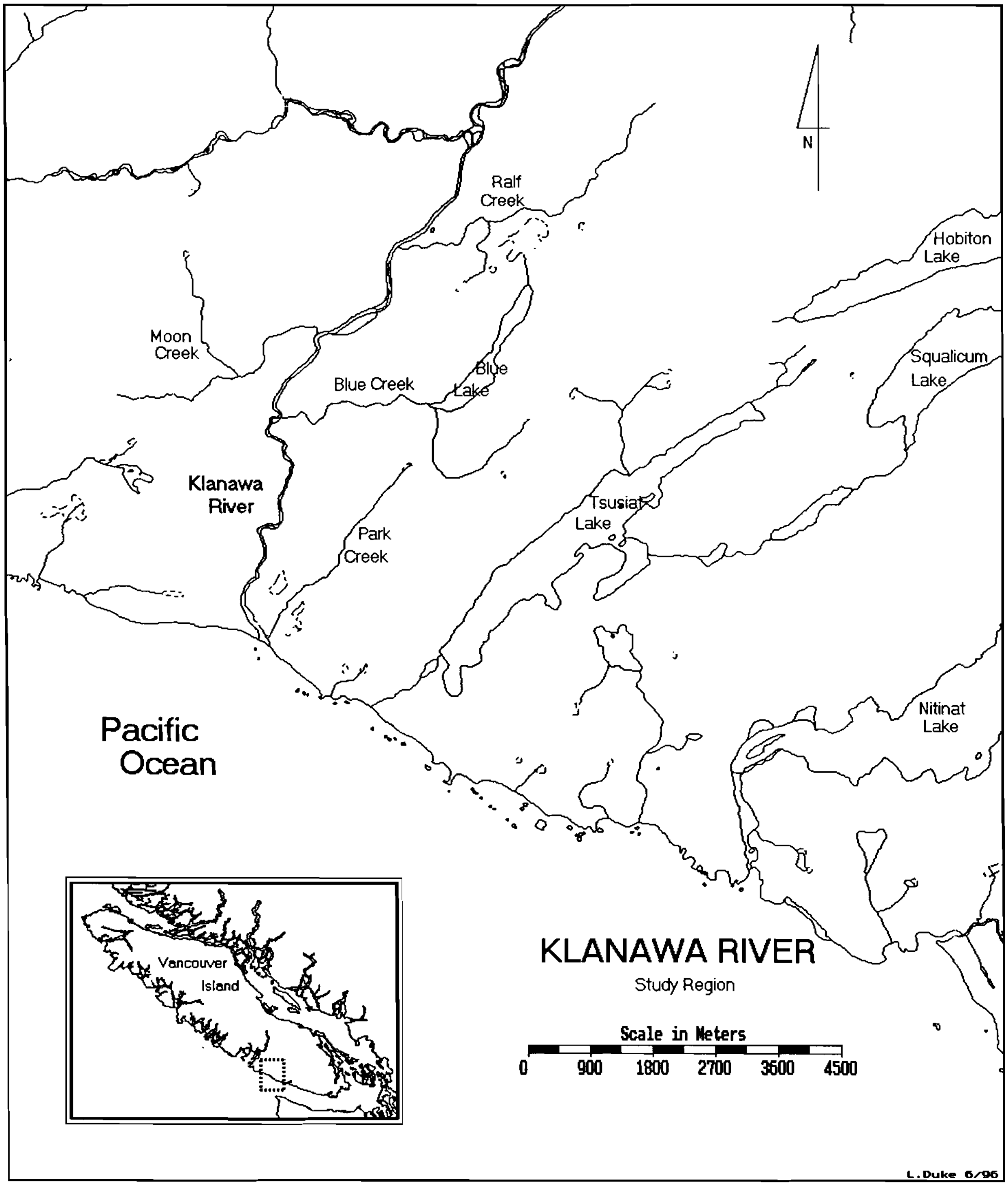



**Figure 1.** Map of the Klanawa River and surrounding region, identifying the four study tributary locations.

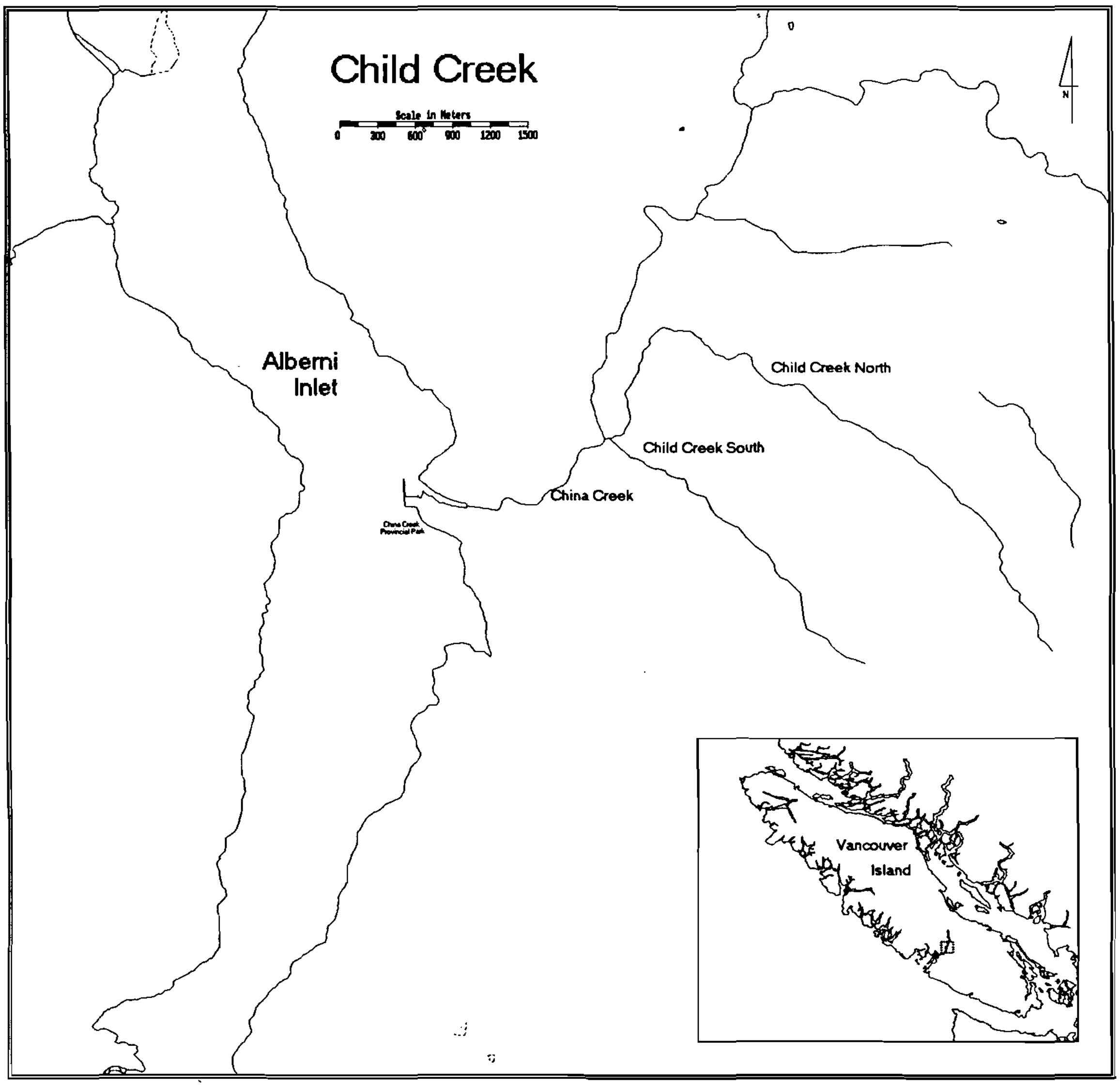
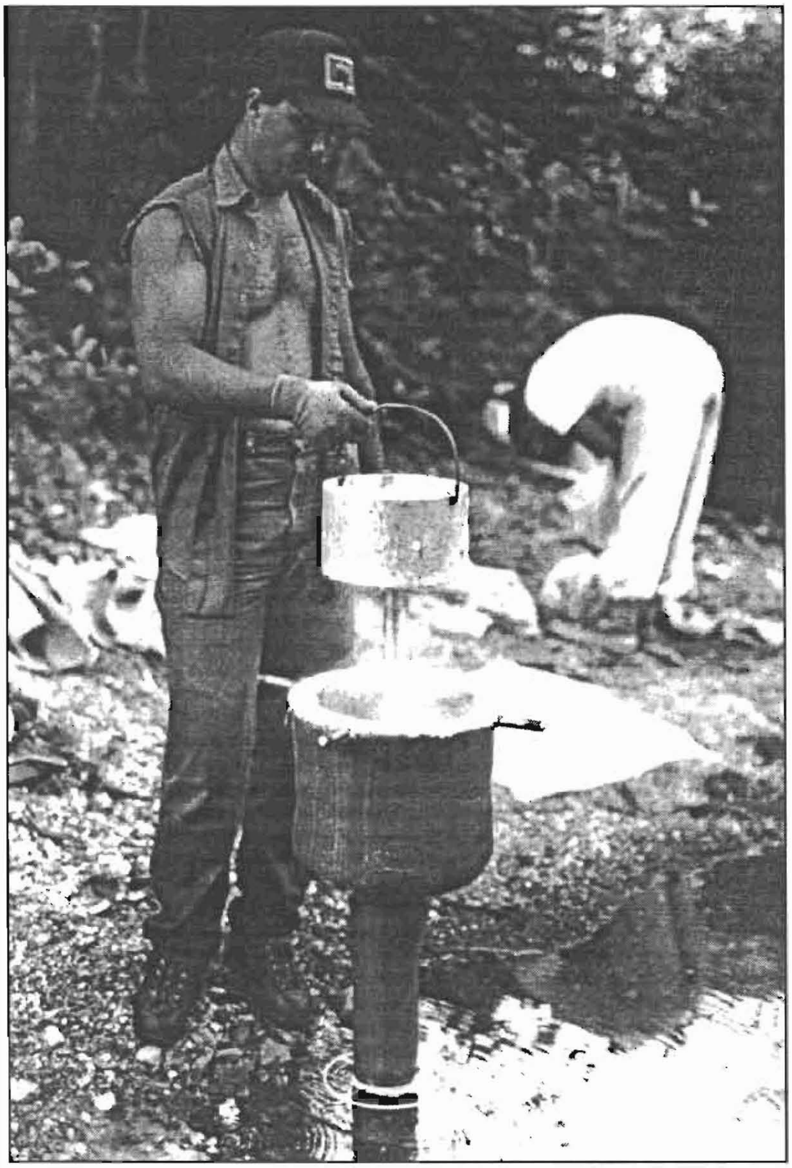
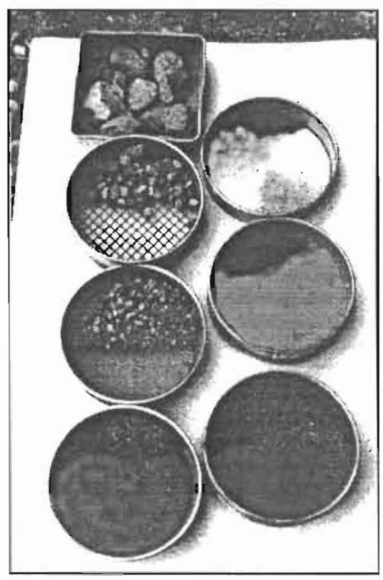



**Figure 2.** Map of Child Creek and surrounding region, identifying the two study tributary locations.



a.

b.



c.

**Figure 3.** Stream bed sampling and its particle size composition. (a) Core sampler; circulating acetone, cooled by dry ice in the insert funnel, freezes the stream bed cores. (b) Frozen stream bed core as it is removed form the stream. (c) Sieves used for subsequent sorting of dried gravel samples.

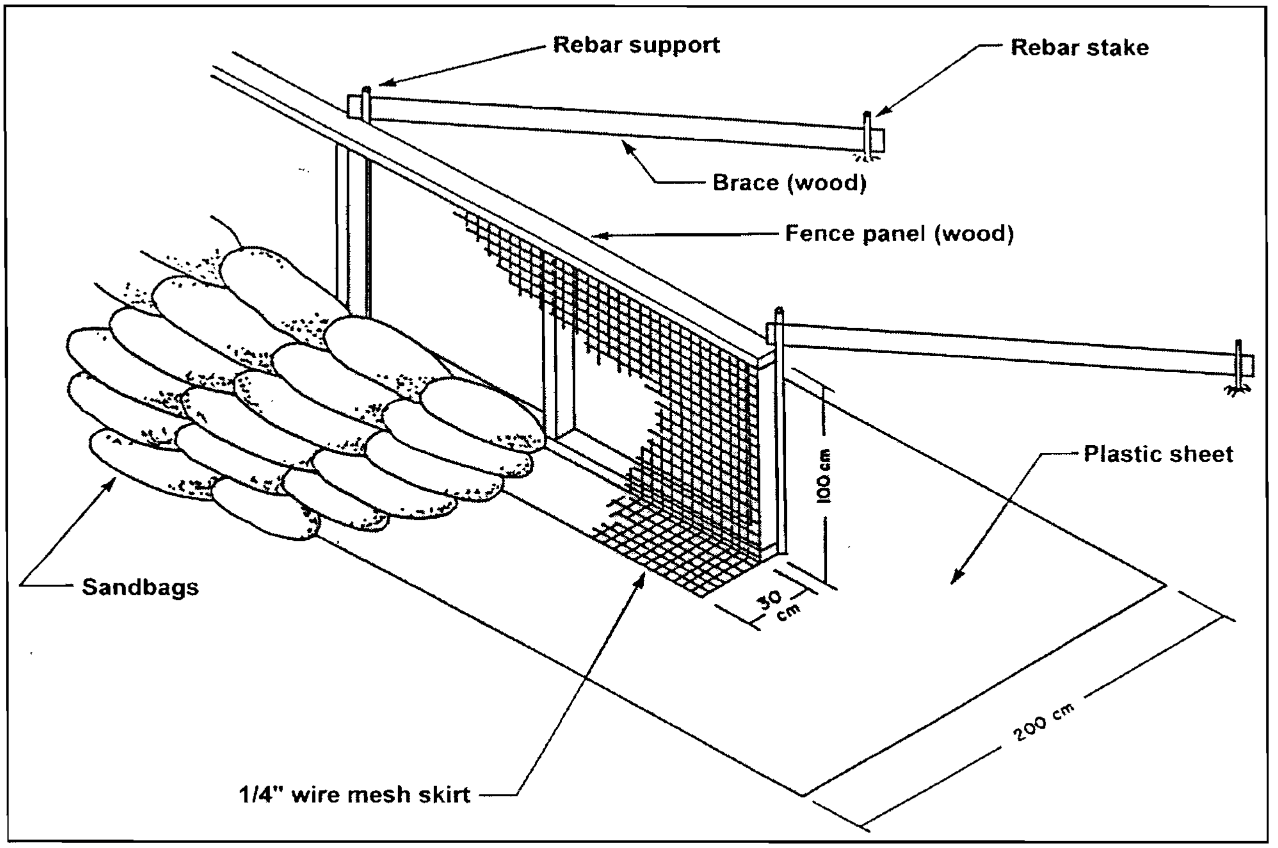



**Figure 4.** Details of downstream smolt fence. Deflection panel configuration.

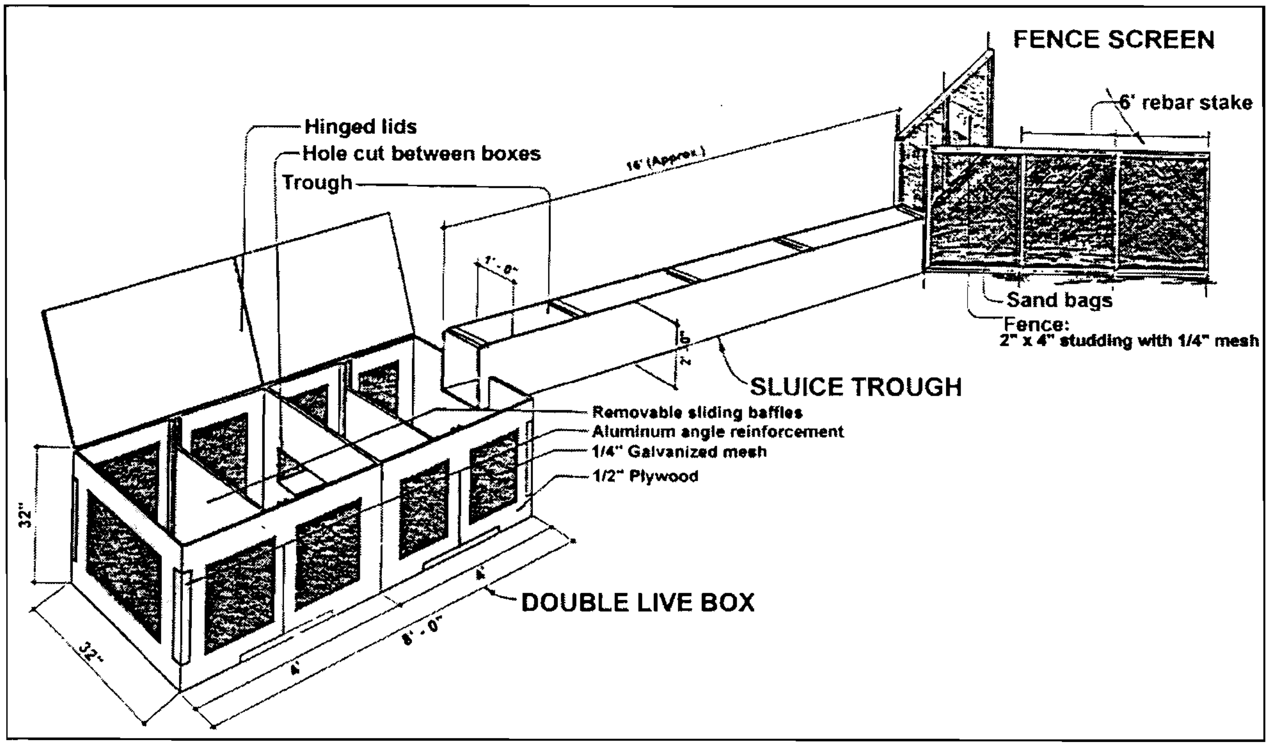



**Figure 5.** Downstream smolt fence and trap configuration. Note: Big-O tube (25 cm in diameter) was inserted within the sluice trough in actual field application.

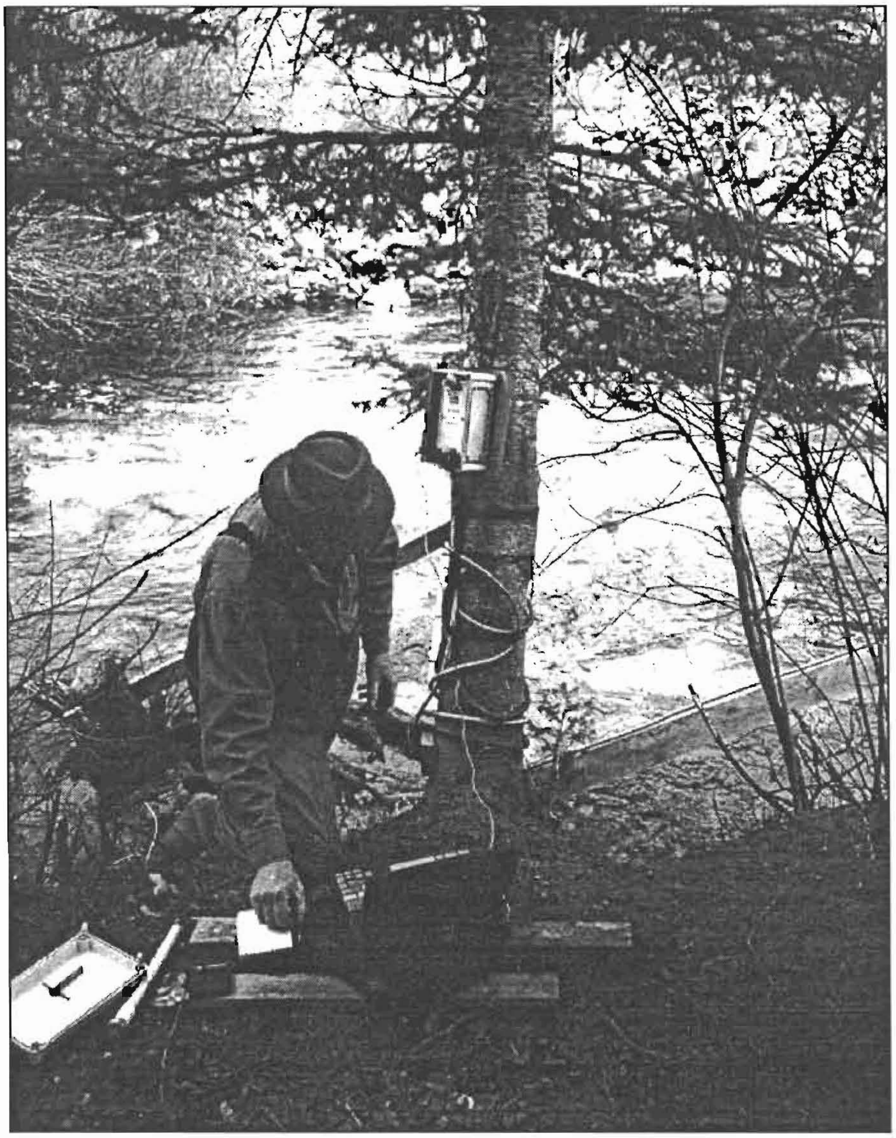


**Figure 6.** Downloading a field data logger using a portable computer. Data recovery occurred every 1-4 months at the beginning of the project and was reduced to twice per year in subsequent years.

## APPENDIX A

Available Physical Data Summary for Child Creek

**Appendix A.** A summary of the data available for Child Creek. Data was collected from July,1989, to May,1995.

| DATE | SOUTH TEMPERATURE | NORTH TEMPERATURE | AIR TEMPERATURE | REMARKS |
|---|---|---|---|---|
| 07/12/89 to 05/21/92 | X | X | X | |
| 05/22/92 to 07/15/92 | | X | X | No Southern arm stream temperatures due to erratic data logger readings. |
| 07/16/92 to 11/25/92 | | X | | No southern arm stream or air temperatures due to erratic data logger readings. |
| 11/26/92 to 09/11/94 | X | X | | No air temperatures due to erratic data logger readings. |
| 09/12/94 to 09/14/94 | | | | Data logger malfunction. |
| 09/15/94 to 05/17/95 | X | X | | No air temperatures due to erratic data logger readings. |

## APPENDIX B

Available Physical Data Summary for Park Creek

**Appendix B.** A summary of the data available for Park Creek. Data was collected from May, 1989, to December, 1995.

| DATE | STREAM TEMPERATURE | STREAM LEVEL | REMARKS |
|---|---|---|---|
| 05/01/89 to 09/06/89 | X | X | |
| 09/07/89 to 09/08/92 | X | | Water level data lost due to depth probe malfunctions and insufficient range. |
| 09/09/92 to 12/16/95 | X | X | |

## APPENDIX C

Available Physical Data Summary for Blue Creek

**Appendix C.** A summary of the data available for Blue Creek. Data was collected from July, 1988, to January ,1996.

| Date | Stream Temperature | Swamp Temperature | Stream Level | Air Temperature | Remarks |
|---|---|---|---|---|---|
| 07/28/88 to 09/08/88 | X | X | X | X | |
| 09/09/88 to 09/29/88 | | | | | Memory full as of 09/08/88 on Lakewood data logging system. Unable to collect data until downloaded and memory cleared. |
| 09/30/88 to 12/12/88 | X | X | X | X | |
| 12/13/88 to 12/19/88 | X | X | X | | Air temperature data not collected as a result of animal interference with temperature probe. |
| 12/20/88 to 04/05/89 | X | X | X | X | |
| 04/06/89 to 04/10/89 | | | | | Memory full. Unable to collect data until data was down loaded and memory cleared. |
| 04/11/89 to 07/30/89 | X | X | X | X | |
| 07/31/89 to 08/23/89 | | | | | Lakewood data logging system malfunctioning. Unit replaced with Unidata logger system. |
| 08/24/89 to 08/31/89 | X | X | | | Unidata logger system only recording stream and swamp temperatures. |
| 09/01/89 to 10/18/89 | | | | | Unidata logger system malfunctions, no data collected during this period. Temporary Unidata logger system replaced with repaired Lakewood system. Unit installed and set to measure stream and swamp temperature, stream level and air temperature. |
| 10/19/89 to 10/29/89 | X | X | X | X | |
| 10/30/89 to 02/06/90 | X | X | X | | Air temperature probe malfunction. |
| 02/07/90 to 04/10/90 | | | | | Memory full. Unable to collect data until memory was downloaded and cleared. |
| 04/11/90 to 05/22/90 | X | X | X | | Air temperature probe malfunction. |
| 05/23/90 to 07/31/90 | | X | | | Experiencing probe problems. New probes installed 07/31/90. |
| 08/01/90 to 09/14/90 | X | X | | | |
| 09/15/90 to 11/04/90 | | X | | | |
| 11/05/90 to 03/19/91 | | | | | Logger malfunction due to high water conditions. Unit replaced with Unidata system 30 m downstream of older Lakewood site. |
| 03/20/91 to 08/29/91 | X | X | X | X | |
| 08/30/91 to 12/16/91 | | | | | Data not recovered due to insufficient battery power. |
| 12/17/91 | X | X | X | | |
| 12/18/91 to 04/24/92 | X | X | X | X | |
| 04/25/92 | | X | | | |

| Date | Stream Temperature | Swamp Temperature | Stream Level | Air Temperature | Remarks |
|---|---|---|---|---|---|
| 04/26/92 to 05/04/92 | | | | | Memory full. Unable to collect data until memory was downloaded and cleared. |
| 05/05/92 | | X | | | |
| 05/06/92 to 07/08/92 | X | X | X | X | |
| 07/09/92 to 09/11/92 | X | | X | X | No swamp data. Site conditions dry. |
| 09/12/92 to 04/02/93 | X | X | X | X | |
| 04/03/93 | X | X | X | | |
| 04/04/93 to 04/05/93 | | | | | Memory full. Unable to collect data until memory was downloaded and cleared. |
| 04/06/93 | X | X | | | |
| 04/07/93 to 09/10/93 | X | X | X | X | |
| 09/11/93 to 10/13/93 | X | | X | X | No swamp data. Site conditions dry. |
| 10/14/93 to 08/14/94 | X | X | X | X | |
| 08/15/94 to 09/07/94 | X | | X | X | No swamp data. Site conditions dry. |
| 09/08/94 to 10/02/94 | X | X | X | X | |
| 10/03/94 | X | X | X | | |
| 10/04/94 to 01/04/95 | | | | | Memory full. Unable to collect data until memory was downloaded and cleared. |
| 01/05/95 | X | X | | | |
| 01/06/95 to 05/14/95 | X | X | X | X | |
| 05/15/95 | X | X | | | |
| 05/16/95 | | | | | Memory full. |
| 05/17/95 | X | X | | | |
| 05/18/95 to 07/16/95 | X | X | X | X | |
| 07/17/95 to 07/25/95 | X | | X | X | No swamp data. Site conditions dry. |
| 07/26/95 to 09/13/95 | X | X | X | X | |
| 09/14/95 to 09/26/95 | X | | X | X | No swamp data. Site conditions dry. |
| 09/27/95 to 01/25/96 | X | X | X | X | |
| 01/26/96 | X | X | | | |

## APPENDIX D

Available Physical Data Summary for Ralf Creek

**Appendix D.** A summary of the data available for Ralf Creek. Data was collected from July, 1988, to November, 1995.

| Date | Stream Temperature | Stream Level | Air Temperature | Remarks |
|---|---|---|---|---|
| | | | | |
| 07/28/88 to 09/21/88 | X | X | X | |
| 09/22/88 | X | | | |
| 09/23/88 to 09/28/88 | | | | Memory full. Unable to collect data until memory was downloaded and cleared. |
| 09/29/88 | X | | | |
| 09/30/88 to 10/26/88 | X | X | X | |
| 10/27/88 | X | X | | |
| 10/28/88 | | | | Data logger down for reprogramming. |
| 10/29/88 to 07/10/89 | X | X | X | |
| 07/11/89 to 08/14/89 | X | X | | Air temperature probe malfunction. |
| 08/15/89 to 02/18/90 | X | X | X | |
| 02/19/90 | X | | | |
| 02/20/90 | | | | Memory full. Unable to collect data until memory was downloaded and cleared. Air temperature probe repaired. |
| 02/21/90 | X | | | |
| 02/22/90 to 12/17/90 | X | X | X | |
| 12/18/90 to 01/18/91 | X | X | | |
| 01/19/91 | X | | | Water level probe washed out. |
| 01/20/91 to 01/22/91 | | | | Memory full. Unable to collect data until memory was downloaded and cleared. Washed out water level probe replaced. |
| 01/23/91 to 04/06/91 | X | X | | |
| 04/07/91 | X | | | |
| 04/08/91 to 04/09/91 | | | | Lakewood data logger system replaced with Unidata system. Logger programmed and installed on April 10th, 1991. |
| 04/10/91 to 06/27/91 | X | X | X | |
| 06/28/91 | X | X | | Logger off-line for downloading. |
| 06/29/91 | | X | X | |
| 06/30/91 to 07/02/91 | X | X | X | |
| 07/03/91 to 07/14/91 | | X | X | Drop in water level, beyond range of temperature probe. |
| 07/15/91 to 07/16/91 | X | X | X | |
| 07/17/91 | X | X | | Fluctuations in available data between 07/17/91 and 08/26/91, is due to problems with sensors. Specifically the 1 metre depth probe did not have enough range to cover the water level changes experienced. |
| 07/18/91 to 07/20/91 | | X | X | |
| 07/21/91 to 07/22/91 | X | X | X | |
| 07/23/91 | X | X | | |
| 07/24/91 to 07/25/91 | | X | X | |
| 07/26/91 | X | X | | |
| 07/27/91 | X | X | X | |
| 07/28/91 | X | X | | |
| 07/29/91 to 08/06/91 | | X | X | |
| 08/07/91 to 08/08/91 | X | X | | |

| Date | Stream Temperature | Stream Level | Air Temperature | Remarks |
|---|---|---|---|---|
| 08/09/91 to 08/10/91 | X | X | X | |
| 08/11/91 to 08/13/91 | | X | X | |
| 08/14/91 to 08/25/91 | | | X | |
| 08/26/91 | X | X | | |
| 08/27/91 to 09/01/91 | X | X | X | |
| 09/02/91 to 09/05/91 | | X | X | |
| 09/06/91 | | X | | Battery dead, existing data downloaded and logger replaced. |
| 09/07/91 to 09/14/91 | | | X | |
| 09/15/91 to 09/19/91 | | | | |
| 09/20/91 to 10/15/91 | | | X | |
| 10/16/91 | X | X | | |
| 10/17/91 | | X | | |
| 10/18/91 to 11/02/91 | | | X | Data logger malfunction. |
| 11/03/91 | | X | | |
| 11/04/91 to 11/10/91 | X | X | X | |
| 11/11/91 | X | X | | |
| 11/12/91 to 11/18/91 | X | X | X | |
| 11/19/91 | X | X | | |
| 11/20/91 to 04/11/92 | X | X | X | |
| 04/12/92 | X | | | |
| 04/13/92 | | | | Memory full. Unable to collect data until memory was downloaded and cleared. |
| 04/14/92 | X | | | |
| 04/15/92 to 04/02/93 | X | X | X | |
| 04/03/93 | X | | | |
| 04/04/93 to 04/05/93 | | | | Downloading of existing data logger and the installation of a new data logger. |
| 04/06/93 | X | | | |
| 04/07/93 to 06/07/93 | X | X | X | |
| 06/08/93 | X | | | |
| 06/09/93 to 10/07/93 | | | | Unable to record data due to a dead battery. |
| 10/08/93 | X | | | |
| 10/09/93 to 01/18/94 | X | X | X | |
| 01/19/94 | X | | | Memory not recovered. |
| 01/20/94 | X | X | | |
| 01/21/94 to 12/29/94 | X | X | X | |
| 12/30/94 | X | X | | Lake of water level data and erratic air temperatures (12/31/94 to 05/15/95) due to probe malfunctions. |
| 12/31/94 to 01/01/95 | X | | X | |
| 01/02/95 | X | | | |
| 01/03/95 to 05/14/95 | X | | X | |
| 05/15/95 | X | | | |
| 05/16/95 to 05/17/95 | | | | Logger servicing. |
| 05/18/95 to 11/06/95 | X | | | |