The Biological Design Process Used in the Development of Federal Government Facilities During Phase I of the Salmonid Enhancement Program

B.G. Shepherd

Salmonid Enhancement Program
Department of Fisheries and Oceans
Vancouver, British Columbia V6E 2P1

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INTRODUCTION

Pearse (1982) recommended a cautious approach to salmonid enhancement, giving top priority to "careful monitoring and evaluation" of Phase I projects; in the interim, he felt "higher priority should be accorded to well proven techniques, smaller and less risky projects ..." than to major projects.

At the time of publication of this report, SEP in fact has become far more conservative in planning and constructing new major projects. This approach has merit if it allows more effort to be directed towards assessment of existing facilities. However, such a strategy also is likely to result in loss of expertise at the detailed facility planning level if there is a prolonged period of evaluation of existing facilities. Having been involved from the outset in the development of an effective bioengineering interface, I felt a formal overview was necessary in order to guard against future potential loss of development expertise.

This report outlines the development of processes that ensured biological input to the design of federal government facilities during Phase I of the Salmonid Enhancement Program (SEP).

THE SCOPE OF THIS REPORT

It is emphasized that this report reviews just one aspect of the enhancement facility design process, the procedures used by the Enhancement Operations group to provide biological input to the design of those new facilities which the group was to operate. In paticular, this report discusses engineering procedures only where they relate to bioengineering interfaces. The Engineering group invests more time and effort in the development of facilities than all other groups combined, making the engineering design process well worth documentation in a separate report. Also, it should be noted that the Special Projects Group also has constructed facilities within SEP, generally using more conservative criteria (Appendix 1) to allow for training of the operating staffs used in their program.

The New Projects Unit approach is not displayed here as the perfect process (although a striking example of parallel evolution is the criteria development process for an Idaho hatchery, as outlined by Jeppson and Taylor, 1981). In fact, the design process as described in this report has never been followed fully for a particular project. Rather, the outline represents the author's personal perspective of the best possible approach.

This report is meant primarily to give Enhancement Operations staff a better understanding of how the present design approach came to be, what its constraints are, and how it can be improved in the future. Secondarily, it is felt that the report may be of wider interest; other groups may find our experiences worth review prior to their becoming involved in a major facility development program.

THE SALMONID ENHANCEMENT PROGRAM

For the reader to appreciate the limited scope of this report, some background on SEP is necessary.

Objectives

In the early 1900s, the potential yield of British Columbia's salmonid stocks was twice that of the 1970s. The primary objective of SEP is to return to that higher level of production. A two-year planning process began in 1975, culminating in a phased multiple-objective program proposal (Anonymous, 1978). The program, to be staged in two or more phases, is to restore historic stock levels by the mix of technologies that will best contribute to the federal government's national income, regional development, employment, native Indian well-being, and environmental preservation goals.[a] The first phase of the program was funded for five years (subsequently extended to seven years with no additional funds) beginning in 1977, and was to increase the annual catch of salmon by 23 million kilograms. From the outset, funding beyond 1984 was to be dependent upon the success of Phase I.

General Organization of SEP

The organizational structure required to drive a multiple-technology, multiple-objective program such as SEP is of necessity complex. The reader is referred to Pearse (1982) for a review of the form and function of the senior directive bodies of SEP; Figure 1 provides an overview of the senior framework up to September of 1983. Prior to that date, there were five line groups which reported to the Executive Director or his Associate Director:

Line Group	Description of Responsibilities
Finance	- Administrative and financial support
Program Development	- Program policy and direction studies - Biological and economic analyses of project 'manageability' and 'desirability' - Systems analysis/statistical support
Special Projects	- Implementation and supervision of community-contracted and public involvement projects - Unmanned stream improvement projects - Program information support - Bioengineering reconnaissance and feasibility studies of 'enhanceability' of new projects

[a] Commonly known as the 'five-account' system.

ABSTRACT

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This report outlines the processes developed to ensure biological input to the design of federal government facilities during Phase I of the Salmonid Enhancement Program. The report details the components of the biological design process in a step-by-step fashion. The report also provides an overview as to the need for such a process where there is commitment to a significant program of development of enhancement facilities.

Key words: hatcheries, enhancement, bioengineering, design, salmonids, Oncorhynchus, criteria, administration.

RÉSUMÉ

Shepherd, B.G. 1984. The biological design process used in the development of federal government facilities during Phase I of the Salmonid Enhancement Program. Can. Tech. Rep. Fish. Aquat. Sci. 1275: v + 188 p.

Le présent rapport porte sur les processus mis au point afin d'assurer un apport biologique à la conception d'installations du gouvernement fédéral au cours de la première phase du Programme de mise en valeur des salmonidés. Les composantes du processus de conception biologuiqe sont détaillées point par point. Le rapport fournit aussi une vue d'ensemble pour ce qui est du besoin d'un tel processus quand existe l'obligation de réaliser un important programme de développement d'installations pour la mise en valeur.

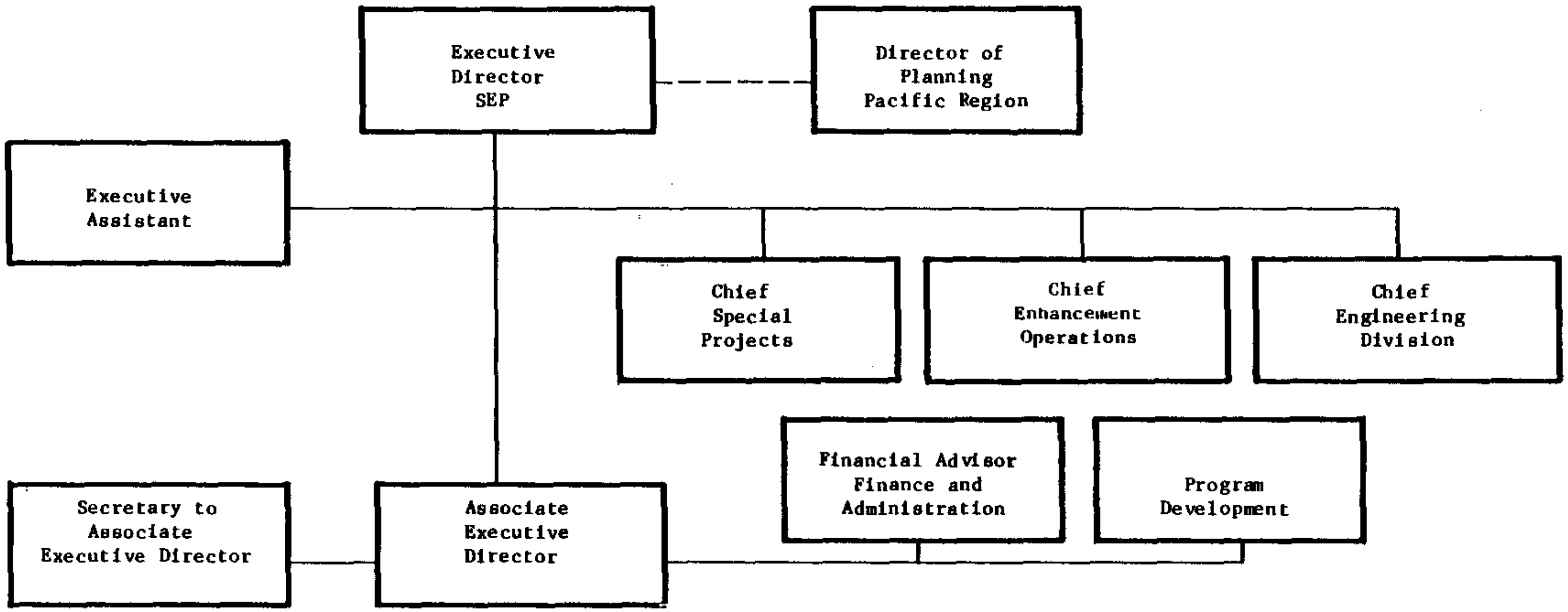

Figure 1. S.E.P. direction and planning: the senior administrative framework prior to September, 1983

Engineering	- Design, construction and maintenance of major projects - Engineering reconnaissance and feasibility studies of 'enhanceability' of new projects
Enhancement Operations	- Operation of federal government enhancement facilities - Biological reconnaissance and feasibility studies of 'enhanceability' of new projects

In September of 1983, reorganization of staff in the Pacific Region resulted in the following changes for SEP:

(1) An Associate Director General of the Pacific Region was appointed, who also serves as the Executive Director for SEP.

(2) The Chiefs of the Special Projects, Enhancement Operations and Engineering Divisions report on a day-to-day basis to the Associate Executive Director of SEP.

(3) The SEP Finance and Administration group was integrated into the Regional Support Services Branch reporting to the Associate Director General.

(4) The SEP Program Development and Regional Planning groups were integrated under one Director reporting to the Director General.

(5) Responsibility for SEP information was transferred to the Regional Director of Communications.

Enhancement Technical Selection Criteria

Regardless of which of the two possible line groups an enhancement project is proposed for, each new project must meet several criteria. These criteria are grouped into three general areas:

(1) Enhanceability. Analysis for enhanceability is typically the first step in the development of a new project. This can be undertaken by any of three line groups (Special Projects, Engineering and Enhancement Operations), and the potential for duplication of effort is high. Enhanceability studies consider water and land availability and suitability, access and power requirements, abundance of donor stocks and their disease profiles, and the

potential impact on other natural resources (detailed in later sections).

(2) Manageability. These analyses are undertaken by one of three[a] Geographic Working Groups (GWG). Each GWG is composed of senior federal and provincial management biologists, the Federal Fisheries District Supervisor, and a representative from the Habitat Management Branch. The GWG also provides a regional perspective for SEP proposals. A planning biologist from the SEP Program Development Group was assigned to each GWG, to transmit SEP project proposals to the GWG and to provide analytical support as required by the GWG. Manageability evaluations focus on assessing whether the stocks to be enhanced can be managed as discrete units without overexploitation or detrimental impacts on other stocks, and whether the proposed production levels are compatible both with the carrying capacities of the environment and with other departmental programs. Decisions and recommendations from the GWGs are forwarded to the SEP Executive Management Committee, which is comprised of the SEP Executive and Associate Directors, the Chiefs of the line groups, and representatives from the Field Services Branch, the Fisheries Research Branch and the province.

(3) Desirability. Planning biologists and economists evaluate each proposal in terms of the five account framework. The federal Treasury Board's Guide to Benefit-Cost Analysis sets the rules under which net national income benefits and benefit-cost ratios are calculated; key indicators for each of the other four accounts are subjectively scored and weighed to provide a rating for each account (for details see Economics Working Group, MS 1977). Technical desirability is not formally assessed for factors such as contribution to technological development, minimization of technological risk and energy needs for operation of facilities, and avoidance of foreclosure of future options. Rather, these items are considered on an ad-hoc basis for individual projects by the biological and engineering groups involved. If dissension between groups is severe, the matter is referred to the Executive Director for a decision.

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[a] North Coast, South Coast, and Fraser R. - Northern B.C. - Yukon; geographic limits of jurisdiction correspond to those of the Field Services Divisions.

Organization of the Enhancement Operations Group

It is perhaps useful to review briefly the evolution of Enhancement Operations. Prior to 1971, Departmental biological activities were organized by the species of salmon associated with major gear types (Southern Net Species, Northern Net Species, and Chinook/Coho Groups). Because the few culture facilities then in operation were dominated by chum, pink and sockeye, with chinook and coho culture largely experimental, the two Net Species groups administered the existing facilities.

In 1971, as a result of a Management By Objective (MBO) exercise, the Department was split geographically into two branches and six divisions:

Branch	Division
North Coast	Northern B.C. and Yukon
	North Coast
	Central Coast
South Coast	West Coast Vancouver Island
	Georgia Strait
	Fraser River - Johnstone Strait

Enhancement facilities were administered by the geographically appropriate division. This arrangement turned out to be somewhat unwieldy and was simplified in 1976 to the present system of three geographic Divisions (North Coast, South Coast, and Fraser River - Northern B.C. - Yukon).

With the formation of the-then Enhancement Services Branch in 1977, there was an initial shift from a geographic to technological grouping of the enhancement facilities into Hatcheries, Spawning Channels, Incubation Systems, and Small Projects sub-groups. This rapidly proved unworkable, what with combination facilities and other logistical difficulties. By mid-1978, the four sub-groups had coalesced into two, a Hatcheries Group and an Incubation Systems Group. Functionally, however, all staff members except the two Group Managers were assigned to one or two facilities, and they thus largely retained a geographic separation in their working relationships. This caused a number of problems, particularly for new facilities. Biological input to the design process was inconsistent, poorly documented, and fragmented in approach. Project engineers would query the biological staff members that they thought could address the particular design problem. Such advice was often given off-hand, without complete appreciation of the particular situation or with only restricted experience of certain technologies, and therefore varied considerably. Some engineers took informal polls of the biological staff and then took it upon themselves to resolve the discrepancies and come to the 'right' answer. This caused a lot of confrontation, and attempts to research the bases for design decisions were often frustrated due to the lack of documentation of the information base and the assumptions used. In 1977, the Hatcheries Group Manager suggested that a large regional fish culture program required the following functional systems: (1) Information; (2) Program Assessment; (3) Technical Support; (4) Operation Support; and (5) New Projects (Sinclair, MS 1977). A major increase in bioengineering reconnaissance activity further emphasized the need for a separate group to deal with new projects on the regional level, and this was reflected in the reorganization of Enhancement Operations into its present structure in 1979.

The Enhancement Operations line group now is divided into five units (Fig. 2). Three of these units are responsible for the operation of existing facilities and have geographic boundaries identical to those of the GWGs and Field Services Divisions.[a] There is also a Biological Program Coordination Unit which is responsible for meshing annual production plans, improving the consistency and rapidity of data reporting from facilities, implementing programs common to all facilities (eg, computer systems and fish food quality control), and assessing the performance of facilities and culture techniques. Finally, there is the New Projects Unit, which is described in greater detail in the next section.

<u>The Role of the New Projects Unit</u>

The duties of the New Projects Unit are:

(1) To gather bioreconnaissance data to a level adequate to support facility design.

(2) In cooperation with the biological staff of Enhancement Operations, to develop biological design criteria for use in facility design.

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[a] The North Coast Unit covers all watersheds draining to the Pacific from the B.C.-Alaska border south to Cape Caution; the South Coast Unit has responsibility for the mainland coastal watersheds between Cape Caution and Howe Sound, Vancouver Island, and all Johnstone-Georgia Strait islands; the Fraser River-Northern B.C.-Yukon Unit handles the Fraser watershed, those watersheds in B.C. draining through the Alaskan Panhandle, and the Yukon.

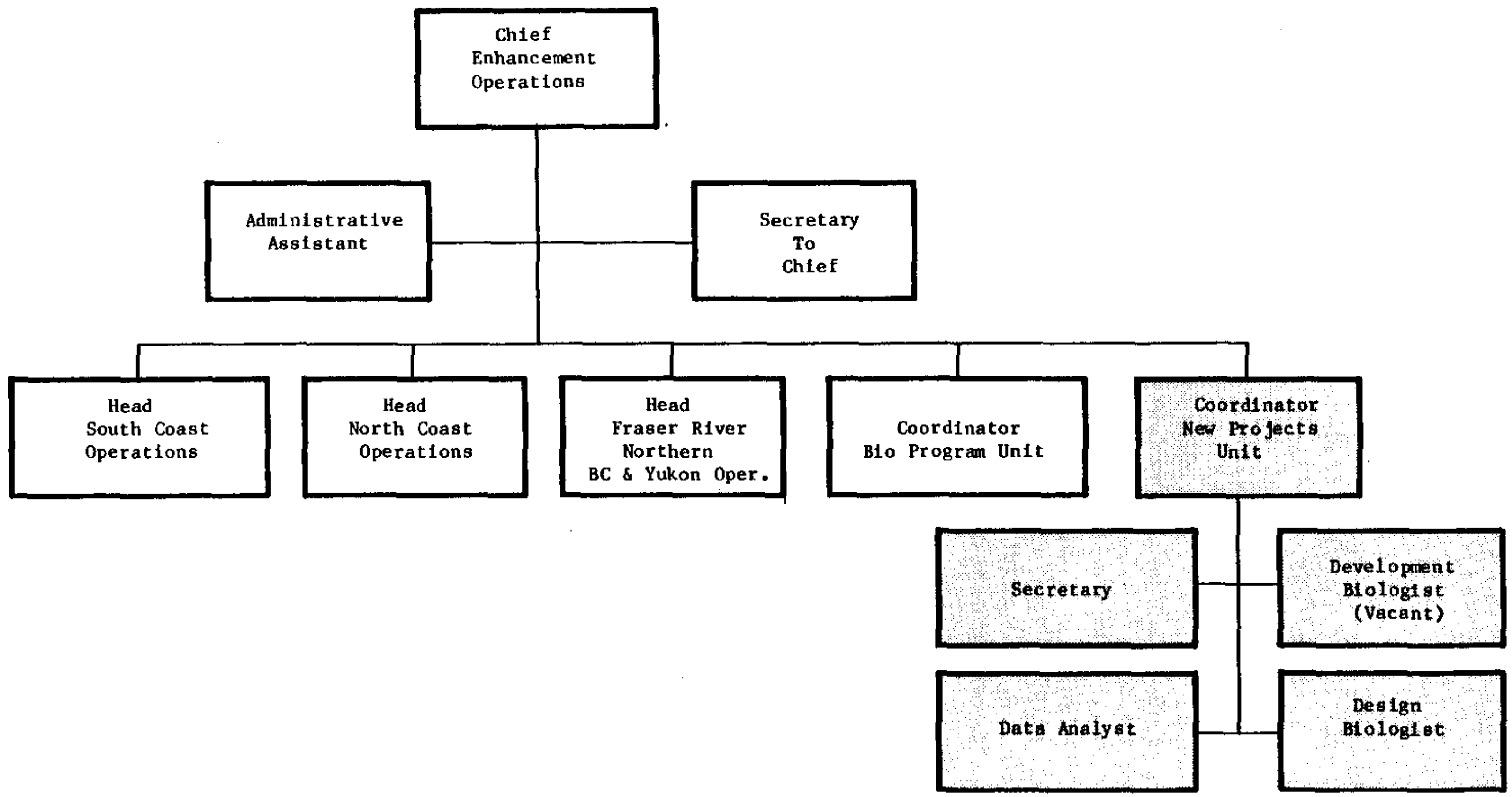

Figure 2. Organization chart for Enhancement Operations group and New Projects Unit

(3) To provide advice and guidance regarding biological criteria to Engineering during facility design, construction, and start-up.

(4) To monitor operational effectiveness of facilities during start-up.

With respect to item (4), manpower limitations have not allowed adequate follow-up, and the New Projects Unit is highly dependent on problem/success feedback from the Operations Units. Although this change has resulted in some items being overlooked in the first few years, it may be a healthy approach in terms of developing group dynamics and inter-unit communication in the long term.

It must be emphasized that the New Projects Unit's role is not to act as the sole source of advice to Engineering, but rather, to focus through coordination the best spectrum of biological expertise on the design problems at hand. The Unit also serves as a communications interface between the rather disparate languages and attitudes of the biological and engineering disciplines. Burrows (1981) felt that such an interface was a necessity.

THE BIOLOGICAL DESIGN PROCESS

AN OVERVIEW OF THE PROCESS

In September of 1976, an inter-agency workshop was held by SEP to review the major salmonid rearing systems that were available. The draft report on that workshop concluded that "...specific engineering design criteria could not be established without the knowledge of site characteristics." (Sinclair, MS 1976). That report called for project planning to "...include a well defined series of events to clearly identify objectives, characterize physical and biological site constraints, systematically assess alternative design options and finally arrive at the most economically efficient and biologically suitable design for the given site." With the exception of a systematic option-assessment procedure, these mechanisms are now part of the basic design cycle.

Table 1 charts the general route that SEP Phase I facility designs have followed (no one project has ever followed this schedule exactly through to completion). The New Projects Unit normally deals with new sites; however, it is also involved where new species or technologies are to be added to existing facilities. Where the expansion of an existing facility is straightforward, the operating personnel deal directly with the Engineering Division. Also, some of the new facilities constructed in Phase I (eg, Chilliwack) were designed before implementation of the present organization. To maintain continuity, those biological staff initially assigned to these projects saw them through to completion with minimal New Projects involvement.

Table 1. Flow chart for design of SEP facilities.

	Item	Groups	Approximate Time Frame
1.	Production objectives	GWG and SEP Senior Executive	
2.	Senior-level reconnaissance to gauge systems' potentials	Bioengineering reconnaissance	4 inspections at key times of year
3.	Detailed feasibility studies	New Projects Unit and Engineering Division	1 - 2 yr
4.	Formal Biological conceptual design	New Projects Unit	2 - 4 wk
5.	Preliminary design drawings	Engineering Division	variable (1 - 6 mo)
6.	Bioengineering concept review	Biological* and Engineering groups	1 - 2 wk
7.	Site layout/flow schematic	Engineering Division	2 - 4 wk
8.	Concept finalization		1 - 2 wk
	a) blueprint review	Biological group	
	b) meeting & concept approval	Biological and engineering groups	
9.	Costing		1 - 2 wk
	a) Operational	Operations Unit	
	b) Capital	Engineering	
10.	Production Forecasts	New Projects Unit	1 wk
11.	Treasury Board submission (includes benefit-cost calculations)	Chief of Engineering Division, Economics Unit section of Program Development group, and New Projects Unit	2 - 4 wk
12.	Treasury Board Approval	Treasury Board	3 wk
13.	Detailed design	Engineering Division (New Projects input as required)	variable (3 wk - 2 mo)
14.	Detailed design review(s) (entire facility, or by components if large)		
	a) blueprint review	Biological group	1 wk
	b) orientation meetings as necessary	Biological and Engineering Groups	0.5 day
	c) review meetings/memo responses	Engineering and Biological groups	1 wk
15.	Design completion	Engineering Division	(min. 1 wk) variable
16.	Final design review/approval meeting (double-check inclusion of amendments)	Biological and Engineering groups*	1 wk
17.	Project to tender	Engineering Division	1 - 2 wk

* Biological group normally includes New Projects coordinator and biologist; Operations Unit head, biologist and manager/advisor; Enhancement Operations Chief; and Fish Culture biologist from B.C. Fish and Wildlife where steelhead or cutthroat are being included.

STEPS IN THE PROCESS

Step 1 - Production Objectives

Initially, facility targets were developed in a piecemeal fashion through internal memos among the Engineering Division, various biological groups, and the GWGs. For the first half of Phase I, the GWGs had to catch up. The formulation of management strategies and priorities for each area required considerable effort, and was further complicated by changes in GWG perspectives with staff and data-base changes. The targetting process has now been standardized to the following procedure. With the assistance of Program Development planning biologists, the GWGs divided their regions into a series of management units. Each unit was reviewed as to its stock status and management characteristics and dependencies. On the basis of these reviews, recommendations on the potential and priority for additional production of each species were distributed as a planning document (Schouwenburg et al, MS 1980; for sample excerpt, see Appendix 2). This document is to be updated at regular intervals. The guidance provided in this document is for the most part at the area level. These general objectives are meshed with the physical potential of the site (evaluated by Engineering and New Projects staffs), and facility-specific strategies and targets normally are negotiated as follows. The New Projects Coordinator usually contacts the SEP Planning representative assigned to the GWG, and the Coordinator provides a memo to the GWG outlining the proposed facility-specific strategies and targets. The GWG meets, reviews the proposal and provides comments back, both through the Planning representative and a confirmatory memo. Where further modifications to the production targets become necessary, the process is repeated until resolution is achieved.

In one way, the delays and changes experienced with facility targets during the first years of SEP were beneficial. Such uncertainty, combined with cash-flow constraints, forced the development of flexible designs. Even where present production objectives may seem clear-cut, it is recommended that as much flexibility as possible be built into a facility. This is emphasized because in practice, few existing hatcheries have maintained their original objectives throughout their operating lifetime.

Step 2 - Senior-level Reconnaissance

When Phase I commenced, a number of enhancement projects had been well-researched and were ready to be implemented. However, the majority of proposed projects[a] required further investigation to confirm their potentials.

Most of the major salmon-bearing areas of British Columbia have now been surveyed and reported on by bioengineering teams normally consisting of the New Projects Coordinator and a Senior Engineer. Whenever possible, the local Fishery Officers are asked to participate in these surveys and impart their additional local knowledge of the systems. These surveys initially were province wide, but more recently have focussed on those priority areas identified by the GWGs in their reviews.

These surveys preferably are done by helicopter. This is because the helicopter offers the speed and range to cover large areas quickly, yet allows close-up examination of any key features noted during the surveys. The surveys are meant to provide an overview, such that the most promising sites can be flagged for more intensive groundwork. Ideally, the reconnaissance team should survey the area four times.

The first general survey is undertaken preferably during a good weather and clear water period in the summer, as it is on this general survey that the team gains its orientation to the geography of the area.

During this and subsequent surveys, the following general information for the watersheds is noted:

- size of watershed (reflects water storage capacity)
- drainage pattern of watershed (eg, dendritic vs radial or parallel networks can indicate stability of subsurface geology)
- watershed topography (eg, low-lying terrain will result in more stable discharge patterns than steep terrain)
- number and size of lakes (buffer sediment load, temperature and magnitude of discharges)
- type and extent of vegetation (buffering effects similar to lakes)
- actual stream flow versus flood channel size and amount of meandering (indicators of stream stability)
- streambed materials, gradient, and amount of braiding (indicators of rearing and spawning potential)
- water color, turbidity, and temperature (water quality indicators)
- type, location and height of any obstructions or high-gradient sections (useful in defining limits to salmon distribution as

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[a] Project listings were developed by each of three GWGs (pre-SEP organization differed, in that each GWG had one or more representatives experienced in enhancement bioengineering).

well as potential for gravity supply[a] of surface water to a facility for fish or power)

- potential for groundwater (eg, springs and delta areas indicate potential; rock outcrops do not)
- competing resource activities in watershed (agriculture, logging, mining, industrial or urban development)
- location and type of human settlement (labor and logistical support potential)
- type and proximity of access to potential sites
- type (single-phase or three-phase) and proximity of power

Often, this first survey will result in the outright elimination of many systems from further consideration. For those systems still remaining, three more surveys should be scheduled for key periods of the year.

A spawning survey is timed to coincide with the peak spawning period of the key stocks in the area. The numbers and distribution of spawners are examined in relation to the physical potential of the habitat. Also, the vulnerability of adults to the various methods of capture is considered (ie, holding areas and potential fence sites are identified).

A winter survey should be undertaken during a period of extreme cold between December and February. This survey is particularly useful in identifying and measuring groundwater outflows. In addition, the team can evaluate potential problems associated with low winter flows, such as dewatering of redds or the impact of icing conditions on the winter operation of any proposed facilities.

A flood survey, mounted during the time of peak runoff, considers factors such as scouring or erosion, the extent of flooding on potential sites, and water turbidity. Depending on circumstances, this survey may be optional.

More recently, the bioengineering team often has been able to make only one joint survey, thereafter breaking into their specialist groups to do the remaining surveys. While in some ways this approach may be more efficient, I feel that both groups gain a far better understanding of the area, as well as of the other group's concerns, when the team participates in all four surveys.

Upon completion of these surveys, a formal memo report is prepared. This report summarizes the observations made and identifies those enhancement opportunities worthy of further feasibility studies.

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[a] A net head of 0.5 - 5.0 m within 0.5 km of the facility site is needed to economically develop an adequate gravity supply to a facility.

The final choice of site may be affected by intangible factors such as political initiatives; where such direction is evident, its impact should be assessed.

In preparation for the continuation of SEP beyond Phase I, various planning exercises have been undertaken. As part of these exercises, an Enhancement Opportunities Subcommittee (EOS) was formed to update the listing of enhancement opportunities. The EOS was made up of representatives from the BCFW, the Habitat Management Division of DFO, and the SEP Enhancement Operations, Engineering, Program Development and Special Projects groups. With the assistance of federal and provincial regional staff, the EOS compiled opportunity lists for each statistical area. The EOS also developed biological, engineering and economic standards, against which each opportunity was then rated (see Lill et al, MS 1983, for details of EOS procedures; a sample listing is provided in Appendix 3). These listings proved quite useful in preparing both general and reconnaissance program submissions for the continuation of SEP.

Step 3 - Feasibility Studies

Those systems and sites identified as having the best potential in the senior-level reconnaissance surveys are subjected to more intensive investigation by Engineering and the New Projects Unit. Such investigations, some of which may be done by either group (Table 2), are comprised of a number of components. In this report, emphasis is placed on those components for which the New Projects Unit takes responsibility.

Ground Inspections of sites should be undertaken jointly with Engineering. They are done in order to obtain additional overview information on site topography, available head, feasibility of access, type of vegetative cover and amount of merchantable timber, soil types and rock outcrops, groundwater seepages, utilization by wildlife, etc.

Biological Baseline Studies can be divided into two major activities: collation of existing data and generation of new data through fieldwork. Initially, the New Projects Unit attempted to collate all existing data of biological value in further biorecon- naissance and facility planning into 'backgrounder' reports. These reports were generated by the Unit's Data Analyst, and temporary help such as summer students. To enable relatively inexperienced staff to cover all potential data sources for each watershed effectively and consistently, a 'Primary Sources Manual' was compiled, which listed key references and contacts by agency and type of information. This manual is kept in looseleaf form to facilitate continuous updating. Only a few backgrounders were formally completed (Helm et al, MS 1980a and MS 1980b; MacDonald and Shepherd, MS 1983), due to a lack of manpower and to midstream switches in project priorities for various reasons -- one example of the latter being the moratorium imposed in 1979 on Nechako River

Table 2. Feasibility studies required for development of a SEP facility (in approximate chronological order).

		Responsibility		
Type of Study	Minimum Duration	New Projects	Engineering	Other
Ground Inspections	1 wk	X	X	
Biological Baseline Studies	1-2 yr	X		
Aerial Photography	3 mo		X	
Authority to Enter Land	3 mo		X	
Ground Control Survey	3 mo		X	
Topography Mapping	3 mo		X	
Economic Overview	3 mo		X	X
Surface water Monitoring	1 yr	X	X	
Groundwater Potential	1 mo		X	
Establish Access	variable		X	
Test Well(s)	2 mo		X	
Groundwater Monitoring	1 yr	X	X	
Alternate Site Analysis	6 mo		X	
Acquisition/Zoning of Land	6 mo		X	X

enhancement, until Departmental concerns with the Kemano II hydroelectric project had been resolved. It is still felt that this type of review would be well worth undertaking, in that it could improve planning and avoid duplication of fieldwork. Unfortunately, continuing constraints in both manpower and timeframe have forced the Unit into only cursory and informal reviews of key data items, which are gathered in New Projects central files, and incorporated into contract specifications for proposed fieldwork. Also, this type of review activity has been increasingly requested as part of consultant biobaseline studies (see below).

With respect to fieldwork, New Projects staff themselves now undertake only minor reconnaissance efforts due to manpower constraints. The majority of biobaseline studies are done through contracts with consultants, BCFW, or through other government programs such as Job Creation. There are definite drawbacks to this approach, such as the loss of in-house staff expertise in fieldwork and local knowledge. Also, the government contracting-out process is lengthy (see outline in Table 3), making it essential to establish an effective working relationship with the Department of Supply and Services (DSS). Various other steps have been taken to streamline contracting procedures, such as standardization of contract specifications (Appendix 4) and the use of word processors.

Depending on the situation, the field studies can incorporate general biophysical reconnaissance for adult and juvenile phases, as well as site-specific feasibility work. Appendix 4A gives a general outline of program specifications as currently requested by Enhancement Operations staff.

Initially, much effort went into attempting to estimate juvenile and adult populations accurately, and to collect and rear fry for coded-wire tagging. These program components were expensive and often conflicted with other program objectives, such as definition of the distribution and duration of rearing. For the purposes of facility design, the start/peak/end dates of the wild fry migration are crucial; accurate enumeration of wild fry populations is needed only where facility fry may be outplanted for final rearing. Similarly, adult migration timing is critical; highly accurate numbers of spawners are no more useful than knowing whether past estimates by Field Services can be used to project average availability of broodstock (to date, independent fishery officer estimates have most often ranged from one-half to equivalency with study estimates). Coded-wire tagging of juveniles is of no direct use to facility design, but was included to provide information on stock contributions to fisheries. The first tag returns from wild stocks that had been pen-reared to taggable size were very poor, and management biologists requested that all such tagging programs be terminated. Elimination of these items

Table 3. Flow chart for contracting out of New Projects biobaseline studies (assuming juvenile downstream migration monitoring required).

Activity	Group[b]	Completion Date
Final selection of study streams	NPU	Nov. 1
Collection of background stream data	NPU	Nov. 15
Design of studies and development of RFP[a]	NPU	Dec. 1
Drafting and typing of RFP specifications	NPU	Dec. 15
Requisition preparation and signature authority to $100,000 level	NPU	Dec. 21
Preparation of RFP and mail-out	DSS	Jan. 1
Bidder preparation of proposal; tender closure	CON	Jan. 21
Evaluation of proposals and bidder selection	NPU	Feb. 15
Negotiation with successful bidder; Ottawa DSS approvals	DSS	Mar. 15
2 wk mobilization; fieldwork begins	CON	Apr. 1

[a] RFP = Request For Proposal

[b] NPU = New Projects Unit
DSS = Dept. Supply & Services
CON = Consultant

resulted in cost savings and allowed coverage of additional systems.

Further logistical and cost savings have been possible, both by consolidating neighbouring systems into a regional study package and by coordinating with other groups where possible. An example of the latter is the addition of an adult coho sampling component to a North Thompson juvenile tagging program undertaken for Field Services by a Job Creation crew. To maximize savings through joint studies requires good communications during planning of fieldwork. Because effective communication is difficult in a large and diverse organization such as DFO, the New Projects Unit encourages production of the 'Fieldwork Bulletin' as a regular update on the reconnaissance plans and activities of the various arms of DFO and BCFW.

At least two years' adult and juvenile data should be collected in order to allow some evaluation of variation between years.

To ensure effective biobaseline contract supervision despite manpower constraints, the New Projects Unit has at times contracted with companies to provide technical monitors (for contract specifications, see Appendix 4B).

A list of the biobaseline reports generated for the New Projects Unit to date is provided in Appendix 5.

Water Quality Monitoring of both surface and groundwater sources is done for at least one full year by New Projects Unit staff. Where possible, sites are geographically grouped, and sampling circuits are undertaken four times over the year. During each visit to a site, a 'hatchery series' water quality sampling is done (see Table 4 for parameters sampled and culture limits; Appendix 4C outlines methods). In addition, a three- or six-month thermograph (generally a submersible model such as the Peabody-Ryan J-90 or J-180) is installed on the first trip and serviced on succeeding trips. Where there is any concern regarding the dissolved gas content of the water, the source will be measured at least once using a tensionometer and an oxygen kit. On every visit, water temperature and pH are measured with a calibrated pocket thermometer and Hach kit.

Where wells are developed by Engineering specifically for enhancement facilities, another water quality sampling sequence is followed. In general, each well is pumped at a minimum 1200 LPM over 96 hr and sampled every 24 hr. Although New Projects Unit staff did all sampling at first, manpower constraints coupled with scheduling uncertainty dictated that the on-site sampling and shipping be contracted out. Appendix 4C outlines the specifications used for that contract. Equipment normally used for

Table 4. Water quality parameter screening table (taken from Sigma, 1983).

CAUTION:
The levels in this table are not criteria; they are intended only to indicate which of the parameters in a water analysis require closer examination and comparison with detailed criteria. Notes outlining the rationale for establishment of the screening levels are given following the table.

Fish Culture Parameters	Recommended Screening Levels[1]	Metals	Maximum Acceptable Levels(ug/l)
Alkalinity[2]	G 15 mg/l as $CaCO_3$	Aluminum (total)[12]	100
Ammonia (total)[3]	L 0.05 mg/l as N	Cadmium (dissolved)	0.3
Carbon Dioxide[4]	L 10 mg/l CO_2	Chromium (total)	40
Dissolved Oxygen[5]	G 11.2 mg/l O_2 and G 95% saturation	Copper (dissolved)	2
		Iron (total)[12]	300
Hardness[6]	G 20 mg/l as $CaCO_3$	Mercury (total)	0.2
Hydrogen Sulphide (total sulphide)[7]	L 0.002 mg/l as H_2S	Manganese (total)[12]	100
Nitrite[8]	L 0.015 mg/l as N	Nickel (total)	45
pH[9]	7.2 to 8.5	Lead (total)	4
Temperature[10]	5 to 10°C	Selenium (total)	50
Total Gas Pressure	L 103%	Silver (dissolved)	0.1
Suspended Solids[11]	L 3 mg/l	Zinc (dissolved)	15

NOTES TO ACCOMPANY TABLE 4

1 G = Greater than; L = Less than

2 This is a suggested minimum level of alkalinity to buffer pH changes in rearing ponds.

3 The total ammonia concentration of 0.05 mg/l as N, at pH 8.5 and T = 18°C, gives an unionized ammonia concentration of 5 ug/l NH_3-N. This value is 50% of the maximum recommended level and therefore allows for an ammonia increase within the hatchery.

(Table 4 continued)

4 The recommended screening level allows for an increase in carbon dioxide within the hatchery.

5 A screening level of 11.2 mg/l O_2 corresponds to the most stringent dissolved oxygen criteria for hatchery operation. This is the minimum acceptable concentration for incubation of eggs just prior to hatch at a temperature of 10°C. The dissolved oxygen levels in any water source should also be examined closely if saturation is depressed below 95%. The causes of the DO drop from equilibrium and the potential for further DO depression should be investigated.

6 This is a suggested minimum level of hardness to reduce risks of toxic effects of metals, low pH and poor fish health. Although insufficient data are available to establish specific criteria for hardness, the importance of hardness (the divalent metallic cations Ca^{2+}, Mg^{2+} and others) in reducing the toxic effects of metals, low pH, total gas pressure, and nitrite has been documented.

7 Hydrogen sulphide is detectable by sense of smell at much lower concentrations than the recommended level.

8 The recommended level assumes that the chloride concentration is very low, thereby maximizing the toxicity of nitrite.

9 A minimum inflow pH of 7.2 makes some allowance for the pH reduction due to CO_2 respiration in a rearing pond. Inflow pH criteria should be evaluated on a site-specific basis with consideration of alkalinity, free CO_2 and fish loading density.

10 This is the safe temperature range for incubation of sensitive species to both high and low temperatures.

11 The characteristics of the suspended solids should be carefully considered. For example, some materials (ie iron hydroxide precipitates) are toxic at lower concentrations than 3 mg/l.

12 Analyses for total aluminum, iron and manganese frequently result in high metal concentrations (exceeding the screening levels) if the water sample contains a significant quantity of suspended silt or clay. These mineral forms of the metal are essentially non-toxic. However, aluminum, iron and manganese precipitates are toxic. Their presence should be investigated if the total metal levels are high and the inert mineral fraction of the suspended solids appears to be relatively low.

on-site sampling includes an ASTM standard reference mercury thermometer, a tensionometer, a barometer, an iodometric kit or membrane electrode meter for oxygen, a pH meter (with glass electrode), and a conductivity meter. Considering the costs involved in mounting a pumptest, it is essential that backup equipment be readily available. At the same time that water quality is tested, aquifer yield is evaluated by a consultant hydrogeologist under contract to the Engineering Division.

The more stable water quality parameters are evaluated at the Pacific Region Laboratory, which is located in West Vancouver and jointly financed by the Departments of Environment and Fisheries and Oceans. Samples are delivered to the lab within 48 hr of being taken.

Upon receipt of data from the lab and consultant, the New Projects Unit summarizes the results and determines the suitability of the supply for salmonid culture. Three types of memo reports are routinely provided. The first summarizes the results of the initial sampling visit, providing logistical details as to location of sampling and thermograph, and first-cut interpretation of water quality (is it worth continuing or expanding monitoring at this site?). The second reports on the suitability of the water source at the conclusion of one year's monitoring. The third collates and interprets pumptest results. In all cases, a standard format is used. Appendix 6 provides an example of each type of report.

The interpretation of water quality data can be likened to a tightrope act. If the analyst does not properly weigh the impact of each parameter as well as synergisms, two types of costly errors can result. If the water supply is deemed acceptable and is not, a facility can be built that will suffer poor production and costly water treatment retrofits. On the other hand, if an overly conservative approach is taken, sites that are actually suitable may be rejected, resulting in additional and unnecessary reconnaissance costs to identify new sites. Because of the importance of accurate water quality criteria, this subject has been reviewed and recently updated (Sigma, MS 1979 and MS 1983). Information on water quality criteria continues to accumulate at rapid rate, and regular updates of the criteria are recommended. It should be emphasized that the limits specified in Table 4 are conservative and are used to screen sample parameters rapidly but thoroughly. Any parameter which falls outside the specified limits is flagged for detailed determination of the site-specific acceptable level.

Where water quality is deemed marginal, a pilot operation is advised (see section on pilots). For example, temporary facilities were constructed in Phase I of SEP at Mathers Creek to examine the effects of marginally high levels of un-ionized ammonia, at Chehalis River to examine low hardness levels, and at Fort St.

James to check marginally high iron levels.

In terms of the various feasibility studies identified in Table 2, the final point to be made is that the biological baseline and water quality monitoring studies require the greatest amount of time to complete, and they are seasonally inflexible. Where projects must be 'fast-tracked' for financial or other reasons, the resulting substandard data base imparts costs in higher-risk and overly-conservative designs. Similar problems will occur where funds for basic planning are not provided in advance of funds for construction.

Step 4 - Biological Design

Biological Criteria

The key operating words for this task are consistency and documentation. The New Projects Unit continues to accumulate all relevant data regarding biocriteria. As new data become available, or where disagreement becomes apparent among the biological staff, the Unit will canvass the Enhancement Operations group (and outside agencies, if appropriate) by mail and telephone, or meeting, in order to produce a consensus approach. Where necessary, that consensus is summarized and distributed back to the group in a memo report. The assumptions and criteria used are always detailed in each facility design memo (see next section), to ensure all participants are aware of the design's constraints.

Criteria for containers commonly used in the production-scale enhancement facilities are summarized in Table 5 and Figures 3 to 5. Detailed design specifications will be catalogued in a future report. Relative merits of various container types are listed in Table 6.

Larger research projects have been handled either by staff from other units (eg, aeration studies done by the South Coast Unit in conjunction with Engineering--see McLean and Boreham, MS 1980), or by contract (eg, review of adult return information in relation to juvenile outplanting techniques--see Lister et al, MS 1981).

Survival standards for Phase I (Appendix 7A) were developed in 1979 by a committee of senior staff using the best data available. Revisions were made up to 1981 on an ad-hoc basis. For the 1982 SEP continuation planning exercise, the EOS reviewed the survival standards, and generated a more comprehensive listing by species and technology (Appendix 7B). At the time that SEP Continuation planning was proceeding, it was recognized considerable existing data could be used in the generation of biostandards. However, it would require a major effort to incorporate these data, as most were not easily accessible or comparable. The Ad Hoc Biostandards Working Group, which consists of representatives from the concerned branches of DFO, was formed in 1982 to work towards documenting and updating the biostandards information base.

Table 5 Criteria for standard units used in salmon culture in British Columbia

UNIT TYPE	TYPICAL KEY DIMENSIONS[a]	SPECIES[b]	UNITS/ LINE	FLOW RATE	LOADING RATE	COMMENTS
A. INCUBATION						
Modified Atkins Box	2 cells/box, each cell 835L x 365W x 315H/250D (55H plenum); box 2010L x 435W x 315H overall;	CM	2 boxes (stepped)	30 LPM/ line	150K eggs/cell 600K eggs/line	- Welded aluminum construction; cement blocks used as stands - Need clean water
Keeper Channel	2000W x 450H/200D x 22000 between breaks; slope 1:250 to 1:500; single layer of 50 dia gravel; 150-300 drop @ breaks	CM (CN)	up to 2 without auxiliary aeration	150 LPM @ start;450 LPM @ end (per line)	SP eggs/m² CM 15K CN 8K	- Cement construction - Need clean water - Channel cover required - used for CN @ Robertson only
Heath Tray	Egg space in tray 390L x 320W x 50D (6200 cc); 8-tray stack with stand 630L x 620W x 810H (outside dim.)	CN CO (CM) (PK)	8 trays/ stack	15 LPM/ stack routinely; 19 LPM/ stack for flushes	SP Eggs/Tray CN 5K CO 8.5K CM 9K PK 16K	- Used at dirty-water stations - PK/CM eggs removed prior to hatch and placed in substrate incubators; CN/CO to ponding - Central or wall-mounted headers - Arranged two stacks high (but separate water supplies)
Freestyle Box	Egg space 790L x 615W x 430D; box outside dim. 1000L x 625W x 510H, incl two 90W headers and 80H plenum	CM (CN)	up to 6	CM 30-40 LPM/line CN 32 LPM	SP eggs/box CM 500K CN 300 - 330K	- simple fabrications - need clean water - used for CN @ Robertson only
Keeper Box	2650L x 1150W x 1000H (outside); 1350L x 1000W x 400 gravel depth, 200H plenum	CM	separate supply to each box	40 LPM @ start; 60 LPM @ end	150K eggs/box	- Aluminum or fiberglass construction - In clean water, can incubate to hatch on screens in box; in dirty-water, used only for hatch-emergence period - Backflush port for cleaning

[a] L = length; W = width; H = height; D = water depth; S = slope; DIA = diameter; RAD = radius. Dimensions in mm unless otherwise specified.
[b] CO = chum; CM = chum; CN = chinook; PK = pink; SK = sockeye; parentheses indicate use is not common.

(Table 5 continued)

UNIT TYPE	TYPICAL KEY DIMENSIONS[a]	SPECIES[b]	UNITS/ LINE	FLOW RATE	LOADING RATE	COMMENTS
Quinsam Box	1220W x 1220H x 1220 - 1830L (variable) gravel depth ~ 500 (750 with pea gravel)	PK	separate supply to each box	180 LPM/ box	max of 750K eggs/box (1830L)	- Water supply via manifold/pea gravel system - Aluminum construction - Clean water preferred but back-flush port provided
Spawning Channel	12000W max x 1500D; gradient 1:500-1:1000; side slope 1.5:1 - 2:1; gravel size range 20 - 150, depth 450 - 600; water vel. 45 - 75 cm/sec.	SK PK CM	Areas range 2200-31800m² (upper limit not determined)	0.19 CMS/ m of width	1.25m² spawning pair	- Settling basing upstream of channels on dirty rivers
B. REARING	**(Exchange rates generally to meet or exceed 1.5 x /hr)**					
Raceway	4000W x 22000L x 1000 - 1700H/700D; slope 1:250	CN CO CM	2/line (44000)	adjust so O_2 meets Davis 'B', eg	CM 15K fry/m² OR	- Greater depths used for adult holding - Lower ends of CM keeper channels can be flooded for start-up feeding in severe climates - Fry normally reared to 1g max CM; 5g CN; 20-25g CO
				fry(g) / °C / kg/LPM / kg/m³ 0.5 / 5 / 1.0 / 11.6 15 / 0.2 / 4.2 25.0 / 5 / 1.9 / 23.3 15 / 0.5 / 8.2 (at ration level of 90% of max)		
Burrows Ponds	15000 - 23000L x 2400W/leg (5200W overall) x 1200H/760 - 900D	CO CN		(as per raceways)		- design details as per Burrows and Chenoweth (1970)

[a] L = length; W = width; H = height; D = water depth; S = slope; DIA = diameter; RAD = radius. Dimensions in mm unless otherwise specified.
[b] CO = chum; CM = chum; CN = chinook; PK = pink; SK = sockeye; parentheses indicate use is not common.

(Table 5 continued)

UNIT TYPE	TYPICAL KEY DIMENSIONS[a]	SPECIES[b]	UNITS/ LINE	FLOW RATE	LOADING RATE	COMMENTS
Pallant Seapen	9000L x 9000W x 3000H/2000D main net of 13mm (stretch) knotless nylon; also quarter-size fry introduction nets of 3mm knotless nylon; 12mm pen frame lines; 12 x 15 kg weight hung inside of main net to prevent billowing	CM (PK) (CO)	3-pen units 2m between pens; 10mm alleys between units	N/A; but site should be well-flushed, 10-30 ppt salinity	400K fry/pen or 3 kg/m^3 (CM); up to 5 kg/m^3 (CO).	- 'Topper' floats used to date; - CM/PK Fry reared from button-up to 2g in pens; CO transferred to pens @ 10g+. - pink reared at Pallant and in various experimental pens at Quinsam. - coho pens attempted in Indian Arm.
Earthen Channel	Up to 100000L x 3000W (btm) x 1600H/1000D side slope 2:1	CM CN CO	routinely 100 max L	(as per raceways)		- Tlupana channels have no lining, lose ~ 0.05 CMS through permeability.
Capilano Trough	6550L x 950W x 600H outside dim; sides rounded at btm (300 RAD); 6400L x 800W x 475D inside dim.	CN CO (CM)	2 (stepped)	120 start 240 end	115 kg/trough max.; intitial loadings 40 K CN or 55K Co/trough	- aluminum or fibreglass - primarily for start-up rearing to 2g or less
Circular Tubs	3250 DIA x 1280H outside dim; 3050 DIA x 910D inside dim; btm slopes to center standpipe (100 cm inner pipe surrounded by 200 cm slotted/screened outer pipe)	CN CO (CM)	1	(as per raceways)		- jets on vertical submerged header pipe promote circular flow - some sites have water level control via standpipe tied into drain at outer edge of tub (more accessible)
C. ADULT HOLDING						
Various of Rearing Containers	Special depth requirements of 2000H/ up to 1700D.	CM CN CO (PK)	-	1.2 kg/LPM	32kg/m^3 long-term; 64 kg/m^3 short-term (for CM only)	- short-term = 1-2 days - special containers for adults holding required only at facilities dealing mainly with species reared for full year.

[a] L = length; W = width; H = height; D = water depth; S = slope; DIA = diameter; RAD = radius. Dimensions in mm unless otherwise specified.
[b] CO = chum; CM = chum; CN = chinook; PK = pink; SK = sockeye; parentheses indicate use is not common.

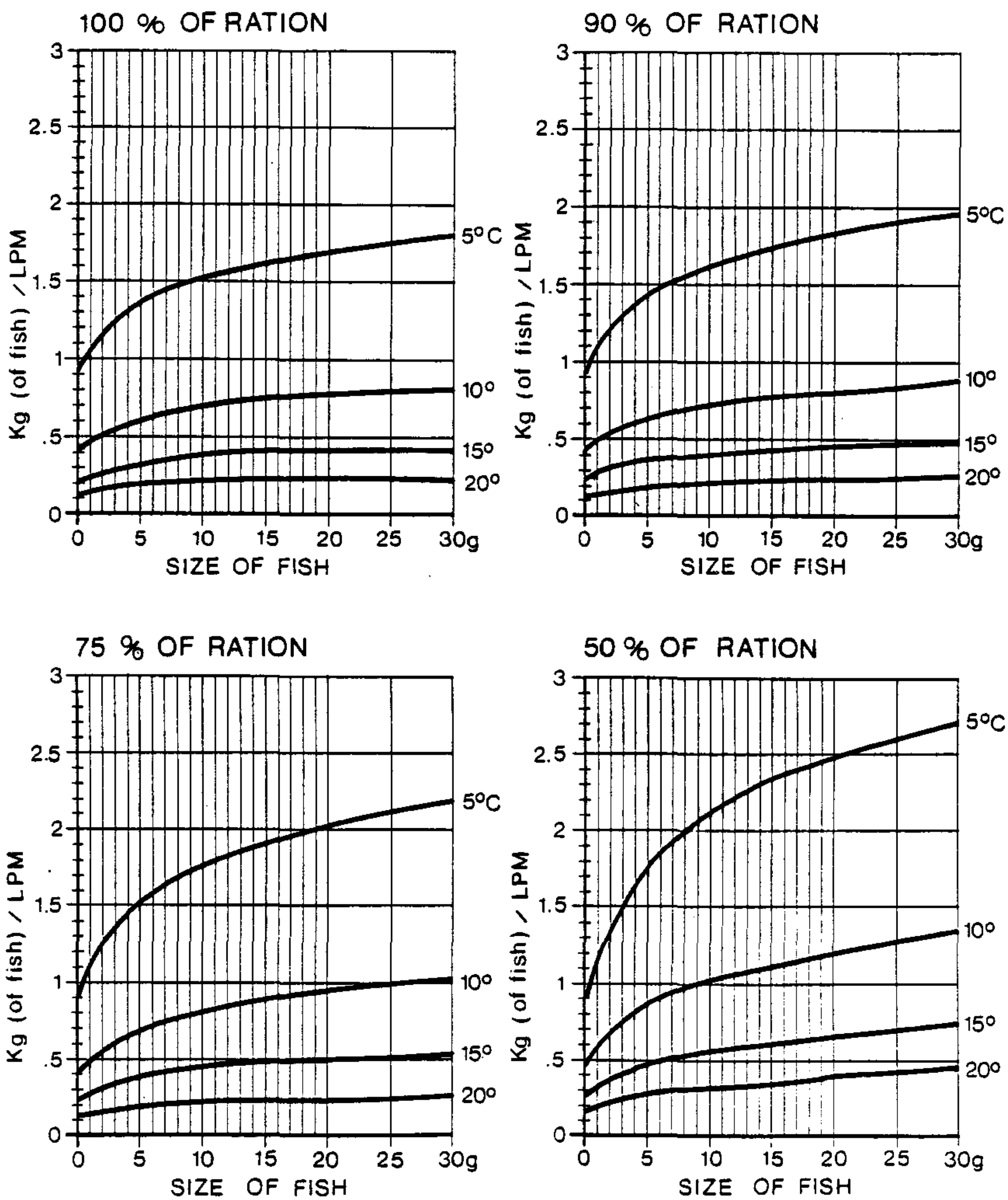

Figure 3 Flow loading criteria over the temperature range and at four ration levels commonly used in design of SEP Phase I facilities (see Appendix 10 for program details).

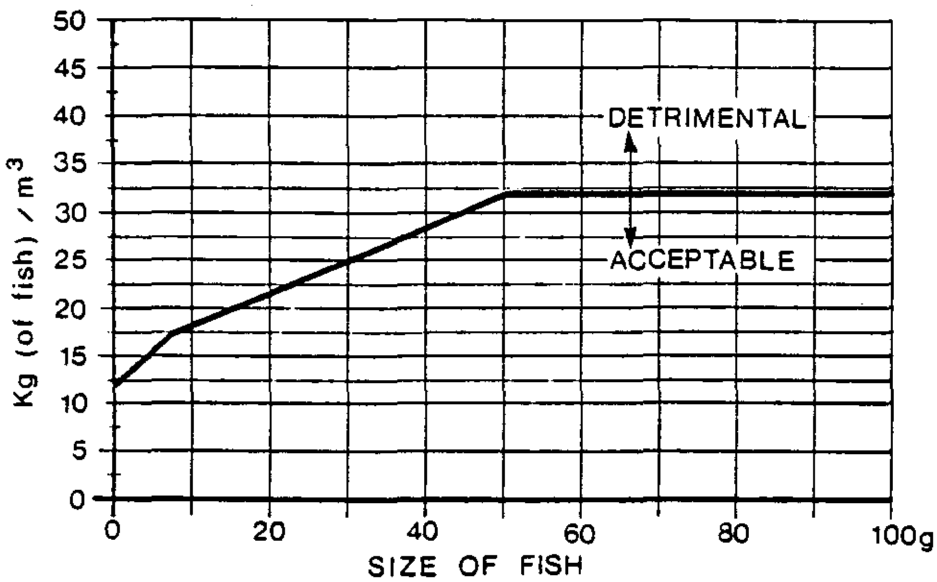

Figure 4 Volume loading criteria used in design of SEP Phase I facilities (see Appendix 10 for program details).

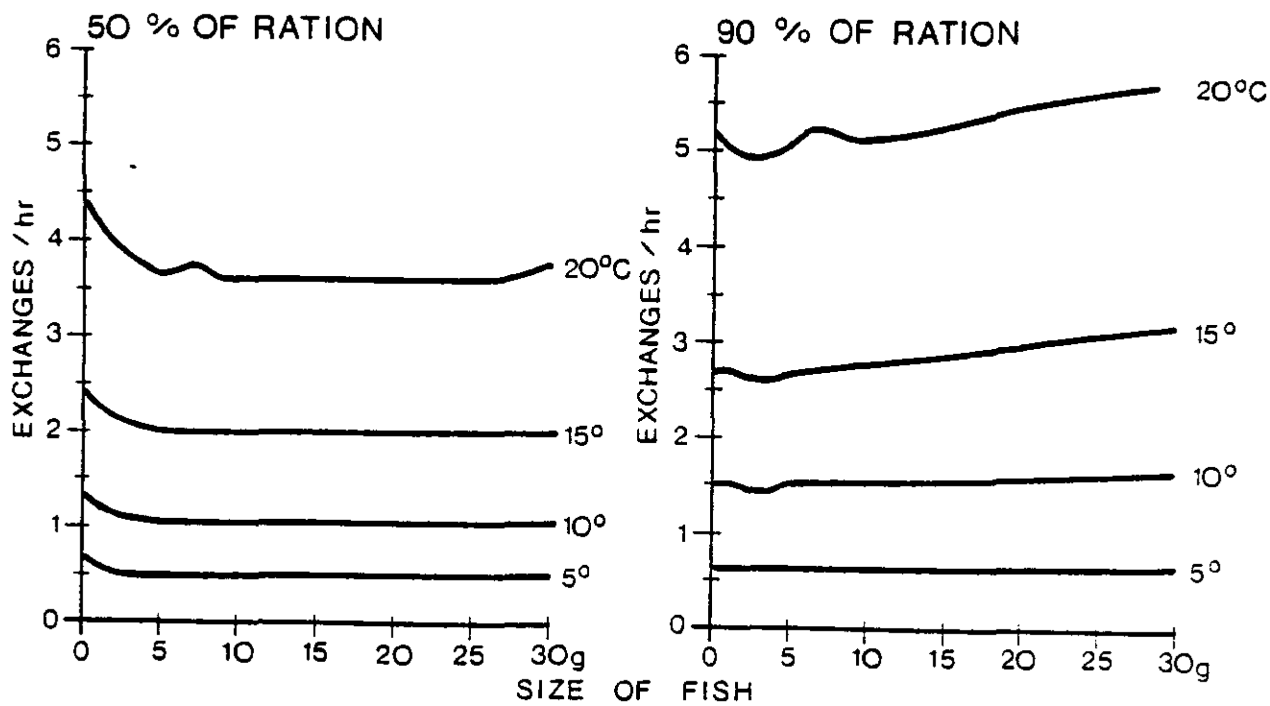

Figure 5 Exchange rates for two ration levels, as calculated from the interrelationship of flow and volume criteria (see Figs 4 and 5).

Table 6. Relative merits of containers used in SEP production facilities.

Type of Container	Useful in Situations Where:	Avoid in Situations Where:
INCUBATION:		
Vertical Tray	. dirty water conditions . controlled/early ponding . chinook/coho to ponding . small egg lots . control of inventory . control spread of fungus . reaeration of water needed	. daily eggtakes exceed 100,000 eggs/stock . chum/pink if held beyond hatch (unless media added) . shortage of labor . low head on water supply . space or water or $ limiting
Modified Atkins Box	. daily eggtakes between 100,000 and 500,000 eggs . water limiting	. dirty water conditions . all species of held beyond hatch . small egg lots . rapid spread of fungus
Bulk Box	. daily eggtakes exceed 500,000 eggs . space or water or $ limiting	. as for modified Atkins boxes
Gravel Box (with egg screens)	. all species to swim-up at own volition . $ limiting . not continuously manned	. space or water limiting . controlled/early ponding . inventory/fungus control . shortage of clean-up labor . dirty water conditions
Keeper Channel (with egg screens)	. chinook/chum/pink hatch to swim-up (some ponding control) . dirty water conditions . inventory/fungus control . low head on water supply	. area limiting . channel can't be kept dark . egg lots small or separated over time
Spawning Channel	. low head on water supply . low manpower/operating $. 'natural' spawning/incubation . single stock enhancement . sockeye/chum/pink	. dirty water conditions . low flow or capital $. prolonged holding of adults . space limiting . broodstock shortage . inventory/disease control . variable topography . rearing required

Table 6 (cont'd.)

Type of Container	Useful in Situations Where:	Avoid in Situations Where:
REARING: Capilano Trough	. small lots (stock/timing differences) . early rearing; chinook/coho ponding to 2 g . space or water limiting . temporary siting (pilots) . 'piggy backing' of species . low water °C during ponding . inventory control . feeding/cleaning control . fish transfers necessary	. few, large groups . input water marginal in quality . labor or operating $ limited . no cover available . rearing beyond 2g . disease triggered by stress of crowding . low head on water supply
Concrete Raceway (Shallow)	. rearing to 60g+ . inventory control . feeding/cleaning control . few, large stocks	. water or capital $ limiting . temporary siting (pilots) . stock or timing separation into small lots . no slope
Concrete Raceway (Deep)	. as per shallow raceway . adult holding	. as per shallow raceway . cleaning more difficult
Modular Aluminum Raceway	. as per shallow raceway . temporary siting (pilots) . medium-large groups of fish	. as per shallow raceway . low head on water supply
'Aqua-Breeder' (Vinyl Liner)	. as per modular aluminum raceway	. as per modular aluminum raceway, but shorter lifetime
Circular Tubs	. no slope . small groups of fish . low manpower (self-cleaning) . flows limiting (recirculation) . velocity control . inventory control . short-term rearing	. input water marginal in quality . low head on water supply . disease problems . routine mechanical crowding
Above-ground Swimming Pool (vinyl liner)	. capital $ limiting . pilot/experimental . short-term rearing . no slope . small-medium groups . inventory control . low flows	. permanent site . input water quality marginal . labor limiting (manual cleaning) . low head on water supply . disease problems . heavy loading (variable circulation)

Table 6 (cont'd.)

Type of Container	Useful in Situations Where:	Avoid in Situations Where:
Burrows Pond	. medium-large production groups . flows limiting . heavy loading (uniform circulation; self-cleaning . inventory control	. input water quality marginal . capital $ limiting . disease problems . routine mechanical crowding . variation in loadings (flow set by hydraulics)
Earthen Channel	. large production groups . smolt quality paramount . low head on water supply . direct release of fish	. flows or space limiting . no slope/irregular topography . cleaning/inventory control . disease/predator problems . fish transfers necessary . porous subsoils . no bank maintenance
Floating Cages	. short-term rearing . space on land limiting . flows limiting . low capital $. saline water required . medium size production groups	. low ambient O_2 . poor flushing circulation . exposure to storms . high/fluctuating temperatures . disease problems . fouling/predator problems . maintenance $ limiting . inventory/feed control . potential pollutants (eg, marinas)

Biological Design. For each facility design, the New Projects Unit issues a standardized memo report outlining the biological needs for the operation of that facility. Each memo report requires certain key site data in addition to general criteria (Table 7). The memo serves the following functions:

- defines targets and enhancement strategy
- formulates incubation and rearing programs
- documents assumptions, criteria, and rationale used to formulate the programs
- outlines the physical requirements that Engineering has to provide to achieve the biological objectives.

In general approach, the calculation system parallels that used by Kramer, Chin and Mayo Inc. (see pp 54-55 of Piper et al, 1982 for an overview). The biological design report for Tenderfoot is appended as a detailed example (Appendix 8). The calculation sequence takes the following steps:

(1) Calculate the numbers of fish of each species and stock required at each life stage, in order to meet the defined production objectives and strategies. For the most part, the survival standards contained in Appendix 7 are used for these calculations. Calculation of the needed number of brood stock requires additional input of the male: female eggtake ratio (generally 3:5) and an estimate of pre-spawning mortality from site-specific data.

(2) Define the start point for each species and stock, using average adult spawning timings from available field data.

(3) Define the end point for each species and stock, using average smolt migration timings from field data.

(4) Determine the seasonal temperature profile, using average monthly temperatures for each water source used in the facility.

(5) Calculate the number of incubation containers and the associated flow, using standard loading criteria (Table 5).

(6) Estimate the duration of incubation from the temperature profile and the prediction methods given in Table 8.

(7) Forecast the growth of fish through the rearing period. This is done using an in-house computer program called 'GROWTH TIMING' which is based on a model developed by Stauffer (MS 1973) and modified by McLean (MS 1979). This program, with inputs of water temperature, fish size and ration level, computes weight at five-day intervals (Appendix 9). If fish must be released at a specific

Table 7. Key information elements required to complete biological design calculations for SEP facilities

	KEY INFORMATION ELEMENT	SOURCE	FOR DETAILS, REFER TO
1.	SPECIES AND STOCK PRODUCTION TARGETS	GWG	p 11
2.	ENHANCEMENT STRATEGY TO BE USED	Senior-level Bioengineering	pp 11 - 14
3.	SURVIVAL RATES FOR SPECIES, STOCK, AND STRATEGY	Biostandards	Appendix 7
4.	SPECIES AND STOCK CHARACTERIZATION a) Start-peak-end timing of adult entry/spawning b) Adult distribution, sex ratio, age composition, and fecundity c) Start-peak-end timing of juvenile migration(s) d) Juvenile rearing history/distribution e) Disease sampling of all stocks	On-site Fieldwork	pp 14 - 18
5.	SEASONAL WATER QUALITY AND TEMPERATURE	Monitoring Program	pp 18 - 22
6.	TIMING CRITERIA BY LIFE STAGE (eg. adult holding, incubation to hatch, etc.)	ATU Predictions; 'Growth' Program	p 31, 33 pp 31 - 34; Appendix 9
7.	LOADING CRITERIA BY LIFE STAGE AND CONTAINER a) Volume - container numbers b) Flow	'Bio-Load' Program; Standard Criteria	pp 23 - 34; Appendix 10
8.	SUPPORT REQUIREMENTS	Fieldwork and Operations Staff	pp 34 - 35

Table 8. Methods used to predict duration of incubation phases for SEP facilities

SPECIES	EYED STAGE	HATCH STAGE	EMERGENT STAGE
CHINOOK	280 ATU	480 - 540 ATU	900 - 1000 ATU
CHUM	300 - 350 ATU	475 - 525 ATU	900 - 1000 ATU
COHO	220 ATU	400 - 500 ATU	700 - 800 ATU
PINK	350 - 400 ATU	550 - 650 ATU	900 - 950 ATU

NOTES:

(A) ATU = Accumulated Thermal Unit. Calculated as the number of degrees Celsius over 0°C that the mean daily temperature is, summed over the number of days. For example, 2 days @ 5°C + 3 days @ 7°C is (2x5) + (3x7) = 31 ATU

D = time in days

T = mean temperature for period in °C

(B) More accurate predictions may be possible in the future with the incorporation of a Q_{10} effect, resulting in an equation of the general form $\ln D = aT+b$, where D is time in days and T is mean temperature for period in°C (MacDonald and Shepherd, MS 1982).

size and date, and if water temperatures can be manipulated, then the program can be re-run with altered temperature and ration levels until the release targets are achieved.

(8) Calculate the numbers of rearing containers and their associated flows. For early rearing, standard loading criteria (Table 5) are used. For rearing beyond 1-2g, an in-house computer program called 'LOAD RATE' is used (see Figures 3-5 and Appendix 10). This program bases flow loading rates on work done by McLean (MS 1979); volume loading rates are based on the curve provided by Mayo (1971), against which existing data from B.C. facilities had been checked and found to fit well. Water temperature, species, inflow and outflow oxygen levels, fish size, and ration level must be defined. Normally, volume and flow requirements are minimum at the start of rearing and maximum at the end--but not always. For example, coho reared for a full year on a surface water supply will often show a peak flow demand in the late summer warm-temperature period. Therefore, where rearing is prolonged and temperature is variable, a monthly tabulation of requirements is necessary.

(9) Calculate adult holding volume and flow requirements, using standard criteria (Table 5). In most cases, the containers for short-term rearing species are available and of adequate size to handle brood stock requirements.

(10) Tabulate total water demand on a monthly basis.

(11) Outline support requirements. This is a list of structures and equipment felt essential to the successful operation of the proposed facility. Table 9 can be used as a checklist to ensure inclusion of all major components required for a project.

Wherever possible, flexibility in design is used, so that future changes in production strategies can be accommodated. This translates into the use of species-interchangeable containers of standard dimensions as much as possible, considering the possibility of expansion at the same time as the initial design, and other such similar approaches.

The above calculation procedures are used by the New Projects Unit for salmon only. Where trout are included in a facility, the Fish Culture Section of BCFW is requested to provide the biological requirements for these species in a compatible format. These requirements are then integrated by New Projects into the biological design memo (see the Kitimat example in Appendix 8).

Table 9. Potential components of a SEP facility.

SITE:
- Land
- Access
- Main/Backup Power Generation
- Communications System(s)
- Landscaping

PROCESS WATER:
- Main Supply
- Secondary Supplies
- Intake/Pumping Facilities
- Distribution System
- Settling/Filtration System
- Temperature/Water Quality Modification of Supply Water
- Aeration Tower
- Water Re-use System
- Flow Meters
- Effluent Waste Treatment

BIOLOGICAL PROCESSES:
- Incubation Area
- Incubator Wash/Pick Area
- Initial Rearing Area (Covered?)
- Feeders
- Final Rearing Area
- Fry Marking Area
- Juvenile Transfer Structure
- Juvenile Release Structure
- Fish Transport Equipment
- Adult Fishway/Trapping Equipment
- Adult Sorting/Holding Structures
- Eggtake/Decontamination Areas
- Offsite Holding/Rearing Facilities

SERVICE:
- Food Storage (Freezer/Cooler)
- Wet Laboratory
- Dry Laboratory
- Special Research Needs
- Workshop
- Mechanical/Electrical Room
- Dry/Volatile Storage
- Equipment/Vehicle Storage

ADMINISTRATION:
- Offices/Sleeping Room
- Lunchroom
- Mudroom/Staff Lockers
- Staff Washrooms
- Public Washrooms
- Lobby/Reception
- Public Display/Viewing Facilities

HOUSING:
- Crew Residence
- Manager's Residence
- Asst. Manager's Residence

CONTROL:

Alarms	- Water Flow
"	- Water Level
"	- Fire
"	- Security
Fencing	- Traffic Direction
	- Security
	- Predator
Fire Stations	

Step 5 - Bioengineering Concept Review

The New Projects Unit distributes copies of the completed biological design memo to various participants for review and comment before or during a review meeting. Copies go to the Engineering staff involved with the project and to a biological advisory group. Normally, the latter group consists of the New Projects Design Biologist and Coordinator, the Support Biologist and Unit Head of the appropriate Operations Unit, a facility manager, and the Chief of Enhancement Operations. Where trout are involved, the BCFW Fish Culture Section also participates. Similar to the conclusion of Jeppson and Taylor (1981), we have found it most valuable to have a facility manager appointed as early in the process as possible. Where this is not possible, the next best approach is for the Operations Unit Head to appoint the manager of an existing facility as advisor to the project. The selection rationale for such appointments has been variable, ranging from providing a training experience, to familiarity with the geographic location or technology involved. It is an inherent assumption that the appointee will ask the advice of other managers when he feels his experience to be lacking.

The New Projects Unit was set up specifically to act as the biological focal point for bioengineering communication; advice coming solely from the New Projects Unit has been deliberately minimized in favor of a consensus approach. Like Fox (1976), we feel that the best way to mesh design criteria and operational reality is to involve the operators at as early a stage as possible, so as to maximize understanding of and commitment to the probable operational mode. Use of this approach forestalls much of the "Why Does It Have to be This Way?" syndrome that has been discussed by Klontz (pers. comm., 1981 Northwest Fish Culture Conference). In addition, this approach also aids in reducing the risk of operating errors by facility staff during start-up.

Where members of the biological advisory group disagree as to any aspect of the proposed design, further discussion within the biological group is arranged by the New Projects Coordinator. When the group cannot reach a consensus, the issue is decided by the New Projects Coordinator in consultation with the Chief of Enhancement Operations. It should be emphasized that where arbitrary decisions are required, it is important that those decisions and their rationale be documented to ensure staff understanding.

Steps 6 and 7 - Site Layout and Flow Schematic Plans, and Concept Finalization

These plans are prepared by the Engineering Division and submitted in duplicate or triplicate[a] to the New Projects Unit for

[a] One copy for biologist review, one copy to the manager-advisor,

distribution to the biological review participants. Review comments are sent back to New Projects for compilation before submission to Engineering. Where disagreement among the biological reviewers arises, the consensus and hierarchical decision-making sequence described in the previous section is used. This pathway ensures consistency of comments back to Engineering. Further meetings are then scheduled through the New Projects Unit, as circumstances dictate.

Although the biological group finds both the site layout and flow schematic diagrams particularly useful in understanding further blueprints, only the former has been regularly provided by the Engineering Division. We strongly agree with Jeppson and Taylor (1981) that visual aids of this nature are far more useful in the initial stages than are complex drawings of the proposed facilities. Another item considered useful and often requested by New Projects, but rarely provided by Engineering, is a written list of assumptions used in developing the design under review. Part of the problem may have been that Engineering was unable to determine those assumptions of relevance to the biological group. Where required to obtain such listings, New Projects staff have undertaken initial reviews of the submitted plans, prepared lists of key questions, met with the project engineers, and added information notes to the plans sent out to biological review.

Step 8 - Costing of Facility Operation

In preparation of the Treasury Board Submission required for all projects over $500,000, ($1,000,000 as of August, 1983) facility operating costs are estimated. Two methods of estimation have been employed. When site and stock logistics are well known, the Head of the relevant Operations Unit may undertake a detailed program budget exercise. When logistics are less certain, the predictive formulae developed for the EOS exercise (see Table 10) have proved useful. Where both methods were used, the difference between the two independent estimates has not exceeded 20% and was normally within 10%.

The Engineering Division works up the estimated capital costs of the facility on the basis of the finalized conceptual design; the only responsibility that Enhancement Operations has in this area is to estimate and ensure inclusion of capital for the purchase of equipment for start-up.

Step 9 - Production Forecasts

The New Projects Unit has responsibility for the development of production forecasts, which also are required for the Treasury Board Submission. Calculations are done up to the point of full adult returns, using a 'VISICALC' program and the best available biostandards information. Sources for the latter include McDonald (MS 1979), the more recent update done by the Ad Hoc Biostandards

Table 10. Predictive formulae for estimating SEP facility operating costs (developed for EOS SEP Continuation planning exercise--see Lill et al, MS 1983).

TYPE OF OPERATION	COST FORMULA (82$)
(1) Manned Facilities	
a) Producing up to 3000 kg	$49,000 + $86/kg
b) Over 3000 kg	$275,000 + $5.50/kg
(2) Satellite Operation (one or two nearby systems)	$90,000 each (Additive to cost of Central Facility
(3) Semi-manned Incubation Box	$9,000 each
(4) Adult Transplant or Trap-and-Truck Operation	$51,000 each
(5) Juvenile Stocking or Colonization	$27,000 each
(6) Juvenile Transplant	
a) Requiring Onsite Box Incubation	$99,000 each (Box + Satellite Costs)
b) Offsite Incubation	$90,000 + $86/kg or $90,000 + $5.50/kg (dependent on size of Central Facility)

NOTE: Does not include capital equipment or maintenance costs.

Committee, and data from the feasibility studies. Any assumptions or criteria used in the absence of actual data are documented within the forecast table. Examples of completed 'hatchery return' and 'natural spawning' production forecasts are provided in Appendix 11 (when the hatchery's objectives include rehabilitation of naturally spawning stocks to historic levels, a secondary forecast is done which predicts the production from the natural spawning of hatchery-origin fish).

Steps 10 and 11 - Treasury Board Submission and Approval

The preparation of a Treasury Board (TB) Submission is required for any capital project exceeding $500,000 ($1,000,000 as of August, 1983). The Chief of SEP Engineering is responsible for completion of the Submission document. The document's format follows TB guidelines, as laid down in various internal policy manuals. The project is assigned to a TB Analyst who advises the Engineering Chief as to procedures and the level of detail required for the Submission (A.F. Lill, pers. comm.). At the request of the Engineering Chief, various of the SEP groups provide work-ups for inclusion as appendices to the Submission. Through the New Projects Unit, Enhancement Operations provides production returns and operations costs (see Steps 8 and 9); Engineering predicts capital costs on the basis of the conceptual design; and socioeconomic evaluations are provided by Program Development economists. The Engineering Chief drafts the text of the Submission, and the package is reviewed for accuracy by the various participants. The Submission is sent to Ottawa, signed by the Deputy Minister or Minister, and passed to the TB Analyst, who prepares a Briefing Note. The Briefing Note is confidential and is the document actually used by the TB in making the decision to fund the project (A.F. Lill, pers. comm.)

It is worth noting that, in the past, the TB Submission often preceded completion of biofeasibility studies, resulting in imprecise project requirements and costs. Often, Amendment Submissions would then have to be made if there were cost overruns. More recently, it has been the practice to make a Preliminary Submission for funds to undertake detailed design work, then to make a Final Submission when the design work is completed. This approach should aid in increasing the accuracy of the Submission's projections. Such accuracy is extremely important, as project performance is held accountable on the basis of the claims made in the Submission.

Step 12 - Detailed Design

Upon receiving TB Approval, SEP Engineering begins detailed design work. Although the major elements of design have been set by the conceptual design, there is a continuing need for biological input throughout this period. Biological advice during work-up of drawings is provided to Engineering in one of three major ways. First, New Projects staff directly input if the criteria are straightforward. Second, where uncertainty exists as to requirements, New Projects staff will query the Operations staff as to their wishes. Third, where it has been possible to appoint a hatchery manager during construction, the manager directly provides much of the biological advice. As has been stated elsewhere, the New Projects Unit is committed to documentation and consistency of biological input to facility design. Thus, in the first two communications pathways, New Projects staff will issue memo reports for all items of consequence. Documentation of input by the manager has generally not been as thorough and some information gaps may exist. Although the initial manager may be aware of the "whys" through direct experience, succeeding managers may have to guess at the rationale that was used. Therefore, formal feed-back by the manager to the New Projects Unit is encouraged, so that all bioengineering design decisions can be included in the as-built review document (see Step 17).

Step 13 - Detailed Design Review

Depending on the size and complexity of the facility, Engineering may choose to break the design work into several contract packages. Prior to each package going out to tender, the drawings are passed by Engineering to the New Projects Unit for biological review (as per Steps 5 and 6). New Projects oversees the biological review sequence; drawings are stamped with a circulation list, and the deadline for completion of review is identified and followed up on. Where the drawings are particularly complex, it is helpful to have an orientation meeting with the project engineers prior to the formal biological review proceeding. As mentioned in Step 7, it is desirable to have Engineering provide visual aids and key assumption lists in order to assist in orientation. At first, the biological review was the last step prior to tendering (the date of which is advertised well in advance). Delays experienced in the prior stages of design accumulated and were directly subtracted from the time allowed for review. This led to inadequate biological review time and, in some cases, rather costly contract amendments or sub-optimal facilities. More recently, the Engineering group has improved this situation by providing preliminary drawings as they are draughted, rather than waiting for their final assembly into the tender package.

When the review rsults in requests for only minor changes, these are informally relayed by New Projects to Engineering; where changes are more substantial, New Projects prepares a memo request. If the review points up serious disagreement between the Engineering approach and biological needs, follow-up meetings may be required to resolve the problem. Prior distribution of the meeting agenda and subsequent distribution of minutes of the meeting (highlighting decisions reached and action items) result in more effective communication. Where agreement cannot be reached at the project level, it will be referred to senior staff, up to the Executive Director's level if necessary, for decision.

Steps 14 to 16 - Design Completion, Final Review, and Project to Tender

Engineering revises the drawings subsequent to the detailed design review and puts them out to tender. The final tender drawings are double-checked by New Projects to ensure inclusion of all changes requested and agreed to, and are circulated to the other biological reviewers for their information.

PILOTS

Where biological feasibility studies point up marginal or uncertain conditions which would make the success of a production-scale facility questionable (water quality, for example), the New Projects Unit will recommend a pilot where possible. These pilots generally have short lifetimes and thus are constructed in a modular or mobile fashion, and they are sized to meet specific experimental needs. The term 'pilot' also has been used in the past for other types of small operations, such as: mini-hatcheries to obtain adequate numbers of juveniles for coded-wire tagging to estimate fishery contributions (such as Atnarko, Fulton and Kitimat chinook); the start-up year of a production-scale facility; minor facilities that deal with small numbers of fish such as Blaney, Inch and Birkenhead; or first-stage facilities operated to give staff logistical knowledge of the area and stocks. From the New Projects Unit's perspective, these are not pilots in that they do not act as guides through difficulties or dangers. The pilots undertaken by Enhancement Operations during Phase I of SEP are listed in Table 11.

The pilots are developed using a design/review process similar to that previously described for production-scale facilities. The New Projects Unit may request research expertise from the Pacific Biological Station to address specific problems. It is preferable to have the relevant Operations Unit heavily involved in operation of the pilot, as errors in fish culture are reduced, staff familiarity with the site and stocks is increased, and much of the logistical load is removed from New Projects. One weakness in this approach is the often severe delays experienced between termination of the pilot and reporting. This problem has yet to be resolved satisfactorily, as manpower allocations have not kept pace with increasing project loads.

AS-BUILT REVIEW DOCUMENT

In order to link design criteria and operational reality, the

Table 11. Pilots undertaken by SEP during Phase I (1976-84).

Pilot(s)	Years Operated	Equipment[a]	Purpose (Species)[b]
Atnarko	75-79	7.4M eggs in gravel incubators.	Test feasibility of gravel incubators at production scale + rebuild odd-year stock (PK).
Bowron (1 stock)	80-81	75K egg gravel box; Cap trough.	Develop cold-water culture techniques (CN).
'Central Interior Package'			Investigate rearing and imprinting success of hatchery outplants:
Clearwater	84-	650K eggs in vertical trays;	+ upstream and downstream outplants (CN/CO)
Shuswap (1 stock)	84-	110K eggs in vertical trays; Cap troughs.	+ upstream colonization above dam (CN)
Spius (3 stocks)	84-	325K eggs in vertical trays; Cap troughs; Al raceways.	+ solar heating and effluent control technology (CN/CO)
Stuart (1 stock)	80-81 83-	110K eggs in vert. trays; Cap troughs.	+ effects of marginally high Fe in groundwater supply (CN).
Chehalis (3 stocks)	80-81	123K eggs in vertical trays; Cap troughs.	Test effects of marginal pH and soft water (CO/RT/CN).
Eagle (4 stocks)	83-	1M eggs in vertical trays; Cap troughs; Al raceways.	Investigate rearing and imprinting success of hatchery outplants (CN/CO).
Indian (2 stocks)	79-81	250K CN eggs in vertical trays; Cap troughs; earthen channels (CN). Seapens (120K CO).	Test low-pH, soft groundwater (CN); examine possibility of establishing resident CO for year-round saltwater sportfishery.
Kalum (1-2 stocks)	80-83	200K eggs in gravel boxes, then vertical trays; Cap troughs.	Develop cold-water culture techniques (80-82); time and size of release (82-83) (CN).
Mathers	80-83	800K eggs in vertical trays and Pallant boxes; Aqua-Breeders' raceways.	Test effect of marginally high ammonia levels in groundwater supply.
Mussel (1-2 stocks)	84-	500K eggs in vertical trays; Cap troughs; swimming pools.	Test impact of sockeye run with IHN above hatchery water supply.
Penny (1 stock)	80-81	75K egg gravel box; Cap trough.	Develop cold-water culture techniques (CN).
Thornton (1 stock)	76-79	1M eggs in Atkins/free-styles; keeper channels; swimming pools.	Test Japanese chum culture techniques (CM).

[a] Cap = Capilano; Al = Aluminum
[b] Species Code CN = Chinook; CO = Coho; CM = Chum; PK = Pink; RT = Rainbow Trout.

New Projects Unit has one last major duty for each new production facility. At the conclusion of the start-up year, the New Projects Unit produces a report integrating all the biological design information with the as-built structures actually provided, and with the additional biological data generated in the first year of operation. The report is meant primarily as a reference document to ensure operator access to original design assumptions and strategy. In addition, capacity and timing calculations are reworked where new data or changes in existing structures make it necessary, data gaps are identified for staff action, and alternate strategies may be suggested where appropriate. This report is complementary to the operations manual produced for each facility by the Engineering Division. The biological review report is distributed to the facility and its manager, the operations support biologist and Head of the Operations Unit, the Biological Program Coordination Unit, the Chief of Enhancement Operations, and the engineers responsible for the project.

As noted for the operation of pilots, formal feedback of start-up data from the operators can be difficult to obtain, yet is essential to ensure relevancy of the final report.

DISCUSSION

PROBLEM AREAS

Communication

A point made throughout this report is that efficient communication on several levels is essential to optimal facility design . Without rapid and accurate feedback to the New Projects Unit from operations biologists, facility managers and fish culturists, outdated criteria or inappropriate containers will continue to be used for new facilities.

In general, complaints regarding inadequate lines of communication are widespread within SEP and DFO and are common in large organizations, whether government or private-sector. It appears that there is a critical size of organization beyond which information/communication systems must be developed and standardized (see Kelly, 1969). In addition to being large, both DFO and SEP are complex, having several geographic and specialist groups. As specialists, biologists and engineers have very basic differences in approach, which seems to stem largely from their professional training rather than from individual personalities. For instance, in dealing with biologists and engineers from the Washington Department of Fisheries, I have observed uncannily similar frictions and attitudes to those seen within SEP. These factors should be considered in any effort to improve communications.

Project Management and Authority

There are a number of ways in which the activities of an organization can be grouped (Barnes et al, 1970). Comments made here relate to the facility design process, which employs an informal version of the "Project Management" or "Task Force" approach.

The Project Management approach is most appropriate for the implementation of large and complex projects requiring inter-disciplinary collaboration (Quick, 1972). Of the three main project management structures (see Table 12), the SEP facility design process comes closest to the "Division Responsibility Project" type. This type of structure, by definition, reduces the project manager's responsibility and authority to a coordination role (see Figure 6). In fact, SEP does not appoint project managers; there is a sharing of leadership dependent on the aspect being dealt with at the time. Dupuis et al (MS 1980) considered it especially important that the project or project manager have a clearly-communicated authority from senior management where a variety of divisions are requested to provide personnel, information, or assistance to accomplish the project. SEP projects do not arise in a consistent manner from a management committee or senior management, but often are identified by units or divisions.

Of the various groups involved in the SEP facility bioengineering process, the senior engineers come closest to functioning as project managers. In terms of project management theory, Enhancement Operations presently carries a confusing blend of project manager, client, and staff responsibilities. In addition, without joint bioengineering planning and updating, critical paths can separate, resulting in either project delay or use of insufficient data in project design.

Finally, a project manager must be responsible for developing effective documentation, communication and updating procedures for both staff and clients, as these are an essential element of project management (Dupuis et al, 1980). Insufficient emphasis has been placed on this aspect of project management for the SEP projects that I have been involved in.

POTENTIAL SOLUTIONS

It is easy to say that communication must be improved; however, there is no standard approach effective in all situations. Kelly (1969) has defined the object of communication to be the reduction of uncertainty. Using that as the operational definition, what could be done to improve the SEP bioengineering process?

(1) Where there is commitment to a significant program for

Table 12. The three major types of project management structure (from Dupuis et al, MS 1980)

1. DURATION PROJECTS
   - the Project Manager and project staff are assigned to the project for the duration of the project's existence
   - assignment is usually on a full time basis
   - certain staff may be only assigned for parts of the project
   - the project manager and staff will not have other tasks assigned to them which could disrupt the planning and scheduling of work on the project

2. MATRIX-BANK PROJECTS
   - the Project Manager is usually full time
   - project staff is matrixed in on a part-time basis to accomplish a certain task
   - the Project Manager coordinates

3. DIVISION RESPONSIBILITY PROJECT
   - functional units or divisions of organization(s) are assigned certain tasks
   - their work is coordinated by a project manager
   - there may be a small project staff working on a part or full-time basis as well

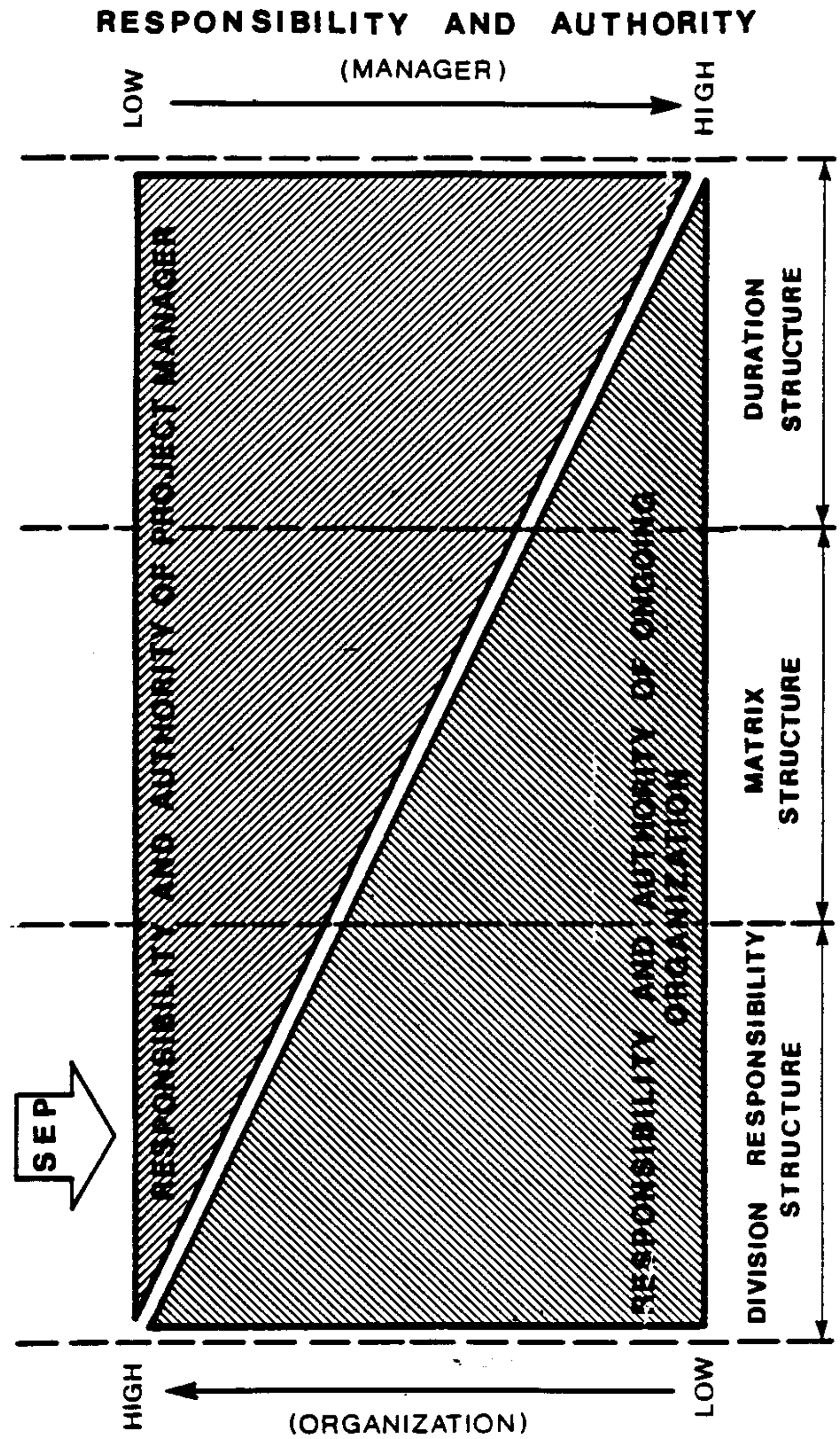

Figure 6 The levels of responsibility and authority of the project manager and the ongoing organization in relation to the types of project management structure (adapted from Dupuis et al., MS 1980).

development of enhancement facilities, appointment of a project manager and clear definition of his authority by senior management could reduce conflict, confusion and duplication of effort. It is worth noting that total elimination of conflict should not be expected, as it is considered inevitable if the project is to progress in a healthy manner (Quick, 1972).

(2) The keystone of the task force management approach is consensus (Quick, 1972). The project manager should not make critical decisions independently. Such an authoritarian approach will result in a lack of staff commitment to the project. Rather, the project manager should have excellent mediation skills and must be able to motivate the most appropriate staff to develop timely and thorough answers to key questions.

(3) The Task Force membership should incorporate both regional and specialist expertise. On a personal level, all members have to strive consciously towards mutual problem-solving, rather than working in a win-lose mode. Strengthening intergroup and interprofessional communications can aid in fostering mutual respect through an awareness of the other's constraints and problems. For example, it is extremely helpful to the biological staff if Engineering staff formally document their assumptions and approaches beyond the initial joint conceptual design of a facility.

(4) Both inside and outside of the task force, formal documentation and feedback channels should be followed, as research into group dynamics indicates that structured communication is usually more effective than unstructured (Kelly, 1969). Examples of productive pathways are: dissemination of minutes of meetings; distribution of group program and activity plans (eg, the Fieldwork Bulletin); and regular update reports (eg, the biweekly Enhancement Operations Status Reports).

To better deal with resource limitations, the New Projects Unit has strived towards further streamlining of its activities. At present, a computer-assisted design program is nearing completion and will be documented in a forthcoming report. Coordination of bioreconnaissance users via Fieldwork Bulletins or other means may result in more effective use of funds through joint studies. Greater use will be made of special-interest groups, such as the Salmonid Culture Managers' Advisory Committee, to address criteria gaps.

ACHIEVEMENTS TO DATE

It is worth making the point that, although the present bioengineering process is not perfect, it has allowed us to implement considerable production capacity successfully. Since 1976, the total egg capacity at Enhancement Operations facilities has been increased by 34%, or an additional 222 million eggs (Table 15). Up to 1982, better than half of this new capacity had been utilized. Of the facilities operating in 1982, those that started in 1980 or earlier were at 58% of capacity while those that started in 1981 or later (excluding Kitimat) were already at 49% of capacity. Large and complex facilities such as Chehalis and Kitimat are going into the operational mode very smoothly. There are many reasons for the smoother and more rapid approach to capacity at recent facilities, but I feel a large measure of the credit is due to improvements in the bioengineering process.

Table 13. Enhancement Operations facilities: status and final capacities as of June, 1983

PROGRAM AREA	PROJECT	YEAR OF FIRST EGGS	CAPACITY IN M EGGS	1982 TAKE IN M EGGS
PRE-SEP	BEAR	1975	5.00	0.00[b]
	BIG QUALICUM	1967	145.46	209.64[d]
	CAPILANO	1971	3.74	2.75
	FULTON	1965	360.00	720.00[d]
	JONES	1954	2.50	0.00[c]
	PINKUT	1966	117.00	280.00[d]
	QUINSAM	1974	10.45	7.90
	ROBERTSON	1972	11.00	12.63
PRE-SEP TOTAL			655.15	1,232.92
SEP	BIRKENHEAD	1979	0.15	0.16
	CHEHALIS	1982	18.10	12.95
	CHILLIWACK	1980	7.40	7.57
	INCH'S	1981	8.25	7.15
	KALUM[a]	1981	0.20	0.22
	KITIMAT	1983	15.13	0.35[a]
	LITTLE QUALICUM	1979	75.00	41.29
	MATHERS[a]	1980	1.10	0.30
	NITINAT	1980	29.50	11.86
	PALLANT	1978	9.80	5.01
	PENNY[a]	1980	0.20	0.20
	PUNTLEDGE	1979	22.80	15.12
	QUESNEL	1981	3.90	1.64
	SNOOTLI	1978	9.47	4.46
	STUART[a]	1980	0.10	0.07
	TENDERFOOT	1982	0.45	0.47
	TLUPANA	1978	25.00	21.83
	TSOLUM	1980	4.00	0.00[c]
SEP TOTALS				
START UP TO 1980			184.52	107.87
START AFTER 1980			46.03	15.63
OVERALL			230.55	123.50

[a] Pilot operation
[b] Odd-year operation only
[c] Off cycle year
[d] Includes river production (flow control on Big Qualicum and Fulton; air lift above falls at Pinkut)

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REFERENCES

Anonymous. 1978. The Salmonid Enhancement Program. Info. Br., Fish. Mar. Serv., Dept. Fish. Env., Vancouver. 86 p.

Barnes, M.C., A.H. Fogg, C.N. Stephens, and L.G. Titman. 1970. Company Organization: Theory and Practice. P.A. Management Consultants Ltd., George Allen and Unwin Ltd., London. 235 p.

Burrows, R.E. 1981. Bio-engineering -- an overview. p. 1 In: L.J. Allen and E.C. Kinney (Eds), Proceedings of the bio-engineering symposium for fish culture, FCS Publ. 1, Amer. Fish. Soc., Bethesda, 307 p.

________, and H.H. Chenoweth. 1970. The rectangular circulating rearing pond. Progr. Fish-Cult. 32(2): 67-80.

Dupuis, Y., P. LaFleur, G. Plante and A. Soucy. MS 1980. Project Management. Handout material for Project Management Course given by Staff Development Branch, June 14-18, 1982, Hull.

Economics Working Group. MS 1977. The economic rationale for salmonid enhancement (Annex III to the Cabinet Document). Unpub. Doc., Fish. Mar. Serv., Vancouver. 46 p. + appendices.

Fox, C.L. 1976. Design criteria and operational reality. (Paper presented at National Fish Culture Workshop, Springfield, MO, January 13-15, 1976.) Tech. Rept. No. 45, Kramer, Chin and Mayo, Inc., Seattle.

Helm, R., D. MacDonald, B. Sinclair, D. Chan, T. Herrington, A. Chalmers and B.G. Shepherd. MS 1980a. A review of the Nechako River Watershed. Internal Rept., Salmonid Enhancement Program, Dept. Fish. Oceans, Vancouver. 128 p.

________, D. MacDonald, B. Sinclair, G. Stuart, A. Chalmers, and B.G. Shepherd. MS 1980b. A review of the Quesnel River Watershed. Internal Rept., Salmonid Enhancement Program, Dept. Fish. Oceans, Vancouver. 72 p.

Jeppson, P., and L.R. Taylor. 1981. How to develop criteria for design and operation of fish facilities. pp. 196-275 In: L.J. Allen and E.C. Kinney (Eds), Proceedings of the bio-engineering symposium for fish culture, FCS Publ. 1, Amer. Fish. Soc., Bethesda, 307 p.

Kelly, J. 1969. Organizational Behavior. Richard C. Irwin, Inc. and the Dorsey Press, Homewood, IL. 666 p.

References (cont'd.)

Kling, A., C. Cross, W.E. McLean, and C.J. West. MS 1983. A guide to the use of the Fishculture Information System for Hatcheries (F.I.S.H.) utility programs and the Apple II+ microcomputer, Draft MS for submission to Can. Spec. Publ. Fish. Aquat. Sci. 129 p.

Lill, A.F., A. Tautz, B. Shepherd, J. Wild, D. Marshall, W. Schouwenburg, and B. Tutty. MS 1983. Opportunities for salmonid enhancement projects in British Columbia and the Yukon. Preliminary report by the Enhancement Opportunities Subcommittee to the Salmonid Enhancement Phase II Planning Committee, Dept Fish. Oceans, Vancouver. 160 p.

Lister D.B., D.G. Hickey, and I. Wallace. MS 1981. Review of the effects of enhancement strategies on the homing, straying, and survival of Pacific salmonids. Report prepared by D.B. Lister and Associates Ltd. for Dept. Fish. Oceans. 51 p. + appendices.

Mayo, R.D. 1971. Hatchery design and operation information (from a slide presentation). pp 71-83 In: T.A. Gaucher (Ed), Aquaculture: A New England Perspective, New England Mar. Resour. Info. Progr., Univ. Rhode Island, Narragansett, 119 p.

MacDonald D.D., and B.G. Shepherd. MS 1982. Incubation of salmon eggs: water temperature and developmental timing. Info Memo No. 45, Dept. Fish. Oceans, Vancouver. 1 p.

________ MS 1983. A review of The Kitimat River Watershed. Internal Rept, Salmonid Enhancement Program, Dept. Fish. Oceans, Vancouver. 164 p.

McDonald, J.E. MS 1979. Summary of biological knowledge of populations of B.C. and Yukon salmonids. Draft MS and update, Salmonid Enhancement Program, Dept. Fish. Oceans, Vancouver. 80 + 35 p.

McLean, W.E.. MS 1979. A rearing model for salmonids. M.Sc. thesis, University of British Columbia, Vancouver, 134 p.

McLean, W.E., and A.L. Boreham. MS 1980. The design and assessment of aeration towers. Internal Rept., Salmonid Enhancement Program, Dept. Fish. Oceans, Vancouver. 63 p.

Pearse, P.H. 1982. Turning the tide: A new policy for Canada's Pacific fisheries. The Commission on Pacific Fisheries Policy Final Report. Info. Br., Dept. Fish. Oceans, Vancouver. 292 p.

References (cont'd.)

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler, and J.R. Leonard. 1982. Fish Hatchery Management. U.S. Dept. Int., Fish. Wildl. Serv., Washington. 517 p.

Quick, T.L. 1972. Your Role in Task Force Management. Doubleday and Co. Inc., Garden City, N.Y. 204 p.

Schouwenburg, W.J., C.C. Graham, J. Barnetson, S. Steele, and M. Peters. MS 1980. Geographic Working Group report. Draft Internal Report, Salmonid Enhancement Program, Vancouver.

Sigma. MS 1979. Summary of water quality criteria for salmonid hatcheries. Report prepared by Sigma Resource Consultants Ltd. for Dept. Fish. Oceans, Vancouver. 72 p.

________ MS 1983. Summary of water quality criteria for salmonid hatcheries (Revised edition). Report prepared by Sigma Environmental Consultants Ltd. for Dept. Fish. Oceans, Vancouver. 166 p.

Sinclair, D. C. MS 1976. Salmonid rearing systems. Bio/Eng criteria for program development and design planning. Mimeo of draft report. Dept. Fish. Oceans, Vancouver. 32 p.

____________ MS 1977. Planning and management problems of a large regional fish culture program. Draft of paper presented to Fish Culture Section at Annual Meeting, Amer. Fish. Soc., Vancouver.

Stauffer, G.D. MS 1973. A growth model for salmonids reared in hatchery environments. Ph.D. thesis, Univ. of Washington, Seattle. 213 p.

Appendix 1 Loading criteria used by Special Projects Division for public- and community-involvement facilities (excerpted from Project Management Guide, Salmonid Enhancement Community Economic Development Program).

LOADING CRITERIA

Loadings in this report are expressed in two measurements, weight per given volume and weight per given flow. When calculating how much to load in a particular container one of these rates will suggest a lower number of fish than the other depending on the container, its flow characteristics, and the species and size of fish involved. Always load the lower suggested number of fish.

ADULT HOLDING

Long Term - Weeks

CHUM	Flow	1.2Kg adults/LPM	10.5 lbs/USGPM
	Density	32 Kg/m^3	2 lbs./Ft^3
CHINOOK	Flow	1.2Kg/LPM	10.5 lbs/USGPM
	Density	32 Kg/m^3	2 lbs./Ft^3
COHO	Flow	1.2Kg/LPM	10.5 lbs/USGPM
	Density	32 Kg/m^3	2 lbs./Ft^3

Short Term - Days

Loadings can double for short periods. Chum salmon in particular can tolerate loading up to 4 lbs./Ft^3.

INCUBATION

Heath Tray	Flow	11 - 15 LPM/8 tray stack	3-4 USGPM/8 tray stack
	Density	5000 - 11000 eggs/tray	
	Eggs/tray	Kg/tray	Litres/tray
COHO	8000	2.1	1.7
CHINOOK	5000	2.1	2.4
CHUM	5000	2.1	2.2
PINK	11500	2.1	-

Comment: If trays are not loaded to capacity use the lower flow to prevent boiling. If capacity loaded use lower flows until advanced eyed then increase flow to upper range until ponding.

Upwelling Gravel Box (Pallant boxes, 50,000 eggs inc. box, etc.)

CHUM	Flow	37 - 57 LPM/100,000 eggs	10-15 USGPM/100,000 eggs
COHO			
CHINOOK	Density	250,000 eggs/m^3 (gravel)	250,000 eggs/1.3 yards

Modified Atkins Box

		1 Box = 2 cells	2 Box = 1 Line =
	Flow	15 - 30 LPM/line	4.0-8.0 USGPM/line
	Density	100 - 150,000/cell	100 - 150,000/cell

Japanese Style

Keeper	- 12-15,000 eggs/m^2
Channels	- water depth = 0.2 m
	- Exchange rate - 1.5 - 2.0 X/hr.
	- Velocity - 1.0 - 3.0 cm/sec.

Comment: Start up flows 1/3 maximum rising to final velocity which is required to flush fry from channels.

REARING

Capilano Troughs

Flow	0.5 Kg/LPM - 1.0Kg/LPM	4.5 - 6.0 lbs./USGPM
Density	32.35 Kg/m^3	2.1 - 3.1 lbs./Ft^3

Comments: Most facilities have Capilano troughs arranged in tandem. Flows should be 120 LPM at ponding and increased to 240 LPM as fish approach 2gms. 5gms is the preferred maximum size fish to be raised in these containers. Chinook are the least tolerant of higher loading densities of all the species.

SUGGESTED LOADING

Capilano Trough	Flow	120 LPM - Ponding - 1 gm.
		240 LPM - 1 gm - release

Ponding Technique

Crowd Fry in top half of trough for two week period at ponding to initiate feedings. Allow fry access to whole trough after the two week period. Pond 23,000 fry/Capilano trough do not raise fish to beyond 5 gms at this density.

Circular Tubs

CHINOOK	Flow	0.5Kg/LPM - 1.0Kg/LPM	4.5 - 6.0 lb./USGPM
	Density	10.0 kg/m^3	0.7 lb./Ft^3
COHO	Flow	0.5Kg/LPM - 1.15Kg/LPM	4.5 - 7.0 lb./USGPM
	Density	10.0 Kg/m^3	0.7 lb./Ft^3

Comments: Circular tubs seem to be useful in raising fish in the larger sizes.

Fish Weight	Tub Diameter	Flow	Depth	Number of Fish
2 - 5 gms.	4'	30 USGPM	3'	2125
	5'	30 USGPM	3'	3350
	6'	40 USGPM	3'	4750
	10'	60 USGPM	3'	13250
5 - 7 gms.	4'	30 USGPM	3'	1500
	5'	30 USGPM	3'	2400
	6'	40 USGPM	3'	3400
	10'	60 USGPM	3'	4500
7 - 20 gms.	4'	30 USGPM	3'	525
	5'	30 USGPM	3'	850
	6'	40 USGPM	3'	1200
	10'	60 USGPM	3'	3350

Burrows Pond - Similar loadings as circular tubs.
- Mixed flow containers.

Earthen or Semi-Natural Rearing Channels

CHINOOK	Flow	0.5Kg - 1.1 Kg/LPM	4.4 - 10.0 lb./USGPM
	Density	10 Kg/m^3	.64 lb/Ft^3
COHO	Flow	0.5 Kg - 1.8Kg/LPM	4.4 - 15.9 lb/USGPM
	Density	10 Kg/m^3	.64 lb/Ft^3

Comments: Calculations for Chinook were based on a size of 2gm at initial ponding and a release at 5 gms. Coho have an initial loading at 2gms and a release size of 20gms. Chum were assumed to have a release weight of not more than 2gms.

Pallant Seapens	-	CHUM	- Released at 1.5 gms. - Loaded at 400,000/Seapen - 3.0 Kg/m^3 - 0.2 $lb./Ft^3$
Puntledge - Quinsam	-	PINK	- Released .75 - 1.0 gms. - Loaded at 50 - 75,000/Seapen - 12.4 Kg/m^3 - 0.83 $lbs./Ft^3$
Wigwam Seapens	-	COHO	- Released 30gms. - Loaded at 50 - 75,000/Seapen - 12.4 Kg/m^3 - 0.83 $lbs./Ft^3$
Japanese Rearing Channels	-	CHUM	1g Release

Flow	1.0Kg/LPM	8.8 lbs./USPGM
Density	21.5Kg/m^3	1.35 $lbs./Ft^3$

Exhange Rate - 1.1 - 1.9 X/hr.

Velocity - 0.9 cm/sec. - 1.7 cm/sec.

TRANSPORT LOADING

Comment: Temperature not exceeding 20°C.
Assume 100% O_2 saturation.

Type of Aeration	Loading Kg/l	lbs./USG	Safe Transport Time
Oxygen	0.1	.8	2-3 hours
Compressed Air	0.1	.8	2-3 hours
None	.013	.1	1 hour

When using no aeration multiply loading by saturation of water supply (Table III) i.e. 70% saturation.
Acceptable Transport Load = (.7) x (0.13) kg/l

= .009 kg/l

Appendix 2 Sample of manageability review (for Statistical Area 5) from Geographical Working Group Report, excerpted from Schouwenburg et al (MS 1980).

MANAGEABILITY STRATEGY **DATE OF REVISION:** June 4, 1980
AREA: 5

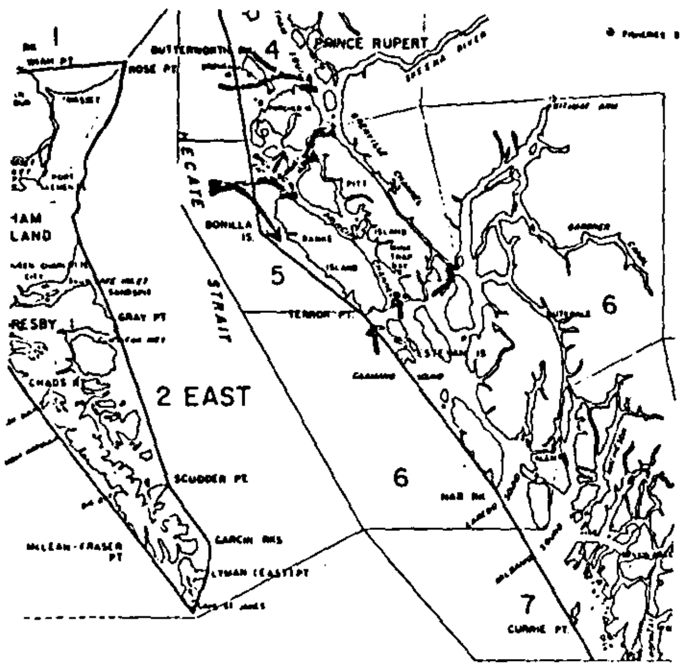
STATUS OF STOCK	SOCKEYE	PINK (EVEN)	PINK (ODD)	CHUM	COHO	CHINOOK	STEELHEAD/ CUTTHROAT
Current - catch	no specific fishery	335,000 3/4 of this catch local	248,000	no specific fishery	24,000	no stock	334
- escapement	25,000	275,000	88,000	22,000	23,000		UND
- opt.escapement	75,000	275,000	150,000	30,000	35,000		UND
- difference	-50,000	0	-62,000	-8,000	-12,000		UND
Rate of Return*	2.3:1	2.8:1	2.3:1	1.8:1	2.5:1		2:1
Present Stock Trends	declined but stable	stable 1:1	declined but stable	down but stable	declined but stable		UND
Reasons for change	overfishing	-	overfishing	overfishing	overfishing		
No. of streams	22	45			35		
Major Producers	Lowe Inl. 10,000 Bonilla Arm 6,500 Curtis Inl. 2,600 Devon Inl. 2,200	Kumealon Inl. 57,000 Bonilla Arm 24,000 Curtis Inl. 11,000 Cap't. Cove 105,000	Kumealon Inl. 22,000 Bonilla Arm 1.000 Curtis Inl. 2,000 Cap't. Cove 4,000	Bonilla Arm 7,200 Wilson 2,500	Bonilla Arm 15,000 Lowe Inl. 10,000 Endhill Cr. 75,000		
Component Changes Abundance Distribution Uniqueness in any Component		southern stocks show decline but not northern					
Migration Information							
Outside Interception	No	DOM.-Area 6 net	DOM.-Area 6 net Lower Area 5 (Principe Channel)	UND	Int.-Alaska net & troll DOM.-NC troll		
Indian Food Fishery							
- catch	1,700	467	467	130	146		
- location	Kitkala 80% Hartley Bay 20%	Kitkala 80% Hartley Bay 20%	Kitkala 80% Hartley Bay 20%	Kitkala 80% Hartley Bay 20%	Kitkala 80% Hartley Bay 20%		

*SEP Standards

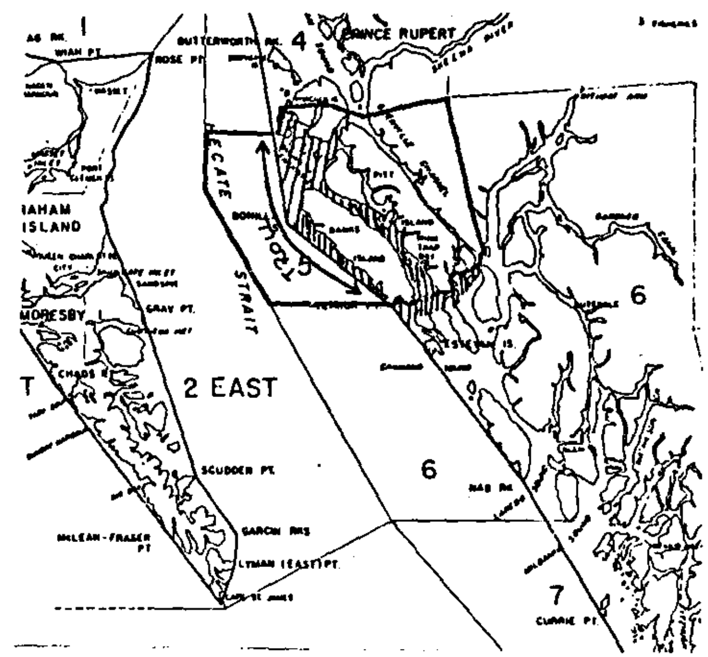
DATE OF REVISION: June 4, 1980

STATUS OF STOCK		SOCKEYE	PINK (EVEN)	PINK (ODD)	CHUM	COHO	CHINOOK	STEELHEAD/ CUTTHROAT
Sport Fishery	- catch	-	-	-	-	negligible		
	- effort	-	-	-	-			
	- location	-	-	-	-			

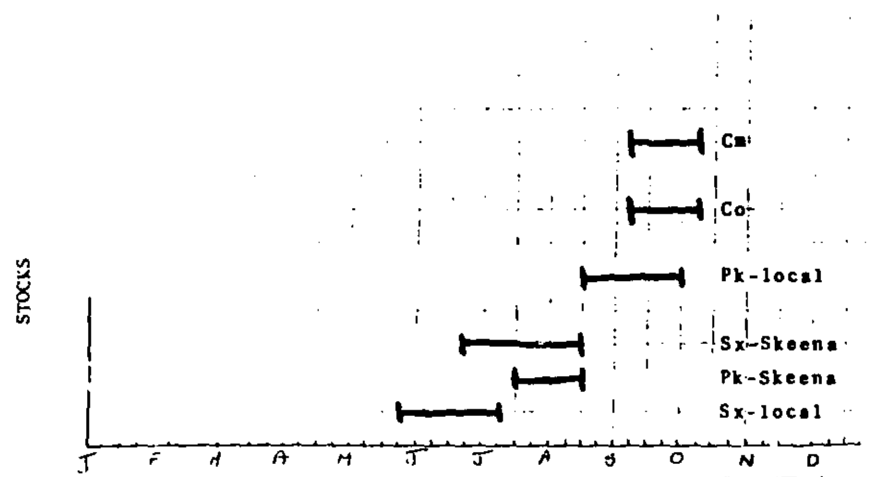
MIGRATION ROUTES



FISHING AREAS



TIMING*



*= based on the timing of local stocks passing through the Area 5 fishery.

DATE OF REVISION: June 4, 1980

Current Management

Current Management Problems and Constraints

- there are no local fisheries on any Area 5 stocks except for PK as most of the returning stocks are intercepted in other areas.
- assessment of PK stocks is a difficult problem. The strength of PK salmon returning to northern Area 5 streams (Browning Entrance-Ogden Channel) is undetermined when heavy Area 4 PK's return through Ogden Channel. Although, present PK stocks in this area seems stable.
- PK stocks in Lower Principe Channel are down. These fish are likely intercepted in the Area 6 fishery.
- in big Skeena years - gear limitation in Ogden Channel and Browning Entrance does become a problem for local stocks.
- Lowe Inlet SX stocks seem stable but not at historical levels. No local fishery exists on SX returning to Lowe. However, these fish are likely intercepted in the Area 6 fishery during late July and early August. Increases in Lowe SX stocks from fertilization program may be intercepted in Area 6 fishery before reaching Lowe Inlet. This may create a problem if considering a terminal fishery in Lowe Inlet.
- during periods of low water, access for Lowe Inlet SX becomes difficult.
- Lowe Inlet SX stocks.

Habitat Concerns

Opportunities

1. Regulatory:

   1. Current: - PK in lower Area 5 are being impacted by fisheries in Area 6 and both stocks are down. Reduced fishery effort could increase escapement.

2. Future: -

2. Biological:
- SX are well separated in timing and with geographic isolation.
- PK geographic isolation for Porcher Inlet and Kumealon Inlet.
- Northern Area 5 PK stocks migrate differently than southern stocks:- could be enhanced separately.
- PK are isolated in timing from upriver Skeena PK but overlap with coastal Skeena PK.
- 3 major CO streams could be developed but overlaps in timing with CM and PK.
- Bonilla Arm geographically separated.

3. Geographical:

Dependencies and Strategies for Management and Enhancement

In comparison with other areas in the North Coast, Area 5 is unique in that it doesn't have any initial management problems that require immediate attention. The opportunity in Area 5 lies mainly with SX and CO rehabilitation, neither of which is presently fished to any great extent. These opportunities (SX, 2 - 4 systems, CO - 3 streams) have favourable management requirements associated with them in that they are isolated in both timing and geography to a large extent.

Because of limited access to the area, to capitalize on the aforementioned opportunities would require minor and simple enhancement techniques.

- SX can be developed at any time because of isolation in timing and geography in Lowe Inlet and Bonilla Arm.
- PK's in northern Area 5 are later than Skeena pinks and could be developed without conflict if Coastal Area 4 PK were developed as well. Southern Area 5 PK will have to be developed in coordination with those in Area 6.

DATE OF REVISION: June 4, 1980

- CM and CO would have to be developed together due to timing overlap. Some PK work would have to be done as well because of an overlap in the early part of the CO and CM run.

Current SEP Activities

Lake fertilization was initiated in 1979 on Curtis, Devon, Bonilla and Lowe Lakes. This fertilization is in line with the strategy outlined above. The fertilization in Curtis and Devon potentially affected juveniles from 3 brood years (1976-78) with the first returns expected in 1982. Manageability studies to determine stock indexing techniques and terminal fishing area should be started in 1981.

Potential Additional Production

SX		115,000
PK	(O)	143,000
PK	(E)	0
CM		14,000
CO		27,000*

*Could be higher

Activity Plan

1) (See Current SEP Activities). The current fertilization program in Area 5 should be continued with the understanding that the results of the 1981 manageability studies may set the pace for future fertilization.

1a) Manageability study to determine:
  1. stock indexing method.
  2. boundaries of terminal fishing area.

1b) A fishery to by-pass the obstruction to Lowe Lake is recommended to ensure that an adequate escapement is achieved under all flow regimes and also to provide an enumeration facility to be used as a stock indexing device for management purposes if the 1a) manageability study indicates that is might be a valid method.

2) CO Development Package - two opportunities exist for CO in Area 5.
   - Lowe Inlet - because of its isolated geography and the existing SX.
   - Bonilla Arm - to be developed with CM because of geographic isolation.

   The harvest on the above development is to be via a terminal net fishery. Other CO producers have potential for enhancement, however, their poor manageability and potential CM impacts make them less desirable.

2a) Manageability study - on Bonilla Arm to determine:
   1. stock indexing methods.
   2. terminal fishing boundaries.

3) Northern Area 4 PK developed may be required depending on coastal Area 4 PK development.

3a) Manageability studies on coastal Area 4 PK development should include an assessment of impacts on Area 5 stocks.

4) Feasibility study to determine potential for inlet development, e.g.: Kumealon and Porcher inlets.

4a) Take advantage of opportunities identified in 4) above.

4b) Manageability study:
   1. fleet size limitation
   2. terminal fishing boundary demarcation

Activity Summary

1. SX - fertilize but upper limit due to fishing space.
2. PK - productivity problems in the south but management is tied to Area 6 PK management.
   - potential available in northern stocks but will require fleet control.
3. CM and CO could be developed but the species interaction between the two species is critical.

Appendix 3 Sample listing of enhancement opportunities for Statistical Area 5, excerpted from Lill et al (MS 1983).

No.	Project/River	Description	Class: Type	Class: Size	Class: Opport	Environment Data: Current Escape	Environment Data: Spawn Capacity	Environment Data: Rear Area	Maximum Spawning Escapement	Site Potential Production	Capital ($,000)	Operating ($,000)	Benefit Cost W/O US/CAN	Benefit Cost WITH US/CAN	Inter-Dependencies -- Alternatives	Remarks
5-1	Porcher Inlet (Beaver Ck.) (Head Ck.) (Porcher Ck.) (Wolf Ck.)	facility and satellites	1 3	2 2	3 3 M)	10 P 35 P(E) CO				20 PK 10 CO (1650 kg)	315 E.F.=1.5	157	0.6	~ 0.7		Kitkatla Community nearby all streams reasonably healthy and could use some stream rehab. No sites identified water sources could be questionable.
5-2	Curtis Ck.	undetermined				35 SK .5 CO 8 PK			19 SX							Poor access. small scale ops? Lake enrichment on-going
5-3A	Lowe Inlet	fishway	2	1	4											Feasibility studies - expenses not warranted.
5-3B*	Lowe Inlet Lakes (Weare, Camble, Simpson Lk)	SX colonization trap/trans-plant	1 TT	3	3 M)					(23 SK cycle (6.750 SK cycle 1)	20	100	0.3	0.5 0.3	5-3C	Assume 6000 brood, trans-2000 intially, Weare & Camble 60' falls. Simpson 3900 hectares - potent. 3900 SX Report by Walker potential 145k SX total stock
5-3C	Lowe Inlet Facility plus Hanging Lakes Co. Transplant (Candidates are: Batchelor Lake Sylvia Lake Redbluff Lake Wyndham Lake)	Trap/Truck Incubation 3 M Sx eggs transplant	6	1	3 M)					13.5 CO 21.6 SK 3400 kg 1st cycle facility no fishing transport 20,000 SK 2nd cycle 67,500 SK	1000 E.F.=2.0	326	~ 0.4	~ 0.6 0.5	5-3B	CO donor stock from Lowe Inlet.

* Denotes project with best potential º Suggested by public (All Escapements and Production in ,000 pieces)
(M) Manageable but uneconomic under present assumed costs and benefits.

AREA: NORTH COAST AREA 5 SYSTEM: GREENVILLE - PRINCIPE DATE: JUNE 30, 1983 DRAFT: #6 AREA 5

No.	Project/River	Description	Class: Type	Class: Size	Class: Opport	Environment Data: Current Escapement	Environment Data: Spawn Capacity	Environment Data: Rearing Area	Environment Data: Maximum Spawning Escapement	Site Potential Production	Capital ($,000)	Operating ($,000)	Benefit Cost W/O US/CAN	Benefit Cost WITH US/CAN	Inter-Dependencies -- Alternatives	Remarks
5-4	Bonilla Arm	undetermined limited pot.			4					CO CM						Stocks not harvestable no access
5-5	Salmon R. (Greenville Channel)	incubation				8 PK 1 CO										Site? returns seen low location?
5-6	Bonilla Lake Curtis Lake Devon Lake	competitor & control							SX							Stickleback populations hampering benefits of lake enrichment. Control may be possible. Alistair Lake pilot to test.

* Denotes project with best potential   ° Suggested by public

GLOSSARY OF TERMS AND EXPLANATION OF ABBREVIATIONS

No. - Project Number

- Prefix gives statistical area or abbreviation for sub-district or river drainage where no statistical area exists.
  e.g. 2E-4D is located in statistical area 2 East.

Letter Prefixes

PG - Prince George
Q - Quesnel
K - Kamloops
L - Lillooet
CH - Chilliwack - Hope
MH - Mission - Harrison
Y - Yukon
S - Stikine

Project/River

- location of the enhancement opportunity.

Description

- type of project and technology which seems most appropriate to the site.

Class

a) Type - projects have been classified into technology types as follows:

1. Fish Culture/Colonization (includes all projects which involve taking eggs and incubating them. The

juveniles will be subsequently reared or outplanted in their native river system.)

2. Spawning Channels, Side Channels, Spawning Structures and Fishways or Obstruction Removals. (Includes formal structures designed to improve spawning or extend the range of spawners.)
3. Habitat Improvement Projects (includes formal structures or habitat modifications which provide better overall conditions for salmonids.)
4. Stream/Lake Enrichment
5. Transplants (includes all operations where stock is to be incubated and released in a completely new river system.)
6. Combination (includes projects combining 2 or more of the above types.)

Codes - Technology type of project

BX - incubation box
CH - spawning channel
CO - colonization from existing hatchery
EI - estuary improvement
FC - flow control
FP - multiple fish production strategies
FT - lake fertilization
FW - fishway
HC - combination channel/hatchery
HX - multiple combination hatchery, channel, flow control
HY - conventional hatchery
JH - hatchery, primarily Japanese style technique
LJ - log jam removal
OR - obstruction removal
SC - side channel
SI - stream improvement
TR - transplant
TT - trap/truck over obstruction

b) Size

1. Major project over $500,000 capital
2. Minor project $50,001 to $499,999 capital
3. Small project under $50,000 capital

c) Opportunity - opportunity status indicates progress in developing the proposal as follows:

1.- Proven feasible, design well advanced, ready for early start-up of construction.
2.- Reconnaissance study done, detailed feasibility assessment still required.
3.- Opportunity not yet checked in the field by SEP.
4.- Opportunity rejected as impractical at this time.
M - Opportunity has received a stock manageability assessment and is considered manageable under present practices and conditions.
T - Candidate project for the SEP Transition Phase 1984/85 or 1985/86.

ENVIRONMENT DATA

a) Current Escape - recent average escapements from stream catalogues.

Species :

CM - chum
CN - chinook
CO - coho
CT - cutthroat
PK - pink
RT - rainbow trout
SK (or SX) - sockeye
ST - steelhead

b) Spawning Capacity - lineal length of stream or actual spawning area if known.

c) <u>Rearing Area</u> - lineal length of stream or actual rearing area if known.

d) <u>Maximum Spawning Escapement</u> - average of three best years in stream catalogue.

<u>Site Potential Production</u>

- gives the total adult production expected if the opportunity was undertaken. Also shown in this column are juvenile production data used for sizing and costing of facilities, including weight of juveniles to be released and release sizes.

<u>Capital ($,000)</u>

- estimated capital cost in 1982 $. Also shown in this column is the E.F. or (Engineering Factor) used in deriving the cost estimate which accounts for anticipated complexity and site factors.

<u>Operating ($,000)</u>

- estimated annual operations cost at full capacity in 1982 $.

<u>Benefit Cost</u>

- estimated ratio of quantifiable economic benefits to costs using a 10% discount rate with and without a U.S./Canada Agreement. An agreement is assumed to allow credit for all fish which would now be caught in U.S. fisheries.

- TBR - to be revised.

Interdependencies/Alternatives

- some projects need to be constructed concurrently or are prerequisites to other projects for stock manageability reasons. In some cases more than one project is possible dealing with the same stock and only one of the alternatives is practical at this time.

Remarks

- Self-explanatory.

Appendix 4 Standard specifications for preparing requests for consultant proposals:

Additional information normally is appended to the specifications, including:

- a list of applicable references for study and area
- water sample collection guidelines
- samples of completed relevant forms
- a list of sample reports with acceptable formats
- a summary of known background information on climate, access, accommodation, spawning, etc.

FILE: **NEW PROJECTS "Request For Proposal" MASTER**

APPENDIX "A"

GENERAL PROGRAM OUTLINE

INTRODUCTION

The goal of the following program is to provide biological and physical information to be used by the Department of Fisheries and Oceans in planning and implementing salmonid enhancement facilities to service salmonid stocks from the ____ ____.

Emphasis is to be placed on ____ ____ ____ ____ ____ ____ ____ ____

PART ____. JUVENILE SALMONID RECONNAISSANCE PROGRAM

OBJECTIVES

( ) To determine the migration timings, numbers, and the size and age distributions of ______________ juveniles emerging, migrating from and/or rearing in the ____ ____ ____ ____

Methods and analyses must be compatible with and complement (fill in data voids) the 198_ study on the __________________________.

( ) To capture, and tag with coded-wire nose tags and do adipose fin-clips on a minimum of 20,000 coho/75,000 chinook juveniles on the ________________ River, in order to determine adult distribution and migration routes and their contribution to the various fisheries.

( ) To inventory habitats in relation to utilization by ______________ fry.

( ) To record daily water temperatures and levels, and to determine water quality in order to assess potential limitation to salmonids.

( ) To submit a final comprehensive report on the methods and results of the above programs, which discusses the implications that the results may have for proposed enhancement techniques. The bidder is referred to consultant reports published in-house during 19__, as to format approaches acceptable to the Scientific Authority (see References Section).____________________

( ) ______________________________

SCHEDULE

Mobilization to begin by ______________ 198_. Field work from __________ to ____________, 198_. Draft report to be received by Scientific Authority by ___________, 198_; final report submitted by ____________, 198_.__________

METHODS

_. Water Temperature, Level, and Quality

( ) Record water temperatures and levels daily on the ________________, three times per week on the ____________, at predetermined sites and at a standardized time. Report temperatures as Max/Mean/Min. per site over the study period. Staff gauges are to be benchmarked to permanent features in case of wash-out. Where possible gauge site used in 19__ should be used again, to allow inter-year comparison.

( ) Collect water samples at selected sites on each river for analysis by the DFO's Cypress Creek Lab, 4195 Marine Drive, West Vancouver, B.C. V7V 1N8. (Details/Sites as per Section _____)

( ) Full series (Enclosure 1) to be taken at approximately monthly intervals from the start of field work. Sampling to be coordinated such that shipment to Cypress Creek will be complete within 48 hrs, and will arrive at the lab before noon on Friday (of a normal work week). Samples to be packed in ice in coolers for shipment.

( ) One-liter samples of river or creek water to be taken whenever discharge is unusually high or dirty. These samples can be frozen (leave air space) for analysis by DFO lab after completion of field work.

( ) Sampling bottles sampling request forms (see Enclosure 2), and reagents will be provided by DFO.

( ) On-site determination of pH (±0.5 units) and temperature (±0.5°C) to be done when lab samples are taken.

( ) Provide stream discharge data for the period of study from Water

( ) Provide stream discharge data for the period of study from Water Survey of Canada records where available, or by standard methods at representative sites and stages.

( ) Obtain daily precipitation data for the period of study from the local weather station, if representative, and/or by installing standard copper rain gauges.

____

____

____

_. <u>Migrating Fry and Smolts</u>

( ) To employ the following traps where appropriate: converging throat weir traps, floating inclined-plane traps, fykenet traps with restrictive throats and liveboxes, wire minnow traps, seines, electroshocking, or other methods acceptable to the Scientific Authority.

( ) Preferred trap types and suggested locations are as follow:__________

____

____

Alternate trap types may be utilized, subject to approval of Scientific Authority. The contractor should recognize that the capture of smolts and the survival of captured fish are to be maximized, and choice of location and set-up should be considered in that light.

( ) Place emergence migration index traps below major spawning grounds, but above significant tidal influence. Smolt migration index traps should be placed downstream of significant rearing areas.

( ) Trap juveniles at least from dusk to dawn (usually the most active period of fry migration), three times per week on alternate nights; trap nightly during periods of significant migration (when nightly migrations exceed 1% of the expected migration.)

( ) Trap juveniles from dusk to dawn (usually the most active period of fry migration), three times per week on each river on alternate nights. Some daytime trapping should be carried out on each river during peak migration periods.

( ) During periods of significant migration (see) carry out 24 hour trapping once a week (more often if large changes in water level occur). On these occasions, the number of fry captured should be determined every 2 hr.

( ) Maintain optimum trapping efficiency by regular inspection and cleaning of trapping gear.

( ) Estimate the entire catch per trap by species, fry and smolt stage, using weight or volume subsamples with a minimum of three replicates, each with 200 - 300 fry, if possible. Count and release immediately incidental species. Retain type specimens preserved in 10% formalin for verification of identification by Technical Monitor/Scientific Authority.

( ) Conduct biological sampling as follows:

( ) sample a minimum of 10 juveniles from each species each trapping day throughout the migration period. (NOTE: "juveniles" includes fry and smolt stages which should be treated separately.) Increase sample size if there are significant size variations;

( ) anaesthetize fish with MS 222 anaesthetic, pat dry, weigh, measure nose-fork length, sample smolts for scale smears (DFO personnel will interpret scales), and examine for degree of yolk absorption and anomalies[a]; release revived fish;

( ) maintain measurement accuracy of ± 0.5 mm for length and ± 0.01 g for weight;

( ) calculate developmental index or condition factor for each sample group.

$$K\Phi = \frac{10^3\, W(mg)}{L(mm)}$$ for alevins and emergent fry;

$$\text{Fulton's } K = \frac{100W(g)}{L^3(cm)}$$ for later fry and juveniles.

( ) Expedite shipment of an appropriate number of live juveniles of each salmonid species found to Diagnostic Services, Pacific Biological Station, Nanaimo, for presumptive disease diagnosis. Sampling and shipping procedures are to be as per DFO Fish Health Regulations Manual of Compliance, page 13. G. Hoskins at the Station will provide system-specific sampling requirements to the successful bidder.

( ) Develop population estimates for ______________ preferably by using trap efficiency based method on mark-recapture (dye-test outlined below), or using proportionate sampling methods (fraction of stream discharge and of cross-sectional area sampled).

---

[a] Including naturally-missing adipose fins, pop eye, fog eye, scale loss, fin or tail rot, fungus, scoliosus, blood fluke, rubbed nose and split dorsal fin.

( ) Conduct dye tests weekly to determine the trapping efficiency of gear (more often if large changes in water level occur that may alter trap efficiency). Initially, one thousand ______________ (if possible) are to be held in Bismarck Brown Y solution (0.5 - 0.7 g dye in 40 l water) for three hours and released at dusk approximately 1 km above traps. Conduct recaptures the following two mornings. Size of succeeding test lots may be altered dependent on numbers of recaptures.

( ) In developing population estimates, consider all bias in the trapping method and limitations of the data, and develop correction factors for the probable sources of error (e.g. proportion of spawners below the traps).

( ) Sampling methods, locations and analyses are to be compatible with those used in the 198_ study done by__________.

_. Rearing Juveniles

( ) Where not done in 198__, by means of standard bio-physical survey methods (eg. B.C. Aquatic Studies Branch or the BCFW "habitat unit" sampling techniques), characterize each homogeneous reach and sidechannel of each river (length, width, depth, substrate, slope, obstructions, cover, etc.) to determine stream area apparently suitable and available to rearing __________________ juveniles.

____

____

____

( ) Determine the duration and distribution of rearing ______________ juveniles by establishing fixed trapping sites to represent specific stream sections (see Section _____, above) and carry out systematic minnow trapping, electroshocking and/or seining over key sampling periods. The sampling program shall include checks of watershed areas upstream of known or suspected partial obstructions to anadromous salmonid migration.

( ) Develop population estimates of rearing juveniles using accepted mark-recapture methods. The estimate made for one stream section may be extrapolated to an adjacent river reach having similar habitat and flow characteristics, using a calibration factor (e.g. 1 fish per minnow trap in the dye-tested section represents 'X' fish in the extended river reach).

( ) Establish growth patterns of juvenile fish for the duration of the sampling program for each river section, for each type of trapping gear used, and by species and stage.

( ) Identify those areas seasonally suitable for in-stream rearing or holding of fry for imprinting.

( ) Methods, sampling locations and morphometric classifications in this section are to be compatible with those used during the ____________ study.

____

____

____

____

____

_. Juvenile Tagging

( ) Trap juvenile ____________________ later in the season at larger fry size (approximately 500 fish/kg or 50 mm length) and tag at the time of capture. Fry are not to be collected during the emergence migration, but rather during the later stages of the rearing fry study.

( ) Construct a weir (fence) trap near the mouth of ______________ Creek below major spawning and rearing areas, or use other appropriate traps (see Section ___).

( ) Operate the traps continuously to obtain the minimum specified quota of ____________ juveniles.

( ) Maintain optimum trapping efficiency by regular inspections and cleaning of fence and live box screens. Potential predators should be removed and subsampled to determine their impact on trap catches of target species.

( ) Trap juveniles early in the season during their active migration and rear in net pens to tagging size.

( ) Trap juveniles later in the season at larger fry size and hold in net pens until sufficient numbers for tagging are accumulated. Do not hold for long periods of time if this interferes with migration timing.

( ) Carry out rearing procedures according to standard DFO fish culture practices (use of OMP food and feeding schedules; regular cleaning, inspecting and sampling (see section _____) of lots, tabular data reporting and daily log keeping).

( ) Provide finclipping and tagging services where required. DFO will provide wire tags and tagging machinery.

( ) Perform quality control tests (tag loss, tag placement, and fin clip) and assess tagging-related mortality.

____

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____

____

_. Estuarine Studies

( ) Employ the following traps where appropriate: wire minnow traps, set nets, seines, or other methods acceptable to the Scientific Authority.

( ) Trap juveniles three times per week in the ____________________ estuary and weekly in the _____ estuary during migration and estuarine rearing.

( ) Contractor is to make periodic checks of trapping mortality, and should make all possible adjustments to minimize mortality.

( ) Maintain optimum trapping efficiency by regular inspection and cleaning of trapping gear.

( ) Estimate the entire catch per trap by species, fry and smolt stage, using weight or volume subsamples with a minimum of three replicates, each with 200 - 300 fry, if possible. Count and release immediately incidental species. Retain type specimens preserved in 10% formalin for verification of identification by the Scientific Authority.

( ) Conduct biological sampling as follows:

- sample a minimum of 10 juveniles from each of the three species on each trapping day throughout the migration period (NOTE: "juveniles includes river and estuary stages which should be treated separately).

- anaesthetize fish with MS 222 anaesthetic, pat them dry, weigh, measure nose-fork length, take scale smears from larger juveniles, and release revived fish.

- maintain measurement accuracy of ± 0.5 for length and ± 0.01 g for weight (use electric balance if available).

- calculate developmental index condition factor for each sample group.

  $K\ \Phi = \frac{10^3\ W(mg)}{L(mm)}$ for emergent fry; Fulton's $K = \frac{100W(g)}{L^3(cm)}$ for all others.

- examine stomach contents of several lots of 10 juveniles collected periodically throughout migration and rearing and identify and enumerate major food species (preferably to genus level). Preserve type specimens for future reference.

( ) Establish growth patterns of juvenile __________ for the duration of the sampling program for each estuary and for each type of trapping gear used.

( ) A "zooplankton watch" is to be conducted at the following sites:

( ) In the nearshore areas of ____________ estuary where __________ fry are observed to be feeding;

( ) At the center of ____
____
__________;

( ) Sampling is to be done at least every five days at each site.

( ) A Miller sampler or similar (200 μ mesh net and 0.01 m^2 mouth) is to be towed at the water surface for approximately 300 - 400 m. The tows are to be done at dusk (about 2000 hr) at speeds of 1 - 2 knots/hr. The distance towed is to be determined with a Gurley Pygmy Current Meter held over the side of the boat. The samples are to be preserved in 10% formalin for analysis.

( ) In analysing the zooplankton samples, the larger organisms such as jelly-fish, tunicates etc., are to be excluded. The remaining organisms are to be identified and enumerated. Samples containing large numbers of organisms can be subsampled using a plankton splitter before identification and enumeration. Results from the examination of subsamples are then to be multiplied by the splitting factor to estimate the numbers of organisms in the total sample.

( ) After enumeration, each sample of plankton is to be filtered through a fine screen (0.2 mm sq. mesh) and the residue weighed after drying for 5 minutes at room temperature on a circle of filter paper. Total weight of each sample is to be used to provide an estimate of zooplankton standing crop (mg/m^3), by dividing total damp weight by the volume of water sampled during tows.

( ) Stomach content samples are to be used together with the plankton samples to develop a key to the major food organisms, including diagrams and photos where possible.

( ) Conduct a habitat survey of ____________ rearing areas in each estuary and prepare map of preferred habitats.

( ) Estimate the potential rearing capacity of the estuary for ______.

( ) ____
____
____
____

_. Reporting

( ) Submit monthly brief progress reports containing summaries of current data and any significant findings.

( ) Submit two copies of a draft report by ____________________, 19__ presented in a clear and comprehensive manner which outlines the methods employed and results obtained and discusses the latter in relation both to prior relevant studies and to potential enhancement measures.

( ) The final report shall also include a watershed description (physical features, climate, land use, access maps, etc.) and a background on the salmonid populations in question based on available records.

( ) Submit the camera-ready originals and one bound copy of the final approved report by _____________ 198_.

( ) Raw data and summaries should be included in a separate bound appendix (2 Copies). Due to publication costs, DFO will not publish appendices.

( ) ____
____
____
____

Part . ADULT SALMONID RECONNAISSANCE PROGRAM

OBJECTIVES

( ) To determine the spawning escapement, timing and distribution of adult __________________ and incidental species in the __________________ ______ River systems.

( ) To obtain length, age and sex composition, fecundity, and egg retention data for the spawning populations of _________________.

( ) To record water temperatures, levels, precipitation, stream discharge and water quality in the systems under study.

( ) To describe those physical aspects of the systems relevant to spawning success, including stream width, depth, gradient, substrate composition and the presence of obstacles to migrants.

( ) ____
____
____
____

( ) To submit a final comprehensive report on the methods and results of the above programs, and which discusses the implications that the results may have for the proposed enhancement techniques. The report must be compatible with that done by ______________ in 198_.

( ) ____
____
____
____

SCHEDULE

Mobilization to occur by ________________, 19__. Field work from ____________________ to _________________ , 19__. Draft report to be received by Scientific Authority by ________________, 19__. Final report to be submitted by ______________, 19__.

METHODS

_. Water Temperature, Level, and Quality

( ) Record water temperatures (max/mean/min) and levels daily at pre-determined sites and at a standardized time. Staff gauges are to be benchmarked to permanent features in case of wash-out.

( ) At the conclusion of the adult field program, the contractor is to continue monitoring of daily water temperatures at ____________ using Ryan thermographs or locally-hired personnel (or another method acceptable to the Scientific Authority). Temperatures are to be monitored until ____________, 19__, and are to be submitted separately from the main report by ______________, 19__.

( ) Collect water samples at selected sites for analysis by the DFO's Cypress Creek Lab, 4195 marine Drive, West Vancouver, V7V 1N8. (Details/Sites as per Section _____).

( ) Full series (Enclosure 1) to be taken at approximately monthly intervals from the start of field work. Sampling to be coordinated such that shipment to Cypress Creek will be complete within 48 hours, and will arrive at the lab before noon on Friday (of a normal work week). Samples to be packed in ice in coolers for shipment.

( ) One-liter samples of river or creek water to be taken whenever discharge is unusually high or dirty. These samples can be frozen (leave air space) for analysis by lab after completion of field work.

( ) Sampling bottles, sampling request forms (see Enclosure 2), and reagents will be provided by DFO.

( ) On-site determination of pH (±0.5 units), and temperature (±0.5°C) when lab samples are taken.

( ) Provide stream discharge data for the period of study from Water Survey of Canada records where available, or by the current meter and velocity-area method at representative sites and stages.

( ) Obtain precipitation data for the period of study from the local weather station, if representative, or by installing standard copper rain gauges.

( ) Measure temperature and salinity at selected sites approximately weekly (so as to delineate the extent of estaurine influence up to 30%) adjacent to the mouth of ______________________, at surface, 2m, and 5m.

( ) ____
____
____
____

METHODS

_. Biophysical Parameters

Where not done in 198_:

( ) By means of standard bio-physical survey methods, (e.g. B.C. Aquatic Studies Branch), characterize each homogeneous reach and side channel of each river (depth, width, slope, substrate, riffle, pool, cover, etc.).

( ) Describe for each homogeneous reach in the main stream and major tributaries the following features: meander length; slope; floodplain and wetted channel width; presence and size of side channels; proportion of area classed as pool, riffle and rapid; and substrate type and composition.

( ) Describe all possible obstacles to upstream passage of salmon migrants.

( ) Using the above data, determine the stream area apparently suitable and available for holding and spawning by salmon.

( ) Determine the morphometry of each estuary by accepted methods.

( ) ____
____
____
____

_. Biological Parameters

( ) Obtain a visual estimate of escapement by conducting foot, boat and/or underwater surveys to obtain counts of active spawners and holding fish by stream section, at time intervals less than the spawner turn-over rate. Derive total population estimates based on estimated total spawning effort the average time spent per adult on the spawning grounds.

( ) Estimate the size of spawning population by tagging and releasing migrating salmonid adults below the spawning grounds, and by determining tagged:untagged ratios among carcasses available for the species in question over the major portion of the run. Tagging of adults in saltwater should be avoided if possible. Capture adults by beach seining or adult fence, or other method acceptable to Scientific Authority, and tag with Petersen tags (supplied by DFO). Estimate the size of a given spawning population by using the Petersen mark-recapture method; apply the tagging and recovery effort necessary to estimate the study area escapement to within ±25%, at the 95% level of confidence (W.E. Ricker, Canadian Journal of Fisheries and Aquatic Sciences Bulletin 191). The total population estimate should take into account sources of error and bias.

( ) Conduct a minimum of three helicopter flights, with one at the time of peak spawning, to obtain an independent visual estimate of salmonid spawners and distribution, particularly in cases where distances preclude coverage of the entire watershed on foot.

( ) Determine migration timing of ________________________ adults (and incidental species) by means of daily counts of fish passing the _____ ___________ fishway, by counting unsuccessful and successful jumpers at the falls at set times during the day, and by inspections at least twice weekly of downstream and estuarine areas.

( ) Record the distribution and abundance of spawning salmon in carcass recovery surveys. Rate subjectively the spawning and holding activity per river section as high, medium, low or scattered and transfer the information to large-scale topographic maps for early, peak and late stages of spawning; determine from above data the timing of river entry, spawning period (start, peak, end) and die-off period for the species in question.

( ) Conduct a continuous carcass recovery survey at approximately weekly intervals during the start of the spawning run and 2-3 times per week throughout the die-off period; use division points established in

198_, establish distinct stream sections for dead recovery so that the division points can be found for future studies; carry out the surveys on foot, by downstream swimming or by river boat; cut in half all recovered carcasses to prevent recounting in subsequent surveys.

( ) Sample carcasses for sex and age composition; length distribution (postorbital-hypural for live and dead fish); weight, fecundity and egg retention in females; record any significant external marks (e.g. missing fins, hook scars); in determining the length and age composition, target for a sample size of 100 fish of each sex, and maintain a measurement accuracy of ± 0.5 cm.

( ) Record race (flesh color) of all fresh chinook carcasses.

( ) For age determination collect scales preferably from live fish to minimize scale resorption; for chum and sockeye salmon remove 2 scales from the left side above the lateral line in the area between the dorsal and adipose fins; for chinook and coho remove 10 scales per fish, 5 from each side from above and below the lateral line; the Department of Fisheries and Oceans will provide scale books and personnel for interpreting the scales.

( ) Collect __________ otoliths for age determination from _____________.

( ) Do fecundity counts on all dead, unspawned female salmon found and on females taken during tagging operations, over the available size range; obtain postorbital-hypural length and scale data for each female sampled; the number of females sacrificed should be restricted to 5-10 individuals, depending on the size of the escapements.

( ) Estimate potential egg deposition of salmon populations under study by using the fecundity data, the number of females in the population, and the mean percent egg retention.

( ) To supplement carcass recovery data, live sampling of migrant _______ _______ from __________________________ is to be attempted. Sampling rate is to be set at 10% of the previous day's run (up to a maximum of 10 fish/species). The fish are to be captured in a_________________ _____________ DFO will provide ______________________________________ ____________. Fish are to be anaesthetized by accepted methods, and sampled as in Section __ (substitute degree of maturity for fecundity and egg retention).

( ) The successful contractor will arrange with G. Hoskins of Diagnostic Services, Pacific Biological Station, Nanaimo, for sampling and/or shipment of adult specimens for determination of endemic disease characteristics of the population. Sampling frequency and intensity are to be determined in consultation with Mr. Hoskins after the award of the contract.

( ) Determine average egg diameters by measuring 10 eggs in line. Eggs to be taken from ripe females over the full size range and water-hardened for 1.5 hours prior to measurement.

( ) Note all incidental observations of rearing juvenile salmon, competitors, predators, etc.

( ) ______________________________
____
____

_. Reporting

( ) Submit monthly brief progress reports containing summaries of current data and any significant findings.

( ) Submit two copies of a draft report by ______________, 19__ presented in a clear and comprehensive manner, which outlines the methods employed and results obtained, and discusses the latter in relation both to prior relevant studies and to proposed enhancement measures (eg. recommend access routes and methods and locations of capture and holding of broodstock).

( ) Submit the camera-ready originals and one bound copy of the final approved report by ________, 19__.

( ) The report shall also include a watershed description (physical features, climate, land use, access maps, etc.) and a background on the salmonid populations in question based on available records.

( ) Raw data and/or summaries are to be included in a separate, bound appendix. (2 copies). Due to publication costs, DFO will not publish appendices.

( ) Temperature data taken beyond the period of adult field work is to be reported separately by means of monthly summary forms, which are to be received by ____________, 19__.

( ) ____
____
____
____

PART . LIMNOLOGICAL SURVEY OF ____________

OBJECTIVES

( ) To determine and report on the suitability of water from ____________ Lake for use in ______________________________
____
____
____
____

_. SCHEDULE

Mobilization to begin by ______________, 19__. Field work within the period ____________, 19__ to ______________, 19__. Draft report to be received by Scientific Authority by ________________, 19__; final report submitted by ____________, 19__.

_. METHODS

The lake is to be surveyed at least four times within the field work period, at times of the year considered critical in determining the seasonal limnological characterization of the lake. The following tasks are to be undertaken during the surveys:

( ) Determine lake morphometry by accepted methods, with special emphasis given to the outlet area.

( ) Establish permanent sampling station(s) for use in the tasks outlined below.

( ) Record lake surface temperature (daily max/mean/min) and level (bench mark staff gauge) throughout study period.

( ) Water quality samples (full series - see following tables) are to be taken from the surface and at 2 m and 10 m, as near to the outlet area as possible. Sampling to be coordinated such that shipment to the DFO Cypress Creek Lab (4195 Marine Drive, West Vancouver) is complete within 48 hours, and will arrive at the lab before noon on Friday (of a normal work week). Samples to be packed in ice in coolers for shipment. All analyses will be done by DFO.

( ) Determine by accepted means, temperature and oxygen profiles to a minimum of 10 m, as near to the outlet as possible and at the deepest point of the lake.

( ) Take and analyze plankton/algae samples using vertical net hauls from 2 m and 10 m. Identify all species taken, and determine abundances using accepted methods.

( ) During warm-weather visit(s), set overnight gill nets and/or other accepted capture methods to sample trout and other species for endemic disease organisms (particularly ______). Arrangements are to be made with G. Hoskins of Diagnostic Services, Pacific Biological Station, Nanaimo, for sampling and shipment of specimens. Test trapping may be attempted in earlier visits.____________________________________

____

____

_. <u>Reporting</u>

( ) A progress report (including DFO water quality analytical results) is to be submitted to the Scientific Authority within one month of the completion of each survey trip.

( ) A draft report is to be submitted by ______________, 19__; the final report is due no later than ____________________, 19__. The final report shall outline the methods employed and results obtained, and discuss the latter in view of the stated objective.

( ) The final report shall include a watershed description (physical features, climates, land use, access maps, etc.) and a background on the salmonid populations in question based on available records.

( ) Raw data and summaries should be included in a separate, bound appendix.

FORM OF TENDER

Costs should be detailed under the following headings:

A. SCHEDULE OF OPERATIONS

- time period of each phase
- personnel allocations in each phase and total

B. PERSONNEL

- level, number, time, charges (per diem rate), availability

1. Planning and administration
2. Mobilization and reconnaissance
3. Field Program - breakdown by tasks
4. Demobilization
5. Literature review
6. Data analysis
7. Report preparation (includes rewrite time after draft review)

C. EXPENSES

1. Equipment and vehicle rentals, leases and charters
   - including specifications and availability.

2. Materials charged

3. Disbursements
   - including travel, accommodation, shipping, communication, copying and miscellaneous services.

4. Analysis
   a) Laboratory
   b) Data Processing

Notes: (1) DFO may not fund work on all of the streams mentioned, or may require approximately the same work on other streams in the same area. Therefore, the above costs should be separated out by adult and juvenile phase, and by stream and estuary such that costs savings from excluding or adding components to the study are shown.

(2) DFO may wish to retain ________________, and the contractor is to deliver it in satisfactory operating condition to___________
____
____

APPENDIX 'A'

SPECIFICATIONS

A. INTRODUCTION

The New Projects Unit of the Department of Fisheries and Oceans is carrying out baseline biological studies of several river systems in B.C. in order to evaluate their specific needs for enhancement. The purpose of this contract is to provide New Projects with monitoring service on the individual projects and to provide on-site technical advice, upon request, to the various contractors. This contract is for two persons.

B. OBJECTIVES

(1) To ensure that all field reconnaissance activities associated with the contracted projects are carried out in a technically sound manner.

(2) To ensure that all such activities meet the biological objectives and/or requirements of the project.

(3) To submit update reports on progress and evaluation of field work.

C. DUTIES AND RESPONSIBILITIES

Under the direction of the Scientific Authority the two successful candidates will monitor the performance of the contractors of biological investigation contracts which are designed to provide knowledge on population size, density, distribution, behavior, timing survival and environmental information for the species and systems designated.

(1) Performs on-site inspection of each study site (as per Form of Tender) once per month or more frequently as the situation requires and offers corrective or preventative advice to the investigator as regards fry trapping and rearing methods and locations and adult sampling, capture and holding.

(2) Evaluates methods, techniques and analysis used by contractors in estimating various biological and physical parameters (population size, distribution, bio-physical characteristics and relation to stream utilization by salmonids).

(3) Submits written report (including diary transcript) on the inspections of each project to Scientific Authority within two weeks of each inspection.

(4) Supervises coded wire tagging, adult capture and field egg takes as required.

(5) Reviews and comments on draft reports on each study.

D. REQUIREMENTS

The two successful candidates must, between them, possess the following expertise:

(1) Knowledge of the biological and morphological characteristics of and experience in identifying the five species of Pacific salmon, related food organisms, predators and competing species in freshwater and estuarine habitats.

(2) Knowledge of and experience in the artificial rearing of juvenile salmon; especially in the detection and treatment of disease and stress related symptoms, feeding schedules and sampling and marking techniques.

(3) Experience in installing, operating and maintaining all types of downstream migrant trapping devices (traps, electroshocking, fences, etc.).

(4) Experience in identification and classification of natural rearing areas in both fresh and salt water.

(5) Experience in determining the distribution of and enumerating resident rearing stocks of juvenile salmon, and with catching equipment such as minnow traps and seines.

(6) Knowledge of the methodology and experience in setting up and operating and repairing coded wire tagging equipment.

(7) Experience in surveys of adult holding and spawning salmon, capture, holding, sampling and tagging techniques and carcass recovery.

(8) Experience in field egg take procedures and organization.

(9) Ability to keep records and write and review reports.

E. SCHEDULE

Field work to commence anytime after April 1, 1981. Inspection frequency and purpose to be arranged in consultation with Scientific Authority. Final inspection or report review to be completed by March 31, 1982.

F. LOCATIONS

On-site inspections and expert consultation will be required for all bio-baseline contracts issued by New Projects in 1981. ______ potential study areas have been identified.

These areas are listed in Enclosure 1.

G. REPORTS

Written reports summarizing inspections and/or consultations are to be submitted to the Scientific Authority within two weeks after the completion of each inspection tour. The Scientific Authority must also be notified by telephone of any developments which may affect the success of the study.

SPECIFICATIONS

A. INTRODUCTION

The New Projects Unit of the Department of Fisheries and Oceans is presently surveying several sites in B.C. as to their feasibility for salmonid culture. The successful contractor will provide baseline water quality information to aid in determining the suitability of selected surface and/or ground water sources as potential enhancement facility supplies.

Water sampling will normally coincide with pump testing of fresh water wells, but may also include surface and salt water sources.

B. OBJECTIVES

(1) To provide on-site sampling and water quality testing of ground water and/or surface water.

(2) To expedite shipment of water samples to the EPS-DFO Water Quality Laboratory for complete water quality analysis.

(3) To submit a written report for each site within two weeks of the completion of each sampling.

C. SCHEDULE

The contractor must be prepared to provide water quality sampling at any site identified by the Scientific Authority (see Locations Section) with as little as one working week's notice (although more notice is usually given). Each pump test normally runs for 96 hours continuously, although the period may be prolonged in the event of breakdowns, etc., or two or more pump tests may be run in sequence. Coordination with pump test personnel is essential.

Field Work: any time between April 1, 198_ and March 15, 198_.

Final Report: March 31, 198_.

D. METHODS

(1) During each pump test, routinely collect a series of water samples at each of the 2, 24, 48, 72 and 96 hour points after pumping begins. Sample bottles and reagents will be provided through the Scientific Authority. Collection techniques are outlined in Enclosure 1.

(2) Collect a sub-surface water sample as near to mid-stream as possible (where appropriate) at approximately the 48 hour point in test pumping.

(3) Collect further surface or ground water (fresh and salt) samples as requested.

(4) Expedite transport of the samples to the EPS-DFO Cypress Creek Laboratory (4195 Marine Drive, West Vancouver, B.C. V7V 1N6), such that each series arrives with a completed analysis request form (Enclosure 2) within 48 hours of sampling.

(5) Provide equipment and expertise on-site to ensure accurate (magnitude of error to be stated in consultant's proposal) measurement of pH, temperature, dissolved oxygen, salinity/conductivity and total gas pressure at 2, 24, 48, 72 and 96 hours after pumping begins.

E. LOCATIONS

Water quality sampling may occur within the contract period anywhere within British Columbia or the Yukon. Known potential sites are shown in Enclosure ___. Due to the uncertainties associated with the program, a firm list of pending locations can not be provided for costing purposes. The contractor is expected to make the most cost-effective travel and accommodation arrangements possible without jeopardizing project results. To allow the Scientific Authority to judge the contractor's initiative in this respect, _____ sample sites are designated below, and the contractor is expected to use them as costing and logistic examples for his proposal. (These particular sites may not necessarily be tested.)

LOCATION	SITE DESCRIPTION	KNOWN ACCESS
____________	________________	____________
____________	________________	____________

Sampling at additional sites or resampling at previous sites may be required at the discretion of the Scientific Authority. For reference, locations of previous sites are also shown in Enclosure __.

F. REPORTS

Reports summarizing on-site analysis and detailing sampling and shipping schedules are to be submitted to the Scientific Authority within two weeks of completion of each pump test or other sampling.

FORM OF TENDER

Costs should be detailed under the following headings.

A. PERSONNEL

- level, number, time, charges (per diem rates)

1. Mobilization - personnel allocations, time required.
2. Field Program - breakdown by tasks.
3. Data Analysis.
4. Report Preparation.

B. EXPENSES

1. Equipment rentals, leases, charters.
   - including vehicles and field equipment
2. Materials charged.
3. Disbursements.
   - including travel, accomodation, shipping, communication, copying and miscellaneous services.
4. Analysis.

NOTE: Examples of total costing should be provided for each of the two sample locations given. In addition, the Contractor should provide daily charge-out rates for the equipment and personnel, such that extrapolation of costs to any other site can be made by the Scientific Authority.

REFERENCES

Chamberlin, T.W. 1980, Aquatic System Inventory. ADP Tech. Paper 1 B.C. Aquatic Studies Branch (R.A.B.), Victoria

Conlin K., and B.D. Tutty 1979. Juvenile Salmonid Field Trapping Manual. Fish Man. Serv. MS Report No. 1530.

DeLeeuw, A.D., 1981. A British Columbia Fish Habitat and Population Stream Inventory System. MS Report. Fish Habitat Improvement Section, B.C. Fish and Wildlife Branch, Victoria.

Dept. of Fisheries and Environment, 1976. Fish Health Protection Regulations: Manual of Compliance. Fish. Man. Serv. Misc. Spec. Pub. 31.

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Canadian Journal of Fisheries and Aquatic Sciences Bulletin 191.

Appendix 5 Listing of study reports prepared for New Projects Unit, up to September of 1983.

These reports have been reproduced on a limited scale for internal use. Microfiche copies can be obtained from the New Projects Coordinator.

1. LISTER, D.B. 1979. Baseline Biological, Physical and Chemical Data Study for Proposed Salmon Enhancement Projects on the Little Qualicum River. Prepared by D.B. Lister and Associates Ltd. 40 pp. plus APPENDIX.

2. GLOVA, G.J., W.A. Grant, P.J. McCart and M.L. Jones. 1979. Chum Salmon Spawning Enumeration, Mathers Creek, Princess Louise Island, British Columbia. 1978. Prepared by P. McCart Biological Consultants Ltd. 59 pp.

3. GLOVA, G.J. and P. McCart. 1979. Salmon Enumeration Studies in Five Streams Draining into Tlupana Inlet, B.C., 1979. Prepared by P. McCart Biological Consultants Ltd. 207 pp.

4. NORTHERN NATURAL RESOURCE SERVICES LTD. 1979. Enumeration of Pacific Salmon Fry in Mathers Creek, Queen Charlotte Islands, in 1979. Prepared by Northern Natural Resource Services Ltd. 76 pp.

5. LISTER, D.B., G.D. Harris and D.G. Hickey. 1979. Juvenile Salmon Downstream Migration Study at Little Qualicum River, British Columbia. Prepared by D.B. Lister and Associates Ltd. 44 pp. plus ADDPENDIX.

6. GLOVA, G.J. and P.J. McCart. 1979. Downstream Migration Enumeration of Salmon Fry in Tlupana Inlet on the West Coast of Vancouver Island. Prepared by P. McCart Biological Consultants Ltd. 190 pp. plus APPENDIX.

7. GRANT, W.A. and P.J. McCart 1980. Attempted Feasibility Study of a Satellite Hatchery Operation at Mathers Creek, British Columbia. Prepared by P. McCart Biological Consultants Ltd. 25 pp.

8. OLMSTED, W.R., P.W. Delaney, T.L. Slaney and G.A. Vigers. 1980. Chinook Salmon (Oncorhynchus tshawytscha) Fry and Smolt Enumeration/Marking Project, Nechako and Quesnel/Horsefly Rivers, B.C. Prepared by E.V.S. Consultants Ltd. 196 pp. plus APPENDIX.

9. OLMSTED, W.R., M. Whelen, and G.A. Vigers 1980. 1979 Investigations of Fall-Spawning Chinook Salmon (Oncorhynchus tshawytscha), Nechako and Quesnel/Horsefly Rivers, B.C. Prepared by E.V.S. Consultants Ltd. 85 pp. plus APPENDIX.

10. McCART, P.J., O. Fleming, W.A. Grant and M. Walsh. 1980. Adult Salmon Enumeration in the Nitinat River, British Columbia. Prepared by P. McCart Biological Consultants Ltd. 69 pp.

11. BIRCH, G.J., T.L. Slaney and M. Milko. 1981. 1980 Investigations of Downstream Migrations and Rearing Distributions in Juvenile Salmonids of the Kitimat River, B.C. Prepared by F.F. Slaney and Company Limited. 104 pp.

12. BIRCH, G.J., T.L. Slaney and M. Milko 1981. 1980 Investigations of Downstream Migrations and Rearing Distribution in Juvenile Salmonids of the Kitimat River, B.C. Prepared by F.F. Slaney and Company Limited. APPENDICES

13. LISTER, D.B., I. Wallace and D.G. Hickey. 1981. Salmonid Enhancement Baseline Investigations at Stuart River, British Columbia. PART 1 - 1980 Juvenile Chinook Salmon Study (VOLUME I). Prepared by D.B. Lister and Associates. 65 pp.

14. LISTER, D.B., I. Wallace and D.G. Hickey. 1981. Salmonid Enhancement Baseline Investigations at Stuart River, British Columbia. PART 1 - 1980 Juvenile Chinook Salmon Study (VOLUME II-APPENDICES) Prepared by D.B. Lister and Associates L.T.D. 39 pp.

15. HICKEY, D.G. and D.B. Lister. 1981. Salmonid Enhancement Baseline Investigations at Stuart River, British Columbia, in 1980. PART II- Adult Chinook Salmon Study. Prepared by D.B. Lister and Associates Ltd. 50 pp. plus APPENDIX.

16. WHELEN, M.A., W.R. Olmsted and R.W.J. Stewart. 1981. Studies of Juvenile Chinook Salmon (Oncorhynchus tshawytscha) and Other Salmonids in the Quesnel River Drainage During 1980. Prepared by E.V.S. Consultants Ltd. 105 pp.

17. WHELEN, M.A., W.R. Olmsted and R.W.J. Stewart. 1980. Studies of Juvenile Chinook Salmon (Oncorhynchus tshawytscha) and Other Salmonids in the Quesnel River Drainage During 1980. Prepared by E.V.S. Consultants Ltd. APPENDICES.

18. OLMSTED, W.R., M.A. Whelen and R.W.J. Stewart. 1981. 1980 Investigations of Fall Spawning Chinook Salmon (Oncorhynchus tshawytscha) Quesnel, Blackwater (West Road) and Cottonwood River Drainages, B.C. Prepared by E.V.S. Consultants Ltd., 85 pp. plus APPENDIX.

19. MURRAY, P.R. and S.R. Hamilton. 1981. Baseline Biological Data on Adult Chum Salmon in the Kemano River System, 1979. Prepared by Envirocon Limited. 68 pp. plus APPENDIX.

20. MURRAY, P.R. and S.R. Hamilton. 1981. Baseline Biological Data on Adult Chum Salmon in the Kemano River System, 1979. Prepared by Envirocon Limited. APPENDICES.

21. MURRAY, P.R., S.R. Hamilton and G.O. Stewart. 1981. Studies on Juvenile Chinook Salmon (Oncorhynchus tshawytscha) in the Bowron and Willow Rivers, B.C., During 1980. Prepared by Envirocon Limited. 85 pp. plus APPENDIX.

22. MURRAY, P.R., S.R. Hamilton and G.O. Stewart. 1981 Data Manuscript for Studies on Juvenile Chinook Salmon (Oncorhynchus tshawytscha) in the Bowron and Willow Rivers, B.C., During 1980. Prepared by Envirocon Limited. APPENDICES.

23. MURRAY, P.R., G.O. Stewart and S.R. Hamilton. 1981. Studies on Adult Chinook Salmon (Oncorhynchus tshawytscha) in the Bowron and Willow Rivers; and Slim Creek, B.C., During 1980. Prepared by Envirocon Limited. 65 pp. plus APPENDIX.

24. MURRAY, P.R., G.O. Stewart and S.R. Hamilton. 1981. Data Manuscript for Studies on Adult Chinook Salmon (Oncorhynchus tshawytscha) in the Bowron and Willow Rivers, and Slim Creek, B.C., During 1980. Prepared by Envirocon Limited. APPENDICES.

25. LISTER, D.B., D.G. Hickey and I. Wallace. 1981 Review of the Effects of Enhancement Strategies on the Homing, Straying and Survival of Pacific Salmonids. VOLUME I. Prepared by D.B. Lister and Associates Ltd. 51 pp.

26. LISTER, D.B., D.G. Hickey and I. Wallace. 1981. Review of the Effects of Enhancement Strategies on the Homing, Straying and Survival of Pacific Salmonids. VOLUME II. Prepared by D.B. Lister and Associates L.T.D. APPENDICES.

27. SLANEY, T., G. Birch and M. deBurgh. 1982. 1981 Investigations of Downstream Migrations and Estuarine Rearing in Juvenile Salmonids of Rivers in Kitimat and Kildala Arms, B.C. Prepared by Aquatic Resources Limited. 144 pp.

28. SLANEY, T., G. Birch and M. deBurgh. 1982. 1981 Investigations of Downstream Migrations and Estuarine Rearing in Juvenile Salmonids of Rivers in Kitimat and Kildala Arms, B.C. Prepared by Aquatic Resources Limited. APPENDICES.

29. deBURGH, M. 1982. Indentification Guide to Contents of Juvenile Chum Stomachs from Kitimat Arm. Prepared by Aquatic Resources Limited. 18 pp.

30. FIELDEN R., and T. Slaney. 1982. 1981 Survey of Salmonids Spawning in Selected Streams of Knight Inlet, British Columbia. Prepared by Aquatic Resources Limited. 88 pp. plus APPENDIX.

31. SLANEY, T.L. and M.P. Milko. 1982. 1981 Adult Salmonid Sampling Program at the Kakweiken River Fishway British Columbia. Prepared by Aquatic Resources Limited. 57 pp.

32. SLANEY, T.L. and M.R. Milko. 1982. 1981 Adult Salmon Sampling Program at the Kakweiken River Fishway British Columbia. Prepared by Aquatic Resources Limited. DATA APPENDICES.

33. BLACK, G. and G. Birch, 1982. Baseline Limnological Survey of Tom Browne Lake. Prepared by Aquatic Resources Limited. 56 pp. plus APPENDIX.

34. SCOTT, K.J., M.A. Whelen, L.B. MacDonald, J.D. Morgan and W.R. Olmsted. 1982. 1981 Biophysical Studies of Selected Chinook (Oncorhynchus tshawytscha) and coho (O. kisutch) Salmon - Producing Tributaries of the North Thompson River Drainage. PART I. Juvenile Salmonid Investigations. Prepared by E.V.S. Consultants Ltd. 169 pp.

35. SCOTT, K.J., M.A. Whelen, L.B. MacDonald, J.D. Morgan and W.R. Olmsted. 1982. 1981 Biophysical Studies of Selected Chinook (Oncorhynchus tshawytscha) and Coho (O. kisutch) Salmon - Producing Tributaries of the North Thompson River Drainage. PART 2. Juvenile Salmonid Investigations VOLUME II APPENDICES. Prepared by E.V.S. Consultants L.T.D.

36. SCOTT, K.J., M.A. Whelen and W.R. Olsmted. 1982.1981 Biophysical Studies of Selected Chinook (Oncorhynchus tshawytscha) and Coho (O. kisutch) Salmon - Producing Tributaries of the North Thompson River Drainage. PART II - Adult Salmon Investigations. Prepared by E.V.S. Consultants L.T.D. 111 pp.

37. SCOTT, K.J., M.A. Whelen and W.R. Olsmted. 1982. 1981 Biophysical Studies of Selected Chinook (Oncorhynchus tshawytscha) and Coho (O. kisutch) Salmon - Producing Tributaries of the North Thompson River Drainage. PART II - Spawning Salmon Investigations. Prepared by E.V.S. Consultants L.T.D. APPENDICES.

38. WHELEN, M.A., L.B. MacDonald, J.D. Morgan and W.R. Olmsted. 1982. 1981 Biophysical Studies of Selected Chinook (Oncorhynchus tshawytscha) and Coho (O. kisutch) Salmon - Producing Tributaries of the South Thompson River Drainage. PART I. Juvenile Salmon Investigations. Prepared by E.V.S. Consultants L.T.D. 169 pp.

39. WHELEN, M.A., L.B. MacDonald, J.D. Morgan and W.R. Olmsted. 1982. 1981 Biophysical Studies of Selected Chinook (Oncorhynchus tshawytscha) and Coho (O. kisutch) Salmon - Producing Tributaries of the South Thompson River Drainage. PART I. Juvenile Salmon Investigations. Prepared by E.V.S. Consultants L.T.D. APPENDICES.

40. WHELEN, M.A. and W.R. Olmsted. 1982. 1981 Biophysical Studies of Selected Chinook (Oncorhynchus tshawytscha) and Coho (O. kisutch) Salmon - Producing Tributaries of the South Thompson River Drainage. PART II. - Adult Salmon Investigations. Prepared by E.V.S. Consultants L.T.D. 133 pp.

41. WHELEN, M.A. and W.R. Olmsted. 1982. 1981 Biophysical Studies of Selected Chinook (Oncorhynchus tshawytscha) and Coho (O. kisutch) Salmon - Producing Tributaries of the South Thompson River Drainage. PART II. Spawning Salmon Investigations VOLUME II. Prepared by E.V.S Consultants L.T.D. APPENDICES.

42. ROSEBERG, G.E. and D. Aitken. Adult Chinook Salmon Studies in Four Tributaries to the Upper Fraser River, 1981. Prepared by Beak Consultants Limited. 139 pp.

43. ROSEBERG, G.E. and D. Aitken. Adult Chinook Salmon Studies in Four Tributaries to the Upper Fraser River, 1981. Prepared by Beak Consultants Limited. APPENDICES.

44. ROSEBERG, G.E., D. Aitken and E. Oguss. Juvenile Chinook Salmon Studies in Four Tributaries to the Upper Fraser River. 1981. Prepared by Beak Consultants Ltd., 150 pp.

45. ROSEBERG, G.E., D. Aitken and E. Oguss. Juvenile Chinook Salmon Studies in Four Tributaries to the Upper Fraser River, 1981. Prepared by Beak Consultants Limited. APPENDICES.

46. ROSEBERG, G.E., C.W. Rice and J. Millar. 1982. Adult Salmonid Reconnaissance Studies in the Gardner Canal Area of British Columbia, 1981. Prepared by Beak Consultants Limited. 133 pp.

47. ROSEBERG, G.E., C.W. Rice and J.M. Millar. 1982. Adult Salmonid Reconnaissance Studies in the Gardner Canal Area of British Columbia, 1981. Prepared by Beak Consultants. APPENDICES.

48. STEWART, G.O., R.B. Lauzier and P.R. Murray. 1983. Juvenile Studies in the North Thompson Region of B.C. 1982. Prepared by Envirocon Ltd., 139 pp.

49. SEBASTIAN, D.C. 1983. Outplanting Opportunities for Chinook, Coho (and Steelhead) in Six Selected Tributaries of the South Thompson Drainage, 1982. Fish. Habitat Improv. Sect. Fish Wild Br. 110 pp.

50. WHELEN, M.A., J.R. Arthur, W.R. Olmsted and J.D. Morgan. 1983. 1982 Studies of Spawning Coho Salmon (Oncorhynchus kisutch) in Tributaries of the South and Mainstem Thompson Rivers, B.C. Prepared by E.V.S. Consultants Ltd. 100 pp.

51. WHELEN, M.A., J.R. Arthur, W.R. Olmsted and J.D. Morgan. 1983. 1982 Studies of Spawning Coho Salmon (Oncorhynchus kisutch) in Tributaries of the South and Mainstem Thompson Rivers, B.C. Prepared by E.V.S. Consultants Ltd. APPENDICES.

52. FIDLER, L.E. 1983. Analysis Methods Applicable to the Prediction of Hatchery Water Conditioning System Characteristics. A Summary and Report. 155 pp.

53. ENVIROCON LTD. and E.V.S. Consultants Ltd. 1983. Studies of the Fish Pathogen Ceratomyxa shasta: Its Effects on Chinook Salmon of the Fraser System. I. Stock Resistance and Salinity Testing.

54. HUTTON, R., C. Manson, M. Lauder and P. Fee. 1983. Coho Studies North Thompson River System. Federal Job Creation Program. 145 pp.

55. ENVIROCON LTD., and E.V.S. Consultants. 1983. Studies of the Fish Pathogen Ceratomyxa shasta: Its Effects on Chinook Salmon of the Fraser System. II. Seasonal testing. 22 pp.

56. SMITH, J.L. and G.F. Bérézay. 1983. Biophysical Reconnaissance of the Morice River System, 1978-1980. 77 pp.

Appendix 6 Sample water quality reports (Shuswap site):

A. First sampling (pp 113 - 119)
B. One-year summary combined with pumptest summary (pp 120 - 140)

of Canada du Canada

MEMORANDUM NOTE DE SERVICE

TO / À
B.G. Shepherd
A/New Projects Coordinator
Salmonid Enhancement Operations

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE

YOUR FILE/VOTRE RÉFÉRENCE

FROM / DE
Bob Hetherington
Data Analyst Clerk-New Projects Unit
Salmonid Enhancement Operations

DATE
May 25, 1982.

SUBJECT / OBJET RE: SHUSWAP FALLS BIORECONNAISSANCE

As per your verbal request, I installed two, six month duration Ryan submersible thermographs at Wilsey Dam. Also on March 31, 1982, a full water quality sample series was taken above the dam near Gatehouse No. 1 (Figure 3) and from Tunnel No. 2 in the powerhouse below the dam Figure 2). I was accompanied to the site by Hugh Shirley of B.C. Hydro.

Thermograph Installation (No's. 62570 and 62571)

The two Ryans are suspended from the floor of the static intake chamber in Gatehouse No. 1. Attached to the cord are three bleach bottle floats, enabling the Ryans to remain at the two feet and thirty feet below the surface of the water, regardless of flashiness. To recover the Ryans, you must unlock and enter Gatehouse No. 1, then find a yellow cord attached to the railing.

Water Quality

The first sample was taken near Gatehouse No. 1 (Figure 3). Spot temperature checks in the resevoir revealed a consistent 2 °C. In this sample only nitrate (NO_3) was over the recommended level, however, in view of the accompanying low phospahte level, the possibility of algal problems is low. Nitrogen as a percentage of saturation was high and oxygen was low. The second water sample was taken from Tunnel No. 2 in the powerhouse below the dam. It was a degree warmer and again nitrogen as a percentage of saturation was high and oxygen was low. None of the other water quality parameters exceeded the recommended levels of fish culture.

Observations

- Flashiness in late May and early June can cause water levels to rise six to eight feet.
- Siltation is heavy and B.C. Hydro has a dredge in the resevoir.
- A campsite has been completed on the north side of the dam which probably contributed to some of the vandalism I noticed.

- Altitude - 450m.
- Two years ago the water was condemned by the Department of Health and Welfare due to high coliform counts.
- Access to the site is good.

Recommendation

Ryan thermographs should be changed by the end of September in concert with the standard water sampling above and below the dam.

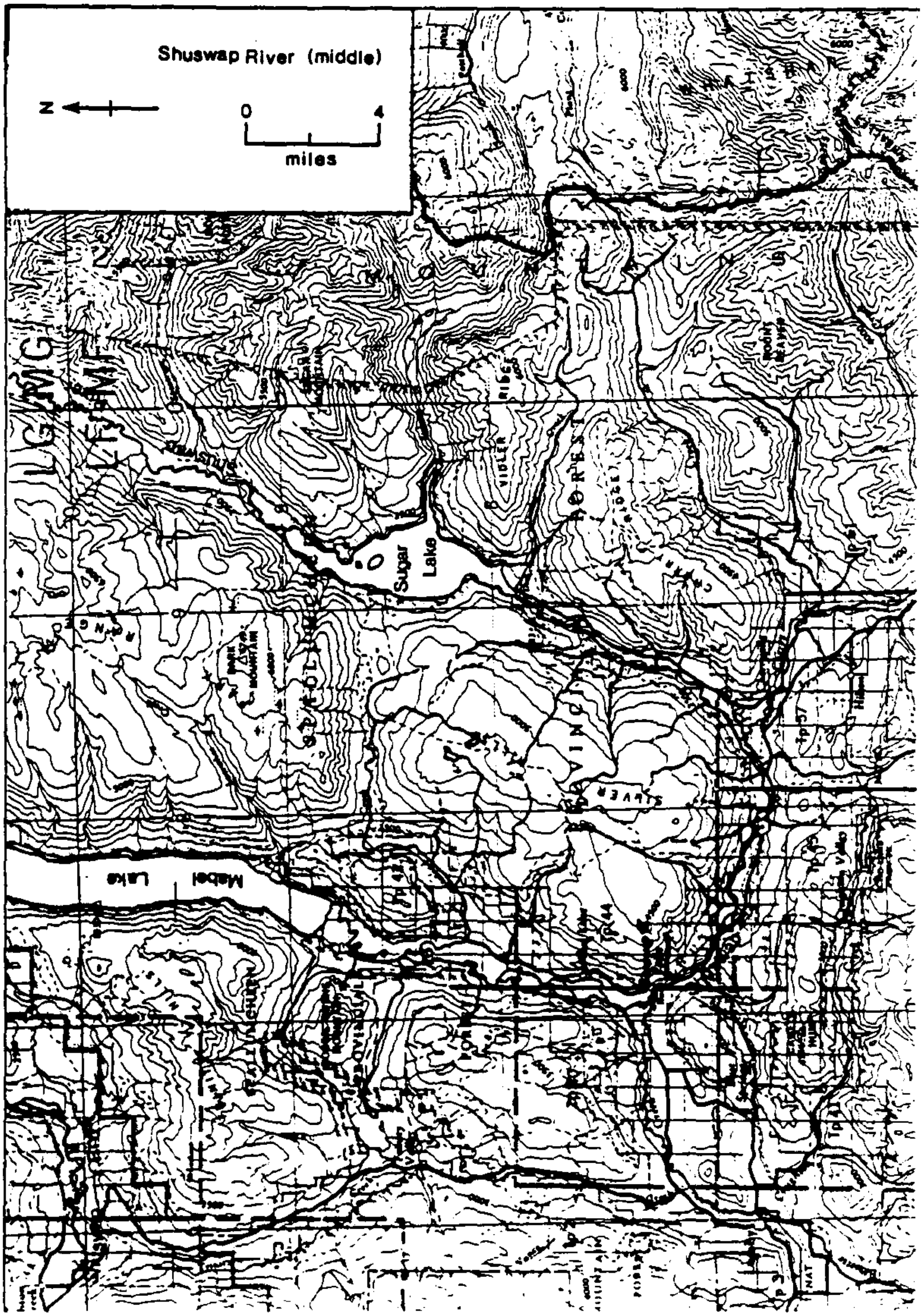
For accessibility at the site contact Hugh Shirley of B.C. Hydro's Vernon office, phone - 545-8111.

Bob Hetherington

BH/mmm

c.c. D.D. MacKinlay

Att. 7


Shuswap River (middle)
N
0
4
miles
Sugar
Lake
Mabel
Lake

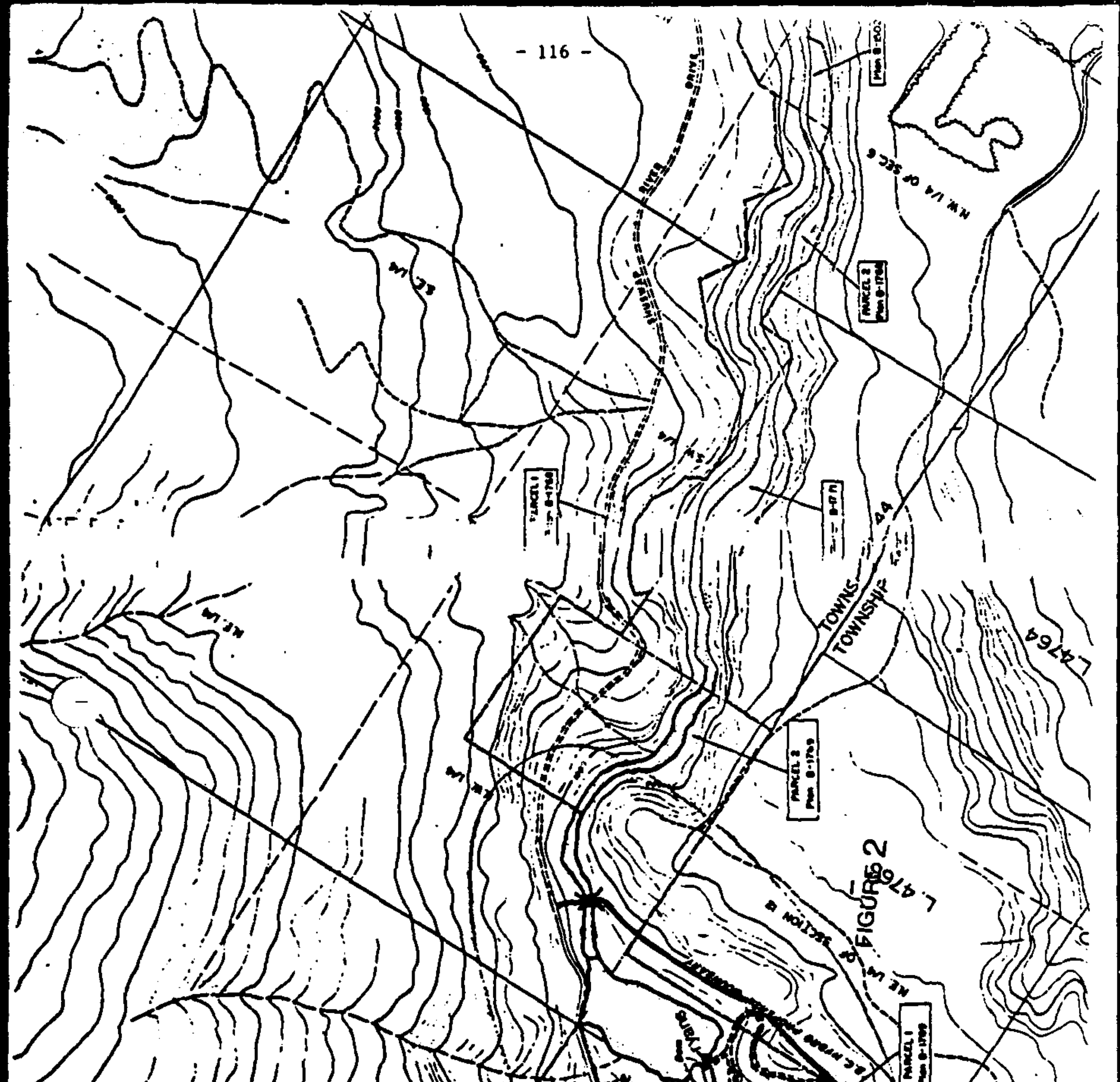
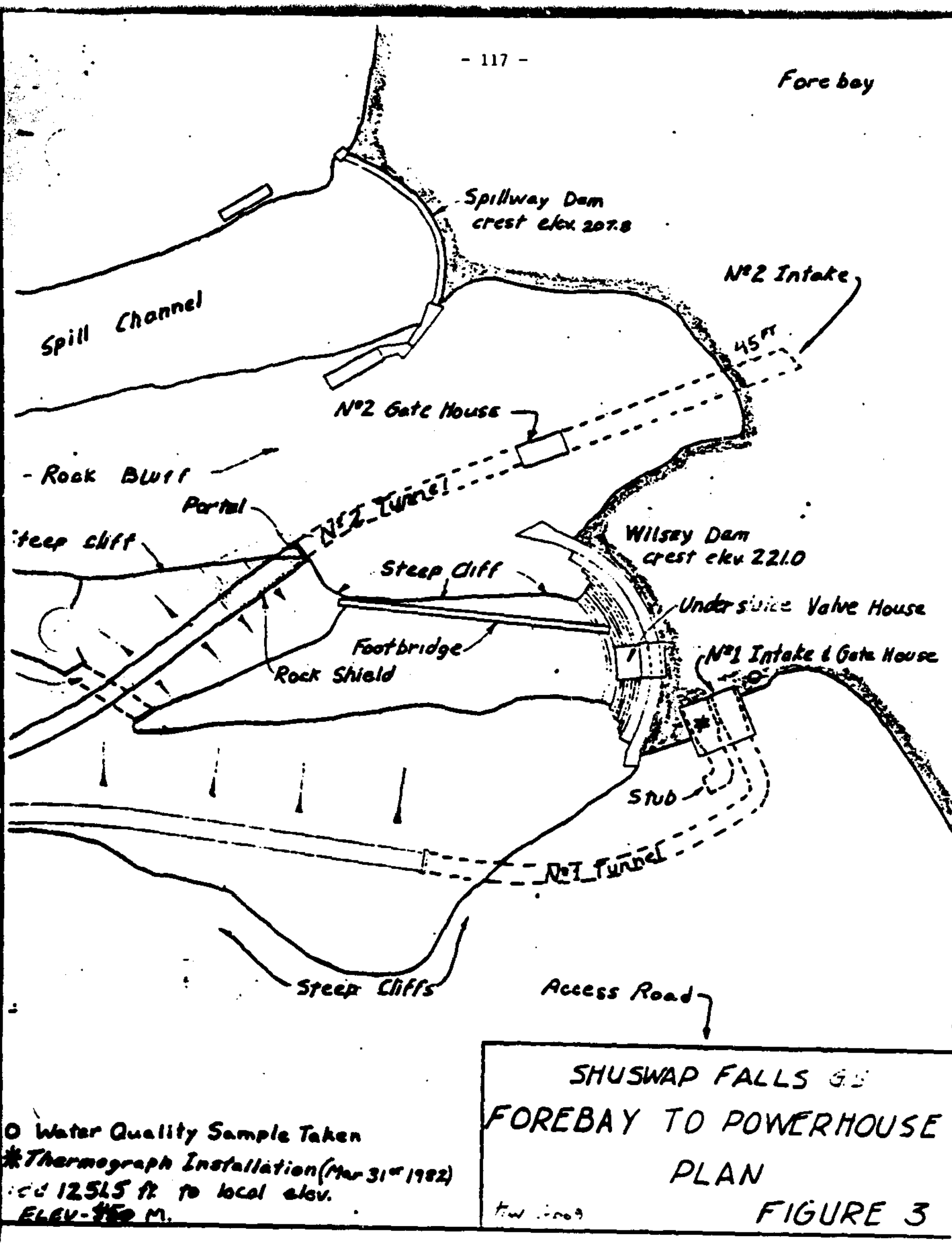


FIGURE 2
TOWNSHIP 44
L.4764
N.W. 1/4 OF SEC 6



SHUSWAP FALLS G.S.
FOREBAY TO POWERHOUSE
PLAN
FIGURE 3

Table 1 (cont'd) Water Quality Criteria of Samples
Circled values indicate unsuitability for fish culture

SITE: SHUSWAP FALLS
DATE SAMPLED: MARCH 30, 1982
SAMPLER: R.D. HETHERINGTON

SITE VALUES
(from PEI or Field test)

ELEMENT	VALUES (mg/l) RECOMMENDED	TOXIC									
Al-aluminum	<.1	5	<.05	<.05							
As-arsenic	<.5	1	<.05	<.05							
Ba-barium	1 (domestic water)		.009	.009							
Ca-calcium	4-150	300	17.4	17.4							
Cd-cadmium	<.0004(soft) <.003(hard)		<0.001	<0.001							
Co-cobalt			<.005	<.005							
Cr-chromium	<.05 trival. <.01 hexavl.		<.005	.368							
Cu-copper	<.006(soft) <.03(hard)		<0.001	<0.001							
Fe-iron	<.3		.037	.043							
Hg-mercury	<.00005	>.0002	<0.0002	<0.0002							
K-potassium		50	0.85	1.02							
Mg-magnesium	< 10	> 100	2.2	2.3							
Mn-manganese	< .05	> 15	.003	.003							
Mo-molybdenum			<.005	<.005							
Na-sodium		20NaOH 500Na+	1.3	1.3							
Ni-nickel	< .01 of 96hr LC50		<.02	<.02							
P-phosphorus	<.0001 for saltwater		<.05	<.05							
Pb-lead	<.01		<0.001	<0.001							
Sb-antimony			<.05	<.05							
Se-selenium	<.001 of 96hr LC50	>2.5	<.05	<.05							
Si-silicon	<10-60		3.1	3.1							
Sn-tin			<.01	<.01							
Sr-strontium			.08	.079							
Ti-titanium			<.002	<.002							
V-vanadium			<.01	<.01							
Zn-zinc	<.005(soft) < 2 (hard)		<.002	<.002							
			ENSTOCK 2S NO.1 SURFACE	ENSTOCK 4S NO 2 [illegible] DAM							

TABLE 1. Water Quality Criteria of Samples
Circled values indicate unsuitability for fish culture

SITE: SHUSWAP FALLS
DATE SAMPLED: MARCH 30, 1992
S[illegible]ER: R.D HETHERINGTON

SITE VALUES
(from PEI or Field test)

PARAMETERS	VALUES (mg/l) RECOMMENDED	TOXIC		
Temperature (°C)	4-18	<2,>25	2.0°C	3.0°C
pH Field	6.5-8.5	<5,>9	8.0	8.0
pH Lab			7.5	7.9
D.Oxygen (mg/ml)	>6-8			
(% satn.)	100%		87.55	82.54
D.Gases-Total	< 103%	>110%	102.27	100.67
-N_2 + Ar	≤ 100%		106.21	105.51
Alkalinity-Ttl.	20-300			
Ammonia (total)	<.002 inc <.005 rear	>.08	<0.005	<0.005
CO_2 (free total)	2-5 (<100%)	>20		
Chloride	<170	>400	0.9	0.7
Colour	<15 TCU		<5	<5
Conduct. Field	150-2000			
Conduct. Lab	(umho/cm)		122.8	123.9
Hardness ($CaCO_3$)	20-400		52.9	53
H[illegible]	<.002	>.004		
N[illegible]te (NO_2)	<.012	.2	<0.005	<0.005
Nitrate (NO_3)	< .12		(0.13)	0.08
Phosphate (Ttl.)	< .05		<0.005	0.005
Residue-Total	< 2000			
- filtrable	70-400		84	83
- non-filtrable	<3 incu. <25 rear.		<5	<5
Salinity °/oo				
Silica (SiO_2)	<10-60		3.4	3.5
Sulfate (SO_4)	<90		8.4	8.3
Taste/Odour	odour free OK taste			
TDS-minerals	500-1000	15000		
Turbidity	1-60 JTU	1000	0.2	0.2
			PENSTOCK 2S NO 1 SURFACE	PENSTOCK 4S NO 2 BELOW DAM

PENSTOCK NO. 2

BELOW DAM IN TUNNEL NO. 2.

METHOD 1 : SATUROMETER READING (MMH(
OXYGEN CONCENTRATION (MG.)

METHOD 2 : % OXYGEN SATURATION

% NITROGEN SATURATION
WHICH METHOD (1 OR 2) ?
*** TOTAL GAS PRESSURE ***

MEASURED SATUROMETER VALUE (MMHG)
?REENTER
MEASURED SATUROMETER VALUE (MMHG) 5

MEASURED BAROMETRIC PRESSURE (MMHG) 7!

MEASURED DISSOLVED OXYGEN (MG/L) 1

MEASURED WATER TEMPERATURE ('C) 3

SOURCE

ME :ED TENSION (MMHG) = 5
ME..RED BAR.PRESSURE (MMHG) = 754
MEASURED DISS. O2 CONC. (MG/L) = 11
MEASURED WATER TEMP ('C) = 3

BUNSEN O2 COEFF. (ALPHA) = .045244706
BUNSEN N2 COEFF. (BETA) = .022019184
WATER VAPOR PRESSURE (MMHG) = 5.688

N2 SATURATION CONC. (MG/L) = 21.5
O2 SATURATION CONC. (MG/L) = 13.33

TOTAL GAS PRESSURE (%) = 100.67
N2 AS % OF SATURATION (%) = 105.51
O2 AS % OF SATURATION (%) = 82.54
DISSOLVED N2 CONC. (MG/L) = 22.68

DO YOU WANT A HARD COPY (Y OR N) ? N

CHANGE TEMP (Y OR N) ? N
CHANGE SOURCE #1 (Y OR N) ? N

PENSTOCK NO 1

*** TOTAL GAS PRESSURE ***

ABOVE DAM AT GATEHOUSE NO. 1

YOU MAY ENTER DATA IN ONE OF TWO METHOD:

METHOD 1 : SATUROMETER READING (MMHG)
OXYGEN CONCENTRATION (MG/L

METHOD 2 : % OXYGEN SATURATION

% NITROGEN SATURATION
WHICH METHOD (1 OR 2) ?
*** TOTAL GAS PRESSURE ***

MEASURED SATUROMETER VALUE (MMHG) 17

MEASURED BAROMETRIC PRESSURE (MMHG) 755

MEASURED DISSOLVED OXYGEN (MG/L) 12

MEASURED WATER TEMPERATURE ('C) 2

SOURCE #

MEASURED TENSION (MMHG) = 17
MEASURED BAR.PRESSURE (MMHG) = 755
MEASURED DISS. O2 CONC. (MG/L) = 12
MEASURED WATER TEMP ('C) = 2

BUNSEN O2 COEFF. (ALPHA) = .0464477978
BUNSEN N2 COEFF. (BETA) = .0225644835
WATER VAPOR PRESSURE (MMHG) = 5.298

N2 SATURATION CONC. (MG/L) = 22.07
O2 SATURATION CONC. (MG/L) = 13.71

TOTAL GAS PRESSURE (%) = 102.27
N2 AS % OF SATURATION (%) = 106.21
O2 AS % OF SATURATION (%) = 87.55
DISSOLVED N2 CONC. (MG/L) = 23.44

DO YOU WANT A HARD COPY (Y OR N) ? N

CHANGE TEMP (Y OR N) ? N

IS THERE A SECOND SOURCE (Y OR N) ? Y
YOU MAY ENTER DATA IN ONE OF TWO METHOD:

Government of Canada Gouvernement du Canada

MEMORANDUM NOTE DE SERVICE

TO / À: B.G. Shepherd
New Project Coordinator
SEP Enhancement Operations

FROM / DE: D.D. MacKinlay
Design Biologist
SEP Enhancement Operations

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE: 5830-13-16
5903-85-S160

YOUR FILE/VOTRE RÉFÉRENCE

DATE: May 2, 1983.

SUBJECT / OBJET: WATER QUALITY AT SHUSWAP FALLS PILOT SITE

This memo reports the results of one year's monitoring of the Shuswap River at Shuswap Falls Dam and the results of pump tests carried out during March 19 to 23, 1983 at a proposed site downstream from the dam. DFO staff collected samples from the dam and placed Ryan thermographs to monitor water temperature. Sigma Resource Consultants carried out sampling during the pump test. Analysis was done on site for some parameters and sample bottles were sent to the EPS DFO Quality Laboratory at Cypress Creek for full "hatchery" series analysis.

1. Surface Water

Water quality parameter values for the four dates when the Shuswap River was sampled are summarized in Table 1. All values except gas pressures (see Appendix 4 for requirements) fall within the recommended limits for fish culture. Routine aeration/stripping can eliminate this problem. There is one anomolously high nitrate value, but nitrate is not toxic to fish. Chromium, copper and zinc were all detected, but not consistently nor at toxic levels.

Samples were taken from four different locations: the surface of the head pond above the dam; inside the powerhouse from Penstock 1 (dams from 45 ft. below the surface) and Penstock #2 (draws from 25 ft. below the surface); and from the river adjacent to the proposed hatchery site, near the wells (see Sigma report, appended, for map.)

Surface water temperatures have also been monitored. The first thermographs placed in the intake chamber to the penstocks were destroyed by water turbulence but one set of data was recovered (Figure 2). Two more thermographs were placed on October 27, 1982 in the head pond, one at 3 ft. deep and the other at 27 ft. deep. The first set of records from these are graphed in Figures 3 to 6. The 3 ft. thermograph is consistently colder than the 27 ft. thermograph, due no doubt to reverse thermocline caused by air temperatures which were colder than the water temperature. Temperature records from the Department of the Environment Inland Waters Directorate book "Water Temperatures, B.C. and Yukon", 1977, are graphed in Figure 7 for comparison. These records indicate that the Shuswap River water temperature does not reach rearing temperature for fish culture (6°C) until May each year.

/2

2. Groundwater Quality

Table 2 summarizes the quality values for the water drawn from Wells #4 and #5 during the pump tests, March 19-23, 1983. The Sigma report (appended) summarizes sampling conditions.

The two wells seem to be tapping different aquifers, although a more informed opinion as to the cause of differnt value profiles for many of the parameters analysed will be provided in the groundwater hydrology consultant's report. Well #5 produced water of higher temperature (8.9 °C) which was virtually anoxic (0.4 mg/l O_2). Detectable ammonia (0.008 mg/l total or 0.000067 mg/l NH_3, see Appendix III) and toxic nitrite (0.099 mg/l) levels were also found. Well #4 produced cooler (7.1°C) water with some high nitrate and detectable nitrite levels. Chromium and zinc showed up in one of the four samples from Well #4, at barely detectable levels. Sigma monitored the river water temperature during the pump test of Well #4 (see Appendix II).

The water from either of these wells would be suitable for fish culture if aeration/stripping were carried out (see Appendix IV for requirements). Well #5 seems to be tapping a stagnant aquifer which may not be very large, indicated by the fact that several values were changing over the period of pumping. The temperature advantage may be useful for small incubation flows. Well #4 water requires less treatment to be acceptable for fish culture and more closely resembles the river water in characteristics.

Recommendations

1. Use either gravity supply from the dam (deep source) or pumped supply from Well #4 for Pilot Hatchery supply. Both sources require aeration.
2. Move the Ryan thermograph from the 3 ft level at the dam and place in in Well #4.

D.D. MacKinlay

DDMACK/mmm

Attachments

c.c. J. McNally
G.O.Nielsen
F.K.Sandercock
C.N.MacKinnon
G.F.Bérézay
D. Buxton

TABLE 1 WATER QUALITY VALUES FOR SHUSWAP FALLS
(BELOW DETECTION LIMIT=0)

PARAM.	RECOMM.	TOXIC	PEN45#1 MAR31/82	PEN25#2 MAR31/82	HEADPOND OCT26/82	PEN45#1 OCT26/82	PEN25#2 OCT26/82	PEN45#1 FEB8/83	RIVER 09:00 MAR22/83
ALK.TOT	20-300		51	50	45	45	45	48	47.5
AMMON.	<.002	>.08	0	0	0	0	0	.019	0
CO2	2-5	>20							
CHLOR.	<170	>400	.7	.9	0	0	0	.6	.8
COLOR	<15		0	0					0
COND.FLD	150-2000								57
COND.LAB	**		123.9	122.8	103	104	104	129	107
DO-PPM	>6-8	<4							12.7
DO-%SAT	100%		82.54	87.55	79.37	75.37	80.87		95.7
DGAS.TOT	<103%	>110%	102.27	100.67	104.13	102.43	101.05		105
DGAS.NIT	100%		106.21	105.51	110.74	109.65	106.45		107.5
HARDNESS	20-400		53	52.9	50.1	50.3	49.3	60.4	49.9
H2S	<.002	>.004							
NITRITE	<.012	.2	0	0	0	0	0	0	.005
NITRATE	<.12	.	.08	.13	.03	.03	.02	2.11	.11
PH-FLD	6.8-8.5	<5,>9			7.75	8	8.25		7.35
PH-LAB	**	**	7.9	7.8	7.8	7.8	7.8	7.7	7.8
PHOSPH.	<.05		.005	0	.006	.007	.006	.01	.008
RESID.TOT	<2000								
RESID.FIL	70-400		53	52.9	50.3	50.3	49.3	90	79
RESID.N.F	<3							0	0
SALIN.									0
SILICA	<10-60		3.5	3.4	2.8	2.8	2.8	3.5	3.3
SULFATE	<90		8.3	8.4	6.8	6.7	6.7	7.8	6.7
TASTE	OK								
T.D.SOL	500-1000	15000							
TEMP.	4-18C	<2,>25	2	3	9	13	10		3.7
TURBID	1-60	>1000	.2	.2	.1	.1	.1	.1	.5
METALS—									
AL	<.1	>5	0	0	0	0	0	0	0
AS	<.5	>1	0	0	0	0	0	0	0
BA	<1		.009	.009	.009	.009	.008	.009	.009
CA	4-150	>300	17.4	17.4	17.1	17.1	16.7	20.8	16.6
CD	<.0004		0	0	0	0	0	0	0
CO			0	0	0	0	0	0	0
CR	<.01		.368	0	0	0	0	0	0
CU	<.006		0	0	0	0	0	.003	0
FE	<.3		.043	.037	.042	.026	.027	.028	.04
HG	<.00005	>.0002	0	0	0	0	0	0	0
K		>50	1.02	.85	.79	.81	.79	.8	.79
MG	<10	>100	2.3	2.2	1.8	1.8	1.8	2	2
MN	<.05	>15	.003	.003	0	.004	.003	.003	.005
MO			0	0	0	0	0	0	0
NA		>500	1.3	1.3	1.2	1.2	1.1	1.2	1.1
NI			0	0	0	0	0	0	0
P			0	0	0	0	0	0	0
PB	<.01		0	0	0	0	0	0	0
SB			0	0	0	0	0	0	0
SE		>2.5	0	0	0	0	0	0	0
SI	<10-60		3.1	3.1	2.6	2.6	2.6	3.1	3.1
SN			0	0	0	0	0	0	0
SR			.079	.08	.075	.073	.072	.007	.072
TI			0	0	0	0	0	0	0
V			0	0	0	0	0	0	0
ZN	<.005		0	0	.004	0	0	.002	0

TABLE 2 WATER QUALITY VALUES OR SHUSWAP FALLS
(BELOW DETECTION LIMITS=0)

PARAM.	RECOMM.	TOXIC	WELL#5 15:00 MAR19/83	WELL#5 8:30 MAR20/83	WELL#5 12 NOON MAR20/83	WELL#4 16:00 MAR21/83	WELL#4 08:30 MAR22/83	WELL#4 16:00 MAR22/83	WELL#4 10:30 MAR23/83
ALK.TOT	20-300		78	88	90	50	50	51	51
AMMON.	<.002	>.08	.007	.008	.009	0	0	0	0
CO2	2-5	>20							
CHLOR.	<170	>400	.8	.9	.9	.9	.9	.8	.9
COLOR	<15		0	0	0	0	0		
COND.FLD	150-2000		120	132	132	68	69	69	68
COND.LAB	**		179	209	214	118	117	117	117
DO-PPM	>6-8	<4	.5	.3	.4	8.9	8	8.3	8.1
DO-%SAT	100%		4.5	2.6	3.6	76	68.9	72.1	70.7
DGAS.TOT	<103%	>110%	90.6	90.4	89.4	105.3	102.3	103.2	102.5
DGAS.NIT	100%		113.5	113.7	112.2	113.1	114	111.5	111
HARDNESS	20-400		89.8	94.6	97.7	55.1	53.8	55.1	57.7
H2S	<.002	>.004							
NITRITE	<.012	.2	.099	.017	.011	.012	.007	0	0
NITRATE	<.12		.04	.07	.04	.17	.15	.16	.15
PH-FLD	6.8-8.5	<5,>9	7.8	7.7	7.7	7.15	7.2	7.1	7.1
PH-LAB	**	**	7.8	8	8	7.5	7.5	7.4	7.4
PHOSPH.	<.05		.022	.022	.022	0	.005	.007	.007
RESID.TOT	<2000								
RESID.FIL	70-400		127	137	136	84	79	80	72
RESID.N.F	<3		0	0	0	0	0	0	0
SALIN.			0	0	0	0	0		
SILICA	<10-60		5.9	5.9	5.9	3.3	3.4	3.4	3.4
SULFATE	<90		15.3	16.7	17	8	7.4	7.1	6.9
TASTE	OK								
T.D.SOL	500-1000	15000							
TEMP.	4-18C	<2,>25	8.9	8.85	8.9	6.7	7	7.1	7.1
TURBID	1-60	>1000	.8	.8	.8	.1	.1	.2	.2
METALS--									
AL	<.1	>5	0	0	0	0	0	0	0
AS	<.5	>1	0	0	0	0	0	0	0
BA	<1		.016	.018	.018	.009	.008	.009	.009
CA	4-150	>300	29.1	30.9	31.9	18.6	18.2	18.6	19.5
CD	<.0004		0	0	0	0	0	0	0
CO			0	0	0	0	0	0	0
CR	<.01		0	0	0	0	0	.013	0
CU	<.006		0	0	0	0	0	0	0
FE	<.3		.157	.205	.209	.01	.006	.038	0
HG	<.00005	>.0002	0	0	0	0	0	0	0
K		>50	1.6	1.67	1.69	.78	.78	.81	.79
MG	<10	>100	4	4.1	4.2	2.1	2	2	2.1
MN	<.05	>15	.038	.045	.046	0	0	.003	0
MO			.02	0	0	0	0	0	0
NA		>500	3.3	3.9	4	1.2	1.1	1.1	1.2
NI			0	0	0	0	0	0	0
P			0	0	0	0	0	0	0
PB	<.01		0	0	0	0	0	0	0
SB			0	0	0	0	0	0	0
SE		>2.5	0	0	0	0	0	0	0
SI	<10-60		5.9	5.5	5.6	3.1	3.1	3.2	3.4
SN			0	0	0	0	0	.01	0
SR			.203	.203	.208	.079	.079	.081	.084
TI			0	0	0	0	0	0	0
V			0	0	0	0	0	0	0
ZN	<.005		0	0	0	0	0	.005	0

Figure 1. Location of Shuswap Falls Site near Lumby, B.C.

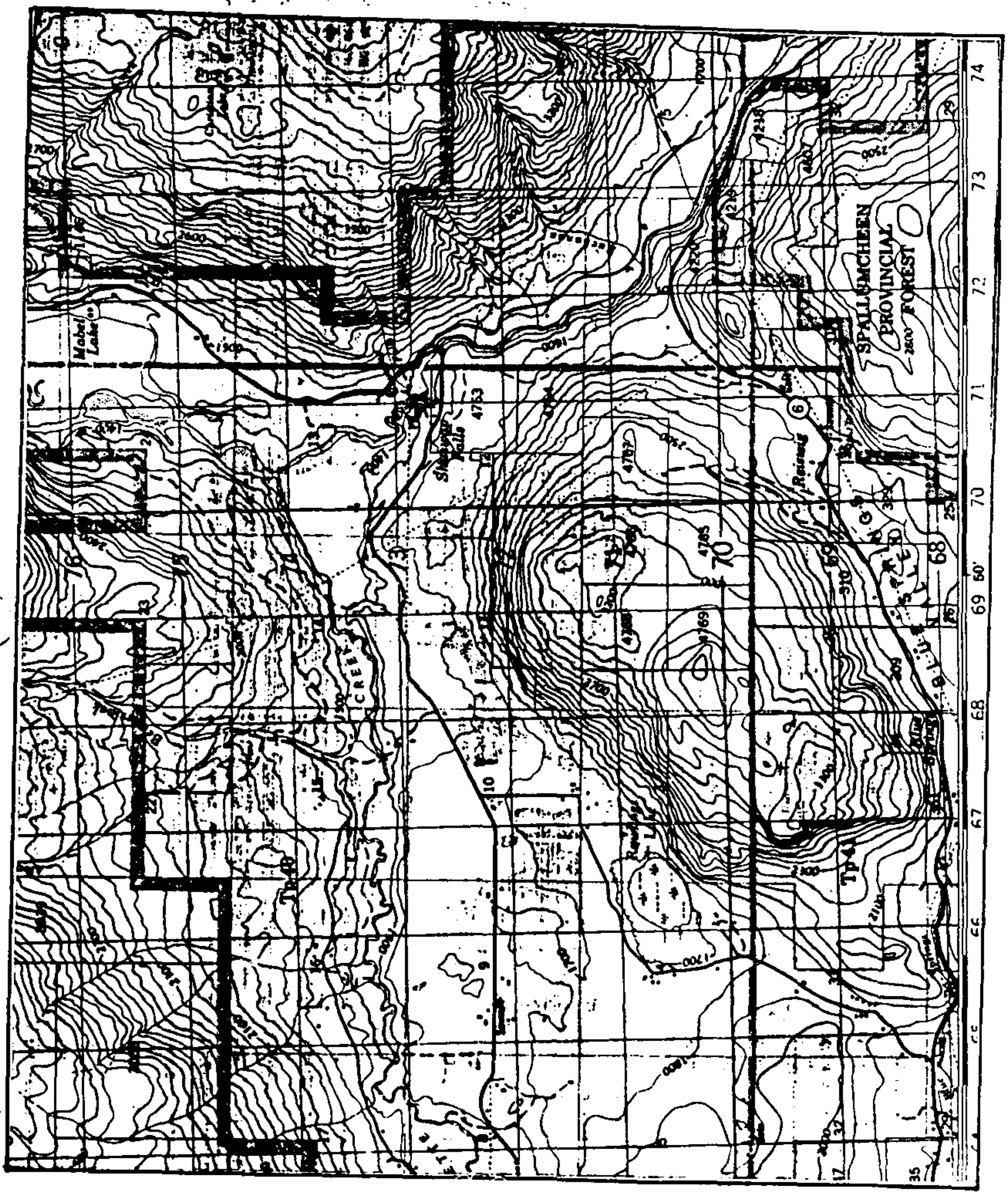


Figure 2. Shuswap River temperatures, intake chamber, 1982.

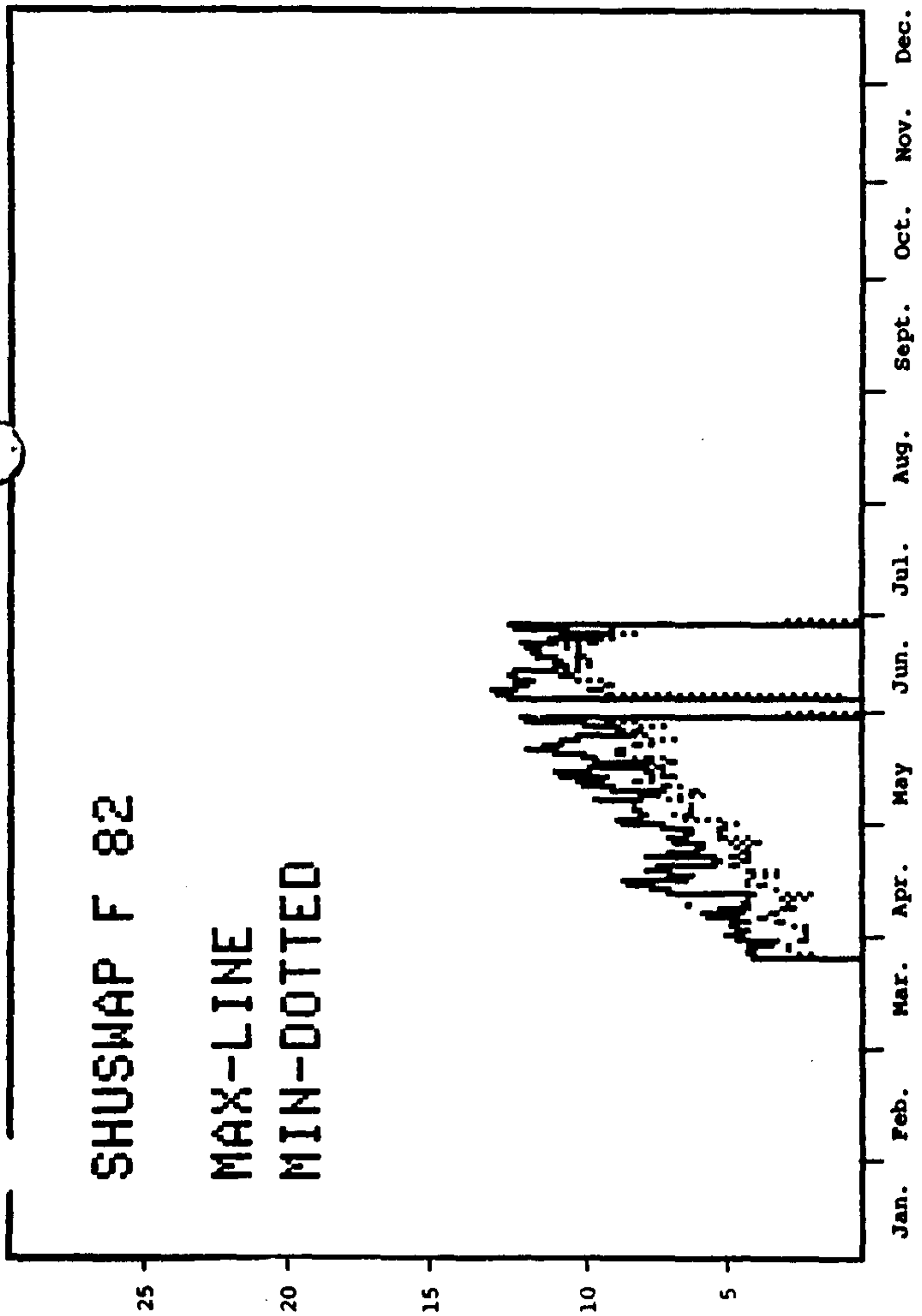


Figure 3. Shuswap River temperatures, 3 ft. deep 1982.

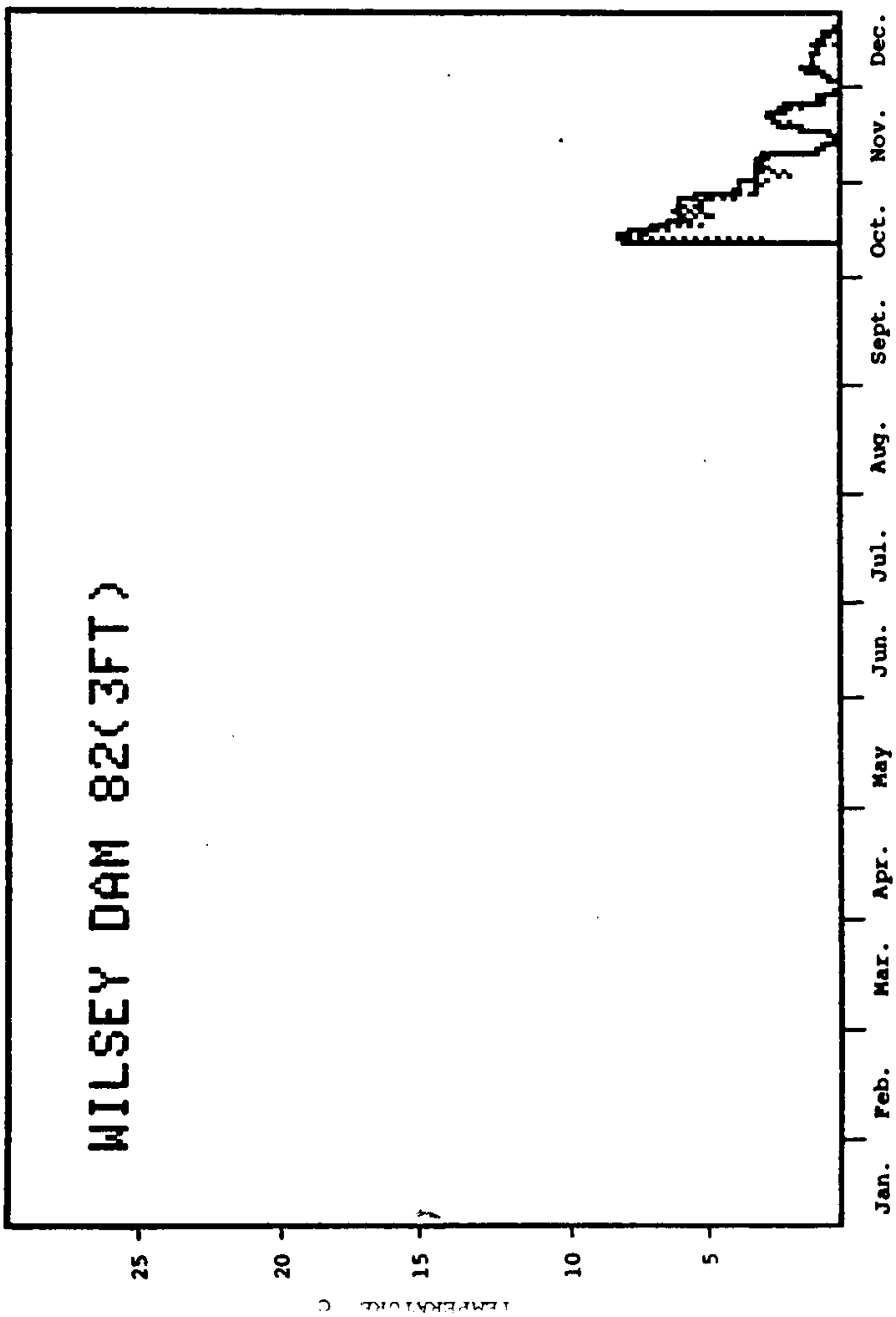


Figure 4. Shuswap River temperatures, 27 ft. deep 1982.

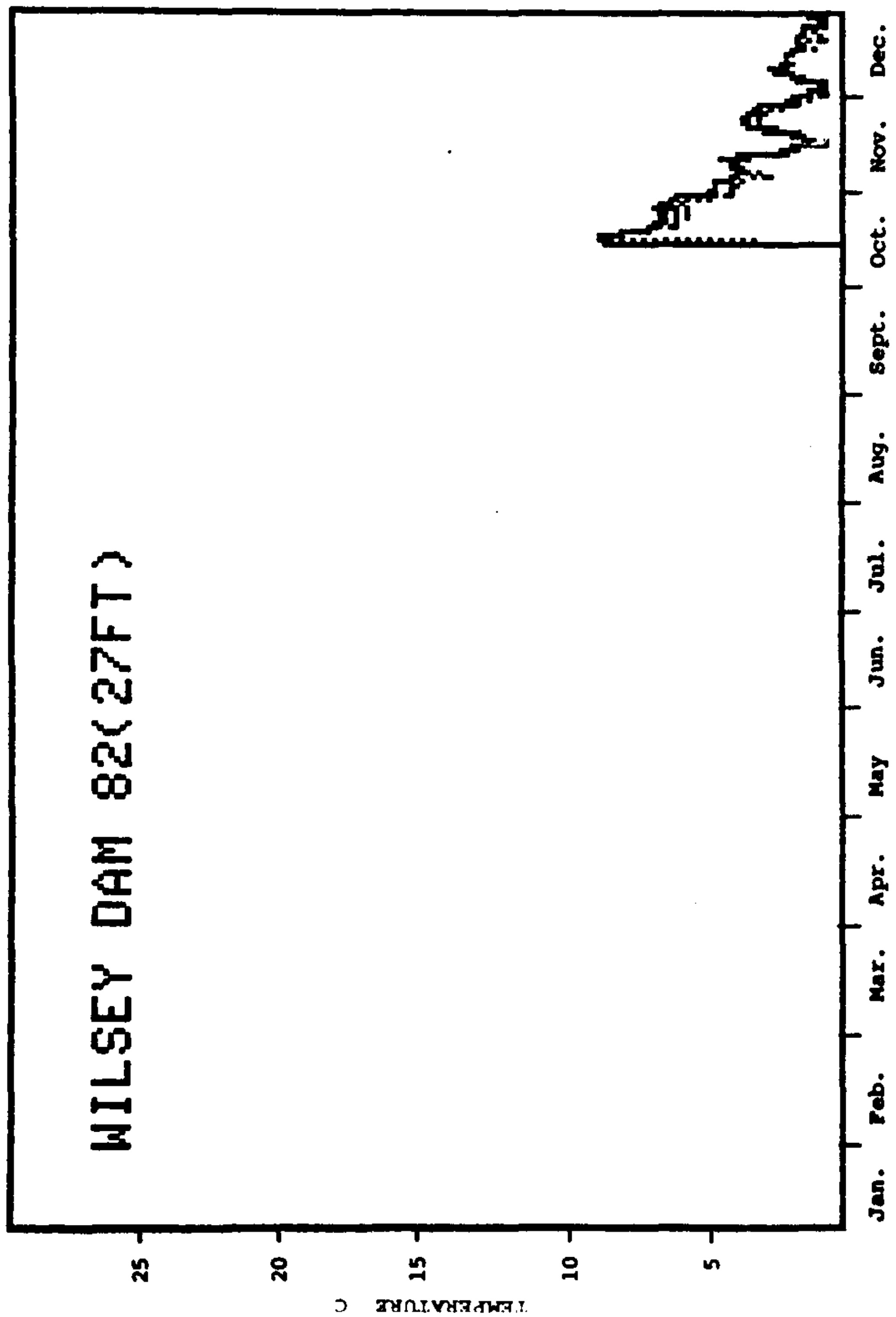


Figure 5. Shuswap River temperatures, 3 ft. deep 1983.

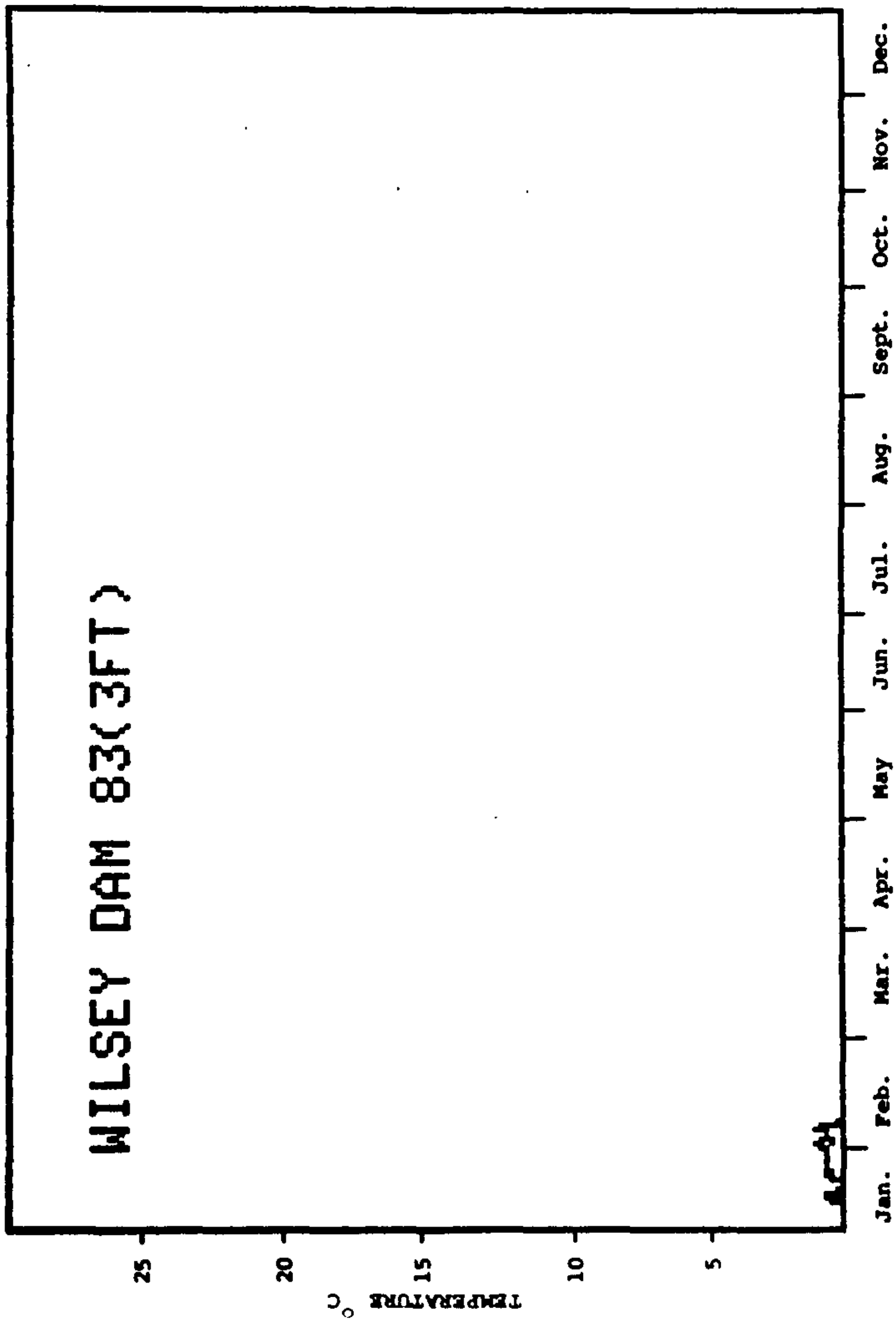


Figure 6. Shuswap River temperatures, 27 ft. deep 1983.

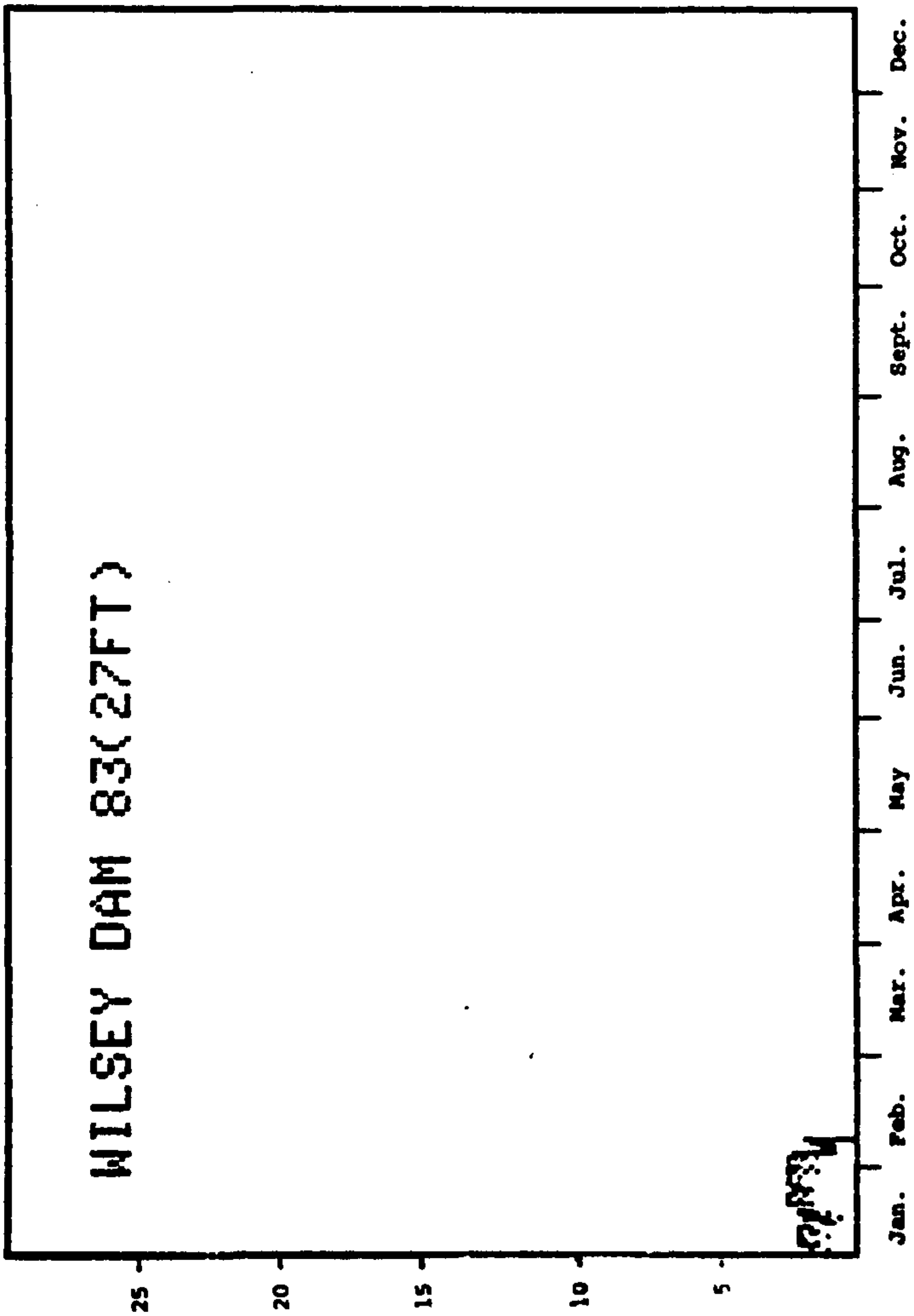
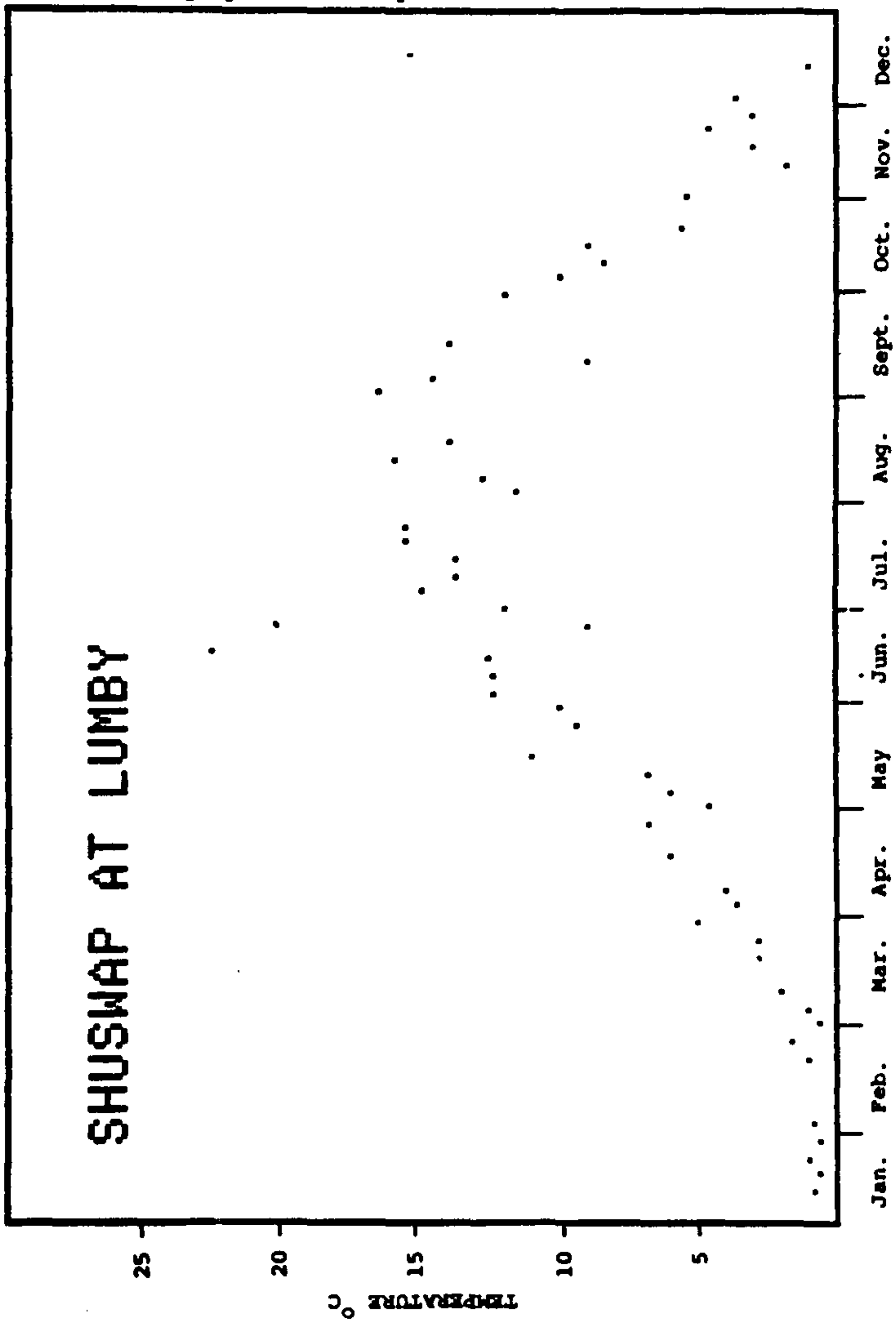


Figure 7. Shuswap River temperatures, spot observations near Lumby by Water Survey of Canada.



Appendix I. SIGMA Sampling report

SIGMA ENVIRONMENTAL CONSULTANTS LTD
801-1155 W. Georgia St., Vancouver, B.C. Canada V6E 3H4
Telephone: (604) 688-8271

March 29, 1983 File: 8055V

Mr Bruce Shepherd
Department of Fisheries and Oceans
1290 West Pender Street
Vancouver, BC

Dear Bruce:

SHUSWAP RIVER WATER QUALITY FIELD DATA

From March 19 to March 23, 1983 water quality samples and field data were collected during a series of pump tests at the proposed Shuswap River hatchery site. Sets of samples were collected from Wells #4 (4 samples) and #5 (3 samples), and the Shuswap River (1 sample). The well locations are roughly as indicated on Figure 1. All well and river sampling procedures and water analyses were performed as to our proposal of March 1982, "Water Quality Analyses of Selected Salmon Enhancement Projects". All field results are summarized in the attached table.

1. SAMPLE COLLECTION AND ANALYSIS

General

Two separate pump tests were performed throughout the testing program. The work regime was as follows:

TEST	TESTING PERIOD	COMMENTS
Well #5	March 19, 13:00 to March 20, 20:00	- 29 hr test duration - screen depth @ 28 m - pumping rate @ 200 US gpm
Well #4	March 21, 14:00 to March 23, 14:00	- 48 hr test duration - screen depth @ 12 m - pumping rate @ 210 US gpm

Samples were collected daily during the pump tests. All field analysis was performed using the continuous flow through sampling method. The water samples were collected from a short hose attached to a faucet on the wellhead. The water from the hose was directed into an overflowing bucket from which the field readings were taken.

One river sample was taken during the testing period. The sample was collected in a fast flowing stretch immediately upstream of the well testing area. As some variation was observed in the water temperature of Well #4 during the pump test, the river temperature was monitored throughout the Well #4 pump test.

The samples collected for lab analysis were transferred back to Vancouver by bus. All samples were received at the lab within the required 48 hr period.

Temperature

Temperatures were measured with a Fisher total immersion primary reference mercury thermometer (range -1.0°C to 50°C) and checked with the thermocouples on the D O and conductivity meters. The expected accuracy of the measurements is ± 0.1°C.

Conductivity, Dissolved Oxygen, Total Gas Pressure, pH and ORP

All instruments functioned satisfactorily and were calibrated prior to each analysis.

Ryznar and Langlier Stability Indices

As has become customary, the Ryznar and Langlier Stability Indices of the different water samples collected have been determined. The calculated indices are based on the field temperature and pH readings, and the Total Filterable Residue, Calcium, and Total Alkalinity which were determined by lab analysis.

2. DISCUSSION OF WATER QUALITY

General

The waters from the two wells had different water quality characteristics. Well #4, which is quite shallow (12 m in depth), seems to be highly influenced by the river. Water from this well was quite high in dissolved oxygen, plus softer, and colder than "average" groundwater. The pumping characteristics of Well #5 which is 16 m deeper than Well #4, were unstable during the test. The Well #5 aquifer appears to contain much "older" groundwater and is anoxic, more mineralized, and much warmer than #4. The waters from both wells appear to be marginal for use as hatchery water supplies.

Well #5

Well #5 is the deeper of the two wells tested. Typical water quality characteristics are as follows:

Conductivity	-	130 umhos/cm @ 8.9°C
TGP	-	90.1%
pH	-	7.75
Temperature	-	8.9°C
D O	-	0.4 mg/l
ORP	-	-30 mV

The calculated stability indices indicate that the water from this source is moderately corrosive (Ryznar = 8.8, Langlier = -1.2).

The well was unstable and had a pumping rate of only 210 US gpm. Indications are that the aquifer is rather poor quality. As stated previously, this well appears to be of marginal quality for hatchery use.

Well #4

Well #4 is the shallower of the two wells tested. Typical water quality characteristics of this well are as follows:

Conductivity	-	68 umhos/cm @ 7.0°C
TGP	-	103.0%
pH	-	7.15
Temperature	-	7.1°C
D O	-	8.3 mg/l
ORP	-	+130 mV

The calculated stability indices indicate that the water from this source is quite corrosive (Ryznar = 10.4, Langlier = -1.8).

With the exception of temperature, the characteristics of this water are in the acceptable range for fish rearing. The well is very shallow, however, and indications are that it might be directly recharged by the river. For this reason, the well may be of only marginal value for hatchery use due to potential temperature variations.

Shuswap River

As stated, the water characteristics of the Shuswap River are very similar to Well #4. The water is quite soft and has a slightly basic pH. Typical water quality characteristics are as follows:

Conductivity	-	57 umhos/cm @ 3.7°C
TGP	-	105.0%
pH	-	7.35
Temperature Range	-	3.6°C to 5.2°C
D O	-	12.1 mg/l
ORP	-	+130 mV

The river showed some diurnal temperature variation. In addition, the fairly high TGP level of the river did not appear to be related to a supersaturation effect from Shuswap Falls, which is located half a kilometer upstream of the sampling point. This observation is based on the small difference in TGP levels from the well site (105.0%) to a point 8 km downstream (103.9%).

It is hoped that the work was performed to your expectations. If you have any questions regarding the testing, please contact me at SIGMA.

Yours truly
SIGMA ENVIRONMENTAL CONSULTANTS LTD

DAVID W GRAHAM, MASc, P Eng

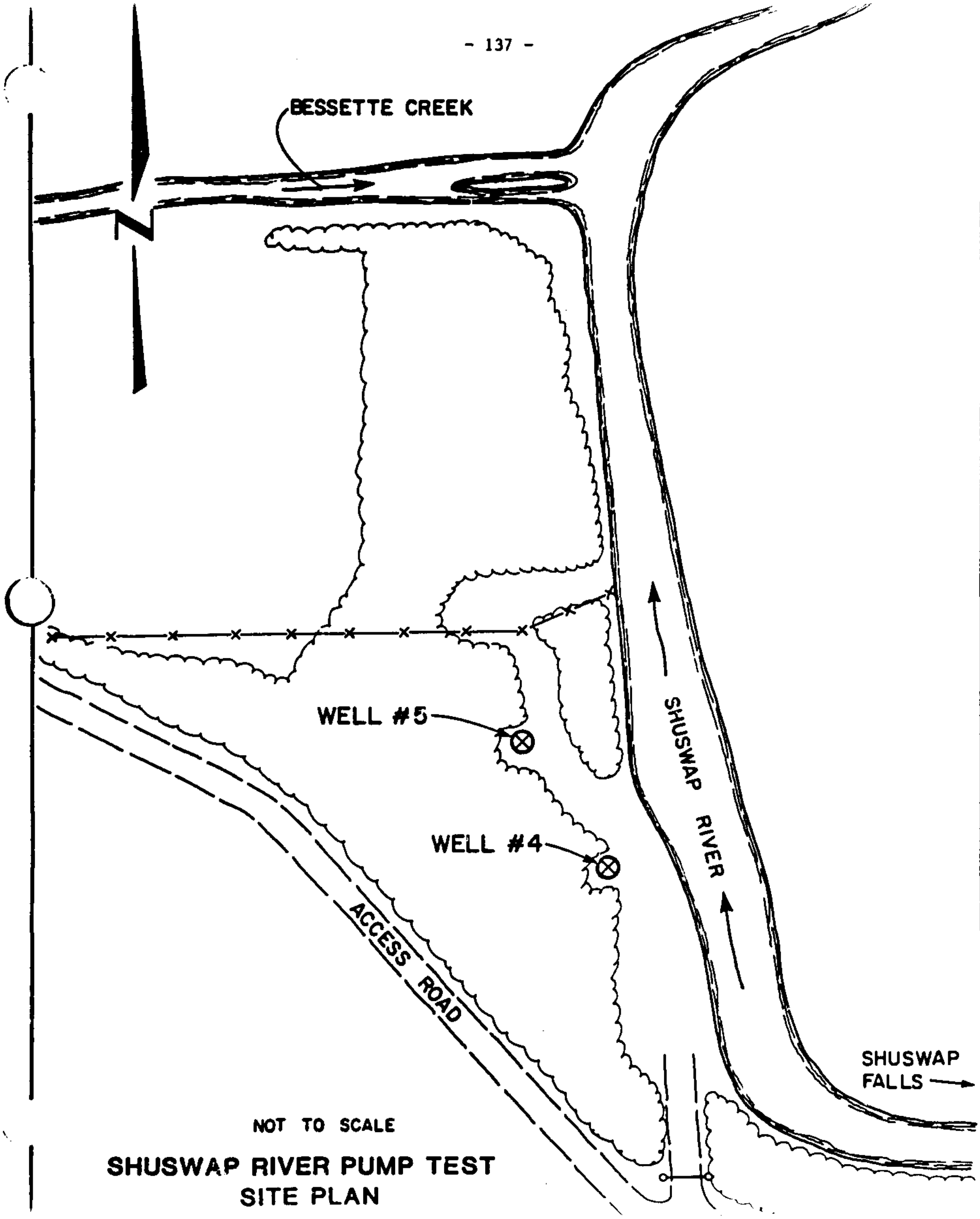
DWG:ejw-27

File: 8055V

FIELD RESULTS: SHUSWAP RIVER PUMP TESTS

Water Sample	Well #5	Well #5	Well #5	Well #4	Well #4	River	Well #4	Well #4
Date, March 1983	19	20	20	21	22	22	22	23
Time of Day	15:00	08:30	12:00	16:00	08:30	09:00	16:00	10:30
Pumping Time (hr)	2	19.5	23	2	18.5	19	26	44.5
Weather	Sunny	Cloudy	Cloudy	Sunny	Cloudy	Cloudy	Lt Rain	Cloudy
Air Temperature (°C)	8.2	5.0	9.8	11.6	3.4	3.6	6.8	6.5
Barometric Pressure (mm Hg)	733	735	733	729	729	729	724	727
Lab Sample Number	830372	830372	830372	830371	830371	830371	830415	830415
Water Temperature (°C)	8.9	8.85	8.9	6.7	7.0	3.7	7.1	7.1
Conductivity (umhos/cm)	120	132	132	68	69	57	69	68
pH	7.8	7.7	7.7	7.15	7.2	7.35	7.1	7.1
Dissolved Oxygen (mg/l)	0.5	0.3	0.4	8.9	8.0	12.1	8.3	8.1
Total Gas Pressure (mm Hg)	-68	-69	-76	+38	+18	+36	+23	+18
ORP (mV)	0	-30	-35	+110	+125	+130	+140	+140
Total Gas Pressure (%)	90.6	90.4	89.4	105.3	102.3	105.0	103.2	102.5
Saturation of Ox. (%)	4.5	2.6	3.6	76.0	68.9	95.7	72.1	70.7
Saturation of Nit. (%)	113.5	113.7	112.2	113.1	114.0	107.5	111.5	111.0
Ryznar Stability Index	9.4	8.8	8.7	10.4	10.4	10.5	10.4	10.4
Langlier Stability Index	-1.6	-1.2	-1.2	-1.8	-1.8	-1.9	-1.8	-1.8

Notes: a) The pump test of Well #4 was started at 13:00, March 19. The pump test of Well #5 was started at 14:00, March 21.



SHUSWAP RIVER PUMP TEST
SITE PLAN

Appendix II. Sigma Water Temperature Monitoring.

MEMORANDUM File: 8055V

To: Bruce Shepherd, Department of Fisheries and Oceans

From: David Graham, Sigma Environmental Consultants Ltd

Subject: Temperature Data Collected at the Shuswap River Pump Test, March 19 to March 23, 1983

Date: April 18, 1983

Please find below the relevant temperature data you requested.

Time (hr)	Time of Day	Well #4 Temperature (°C)	Shuswap River Temperature (°C)	Air Temperature at Well (°C)
2 hr	16:00	6.7	5.15	11.6
18.5 hr	08:30	7.0	3.7	3.4
19.0 hr	09:00	-	3.7	3.6
22.0 hr	12:00	7.2	4.1	-
24.0 hr	14:00	-	4.6	8.5
26.0 hr	16:00	7.1	4.5	6.8
28.0 hr	18:00	7.1	4.3	4.5
42.5 hr	08:30	-	4.0	-
44.5 hr	10:30	7.1	4.7	6.5
48.0 hr	14:00	7.1	4.8	-

DAVID W GRAHAM

DWG:eiw-18

Appendix III. Calculation of Ammonium concentration from Total Ammonia, pH and Temperature for Well #5 Pump test.

Hours Pumped	Temperature (°C)	pH	Total NH (mg/1)	Toxic Fraction NH_3 (mg/1)
2	8.9	7.8	.007	0.0000744
19.5	8.85	7.7	.008	0.0000674
23	8.9	7.7	.009	0.0000761

Appendix IVa. Aeration Requirements for Various Input Values.

INITIAL O2 CONC. (% SAT) = .3
NUMBER OF SCREENS = 20
SCREEN DISTANCE (CM) = 20.3
AERATION CONSTANT = .35
SCREEN TYPE = PACKED COLUMN

SCREEN #	O2 (% SAT)
0	.3
1	29.73
2	50.47
3	65.09
4	75.39
5	82.65
6	87.77
7	91.38
8	93.93
9	95.72
10	96.98
11	97.87
12	98.5
13	98.94
14	99.26
15	99.47
16	99.63
17	99.74
18	99.82
19	99.87
20	99.91

Appendix 7. Survival Standards:

A. Used for Phase I planning and design (p 143)
B. Used by Enhancement Opportunities Subcommittee for SEP Continuation planning (pp 144 - 149).

SALMONID ENHANCEMENT PROGRAM — DESIGN CRITERIA FOR AVERAGE PERCENT SURVIVAL — UPDATED - March 23, 1981

INTERIM STANDARD FOR PHASE 1 — AFL, RMG, DWK, FEAW.

These standards are a revision of the preliminary ones developed by FKS, RMG and DS. They are for the purpose of improving the estimates for the Phase 1 model in time for decisions relating to the 80-81 program. They will be improved and revised when the new computer model is available. Input received from RMG, EZ, AWA, DA, JW, HS, FKS, FJF. UNLESS NOTED IN THE "EXCEPTIONS" TABLE, THESE STANDARDS WILL BE APPLIED TO PROJECTS IN THE PHASE 1 MODEL, BUILT TO LONG-TERM STANDARDS, WITH FULLY EXPERIENCED STAFF, AT LEVELS ESTABLISHED BY THE FACILITIES OPS. GROUP - higher risk facilities draft standards are under review.

Sockeye	Eggs°	C/E°	% Egg Fry ×	% Fry Smolt ×	% Smolt Adult =	% Egg Adult
Natural	(Deposition					
Coastwide ex.	3,000	1.3/1	15	22	4.5	0.15
Fraser	4,000	4/1	15	28	6.0	0.25
Channel[1] (1.5 yds²/female)	Coastwide ex.		50[1]	20	4.5	0.45[1]
	Fraser		60[1]	28	6.0	1.01[1]
Lake Fertilization			Site Specific			
Chum (Revised Aug. 29/79)	2,800				Fry/Adult	
Natural	Coastwide	0.8/1	9		1.4	0.13
Channel[1] (1.5 yds²/female)	Coastwide		60[1]		0.8	0.48
Box	Coastwide		80		0.8	0.64
Incub. and Rearing* (freshwater)	Coastwide where applicable		90	80 (fed fry)	2.0*	1.44*
Incub. and Rearing (Marine - 4 g)	Coastwide where applicable		72 to pens	90 (Marine release)	2.5	1.62
Pinks						
Coastwide (even)	1,500	1.8/1	13		2.8	0.37
Coastwide (odd) and Q.C.I. (even)	1,500	1.3/1	12		2.5	0.30
Fraser (odd)	2,000	2.8/1	13		2.9	0.38
Channel[1] (1.5 yds²/female)			50[1]		2.5	1.25[1]
Box			80		2.5	2.00
Coho	2,500				Smolt/Adult	
Natural		1.25/1	16	8	15	0.18
Box - natural			80	8	15	0.96
- rearing			80	75	15	9.00
Incub. - rearing		NB 3:1 Fraser	90	75	15	10.13
Steelhead (Revised July 6/78) N.S.	Eggs°	C/E°	% Egg Fry ×	% Fry Smolt ×	% Smolt Adult =	% Egg Adult
Natural	4,000	1/1	15	8	8	0.10
Hatchery 2 year rearing			75	60	4	1.80
Hatchery Winter 1 year			75	70	4	2.10
Hatchery Summer 1 year			75	70	3	1.58
Cutthroat (corrected July 10/78) N.S.						
Natural	1,100	2/1	16	14	25	0.56
Hatchery - 1 year rearing			80	60	10	5.60
Hatchery - 2 year rearing			80	54	25	10.80
Chinook (Revised Nov. 23/78, July 4/78)	5,000					
Natural (Maint. Level) (Coastal)		4/1	15	33	6	0.30
Box - Rearing* Coastal 90 days (90/lb)		NB 8/1 on Fraser	80	80	3	1.92
Coastal 1 year (Super-Smolts)			80	65	6	3.12
Up River° 90 days			80	80	2.25	1.44
1 year (Natural 1 - year smolts)			80	65	6	3.12
Heath Rearing Coastal 90			90	80	3	2.16
Coastal 1 year (Super-Smolts)				65	6	3.51
Up River 90			90	80	2.25	1.62
Up River 1 year (Natural 1-year smolts)			90	65	6	2.51

*Japanese Technique-areas where poorer conditions are expected to be encountered reduce smolt/adult to 1.5 - 1.0

°Up River-Fraser above hope, Skeena above Hazelton, Yukon @ Whitehorse.

[1] Side Channels-reduce channel standard by 50%, reduce by 25% if gravel replaced to channel specs. life reduction bases on flood-proofing also to be applied.

Exceptions

Big and Little Qualicum Chum Channels egg deposition	2,890	73.4	% Fry/Adult 0.634	0.5

°Note: The C/E Ratios and egg depositions are intended only as a guide and where specific site information is known it should be applied. The C/E ratio should not exceed 4/1 for all projections on enhanced net stocks with "terminal" fisheries, and will be lower in may cases, to allow for mixed stock fisheries.

[2] Note: Adult is defined as caught or escapement, regardless of maturity.

ENHANCEMENT OPPORTUNITIES SUB-COMMITTEE C SURVIVAL/CAPACITY 1/6
BIO-ENGINEERING STANDARDS 1 SOCKEYE

TECH	PROD AREA	FECUNDITY	DESCRIPTION	OUTPUT SIZE	EGG/FRY %	FRY/SMOLT %	SMOLT/ADULT %	EGG/ADULT %	ADULT/UNIT	KG/JUV. 1000 ADULT	REMARKS
CO TT FW	Except UPFR LWFR	3000	Natural	0.3 g	15	22	4.5	0.15	$3.0/m^2$ 9000/km	-	
CH	- " -	- " -	Channel $1.25m^2$/pair	- " -	50	22	4.5	0.495	$11.96/m^2$	30 kg	
SC	- " -	- " -	Imp. Side Channel 1.25 m^2/pair	- " -	31	22	4.5	0.307	$7.42/m^2$	-	75^k fry/ $100m^2$
SC	- " -	- " -	Side Channel $1.25m^2$/pair	- " -	28	22	4.5	0.225	$6.63/m^2$	-	67^k fry/ $100m^2$
BX TR	- " -	- " -	Incubation Box	- " -	80	20	4.5	0.720	$360/50^k$ egg box	33 kg	
CO TT FW	UPFR LWFR	4000	Natural	0.3 g	15	28	6.0	0.25	$6.67/m^2$ 20,000/km		
CH	- " -	- " -	Channel $1.25m^2$/pair	- " -	50	28	6.0	1.01	$32.3/m^2$	18 kg	
IC	- " -	- " -	Upwell Inc. Chan-Transplant	- " -	75	28	6.0	1.26	-	24 kg	
SC	- " -	- " -	Imp. Side Channel	- " -	23.4	28	6.0	0.39	$12.60/m^2$		75^k fry/ $100m^2$
SC	- " -	- " -	Side Channel	- " -	20.9	28	6.0	0.35	$11.26/m^2$		67^k fry/ $100m^2$
BX	- " -	- " -	Incubation Box	- " -	80	25	6.0	1.20	$600/50^k$ egg box	25 kg	

TECH	PROD AREA	FECUNDITY	DESCRIPTION	OUTPUT SIZE	EGG/FRY %	FRY/SMOLT %	FRY/ADULT %	EGG/ADULT %	ADULT/ UNIT	KG/JUV. 1000 ADULT	REMARKS
CO TT FW SP	Even years except Q.C.I.	1500	Natural	0.4 g	13		2.8	0.37	5.46/m^2 16,380/km		
CH	Except	- " -	Channel 1.25m^2/pair	- " -	50		2.5	1.25		16 kg	
SC	Odd years except Fraser, Q.C.I.	- " -	Side Channel	- " -			2.8		9.52/m^2		34^k fry/ 100m^2
SC	Except Fraser	- " -	Improved side channel	- " -			2.8		17.64/m^2		63^k fry/ 100m^2
BX HY	Except Fraser	- " -	Incubation Box/HY	- " -	80		2.5	2.00		16 kg	
CO TT	Odd years except Fraser, Q.C.I.	- " -	Natural	0.4 g	13		2.5	0.30	4.5/m^2 13,500/km	16 kg	
SC	- " -	- " -	Side Channel	- " -	25		2.5	0.625	8.5/m^2	16 kg	
CO TT FW SP	Fraser (odd)	2000	Natural	- " -	13		2.9	0.38	7.54/m^2 22,620/km		
CH	- " -	- " -	Channel 1.25m^2/pair	- " -	50		2.5	1.25		15 kg	
SC	- " -	- " -	Side Channel	- " -			2.5		9.86/m^2		
SC	- " -	- " -	Improved Side Channel	- " -			2.5		18.27/m^2		
BX HY	- " -	- " -	Incubation box hatchery	- " -	80		2.5	2.00		16 kg	

ENHANCEMENT OPPORTUNITIES SUB-COMMITTEE
BIO-ENGINEERING STANDARDS

C SURVIVAL/CAPACITY 3/6
3 CHUM

TECH	PROD AREA	FECUNDITY	DESCRIPTION	OUTPUT SIZE	EGG/FRY %	FRY/SMOLT %	FRY/ADULT %	EGG/ADULT %	ADULT/ UNIT	KG JUV. / 1000 ADULT	REMARKS
FW OR CO SP	All	2800	Natural	0.4 g	9		1.4	0.13	$2.35/m^2$ 7,050/km		
SC	- " -	- " -	Side Channel (River Flow)	- " -	10.7		1.4	0.15	$3.36/m^2$		24,000 fry/100m^2
SC	- " -	- " -	Side Channel (Groundwater)	- " -	12		1.4	0.168	$3.78/m^2$		27,000 fry/100m^2
SC	- " -	- " -	Improved Side Channel	- " -	20		1.4	0.28	$6.3/m^2$		45,000 fry/100m^2
CH	- " -	- " -	Channel 1 PR/1.25m^2	- " -	60		0.8	0.48	$10.75/m^2$		
BX			Incubation Box/Pit	- " -	80		0.8 SMOLT/ADULT	0.64	$320/50^k$ Box	50	
JH	- " -	- " -	Hatchery Rear	1.0 g	90	80	2.0	1.44	- " -	50	
JH	- " -	- " -	Hatchery Marine Rear	2.0 g	90	80	2.5	1.62	- " -	80	

TECH	PROD AREA	FECUNDITY	DESCRIPTION	OUTPUT SIZE	EGG/FRY %	FRY/SMOLT %	SMOLT/ADULT %	EGG/ADULT %	ADULT/UNIT	KG JUV./1000 ADULT	REMARKS
FW OR SP CU SC	All	2500	Natural	0.5 g	15	8	15	0.18	$6/100m^2$ 218/km		Flow control 2X survival
BX	All	- " -	Incubation Box - no Rearing	0.5 g	80	8	15	0.96	480/50k incubation box	78	
HY TR	- " -	- " -	Hatchery spring release	2 g	90	9 (90 HY x 10 WILD)	15	1.22	-	200	
HY	- " -	- " -	Hatchery fall release	5 g	90	16 (80 HY x 20 WILD)	15	2.16	-	167	
HY	- " -	- " -	Hatchery smolt release	20 g	90	75	15	10.13	-	133	

ENHANCEMENT OPPORTUNITIES SUB-COMMITTEE
BIO-ENGINEERING STANDARDS

C SURVIVAL/CAPACITY 5/6
5 CHINOOK

TECH	PROD AREA	FECUNDITY	DESCRIPTION	OUTPUT SIZE	EGG/FRY %	FRY/SMOLT %	SMOLT/ADULT %	EGG/ADULT %	ADULT/ UNIT	KG JUV. 1000 ADULT	REMARKS
CO TT	Coastal - Sub 1 -	5000	Natural	5 g	25	16	5	0.20	$1.8/100m^2$ 348/km		
HY	- " -	- " -	Hatchery	5 g	90	80	3	2.16	-	167	
BX	- " -	- " -	Box	0.5 g	80	10	5	0.40	-	100	
Hy	Up River - Sub 1 -	6000 (Fraser)	Hatchery 5g migrant	5 g	90	80	2.25	1.62		222	
CO TT FW OR	Up River - Sub 2 -	6000 (Fraser)	Natural	0.5 g	30	10	7.5	0.225	$2.7/100m^2$ 300/km		
HY	- " -	- " -	Hatchery 2g release	2 g	90	8.5 (85 HY x 10 WILD)	7.5	0.57		316	
HY	- " -	- " -	Hatchery 5g over-winter	5 g	90	16 (80 HY x 20 WILD)	7.5	1.08		333	
HY	- " -	- " -	Hatchery 1yr rearing	50 g	90	65	4	2.34		1250	
BX	- " -	- " -	Gravel incubators no rearing	0.5 g	80	8	7.5	0.48		83	

NOTE: CHINOOK SURVIVALS ARE EXTREMELY VARIABLE AND THE DATA BASE IS VERY POOR.
DO NOT ADJUST FECUNDITY WITHOUT ADJUSTING SURVIVAL RATES.

TECH	PROD AREA	FECUNDITY	DESCRIPTION	OUTPUT SIZE	EGG/FRY %	FRY/SMOLT %	SMOLT/ADULT %	EGG/ADULT %	ADULT/ UNIT	KG JUV. / 1000 ADULTS	REMARKS
STEELHEAD											
CO FW OR SP	All	4000	Natural	0.5 g	15	8	8	0.10	10/km coast 50/km interior		
TT HY	- " -	- " -	Hatchery- Fry Stocking	0.5 g 2.0 g	75 75	8 12.5	8 8	0.36 0.75		78 kg 200 kg	
HY	- " -	- " -	Hatchery - Smolt (winter)	60 g	75	70	4	2.10		1500 kg	
HY	- " -	- " -	Hatchery - Smolt (summer)	60 g	75	70	3	1.58		2000 kg	
CUTTHROAT											
CO FW OR SP	All	1100	Natural	0.5 g	16	14	10	0.22		36 kg	
TT HY	All	- " -	Hatchery 1 yr rear	60 g	80	60	10	4.80		600 kg	

Appendix 8. Sample biological design memo (Tenderfoot facility).

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MEMORANDUM — NOTE DE SERVICE

SECURITY · CLASSIFICATION · DE SECURITE

OUR FILE/NOTRE RÉFÉRENCE: 5830-85-S370

YOUR FILE/VOTRE RÉFÉRENCE:

DATE: January 30, 1981

TO / A:
Mr. Jim Wild
Sr. Implementation Eng.
Mr. Roy McGechaen
Sr. Project Eng.

FROM / DE:
Dr. F.K. Sandercock
Chief, Enhancement Operations
Mr. B.G. Shepherd
A/New Projects Coordinator
Mr. D.D. MacKinlay
Design Biologist

SUBJECT / OBJET: TENDERFOOT CREEK HATCHERY BIO-CRITERIA

This memo expands on the memo from B. Shepherd to R. McGechaen of August 8, 198 on this file. It presents relevant biological criteria for the development of a coho and chinook facility on Tenderfoot Creek near Squamish, B.C., and includes steelhead requirements as outlined by the Ludwig to Shepherd memo January 6, 1981.

1. Production Objectives

Species	No. of Eggs[a]	No. of Fry[b]	No. of Fingerlings[c]	No. of Smolts[d]	No. of Donors Req'd. Female[e]	Male	Total[f]	Total Return
Coho	75K	67K	60K	50K	30	18	48	7500
Chinook	232K	209K	188K	167K	47	28	75	5000
Steelhead	140K	105K	102K	--	35	35	70	1000

a) Eggs required are back calculated from survivals to adult: CN, 10.13%; CO, 2.16%; SH, 7.14%.

b) Fry (Swim-up) based on survival in Heath trays: CO, 90%; CN, 90%; SH, 75%.

c) Fingerlings (2 gram size) based on survival in Capilano troughs: CO, 90%; CN, 90%; SH, 97%.

d) Smolts (size) based on survival in rearing ponds: CO(20g), 75%; CN(5g), 80%.

e) Female donors required based on average fecundities: CO, 2500; CN, 5000; SH, 4000.

f) Total donors based on total: female ratio: CO, 1.6:1; CN, 1.6:1; SH, 2:1.

2. Incubation to Hatching Requirements

a) Equipment

	Species		
	Coho	Chinook	Stealhead
No. of Eggs	75K	232K	140K
Unit Type		Heath Incubation Trays (8 trays/stack)	
Unit Loading	8500/tray	5000/tray	10,000/tray
No. of Units[a]	9 trays 2 stacks	47 trays 6 stacks	14 trays 2 stacks
b) Flows[b]			
Loading : Normal	15 LPM/stack	15 LPM/stack	15 LPM/stack
: Flush[c]	19 LPM/stack	19 LPM/stack	23 LPM/stack
Flows : Normal	30 LPM	90 LPM	30 LPM
: Flush[c]	38 LPM	114 LPM	46 LPM
c) Period			
Earliest Egg-take[d]:	Nov. 17	Jun. 29	Jun. 1
Latest swim-up[e] :	May. 15	Feb. 14	Aug.15

a) Since steelhead incubation timing is out of synchrony with chinook and coho, only 8 stacks are required (see Table 1).
b) Flows are to be aerated groundwater only.
c) Plumbing to all stacks to be sized to flush flow (see Table 1).
d) Spawning dates for coho and chinook are based on evidence from D.F.O. F381 spawning files and from reports by Argue and Wilson (1978) and Wilson, Armstrong and Argue (1977). Three egg take dates are used for coho and chinook (see Tables 4 and 5) as examples of range of timing.
e) Eyed, hatch and swim-up dates for coho and chinook are based on Accumulated Thermal Units (ATU's) in degree Celcius days:
CO-eyed, 220;hatch,400-500;swim-up,700-800
CN-eyed, 280;hatch,480-540;swim-up,900-1000

3. Initial Rearing Requirements

a) Equipment

	Species		
	Coho	Chinook	Steelhead
No. of Fry	67K	209K	105K
Unit Type	Capilano-style Rearing Troughs. (2 troughs/line)		
Unit Loading	54K/trough	54K/trough	N/A[a]
No. of Units[b]	2 troughs 1 line	4 troughs 2 lines	1 trough 1 line
b) Flows[c]			
Loading Rate	Start 120 LPM/End 240 LPM/line		N/A[a]
Flows :Start	120	240	50[a]
:End	240	480	100[a]
c) Period[d]			
Earliest start	Mar. 6	Nov. 1	Aug. 15
Latest end	Aug.23	Apr.30	Sept.15

a) Steelhead loadings are as per Ludwig-Shepherd memo of Jan. 6, 1981, from B.C.F.W. (attached). Steelhead are planted out as 0.5g fry.
b) Since steelhead rearing timing is out of synchrony with coho and chinook, steelhead can double use one of the 3 salmon lines of troughs available.
c) Flows are to be aerated groundwater only.
d) Timings for coho and chinook are from Tables 4 and 5, based on rearing to 2 gram size in Capilano troughs. GROWTH model determined growth rate from swim-up (CO.3g,CN.4g)based on appropriate temperature (using Fourier generation from projected temperatures - Table 5) and ration (CO,0.6;CN,0.9 of theoretical maximum).

4. Final Rearing Requirements

a) Equipment

	Species	
	Coho	Chinook
No. of Fingerlings (size)	60K(2g)	188K(2g)
No. of Smolts Released (size)	50K (25g)	167K(5g)
Volume Loading Rate[a]	22.7 Kg/m^3	15.2 Kg/m^3
Volume Required	55 m^3	55 m^3
Unit :Type[b] Gravel Rearing Channel (as per Chilliwack Steelhead)		
:Cross Section	5 m^2	5 m^2
:Length	11 m	11 m
b) Flows		
Flow Loading[c]: start	.83 Kg/LPM	.86 Kg/LPM
: end	1.48Kg/LPM	.86 Kg/LPM
Flows[d] : start	145 LPM	440 LPM
: end	845 LPM	975 LPM
c) Period[e]		
Earliest start:	Jun. 19	Jan. 15
Latest end :	Jun. 29 (next yr.)	Jun. 29

a) Volume loadings based on Mayo Curve for appropriate fish size.
b) Rearing channels should be smaller version (as deep but not as wide) as Chilliwack model.
c) Flow loadings are based on LOAD model at appropriate fish size, temperature (Fourier generation of projected temperatures-Table 6) and ration (CO, .6; CN, .9 of maximum).
d) Flows are aerated ground water.
e) Timings based on LOAD model - see Tables 4 and 5.

5. Adult Holding Requirements

i) No coho and chinook adult holding facilities, as such, are to be built at Tenderfoot at this time. However, the following table shows that available space in the chinook rearing channel is sufficient for coho and chinook adult holding.

Species	Donors	Biomass		Required		Available	
		per fish	Total	Volume	Flow	Volume	Flow
Coho	48	3 Kg	144Kg	$4.5m^3$	110LPM		
Chinook	75	5 Kg	375Kg	$11.7m^3$	313LPM		
Total	123		519Kg	$16.2m^3$	333LPM	$55m^3$	975LPM

- loadings are: Volume, 32Kg/m; Flow, 1.2Kg/LPM

ii) -Steelhead requirements are laid out in Appendix 1. Requested is a holding tank (7.3mL x 1.2mW x 1.2mD, .8m water D) supplied with 187LPM of aerated groundwater introduced via an upwelling inlet structure. Fish and Wildlife Branch are concerned that concrete sides on this pond may be too hard and rough for holding steelhead from this area, which are notorious for their 'spooky' nature. They suggest (B.Ludwig telecon Feb. 12/81) that a preferred alternative to a concrete holding pond would be to supply two pre-fabricated plywood or fibreglass tanks similar to those in use at Abbotsford (4.9mL x 1.2mW x 1.2mD, .8m water D-with upwelling inlet; plans to be supplied by B.C.F. & W with one month's notice), each of which would receive 100LPM of aerated ground water.
-It is essential that any steelhead holding containers have both solid covers and the ability to compartmentalize into 1.5m sections with 'broomstick' fences or screens.
-Period of flow is from January till early June.

6. Support Facility Requirements

1. Aeration/stripping of well water (see MacKinlay to Shepherd memo, Dec. 17, 1980 on file 5830-13-16).

2. Dog-proof fencing of site, since it may be operated on a commuter basis for several months of the year.

3. Hatchery building containing:
   a. Lunchroom (crew size with kitchen)
   b. Washroom (with shower)
   c. Office (useable as sleeping quarters)
   d. Incubation room (with egg-pick sinks)
   e. Storage room (for tools, dry goods)

4. Remote alarm system.

5. Standby generator and water supply backup.

6. Approximately 120 cu. ft. of food storage freezer space is required for this facility (see Appendix 2 for requirement calculations). This would require six (6) 22 cu. ft. chest freezers. Considering that this facility may expand to at least double present capacity (or more if steelhead are reared to smolt size), investment in a small (~ 250 cu. ft.) walk in freezer is recommended.

F.K. Sandercock
Chief, Enhancement Operations

B.G. Shepherd
A/New Projects Coordinator

D.D. MacKinlay
Design Biologist

/mmm

c.c. C. MacKinnon, H. Sparrow, B. Ludwig, F.E.A. Wood, A. Lill, R. Harrison, G. Berezay, D. Harding, G. Dixon

TABLE 1 **Summary of Maximum Flows to Hatchery Components**

	Unit	No. of Units	Min-Max Flow/Unit	Maximum Flow
1.	Heath trays	8 stacks	15 LPM/23 LPM	184 LPM
2.	Capilano/style troughs	3 lines	120 LPM/240LPM	720 LPM
3.	Rearing ponds	2 ponds	145 LPM/975LPM	1892 LPM
4.	Adult holding ponds	2 ponds	100 LPM/pond	200 LPM

TABLE 2. Tenderfoot Creek Project - Rearing Strategies

Phase	Method	Coho	Chinook	Steelhead
INCUBATION	Number of Eggs	75,000	232,000	140,000
	in Heath Trays/stacks	9/2	47/6	14/2
	at Flow-Normal/Flush(LPM)	30/38	90/114	14/23
	for Period	Nov 17 - May 15	Jun 29 - Feb 14	Jun 1 - Aug 15
		↓	↓	↓
INITIAL REARING	Number of Fry	67,000	209,000	102,000
	in Capilano troughs/lines	2/1	4/2	1/1
	at Flow-start/end(LPM)	120/240	240/480	50/100
	for Period	Mar 6 - Aug 23	Nov 1 - Apr 30	Aug 15 - Sept 15
		↓	↓	
FINAL REARING	Number of Fingerlings	60,000	188,000	
	in Raceway	55 m^3	55 m^3	
	Flow-start/end(LPM)	145/845	440/975	
	for Period	Jun 19 - Jun 19 (next year)	Jan 15 - Jun 29	

- Range from earliest start to latest end is shown on this table, as per growth shown in Tables 4 and 5. Peak spawning date used in water demand calculations in the 'middle' egg take date.

TABLE 3 Tenderfoot Water Demand Table

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Incubation												
Coho	30	30	30	30	15						15	15
Chinook	60	30					30	60	90	90	90	90
Steelhead						30	30	30				
Initial Rearing												
Coho			120	150	180	210	240	240				
Chinook	300	360	420	480							120	240
Steelhead								75	100			
Final Rearing												
Coho	917	917	917	917	917	917/917	917	917	917	917	917	917
Chinook	917	917	917	917	917	975						
Adult Holding												
Steelhead	200	200	200	200	200	200						
Sub-Totals												
Heath Trays	90	60	30	30	15	30	60	90	90	90	105	105
Capilano Troughs	300	360	540	630	180	210	240	315	100		120	240
Rearing Ponds	1,834	1,834	1,834	1,834	1,892	917	917	917	917	917	917	917
Adult Holding	200	200	200	200	200	200						
Coho	947	947	1,067	1,097	1,112	1,127	1,157	1,157	917	917	932	932
Chinook	1,277	1,307	1,337	1,397	975	975	30	60	90	90	210	330
Steelhead	200	200	200	200	200	230	30	105	100			
GRAND TOTAL	2,424	2,454	2,604	2,694	2,287	2,332	1,217	1,322	1,107	1,007	1,142	1,262

- Timings in water demand table are based mainly on the peak (middle) subgroups for coho and chinook (as per Tables 4 and 5), with some allowance for earlier and later timings.
- Final rearing flows are based on a minimum exchange rate of 1.0 per hour for the the channel requested.

Table 4. Chinook Growth

	Early	Middle[a]	Late
Egg Take	Jun. 29	Aug. 18	Oct. 2
Eyed	Aug. 8	Sep. 27	Nov. 11
Hatch	Sep. 2	Oct. 22	Dec. 11
Swim-up(.4g)	Nov. 1	Dec. 26	Feb. 14
1 g.	Dec. 6	Feb. 4	Mar. 26
2 g.	Jan. 15	Mar. 16	Apr. 30
3 g.	Feb. 9	Apr. 10	May 25
4 g.	Mar. 1	Apr. 30	Jun. 14
5 g.	Mar. 21	May 15	Jun. 29
6 g.	Apr. 5	May 30	Jul. 9
7 g.	Apr. 20	Jun. 9	
8 g.	Apr. 30	Jun. 19	
9 g.	May 10		

- a) This date is the main egg take date used in determining water demand.

TABLE 5. Coho Growth

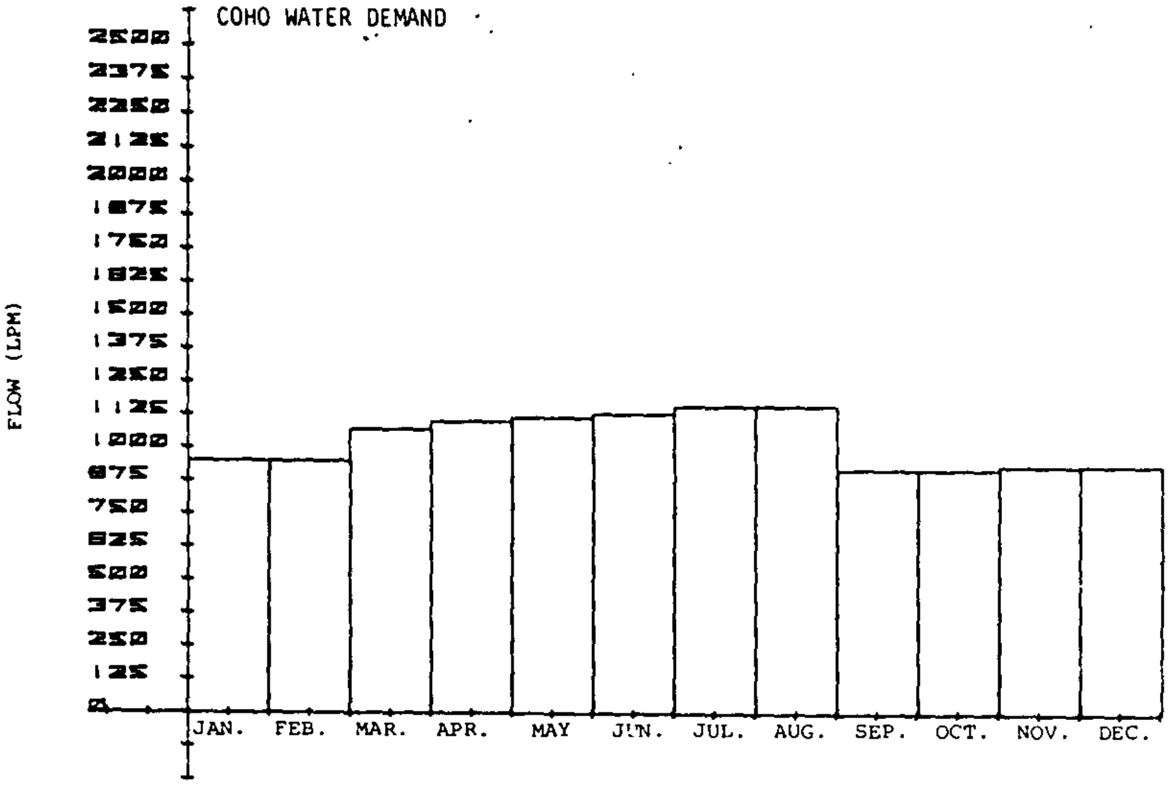
	Early	Middle[a]	Late
Egg Take	Nov. 17	Jan. 1	Jan. 30
Eyed	Dec. 16	Feb. 4	Mar. 6
Hatch	Jan. 20	Mar. 6	Apr. 5
Swim-up(.4g)	Mar. 6	Apr. 20	May 15
1 g.	May 5	Jun. 14	Jul. 9
2 g.	Jun. 19	Jul. 29	Aug. 23
3 g.	Jul. 19	Aug. 28	Sep. 22
4 g.	Aug. 13	Sep. 22	Oct. 17
5 g.	Sep. 2	Oct. 17	Nov. 11
6 g.	Sep. 22	Nov. 1	Nov. 25
7 g.	Oct. 7	Nov. 21	Dec. 16
8 g.	Oct. 11	Dec. 6	Dec. 31
9 g.	Nov. 6	Dec. 21	Jan. 15
10 g.	Nov. 21	Jan. 5	Jan. 30
11 g.	Dec. 1	Jan. 20	Feb. 14
12 g.	Dec. 16	Jan. 30	Mar. 1
13 g.	Dec. 26	Feb. 14	Mar. 11
14 g.	Jan. 10	Feb. 24	Mar. 26
15 g.	Jan. 20	Mar. 6	Apr. 5
16 g.	Jan. 30	Mar. 21	Apr. 15
17 g.	Feb. 9	Mar. 31	Apr. 25
18 g.	Feb. 19	Apr. 10	May 5
19 g.	Mar. 1	Apr. 15	May 10
20 g.	Mar. 11	Apr. 25	May 20
21 g.	Mar. 21	May 5	May 30
22 g.	Mar. 31	May 10	Jun. 4
23 g.	Apr. 5	May 20	Jun. 14
24 g.	Apr. 15	May 25	Jun. 19
25 g.	Apr. 25	Jun. 4	Jun. 29
26 g.	Apr. 30	Jun. 9	
27 g.	May 5	Jun. 19	
28 g.	May 15	Jun. 24	
29 g.	May 20	Jun. 29	
30 g.	May 25		

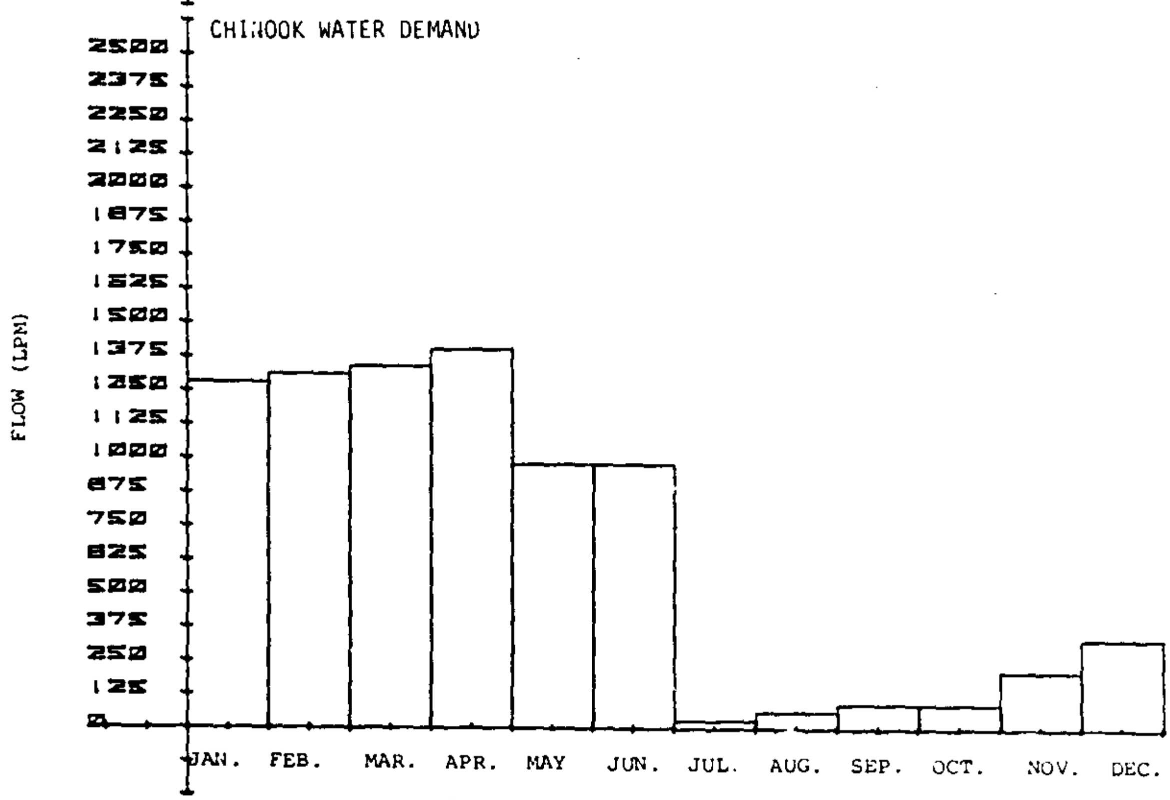
- a) This date is the main egg take date used in determining water demand.

TABLE 6. Projected Temperatures of Groundwater at Tenderfoot Creek

Month	Temperature
Jan.	7.5
Feb.	6.5
Mar.	7.0
Apr.	7.5
May	8.0
Jun.	8.0
Jul.	8.0
Aug.	8.0
Sep.	8.0
Oct.	7.5
Nov.	7.5
Dec.	7.5

Fourier Coefficients	A_0	7.5555555556
	A_1	.5235987756
	A_2	.0277777778
	B_1	.1592236335
	B_2	-.2405626122


COHO WATER DEMAND
FLOW (LPM)
2500
2375
2250
2125
2000
1875
1750
1625
1500
1375
1250
1125
1000
875
750
625
500
375
250
125
0
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.


CHINOOK WATER DEMAND
FLOW (LPM)
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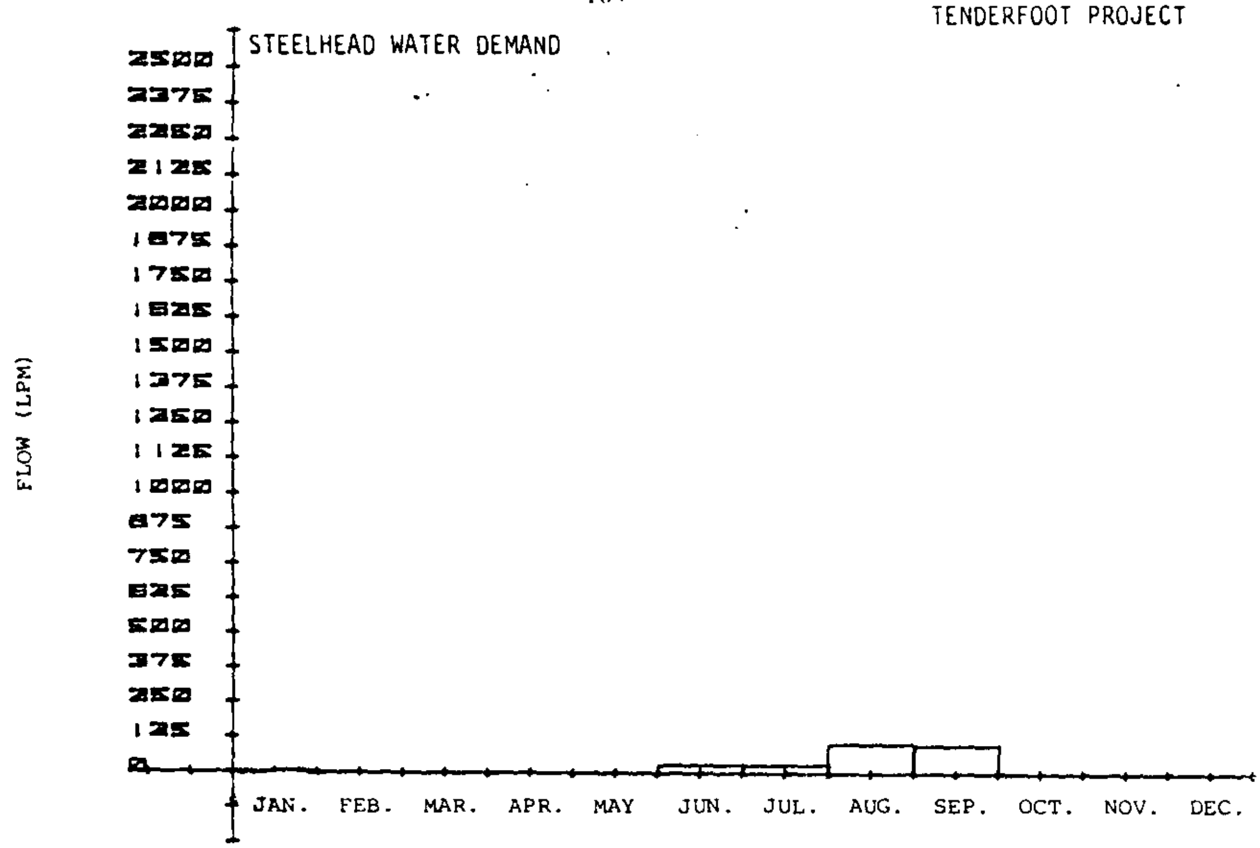
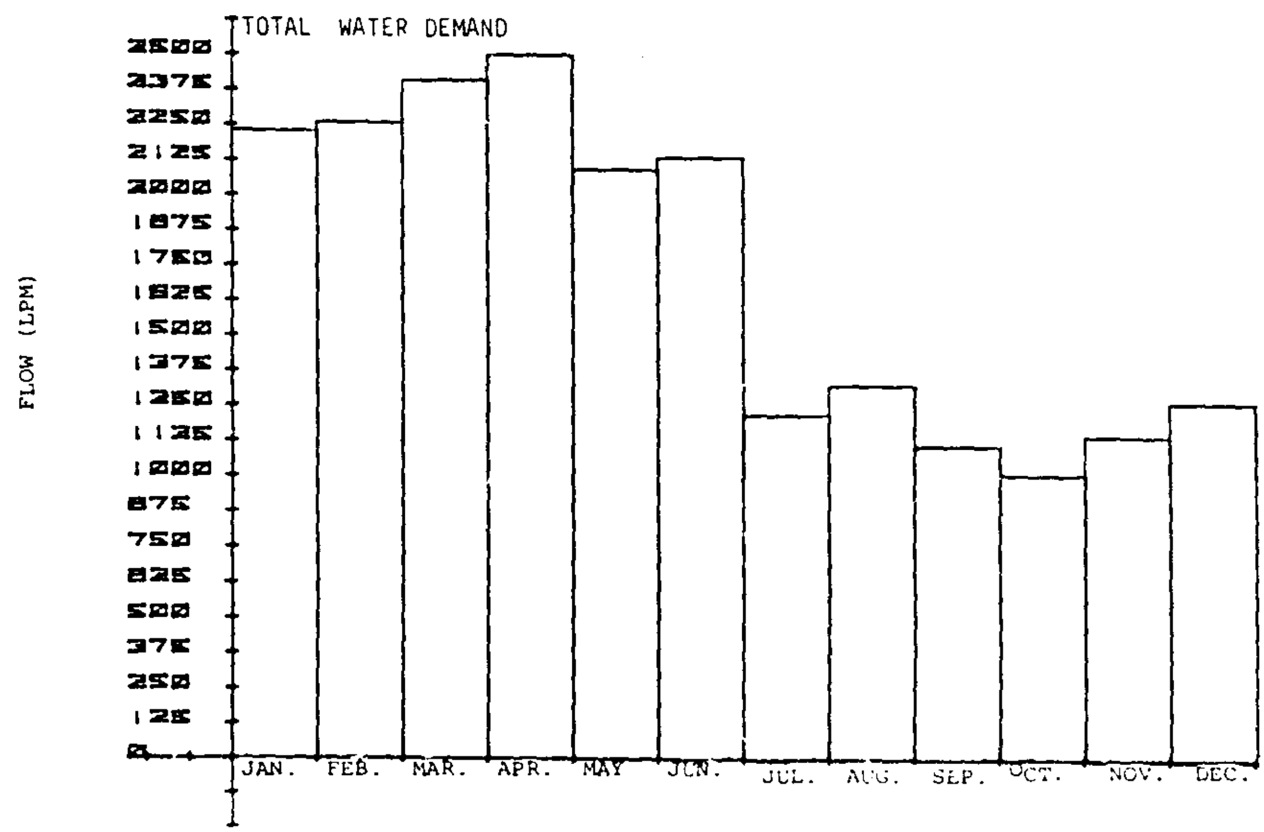
2375
2250
2125
2000
1875
1750
1625
1500
1375
1250
1125
1000
875
750
625
500
375
250
125
0
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.


STEELHEAD WATER DEMAND
FLOW (LPM)
2500
2375
2250
2125
2000
1875
1750
1625
1500
1375
1250
1125
1000
875
750
625
500
375
250
125
0
JAN.
FEB.
MAR.
APR.
MAY
JUN.
JUL.
AUG.
SEP.
OCT.
NOV.
DEC.


TOTAL WATER DEMAND
FLOW (LPM)
2500
2375
2250
2125
2000
1875
1750
1625
1500
1375
1250
1125
1000
875
750
625
500
375
250
125
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JAN.
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OCT.
NOV.
DEC.

APPENDICES

Province of British Columbia

Ministry of Environment

Fish and Wildlife Branch
400, 1019 Wharf Street
Victoria
British Columbia
V8W 2Y1

YOUR FILE ....

OUR FILE 1719

FILE 5830-P5-S370

January 6, 1981

Appendix 1

Mr. B.G. Shepherd
A/New Projects Coordinator
Fisheries and Oceans
Enhancement Services Branch
1090 West Pender Street,
Vancouver, British Columbia
V6E 2P1

Dear Bruce:

Re. Rearing Requirements for Steelhead at Tenderfoot Creek

As you requested (Shepherd - Sparrow letter - Dec. 29, 1980), here are our rearing requirements for Cheakamus steelhead at Tenderfoot Creek. Although we would prefer to release steelhead from this facility at the smolt-stage, we agree that the capital and operating costs of heating the water that would be required for raising one-year old smolts would not be feasible on the existing project budget. As an alternative, we propose to rear fry to as large a size as possible by mid-September and then release them to the Cheakamus river. Requirements are based on the use of well water (7 °C) for adult holding, incubation, and fry rearing. As noted by D. MacKinlay (MacKinlay - Shepherd design memo, Dec. 17, 1980) well water will require aeration.

Production Goals

Based on freshwater fry survivals of 50%/year for 3 years (3 year old smolts) and 8% smolt to adult survival, 102,000 fry must be released to produce a return of 1,000 adults.

Adult Holding - see attachment for requirements

The holding tank should have an inlet structure which provides an upwelling water source. One screen divider would also be required.

Incubation - see attachment

Trough Rearing - see attachment

Fry should reach 0.5 (g) in weight by mid-September. The optimum size for fry planting appears to be 1 g in weight. However, in order to allow the fry an "acclimation period" in the stream prior to the onset of winter water conditions, we must release the fish by mid-September.

Capilano troughs will require covers (vexar screening and plywood) if rearing is to be outside. If you have further questions, please do not hesitate to contact us.

R.A.H. Sparrow
i/c Fish Culture

B.W. Ludwig
Fish Culture Biologist, S.E.P.

BWL/ca

Attachment

cc: D. Narver
A. Tautz
P. Caverhill
J. Wild

[illegible]: Tenderfoot Creek

A) Production Objectives (as outlined by G.W.G.)

Species	No. Fry	Catch/ Escapement	Adult Return Catch	Adult Return Total
Steelhead	102,000	--	--	1,020

B) Adult Holding

Species	No. Fish [A]	Biomass [B] (kg)	Required Water Vol. (m^3)	Required Water Flow (l/min)	Holding Period	Recommended Holding Tank Dimensions (m)
Steelhead	70	224	7	187	Jan. - June	7.3 x 1.2 x 0.8 (wate[r] dept[h])

A - 4,000 eggs/♀ 1/1 sex ratio

B - 3.2 kg/fish

C) Incubation

Species	No. Eggs	No. Heath Trays	No. 8 tray Stacks	Approx. Egg-take Date	Water flow l/min per 8 tray Stack	Total Req. Flow (l/min)	Approximate Incubation Period
Steelhead	140,000	14	2	June 1	23	46	June - Aug.

D) Trough Rearing

Species	Approximate Rearing Period	Fish Size At Release(g)	No. Fish	Biomass (kg)	No. Capilano Troughs	Required Water Flow (l/min/trough)
Steelhead	Aug. - Sept.	0.53	102,000	54.1	1	92.4

E) Final Rearing

Species	Smolt Size(g)	No. Fish	Biomass(kg)	Required Water Vol. (m^3)	Required Water Flow/raceway (l/min)	Approximate Raceway Dimensions(m)
			NA			

Facility: Tenderfoot Creek
Species: Steelhead

Eggtake: June 1 - 140,000
Incubate: 7°C - 520 H.U. - 75 days
Swim-up: August 14

Date	Water Temp °C River	Water Temp °C Well	Water Temp °C Rearing	Predicted Fish Weight(g)	Mort. %/Day	No. Fish	Biomass (kg)	Available O_2 (Inflow - 6) (mg/l)	Minimum Req. Flow (l/min) (Outflow O_2 = 6)	Safety Factor	Req. Flow [Min. x Safety Factor] Well (l/min)	Req. Flow [Min. x Safety Factor] River (l/min)	Predicted Outflow O_2(mg/l) at Req. Flow $\left(\text{Avail. } O_2 \cdot \left[1-\frac{1}{\text{Safety Factor}}\right]+6\right)$
Aug. 14	—	7	7	0.2	.09	105,000	21	6.2	26.2	1.67	43.6	—	8.5
Sept. 1	—	7	7	0.35	↓	103,394	36.2	6.2	40.3	↓	67.2	—	8.5
Sept. 15	—	7	7	0.53	↓	101,998	54.1	6.2	55.4	↓	92.4	—	8.5

Appendix 2 Tenderfoot Project - Food Storage Requirements

Method 1. Food Conversion

Assumptions - a.) Heaviest food requirement is 3 months from April to June each year.

- b.) During that time, chinook gain 5 grams, new coho gain 2 grams and old coho gain 5 grams (20-25 grams). This assumes coho put on 80% of growth by winter.

- c.) Feed conversion rate of 2.0:1, OMP:FISH.

For April - June each year:

CN @ 5g gain x 167K = 835 Kg
CO1@ 2g gain x 67K = 134 Kg
CO2@ 5g gain x 50K = 200 Kg
= 1,169 Kg Fish
x2.0 Kg Feed Conversion
= 2,338 Kg Feed

Method 2. Daily Ration

Assumptions - a.) Based on average OMP requirement between begining and end of heavy period.

	Start					End				
Stock	Size	No.	Rate	Ration	Daily Food	Size	No.	Rate	Ration	Daily Food
CN	.5g	188K	5.52%	.9	4.67	5g.	167K	2.89%	.9	21.720
CO^1	.5g	67K	5.52%	.6	1.11	2g.	60K	3.93%	.6	2.830
CO^2	20g	60K	1.82%	.6	13.10	25g.	50K	1.69%	.6	12.675
					18.88					57.230
						(18.88+57.23)/2 = 28.06				

Average 28.06Kg/day
x90 days
= 2,525.4Kg

Freezer Space Required

(2338+2525.4)/2 = 2431.7Kg 22.7Kg/bag = 108 bags

108 bags 19 bags/freezer = 6 freezers.

Appendix 9. 'GROWTH MODEL' (excerpted from Kling et al, MS 1983).

GROWTH MODEL

PURPOSE GROWTH MODEL will predict mean fish weight over a period of time at any particular level of feed rate.

INPUT	Food type	Screen 1
	Mean fish weight (g)	"
	Mean monthly temperature (°C)	"
	Ration level (%)	"

OUTPUT Fish weight
Specific growth rate
Feed rate

USING THE PROGRAM

Screen #1 — Input the type of food being fed. Note that OMP is considered to have 30% moisture and dry food 0%. If you are dealing with a different amount of moisture you may alter line 55 of the program. Where the line reads "FLG = 1 / .7" change the .7 to the appropriate fraction of solid in your food. (for example, 12% moisture gives 88% solid so that .7 is replaced by .88). It is advisable to change the labels in lines 35 - 40 as well so that you do not forget your changes.

Screen #2 Input the data as prompted (for more information see program particulars).
If you ask for HARDCOPY, you are given the opportunity to enter a title for the table. If you wish to run the program again, type "Y" in response to the appropriate question. If you choose to use the same food again, the output will remain on the screen so that you may enter the weight at day 30 for progressive growth. To re-enter any value, simply press <Return>.
NOTE : if ration level is entered as more than 100%, the program will automatically reduce the level to 100% for all calculations.

PROGRAM PARTICULARS

This program is designed to predict the average fish weight (grams) over time (days). The initial weight, the average water temperature (°C) over the time period of interest (up to 30 days) and the ration level must be known. With these inputs, the program predicts the average weight at five day intervals. At the end of 30 days an option is provided for new input data and continuation of the program. Ration input must be expressed in terms of the fraction of the maximum Stauffer ration. Typical levels are shown in Table 1, which is very close, but not identical to the NEW O.M.P. maximum ration guide (Table 2)

Table 1. The maximum ration (Stauffer, 1973) expressed in terms of grams of O.M.P. per 100 grams of fish per day (or % O.M.P. per day)*

TEMP. C	.80	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	12.0	14.0	16.0	18.0	20.0
3	1.77	1.64	1.30	1.14	1.04	.96	.90	.86	.82	.79	.76	.72	.68	.65	.63	.61
4	2.55	2.36	1.88	1.64	1.49	1.38	1.30	1.24	1.18	1.14	1.10	1.03	.98	.94	.90	.87
5	3.29	3.05	2.42	2.12	1.92	1.79	1.68	1.60	1.53	1.47	1.42	1.33	1.27	1.21	1.16	1.12
6	4.00	3.71	2.95	2.57	2.34	2.17	2.04	1.94	1.86	1.78	1.72	1.62	1.54	1.47	1.42	1.37
7	4.68	4.34	3.45	3.01	2.74	2.54	2.39	2.27	2.17	2.09	2.02	1.90	1.80	1.72	1.66	1.60
8	5.33	4.95	3.93	3.43	3.12	2.89	2.72	2.59	2.47	2.38	2.30	2.16	2.05	1.96	1.89	1.82
9	5.96	5.53	4.39	3.84	3.49	3.24	3.04	2.89	2.77	2.66	2.57	2.42	2.30	2.20	2.11	2.04
10	6.56	6.09	4.84	4.23	3.84	3.56	3.35	3.19	3.05	2.93	2.83	2.66	2.53	2.42	2.33	2.25
11	7.15	6.64	5.27	4.69	4.18	3.88	3.65	3.47	3.32	3.19	3.08	2.90	2.75	2.63	2.53	2.45
12	7.71	7.16	5.68	4.96	4.51	4.19	3.94	3.74	3.58	3.44	3.32	3.13	2.97	2.84	2.73	2.64
13	8.26	7.67	6.08	5.32	4.83	4.48	4.22	4.01	3.83	3.69	3.56	3.35	3.18	3.04	2.93	2.82
14	8.79	8.16	6.47	5.66	5.14	4.77	4.49	4.26	4.08	3.92	3.79	3.56	3.38	3.24	3.11	3.01
15	9.30	8.63	6.85	5.98	5.44	5.05	4.75	4.51	4.32	4.15	4.01	3.77	3.58	3.43	3.29	3.18
16	9.79	9.09	7.22	6.30	5.73	5.32	5.00	4.75	4.55	4.37	4.22	3.97	3.77	3.61	3.47	3.35
17	10.28	9.54	7.57	6.61	6.01	5.58	5.25	4.99	4.77	4.59	4.43	4.17	3.96	3.79	3.64	3.51
18	10.74	9.97	7.92	6.92	6.28	5.83	5.49	5.21	4.99	4.80	4.63	4.36	4.14	3.96	3.81	3.67
19	11.20	10.40	8.25	7.21	6.55	6.08	5.72	5.44	5.20	5.00	4.83	4.54	4.31	4.13	3.97	3.83
20	11.64	10.81	8.58	7.49	6.81	6.32	5.95	5.65	5.40	5.20	5.02	4.72	4.48	4.29	4.12	3.98

*It is assumed that the O.M.P. has a 30% moisture content.

To get the quantity of dry food per 100 grams of fish per day multiply the values shown in the Table by 0.7.

Table 2. Maximum ration guide developed by Moore-Clark.

OREGON PELLET FEEDING CHART

Estimated quantity of food that fish will consume if held at constant water temperature and fed two (2) times per day - seven (7) days per week[1]

(Feeding rates expressed as percentages of body weight; ie. grams of OMP per 100 grams of fish per day)

Water Temperature (F)	FISH SIZE - NUMBER PER POUND							
	90 to 75	75 to 65	65 to 55	55 to 45	45 to 39	39 to 34	34 to 29	29 to 25.5
38					0.90	0.85	0.85	0.80
39					0.95	0.90	0.90	0.85
40	1.45	1.30	1.20	1.10	1.00	1.00	0.90	0.90
1	1.65	1.50	1.40	1.25	1.15	1.10	1.00	0.90
2	1.85	1.70	1.60	1.40	1.30	1.20	1.10	1.00
3	2.05	1.90	1.80	1.60	1.50	1.40	1.30	1.20
4	2.20	2.10	2.00	1.80	1.70	1.60	1.50	1.40
45	2.45	2.30	2.15	2.00	1.90	1.80	1.70	1.60
6	2.65	2.50	2.30	2.20	2.10	1.95	1.85	1.75
7	2.85	2.65	2.50	2.40	2.25	2.10	2.00	1.90
8	3.05	2.80	2.65	2.50	2.40	2.25	2.15	2.05
9	3.25	2.95	2.80	2.70	2.55	2.45	2.30	2.20
50	3.50	3.20	3.00	2.85	2.75	2.65	2.50	2.40
1	3.65	3.30	3.15	3.00	2.90	2.75	2.65	2.55
2	3.80	3.45	3.30	3.20	3.05	2.95	2.80	2.70
3	3.95	3.60	3.45	3.35	3.20	3.05	2.90	2.80
4	4.10	3.75	3.60	3.50	3.35	3.20	3.10	2.95
55	4.25	3.90	3.75	3.65	3.50	3.35	3.20	3.05
6	4.40	4.05	3.90	3.75	3.60	3.45	3.35	3.20
7	4.60	4.20	4.05	3.90	3.70	3.60	3.50	3.30
8	4.80	4.35	4.20	4.05	3.90	3.75	3.60	3.40
9	4.95	4.50	4.35	4.15	4.00	3.85	3.70	3.50
60	5.10	4.70	4.50	4.30	4.10	3.95	3.80	3.60

[1] Based on laboratory experiments with coho fingerlings held at constant water temperatures.

With the proper input data the program proceeds to calculate the following values daily (output every fifth day):

(a) the mean fish weight (grams)

(b) the specific growth rate in units of gram of growth per gram of fish per day. (Note : multiply by 100 to get % weight gain per day)

(c) the feed rate in units of grams of dry feed or OMP per 100 grams of fish per day (this is just % dry food or OMP per day; i.e. % body weight).

(d) the predicted food conversion calculated from:

$$\frac{\text{Food rate (\% food/day)}}{\text{Specific growth rate} * 100}$$

This model was developed by Gary Stauffer (1973). It has many assumptions and weak points but we believe it is the best to date. The Stauffer growth model is a more general case of the Fish and Wildlife steelhead growth model (Iwama and Tautz, 1981). Under conditions of maximum ration (ration level = 1) and constant temperature the two growth models are almost identical. Because growth is dependent on ration level, Stauffer's model should be used in place of the steelhead model when the maximum ration is not fed throughout. Both of these models have a number of limitations :

(i) they do not apply to newly ponded fish. Swim-up fry can be very inefficient feeders and we often feed over the maximum ration just to get the fish started. Of course, the model assumes that all the the food presented is ingested, so growth predictions are optimistic.

(ii) the models do not take into account seasonal variations in growth. For example, it is well known that coho growth slows down in October-November. This reduction occurs even at ground water hatcheries where the temperature is nearly constant. The reduction is probably a response to decreases in photoperiod or light intensity and is not taken into account by the model. For coho the program gives realistic predictions from May to October and from December to release.

(iii) growth models assume healthy fish and reasonable fish culture practices.

(iv) predicted values have little value during periods of intensive pond disturbance. (eg. marking, predation, etc.)

(v) the program is not sensitive to species (however the program was developed with coho, chinook and steelhead in mind).

GROWTH MODEL

GROWTH MODEL Screen #1

*** GROWTH MODEL ***

SELECT #

(1) OMP (30% MOISTURE)

(2) DRY FOOD (0 % MOISTURE) .

GROWTH MODEL Screen #2 (sample screen, dry food)

*** GROWTH MODEL ***

INITIAL WEIGHT (GM) = 5
MEAN TEMP (30 DAY AVERAGE (°C)) = 10
RATION (PERCENT OF MAXIMUM) = 80

DAY	WEIGHT	SPEC. GROWTH RATE	FEED RATE (% DRY / DAY)	FOOD CONVERS'N RATE
0	5	.0166	1.9959	1.202
5	5.427	.0162	1.9521	1.199
10	5.878	.0158	1.8911	1.197
15	6.353	.0154	1.8428	1.197
20	6.853	.015	1.7969	1.198
25	7.378	.0146	1.7532	1.201
30	7.929	.0143	1.7116	1.197

HARDCOPY <Y/N>
TITLE =

Appendix 10. 'LOAD RATE' and 'BIO-LOAD' models (excerpted from Kling et al, MS 1983).

LOAD RATE

PURPOSE This program wll calculate the metabolic oxygen uptake rate of the fish in a pond, and the recommended loading rates ("maximum" and "safe").

INPUT

	Oxygen concentration in outflow (ppm)	Screen 1
	Food rate (percent of maximum)	"
	Weight (individual) (grams)	"
	Temperature (°C)	"
	Barometric pressure (mmHg) (default = 760 mmHg)	"
	Salinity (ppt)	"
	Inflow dissolved O2 concentration (% of saturation)	"

OUTPUT

- Load rate (Kg/liter/minute)
- Safe load rate (Kg/liter/minute)
- Metabolic rate of oxygen uptake (RO) (mg O2/kg/hour)
- Inflow dissolved oxygen (mg/L)
- Daily ration (% dry / day)

USING THE PROGRAM

Screen #1 Enter data as prompted.
Food rate is the percent of the maximum recommended food level which is being fed. If food rate is greater than 100%, it will automatically be reduced to 100% for the calculations.
Farometric pressure defaults to 760 mmHg. If this value is suitable, press <Return>. If not, enter the appropriate value over the 760.

If you ask for another run, <Return> will re-enter any value.

NOTE : the model is only valid between 3°C and 16°C because of inbuilt limitations. However this is the best presently available.

LOAD RATE

LOAD RATE Screen #1

```
        ***    LOAD RATE CALCULATION    ***
               W.  MCLEAN , AUG.  31/81

    ENTER :

        O2 PPM IN OUTFLOW              =
        PERCENT OF MAXIMUM RATION      =
        WEIGHT (GMS) (INDIVIDUAL)      =
        TEMPERATURE (°C)               =
        BAROMETRIC PRESSURE (MMHG)     = 760
        SALINITY  (PPT)                =
        INFLOW DO
          (PERCENT OF SATURATION)      =

             LOAD RATE (KG/LPM) =
        SAFE LOAD RATE (KG/LPM) =
                    RO(MG/KG HR)=
                 INFLOW DO(MG/L)=
          DAILY RATION (%DRY/DAY)=

    HARDCOPY <Y/N>
    ANOTHER RUN <Y/N>
```

BIO-LOAD

PURPOSE This program uses the same premises as LOAD RATE in essence, but is a simplified version. It calculates maximum safe loading rates in kg/lpm and kg/cu.m.

INPUT Water temperature (°C)
Species
and if chosen :
- Inflow dissolved oxygen (%)
- Dissolved oxygen outflow (mg/L) (Davis' B level)
- Weight (individual) (grams)
- Food rate (% OMP of body weight/day)
- Metabolic correction factor

Pond type

OUTPUT Biomass
Maximum safe loading rate in kg/lpm and kg/cu.m
Loading requirements in lpm and cu.m

USING THE PROGRAM

Screen #1 Input data as prompted. When you select the species, the program makes automatic assumptions regarding the weight of the fish and the rate at which they are fed, which can be changed to suit your situation

BIO-LOAD Screen #1 (sample screen)

```
              <<<<<BIO-LOAD PROGRAM>>>>>

     WATER TEMPERATURE (°C) = 10
     NUMBER OF FISH REARED  = 10000
     SPECIES RAISED IS      = 1 CHINOOK
          (SELECT NUMBER)
            1 CHINOOK
            2 COHO
            3 CHUM

     ASSUMED VALUES :
     1.  % INFLOW DO          = 95
     2.  MG/ML DO OUTFLOW     = 6.44
          (DAVIS' 'B' LEVEL)
     3.  GRAMS PER FISH       = 5
     4.  % OMP FEEDING RATE   = 90
     5.  METABOLIC CORRECTION = 1.35

     CHANGE ANY <Y/N> Y
     SELECT NUMBER

     BIOMASS (KGS) = 50

     POND TYPE USED IS :  1 MIXED FLOW
       1 BURROWS OR CIRCULAR POND
       2 CHANNEL, RACEWAY OR TROUGH

     MAXIMUM SAFE LOADING RATES ARE:

         FLOW LOADING (KG/LPM) = .646
         VOLUME LOAD (KG/CU.M) =12.229

     LOADING REQUIREMENTS ARE:

         FLOW (LPM)     = 77.399
         VOLUME (CU.M) = 4.089

     HARDCOPY <Y/N>
     ANOTHER RUN <Y/N>
```

Appendix 11. Sample production forecasts using VISICALC program (for Kitimat facility):

A. (Table 1) Hatchery returns
B. (Table 2) Natural spawning (augmentation of natural spawning stocks by surplus hatchery-origin fish)

TABLE 1. PRODUCTION FORECAST FOR KITIMAT CHINOOK PRODUCTION FROM HATCHERY.

ASSUMPTIONS	FRACTION STOCK AT		FRACTION FEMALE AT		FECUNDITY AT					
	:2 YEARS:		:2 YEARS:	.5	:2 YEARS:	8000	EGG TO ADULT SURV:	.0216	NATURAL ESCAPEMENT:	1500
	:3 YEARS:	.2	:3 YEARS:	.5	:3 YEARS:	8000	AVERAGE FR FEMALE:	0.50	HATCHERY CATCH RATES	
	:4 YEARS:	.4	:4 YEARS:	.5	:4 YEARS:	8000	AVERAGE FECUNDITY:	8000	HATCHERY:	.3
START YR: 1981	:5 YEARS:	.35	:5 YEARS:	.5	:5 YEARS:	8000	MAX EGGS HATCHERY:	3000	WILD:	.1
	:6 YEARS:	.05	:6 YEARS:	.5	:6 YEARS:	8000	CAN HANDLE (1000'S)		COMMERCIAL CATCH RATE:	.9

BROOD YEAR	EGGS (1000'S) AVAILABLE	USED	BROOD YR PRODUC.	ADULT PRODUCTION 1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1981	600	100	2160	0	432	864	756	108													
1982	600	250	5400		0	1080	2160	1890	270												
1983	600	350	7560			0	1512	3024	2646	378											
1984	651.84	500	10800				0	2160	4320	3780	540										
1985	833.28	1000	21600					0	4320	8640	7560	1080									
1986	1131.36	1000	21600						0	4320	8640	7560	1080								
1987	1461.84	2000	43200							0	8640	17280	15120	2160							
1988	1986.72	2000	43200								0	8640	17280	15120	2160						
1989	2654.16	2654.16	57330									0	11466	22932	20065	2866					
1990	3645.6	3000	64800										0	12960	25920	22680	3240				
1991	4747.2	3000	64800											0	12960	25920	22680	3240			
1992	5993.517	3000	64800												0	12960	25920	22680	3240		
1993	6980.633	3000	64800													0	12960	25920	22680	3240	
1994	7932.654	3000	64800														0	12960	25920	22680	3240
1995	8331.179	3000	64800															0	12960	25920	22680
1996	8376	3000	64800																0	12960	25920
1997	8376	3000	64800																	0	12960
1998	8376	3000	64800																		0
1999	8376	3000	64800																		
2000	8376	3000	64800																		
TOTAL PRODUCTION:				0	432	1944	4428	7182	11556	17118	25380	34560	44946	53172	61105	64426	64800	64800	64800	64800	64800
COMMERCIAL CATCH:				0	389	1750	3985	6464	10400	15406	22842	31104	40451	47855	54995	57984	58320	58320	58320	58320	58320
ESCAPEMENT:				0	43	194	443	718	1156	1712	2538	3456	4495	5317	6111	6443	6480	6480	6480	6480	6480
STOCK REQUIRED:				70	100	200	200	400	400	531	600	600	600	600	600	600	600	600	600	600	600
SURPLUS:				-70	-57	-6	243	318	756	1181	1938	2856	3895	4717	5511	5843	5880	5880	5880	5880	5880

TABLE 2. PRODUCTION FORECAST FOR KITIMAT CHINOOK PRODUCTION FROM SURPLUS

ASSUMPTIONS	FRACTION STOCK AT		FRACTION FEMALE AT		FECUNDITY AT					
	:2 YEARS:		:2 YEARS:	.5	:2 YEARS:	8000	EGG TO ADULT SURV:	.003	NATURAL ESCAPEMENT:	0
	:3 YEARS:	.2	:3 YEARS:	.5	:3 YEARS:	8000	AVERAGE FR FEMALE:	0.50	HATCHERY CATCH RATES	
	:4 YEARS:	.4	:4 YEARS:	.5	:4 YEARS:	8000	AVERAGE FECUNDITY:	8000	HATCHERY:	1
START YR: 1984	:5 YEARS:	.35	:5 YEARS:	.5	:5 YEARS:	8000	MAX EGGS HATCHERY:	50000	WILD:	0
	:6 YEARS:	.05	:6 YEARS:	.5	:6 YEARS:	8000	CAN HANDLE (1000'S)		COMMERCIAL CATCH RATE:	.9

BROOD YEAR	SURPLUS STOCK	EGGS (1000'S)	BROOD YR PRODUC.	ADULT PRODUCTION 1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
1984	0	0	0	0	0	0	0	0													
1985	0	0	0		0	0	0	0	0												
1986	243	972	2916			0	583	1166	1021	146											
1987	318	1272	3816				0	763	1526	1336	191										
1988	756	3024	9072					0	1814	3629	3175	454									
1989	1181	4724	14172						0	2834	5669	4960	709								
1990	1938	7752	23256							0	4651	9302	9140	1163							
1991	2856	11424	34272								0	6854	13709	11995	1714						
1992	3895	15580	46740									0	9348	18696	16359	2337					
1993	4717	18868	56604										0	11321	22642	19811	2830				
1994	5511	22044	66132											0	13226	26453	23146	3307			
1995	5843	23372	70116												0	14023	28046	24541	3504		
1996	5880	23520	70560													0	14112	28046	24696	3528	
1997	5880	23520	70560														0	14112	28224	24696	3528
1998	5880	23520	70560															0	14112	28224	24696
1999	5880	23520	70560																0	14112	28224
2000	5880	23520	70560																	0	14112
2001	5880	23520	70560																		0
2002	5880	23520	70560																		
2003	5880	23520	70560																		
TOTAL PRODUCTION:				0	0	0	583	1930	4361	7945	13686	21571	31905	43175	53941	62624	68135	70004	70538	70560	70560
COMMERCIAL CATCH:				0	0	0	525	1737	3925	7150	12317	19414	28715	38857	48547	56362	61321	63005	63484	63504	63504
ESCAPEMENT:				0	0	0	58	193	436	794	1369	2157	3191	4317	5394	6262	6813	7001	7054	7056	7056