A REVIEW OF THE BIOLOGICAL DESIGN CRITERIA

FOR THE

EAGLE RIVER SALMONID ENHANCEMENT FACILITY

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INTRODUCTION

PURPOSE OF REPORT

The New Projects Unit of the Enhancement Operations Division of the Salmonid Enhancement Program (SEP) is responsible for providing biological input to the design of salmonid enhancement projects in British Columbia and the Yukon. This responsibility includes site reconnaissance, selection of enhancement and operational strategies, conceptual design, and review of detailed design and construction. For each project, selected staff from the appropriate Geographic Operations Unit are also involved in the development through the coordinating efforts of the New Projects Unit. The geographical Operations Unit (South Coast, North Coast or Fraser River) takes over responsibility for operation of a facility upon its completion.

The purpose of this report is to consolidate and update the biological data and design criteria for the Eagle River Salmonid Enhancement Facility, and relate these to production capabilities of the as-built facility. This review was prepared after two years of operation were complete, such that the projected performance from design memos could be compared to actual performance. The review is meant to inform interested parties as to why the facility was planned and built the way it was, and how it was expected to operate. Future changes in priorities, methods, resources and enhancement strategies no doubt will result in operational strategy changes and adaptation of the structures now provided to serve new needs. Knowledge of the original plans should facilitate such modifications.

PROJECT HISTORY

The Eagle River Salmonid Enhancement Facility is located near the Canadian Pacific Railway siding at Taft, approximately 32 km east of Sicamous, B.C. on the Trans Canada Highway (Figure 1). Land for the facility was acquired in 1981 by obtaining a Special Use permit from the B.C. Forest Service and by purchase of private property.

General reconnaissance was carried out throughout the Thompson River system from 1978-1981 to identify potential hatchery sites (Ginetz and Neilson, 1981). Four facilities have recently been built to serve the stocks of the main Thompson tributaries: Clearwater (at Clearwater) for North Thompson stocks, Eagle (at Taft) for Eagle and Salmon stocks, Shuswap (at Shuswap Falls) for Shuswap stocks and Spius (at Canford) for Nicola stocks. These facilities have been

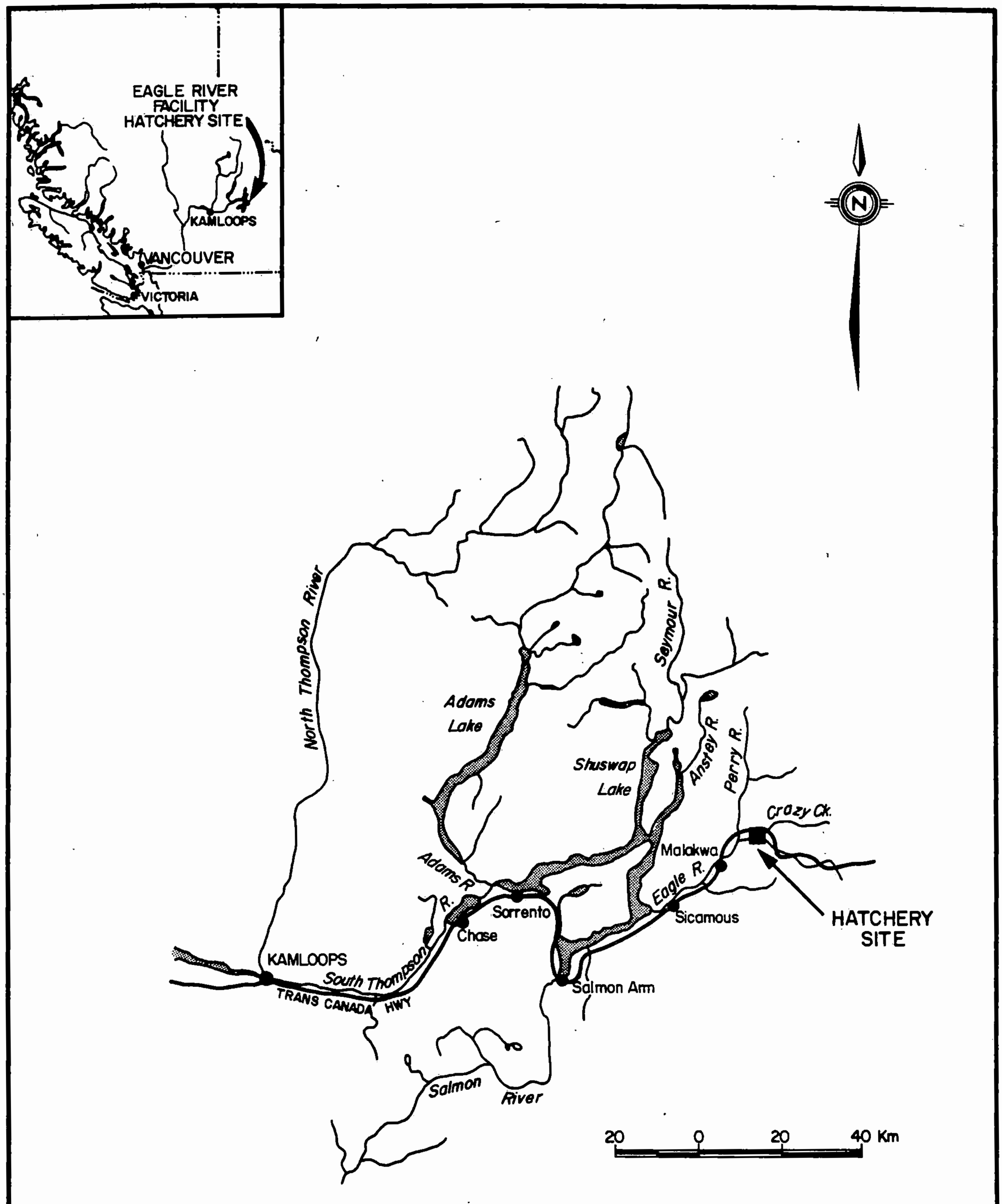

Figure 1 Location Map for the Eagle River Facility

collectively known as the Central Interior Pilots. A provincial hatchery at Loon Creek already serves Bonaparte stocks.

The Eagle River site was attractive due to:

a. Potential for a high head, gravity feed surface water supply from Crazy Creek, which used to serve as the water source for a community at Taft (up to 1,500 people). A small hatchery was operated at Taft during the 1920s and 1930's, first as a satellite sockeye rearing station by the federal Cultus Lake research station and then as a trout hatchery by the Revelstoke Rod and Gun Club, with permission from the B.C. Game Commission.

b. The nearby existence of an aquifer with warm (5°-9°C) water in winter, which has been used for the supply of a trout farm about 2 km away since 1960. Groundwater exploration at the Taft siding site proved-out a high-yield aquifer with very good water quality.

c. The majority of the land suitable for a hatchery site was owned by the Crown, making it inexpensive for DFO to acquire.

d. The site is situated well upstream in the Eagle River system, reducing the likelihood that outplanted stocks would return to the hatchery rather than to their natal streams.

The facility as presently constructed on the site has been a product of the amount and kind of funding available. A special employment initiative (the so-called "Senator's Package") was created in 1982 to provide local economic stimulus and to aid in halting the serious decline in Interior chinook stocks. Six projects were funded that involved the Enhancement Operations Division, the Spius, Eagle, Shuswap, Clearwater and Stuart pilot facilities and the 1982 Adams public display. The pilot facilities were sized to handle a few hundred thousand eggs to provide tag groups of fry to test various release strategies.

A major constraint of these small facilities was that the results of experimental releases carried out would have to be pooled to gain insight into the effect of different strategies, introducing the possibility of site-specific effects confounding the analysis.

A second constraint of the Senator's Package was that local labour and materials were to be used as much as possible. This resulted, for instance, in wooden-frame buildings rather than metal-framed or concrete block. Although less durable, this made them much less expensive to construct than previous hatchery buildings.

A third constraint of the Senator's Package was that the construction of each facility had to be completed to an operable status with quite limited funds. The facilities built were minimum, and the production from each was not of substantial economic benefit. The approach taken was to construct the pilots so as to facilitate expansion when more funds became available.

Funding for expansion came from the SEP Transition Plan in 1983, which aimed to address the problem of declining stocks of Fraser River chinook and coho. Unlike SEP Phase I projects like the Quesnel facility, which had to pass Treasury Board (TB) scrutiny in terms of benefit/cost analysis, these Transition projects did not, since the expansions were less than the $1M TB limit. This left the expanded pilots uncommitted to specific fish production or benefit/cost targets.

This development was used by the biological group as an opportunity to do the research needed to define enhancement techniques that would be appropriate for Interior hatcheries. Expansion of the Eagle as well as three other Central Interior pilots was meant to result in each operation being better able to deliver a more-rounded experimental program that minimized the possibility of site-specific factors confounding results. They were also designed to enable the testing of several strategies each year to guard against a complete adult return failure that could be associated with a single strategy. In this vein, the objectives of facilities on the Thompson River tributaries moved from 'pilot' to 'experimental' status, being too big to be considered 'pilots'; but without the specific adult return goals of 'production' facilities.

The credibility of the SEP Interior hatchery program is linked to proper assessment of these techniques before they are expanded to full production.

Facility design commenced in 1980 with exploratory drilling, groundwater testing and production well development. The site was cleared and filled and the pilot hatchery construction began in 1982. The hatchery staff first took eggs in 1983. Construction of the Pilot hatchery was completed in 1983. Expansion of the Pilot was undertaken in 1984, resulting in the facility described in this report (Figure 2). One concern that persists at the Eagle facility is the effect of hatchery effluent on the low flows of the Eagle River, which are

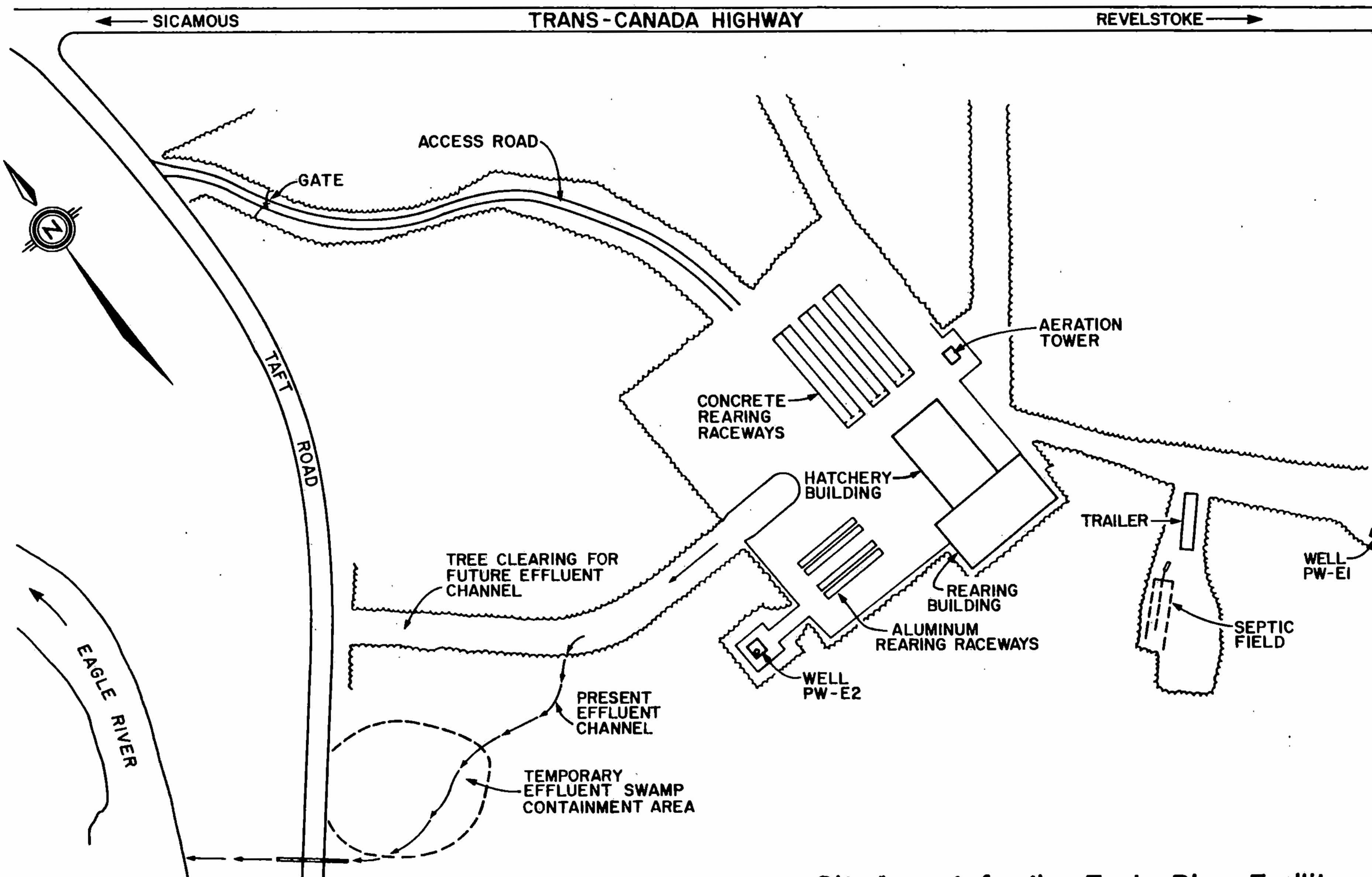

Figure 2 Site Layout for the Eagle River Facility

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already nutrient enriched naturally and from agricultural and urban development. As the facility will presumably be expected to meet Provincial Pollution Control Branch effluent standards, future provision for land disposal of cleaning wastes has been considered in the design.

PRODUCTION OBJECTIVES

General

The Eagle facility currently services Eagle River and Salmon River chinook and coho stocks. Although they have been targetted for enhancement, the Adams, South Thompson, South Pass and Seymour river stocks are not currently included in the operation. The future use of Adams stock may be argued against by the International Pacific Salmon Fisheries Commission. If preferred, South Thompson mainstem chinook stocks could be substituted for Adams. In 1984-85 the Eagle facility also serviced stocks from the Shuswap River, as back-up in the event of failure at the Shuswap facility.

Project Stages

There were a number of stages in the development of the Eagle River facility:

- Ultimate based on the original GWG target - the maximum stock handling requirement based on translation of the original recommendations for area streams to be serviced into facility requirements (Appendix 1a).
- Pilot as designed - the original Pilot plan based on 250K eggs from each of the Eagle and Salmon River chinook and coho stocks (Appendix 1b).
- Pilot as built - the capacity constructed to provide fish culture capability for the above Pilot targets.
- Pilot as operated - the actual fish culture operations for the first two years, prior to expansion.
- Experimental as proposed - the requirements of the expanded Experimental design proposed to test a number of enhancement strategies (Appendix 1c).
- Experimental as designed - the capacity of the 'downsized' requests for structures to meet the Experimental requirements (Appendices 1d and 1e).
- Experimental as built - the capacity of the structures actually provided to date
- Ultimate per site capacity - the limitations of the site in terms of water and space available.

This report compares these different concepts for the Eagle Facility, focusing on the present situation of carrying on the Experimental program with the structures provided to date. The words Pilot, Experimental and Ultimate are capitalized throughout this report when referring to those specific stages of the project development.

General Targets

The Fraser River Geographic Working Group (GWG) recommended enhancement targets for the main Fraser River stocks of salmon and anadromous trout (Appendix 2). These recommendations formed the basis for sizing most of the major Fraser River enhancement projects (e.g. Inch, Chehalis, Chilliwack, Quesnel). In 1982 the GWG reduced the targets for mainstem and all coho stocks to one half of the original recommendations. Since the original design was based on the full-sized targets, they are used in this report. It should be pointed out that these targets are no longer considered valid by the management biologists.

~~The adult production targets of the Central Interior Pilots are much lower than the GWG recommendations. As Experimental facilities, their present purpose is not to produce adults so much as to investigate the most effective means of accomplishing Interior enhancement.~~

The actual structures provided during construction are based on the biological criteria set out in the design memos (Appendix 1) but do not necessarily reflect the structures requested. Engineering constraints, particularly the costs and convenience of construction, dictated that more or less than the requested structures be provided during a particular phase of project development. Nor was it felt necessary that the structures provided exactly match those requested, as the Experimental targets were quite flexible. For the Eagle River project, the containers provided have normally been more than those requested (Table 1) whereas the water flow available has been insufficient.

The original, Ultimate GWG target design memo (Appendix 1a) dealt with a large number of options for various stocks and strategies. These included a large and small facility approach, as well as inclusion of a number of extra stocks in a large facility. Strategies included the rearing of coho to 2 g, 5 g and 25 g release. Some of the systems suggested in that design memo are now serviced by other facilities, and only stocks from the Eagle and Salmon have been dealt with in the production to date. Updated data for fecundity, event timing etc. are not currently available for South Thompson or Adams stock. Furthermore, the

Table 1. Summary of the Egg and Container Capacities at the Eagle River Facility

	Eggs (#K)	Incubator Stacks (#)	Capilano Troughs (#)	Rearing Space (m^3)	Maximum Flow (LPM)
Pilot					
- As Planned	1000	20	8	116	3800
- As Built					
1983-84	849	20	12	200	2760
1984-85	2362	72	28	730	9360
Experimental					
- Requested	2475	55	48	540	12600[a]
- As Built	2880CN or 4896CO	72	56	752	9360
Ultimate					
- Site Limited	5000	144	66	1292[b]	33500[c]
- GWG Target	7870	194	176	2162	34599

Notes - Capilano trough figures represent actual troughs or their equivalent in large starter units and aluminum raceways.

[a] Extreme case maximum (all containers in use)

[b] Includes site potential maximum for six more concrete raceways

[c] Includes another 5000 LPM well and 18000 LPM gravity feed surface water from Crazy Creek

original design memo only made detailed requests based on the service of Eagle and Salmon stocks. Only rough comparisons for sizing with the inclusion of the other systems were made.

Experimental Plan

During formulation of the current Eagle objectives, it was stressed that targetting should remain flexible, emphasizing that there are a multitude of equally workable strategies possible.

The Pilot stage provided enough incubation and rearing capacity for a few lots of tag groups of coho and chinook, subdivided to test gross release strategies. The size of each lot was based on an estimate of the number of validly tagged fish released in order to obtain enough returning adults to obtain statistically significant survival values (see attachment to Appendix 1b). The minimum tag lot required was considered to be equivalent to about 100K eggs, which could remain separable through to release.

The Experimental stage was designed to address specific questions regarding the applicability of various enhancement strategies to Central Interior project conditions. The main purpose was to determine what release methods would maximize survival-to-adult and utilization of natural rearing habitat, while minimizing adult straying. A modular approach was taken to the individual Experimental program design for each facility. This approach allowed for differences in optimal enhancement strategy between the different geographical areas. The modules were set up to include the following variations in releases for each species:

- Size of fish; from 2-5 g in spring to 5-10 g in fall to 10-20 g in the second spring. This would test survival and imprinting, with evaluation by assessment of coded wire tag (CWT) adult returns.

- Time of release; gross timing as above and fine tuned using separate releases up to four weeks on either side of the peak natural downstream migration. This would test survival, again evaluated by CWT in adult returns.

- Location of release; upstream versus downstream of the facility and single point versus scattered locations. This would test imprinting, habitat utilization and survival, by studying rearing distributions using marked fish.

- Method of release; varying holding/rearing periods in the outplant streams from none to up to one month. This would mainly test imprinting, with evaluation by CWT returns of adults.

- Density of outplants; varying the number of fish released into various habitat types. This would help determine the rearing capacity of apparently underutilized streams, with evaluation by pre- and post-release rearing studies.

The size of each lot was again based on an estimate of the number of validly tagged fish required in order to obtain enough returning adults to be able to detect statistically significant differences in survival between different strategies. The preferred tag release lot was considered equivalent to about 100K eggs, although smaller lots could be used (as low as 25K tags), depending on the expected survival rates. See Appendix 1c for detailed lot size requirements for each Experimental module.

Chinook Objectives

Chinook objectives and actual production for the Eagle River facility through its various stages of development are listed in Table 2.

Chinook stocks originally planned for enhancement included the Eagle, Salmon, South Thompson, Adams and Seymour Rivers. Shuswap stocks were also included in the Eagle plans, but will now be serviced by the Shuswap facility. The Pilot operation was to service only Eagle and Salmon chinook but some Shuswap chinook were handled in 1984-85.

The Experimental Plan called for service of Adams and Seymour stocks in addition to Eagle and Salmon. To date, these have not been included in the operation and are not planned for the 1985 egg take, which will be conducted on the Eagle and Salmon only. Due to low escapements the collection of brood stock from the Seymour River may be difficult in the future.

Chinook survivals generally exceeded the SEP bio-standards (Appendix 3) for incubation (94.6-97.7% versus 90%) and initial rearing (85.1-99.5% versus 90%) during the two years of Pilot operation. In the late winter and spring of 1985, however, heavy mortality was experienced in ponded chinook from both Eagle and Salmon broods (approximately 30% by May 1). The cause has not been determined, although it may be related to water quality of well PW-E2. The water

Table 2 Chinook Production for the Eagle River Facility

Species/ Stock	Eggs (#K)	Swimup Fry (#K)	Fingerlings (2g) (#K)	Smolts (5-10g) (#K)	Adult Return (#)
PILOT					
Planned Stocks[a]					
Eagle	250	225	202.5	180	4050
Salmon	250	225	202.5	180	4050
Total	500	450	405	360	8100
1983-84 Brood[b]					
Eagle	127	121	103		2057[c]
1984-85 Brood[b]					
Eagle	566	553	550		9007[c]
Salmon	396	375	370		6075[c]
Total	962	928	920		15082
EXPERIMENTAL PROPOSED[a]					
Year One					
Eagle	500	450	405	360	8100
Salmon	300	270	243	216	4860
Adams	500	450	405	360	8100
Seymour	50	45	41	36	810
Total	1350	1215	10945	972	21870
Year Two					
Eagle	600	540	486	432	9720
Salmon	300	270	243	216	
Adams	300	270	243	216	
Seymour	50	45	41	36	810
Total	1250	1125	1013	900	10530
GWG TARGET[a]					
Eagle	432	389	350	311	7000
Salmon	309	278	250	222	5000
South Thompson	4938	4444	4060	3555	80000
Adams	1481	1333	1200	1666	24000
Total	7160	6444	5860	5754	116000

[a] Survival rates based on SEP Biostandard - egg to swim-up, 90%; swim-up to fingerlings, 90%; swim-up to fingerlings, 90%; swim-up to smolt, 80%; egg to adult, 1.62% for spring release.

[b] Actual inventories during Pilot operation.

[c] Projected returns from actual egg numbers based on biostandard survival of 1.62% egg to adult.

distribution systems from the aeration tower for the individual wells have now been separated. This will allow isolation and comparative testing of the effect on the fish of the individual supplies.

Coho Objectives

Coho stocks suggested for the Eagle facility have included Eagle, Salmon, Adams, South Pass, Seymour, Wap Creek and Bessette Creek, but only Eagle and Salmon coho have been included in the operation to date.

The Experimental plan mentioned South Pass, Adams and Seymour coho. Due to low escapements, South Pass collections may be limited by broodstock availability, although a fence could be built in that system.

Coho survivals have exceeded bio-standards for incubation (92.9-97.4% versus 90%) and initial rearing (92.0-98.1% versus 90%) during the first two years of the operation (from data in Table 3).

There appears to be enough container space and flow at the as-built facility to meet the requirements of the Experimental Plan objectives for both chinook and coho in any given year.

FACILITY DESCRIPTION

ADULT HOLDING

Capture and Holding Facilities

The design memos proposed that adult holding be carried out in the rearing containers. Enough space was to be available on-site to hold all the adults, although it was assumed that some satellited stocks would not be held, due to off-site egg-takes.

In 1984, adult salmon were held in the four aluminum raceways used for rearing coho. For details on these containers, refer to their descriptions in the subsequent sections on rearing.

Table 3. Coho Production for the Eagle River Facility

Species/ Stock	Eggs (#K)	Swimup Fry (#K)	Fingerling (2g) (#K)	Smolts (15-20g) (#K)	Adult Return (#)
PILOT					
Planned Stocks[a]					
Eagle	250	225	202.5	169	5400
Salmon	250	225	202.5	169	5400
Total	500	450	405	338	10800
1983-84 Brood[b]					
Eagle	511	487	448		6234[c]
Salmon	211	196	190		2574[c]
Total	722	683	638		8808
1984-85 Brood[b]					
Eagle	873	850	834		10650[c]
Salmon	558	535	515		6808[c]
Total	1431	1385	1349		17458
EXPERIMENTAL PROPOSED[a]					
Year One					
Eagle	400	360	324	270	4880
South Pass	25	23	20	17	305
Salmon	300	270	243	203	3660
Adams	375	338	304	253	4575
Seymour	25	23	20	17	305
Total	1125	1014	911	760	13725
Year Two					
Eagle	300	270	243	203	3660
South Pass	50	45	41	34	610
Salmon	400	360	324	270	4880
Adams	375	338	304	253	4575
Seymour	25	23	20	17	305
Total	1150	1036	932	777	14030
GWG TARGET[a]					
Eagle	326	293	264	220	33000
Salmon	227	204	184	153	23000
Adams	49	44	40	33	5000
Wap Creek	39	36	32	27	4000
Bessette Creek	69	62	56	47	7000
Total	710	639	576	480	72000

[a] Survival rates based on SEP Biostandard - egg to swim-up, 90%; swim-up to fingerlings, 90%; swim-up to fingerlings, 90%; swim-up to smolt, 75%; egg to adult, 2.16% for fall release; 1.22% for spring release; 10.13% for 1 year rearing.

[b] Actual inventories during Pilot operation.

[c] Projected returns from actual eggs taken, based on SEP Biostandard survival of 1.22% egg to adult.

The aluminum raceways were covered with plywood in 1983-84 and stretched tarpaulins in 1985 to reduce stress during holding. Adult fish were easily dipnetted out when needed.

The 1983 broodstocks were held in Capilano troughs to start but were shifted to the aluminum raceways after two weeks because the fish were overly active and battered themselves in the troughs during their maturation. The aluminum raceways worked very well for adult holding.

The standard SEP criteria for holding all salmonid adults are 32 kg per m^3 of water and 1.2 kg per LPM of flow (Shepherd, 1983).

To calculate adult holding requirements, the target number of eggs is divided by the fecundity of each species, yielding the number of females required, which when adjusted by the required sex ratio, gives the total donor broodstock requirement.

Fecundities from the Eagle and Salmon broodstocks collected to date (Table 4) indicate that both stocks of chinook are less fecund than the coastwide bio-criteria used in the design memos for requirement calculations. Although no weights are available, presumably both Eagle and Salmon stocks are also smaller than the bio-standards, as they are less fecund. The coastwide average of 5 kg per fish has been used in the calculations.

Table 4. Fecundities Calculated from Egg-Takes of 1983 and 1984 Brood Stock at the Eagle River Hatchery

Species	Stock	1983	1984	Mean
Chinook	Eagle	4777	4872	4825
	Salmon	-	4302	4302
Coho	Eagle	2375	2618	2500
	Salmon	1823	2028	1925

Note: SEP biocriteria coastwide average fecundities are 5000 for CN, 2500 for CO.

Bio reconnaissance studies conducted in these systems (Whelen et al, 1983; Whelen and Olmsted, 1982) provided only estimates of fecundity based on mean post-orbital hypural length measurements. These rough estimates were all higher than the actual fecundity recorded during the egg-take operations.

Coho from the Eagle River appear to match the bio-standard fecundity exactly (2500) while those from the Salmon River appear to be smaller and less fecund (approximately 2000 eggs/female). More females would be required to meet egg targets but, since the fish are smaller than the average coho (no weight data are available), the volume and flow requirements would be similar to those calculated in Table 5.

Until recently, the practice at SEP facilities has been to use about 3 males to 5 females in pooled lots (sex ratio 0.6M:1.0F) during egg-takes. This ratio was used for sizing adult holding in the earlier design memos. Geneticists have recommended using the same number of males as females to help a maintain larger gene pool for hatchery stocks. The natural sex ratio on spawning grounds can often be 2-3 males per female during the spawning act.

At Eagle in 1984, eggs from a single female were mixed with sperm from one male, then sperm from a second male was introduced to ensure fertilization.

Chinook and coho brood stock from both the Eagle and Salmon Rivers are captured using semi-permanent fences erected on both systems during the spawning period.

The fence on the Eagle River is located approximately 1 km downstream of the hatchery on private land. It utilizes an old sill constructed in the river for a kokanee collection fence by the BC Fish and Wildlife Branch in the 1960s.

The fence on the Salmon River, constructed in 1984, is located on private property approximately 12 km upstream of Salmon Arm below the Silver Creek confluence.

Both fences have permanent wooden sills left in the river year round. During the migration, hinged aluminum fence panels are erected and adults directed to converging throat traps. Live boxes are sunk below the river bed to create a quiet-water holding area.

Fences allow fish to be taken over the entire run, which enables collection of sufficient broodstock even though escapements are low. The total number of both species are counted by sex at both fences. Operation of the fences for counting is continued after the egg-take commitments have been met.

The fish are transported approximately 80 km from the Salmon River adult collection site to the hatchery in a 1400 L fibreglass tank on a 1 ton flatbed truck. Even with temperature changes ranging from up to 24°C from the Salmon River to 7.5°C at the hatchery, no transport problems have occurred.

Chinook

Adult chinook generally have been held at the hatchery for 2-6 weeks prior to egg-take.

Three Eagle River chinook were lost during holding in 1983 and three Salmon River chinook were lost in 1984, equating to low prespawn mortalities of 5.6% and 1.6%, respectively.

The design memos (Appendix 1) used an assumed fecundity of 5500 and a sex ratio of 0.6:1.0 males:females to calculate the number of chinook broodstock required. The egg take record (Table 4) indicates a fecundity of about 4300 eggs per females for the Salmon chinook and 4800 for the Eagle stocks. Sex ratio has been increased to 1M:1F for these calculations used in this report.

Table 5 lists the adult chinook holding requirements for the Eagle River facility based on the various design memos and the actual 1983-85 brood statistics.

In Table 5, the assumed fecundity of 5500 has been applied to Adams and South Thompson stocks and the actual mean fecundities for 1983/84 to the Eagle and Salmon stocks.

Although it is assumed that only Eagle and Salmon chinook would be held at the hatchery and the others would be held in their respective rivers, Table 5 indicates that there is adequate space to accommodate all stocks identified in any of the design memos.

Coho

Adult coho holding requirements for the Eagle River facility are listed in Table 6 for the various stages of the hatchery design and for the 1983-84 actual brood stocks.

Coho are collected at the fences and held at the hatchery in an identical manner as are chinook.

Table 5. Adult Chinook Holding at the Eagle River Facility

Species/ Stock	Eggs (#K)	Female Donors (#)	Total Donors (#)	Volume Required (m^3)	Flow Required (LPM)
PILOT					
Planned Stocks					
Eagle	250	52	104	16	433
Salmon	250	58	116	15	417
Total	500	110	220	34	850
1983-84 Brood					
Eagle	127	32	53	8	220
1984-85 Brood					
Eagle	556	115	182	28	758
Salmon	375	107	181	28	754
Total	931	222	363	56	1512
EXPERIMENTAL PROPOSED					
Year One					
Eagle	500	104	208	33	887
Salmon	300	70	140	22	583
Adams	500	91	182	28	758
Seymour	50	9	18	3	75
Total	1350	274	548	86	2303
Year two					
Eagle	600	125	250	39	1041
Salmon	300	70	140	22	583
Adams	300	55	110	17	458
Seymour	50	9	18	3	75
Total	1250	259	518	81	2175
GWG TARGET					
Eagle	432	70	180	28	750
Salmon	309	72	144	23	600
South Thompson	4938	898	1796	281	7883
Adams	1481	270	540	84	2250
Total	7160	1330	2660	416	11083
Present Adult Holding Capacity					
- Concrete raceways (6)				540	6600
- Aluminum raceways (4)				120	3000
Total				660	9600

Table 6. Adult Coho Holding at the Eagle River Facility

Species/ Stock	Eggs (#K)	Female Donors (#)	Total Donors (#)	Volume Required (m^3)	Flow Required (LPM)
PILOT					
Planned Stocks					
Eagle	250	100	200	19	500
Salmon	250	130	260	24	650
Total	500	230	460	43	1150
1983-84 Brood					
Eagle	511	188	325	30	813
Salmon	211	117	178	17	445
Total	722	305	503	47	1258
1984-85 Brood					
Eagle	873	352	521	49	1303
Salmon	558	277	381	36	952
Total	1431	629	902	85	2255
EXPERIMENTAL PLAN					
Year One					
Eagle	400	160	320	30	800
Salmon	300	156	312	29	780
Adams	375	150	300	28	750
Seymour	25	10	20	2	50
South Pass	25	10	20	2	50
Total	1125	486	972	91	2430
Year Two					
Eagle	300	120	240	23	600
Salmon	400	208	416	39	1040
dams	375	150	300	28	750
Seymour	25	10	20	2	50
South Pass	50	20	40	4	100
Total	1150	508	1016	96	2540
GWG TARGET (1 year option)					
Eagle	326	130	260	24	650
Salmon	227	118	236	22	590
Adams	49	20	40	4	100
Wap Creek	39	16	32	3	80
Bessette Creek	69	28	56	5	140
Total	710	312	624	58	1560
Present Adult Holding Capacity					
- concrete raceways (6)				540	6600
- aluminum raceways (4)				120	3000
total				660	9600

Coho in 1984 were held 2 to 3 weeks in the aluminum raceways prior to egg-takes.

Coho mortality was very low at 9 fish (1.8%) in 1983 and 10 fish (1.9%) in 1984. Adult coho holding mortality has therefore been insignificant date.

The design memos (Appendix 1) used a fecundity of 2500 and a sex ratio of 0.6:1.0, males:females to calculate the number of coho broodstocks required for the Eagle facility. The 1983-84 egg take record indicated mean fecundities of about 2000 eggs per female for Salmon River and 2500 for Eagle River coho. As for chinook, the sex ratio for coho has been increased to 1M:1F to maintain genetic diversity. In the absence of actual data, assumed fecundity for the other targetted stocks has been left at 2500 eggs. Although Salmon River coho appear to be slightly smaller than the coastwide average (based on fecundity), a mean weight of 3 kg for all coho broodstock has been used in the calculations, for lack of actual weight data.

The aluminum raceways could hold 3840 kg of adults. This is more than adequate to meet the requirements of the Pilot (1100 kg CN, 1380 kg CO) and the Experimental (2740 kg CN, 3048 kg CO). The GWG targets for the Eagle and Salmon alone require only 1620 kg, but the original South Thompson target would require 8980 kg or 280 m^3.

As there is no major overlap in the holding requirements of adult chinook and coho, the containers can be entirely devoted to both species as needed. There is adequate space to accommodate the adult holding requirements for any targets proposed to date.

Broodstock Availability

Considering recent escapements, there may be difficulty in acquiring sufficient females to meet the requirements for the Experimental objectives for Eagle, Salmon and Seymour chinook and for Salmon, Adams, Southpass and Seymour coho (Table 7).

The use of fences is highly recommended for the smaller target systems as it would allow collection of broodstock over the full run timing, while ensuring optimal regulation of natural spawning.

Table 7 Broodstock Limitations at the Eagle River Facility

Species/ Stock	Ten Year Escapements(1974-84) Mean	Maximum	Minimum	Pilot Egg-Take 1983	1984	Experimental Target Maximum	Broodstock Limitation
Chinook							
Eagle	394	775	250	53	182	250	118
Salmon	355	850	50	-	181	140	107
Adams	982	2200	250	-	-	182	295
Seymour	-	20	0	-	-	18	
S. Thompson	4590	7000	1500	-	-	-	1377
Coho							
Eagle	2268	7100	850	325	521	320	680
Salmon	1217	2000	500	178	381	416	365
South Pass	33	60	10	-	-	40	10
Adams	173	500	10	-	-	300	52
Wap Cr.	206	516	20	-	-	-	62
Bessette Cr.	255	1500	10	-	-	-	68
Seymour	-	50	0	-	-	20	-

Notes:

1. Only sporadic data were available for both coho and chinook escapement to the Seymour River (5 years had no fish recorded or none observed).

2. Broodstock limitation is defined as 30% of the wild escapement (10 yr mean used as 100%); assumed 1M:1F sex ratio for returning adults.

Spawner Timing

DFO stream files report that Eagle chinook arrive in mid-August, reach peak spawning in late September and are finished in October, while Salmon River chinook are earlier, arriving in late June and peaking in mid September (Table 8).

Table 8 Event Timing for the Eagle River Facility

Species/ Stock	Adult Holding and Egg Takes	Incubation	Ponding of Fry	2g Size	Release (5 g)
Chinook					
Projected	Sep 5 - Oct 15	Sep 5 - Feb 19	Jan 20 - Feb 25	Apr 1 - May 5	May 30 - Jul 5
Pilots 1983/85	Sep 5-30	Sep 6 - Jan 24	Dec 28 - Jan 24	Apr 12 - May 1	May 15-18
Coho					
Projected	Oct 25 to Dec 1	Oct 25 - Feb 5	Feb 10 - Mar 15	May 15 - Jun 20	Jul 15 - Aug 15
Pilots 1983/85	Oct 22 to Nov 27	Oct 22 - Jan 28	Jan 20 - Feb 20	May 2 - May 29	May 7 - May 29

Table 9. Egg Development Timing at the Eagle River Facility

Species	Stage	Actual ATU	Projected ATU
Chinook	- eyed	194-215	280
	- hatch - initial	498-527	520
	- final	536-549	
	- ponding 1983 brood	901-965	980
	1984 brood	890(mean)	
Coho	- eyed	200-214	220
	- hatch - initial	433-455	480
	- final	477-499	
	- ponding	692-732	780

Eagle coho are reported to arrive in early October, peak in mid November and finish spawning in December. Salmon River coho arrive later (mid October), but also reach peak spawning in early November and finish earlier, by the end of November.

Chinook brood stock were collected September 6-24 in the Salmon River and September 7-4 in the Eagle River in 1984. In 1983, brood stock were first captured August 16 in the Eagle (no Salmon River chinook were collected).

Coho brood stock were captured October 30 - November 22 in the Salmon River and November 1-19 in the Eagle in 1984 and October 17 - November 23 and October 14 - November 7, respectively in 1983.

These adults arrival and holding periods were predicted correctly in the design memos, largely because of the adult reconnaissance study data.

INCUBATION

General

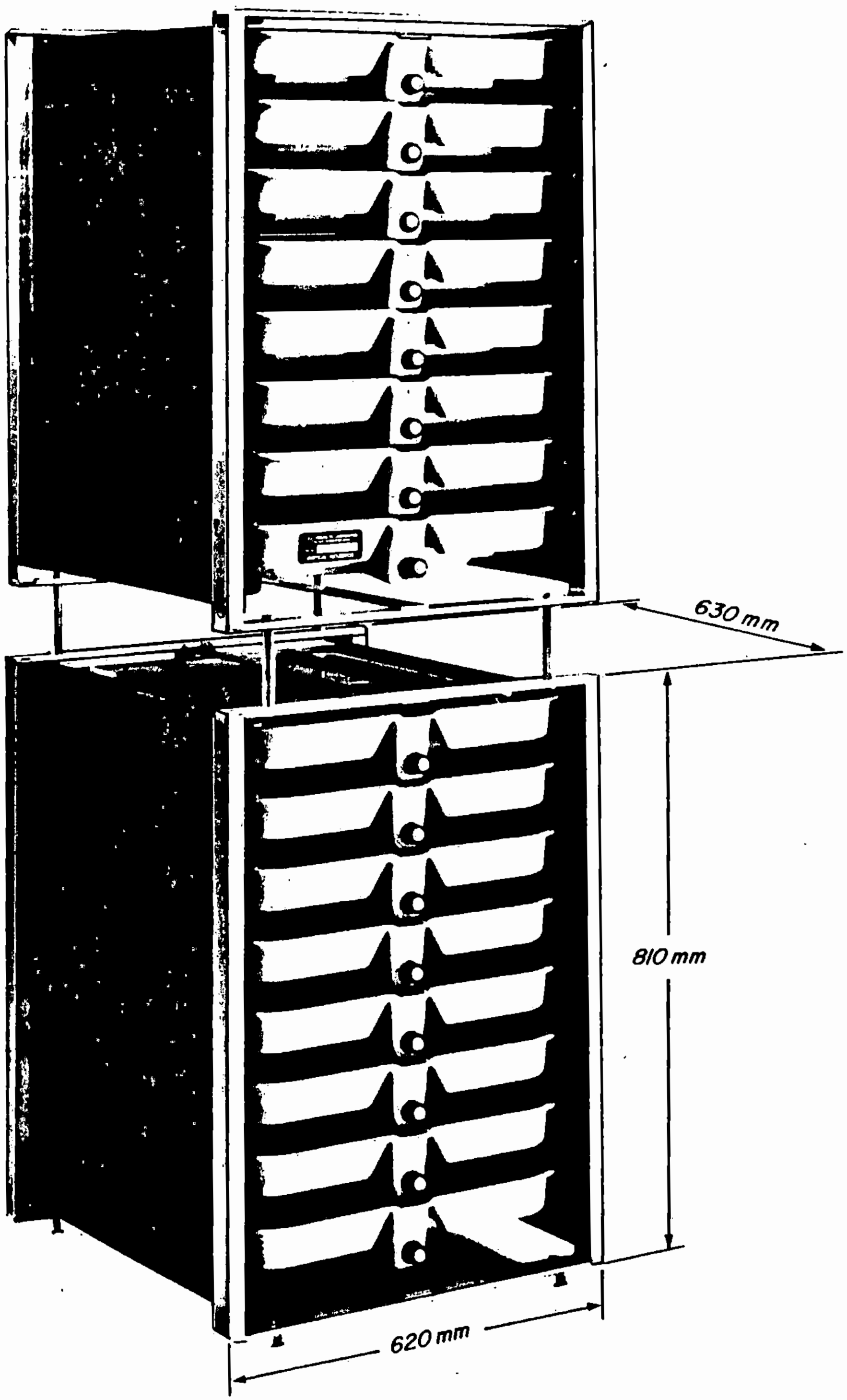
Egg takes at the Eagle River hatchery have been done by the dry method. Eggs are collected in buckets and sperm in Whirl-paks. Sperm is introduced to the eggs, the mixture is stirred, then sperm from a second male is added to ensure fertilization.

Eight-tray incubation stacks (Figure 3) are used for both chinook and coho incubation.

Eggs from individual females are pooled after fertilization and washed when they are placed in the incubator trays.

Egg takes for chinook in 1984 were from September 6 - Oct 4, while those for coho were from October 30 - November 27. These periods were correctly predicted during design.

The hatchery design correctly predicted the general periods and ATU's for most event timings for chinook and coho at the Eagle facility. Exceptions most apparent are that fry were ponded at a lower ATU, therefore has earlier than projected for both species, and this determines the initial rearing period.



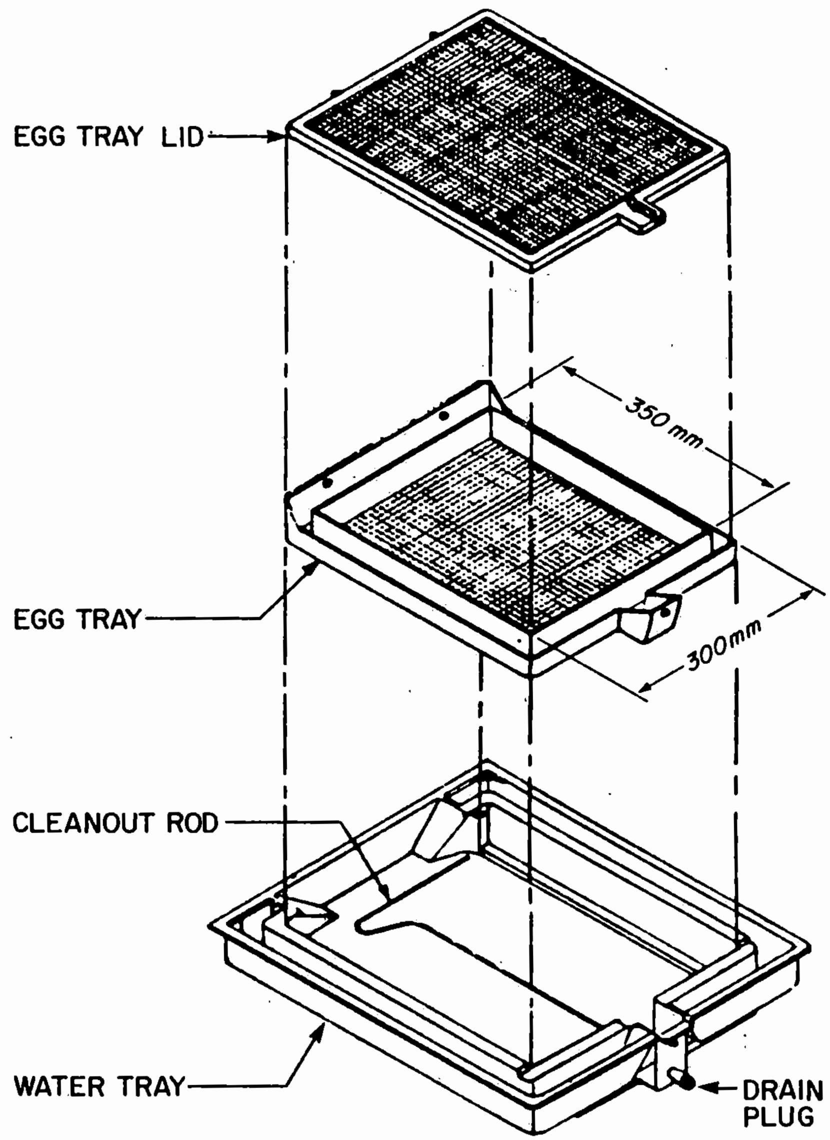


Figure 3 Vertical Tray Incubator

There were 72 eight-tray stacks in the Eagle incubation room in 1984 and 20 in 1983. The Pilot design memo requested 20 stacks, the Experimental requested 55 stacks and the original GWG target memo requested 87 stscks for small spring release option. The incubation room is currently plumbed for double the present tray capacity at full capacity, for an approximate maximum tray capacity of 144 stacks or 1152 trays. The maximum egg capacity is therefore 5.8M chinook or 9.8M coho.

Neither the 72 stacks nor the potential 144 stacks in the incubation room are not enough to meet the requirements for the original GWG target (7.9M eggs, 194 stacks), but the 144 stacks would be enough for the revised (1/2 mainstem chinook, 1/2 all coho) GWG target (5M eggs, 125 stacks).

The incubation tray stacks are presently aligned as follows: (two stacks per column)

1 back-to-back row of 9 columns =	36 stacks
1 back-to-back row of 5 columns =	20 stacks
1 row of 8 columns =	16 stacks
Total =	72 stacks

The original design memo called for provision of full backup with surface water to be used in emergency, and to one bank of stacks for temperature adjustment. The incubation room is currently double plumbed for this purpose although the two supplies now corresponds to the two wells rather than surface and wells.

Each tray has a screen-lined insert for holding eggs with inside measurements of 35 cm wide by 30 cm high by 4 cm deep, for an approximate egg holding volume of 4 L.

Each eight-tray stack measures 81 cm high by 62 cm wide by 63 cm deep. Therefore, each column of 2 stacks (16 trays) takes up about 0.40 m^2 of floor space or approximately 15 m^2 total for the 72 stacks in place. The aisles between the rows of stacks are approximately 1.0 m wide.

Each stack is designed to receive a maximum (flush) flow of 19 LPM. Regular flows are 10-15 LPM at most facilities. The Eagle facility has been operating at 15 LPM except when weekly malachite green treatments were conducted. During these treatments, flows are reduced to 12 LPM. Individual header tanks supply aerated mixed well water to the upper and lower groups of stacks in each column.

One stack was left empty during the 1984-85 incubation period for the 1984 brood.

The setup in 1984-85 required 1080 LPM of regular flow and 1368 LPM of flush flow for all stacks.

The top tray in each stack is routinely left empty of eggs to reduce air bubbles.

Chinook

Chinook are incubated in vertical tray stacks (described above). The requirements are listed in Table 10.

Tray loading for chinook has been calculated at 5000 eggs per tray, equating to 40K eggs per stack. The top tray in each stack is normally left empty to eliminate air bubble problems, reducing capacity to 35K eggs per stack, however, this tray is still available for use if required.

Chinook egg incubation has been exclusively on mixed, aerated well water to date.

In 1984, 566K Eagle River and 396K Salmon River chinook eggs were incubated at the Eagle River hatchery. In addition, 40K Shuswap River chinook were incubated to provide a safeguard against failure at the Shuswap facility. In 1983, 127K chinook eggs were incubated, taken only from the Eagle River stock.

From the 1984 brood year, a total of 553K Eagle River 374K Salmon River and 38K Shuswap River chinook fry were ponded. The 1983-84 egg-to-ponding fry mortality for chinook was 2.3% for Eagle and 5.5% for Salmon River broods, less than the SEP bio-criteria standard of 10%.

The Experimental maximum objectives translate to a requirement of 36 stacks, leaving a further 36 to meet coho Experimental requirements.

The original GWG target of 7160K chinook eggs translates to a requirement of 1434 trays in 181 stacks, which would require 2715 LPM regular and 3439 LPM flush flows. There is not enough potential incubation space in the as-built facility to meet the requirements of the GWG target, even if only chinook were incubated. However, service only the Eagle and Salmon chinook objectives for

Table 10. Chinook Incubation at the Eagle River Facility

Species/ Stock	Eggs (#K)	Trays[a] (#)	Stacks[b] (#)	Flow[c] Normal (LPM)	Flush (LPM)
PILOT					
Planned Stocks					
Eagle	250	50	7	105	133
Salmon	250	50	7	105	133
Total	500	100	14	210	266
1983-84 Brood					
Eagle	127	26	4	60	76
1984-85 Brood					
Eagle	556	113	15	225	285
Salmon	375	75	10	150	190
Total	931	188	25	375	475
EXPERIMENTAL PLAN					
Year One					
Eagle	500	100	13	195	247
Salmon	300	60	8	120	152
Adams	500	100	13	195	247
Seymour	50	10	2	30	38
Total	1350	270	36	540	684
Year two					
Eagle	600	120	15	225	285
Salmon	300	60	8	120	152
Adams	300	60	8	120	152
Seymour	50	10	2	30	38
Total	1250	250	33	495	627
GWG TARGET					
Eagle	432	87	11	165	209
Salmon	309	62	8	120	152
S. Thompson	4938	988	124	1800	2356
Adams	1481	297	38	570	772
Total	7160	1434	181	2715	3439
AS-BUILT CAPACITY					
Present	2880	576	72	1080	1368
Potential (site limitation)	5760	1152	144	2160	2736

[a] Chinook load rate 5000 eggs per tray
[b] Eight trays per stack
[c] Flows - 15 LPM normal, 19 LPM flush per stack

GWG target, 149 trays in 19 stacks would be required. This leaves a further 53 stacks available to meet coho or other system chinook objectives.

Chinook were ponded at 900-965 ATU in 1983 and at a mean of 890 ATU in 1984. The design memo predicted chinook eggs to be eyed by 280 ATU and hatched by at 520 ATU. The actual experienced was 195-215 ATU to eyeing and a 500-550 ATU to hatch with the 1983 and 1984 broods. Swim-up fry were ponded earlier in 1984 because they were ready to start feeding as shown by a small test group which was ponded first to test the feeding response.

Chinook incubation has extended from initial egg takes in early September to the final ponding of fry in late January. This period was predicted correctly in the design memo, except that ponding was predicted to continue until the middle of February.

Coho

Coho eggs are also incubated in vertical stack tray incubators at the Eagle facility. Requirements are shown in Table 11.

The loading rate for coho during the Eagle Pilot operation was 6500 to 8000 eggs per tray, or 52K to 64K per stack. In 1984 the top tray was left empty, equating to 45.5K to 56K per stack. The design memos used the SEP biostandard of 8500 eggs per tray equating to 68K per stack to calculate the requirements. The biostandard loading was used for this report.

Coho eggs eyed at 200-215 ATU and hatched at 430-500 ATU during the Pilot, close to the design memo predictions of 220 ATU and 480 ATU.

In 1984, 872K Eagle and 558K Salmon coho eggs were incubated and 834K Eagle and 515K Salmon coho fry were ponded. In 1983, 511K Eagle and 211K Salmon coho eggs were incubated and 487K Eagle and 196K Salmon coho fry were ponded.

The ponding mortalities for coho were 4.7% and 2.6% for Eagle coho, and 7.1% and 4.1% for Salmon coho, respectively for the 1983 and 1984 broods, less than the bio-criteria standard of 10%.

To meet the maximum requirements in the Experimental design memo, there is enough incubation space to service both the chinook and coho objectives in any one year. There is also enough space to meet all the GWG coho objectives.

Table 11. Coho Incubation at the Eagle River Facility

Species	Eggs (#K)	Trays[a] (#)	Stacks[b] (#)	Flow[c] Normal (LPM)	Flow[c] Flush (LPM)
PILOT					
Planned Stocks					
Eagle	250	30	4	60	76
Salmon	250	30	4	60	76
Total	500	60	8	120	152
1983-84 Brood					
Eagle	511	61	8	120	152
Salmon	211	25	4	60	76
Total	722	86	12	180	228
1984-85 Brood					
Eagle	873	103	13	195	247
Salmon	558	66	9	135	171
Total	1431	169	22	330	418
EXPERIMENTAL PLAN					
Year One					
Eagle	400	47	6	90	114
Salmon	300	36	5	75	95
Adams	375	45	6	90	114
Seymour	25	3	1	15	19
South Pass	25	3	1	15	19
Total	1125	134	19	285	361
Year two					
Eagle	300	36	5	75	95
Salmon	400	47	6	90	114
Adams	375	45	6	90	114
Seymour	25	3	1	15	19
South Pass	50	6	1	15	19
Total	1150	137	19	285	361
GWG TARGET					
(1 yr rearing option)					
Eagle	326	39	5	75	90
Salmon	327	27	4	60	76
Adams	49	6	1	15	19
Wap Creek	39	5	1	15	19
Bessette Creek	69	9	2	30	38
Total	710	86	13	195	242
AS-BUILT CAPACITY					
Present	4896	576	72	1080	1368
Potential (site limited)	9792	1152	144	2160	2736

[a] Coho load rate is 8500 eggs per tray
[b] Eight trays per stack
[c] Flows are 15 LPM normal, 19 LPM flush per stack

The coho incubation period extends from the first egg take in late October until the final ponding at the end of February (Table 8). The design memo predicted this correctly, except that ponding was projected to continue until March 20.

There should be provision for temperature manipulation at the Eagle River facility during coho incubation to control hatching in order to advance or delay timing to separate the stocks. A supply of surface water to allow this was requested in the original design memo and in the Pilot design memo. The requests for the Experimental design called for the provision of heated water to the incubation room to raise the temperature to 2.0°C above ambient. Neither heated nor surface water is currently supplied to the as-built facility, so temperature manipulation is not yet possible.

REARING

Capilano Troughs

Capilano troughs (Figure 4) are used at many SEP facilities for start-up rearing of salmonid fry.

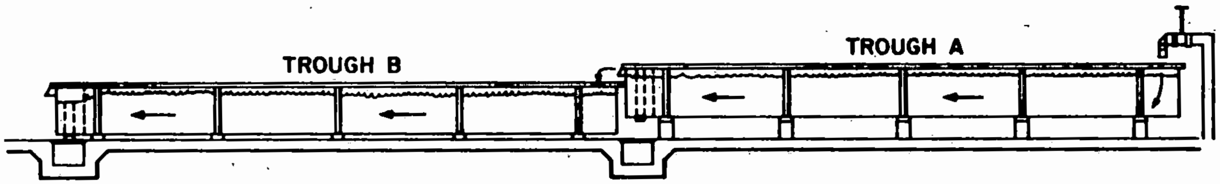
Each trough is 6.4 m long by 0.8 m wide by 0.6 m high with an operating water depth of about 0.5 m. Each trough holds 2.3-2.5 m^3 of water, depending on the overflow setting and bottom slope. A 0.4 m section separated by the tail screen limits the volume available for fish rearing to 2.2 m^3.

The troughs are normally aligned in two so that one water supply feeds both troughs in a series.

The troughs are set on 200 mm wide by 2 m long solid concrete blocks, with the first trough set 300 mm above the ground and the second trough 100 mm above the ground. This allows the overspill from the first trough to drop 200 mm into the second, providing some re-aeration.

The troughs at the Eagle facility are constructed of welded aluminum sheets with support struts.

The technique for rearing in Capilano troughs involves crowding newly ponded fry into the upstream end by placing a screen one third the distance to the outlet. Crowding helps to initiate the feeding response. Once the young fish are accepting food, the rearing area available is increased by screen removal or repositioning.



SIDE VIEW OF ARRANGEMENT

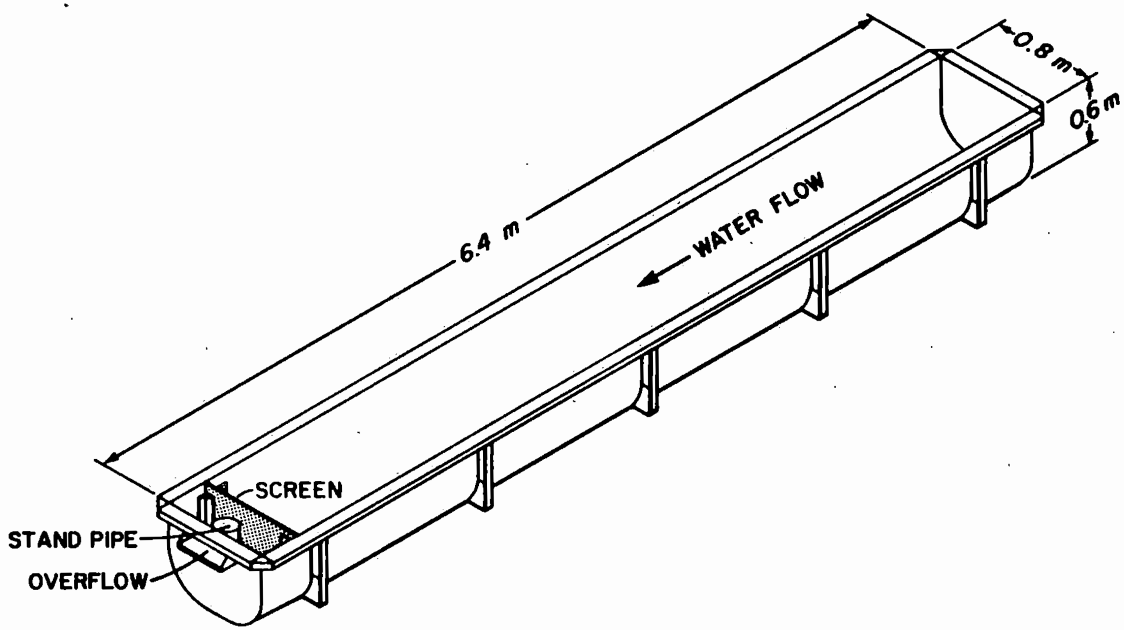


Figure 4 Capilano Style Rearing Trough

During the 1983 Pilot, eight troughs (18 m^3 of initial rearing volume) were located under cover in the area designated for the workshop of the to-be-completed hatchery building. As a temporary measure during the 1984 Pilot operation, 28 Capilano troughs (14 lines; 62 m^3 of volume) were set up in the partially complete covered rearing building located adjacent to the hatchery building. The completed rearing building will contain eight Capilano troughs (four lines; 18 m^3) plus eight large starter units (at 11.5 m^3 each equals 92 m^3), for a total initial rearing volume of 110 m^3.

Operational flows to each line of Capilano troughs begin at 120 LPM for newly ponded fry and increase to a maximum of 240 LPM by the time fish attain 1.5 g. Each trough exchanges its water once every 9 min. at maximum flow, or about 6.5 times per hours, although the two troughs in a row require twice as long to exchange (18 min). The maximum flows required to service the trough capacities for the 1983 and 1984 pilots and the troughs in the completed rearing building are 960 LPM, 3360 LPM and 960 LPM, respectively.

Large Starter Units

The rearing building, completed in 1985, contains eight large starter units (LSU) (Figure 5). The volume and flow loading rates for one of these units were considered to be equivalent to two lines of Capilano troughs.

The large starter units measure 13 m overall length, although the inlet and outlet structures will take up 0.5 m each, leaving 12 m of usable length for fish rearing. Walls height is 1.2 m and inside width is 1.2 m. Walkways between starter units are approximately 1 m wide.

Screen guides are located at 0.5, 3.5, 6.5, 9.5 and 12.5 m from the upstream end.

The units have a 1% slope and are constructed of 150 mm thick walls mounted on a 150 mm concrete slab.

With a projected operating water depth of 0.8 m (0.4 m freeboard to prevent fry jump-out), the usable volume of each large starter unit will be 11.5 m^3. The total volume available for initial rearing is 92 m^3 for the large starter units and 17.6 m^3 for the Capilano troughs for a total of 110 m^3.

At a projected initial input flow of 240 LPM, the exchange rate in the large

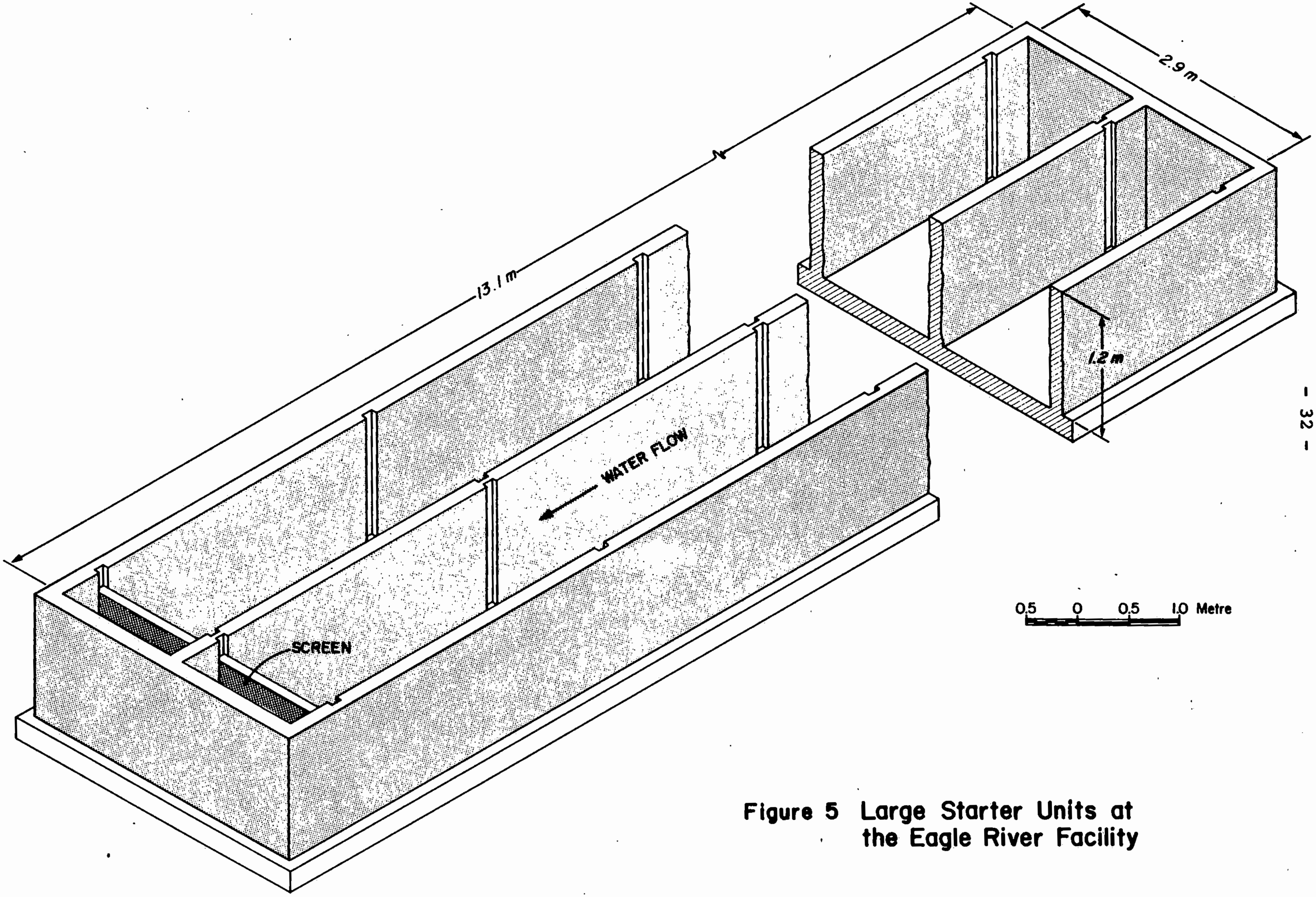


Figure 5 Large Starter Units at the Eagle River Facility

starter units is once every 48 min. At maximum flow of 480 LPM per unit, one exchange occurs every 24 min.

The as-built rearing building capacity at Eagle is equivalent to 40 Capilano troughs (four lines of Capilano troughs and eight starter units).

The flow requirement for the rearing building are 4800 LPM (960 LPM plus 3840 LPM) at maximum flow.

There is potential space for two more large starter units and one more line of Capilano troughs in the as-built rearing building for a total capacity equivalent to 50 troughs requiring 6000 LPM. The space is presently being used for vehicle storage.

Aluminum Raceways

Four aluminum raceways (Figure 6) are located at the hatchery and were used for adult holding and coho rearing during the Pilot program. These structures were part of the Pilot design, and were intended to be portable.

The aluminum raceways measure 21 m in overall length. Inlet and outlet areas at the ends take up 0.5 m each, leaving a usable length of 20 m.

Inside width is 1.8 m and wall height is 1 m. With an operational water depth of 0.75 m, usable volume is approximately 27 m^3, or 108 m^3 for all four raceways combined. This is slightly less than the 116 m^3 requested for the Pilot.

The raceways are set at .15% slope to allow complete drainage. Water outlet is through a removable standpipe.

Maximum designed flow to each of the aluminum raceways is 750 LPM. At this flow, the 27 m^3 of water in each aluminum raceway would take approximately 36 minutes to exchange.

Concrete Raceways

Six concrete raceways (Figure 7) are situated to the north of the hatchery building. They were meant for both chinook and coho rearing but have been used primarily for chinook to date.

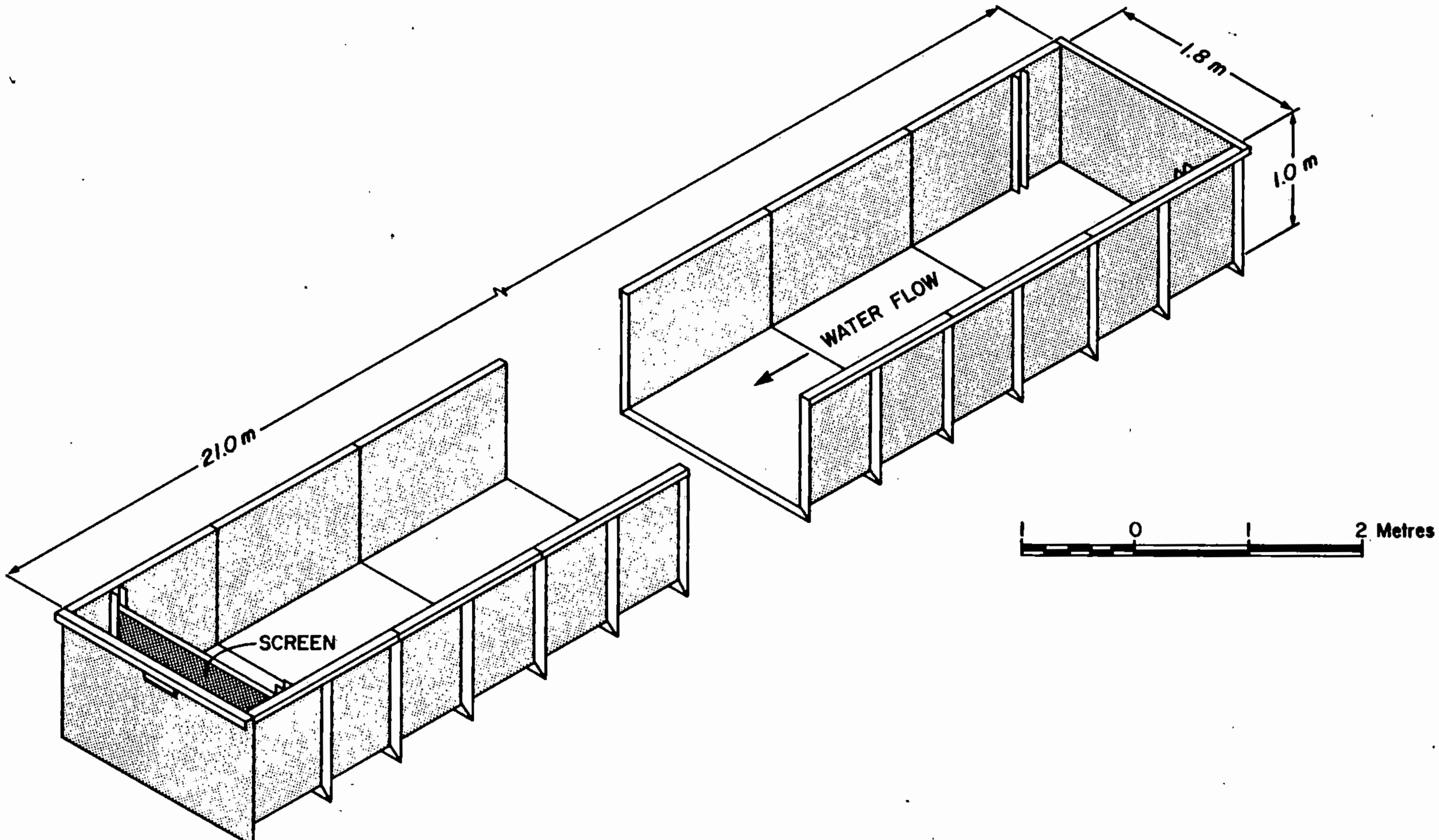


Figure 6 Aluminum Rearing Raceways at the Eagle River Facility

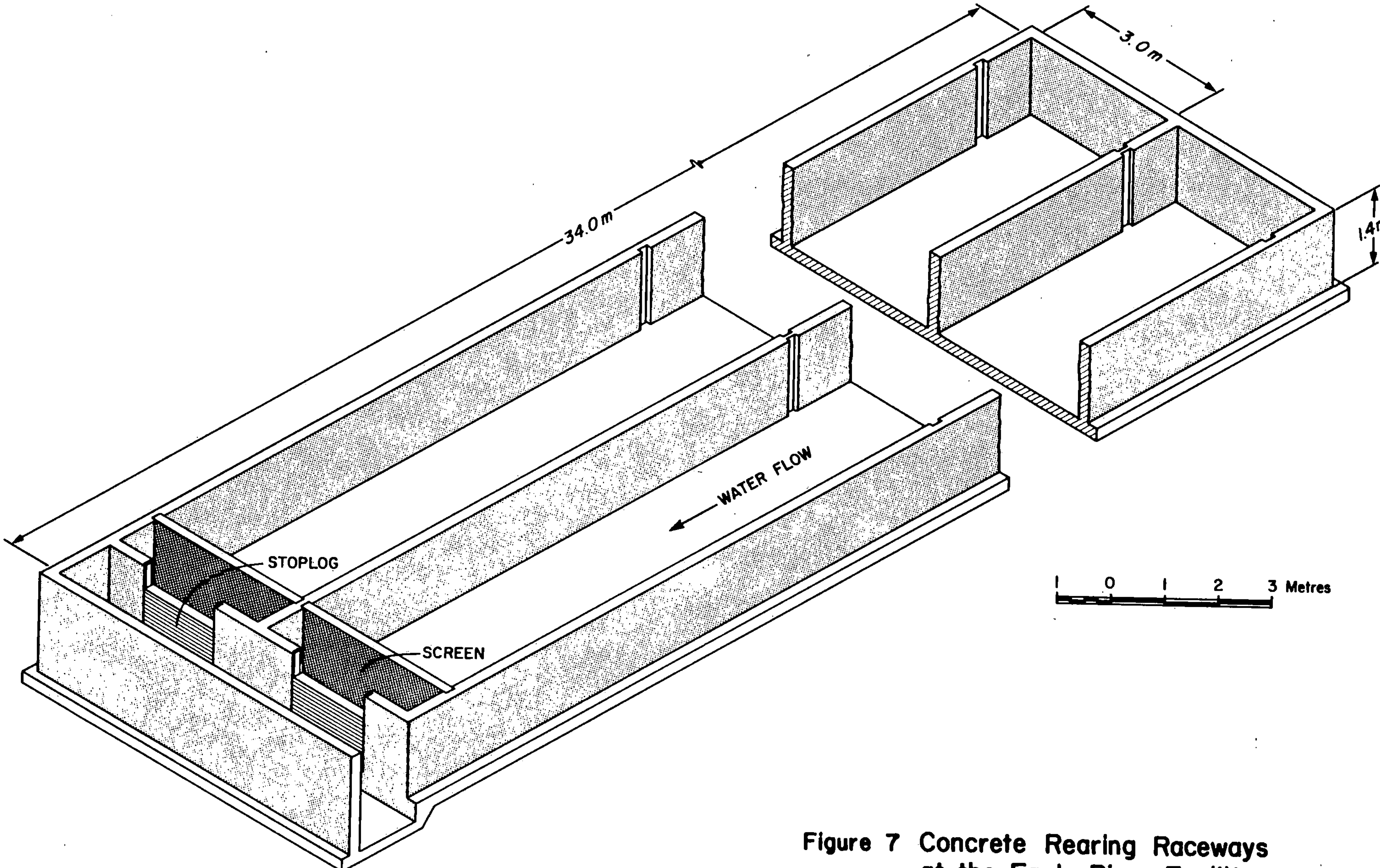


Figure 7 Concrete Rearing Raceways
at the Eagle River Facility

The raceways are arranged in three side by side pairs. Each raceway measures 3 m inside width. Wall heights are 1.4 m, although normal water depth during operation is 1.0 m, allowing a 0.4 m freeboard to prevent fry jump-out.

Each raceway is 34 m long from end to end. The intake structures take up 1.5 m of the upstream end and the outlet structure and the transport channel take up 2.5 m of the downstream end, leaving a usable length of 30 m. This provides 90 m^3 of rearing space per raceway, or 540 m^3 for all six raceways, which is identical to the design memo request for the Experimental plan.

Screen guides for the usable 30 m are located at 0 m, 10 m, 20 m and at the downstream end of each raceway. There are stoplog guides at each outlet.

The exterior walls are 200 mm thick reinforced concrete, while the divider wall between each pair is 150 mm thick. The raceways lay on a 200 mm thick concrete slab set at slope of 0.3%.

The raceways are plumbed for two water supplies. During the Pilot they could only receive mixed well water. Presently they can receive water from each well separately. In the future, one of the supply lines could provide surface water.

Each raceway was supplied with mixed aerated well water at 950-1250 LPM (mean 1100 LPM) during the 1984-85 operation. This was the flow available when all the outside rearing units were being used simultaneously.

The 90 m^3 of rearing volume in each raceway take approximately 82 min to exchange on well water (94 to 72 min) with these flows.

The raceways are cleaned using a modified swimming pool type vacuum head attached to a portable water pump. Daily cleaning of raceways was necessary in 1984, due to low flow restrictions. The operators felt that more flow would reduce cleaning requirements by flushing out more of the wastes rather than allowing them to settle out.

Rearing practices at Eagle include sterilization of nets and hoses with Roccal when gear is transferred between containers.

Chinook

Initial Rearing

Chinook rearing normally begins in Capilano troughs at SEP facilities. In 1984-85 at Eagle this was done in the 28 Capilano troughs at a mean loading rate of 38K fry per trough.

Chinook were ponded December 28 to January 24 and reared in the Capilano troughs to 0.75 - 1.0 g, then transferred to the concrete rearing raceways January 25 to February 1. As mentioned under "Incubation", pondings were earlier than predicted.

If used exclusively for chinook, there is initial rearing capacity in the rearing building for 1600K fry at a load rate of 40K fry per trough and 160K fry per starter unit. The potential capacity of the rearing building is 2000K fry. If each aluminum raceway were considered to be the equivalent of 1.5 starter units (or six Capilano troughs), the as-built capacity for initial rearing of chinook would be 2.5M fry (Table 12). The Ultimate capacity would add the extra troughs and starter units in the rearing building, for a capacity of almost 3M fry.

The design memos originally calculated initial rearing requirements based on a load rate of 50K chinook fry per Capilano trough and an egg to fry survival of 90%. The original pilot design memo indicated that these requirements were excessive from a logistics point of view and instead requested shallow start-up raceways for both chinook and coho.

Initial rearing requirements have been recalculated using a load rate of 40K fry per Capilano trough for chinook initial rearing.

Maximum initial rearing requirements for the Experimental objectives were 32 troughs in 17 lines or their equivalent. This would leave an equivalent of eight Capilano troughs of initial rearing space not used for chinook.

Table 12 indicates that to meet the original GWG chinook target requirements, 162 troughs in 82 lines or their equivalent are required. Eagle and Salmon stocks alone would require 17 troughs in nine lines. These could be contained by three large starter units and three lines of Capilano troughs in the rearing building, leaving a further capacity for an additional 400K chinook fry. The

Table 12. Chinook Initial Rearing at the Eagle River Facility

Species/ Stock	Fry (#K)	Troughs (#)	Lines (#)	Flow Start (LPM)	Flow End (LPM)
PILOT					
Planned Stocks					
Eagle	225	6	3	360	720
Salmon	225	6	3	360	720
Total	450	12	6	720	1440
1983-84 Brood					
Eagle	121	3	2	240	480
1984-85 Brood					
Eagle	553	14	7	840	1680
Salmon	375	10	5	600	1200
Total	928	24	12	1440	2880
EXPERIMENTAL PLAN					
Year One					
Eagle	450	12	6	720	1440
Salmon	270	7	4	480	960
Adams	450	12	6	720	1440
Seymour	45	1	1	120	240
Total	1215	32	17	2040	4080
Year two					
Eagle	540	14	7	840	1680
Salmon	270	7	4	480	960
Adams	270	7	4	480	960
Seymour	45	1	1	120	240
Total	1125	29	16	1920	3840
GWG TARGET					
Eagle	389	10	5	600	1200
Salmon	278	7	5	600	1200
S. Thompson	4444	111	56	6720	13440
Adams	1333	34	17	2040	4080
Total	6444	162	82	9960	19920
AS BUILT CAPACITY					
Troughs	320	8	4	480	960
Aluminum raceways	960	4		3000	3000
Starter units	1280	8		1920	3840
Total	2560	20	4	5400	7800

*Notes
- Load rate 40K chinook per trough
- Flow starts at 120 LPM per line, ends at 240 LPM per line
- Each aluminum raceway and large starter unit is considered equivalent to four Capilano troughs

requirements to meet the GWG target for the South Thompson stock alone far outstrip the rearing building capacity.

Final Rearing

Chinook fry were transferred to the concrete raceways for final rearing in 1985. In 1984, chinook fry were transferred to the aluminum raceways.

Loading rates were 145K - 187K fry per raceway (mean 165K) in 1985 equivalent to 990K chinook in the six raceways. At a fry weight of 5 g this equates to 9.2 kg/m^3 and 0.75 kg/LPM which are within the maximum safe loading rates of 15.6 kg/m^3 and 0.97 kg/LPM generated by the LOAD RATE model (Appendix 5a) that were used in the design.

Feed rates for chinook at Eagle are standard at the Stauffer/OMP recommended level (Appendix 5a). Depending on how well fish take food, the rate is increased or decreased to maximize growth and minimize waste. Chinook fry are hand-fed an average of twice per hour.

The chinook raceways are vacuum cleaned daily.

Chinook rearing in 1983 extended from the first ponding on January 5 to the releases May 15-18. In 1984, chinook were ponded earlier (December 28) at slightly lower ATU and releases were made at size and time intervals to accommodate assessment studies in 1985 and 1986. Although the initial ponding times were earlier, the dates of reaching 2g and release size were as predicted in the design memos.

Due to unknown reasons, high mortality occurred in the 1984 chinook brood after transfer to the concrete raceways in 1985. To May 29, 1985, approximately 37.7% of the Eagle stock and 33.8% of the Salmon stock had been lost to mortality. This is higher than the SEP biostandard rate of 28% from egg to release. There is speculation that the cause of the mortality is related to the water quality of Well PW-E2 and possibly the accumulation and synergistic effects of metals such as zinc and iron.

The Experimental stage requires a maximum of 283 m^3 and 4562 LPM for chinook (Table 13), based on the LOAD RATE model (Appendix 5a). The concrete raceways now supply 540 m^3 with 6600 LPM flow. The aluminum raceways would provide

Table 13 Chinook Final Rearing at the Eagle River Facility

Species/ Stock	Maximum Size (g)	Number (#K)	Biomass (kg)	Flow (LPM)	Volume (cu.m)
PILOT					
Planned Stocks					
Eagle	5	180	900	930	58
Salmon	5	180	900	930	58
Total		360	1800	1860	116
1983-84 Brood					
Eagle	3	103.5	310.5	350	22
1984-85 Brood					
Eagle	3	390		1318	84
	5	225	1125	1162	72
	10	125	1250	1149	70
	20	50	1000	818	47
Salmon	3	260	1300	1343	83
Total		750	4675	5790	356
EXPERIMENTAL (Maximum)					
Eagle	5	375	1875	1936	120
Salmon	5	200	1000	1033	64
Adams	5	310	1550	1601	99
Seymour	2	50	100		
Total				4562	283
ULTIMATE GWG TARGETS					
Eagle	5	311	1555	1606	99
Salmon	5	222	1110	1146	71
S.Thompson	5	3556	17780	18368	135
Adams	5	1067	5335	5511	341
Total		5156	25780	26631	1646
AS-BUILT CAPACITY					
Large Starter Units				3840	92
Aluminum Raceways				3000	108
Concrete Raceways				6600	540
Total				13440	740

Notes
Calculations based on LOAD RATE model at 7.2°C, 95% O_2

another 108 m^3 and the LSU another 92 m^3, for a total of 740 m^3. All raceways thus currently on the site could potentially hold 2.3M chinook smolts to 5 g.

To meet the GWG target objectives would require 26631 LPM and 1646 m^3 of rearing space. This is over double the rearing currently supplied. The GWG objectives for South Thompson River form the bulk of these requirements. If this stock were not included, 8263 LPM and 511 m^3 would be required. The concrete raceways alone would provide sufficient space to rear the remaining stocks to 5 g.

Coho

Initial Rearing

The 1984 brood of coho were immediately ponded as swim-up fry to the aluminum raceways and to one of the concrete raceways. They were directly ponded to the aluminum raceways on 2 m by 10 m net screens. This gave the fry approximately 10 cm of water depth at initial ponding in order to allow them to adjust to the raceway environment. Two to three hours after introduction they were liberated to the raceway.

Loading rates were a mean of 240K fry to each aluminum raceway and 380K fry to the concrete raceway.

Coho raceways are cleaned every two days using the same vacuum system as for chinook.

In addition, in 1985, 60K coho fry were reared in the hatchery outlet channel, measuring approximately 10 m x 3 m and 0.5 m deep. Netting was placed over it to prevent bird predation and the inlet and outlet were screened with temporary structures. These fry were released to the lower Perry River. This group, fed on a less frequent schedule, may have complemented their diet with some natural food.

The feed rate for coho at the Eagle hatchery initially follows the Stauffer/OMP recommended maximum level (Appendix 5a). This rate is decreased as fish are held longer to slow their growth rate during extended rearing. Coho are fed hourly.

Coho rearing for the 1983 brood extended from the first ponding January 29 to final releases May 29. The 1984 brood was ponded January 29 to February 20, 1985, and various rearing and release strategies are being carried out during 1985 and 1986 for assessment purposes. Although the initial pondings were earlier, the time to reach 2g and release size were as predicted in the design memos.

Table 14 shows the initial rearing requirements for coho using a 57K fry per trough loading rate. For in excess of the projected number of coho eggs for the Pilot (450K) were actually taken in 1983 (683K) and 1984 (1.4M) because the as-built Pilot had greater capacity than requested. However, there was barely sufficient water to rear the extra fish to release size in 1985.

To meet the requirements of the Experimental objectives 20 Capilano troughs or their equivalent rearing space are required. The rearing building supplies the equivalent of 40 Capilano troughs, but to accommodate both chinook and coho initial rearing, 52 troughs or their equivalent are needed. Coho fry may have to continue to be ponded directly to the raceways in order to free the rearing building for the chinook. Direct ponding of coho to the aluminum raceways has proven successful during the two years of operation. If this practiced were continued the Experimental coho objectives would require only four troughs in the rearing building, to maintain stock separation. Therefore, there is adequate initial rearing at the as-built facility to meet the Experimental objectives for coho.

The original GWG targets required only 14 troughs to accommodate coho fry if the one-year rearing strategy was used and survivals met the biostandards.

Final Rearing

To meet the Experimental maximum requirement, 265 m^3 are needed (Table 15). All of the aluminum and two concrete raceways are needed to meet these objectives.

There is sufficient space at the as-built facility to accommodate both chinook and coho maximum requirements for the Experimental phase.

If the Ultimate GWG targets were considered, however, coho (1 year rearing option) would require 516 m^3 and both chinook and coho combined would require 2162 m^3, which exceeds the as-built total container capacity by almost three times.

Table 14 Coho Initial Rearing at the Eagle River Facility

Species/ Stock	Fry (#K)	Units (#)	Lines (#)	Flow Start (LPM)	Flow End (LPM)
PILOT					
Planned Stocks					
Eagle	225	4	2	240	480
Salmon	225	4	2	240	480
Total	450	8	4	480	960
1983-84 Brood					
Eagle	487	9	5	600	1200
Salmon	196	4	2	240	480
Total	683	13	7	840	1680
1984-85 Brood					
Eagle	850	103	13	195	247
Salmon	535	66	9	135	171
Total	1385	25	13	1560	3120
EXPERIMENTAL PLAN					
Year One					
Eagle	360	7	4	480	960
Salmon	270	5	3	360	720
Adams	337.5	6	3	360	720
Seymour	22.5	1	1	120	240
South Pass	22.5	1			
Total	1012.5	20	11	1320	2540
Year two					
Eagle	270	5	3	360	720
Salmon	360	7	4	480	960
Adams	337.5	6	3	360	720
Seymour	22.5	1	1	120	240
South Pass	45	1			
Total	1035	20	11	1320	2640
GWG TARGET					
Eagle	293	6	3	360	720
Salmon	204	4	2	240	480
Adams	44	1	1	120	240
Wap Creek	36	1			
Bessette Creek	62	2	1	120	240
Total	639	14	7	840	1680
AS-BUILT CAPACITY		Units	Trough Equivalents		
Troughs	460	8	8	480	960
Aluminum raceways	1.4	4	24	1920	3840
Starter units	1.8	8	32	3840	7680
Total	3.6		64		

*Notes
- Load rate is 57K coho per trough
- Flow start 120 LPM per line, end 240 LPM per line
- Each large starter unit is considered equivalent to four Capilano troughs, each aluminum raceway equivalent to six troughs.

Table 15 Coho Final Rearing at the Eagle River Facility

Species/ Stock	Maximum Size (g)	Number (#K)	Maximum Biomass (kg)	Maximum Flow (LPM)	Maximum Volume (cu.m)
PILOT					
Planned Stocks					
Eagle	5	169	845	780	57
Salmon	5	169	845	780	57
Total		338	1690	1560	114
1983-84 Brood					
Eagle	3	487	1461	1498	105
Salmon	3	196	588	603	42
Total		683	2049	2101	147
1984-85 Brood					
Eagle	3	850	2550	2615	184
	10	100	1000	807	56
	20	25	625	415	27
Salmon	3	535	1605	1646	115
Total	3	1385	4155	4261	299
EXPERIMENTAL PLAN (Maximums)					
Eagle	5	260	1300	1200	83
Salmon	5	225	1125	1039	72
Southpass	5	20	100	92	7
Adams	5	300	1500	1385	96
Seymour	5	20	100	92	7
Total		825	4125	3808	265
ULTIMATE GWG TARGET (1 yr rearing option)					
Eagle	25	220	5500	3652	237
Salmon	25	153	3825	2540	165
Adams	25	33	825	548	34
Wap Creek	25	27	675	448	29
Bessette Creek	25	47	1175	780	51
Total		480	12000	7968	516
AS-BUILT CAPACITY					
Large Starter Units				3840	92
Aluminum Raceways				3000	108
Concrete Raceways				6600	540
Total				13440	740

Notes: Based on LOAD RATE at 7.2°C and 95% O_2

Release Strategies

All coho and chinook are released back to their river of origin. Releases have been scattered in both systems. For instance in the Eagle System, releases have been conducted over 26.5 km of the Eagle River and to the Perry River.

Downstream enumeration after release in 1984 was undertaken by hatchery personnel using an inclined plane trap in the Eagle River at the adult fence location. The work was undertaken again in 1985 by a contractor.

In 1984, release size for the 1983 brood of both coho and chinook was 2-3 g.

A total of 103.5K chinook were released to the Eagle in 1984, while 448K coho and 190K coho were released to the Eagle and Salmon Rivers respectively.

In 1985 and 1986 a variety of release strategies are planned for the 1984 brood, to assess the short term fate and long term survival of hatchery fish and interactions with wild fish. For the Eagle River brood, these are planned as per the following table for the first year for the Experimental program.

	Coho		Chinook	
Release date	Size(g)	No. CWT	Size(g)	No. CWT
May 1985	2	100K	5	100K
Fall 1985	10	75K	10	75K
Spring 1985	15-20	25K	10-20	50K

The May and Fall releases are scattered throughout the watershed. In Spring 1985, some fish were released directly from the hatchery.

Fish are moved to release sites in 11,000 L capacity aerated stainless steel tanks on a 5 ton diesel truck.

Following releases, instream rearing and migration assessments are to be made of standing crop, stream rearing capacity, predation, cannibalism, and movements and behavior of outplanted fish.

50,000 coho were released in the downstream areas of Crazy Creek in 1985.

In the Salmon River, releases of 2.3 g coho and 2.3 g chinook were carried out pre- and post-freshet.

Predicted fry stocking capacities, generated from reconnaissance studies conducted in the South Thompson area (Whelan et al. 1982; Sebastian, (1983) provide first-cut estimates of habitat availability. However, these estimates of fry stocking capacities should be continuously reviewed as current assessment studies become available.

In total, the currently unutilized areas of South Thompson streams have been estimated to be able to support an additional 5.7M coho fry, far more than any of the production objectives set forth to date. Chinook outplant opportunities in some of the systems are limiting due to natural physical and wild population biological factors.

Table 16. Rearing Capacities of South Thompson Area Systems

System	Predicted Fry Stocking Capacity	Remarks
Eagle R	3160K CO	Chinook releases not recommended on basis of natural emigration from headwaters
Salmon R	1430K CO	Not recommended due to low flows and high temperatures in summer and wild fry overwintering
Adams R	280K CO	
South Thompson R	760K CO	
Seymour R	84K CN	5g chinook and fall coho outplant
Perry	114K CN	Inaccessible and accessible
	25K CO	reaches combined
Crazy Cr	45K CO	Inaccessible portions only
Southpass Cr	7K CO	
Tappen Cr	25K CO	
Trinity Cr	75K CN	

Flow Demand

A summary of the rearing strategy for the 1984 brood year derived from actual hatchery operation is presented in Table 17 to allow evaluation of how space and flow was utilized during actual operation.

Following is the projected rearing strategy and demands required to meet the objectives of the Experimental program in Table 18. These have been estimated using biological data and event timing from the Pilot for the Experimental facility.

A flow bottleneck occurred at the Pilot facility from late January through February of 1985, when water supply to the incubation room, the rearing building and the raceways was required simultaneously.

Pump outputs are currently 2760 LPM for Well PW-E1 and 6600 LPM for Well PW-E2, for an as-built maximum flow capacity of 9360 LPM. The wells are currently the only water supplies available.

The rearing strategy summaries were used to develop estimates of flow demand (Tables 19 and 20, Figure 8) at the Eagle facility for the Pilot operation in 1984-85 and the maximum requirements to meet the objectives of the Experimental program.

There are some differences apparent between the water demands of the Experimental program and those projected in the design memo for the Eagle expansion (Appendix 1e). This stems from adjustments made based on actual timing experienced for ponding and rearing of fry, which have shifted the highest demand from June to April.

If all containers (Capilano troughs, larger starter units, aluminum and concrete raceways) were used to capacity simultaneously for final rearing, the water demand would be 15360 LPM. The Experimental design memo requested a maximum of 12600 LPM, although the current output capacity of the two wells is only approximately 9360 LPM.

Table 17. Pilot Operation (1984-85) Rearing Strategy Summary at Eagle River

Event	Chinook	Coho
ADULT HOLDING		
Adults(#)	363	902
in space(cu.m)	57	85
at flow(LPM)	1512	2255
from	Sep. 7	Oct. 30
to	Sep. 30	Nov. 27
INCUBATION		
Eggs(#K)	971	1431
in trays(#)	194	169
in stacks(#)	25	22
at flow(LPM)	375	330
from	Sep. 6	Oct. 30
to	Jan. 24	Feb. 30
INITIAL REARING(CN)		
Fry(#K)	966	
in space(cu.m)	70	
at flow(LPM)	3360	
from	Dec. 28	
to	Feb. 10	
FINAL REARING		
2g Fingerlings(#K)	957	1349
in space(cu.m)	450	210
at flow	5500	4100
from	Jan. 25	Jan. 20
to	May 1	May 15
EXTENDED REARING		
to size 5g(#K)	230	
in space(cu.m)	90(1 CR)	
at flow(LPM)	1100	
from	May 1	
to	May 15	
to size 10g(#K)	130	100
in space(cu.m)	90(1 CR)	90(3 AR)
at flow(LPM)	1100	2250
from	May 15	May 15
to	Sep. 30	Sep. 30
to size 20g(#K)	50	25
in space(cu.m)	90(1 CR)	30(1 AR)
at flow(LPM)	1100	750
from	Sep. 30,1985	Sep. 30,1985
to	May 1,1986	May 1,1986

Notes
- Extended rearing space and flow requirements from LOAD-RATE model, assumptions 7.2°C, 95% O_2
- CR - concrete raceway
- AR - aluminum raceway

Table 18. Experimental Plan Rearing Strategy Summary for the Eagle River Facility (maximum requirements)

Event	Chinook	Coho
ADULT HOLDING		
Adult(#)	548	1016
in space(cu.m)	86	96
at flow(LPM)	2303	2540
from	Sep. 5	Oct. 30
to	Sep. 30	Nov. 30
INCUBATION		
Eggs(#K)	1350	1150
in trays (#)	270	137
in stacks(#)	36	19
at flow(LPM)	540	285
from	Sep. 6	Oct. 30
to	Jan. 31	Feb. 30
INITIAL REARING		
Fry(#K)	1215	1035
in space(cu.m)	85	55
at start flow(LPM)	2040	1320
at end flow(LPM)	4080	2640
from	Dec. 20	Jan. 20
to	May 1	May 20
FINAL REARING		
Fingerlings(#K)	885	825
in space(cu.m)	283	261
at start flow(LPM)	2132	1837
at end flow(LPM)	4562	3716
from	Apr. 1	May 1
to	Jun 25	July 30

Notes

- Final rearing requirements based on LOAD-RATE model (Appendix 5a), assumptions 7.2°C, 95% 0_2.

Table 19. Pilot Operation (1984-85) Flow Demand at the Eagle River Facility
(All flows are in LPM)

COMPONENT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INCUBATION												
Chinook	200								200	375	375	375
Coho	330	330									160	330
Total	530	330							200	375	535	705
INITIAL REARING												
Chinook	3360	3360										1680
Coho	2050	4100	4100	4100	4100							
Total	5410	7460	4100	4100	4100							1680
FINAL REARING												
Chinook	2200	5500	5500	5500	2750	1100	1100	1100	1100	1100	1100	1100
Coho						2250	2250	2250	2250	750	750	750
Total	2200	5500	5500	5500	2750	3350	3350	3350	3350	1850	1850	1850
ADULT HOLDING												
Chinook									1500			
Coho											2255	
Total									1500		2255	
GRAND TOTAL	8140	13290	9600	9600	6850	3350	3350	3350	5050	2225	4640	4235

Notes:

- Flow demands for chinook and coho Jan. - Apr. include requirements to rear targetted number of fry in 1985 to allow proposed assessment studies (final releases assumed to be May 1, 1986).

- note operational February water demand bottleneck which caused problems with water distribution and allocation to various components of the hatchery during this period.

Table 20. Projected Experimental Plan Flow Demand at the Eagle River Facility (All flows are in LPM)

COMPONENT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INCUBATION												
Chinook	270								270	540	540	540
Coho	285	285									150	285
Total	555	285							270	540	690	825
INITIAL REARING												
Chinook	2040	3000	3500	4080								2040
Coho	1320	1600	2000	2400	2640							
Total	3360	4600	5500	6480	2640							2040
FINAL REARING												
Chinook				2130	3000	4500						
Coho					2000	3000	3700					
Total				2130	5000	7500	3700					
ADULT HOLDING												
Chinook									2300			
Coho											2540	
Total									2300		2540	
GRAND TOTAL	3915	4885	5500	8610	7640	7500	3700		2570	540	3230	2865

Note: Experimental Plan demands reflect rearing fry to 5 g only

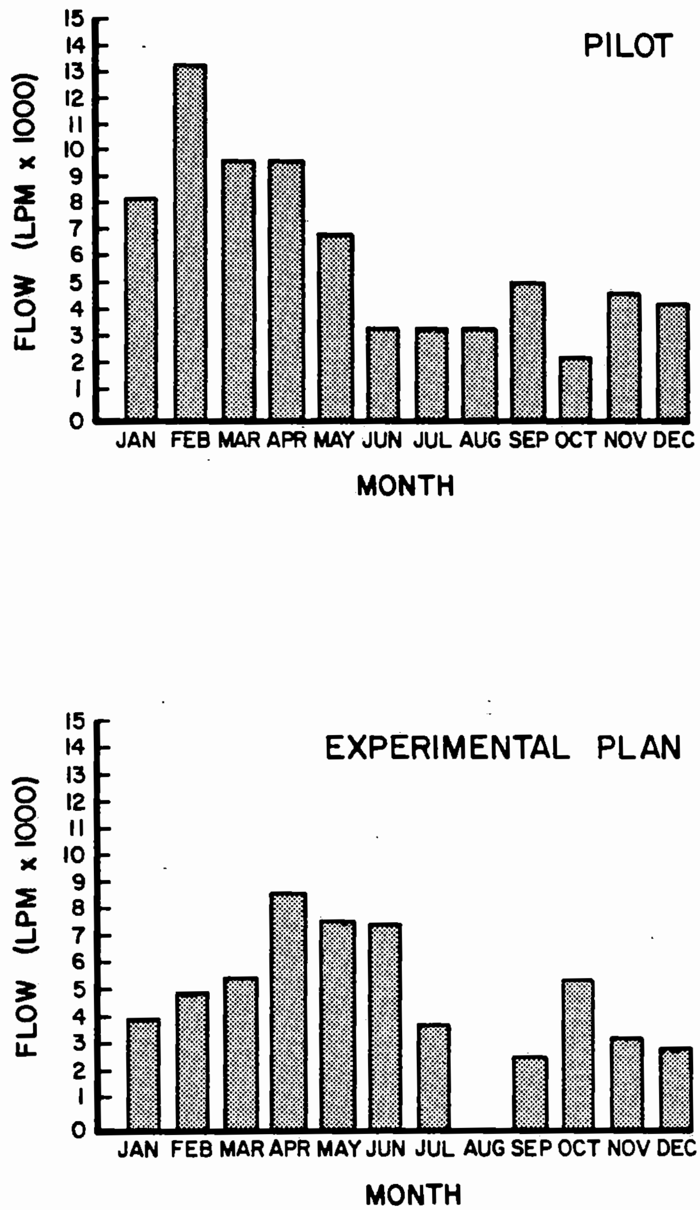


Figure 8 Flow Demands at the Eagle River Facility

WATER SUPPLY

WATER QUANTITY

Well Water

Presently, two wells are in operation at the Eagle hatchery, namely PW-E1 and PW-E2. The aquifer is capable of supporting several more high capacity wells should they be required (Piteau & Assoc., 1983). The original design memo assumed the present aquifer capability to be at least 9000 LPM.

The first well drilling program was carried out during March of 1980. Well PW-E1 was drilled at a diameter of 250 mm to a depth of 34 m and screens placed between 22.7 and 33.2 m.

Well PW-E1 was pump tested at 300 LPM for 72.5 hours, then developed and run for a one-year period prior to the Pilot hatchery operation.

Well PW-E1 currently pumps about 2760 LPM, although it was designed to produce 3600 LPM. The well capacity was estimated to be 6000 LPM, limited by the open area of the screen.

Drilling and development of a second well at the site (PW-E2) was conducted March 14 - May 4, 1983. Well PW-E2 is drilled to a total depth of 41.5 m and is 390 mm. in diameter. It has screens placed between 19.6 m and 25.9 m and between 31.8 m and 39.6 m.

Pumptests on Well PW-E2 were made May 6-11, 1984, at step drawdowns (4620, 5658, 6666, and 7056 LPM) for half an hour each and at a continuous rate of 6790 LPM for 94 hrs.

Well PW-E2 has a current output of about 6600 LPM, the maximum safe yield was estimated to be 8280 LPM with both wells in operation.

The output of both wells together (9660 LPM) is less than the maximum estimated yield 14280 LPM (Table 21) suggested by the groundwater consultants.

Both wells have steel casings with stainless steel screens.

The pump for Well PW-E1 is a submersible design, while that for Well PW-E2 is a vertical turbine design.

Emergency power for the Well PW-E1 pump is supplied by the mechanical room genset, while the Well PW-E2 pump has an independent right angle drive standby diesel housed in the pumphouse. Well #1 is on main power mainly supply backed by the genset. Well #2 is on a separate panel with separate standby diesel.

Well PW-E1 is supplied with a 200-250 mm diameter pipeline for water transport to the aeration tower. The size was adjusted with construction of the aeration tower in 1984 to accommodate a higher output pump in the future.

Well PW-E2 is supplied with a 350 mm diameter pipeline for water transport to the aeration tower.

Both pumps are gauged and have low water alarms. The flow meter for the pump in Well PW-E1 is a vertical upflow type, that for the pump in Well PW-E2 is a vertical downflow propeller meter.

Table 21 Well Characteristics at the Eagle River Facility

Well Number	Diameter of Casing (mm)	Screens Located Between (m deep)	Size of Pump Installed (hp)	Maximum Estimated Yield(LPM)
PW-E1	250	22.7 - 33.2	35 submersible	6000
PW-E2	390	19.6 - 25.9 31.8 - 39.6	75 vertical shaft turbine	8280
Total				14280

The present water supply appears to be sufficient to meet the requirements of the Experimental objectives. However, a chronic shortage occurred in 1985 during February when the incubation room, rearing building and aluminum raceways were all in operation. The 1984-85 operation cultured a total of 2362K eggs while the maximum requirement of the Experimental is about 2500K eggs. A similar shortage could occur during the Experimental program if too many fish are reared to a large size.

If total simultaneous use of all containers on site for rearing occurred, demand would be in excess of 15000 LPM. Another well with at least 5000 LPM capacity would provide the hatchery with enough flow to meet all operational situations with the as-built container set-up.

Another option available to alleviate the water shortage would be to supply a gravity feed pipeline to supply surface water from Crazy Creek. However, the chronic operational shortage occurred in late January through February, when thermograph records indicate that Crazy Creek averages only 0.0°C which may cause icing problems.

Surface Water

The facility is plumbed to distribute surface water to all points, although none is currently supplied. Crazy Creek has been estimated to be able to supply at least 18000 LPM (the minimum winter flow for the 1 in 100 year record) of gravity-fed surface water.

WATER QUALITY

Well Water

Water quality analysis results from testing on Well PW-E1 and PW-E2 are compared to the recommended values for intensive fish culture (Sigma, 1983) in Tables 22 and 23.

Both wells are low in dissolved oxygen (<40%) and high in dissolved nitrogen (>100%). Well PW-E2 is the worst case (14-21% oxygen, 117% nitrogen). The aeration tower at Eagle adequately improves these gas characteristics to levels acceptable to the fish.

Both well and surface waters at the site have a relatively high nitrate concentration and are phosphate limited. This led to early concerns that phosphate input to the Eagle River could substantially enhance periphyton growth. Algal bloom mats have been seen in outflow channel, but the effect of this extra nutrient loading on the Eagle River downstream has not been determined.

The Ryznar Stability Index for Well PW-E1 during tests indicated the water to be corrosive to metals. As all piping is made of plastic, this is not a concern.

Well PW-E1 is more slightly acidic (<6.6 pH) than recommended.

Table 22. Water Quality Values For Eagle Well #1 (Below Detection Limits=0)

PARAMETER	RECOMM.	TOXIC	MAR16/80 1.5 HRS WELL #1	MAR17/80 24 HRS WELL #1	PUMP TEST MAR18/80 48 HRS WELL #1	MAR19/80 72.5 HRS WELL #1	AUG04/82 EAGLE WELL #1
ALKALINITY	20-300		28.2	29.7	30.7	31	34
AMMONIA	<.002	>.08	0	0	0	0	.008
CO2	2-5	>20					
CHLORIDE	<170	>400	1.6	2.12	1.75	1.79	7.5
COLOR	<15		0	0	0	0	
COND.FIELD	150-2000		58	59	55	57	
COND.LAB	""		82.5	88	87.8	90.4	114
DO-PPM	>6-8	<4	4.3	4.1	4	4.2	
DO-%SATURATION	100%		36.9	35.8	33.7	35.5	
DGAS.TOTAL	<103%	>110%	92	93.7	94.3	94.2	
DGAS.NITROGEN	100%		106.6	109.1	110.5	109.8	
HARDNESS	20-400		35.8	36.5	38	38.9	54.4
H2S	<.002	>.004					
NITRITE	<.012	.2	0	0	0	0	0
NITRATE	<.12		.324	.387	.155	.245	.12
pH-FLD	6.8-8.5	<5,>9	6.5	6.4	6.4	6.6	
pH-LAB	""	""	6.4	6.4	6.5	6.5	6.7
PHOSPHATE	<.05		0	0	0	0	0
RESIDUE.TOTAL	<2000						
RESID.FIL	70-400		58	63	64	64	76
RESID.NONFILT	<3		0	0	0	0	17
SALINITY							
SILICA	<10-60		58	5.57	5.48	5.65	5.4
SULFATE	<90		0	8.2	8.25	7.9	9.5
TASTE	OK						
T.D.SOL	500-1000	15000	5.59				
TEMPERATURE	4-18C	<2,>25	7.7	7.1	7.3	7.4	
TURBIDITY	1-60	>1000		0	0	0	2.7
METALS--							
AL	<.1	>5	.118	0	0	0	0
AS	<.5	>1	0	0	0	0	0
BA	<1		.0079	.0056	.0058	.006	.006
CA	4-150	>300	11.3	11.6	12.1	12.4	13.8
CD	<.0004		.0022	.0011	0	0	.0007
CO			0	0	0	0	.007
CR	<.01		0	0	0	0	0
CU	<.006		.0066	.0026	.0026	.0028	.006
FE	<.3		.128	.026	.038	.019	6.38
HG	<.00005	>.0002	0	0	0	0	0
K		>50	1.26	1.23	1.28	1.28	1.5
MG	<10	>100	1.83	1.84	1.89	1.92	2
MN	<.05	>15	.0093	0	.0032	0	.017
MO			0	0	0	0	0
NA		>500	1.86	1.9	2.12	2.22	2.7
P			0	0	0	0	0
PB	<.01		0	0	0	0	0
SE		>2.5	0	0	0	0	0
SI	<10-60		5.85	5.58	5.78	5.77	5.7
SR			.0655	.0664	.0699	.0712	.079
TI			0	0	0	17	0
ZN	<.005		.0174	.0141	.0066	.008	.003

Table 23. Water Quality Values for Eagle Well #2 (Below Detection Limits=0)

PARAM.	RECOMM.	TOXIC	APR05/83 EAGLE WELL #2	PUMP TEST MAY07/83 2 HRS WELL #2	MAY07/83 7 HRS WELL #2	MAY07/83 11 HRS WELL #2	MAY08/83 24 HRS WELL #2	MAY09/83 48 HRS WELL #2	MAY10/83 72 HRS WELL #2	MAY11/83 96 HRS WELL#2
ALKALINITY	20-300		63	58.5	57.5	58	57	55	56	55
AMMONIA	<.002	>.08	.033	.02	.019	.018	.021	.022	.017	.014
CO_2	2-5	>20								
CHLORIDE	<170	>400	5.5	3.7	3.5	3.4	3.2	3.1	2.9	3
COLOR	<15									
COND.FIELD	150-2000									
COND.LAB	""		239	208	202	198	191	183	179	177
DO-PPM	>6-8	<4			2.4	2.3	2.1	1.7	1.6	
DO-%SATURATION	100%				22.27	21.08	19.18	14.76	14.26	
DGAS.TOTAL	<103%	>110%			98.32	96.5	96.65	95.57	95.31	
DGAS.NITROGEN	100%				118.5	116.5	117.2	117	116.8	
HARDNESS	20-400		92.9		72.5	68.6	67.7	66.5	65.1	
H_2S	<.002	>.004	PRESENT	PRESENT	PRESENT	PRESENT				
NITRITE	<.012	.2	0	0	0	0	0	0	0	0
NITRATE	<.12		0	.02	.06	.03	.09	.41	.06	.04
pH-FLD	6.8-8.5	<5,>9	8.3		8.75	7.75	7.7	7.45	7.25	
pH-LAB	""	""	8.2	7.8	7.7	7.7	7.6	7.6	7.6	7.5
PHOSPHATE	<.05		.229	.025	.007	.021	.079	.022	.019	.02
RESIDUE.TOTAL	<2000									
RESID.FIL	70-400		148	120	124	127	123	115	111	119
RESID.NONFILT	<3		143	0	0	0	0	0	0	8
SALINITY										
SILICA	<10-60		5.9	6	5.9	5.9	5.9	5.4	5.2	5.1
SULFATE	<90		38.5	32.4	31.2	30.4	28.4	27.1	24.9	23.9
TASTE	OK		BAD							
T.D.SOL	500-1000	15000								
TEMPERATURE	4-18C	<2,>25	9.5		9.7	9.2	9.2	8.7	8.6	
TURBIDITY	1-60	>1000	34	.1	.1	.1	.1	.1	.1	0
METALS--										
AL	<.1	>5	.95		0	0	.05	0	0	
AS	<.5	>1	0		0	0	0	0	0	
BA	<1		.042		.023	.022	.022	.021	.021	
CA	4-150	>300	26.5		24.2	22.9	22.5	22.1	21.7	
CD	<.0004		0		0	0	0	0	0	
CO			0		0	0	0	0	0	
CR	<.01		0		0	0	.024	.015	.022	
CU	<.006		.061		.001	0	.006	0	0	
FE	<.3		4.17		.095	.049	.079	.053	.039	
HG	<.00005	>.0002	0		0	0	0	0	.0002	
K		>50	3.42		1.81	1.72	2.19	2.22	1.99	
MG	<10	>100	3.3		2.8	2.7	2.6	2.6	2.6	
MN	<.05	>15	.118		.056	.052	.058	.104	.07	
MO			0		0	0	0	0	0	
NA		>500	15		11.8	10.8	10.1	10	9.1	
P			.1		0	0	0	0	0	
PB	<.01		.003		0	0	0	0	0	
SE		>2.5	0		0	0	0	0	0	
SI	<10-60		6.7		5.7	5.6	5.6	5.6	5.6	
SR			.193		.168	.16	.155	.152	.148	
TI			.047		0	0	.002	0	0	
ZN	<.005		.008		.03	0	.012	.01	.004	

Heavy metal concentrations could be of concern at Eagle. High levels of zinc have been detected in both well waters. Well PW-E2 has consistently high levels of manganese (>0.05 mg/l). The recommended levels of copper and iron have been exceeded in certain samples from both wells. Cadmium has been exceeded in samples from Well PW-E1, while chromium has been exceeded in Well PW-E2. However, heavy metals detections have been sporadic and inconsistent, so no clear interpretation can be made without further sampling.

Hydrogen sulphide (H_2S) was detected from Well PW-E2 samples and is periodically evident by its odor inside the aeration tower. Although H_2S presumably blows off during aeration, it is very toxic and may have played a part in high mortalities in 1985.

In December 1984, Well PW-E2 water was tested for possible adverse effects on eggs and alevins. The water did not immediately have undesirable effects on the fish.

The water quality from Well PW-E1 is generally good with some reservations as to periodic, marginally high heavy metal levels. The water from Well PW-E2 has proven to be worse than originally thought and should either be revamped to tap the same aquifer as Well PW-E1 or be replaced.

Surface Water

Water quality results from Eagle River and Crazy Creek sampling are shown in Tables 24 and 25, respectively, compared to the recommended limits for intensive fish culture (Sigma, 1983).

Both surface water sources show high nitrate content indicating that simple dilution of hatchery effluent water may not be good enough to eliminate downstream, eutrophying effects.

The level of chromium was exceeded in one sample from the Eagle River. Generally, the water quality from both surface water sources is good.

WATER TEMPERATURE

Well Water

The temperature of well water at the Eagle hatchery has been very stable at 7.2 - 7.4°C during the first two years of operation.

Table 24. Water Quality Values for the Eagle River (Below Detection Limits=0)

PARAMETER	RECOMM.	TOXIC	MAR18/80 EAGLE RIVER	APR21/81 EAGLE RIVER	MAY27/81 EAGLE RIVER	JUN30/81 EAGLE RIVER	JUL21/81 EAGLE RIVER	AUG25/81 EAGLE RIVER	SEP24/81 EAGLE RIVER	OCT20/81 EAGLE RIVER	MAY09/83 EAGLE RIVER
ALKALINITY	20-300		23.3	21.5	15.4	16.3	16	24.3	23.4	20.9	19.5
AMMONIA	<.002	>.08	0	0	0	0	0	.0072	.021	.0056	.006
CO2	2-5	>20									
CHLORIDE	<170	>400	1.68	.65	.81	.54	.827	.85	.53	.78	.6
COLOR	<15		5								
COND.FIELD	150-2000										
COND.LAB	""		75.7	58	44.7	43.5	48	70	65	61	55.7
DO-PPM	>6-8	<4	13.2								
DO-%SATURATION	100%		97.1								
DGAS TOTAL	<103%	>110%	102.2								
DGAS NITROGEN	100%		103.6								
HARDNESS	20-400		28	24.8	18.2	17.1	18.6	28.3	26.9	24.7	23.5
H2S	<.002	>.004									
NITRITE	<.012	.2	0	0	0	0	0	0	0	0	0
NITRATE	<.12		.309	.13	.12	.061	.0479	.169	.061	.073	.19
pH-FIELD	6.8-8.5	<5,>9	6.9								
pH-LAB	""	""	7.2	7.4	7.1	7.3	7.5	7.6	7.6	7.9	7.3
PHOSPHATE	<.05		.005	.009	.018	0	.0118	.0061	.01	0	.008
RESIDUE TOTAL	<2000										
RESID.FILT	70-400		55	49	40	43.5	48	49	51	47	40
RESID.NONFILT	<3		0	0	22	0	0	0	0	0	8
SALINITY			0								
SILICA	<10-60		5.58	3.27	3.2	2.6					
SULFATE	<90		9.7	5.3	4.8	4.5	4.2	8.8	7.3	7.7	6.5
TASTE	OK										
T.D.SOL	500-1000	15000									
TEMPERATURE	4-18C	<2,>25	2	7	8	9	12.5				8.2
TURBIDITY	1-60	>1000	0	1.8	3.6	0	1.3	0	0	0	.5
METALS—											
AL	<.1	>5	0	.262	.463	.105	0	0	0	.07	
AS	<.5	>1	0	0	0	0	0	0	0	0	0
BA	<1		.0096	.0119	.0106	.0065	.0083	.009	.0088	.0083	.008
CA	4-150	>300	9.6	7.85	5.74	5.49	5.93	9.23	8.78	7.93	7.5
CD	<.0004		0	0	0	0	0	0	0	0	
CO			0	0	0	0	0	0	0	0	0
CR	<.01		.022	0	0	0	0	0	0	0	0
CU	<.006		0	0	.0017	0	0	0	0	0	
FE	<.3		.092	.325	.479	.107	.129	.0946	.0796	.0735	.063
HG	<.00005	>.0002	0	0	0	0	0	0	0	0	0
K		>50	.935	.904	.752	.613	.63	.846	.848	.802	.8
MG	<10	>100	.98	1.27	.93	.82	.92	1.28	1.22	1.18	1
MN	<.05	>15	.0048	.0121	.0106	.0038	.0054	.003	.0028	0	0
MO			0	0	0	0	0	0	0	0	0
NA		>500	1.63	1.25	.86	.76	.75	1.26	1.27	1.11	1.1
P			0	0	0	0	0	0	0	0	0
PB	<.01		0	0	0	0	0	0	0	0	
SE		>2.5	0	0	0	0	0	0	0	0	0
SI	<10-60		3.79	4.13	2.83	2.58	2.51	3.34	2.97	3.24	3.2
SR			.0561	.0518	.0329	.0295	.0316	.047	.047	.0434	.04
TI			0	.0179	.037	0	.0131	.009	.0095	0	0
ZN	<.005		0	.0011	.0021	0	.0013	.0013	0	0	

Table 25. Water Quality Values for Crazy Creek (Below detection limits=0).

PARAMETER	RECOMM.	TOXIC	Aug22/79	Nov29/79	Mar18/80	Apr17/80	Jul21/80	Jul25/82	Aug22/82	Sep13/82	Oct15/82
ALKALINITY	20-300		22.9	24.3	20.9	14.5	17	15	18.5	17	21
AMMONIA	<.002	>.08	0	0	0	0	0	0	0	0	0
CO2	2-5	>20									
CHLORIDE	<170	>400	0	.5	0	0	0	0	0	.6	0
COLOR	<15		0	0	0	15					
COND.FIELD	150-2000				40						
COND.LAB	""		61.2	66.9	56.2	37.4	43.7	37	45.8	40.4	48.1
DO-PPM	>6-8	<4			13						
DO-%SATURATION	100%				98.5						
DGAS.TOTAL	<103%	>110%			102.6						
DGAS.NITROGEN	100%				103.7						
HARDNESS	20-400		16.9	28.4	26	18.5	19.4	16.1	19.1	17.6	20.6
H2S	<.002	>.004									
NITRITE	<.012	.2	0	0	0	0	0	.006	0	0	0
NITRATE	<.12		.119	.208	.179	.209	.0776	.09	.17	.09	.12
pH-FLD	6.8-8.5	<5,>9			6.8						
pH-LAB	""	""	7.5	7.4	7.3	7.1	7.1		7.6	7.2	7.5
PHOSPHATE	<.05		0	0	0	0	0	0	.005	0	0
RESIDUE.TOTAL	<2000										
RESID.FIL	70-400		47	28.4	44	33	35	30	32	41	43
RESID.NONFILT	<3		0		0	0	0	5	0	0	6
SALINITY					0						
SILICA	<10-60		2.9	3.6	3.33	3.1	2.55	2.2	2.8	2.7	2.4
SULFATE	<90		5.18	6.95	5.25	3.9	3.6	3.2	5.1	4	4.8
TASTE	OK										
T.D.SOL	500-1000	15000									
TEMPERATURE	4-18C	<2,>25									
TURBIDITY	1-60	>1000	0	0	0	1.6	1	0	0	0	0
METALS--											
AL	<.1	>5	0	0	0	.159	0	.06	.05	.06	0
AS	<.5	>1	0	0	0	0	0	0	0	0	0
BA	<1		0037	.0141	.0136	.0065	.015	.01	0	.011	.012
CA	4-150	>300	5.94	8.32	7.76	5.71	6	4.9	6	5.2	6.3
CD	<.0004		0	0	0	0	0	0	0	0	0
CO			0	0	0	0	0	0	0	0	0
CR	<.01		0	0	0	0	0	0	0	0	0
CU	<.006		0	0	0	0	0	0	0	0	0
FE	<.3		.018	0	.012	.095	.019	.025	.018	.042	.01
HG	<.00005	>.0002	0	0	0	0	0	0	0	0	0
K		>50	1.1	.963	.852	.716	.757		.83	.74	.89
MG	<10	>100	.492	1.85	1.62	1.04	1.08	.9	1	1	1.2
MN	<.05	>15	0	0	0	0	0	0	0	.005	.001
MO			0	0	0	0	0	0	0	.005	0
NA		>500	1.1	1.28	1.02	.635	.694	.5	0	.7	.9
P			0	0	0	0	0	0	0	0	0
PB	<.01		0	0	0	0	0	0	0	0	0
SE		>2.5	0	0	0	0	0	0	0	0	0
SI	<10-60		2.41	2.81	3.5	3.03	2.53	2.4	2.5	2.3	2.6
SR			.0372	.0392	.0369	.0232	.0258	.021	.027	.023	.029
TI			0	0	0	0	0	0	0	.002	0
ZN	<.005		0	0	0	0	0	0	0	0	0

Heat losses during winter in the aeration tower sometimes depress the temperatures to 7.0°C.

During the initial operation of Well PW-E2, water temperature was 9.0°C, but later stabilized to a constant 7.2 - 7.4°C, similar to Well PW-E1.

Surface Water

Crazy Creek water temperature was monitored in 1979 - 1980 using a Ryan thermograph (Table 26).

The mid-winter temperature dropped to 0.0°C, which might cause pipe icing if this source were used to supplement well output during these periods. The maximum summer temperature recorded was 13°C.

Mean monthly spot temperatures recorded for the Eagle River at Malakwa indicate a maximum of 23.5°C in August and a minimum of 0°C in mid winter.

Table 26. Monthly Mean Water Temperatures at the Eagle River Facility

Month	Wells	Crazy Creek	Eagle River
January	7.2	0	0
February	7.2	0	0.6
March	7.2	No data	2.8
April	7.2	3.6	4.6
May	7.2	5.3	7.2
June	7.2	7.3	9.8
July	7.2	9.1	10.7
August	7.2	12.9	13.6
September	7.2	9.6	12.0
October	7.2	5.9	6.3
November	7.2	0.9	3.2
December	7.2	0	0.5

SUPPORT STRUCTURES

HATCHERY BUILDING

The Eagle River facility hatchery building is 28 m by 17 m (476 m^2). Compared to those of other recently constructed facilities (Table 27), its room sizes are slightly smaller than average. Egg capacities are given as an indication of the overall size of the facilities. Refer to the building layout (Figure 9) for the following discussion.

Table 27 Building Component Sizes - Eagle compared to other Recently Constructed SEP Facilities (m^2)

Facility	Egg[a] Capacity (M)	Office Area	Lab. Area	Work shop Area	Lunch Storage Area	Wash Room Area	Lobby Area	Room Area
Eagle	6	41	26	72	40	23	10.5	22
Chehalis	18	53	52	94	152	22	16	14
Chilliwack	7	43	69	80	41	24	17	17
Conuma	25	22	28	65	252	24	0	15
Inch	10	62	15	157	110	27	0	17
Kitimat	14	53	44	160	29	18	23	41
Nitinat	29	54	19	88	9	22	18	37
Puntledge	22	28	38	144	23	23	27	19
Quesnel	4	18	15	70	10	12	0	10
Spius	4	26	18	81	7	15	0	11
Means		40	32	101	67	21	11	20

[a] egg capacity for Eagle is potential, currently it is 2.5 - 3 million.

The incubation room presently measures 10 m by 8.5 m (80.5 m^2). A 7 m by 8.5 m (60 m^2) area adjacent to it, plumbed and available for future incubation expansion, is currently used as a tagging and fin-clipping room. Two Capilano troughs are provided in the tagging room for fry handling.

In the tagging room, tables and space are provided to accommodate a crew of four CWT machine operators and eight fin-clippers.

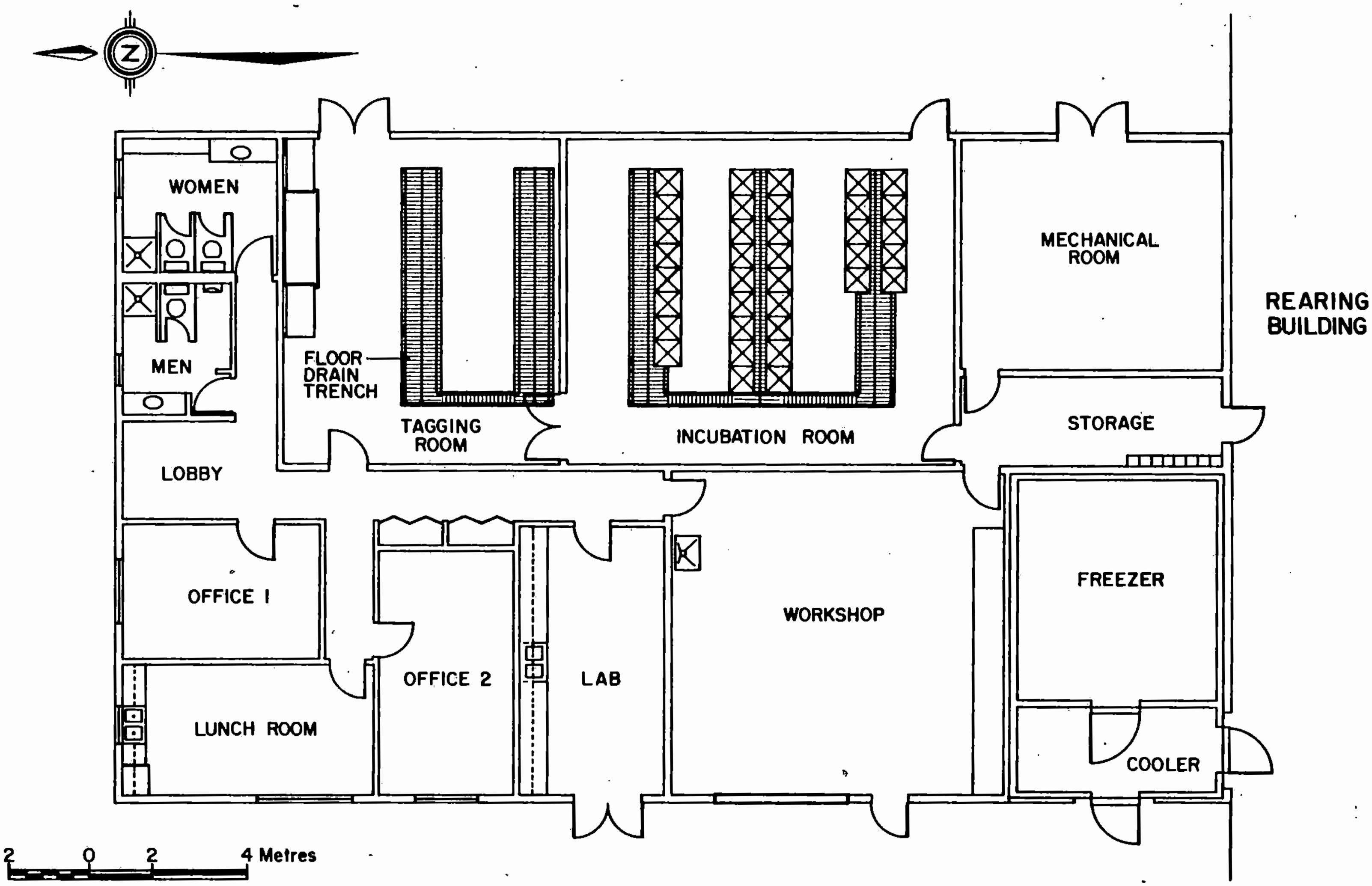


Figure 9 Eagle River Hatchery Building Layout

Both the incubation room and tagging room are plumbed for surface water supply, although none is provided presently.

A laboratory (7.0 m by 3.7 m; 26 m^2) is located down a hallway from the entrance to the tagging room. It is used for microscope work, weighing, chemical storage and mixing. One bank of sinks has been mounted along one wall and plumbed.

Two large office areas have been provided, including the manager's, (3.5 m by 5 m; 18 m^2) located adjacent to the entrance lobby, and a general office used by hatchery staff (3.5 m by 6.5 m; 22.75 m^2). Both are supplied with large work tables and a desk. The general office has an Apple IIe computer and Epson printer for data storage and retrieval.

The staff lunchroom measures 6.5 by 3.5 m (22.75 m^2) and is supplied with a table, microwave oven, fridge, cupboards and coffee maker.

The workshop is 8.5 m by 8.5 m (72 m^2) and is supplied with a large overhead door, workbenches, cabinets and a janitor's sink.

One pair of men's and women's washrooms has been provided in the facility for use by staff and visitors. Both have shower facilities.

The mechanical room (6 m by 6.5 m; 39 m^2) contains the emergency power genset, the pump #1 control panel, the alarm panel, and electrical panels.

The freezer area measures 5 m by 6 m (30 m^2) with 22680 kg capacity and has a separate 5 m by 2 m (10 m^2) walk-through cooler area for food weighing and daily ration storage.

REARING BUILDING

The open-sided, covered rearing building (Figure 10) adjoined to the hatchery building to the south measures 33 m x 17 m (560 m^2). A covered initial rearing area was requested because of the heavy snowpack in the area (e.g. 3 m deep 1984-85).

In 1984, this structure housed 28 Capilano troughs. Construction in 1985 incorporated eight Capilano troughs and eight large starter units.

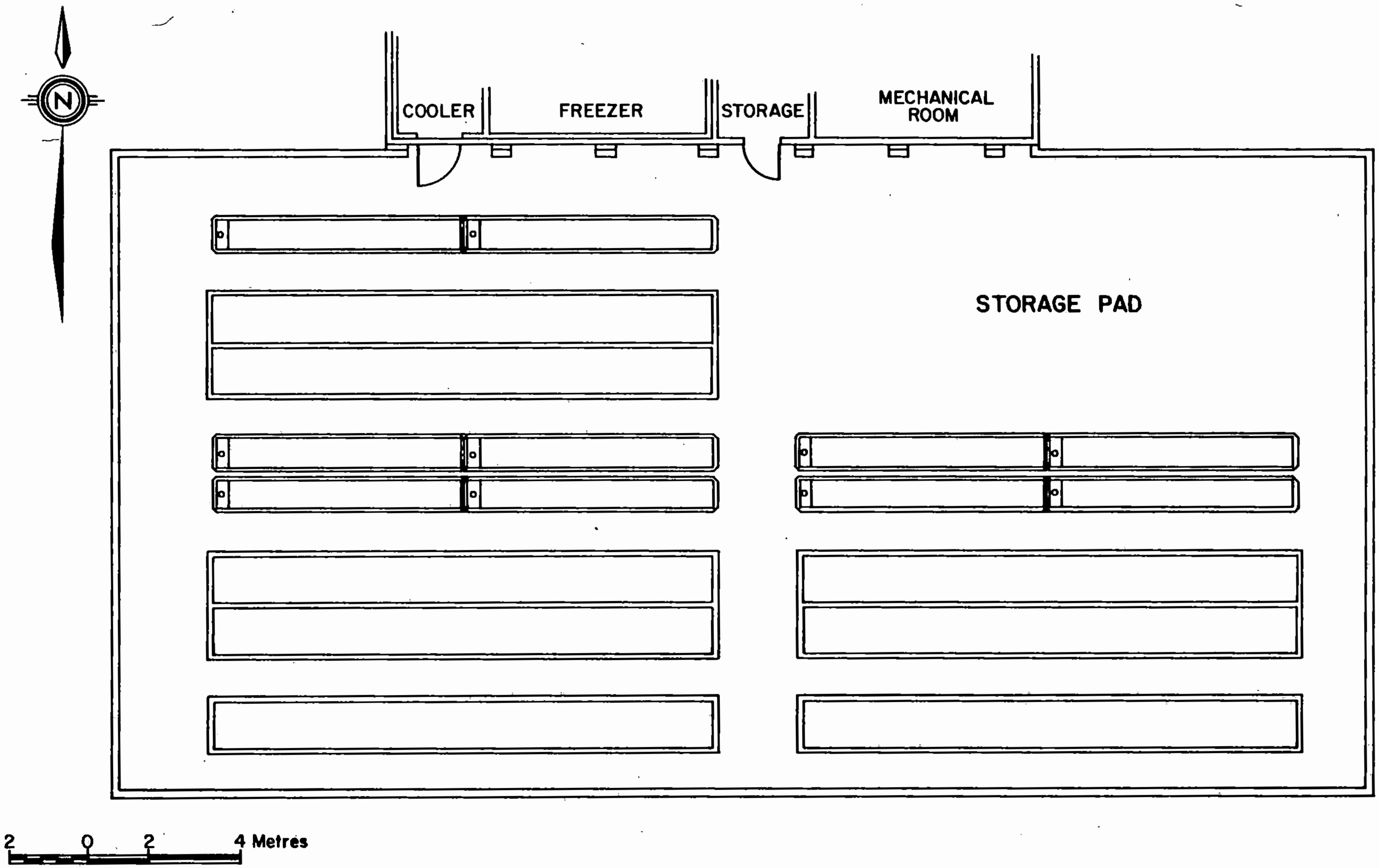


Figure 10 Eagle River Hatchery Rearing Building Floor Plan

The rearing building is a structure made of steel posts and tie rods with turn buckle cross bracing, with a steel sheet, peaked roof. The floor is a 100 mm thick concrete slab.

A concrete pad for vehicle and equipment storage (8.4 m x 16 m; 135 m^2) has been left in the unused north-east corner of the structure. This area can be used for potential container additions.

PUMP HOUSES

The pumphouse at Well PW-E1, located to the east of the hatchery, was built for the pilot facility and is plywood clad with a sloped roof.

The pumphouse at Well PW-E2, located to the west of the hatchery, was built during expansion in 1984. It is a pre-finished metal clad structure with a peaked roof.

AERATION TOWER

The aeration tower at the Eagle River hatchery (Figure 11) serves to improved dissolved gas characteristics and to distribute water to the facility.

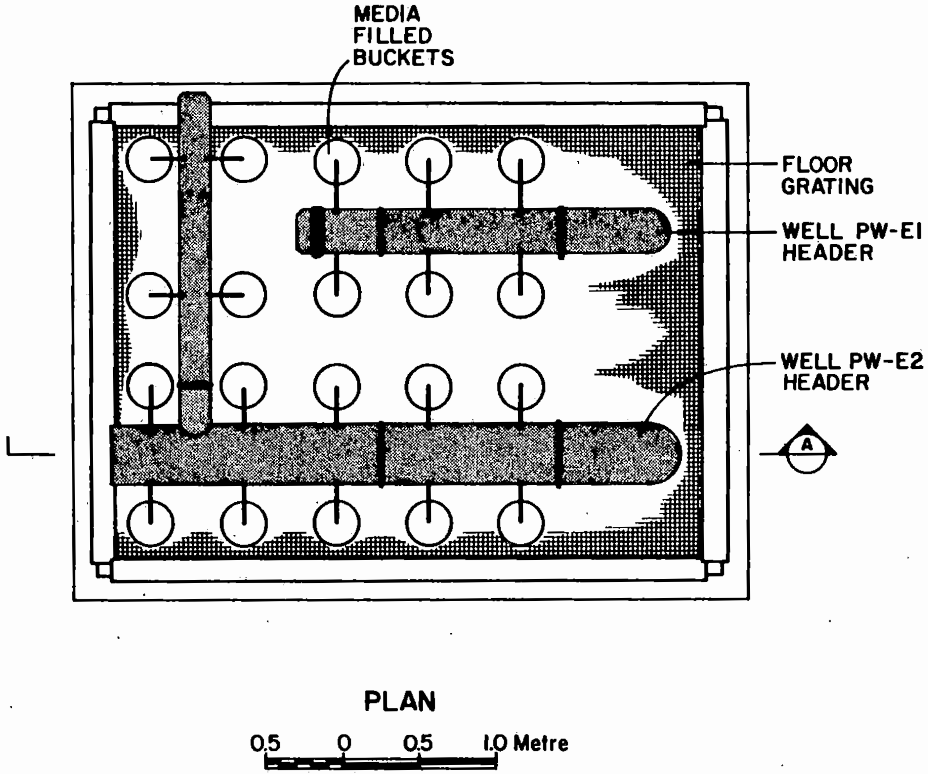
The tower is a square concrete tank with a metal access ladder up to a steel-roofed, aluminum louvered tower. Head tank walls are 300 mm thick concrete.

Water from both wells is pumped to the top of the tower and distributed via manifolds to 20 columns of bucket aerators.

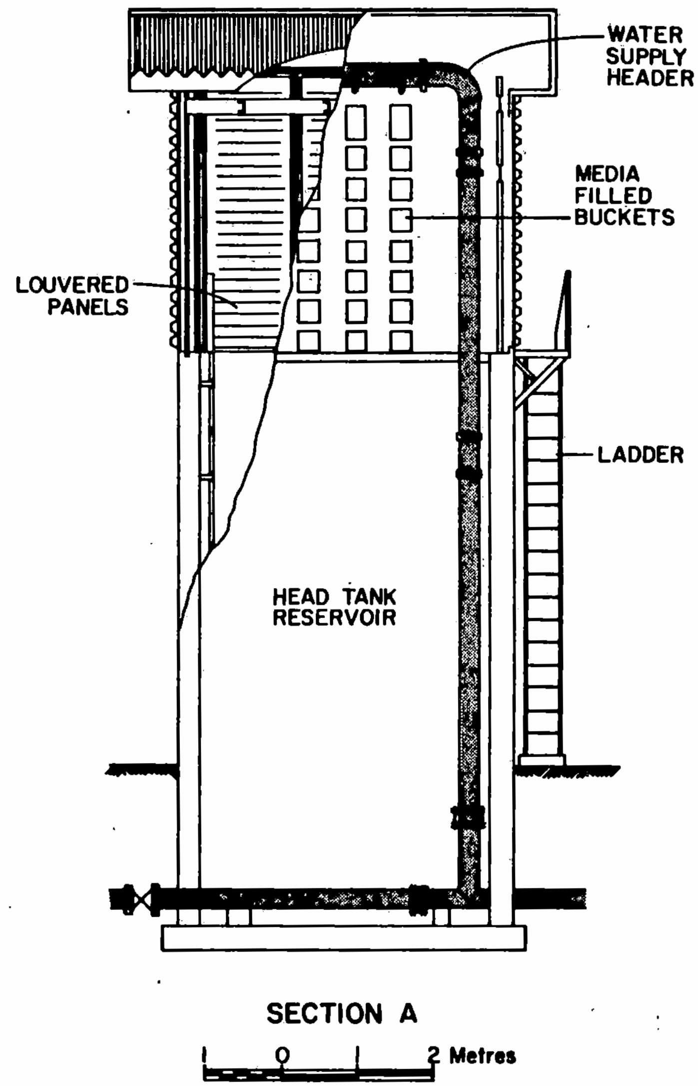
Water from each well is distributed to separate headers and columns within the tower. Well PW-E1 water is distributed to six columns, Well PW-E2 water goes to the remaining 14, which are arranged at right angles (Figure 11).

The columns are set in pairs on eight supporting steel poles, and singly on four poles.

Each of the 20 packed columns has one double and seven single aerator pots for water distribution and aeration. The pots are filled with 38 mm diameter 'Bio-rings' which rest on an aluminum screen across the pot bottom. The rings are plastic cylinders designed to maximize the breaking up of falling water into



PLAN



SECTION A

Figure 11 Aeration Tower Details at the Eagle River Facility

small droplets to afford the greatest exposure of water surface area to the atmosphere. The Aeration Model (Appendix 5c) was used to determine how many segments to use.

Once aerated, water from both wells was previously mixed in a common distribution chamber. Separate distribution chambers now allow isolated supply of each of the well waters at the fish culture containers.

From the distribution chamber, a 200 mm pipe transports water to the aluminum raceways, a 300 mm pipeline to the intermediate rearing area, a 400 mm pipeline to the concrete raceways and a 250 mm pipeline to the incubation room.

The temporary aeration tower used in 1983 and replaced in 1984 was toppled by heavy snow pack which slid off the hatchery building roof during the 1984-85 winter.

CREW RESIDENCE

A 4.3 m by 18.3 m (78.7 m^2) mobile trailer is provided as living area for personnel on standby at the site. It is supplied with laundry facilities, a kitchen with microwave, range and fridge, three beds in two bedrooms and living room furniture including television. It is situated approximately 100 m southeast of the hatchery building and supplied with a septic tank and field.

FISHWAY

All effluent water flow exits the property via a channel located to the east of the facility. At present no adult transport and collection structures have been supplied to allow adults to swim into the hatchery. It has been assumed that adult collection at the fence sites and at remote in-stream locations would be adequate for the foreseeable future.

For adults to return to the hatchery, the outlet channel would have to be modified by culvert replacement under the Taft Road. Hatchery effluent flows will likely have to be increased and the exit channel deepened.

EFFLUENT LAGOON

At present, the hatchery effluent flows through an outlet channel to the west of the property into a large (approximately 100 m diameter by 1 m deep) natural swamp area. From here the water flows under the Taft roadbed through a culvert via a 1 m wide channel into the Eagle River.

The B.C. Waste Management Branch (WMB) has inspected the site and found the swamp suitable as an effluent lagoon for the present hatchery size. Algal growth is apparent on the lagoon substrate.

All raceway vacuum cleaning material is disposed of on dry land adjacent to the facility.

Because the Eagle River is high in nitrate and is phosphate limited, there was early concern that an increase in phosphate loading may cause enhanced periphyton growth in hatchery effluent receiving waters. This effect has not been evaluated to date.

SITE FENCING

At present, no site fencing is provided at the Eagle hatchery. The only security structure in place is a chain link gate across the access road from Highway No. 1.

According to the staff, these existing security measures are not adequate in the light of vandalism prevalent in the area and personnel are required to be on site at all times.

CONCLUSION

PROJECT COMPLETION

In general, the Eagle River project development has been successful to date. However, future expansion could be at risk with the existing water supply due to the limited flow, lack of back-up and questionable water quality.

The following is an unpriorized list of needs associated with the existing facility as related by the hatchery manager (Appendix 6).

- separate public washrooms
- security fencing around hatchery grounds

- paving around existing concrete raceways
- fry outlet screens for the aluminum raceways
- outside walls on the intermediate rearing building
- storage shed for boats, vehicles and equipment
- access road improvement
- outside display shelter for public information
- snow shed for residence trailer

FUTURE DEVELOPMENT

For expansion of the facility the following are needed:

- a surface water supply pipeline from Crazy Creek
- a third well, as the existing two have insufficient flow to supply the rearing raceways and the hatchery building all at the same time during the critical period from the end of January through February
- a larger culvert from the effluent lagoon to the Eagle River to allow adults to enter the hatchery
- an engineered effluent lagoon may be required, depending on the results of the effluent monitoring program as recommended by the Waste Management Branch of the B.C. Ministry of the Environment.

Future expansion of the Eagle hatchery to a large scale, production mode should not proceed without a complete assessment of the following:

1. Manageability of the enhanced fish produced.
2. Review of the experimental return data in order to select the optimal enhancement strategies.
3. Determination of the actual carrying capacities of the Eagle, Salmon and other outplant systems.
4. Long term monitoring of the groundwater aquifer production in terms of water yield, quality and temperature.

ACKNOWLEDGEMENTS

The Eagle River project design team was made up of the following individuals:

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APPENDICES

APPENDIX 1. DESIGN MEMOS

a. Original Full Scale Facility Design Memo

b. Senator's Package Pilot Design Memo

c. Experimental Pilot Proposal

d. Gross Sizing of Experimental Plan

e. Detailed Flows for Experimental

APPENDIX 1a. ORIGINAL FULL SCALE FACILITY DESIGN MEMO

TO / À: A.F. Lill, J. McNally, W. Peterson
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FROM / DE: F.K. Sandercock, B.G. Shepherd, D.D. MacKinlay
Facility Operations
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SECURITY - CLASSIFICATION - DE SÉCURITÉ	
OUR FILE/NOTRE RÉFÉRENCE	5903-85-E7,
YOUR FILE/VOTRE RÉFÉRENCE	
DATE	July 31, 1981.

SUBJECT / OBJET: RE: BIOLOGICAL CRITERIA FOR EAGLE FACILITY (WITH GENERAL SIZING FOR SOUTH THOMPSON STOCKS).

This memo is meant as a first-pass working paper for the establishment of tentative water demand curves and facility sizings for the South Thompson stock complex, with detailed emphasis on a 'small' facility to be constructed in 1981-82.

PROJECT OBJECTIVES AND CONSTRAINTS:

The following key assumptions affecting objectives and strategy have been used in this work-up:

1) Stocks and maximum targets (Table 1) are those proposed in the Harrison memo of February 27, 1980, on file 5830-13-1.

2) Within the combined manageability/enhancement strategy document prepared by Schouwenburg _et al_, the Fraser River G.W.G. has requested that coho enhancement focus on 'semi-natural' techniques. In an attempt to satisfy this request, and to minimize potential effluent problems (see item 9, below), outplant of coho fry at 2g has been examined as the primary option. As alternate strategy of holding fry over any low summer flow 'bottleneck' and releasing in the fall at 5g has been only generally addressed as it appears to be the general consensus that present natural rearing habitat in the Thompson is underutilized, and extended hatchery operation would increase its pollution potential significantly.

/2

3) In order to investigate the assumptions in (2) above, and to refine outplant techniques, the first step is envisioned as a 'small' facility dealing with Eagle and Salmon chinook and coho stocks only, with the hatchery staff committed to detailed assessment of the success of the outplant procedures employed in the initial years. Regardless of the success of the outplant program, the additional incubation space required could be utilized in any future expansion.

4) Stocks to be dealt with at the 'large' Eagle facility have been tentatively identified in Table 1, on the bases of stock size and geographic grouping (although it is suggested that the South Thompson stock could stand alone, if a suitable site was found). Other stocks considered 'extra' have been included in this analysis in case of future inclusion in the Eagle complex. but it is presently assumed that they will be handled by other facilities or programs in the area.

5) For the purposes of optimizing siting of the 'small' facility with reference to the 'large', a worst-case option (from the point of view of space requirements) of one-year rearing for coho also has been worked up for the 'small' facility. The 'large' facility similarly has been examined on the basis of full rearing.

6) Further production assumptions are outlined in the attached production forecasts (Appendix 1).

7) The facility can be supplied with at least 18,000 LPM (minimum winter flow/1 in 100 yr) gravity-fed surface water from Crazy Creek (temperature data from 1979-80

thermograph records are summarized in Fig. 1). In addition, the existing 25cm well can provide 3000 LPM of pumped groundwater at 7.0 -7.5°C relatively constant temperature (based on pumptest data and operating experience of nearby trout farm of B. Cullis); ultimate aquifer capability is estimated to be 9000 LPM minimum.

8) Well water must be treated to meet culture criteria of <95% O_2 and > 102-103% N_2, or the loading rates used will be inappropriate.

9) According to HPU, (Nassichuk-Lill memo of March 6, 1981), the Eagle system is probably phosphate-limited, and conventional hatchery operations between August and March may produce undesirable benthic algal accumulation in downstream areas. HPU has recommended that techniques to reduce effluent phosphorus concentrations be investigated for this facility.

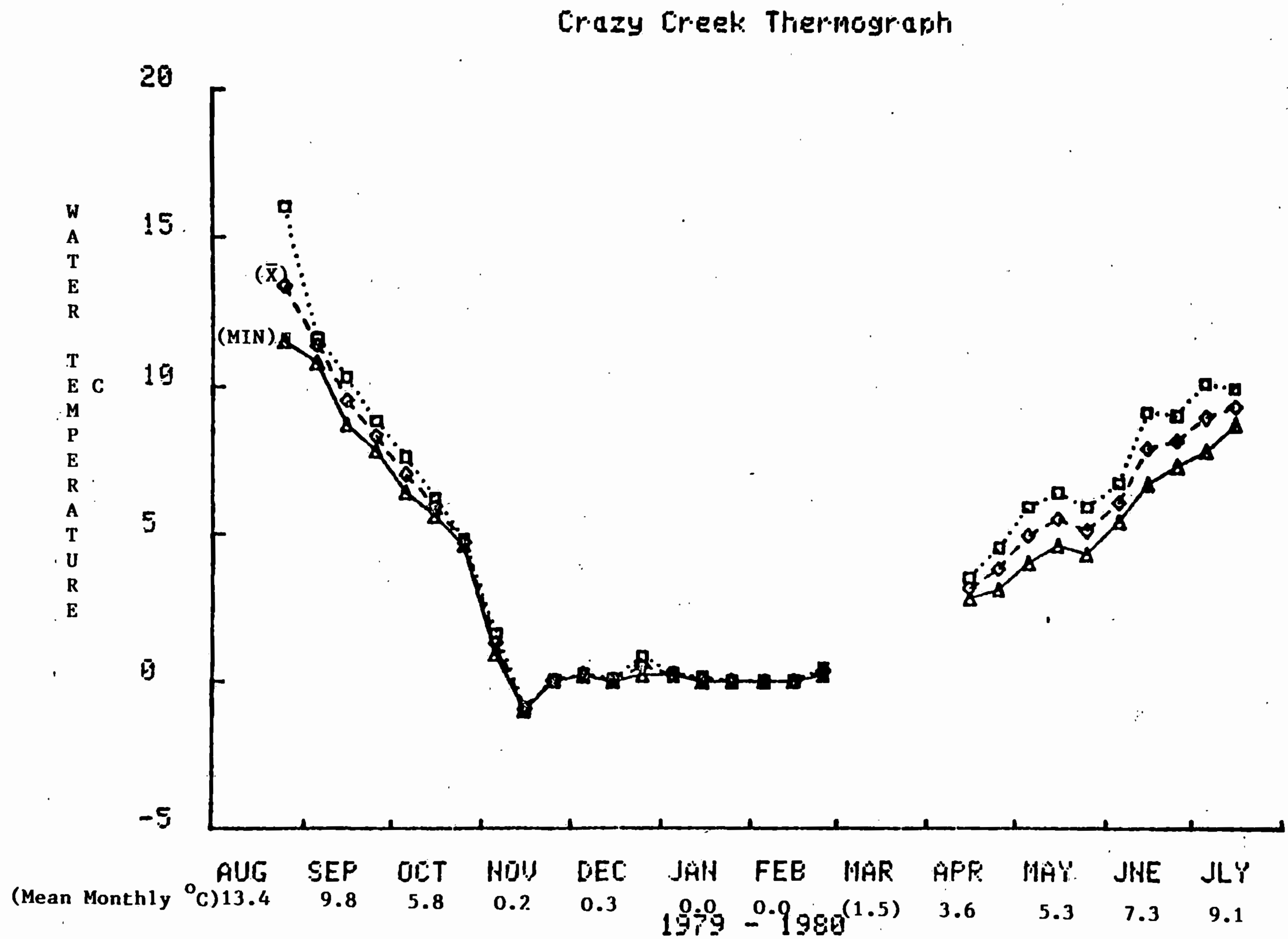
BIOLOGICAL REQUIREMENTS

For clarity of presentation, design details are discussed for the 'small' 2g coho outplant ~~raceway~~ first, followed by sections dealing in a more general manner with the requirements of a 'small' 5g coho outplant facility, a 'small' one-year coho rearing option, and a 'large' expansion. Adult arrival and spawning timings (Table 2A) were taken from F381 spawning files. Wild emergent fry downstream migration timings for 1981 were provided by E.V.S. Consultants (Table 2B-P. Delaney, pers. comm.). Incubation timings were calculated using ATU listed in Table 3; also each species range has been evaluated as to the relative contributions of subgroups of different timing.

OPTION 1. 'SMALL' FACILITY (2g COHO OUTPLANT)

An overall summary is presented in Table 4; requirements are further detailed by phase below.

Figure 1: Eagle River Project - S.   :y of available temperature data



Incubation

Equipment
- both CN and CO to be held to swim-up stage in Heath trays
- 19 8-tray Heath stacks for CN (Table 5A) and 68 8-tray Heath stacks for CO (Table 5A) are required, for a total of 87 8-tray stacks (no double-use possible; see flow requirements below).

Flows
- note also that Eagle/Salmon stock separation must be maintained
- requirements are outlined in Tables 5A and 6A for both routine (volume demand) and flush (size pipes to provide in short-term) flows;

  overall maximum demands in LPM are:

Flow	CN	CO	Total
Routine	285	1020	1305
Flush	361	1292	1653

- routine source for incubation should be exclusively well water (Table 4) but full backup with surface water is required for emergency situations, and to allow temperature adjustment (ie, delay hatching) during incubation as required.
- maximum duration of incubation is projected to be October 27-March 21 for CO and September 7-February 19 for CN (Table 3).

Rearing, Swim-up to 2g

Equipment
- both CN and CO could be ponded exclusively into Capilano-style troughs; however, this would dictate excessive numbers of troughs (14 troughs/7 lines CN, 70 troughs/36 lines CO) from the point of view of operating logistics

- the preferred alternate strategy would be to pond CN directly into shallow raceways at the upper end of the CN rearing channels, and to locate similar start-up raceways for CO at the head end of future potential CO channels. This would require a minimum of 4 start-up raceways to provide species and stock separations, each capable of being partitioned with fry-proof screens into at least thirds. Those for coho would require additional partitioning and provision for crowding and transfer of fry into trucks at the downstream ends (eg, crowder screens, sump). Total raceway volumes (see Table 7) required are:

Stock	CN	CO
Eagle	$20m^3$	$129m^3$
Salmon	15	89
Total	35	218

Flows - start-up raceway requirements are outlined in Table 7;
- maximum overall flows required are 1463 LPM for CN and 7996 LPM for CO (not additive due to differential overlap.)
- routine source again is exclusively well water, but requiring full surface water backup and mixing capabilities.
- rearing to 2g will span February 9-June 24 for coho and January 15-May 5 for chinook (Table 4).

Final Rearing (Chinook only, 2g to 5g)

Equipment - channel type could be concrete or earthen, but must be amendable to crowding and transfer of fish into tank trucks (ie, crowder screens, concrete sumps at lower end), at least for the Salmon River stock.

- sizing calculations (Table 8) give volume requirements of $99m^3$ for Eagle stock and $71m^3$ for Salmon stock or 170 m^3 total. Assuming that the start-up raceways can be double-used in final rearing the net volume requirement is $79m^3$ for Eagle and $56m^3$ for Salmon.
- recommended cross-section dimensions are:

Channel Type	Preference Prototype	Wetted Cross-section	Water Depth	Total Lengths[a] Eagle	Salmon
Earthen	Chilliwack STHD	$5m^2$	0.8m	15.8m	11.2m
Concrete	As per start-up raceway	2	0.8	39.5	28.0

[a] in addition to start-up requirements.

- there is some potential for double-use of the CO start-up raceways by CN for final rearing but a 2-6 week overlap in timing is projected (ie, 20% of the CN have completed final rearing to 5g by the time 80% of the CO have reached 2g- Table 4); this coupled with the need to keep stocks separate, precludes realistic calculation of such potential at this time.

<u>Flows</u> - requirements are detailed in Table 8; maximum flow demand is 1637 LPM for Eagle and 1169 LPM for Salmon, or 2806 LPM total.

- source would be well water only until surface water temperature met that of the well (ie, last 2 weeks of June); thereafter, complete turnover to the surface supply would be desirable.
- duration of final rearing would be March 31 - June 29 (Table 4).

Adult Holding

Equipment – holding of 100% of the adults of either species at the facility is unlikely, however there is potential to do so if the CN and CO rearing channels are double-used to hold adults. Adult volume requirements compared to those for rearing (Tables 4-7) are:

SP	Stock	Rearing Volumes	Adult Volumes	Rearing-Adult Differences
CN	Eagle	99m^3	20m^3	+ 79m^3
	Salmon	71	14	+ 57
	Total	170	34	+136
CO	Eagle	129	163	– 34
	Salmon	89	113	– 24
	Total	218	276	– 58

– use of the rearing channels, however, will require either higher walls or the provision of bounce-panels to retain jumpers.

Flows – comparison of maximum rearing and adult holding requirements (Tables 4-7) would indicate that holding can be easily accomplished using existing rearing flows:

SP	Stock	Rearing Flows	Adult Flows	Rearing-Adult Differences
CN	Eagle	1637 LPM	525 LPM	+1112 LPM
	Salmon	1169	375	+ 794
	Total	2806	900	+1906
CO	Eagle	4263	4328	– 65
	Salmon	2962	3018	– 56
	Total	7225	7346	– 121

- adult holding would require largely surface water, but the capacity to mix to adjust temperature is necessary, particularly for chinook held in August and for coho in November-December.

Support Items:

1. Aerator capable of achieving 102-103% N_2 and 95% O_2 for well water.
2. Site fencing
3. Hatchery building(s) including:
    a. Washroom
    b. Office
    c. Incubation/egg-pick/marking areas
    d. Storage/Workshop
    e. Covered egg-take/exterior storage areas
4. Crew residence (4-bedroom)
5. Remote alarm system
6. Standby generator
7. 75m^3 walk-in cooler/freezer for OMP storage (see Appendix 2 for calculations)
8. No off-site rearing/adult trapping structures are requested at this time, but may be necessary in the future
9. Effluent treatment[1] (see Appendix 3 for treatment investigations)
    a) sludge lagoon for cleaning wastes
    b) continuous-use settling lagoon (as large as possible)

Water Demand

- Table 9 summarizes the projected water demand by month purpose, species, and source.

[1] In the face of no applicable small-scale technology for Phosphorous removal (see Appendix 3) and a general lack of site-specific data, operating staff must set up an effluent monitoring program to allow proper planning for a 'large' facility.

OPTION 2. 'SMALL' FACILITY (5g COHO OUTPLANT)

The following addresses only the major differences between Option 1 and 2; where requirements are not stated below assume those from Option 1.

Incubation

Because released fry-to-smolt survivals will increase from 10-16% (biostandards), only approximately 63% of the incubation capacity of Option 1 would be required.

Rearing

CO initial rearing to 2g would similarily decrease to 63% of Option 1, but rearing of approximately 2117K 2g fry up to 5g (Table 10), would take an additional 135 days (rearing period May 15-Nov 7 overall; May 30-Oct 15 middle-timing) and would require 676m^3 of channel (less 197m^3 already in start-up raceways gives net of 479m^3) and a maximum of 13,250 LPM of surface water (ie, an additional 6,025 LPM beyond 2g requirements).

Adult Holding

CO requirements will decrease to 63% of Option 1.

Support Items

All items remain the same, except for effluent treatment. Extended rearing into the fall period probably would worsen the effluent impact on Eagle River, and would require further consideration. Freezer capacity would not change as it approaches the capacity of a semi-truck load even in Option 1.

OPTION 3. 'SMALL' FACILITY (1-YR COHO REARING)

As a further comparison, the consequences of opting for full rearing of coho to the 25g smolt size are considered below. Coho production numbers (Table 11) would shift dramatically. For example, instead of the 4590K eggs required in Option 1, only 553 K eggs would be needed to achieve the same total adult production. Sizing details are provided in Tables 12 and 13; a comparison of the coho requirements of Options 1 and 3 is listed below:

	OPTION 1 (2g Outplant)	OPTION 3 (1-Yr Rearing)
Incubation		
– no. of eggs	4590K	553K
– no. of trays/stacks	541/68	66/9
– routine flows(LPM)	1020	135
Initial Rearing		
– no. of 2g fry	3718K	448
– m^3 of rearing volume	218	10 Cap. troughs(5 lines)
– maximum LPM	7996	1200
Final Rearing		
– no. of 25g smolts	0	373K
– m^3 of rearing volume	–	402
– maximum LPM	–	5687

Note that the maximum LPM required for the 2g outplant option is 141% of that required for 1-year rearing, but rearing volume for Option 1 is less than 49% of that required for Option 3.

'LARGE' FACILITY

Sizing details have been provided in Sections B ('large' stocks) and C ('extra' stocks) of Tables 5,6,8 and 11-14. Note that there also will be a timing shift (Table 3) with the addition of new stocks differing in spawning timing (Table 2). An overall container summary by option is provided in Table 15.

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FINAL COMMENT

It appears unlikely that the 'small' facility in any of its option forms can be built with the funds allocated (approx. $400K). If this indeed is the case, general cuts in target size will have to be investigated.

****

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1: Eagle River Project - Coho (2g outplant) chinook production numbers
(survival rates as per design standards)

STOCK	EGGS	%	EMERGENT FRY	%	FINGERLINGS	%[a]	RELEASED FRY	%[b]	TOTAL RETURN	FEMALE DONORS[c]	TOTAL DONORS[d]
A. SMALL FACILITY											
CHINOOK											
Eagle	432K	90	389K	90	350K	80	311K	1.62	7K	79	126
Salmon	309K	90	278K	90	250K	80	222K	1.62	5K	56	90
Total	741K		667K		600K		533K		12K	135	216
COHO											
Eagle	2705K	90	2434K	–	–	90	2191K	1.22	33K	1082	1731
Salmon	1885K	90	1697K	–	–	90	1527K	1.22	23K	754	1207
Total	4590K		4131K				3718K		56K	1836	2938
B. LARGE FACILITY (EXPANSION OF SMALL FACILITY)											
CHINOOK											
Eagle	432K	90	389K	90	350K	80	311K	1.62	7K	79	126
Salmon	309K	90	278K	90	250K	80	222K	1.62	5K	56	90
S. Thompson	4938K	90	4444K	90	4000K	80	3556K	1.62	80K	898	1437
Adams	1481K	90	1333K	90	1200K	80	1067K	1.62	24K	269	431
Total	7160K		6444K		5800K		5156K		116K	1302	2084
COHO											
Eagle	2705K	90	2434K	–	–	90	2191K	1.22	33K	1082	1731
Salmon	1885K	90	1697K	–	–	90	1527K	1.22	23K	754	1207
Adams	410K	90	369K	–	–	90	332K	1.22	5K	164	262
Total	5000K		4500K				4050K		61K	2000	1200
C. EXTRA STOCKS (POSSIBLE FUTURE INCLUSION IN LARGE FACILITY)											
CHINOOK											
M. Shuswap	494K	90	444K	90	400K	80	356K	1.62	8K	90	144
L. Shuswap	9383K	90	8444K	90	7600K	80	6756K	1.62	152K	1706	2730
Total	9877K		8888K		8000K		7112K		160K	2606	2874
COHO											
L. Shuswap	410K	90	369K	–	–	90	332K	1.22	5K	164	262
Wap Creek	328K	90	295K	–	–	90	266K	1.22	4K	131	210
Bessette	574K		516K	–	–	90	465K	1.22	7K	230	367
Total	1312K		1180K				=1062K		16K	525	839
TOTAL (B + C)											
CHINOOK	17037K		15332K		13800K		12268K		276K	3098	4958
COHO	6312K		5680K		–		5112K		77K	2525	4039

[a] Survival from emergent fry to released fry

[b] Survival from egg to adult (CN fry-smolt survival of 80%, smolt-adult 2.25%; CO fry-smolt of 10% for 2g outplants, smolt-adult 15%)

[c] Assumed average fecundities of 5500 CN: 2500 CO

[d] Assumed egg-take ratio of 3:5 M:F

TABLE 2A: Eagle River Project - Spawning timing from F381 files.

CHINOOK	Arrive	Start	Peak	End
Eagle	Mid Aug	Mid Sep	Late Sep	Oct
Salmon	Mid Jul	Early Sep	Mid Sep	Late Sep
Adams	Early Sep	Mid Sep	Early Oct	Mid Oct
Shuswap	Mid Jul	Mid Sep	Late Sep	Early Nov
Bessette	Early Sep	Early Sep	Mid Sep	Mid Oct
S.Thompson	Mid Aug	Mid Sep	Early Oct	Early Nov
COHO				
Eagle	Early Oct	Late Oct	Mid Nov	Dec
Salmon	Mid Oct	Late Oct	Early Nov	Late Nov
Adams	Mid Oct	Late Oct	Mid Nov	Dec
Shuswap	Early Oct	Late Oct	Mid Nov	Late Nov
Bessette	Early Oct	Late Oct	Mid Nov	Dec
S.Thompson	-	-	-	-

TABLE 2B: Eagle River Project - Preliminary juvenile downstream timings (P. Delaney, E.V.S. - pers. comm.).

	0+ Emigrant Fry			
CHINOOK	Start	Peak	End	1+ Smolts
Eagle	before Apr 5	mid Apr	late May (?)	
Salmon			(low from mid-May on)	
Adams	before Apr 5	early May	late May (?)	mid Apr
COHO				
Eagle	before Apr 5	mid Apr	late May (?)	late Apr late May
Salmon			(low from mid-May on)	
Adams	before Apr 5	mid May	June (?)	mid-late Apr

TABLE 3: Eagle River Project – Incubation timing.

CHINOOK – Small Facility			
Stage	Early	Middle	Late
Start[a]	Sep 7	Sep 22	Oct 2
Eyed[b]	Oct 17	Oct 27	Nov 11
Hatch[b]	Nov 16	Dec 1	Dec 16
Swimup[b]	Jan 15	Feb 4	Feb 19
	[d](7.5°C)	(7.3°C)	(7.0°C)

COHO – Small and Large Facility			
Stage	Early	Middle	Late
Start[a]	Oct 27	Nov 11	Dec 1
Eyed[c]	Nov 26	Dec 11	Dec 31
Hatch[c]	Dec 31	Jan 15	Feb 9
Swimup[c]	Feb 9	Feb 24	Mar 21
	[d](7.5°C)	(7.3°C)	(7.0°C)

CHINOOK – Large Facility			
Stage	Early	Middle	Late
Start[a]	Sep 7	Oct 7	Nov 6
Eyed[b]	Oct 17	Nov 16	Dec 16
Hatch[b]	Nov 16	Dec 21	Jan 20
Swimup[b]	Jan 15	Feb 24	Mar 26
	[d](7.5°C)	(7.3°C)	(7.0°C)

[a] Spawning timings as per Table 2A.

[b] Chinook : Eyed 280 ATU, Hatch 520 ATU, Swimup 980 ATU.

[c] Coho : Eyed 220 ATU, Hatch 480 ATU, Swimup 780 ATU.

[d] Worst-case temperature regime assumed to produce largest temporal range.

TABLE 4: Eagle River Project - Small facility strategy summary (2g coho outplant option).

PHASE	CONTAINER	COHO Early[a]	COHO Middle[a]	COHO Late[a]	CHINOOK Early[a]	CHINOOK Middle[a]	CHINOOK Late[a]
	Eggs in	918K	2754K	918K	148K	445K	148K
INCUBATION	Heath trays/stacks @	108/14	325/40	108/14	30/4	89/11	30/4
	LPM in	210	600	210	60	165	60
	Source (Temp) for	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)
	Period	Oct 27-Feb 9	Nov 11-Feb 24	Dec 1-Mar 21	Sep 7-Jan 15	Sep 22-Feb 4	Oct 2-Feb 19
	Fry in	747K	2240K	746K	133K	401K	133K
	Start-up raceways (m^3) @	44	130	44	7	21	7
INITIAL REARING	LPM (start/end) in	509/1599	1525/4798	509/1599	86/293	259/877	86/293
	Source (Temp) for	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)
	Period	Feb 9-May 15	Feb 24-May 30	Mar 21-Jun 24	Jan 15-Mar 31	Feb 4-Apr 20	Feb 19-May 5
	Fingerlings in				120K	360K	120K
	Raceways (m^3) @				7	21	7
FINAL REARING	(start/end) LPM in				34/573	101/1720	34/573
	Source (Temp) for				Well (7.3°C)	Well (7.3°C)	Well/Sfc.
	Period				Mar 31-May 30	Apr 20-Jun 19	May 5-Jun 29

[a] Assumed proportions: - Early 20%, Middle 60%, Late 20%, of total stocks.

TABLE 5: Eagle River Project - Chinook incubation, initial rearing and adult holding sizing.

Stock	Incubation[a]		Initial Rearing[b]		Adult Holding[c]		
	Trays/Stacks	Flows (LPM) Routine/Flush	Vol in m^3	Flows (LPM) Start/End	Flows (LPM)	Volume (m^3)	Weight (KG)
A. SMALL FACILITY							
Eagle	87/11	165/209	20	250/849	525	19.7	630
Salmon	62/8	120/152	15	181/614	375	14.1	450
Total	149/19	285/361	35	431/1463	900	33.8	1080
B. LARGE FACILITY (EXPANSION OF SMALL FACILITY)							
Eagle	87/11	165/209	20	250/849	525	19.7	630
Salmon	62/8	120/152	15	181/614	375	14.1	450
S.Thompson	988/124	1860/2356	234	2867/9756	5988	224.5	7185
Adams	297/38	570/722	71	860/2927	1796	67.3	2155
Total	1434/181	2715/3439	340	4158/14146	8684	325.6	9340
C. EXTRA STOCKS (POSSIBLE FUTURE INCLUSION IN LARGE FACILITY)							
M. Shuswap	99/13	195/247	146	287/976	600	22.5	720
L. Shuswap	1877/235	3525/4465	444	5448/18537	11375	426.6	13650
Total	1976/248	3720/4712	590	5735/19513	11975	449.1	14370
TOTAL (B + C)	3420/429	6435/8151	930	9893/33659	20659	774.7	24790

[a] Incubation standards: 5,000 eggs/tray; 8 trays/stack; 15 LPM/stack routine flow; 19 LPM/stack flush flow

[b] Start-up raceway standards: given in Table 7

[c] Adult holding standards: flow loading at 1.2 Kg/LPM, volume loading at 32 Kg/$1m^3$; average fish size of 5.0 kg.

TABLE 6: Eagle River Project – Coho incubation, rearing and adult holding sizing for 2g outplant option.

Stock	Incubation[a] Trays/Stacks	Incubation[a] Flow (LPM) Routine/Flush	Initial Rearing[b] Vol in m^3	Initial Rearing[b] Flow (LPM) Start/End	Adult Holding[c] Flows (LPM)	Adult Holding[c] Volume (m^3)	Adult Holding[c] Weight (KG)
A. SMALL FACILITY							
Eagle	319/40	600/760	129	1500/4718	4328	162.3	5193
Salmon	222/28	420/532	89	1043/3278	3018	113.2	3621
Total	541/68	1020/1292	218	2543/7996	7346	275.5	8814
B. LARGE FACILITY (EXPANSION OF SMALL FACILITY)							
Eagle	319/40	600/760	129	1500/4718	4328	162.3	5193
Salmon	222/28	420/532	89	1043/3278	3018	113.2	3621
Adams	49/6	90/114	20	227/714	655	24.6	786
Total	590/74	1110/1406	~~217~~ 238	2770/8710	8001	300.1	9600
C. EXTRA STOCKS (POSSIBLE FUTURE INCLUSION IN LARGE FACILITY)							
L.Shuswap	49/6	90/114	20	227/714	655	24.6	786
Wap Creek	39/5	75/95	16	182/572	525	19.7	630
Bessette	68/9	135/171	27	318/1000	918	34.4	1101
Total	156/20	300/380	63	727/2286	2098	78.7	2517
TOTAL (B + C)	746/94	1410/1786	280	3497/10996	10098	378.8	12117

[a] Incubation Standards: 8,500 eggs/tray, 8 trays/stack; 15 LPM routine flow; 19 LPM flush flow per stack.

[b] Start-up raceway given in Table 7.

[c] Adult holding standards: flow loading at 1.2 Kg/LPM, volume loading at 32 Kg/m^3; average fish size of 3.0Kg.

TABLE 7: Eagle River Project - (coho 2g outplant option). Criteria calculations for start-up raceways (small facility only).

ITEM		CN		CO	
No. of fry (size in g)	- Start	667K(0.4g)		4131K(0.4g)	
	- End	600K(2.0g)		3718K(2.0g)	
Total kg of fry	- Start	267		1653	
	- End	1200		7436	
Volume loading[a]	- Start	____	7.6kg/m^3	____	
	- End	____	36.1kg/m^3	____	
m^3 Volume required	- Start	35		218	
	- End	34		206	
Water depth[b] in m (wall height)[c]		____	0.75(1.3)	____	
Raceway width in m[c]		____	2.5	____	
Raceway length in m	- Overall	19	(100%)	116	(100%)
	- Eagle	11	(58%)	69	(59%)
	- Salmon	8	(42%)	47	(41%)
kg/LPM loading [d]	- Start	.62		.65	
	- End	.82		.93	
LPM Required:					
(1) Overall	- Start	431		2543	
	- End	1463		7996	
(2) Eagle	- Start	250		1500	
	- End	849		4718	
(3) Salmon	- Start	181		1043	
	- End	614		3278	

[a] Converted from Capilano trough loadings of 57K 0.4g fry and 54K 2.0g fingerlings/trough.

[b] As per Chehalis start-up raceways.

[c] As per Thornton/Quesnel CN rearing channels (could be wider if necessary).

[d] Based on BIO-LOAD at 7.3°C, 95% O_2 .

..BLE 8: Eagle River Project - Chinook rearing s..ing. sizing

Stock	Weight		Water Demand				Space Requirements			
	Start	End	Start		End		Start		End	
	@2g	@5g	Loading	Flow	Loading	Flow	Loading	Volume	Loading	Volume
	Kg	Kg	Kg/LPM	LPM	Kg/LPM	LPM	Kg/m^3	m^3	Kg/m^3	m^3
A. SMALL FACILITY										
Eagle	700	1555	.82	854	.95	1637	13.0	54	15.7	99
Salmon	500	1110	.82	610	.95	1169	13.0	39	15.7	71
Total	1200	2665		1464		2806		93		170
B. LARGE FACILITY (EXPANSION OF SMALL FACILITY)										
Eagle	700	1555	.82	854	.95	1637	13.0	54	15.7	99
Salmon	500	1110	.82	610	.95	1169	13.0	39	15.7	71
S.Thompson	8000	17780	.82	9756	.95	18716	13.0	615	15.7	1133
Adams	2400	5335	.82	2927	.95	5616	13.0	185	15.7	340
Total	11600	25780		14147		27138		893		1643
C. EXTRA STOCKS (POSSIBLE FUTURE INCLUSION IN LARGE FACILITY)										
M. Shuswap	800	1780	.82	976	.95	1874	13.0	62	15.7	113
L. Shuswap	15200	33780	.82	18537	.95	35558	13.0	1169	15.7	2152
Total	16000	35560		19513		37432		1231		2265
TOTAL (B + C)	27600	61340		33660		64570		2124		3908

TABLE 9: Water demand for small facility with 2g coho outplant option (in LPM)

PHASE	SPECIES	STOCK	SOURCE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YR MAX
INCUBATION																
	COHO	EARLY	WELL	210	210								210	210	210	210
		MIDDLE		600	600									600	600	600
		LATE		210	210	210									210	210
		TOTAL		1020	1020	210	0	0	0	0	0	0	210	810	1020	1020
																0
	CHINOOK	EARLY	WELL	60								60	60	60	60	60
		MIDDLE		165	165							165	165	165	165	165
		LATE		60	60								60	60	60	60
		TOTAL		285	225	0	0	0	0	0	0	225	285	285	285	285
																0
	TOTAL			1305	1245	210	0	0	0	0	0	225	495	1095	1305	1305
																0
INITIAL REARING																
	COHO	EARLY	WELL		763	1101	1439	1599								1599
		MIDDLE			1759	2694	3629	4798								4798
		LATE				677	1012	1347	1599							1599
		TOTAL		0	2522	4472	6080	7744	1599	0	0	0	0	0	0	7744
																0
	CHINOOK	EARLY	WELL	127	210	293										293
		MIDDLE			444	692	877									877
		LATE			124	199	274	293								293
		TOTAL		127	778	1184	1151	293	0	0	0	0	0	0	0	1184
																0
	TOTAL			127	3300	5656	7231	8037	1599	0	0	0	0	0	0	8037
																0
FINAL REARING																
	CHINOOK	EARLY	WELL			34	304	573	2866							2866
		MIDDLE					461	1180	1720							1720
		LATE						304	573							573
		TOTAL		0	0	34	765	2057	5159	0	0	0	0	0	0	5159
																0
ADULT HOLDING																
	COHO	ALL	SURFACE										7346	6610	1175	7346
			WELL											735	294	735
			TOTAL	0	0	0	0	0	0	0	0	0	7346	7345	1469	7346
																0
	CHINOOK	ALL	SURFACE								630	900	180			900
			WELL								270					270
			TOTAL	0	0	0	0	0	0	0	900	900	180	0	0	900
																0
	TOTAL			0	0	0	0	0	0	0	900	900	7526	7345	1469	7526
																0
COHO	Total			1020	3542	4682	6080	7744	1599	0	0	0	7556	8155	2489	8155
																0
CHIN	Total			412	1003	1218	1916	2350	5159	0	900	1125	465	285	285	5159
																0
WELL	Total			1432	4545	5900	7996	10094	6758	0	270	225	495	1830	1599	10094
																0
SFC	(Total)			0		0	0	0	0	0	[illegible]	900	7526	6610	[illegible]	7526

TABLE 10 : Eagle River Project - Rough calculations of 2g to 5g Coho rearing requirements.

Days (Month) of Rearing		Size in g	kg[a]	°C	Load Rates[b] Kg/LPM	Kg/m^3	Required LPM	m^3
15	(Jun)	2.25	4763	5.3	1.32	13.23	3609	360
45	(Jul)	2.75	5822	7.3	1.00	13.67	5822	426
75	(Aug)	3.13	6626	9.1	0.80	14.00	8283	473
105	(Sep)	4.09	8659	13.4	0.50	14.85	13252	583
135	(Oct)	5.00	10585	9.8	0.81	15.66	13067	676

[a] Assumes 2117K CO throughout (ie, no mortality allowance)

[b] BIO-LOAD, assuming 0.6R, 95% O_2.

TABLE 11: Eagle River Project - Coho (one-year rearing option) production numbers (survival rates as per design standards).

	EGGS	%	EMERGENT FRY	%	FINGERLINGS	%[a]	RELEASED FRY	%[b]	TOTAL RETURN	FEMALE DONORS[c]	TOTAL DONORS[d]
A. SMALL FACILITY											
COHO											
Eagle	326K	90	293K	90	264K	75	220K	10.13	33K	130	208
Salmon	227K	90	204K	90	184K	75	153K	10.13	23K	91	145
Total	553K		497K		448K		373K		56K	221	353
B. LARGE FACILITY (EXPANSION OF SMALL FACILITY)											
COHO											
Eagle	326K	90	293K	90	264K	75	220K	10.13	33K	130	208
Salmon	227K	90	204K	90	184K	75	153K	10.13	23K	91	145
Adams	49K	90	44K	90	40K	75	33K	10.13	5K	20	32
Total	602K		541K		488K		406K		61K	241	385
C. EXTRA STOCKS (POSSIBLE FUTURE INCLUSION IN LARGE FACILITY											
COHO											
L. Shuswap	49K	90	44K	90	40K	75	33K	10.13	5K	20	32
Wap Creek	39K	90	36K	90	32K	75	27K	10.13	4K	16	25
Bessette	69K	90	62K	90	56K	75	47K	10.13	7K	28	44
Total	157K		142K		128K		107K		16K	64	101
TOTAL (B + C)	759K		683K		616K		513K		77K	305	486

[a] survival from emergent fry to released fry

[b] smolt-adult survival of 15%

[c] assumed average fecundity of 2500

[d] assumed egg-take ratio of 3:5 M:F

TABLE 12: Eagle River Project - Coho incubation, initial rearing and adult holding sizing (one-year rearing option).

Stock	Incubation[a]		Initial Rearing[b]		Adult Holding[c]		
	Trays/Stacks	Routine/Flush	Troughs/Lines	Flows(LPM) Start/End	Flows	Volume	Weight
A. SMALL FACILITY							
Eagle	39/5	75/95	6/3	360/720	520	19.5	624
Salmon	27/4	60/76	4/2	240/480	363	13.6	435
Total	66/9	135/171	10/5	600/1200	883	33.1	1059
B. LARGE FACILITY (EXPANSION OF SMALL FACILITY)							
Eagle	39/5	75/95	6/3	360/720	520	19.5	624
Salmon	27/4	60/76	4/2	240/480	363	13.6	435
Adams	6/1	15/19	1/1	120/240	80	3	96
Total	72/10	150/190	11/6	720/1440	963	36.1	1155
C. EXTRA STOCKS (POSSIBLE FUTURE INCLUSION IN LARGE FACILITY)							
L.Shuswap	6/1	15/19	1/1	120/240	80	3	96
Wap Creek	5/1	15/19	1/1	120/240	63	2.4	75
Bessette	8/1	15/19	2/1	120/240	110	4.1	132
Total	19/3	45/57	4/3	360/720	253	9.5	303
TOTAL (B + C)	91/13	195/247	15/9	1080/2160	1216	45.6	1458

[a]Incubation standards: 8,500 eggs/tray, 8 trays/stack; 15 LPM regular, 19 LPM flush flows

[b]Capilano trough standards: 54K fry/trough, 2 troughs/line; 120 LPM start, 240 LPM end flows/line

[c]Adult holding standards: 1.2Kg/LPM, 32Kg/m^3 loading.

TABLE 13: Eagle River Project - Coho rearing sizing (one-year rearing option).

Stock	Weight		Water Demand				Space Requirement			
	Start @2g	End @25g	Start Loading	Start Flow	End Loading	End Flow	Start Loading	Start Volume	End Loading	End Volume
	Kg	Kg	Kg/LPM	LPM	Kg/LPM	LPM	Kg/m^3	m^3	Kg/m^3	m^3
A. SMALL FACILITY										
Eagle	528	5500	.93	567	1.64	3355	13.0	41	23.2	237.1
Salmon	368	3825	.93	396	1.64	2332	13.0	28	23.2	164.9
Total	896	9325		963		5687		69		402.0
B. LARGE FACILITY (EXPANSION OF SMALL FACILITY)										
Eagle	528	5500	.93	567	1.64	3355	13.0	41	23.2	237.1
Salmon	368	3825	.93	396	1.64	2332	13.0	28	23.2	164.9
Adams	80	825	.93	86	1.64	503	13.0	6	23.2	35.6
Total	976	10150		1049		6189		75		437.6
C. EXTRA STOCKS (POSSIBLE FUTURE INCLUSION IN LARGE FACILITY)										
L.Shuswap	80	825	.93	86	1.64	503	13.0	6	23.2	35.6
Wap Creek	64	675	.93	69	1.64	412	13.0	5	23.2	29.1
Bessette	112	1175	.93	120	1.64	716	13.0	9	23.2	50.6
Total	256	2675		275		1631		20		115.3
TOTAL (B + C)	1232	12825		1324		7820		95		552.9

TABLE 14: Eagle River Project- Large facility strategy summary (one-year coho rearing).

PHASE	CONTAINER	COHO Early[a]	COHO Middle[a]	COHO Late[a]	CHINOOK Early[a]	CHINOOK Middle[a]	CHINOOK Late[a]
	Eggs in	120K	362K	120K	1432K	4296K	1432K
INCUBATION	Heath trays/stacks @	16/2	48/6	16/2	288/36	872/109	288/36
	LPM in	30	90	30	540	1635	540
	Source (Temp) for	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)
	Period ↓	Oct 27-Feb 9	Nov 11-Feb 24	Dec 1-Mar 21	Sep 7-Jan 15	Oct 7-Feb 24	Nov 6-Mar 26
	Fry in	108K	325K	108K	1289	3866	1289
INITIAL REARING	Cap. troughs/lines(CO) Start-up raceways(CN) @	4/2	6/3	2/1	$68 m^3$	$204 m^3$	$68 m^3$
	LPM (start/end) in	240/480	360/720 LPM	120/240 LPM	832/2829	2494/8488	832/2829
	Source (Temp) for	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)	Well (7.3°C)
	Period ↓	Feb 9-May 15	Feb 24-May 30	Mar 21-Jan 24	Jan 15-Mar 31	Feb 24-May 10	Mar 26-Jun 4
	Fingerlings in	97K	294K	97K	1160K	3480K	1160K
FINAL REARING	Raceways @	$88 m^3$	$262 m^3$	$88 m^3$	$328 m^3$	$986 m^3$	$328 m^3$
	LPM(start/end) in	38/1410	112/4228	38/1410	2829/5428	8488/16282	2829/5428
	Source for	Sfc.	Sfc.	Sfc.	Well	Well/Sfc. (Switch in Jun)	Sfc. (Switch in Jun)
	Period	May 15-May[b]	May 30-May[b]	Jun 24-May[b]	Mar 31-May 30	Feb 24-Jul 9	Jun 4-Jul 30

[a] Approximate proportions - Early 20%, Middle 60%, Late 20% of total stocks.
[b] of next year

TABLE 15: Eagle River Project - Container summary for all options (Approximate numbers; for purposes of comparison only).

CONTAINER	OPTION 1 (2g CO outplant) SMALL	LARGE	ALL STOCKS	OPTION 2 (5g CO outplant) SMALL	LARGE	ALL STOCKS	OPTION 3 (25g CO Smolts) SMALL	LARGE	ALL STOCKS
INCUBATION:									
Heath Trays	690	2024	4166	435	1276	2625	215	1506	3511
Stacks	87	255	523	55	161	330	28	191	442
Routine LPM	1305	3825	7845	823	2410	4943	420	2865	6630
INITIAL REARING:									
(1) Capilano Troughs (Lines)	-	-	-	-	-	-	10 (5)	11 (6)	15 (9)
Maximum LPM	-	-	-	-	-	-	1200	1440	2160
(2) Start-up Raceway Vol. (m^3)	253	557	1210	160	351	763	35	340	930
Maximum LPM	9459	22856	44655	5960	14400	28133	1463	14146	33659
FINAL REARING:									
Volume (m^3)	170	1643	3908	846	1856	4034	572	968	4461
Maximum LPM	2806	27138	64570	13250	32013	62544	8493	33327	72390
ADULT HOLDING:									
Volume (m^3)	309	626	1154	195	395	728	67	362	821
Maximum LPM	8246	16685	30757	5195	10512	19377	1783	9647	21875

APPENDIX 1

Production Forecasts

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - EAGLE RIVER CHINOOK

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION 1983	1984	1985	1986	1987	1988	1989	1990		BROOD YEAR PRODUCTION
1981	18	100.0K	29	0	680	810	130						1,620
1982	39	216.0K	63			1470	1749	280					3,499
1983	75	422.7K	120				2876	3424	548				6,848
1984	77	432.0K	123					2940	3500	560			7,000
1985	77	432.0K	123						2940	3500	560		7,000
										2940	3500		
											2940		
C/E				8/1									
Total Annual Production from Hatchery				0	680	2280	4755	6644	6988	7000	7000		
Comm. Catch of Hatchery Fish				0	605	2029	4232	5913	6219	6230	6230		
Escapement of Hatchery Fish				0	75	251	523	731	769	770	770		
Hatchery Stock Required (3:5 M:F)				120	123	123	123	123	123	123	123		
Surplus*				-120	-48	+128	+400	+608	+646	+647	+647		

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - EAGLE RIVER CHINOOK

		Start		Final
Target Production		100,000	eggs	432,000
Year of Start - 1981	.90	90,000	emergent fry	389,000
(Adult Production Goal Achieved - 1989)	.90	81,000	fingerlings (2g)	350,000
	.80	64,800	released fry (5g)	311,000
(Egg - Adult = 1.62%)	.025	1,620	adults	7,000

Current Natural Spawners (F381)

1951 - 1980 $\overline{X}$ = 965
1971 - 1980 $\overline{X}$ = 401

Maximum = 3,500

1979 = 300
1980 = 250

Best Estimate = 400

Target Natural Spawners
(60% of Maximum) = 2,100

Commercial Exploitation Rate (C/E) 8/1 (89%)[7]

Hatchery Capture Rate Wild Stock .3
Hatchery (Esc) .7

Species	Age	Fraction Stock[1]	Fraction Female[2]	Fecundity[3]
CN	3	.42	.18	4,875[4]
	4	.50	.71	5,738[5]
	5	.08	.65	6,044[6]

[1]From Management Dead Pitch Data (n=12).
[2]Average of S. Thompson and Adams River Dead Pitch Data (minus 10% to account for skewing towards females).
[3]From Chinook Test-Fishery Data (1964-66) for July 15-Aug. 30; the period corresponding to migration of Thompson System Chinooks (P. Starr, pers. comm.) towards females in sampling.
[4]n=4
[5]n=42
[6]n=34
[7]B. Pearce, 1980 memo

Corrected $\overline{X}$ Fecundity = 5,636 eggs/female.

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - SALMON RIVER CHINOOK

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION 1983	1984	1985	1986	1987	1988	1989								BROOD YEAR PRODUCTION
1981	18	100.0K	29	32	454	988	146											1,620
1982	27	154.5K	43		50	701	1527	225										2,503
1983	55	309.0K	88			100	1400	3050	450									5,000
1984	55	309.0K	88				100	1400	3050	450								5,000
								100	1400	3050								
									100	1400								
										100								
C/E				8/1														
Total Annual Production from Hatchery				32	504	1789	3173	4775	5000	5000								
Comm. Catch of Hatchery Fish				28	449	1592	2824	4250	4450	4450								
Escapement of Hatchery Fish				6	55	197	349	525	550	550								
Hatchery Stock Required (3:5 M:F)				88	88	88	88	88	88	88								
Surplus*				-82	-33	+109	+261	+437	+462	+462								

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - SALMON RIVER CHINOOK

	Start		Final
Target Production	100,000	eggs	309,000
	.90 ↓		↓
Year of Start - 1981	90,000	emergent fry	278,000
	.90 ↓		↓
(Adult Production Goal Achieved - 1988)	81,000	fingerlings (2g)	250,000
	.08 ↓		↓
	64,800	released fry (5g)	222,000
	.025 ↓		↓
(Total Egg - Adult=1.62%)	1,620	adults	5,000

Current Natural Spawners (F381)

1951 - 1980 = 308
1971 - 1980 = 300

Maximum = 1,500

1979 = 300
1980 = 700

Best Estimate = 300

Target Natural Spawners
(60% of Maximum) =

Commercial Exploitation Rate (C/E) 8/1 (89%)[1]

Hatchery Capture Rate Wild Stock .3
Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CN	3	.28	.18	4,875[5]
	4	.61	.71	5,738[6]
	5	.09	.65	6,044[7]

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[1] B. Pearce, 1980 memorandum.
[2] Average of S. Thompson, Adams, Lower Shuswap and Middle Shuswap River Dead Pitch and CWT Data.
[3] Average of S. Thompson and Adams River Dead Pitch Data (minus 10% to account for skewing towards females).
[4] From Chinook Test-Fishery Data (1964-66) for July 15-Aug. 31 and the period corresponding to migration of Thompson System Chinooks (P. Starr, pers. comm.)
[5] n=4
[6] n=42
[7] n=34

N.B. Corrected Mean Fecundity = 5,691 egg/s female.

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - SOUTH THOMPSON RIVER CHINOOK

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION														BROOD YEAR PRODUCTION
				3	4	5	6	7	8	9	10	11						
1	430	2469.00K	687	2760	5160	26760	5320											40,000
2	563	3237.25K	900		3619	6765	35085	6975										52,444
3	563	3237.25K	900			3619	6765	35085	6975									52,444
4	744	4278.00K	1190				4782	8940	46364	9218								69,304
5	859	4938.00K	1374					5520	10320	53520	10640							80,000
6	859	4938.00K	1374						5520	10320	53520	10640						80,000
										5520	10320	53520						
											5520	10320						
												5520						
C/E				8/1														
Total Annual Production from Hatchery				2760	8779	37144	51952	56520	69179	78578	80000	80000						
Comm. Catch of Hatchery Fish				2456	7813	33058	46237	50303	61569	69934	71200	71200						
Escapement of Hatchery Fish				304	966	4086	5715	6217	7610	8644	8800	8800						
Hatchery Stock Required (3:5 M:F)				900	1190	1374	1374	1374	1374	1374	1374	1374						
Surplus*				-596	-244	+2712	+4341	+4843	+6236	+7270	+7426	+7426						

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - SOUTH THOMPSON RIVER CHINOOK

	Rate	Start	Stage	Final
Target Production		2,469,000	eggs	4,938,000
Year of Start -	.90	2,222,100	emergent fry	4,444,200
(Adult Production Goal Achieved - yr. 10)	.90	1,999,890	fingerlings (2g)	3,999,780
(Total Egg - Adult=1.62%)	.80	1,599,912	released fry (5g)	3,199,824
	.025	40,000	adults	80,000

Current Natural Spawners (F381)

1951 - 1980 $\overline{X}$ = 3,897
1971 - 1980 $\overline{X}$ = 4,460

Maximum = 7,500

1979 = 6,000
1980 = 3,000

Best Estimate = 3,000

Target Natural Spawners
(60% of Maximum) = 4,500

Commercial Exploitation Rate (C/E) 8/1 (89%)[1]

Hatchery Capture Rate Wild Stock .3
Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CN	3	.129	.18	4,875[5]
	4	.669	.71	5,738[6]
	5	.133	.65	6,044[7]

[1] B. Pearce, 1980 Memorandum.
[2] Average of management Dead Pitch Data (1975-1980) n=317 for S. Thompson.
[3] Average of S. Thompson, Adams River Dead Pitch Data (minus 10% to account for skewing towards females in sampling)(1975-1980).
[4] From Chinook Test Fishery Data (1964-1966) for July 15-Aug. 30; the period corresponding to migration of Thompson System Chinooks (P. Starr, pers. comm.).
[5] n=4
[6] n=42
[7] n=34

N.B. Corrected Mean Fecundity = 5,748

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - ADAMS RIVER CHINOOK

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION 3	4	5	6	7	8	9	10							BROOD YEAR PRODUCTION
1	128	740.5K	204	348	2052	6852	2748											12,000
2	244	1415.2K	390		665	3920	13091	5250										22,926
3	244	1415.2K	390			665	3920	13091	5250									22,926
4	256	1481.0K	409				696	4104	13704	5496								24,000
5	256	1481.0K	409					696	4104	13704	5496	→						24,000
↓	↓	↓	↓						696	4104	13704	→						↓
										696	4104	→						
											696	→						
C/E				8/1	→													
Total Annual Production from Hatchery				348	2717	11437	20455	23141	23754	24000	24000	→						
Comm. Catch of Hatchery Fish				310	2418	10179	18205	20596	21141	21360	21360	→						
Escapement of Hatchery Fish				38	299	1258	2250	2545	2613	2640	2640	→						
Hatchery Stock Required (3:5 M:F)				390	409	409	409	409	409	409	409	→						
Surplus*				-352	-110	+849	+1841	+2136	+2204	+2231	+2231	→						

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - ADAMS RIVER CHINOOK

	Survival	Start		Final
Target Production		740,500	eggs	1,481,000
Year of Start -	.90	666,450	emergent fry (2g)	1,332,900
(Adult Production Goal Achieved -)	.90	599,805	fingerlings (5g)	1,199,610
(Total Egg - Adult=1.62%)	.80	479,844	released fry	959,688
	.025	12,000	adults	24,000

Current Natural Spawners (F381)

1951 - 1980 $\bar{X}$ = 1,828

1971 - 1980 $\bar{X}$ = 1,320

Maximum ≐ 5,000

1979 = 1,000
1980 = 350

Best Estimate = 1,300 (Esc.=400 in 1980, 1984, 1988, etc.)*

Target Natural Spawners
(60% of Maximum) = 3,000

Commercial Exploitation Rate (C/E) 8/1 (89%)[1]

Hatchery Capture Rate: Wild Stock .3; Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CN	3	.171	.18	4,875[5]
	4	.571	.71	5,738[6]
	5	.229	.65	6,044[7]

[1]B. Pearce, 1980 Memorandum.
[2]Average of management Dead Pitch Data (1975-1980) n=105.
[3]Average of S. Thompson, Adams River Dead Pitch Data (minus 10% to account for skewing towards females in sampling)(1975-1980).
[4]From Chinook Test Fishery Data (1964-1966) for July 15-Aug. 30; the period corresponding to migration of Thompson System Chinooks (P. Starr, pers. comm.)
[5]n=4
[6]n=42
[7]n=34
* Will not be used in forecasts until start-up date is firm
N.B. Corrected Mean Fecundity = 5799 eggs/female.

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - MIDDLE SHUSWAP RIVER CHINOOK

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION														BROOD YEAR PRODUCTION
				3	4	5	6	7	8									
1	45	247K	72	16	1312	2388	284											4,000
2	90	494K	144		32	2624	4776	568										8,000
3	90	494K	144			32	2624	4776	568									8,000
							32	2624	4776									
								32	2624									
									32									
C/E				8/1														
Total Annual Production from Hatchery				16	1344	5044	7716	8000	8000									
Comm. Catch of Hatchery Fish				14	1196	4489	6867	7120	7120									
Escapement of Hatchery Fish				2	148	555	849	880	880									
Hatchery Stock Required (3:5 M:F)				144	144	144	144	144	144									
Surplus*				-142	+4	+411	+705	+736	+736									

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - MIDDLE SHUSWAP RIVER CHINOOK

	Survival	Start	Stage	Final
Target Production		247,000	eggs	494,000
Year of Start -	.90	222,300	emergent fry (2g)	444,600
(Adult Production Goal Achieved - yr. 7)	.90	200,070	fingerlings (5g)	400,140
(Total Egg - Adult=1.62%)	.80	160,056	released fry	320,112
	.025	4,000		8,000

Current Natural Spawners

1951 - 1980 $\overline{X}$ = 772

1971 - 1980 $\overline{X}$ = 495

Maximum = 1,500
1979 = 500
1980 = 500
Best Estimate = 500

Target Natural Spawners
(60% of Maximum) = 900

Commercial Exploitation Rate (C/E) 8/1 (89%)[1]

Hatchery Capture Rate — Wild Stock .3
Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female	Fecundity[5]
CN	3	.328	.59[4]	4,875[6]
	4	.597	.68[3]	5,738[7]
	5	.071	.51[3]	6,044[8]

[1] B. Pearce, 1980 Memorandum.
[2] Average of Management Dead Pitch Data (1975-1980)(n=253) for Middle Shuswap River.
[3] Average of Management Dead Pitch Data (1975-1980) for Middle Shuswap River (minus 10% to account for skewing towards females in sampling).
[4] Average of F381 and Management Dead Pitch Data (1975-1980) for Middle Shuswap River (n=83)(minus 10% to account for skewing towards females in sampling).
[5] From Chinook Test Fishery Data (1964-1966) for July 15-Aug. 30; the period corresponding to migration of Thompson System Chinooks.
[6] n=4
[7] n=42
[8] n=34

N.B. Corrected Average Fecundity = 5,493 eggs/female.

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - LOWER SHUSWAP RIVER CHINOOK

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION														BROOD YEAR PRODUCTION
				3	4	5	6	7	8	9	10							
1	83	4691.5K	1330	5548	14060	50540	5852											76,000
2	1500	8475.0K	2400		10023	25400	91301	10571										137,295
3	1500	8475.0K	2400			10023	25400	91301	10571									137,295
4	1661	9383.0K	2658				11096	28120	101080	11704								152,000
5	1661	9383.0K	2658					11096	28120	101080	11704							152,000
									11096	28120	101080							
										11096	28120							
											11096							
C/E				8/1														
Total Annual Production from Hatchery				5548	24083	85963	133649	141088	150867	152000	152000							
Comm. Catch of Hatchery Fish				4938	21434	76507	118948	125568	134272	135280	135280							
Escapement of Hatchery Fish				610	2649	9456	14701	15520	16595	16720	16720							
Hatchery Stock Required (3:5 M:F)				2400	2658	2658	2658	2658	2658	2658	2658							
Surplus*				-1790	-9	+6798	+12043	+12862	+13937	+14062	+14062							

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

UDM/UDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - LOWER SHUSWAP RIVER CHINOOK

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION 3	4	5	6	7	8	9	10							BROOD YEAR PRODUCTION
1	83	4691.5K	1330	5548	14060	50540	5852											76,000
2	1500	8475.0K	2400		10023	25400	91301	10571										137,295
3	1500	8475.0K	2400			10023	25400	91301	10571									137,295
4	1661	9383.0K	2658				11096	28120	101080	11704								152,000
5	1661	9383.0K	2658					11096	28120	101080	11704							152,000
									11096	28120	101080							
										11096	28120							
											11096							
C/E				8/1														
Total Annual Production from Hatchery				5548	24083	85963	133649	141088	150867	152000	152000							
Comm. Catch of Hatchery Fish				4938	21434	76507	118948	125568	134272	135280	135280							
Escapement of Hatchery Fish				610	2649	9456	14701	15520	16595	16720	16720							
Hatchery Stock Required (3:5 M:F)				2400	2658	2658	2658	2658	2658	2658	2658							
Surplus*				-1790	-9	+6798	+12043	+12862	+13937	+14062	+14062							

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - LOWER SHUSWAP RIVER CHINOOK

	Start		Final
Target Production	4,691,500	eggs	9,383,000
	.90		
Year of Start -	4,222,350	emergent fry (2g)	8,444,700
	.90		
(Adult Production Goal Achieved -yr. 9)	3,800,115	fingerlings (5g)	7,600,230
	.80		
(Total Egg - Adult=1.62%)	3,040,092	released fry	6,080,184
	.025		
	76,000		156,000

Current Natural Spawners (F381)

1951 - 1980 $\overline{X}$ = 5,922

1971 - 1980 $\overline{X}$ = 8,490

Maximum = 17,500

1979 = 10,000
1980 = 4,000

Best Estimate = 8,000

Target Natural Spawners
(60% of Maximum) = 10,500

Commercial Exploitation Rate (C/E) 8/1 (89%)[1]

Hatchery Capture Rate Wild Stock .3
Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CN	3	.185	.40	4,875[5]
	4	.665	.65	5,738[6]
	5	.077	.57	6,044[7]

[1] B. Pearce, 1980 Memorandum.
[2] Average of Management Dead Pitch Data (n=574)(1975-1980) and CWT Data (1980)(n=25) for Lower Shuswap River.
[3] Average of Management Dead Pitch Data (n=574) for Lower Shuswap River (minus 10% to account for skewing towards females in sampling)(1975-1980).
[4] From Chinook Test Fishery Data (1964-1966) for July 15-Aug. 30; the period corresponding to migration of Thompson System Chinooks.
[5] n=4
[6] n=42
[7] n=34

N.B. Corrected Mean Fecundity = 5,646

EAGLE PRODUCTION FORECAST ASSUMPTIONS - LOWER SHUSWAP RIVER CHINOOK

		Start		Final
Target Production		4,691,500	eggs	9,383,000
Year of Start -	.90	4,222,350	emergent fry (2g)	8,444,700
(Adult Production Goal Achieved - yr. 9)	.90	3,800,115	fingerlings (5g)	7,600,230
(Total Egg - Adult=1.62%)	.80	3,040,092	released fry	6,080,184
	.025	76,000		156,000

Current Natural Spawners (F381)

1951 - 1980 $\bar{X}$ = 5,922

1971 - 1980 $\bar{X}$ = 8,490

Maximum = 17,500

1979 = 10,000
1980 = 4,000

Best Estimate = 8,000

Target Natural Spawners
(60% of Maximum) = 10,500

Commercial Exploitation Rate (C/E) 8/1 (89%)[1]

Hatchery Capture Rate Wild Stock .3
Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CN	3	.185	.40	4,875[5]
	4	.665	.65	5,738[6]
	5	.077	.57	6,044[7]

[1] B. Pearce, 1980 Memorandum.
[2] Average of Management Dead Pitch Data (n=574)(1975-1980) and CWT Data (1980)(n=25) for Lower Shuswap River.
[3] Average of Management Dead Pitch Data (n=574) for Lower Shuswap River (minus 10% to account for skewing towards females in sampling)(1975-1980).
[4] From Chinook Test Fishery Data (1964-1966) for July 15-Aug. 30; the period corresponding to migration of Thompson System Chinooks.
[5] n=4
[6] n=42
[7] n=34

N.B. Corrected Mean Fecundity = 5,646

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - EAGLE RIVER COHO

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION 1984	1985	1986	1987	1988	1989	1990								BROOD YEAR PRODUCTION
1981	82	205.0K	131	1135	85													1,220
1982	375	937.5K	600		10637	801												11,438
1983	375	937.5K	600			10637	801											11,438
1984	499	1247.5K	799				14154	1066										15,220
1985	1082	2075.0K	1731					30690	2310									33,000
1986	1082	2075.0K	1731						30690	2310								33,000
										30690								
C/E				3/1														
Total Annual Production from Hatchery				1135	10722	11438	14955	31756	33000	33000								
Comm. Catch of Hatchery Fish				851	8042	8579	11216	23817	24750	24750								
Escapement of Hatchery Fish				284	2680	2859	3739	7939	8250	8250								
Hatchery Stock Required (3:5 M:F)				799	1731	1731	1731	1731	1731	1731								
Surplus*				-515	+949	+1128	+2008	+6208	+6519	+6519								

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - EAGLE RIVER COHO

	Start		Final
Target Production	100,000	eggs	2,705,000
	.90 ↓		↓
Year of Start - 1981	90,000	emergent fry	2,434,500
	.90 ↓		↓
(Adult Production Goal Achieved - 1989)	81,000	released fry (2g)	2,191,050
	.0151 ↓		↓
(Egg - Adult = 1.22%)	1,220		33,000

Current Natural Spawners (F381)

1951 - 1980 $\overline{X}$ = 2,107
1971 - 1980 $\overline{X}$ = 1,819

Maximum = 7,500

1979 = 2,500
1980 = 1,500

Best Estimate = 2,000

Target Natural Spawners
(60% of Maximum) = 4,500

Commercial Exploitation Rate (C/E) 3/1 (75%)[1]

Hatchery Capture Rate Wild Stock .3
Hatchery (Esc) .7

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CO	3	.93	.51	2,500
	4	.07	.51	2,500

[1] B. Pearce, 1980 Memorandum.
[2] From Management Dead-Pitch Data (n=57).
[3] Average of F381 and Management Dead-Pitch Data minus 10% to account for skewing towards females in sampling.
[4] Biostandards.

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - SALMON RIVER COHO

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION														BROOD YEAR PRODUCTION
				1984	1985	1986	1987	1988	1989	1990								
1981	40	100.0K	64	1183	37													1,220
1982	338	845.0K	540		10000	309												10,309
1983	338	845.0K	540			10000	309											10,309
1984	393	982.5K	629				11627	360										11,987
1985	754	1885K	1207					22310	690									23,000
1986	754	1885K	1207						22310	690								23,000
										22310								
C/E				3/1														
Total Annual Production from Hatchery				1183	10037	10309	11936	22670	23000	23000								
Comm. Catch of Hatchery Fish				887	7528	7732	8952	17003	17250	17250								
Escapement of Hatchery Fish				296	2509	2577	2984	5667	5750	5750								
Hatchery Stock Required (3:5 M:F)				629	1207	1207	1207	1207	1207	1207								
Surplus*				-333	+1302	+1370	+1777	+4460	+4543	+4543								

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - SALMON RIVER COHO

	Start		Final
Target Production	100,000	eggs	1,885,000
	.90		
Year of Start - 1981	90,000	emergent fry	1,696,500
	.90		
(Adult Production Goal Achieved - 1989)	81,000	released fry (2g)	1,526,850
	.0151		
(Egg - Adult = 1.22%)	1,220	adults	23,000

Current Natural Spawners (F381)

1951 - 1980 $\bar{X}$ = 1,705
1971 - 1980 $\bar{X}$ = 1,709

Maximum = 7,500

1979 = 2,000
1980 = 5,000

Best Estimate = 1,800

Target Natural Spawners
(60% of Maximum) = 4,500

Commercial Exploitation Rate (C/E) 3/1 (75%)[1]

Hatchery Capture Rate — Wild Stock .3
Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CO	3	.97	.46	2,500
	4	.03	.46	2,500

[1]B. Pearce, 1980 memorandum.
[2]From Management Dead Pitch Data (n=60).
[3]Average of F381 and Management Dead-Pitch Data minus 10% to account for skewing towards females in sampling.
[4]Biostandards.

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - ADAMS RIVER COHO

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION 4	5	6	7	8	9	BROOD YEAR PRODUCTION
1	82	205000	131	2375	125					2,500
2	82	205000	131		2375	125				2,500
3	82	205000	131			2375	125			2,500
4	164	410000	262				4750	250		5,000
5	164	410000	262					4750	250	5,000
									4750	
C/E				3/1						
Total Annual Production from Hatchery				2375	2500	2500	4875	5000	5000	
Comm. Catch of Hatchery Fish				1782	1875	1875	3656	3750	3750	
Escapement of Hatchery Fish				593	625	625	1219	1250	1250	
Hatchery Stock Required (3:5 M:F)				262	262	262	262	262	262	
Surplus*				+331	+363	+363	+957	+988	+988	

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - ADAMS RIVER COHO*

*At least 4 stocks make up the run of coho salmon entering the Adams River system. These include Adams River, Upper Adams River, Momich River and Sinmax Creek fish. In addition to these, several minor stocks probably exist, including Hiuihill (Bear) Creek. The minor stocks will not be included in total until escapement data is obtained.

Target Production		Start		Final
Year of Start -		205,000	eggs	410,000
	.90	184,500	emergent fry (2g)	369,000
(Adult Production Goal Achieved - yr. 8)	.90	166,050	released fry (5g)	332,100
(Overall Egg - Adult=1.22%)	.0151	2,500	adults	5,000

Current Natural Spawners (F381)[5]

	Adams R.	U. Adams R.	Sinmax	Momich	Total
1951 - 1980 $\overline{X}$ =	767	863	227	142	1,999
1971 - 1980 $\overline{X}$ =	185	180	96	39	500
Maximum =	3,500	3,500	750	750	8,500
1979 =	100	475	140	150	865
1980 =	200	75	30	N/O	305
Best Estimate =	162	175	60	40	437
Target Natural Spawners (60% of Maximum) =	2,100	2,100	450	450	5,100

Commercial Exploitation Rate (C/E) 3/1 (75%)[1]

Hatchery Capture Rate Wild Stock .3
Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CO	3	.95	.48	2,500
	4	.05	.48	2,500

[1]B. Pearce, 1980 Memorandum.
[2]Average of 1978, 1980 Management Dead-Pitch data for S. Thompson streams (Eagle River, Salmon River).
[3]Average of F381 and Management Dead-Pitch Data (minus 10% to account for skewing towards females in sampling) for S. Thompson streams (Eagle River, Salmon River).
[4]Biostandards.
[5]There appears to be several small runs of Coho to some of the smaller tributaries to Adams River and Adams Lake. No spawning files exist for streams such as Hiuihill (Bear) Creek and Nikwikaia Creek, but 10-30 spawners appear to use these streams (and others) annually (B. Kurtz, F.O. Salmon Arm).

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - LOWER SHUSWAP RIVER COHO

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION														BROOD YEAR PRODUCTION
				4	5	6	7	8	9	10	11	12						
1	56	140.6K	90	1630	86													1,716
2	56	140.6K	90		1630	86												1,716
3	56	140.6K	90			1630	86											1,716
4	133	332.5K	212				3854	203										4,057
5	142	355.0K	228					4115	216									4,331
6	142	355.0K	228						4115	216								4,331
7	164	410.0K	262							4750	250							5,000
8	164	410.0K	262								4750	250						5,000
												4750						
C/E				3/1														
Total Annual Production from Hatchery				1630	1716	1716	3940	4318	4331	4966	5000	5000						
Comm. Catch of Hatchery Fish				1223	1287	1287	2955	3239	3248	3725	3750	3570						
Escapement of Hatchery Fish				407	429	429	985	1079	1083	1241	1250	1250						
Hatchery Stock Required (3:5 M:F)				212	228	228	262	262	262	262	262	262						
Surplus*				+195	+201	+201	+723	+817	+821	+979	+988	+988						

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - LOWER SHUSWAP RIVER COHO

	Survival	Start		Final
Target Production		140,625	eggs	410,000
Year of Start -	.90	126,563	emergent fry	369,000
(Adult Production Goal Achieved - yr. 11)	.90	113,906	released fry (2g)	332,100
(Egg to Adult Survival=1.22%)	.0151	1,716	adults	5,000

Current Natural Spawners (F381)

1951 - 1980 $\overline{X}$ = 954

1971 - 1980 $\overline{X}$ = 192

Maximum = 3,500

1979 = 300
1980 = 350

Best Estimate = 300

Target Natural Spawners
(60% of Maximum) = 2,100

Commercial Exploitation Rate (C/E) 3/1 (75%)[1]

Hatchery Capture Rate — Wild Stock .3; Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CO	3	.95	.49	2,500
	4	.05	.49	2,500

[1]B. Pearce, 1980 Memorandum.
[2]Average of 1978, 1980 Management Dead Pitch Data for S. Thompson streams (Eagle River, Salmon River).
[3]Average of F381 and Management Dead Pitch Data (minus 10% to account for skewing towards females in sampling) for S. Thompson streams (Eagle River, Salmon River).
[4]Biostandards.

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - WAP CREEK COHO

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION 4	5	6	7	8	9									BROOD YEAR PRODUCTION
1	56	140.6K	90	1630	86													1,716
2	56	140.6K	90		1630	86												1,716
3	56	140.6K	90			1630	86											1,716
4	131	328.0K	210				3800	200										4,000
5	131	328.0K	210					3800	200									4,000
									3800									
C/E				3/1														
Total Annual Production from Hatchery				1630	1716	1716	3886	4000	4000									
Comm. Catch of Hatchery Fish				1223	1287	1287	2915	3000	3000									
Escapement of Hatchery Fish				407	429	429	971	1000	1000									
Hatchery Stock Required (3:5 M:F)				210	210	210	210	210	210									
Surplus*				+197	+219	+219	+761	+790	+790									

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - WAP CREEK COHO

		Start		Final
Target Production		140,625	eggs	328,000
Year of Start -	.90	126,563	emergent fry	295,200
(Adult Production Goal Achieved - yr. 8)	.90	113,906	released fry (2g)	265,680
(Total Egg to Adult = 1.22%)	.0151	1,716	adults	4,000

Current Natural Spawners (F381)

1968 - 1980 $\overline{X}$ = 215

1971 - 1980 $\overline{X}$ = 216

Maximum = 516

1979 = 400
1980 = 250

Best Estimate = 300

Target Natural Spawners
(60% of Maximum) = 310

Commercial Exploitation Rate (C/E) 3/1 (75%)[1]

Hatchery Capture Rate — Wild Stock .3
Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CO	3	.95	.50	2,500
	4	.05	.50	2,500

[1]B. Pearce, 1980 Memorandum.
[2]Average of 1978, 1980 Management Dead Pitch Data for S. Thompson streams (Eagle River, Salmon River).
[3]Average of F381 and Management Dead Pitch Data (minus 10% to account for skewing towards females in sampling) for S. Thompson streams (Eagle River, Salmon River).
[4]Biostandards.

DDM/DDM/BGS
June 4, 1981

EAGLE PRODUCTION FORECAST - BESSETTE CREEK COHO

BROOD YEAR	DONOR FEMALES	EGG NUMBER	TOTAL DONORS	ADULT PRODUCTION														BROOD YEAR PRODUCTION
				4	5	6	7	8	9									
	103	257.5K	165	3028	114													3,142
	103	257.5K	165		3028	114												3,142
	103	257.5K	165			3028	114											3,142
	230	574.0K	367				6748	252										7,000
	230	574.0K	367					6748	252									7,000
									6748									
C/E				3/1	→													
Total Annual Production from Hatchery				3028	3142	3142	6862	7000	7000	→								
Comm. Catch of Hatchery Fish				2271	2357	2357	5147	5250	5250	→								
Escapement of Hatchery Fish				757	785	785	1715	1750	1750	→								
Hatchery Stock Required (3:5 M:F)				367	367	367	367	367	367	→								
Surplus*				+390	+418	+418	+1348	+1383	+1383	→								

(For assumptions used in developing this forecast, see attached sheet).

* Surplus may be assigned to natural spawning, increased C/E (i.e. implementation of terminal fishery), etc.

EAGLE PRODUCTION FORECAST ASSUMPTIONS - BESSETTE CREEK COHO*

	Rate	Start		Final
Target Production		257,500	eggs	574,000
Year of Start -	.90	231,750	emergent fry	516,600
(Adult Production Goal Achieved - yr. 8)	.90	208,575	released fry (2g)	464,940
(Total Egg to Adult = 1.22%)	.0151	3,142	adults	7,000

Current Natural Spawners (F381)*

1962 - 1980 $\overline{X}$ = 917

1971 - 1980 $\overline{X}$ = 782

Maximum = 2,500

1979 = 530
1980 = 60

Best Estimate = 550

Target Natural Spawners
(60% of Maximum) = 1,500

Commercial Exploitation Rate (C/E) 3/1 (75%)[1]

Hatchery Capture Rate Wild Stock .3
Hatchery (Esc) .3

Species	Age	Fraction Stock[2]	Fraction Female[3]	Fecundity[4]
CO	3	.964	.53	2,500
	4	.036	.53	2,500

[1]B. Pearce, 1980 Memorandum.
[2]Average of 1978, 1980 Management Dead Pitch Data for Bessette Creek.
[3]Average of 1978, 1980 Dead Pitch Data (minus 10% to account for Bessette and S. Thompson streams (Eagle River, Salmon River).
[4]Biostandards.
*Includes returns to Bessette, Creighton, Duteau and Harris Creeks.

APPENDIX 2

Eagle River Project

Food Storage Requirements

Appendix 2 **Eagle River Project - Food Storage Requirements**

Method 1. Food Conversion

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

b.) During that time, chinook gain a maximum of 4.5 grams, and coho gain 1.5 grams

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

For April - June each year:

CN @ 4.5 g gain x 533 = 2399Kg

CO @ 1.5g gain x 3718 = 5577Kg

= 7976Kg Fish

x2.0Kg Feed Conversion

= 15,952Kg Feed

(N.B. Semi load is 15,000Kg)

Method 2. Daily Ration

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

Stock	Size	No.	Rate	Ration	Daily Food	Size	No.	Rate	Ration	Daily Food
CN	.5g	667K	5.52%	.9	16.57	5g	533K	2.54%	.9	60.92
CO	.5g	4131K	5.52%	.6	68.41	2g	3718K	3.45%	.6	153.93
					84.98					214.85

Average (84.98 + 214.85)/2 = 149.92 Kg/day
149.92Kg/day x 90 days = 13,493 Kg Feed

Freezer Space Required

(15,952 + 13,493)/2 = 14,773Kg 22.7Kg/bag = 651 bags

651 bags x 0.06m^3/bag = 3.9m^3 bag volume

651 bags + 30 bags per 1/m^2 stack = 22m^2

22m^2 OMP space + 4m^2 aisle space = 26m^2 freezer area

5m^2 cooler area

31m^2 total area

2.4m ceiling height gives 63m^3 freezer/12m^3 cooler/75m^3 total.

APPENDIX 1b. SENATOR'S PACKAGE PILOT DESIGN MEMO

TO / À: SEE DISTRIBUTION

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE: 5903-85-E7

YOUR FILE/VOTRE RÉFÉRENCE

DATE: November 9, 1981.

FROM / DE: B.G. Shepherd
A/New Projects Coordinator

D.D. MacKinlay
Design Biologist
E.S.P.

SUBJECT / OBJET: RE: EAGLE PILOT DESIGN AND EXPANSION STRATEGY

The following approach has been developed following discussions with T. Perry, R. Harrison and B. Pearce, and a meeting with G. Bérézay, J. McNally and W. Peterson on October 29, 1981.

PILOT DESIGN

OBJECTIVES AND CONSTRAINTS:

The following key assumptions have been made (see also memos of July 31 and August 21, 1981, on this file):

1) Pilot funding is limited to a maximum of \$500K; if additional funding becomes available, key components of the full-scale facility will be built incorporating the pilot features. Realistically, this level of funding will allow a facility size of less than 1M eggs.

2) A facility of less than 1M eggs will have few stock management constraints imposed on it by the Fraser GWG, and would be allowed to run in an experimental mode aimed towards optimizing enhancement strategies for the South Thompson.

3) The fundamental questions that the pilot must answer are as follows:

   a) To what degree is the present rearing habitat under-utilized (quantify)?

   b) What are the best release methods to maximize rearing in underutilized areas, and to ensure proper imprinting of satellite stocks?

   c) If the optimum outplant strategy requires hatchery operation through the summer, how might effluent treatment be approached?

T. Perry has approximated the minimum sizes of tag groups required in order to answer the outplant questions, which would require a minimum facility size of 507K eggs with a largest stock size of 237K eggs (see Attachment 1).

4) Using the assumptions as developed in the July 31 memo, chinook stock sizes initially will be adequate to support egg-takes of not much more than 250K eggs on the Eagle and Salmon Rivers (hatchery capture rates of 20-25%, versus the 30% wild stock maximum normally followed).

Therefore, it is proposed that the pilot facility will deal with a maximum of 250K eggs of both chinook and coho stocks from each of the Salmon and Eagle Rivers, for a maximum total facility size of 1M eggs (see Table 1).

BIOLOGICAL REQUIREMENTS:

Incubation

Equipment
- both CN and CO held to swim-up in Heath trays
- each stock of 250K CN eggs @ 5000 eggs/tray , requires 50 trays; 250K CO @ 8500 eggs/tray require 30 trays
- Each river therefore would require 80 trays (10 eight-tray stacks) to handle both species, or 160 trays (20 eight-tray stacks) in total

Flows
- routine/flush flows are 15/19 lpm per stack. Corresponding maximum demands (in lpm) are:

Flow	(Each River) CN	(Each River) CO	River Total[a]	Grand Total
Routine	105	60	150	300
Flush	133	76	190	380

[a]Less than species total due to sharing of stacks by species within each river.

/3

- routine source for incubation will be well water, but full backup with surface water is required for emergency situations.
- period of incubation is October 27-March 21 for CO and September 7-February 19 for CN (see July 31 memo).

Rearing, Swim-up 2g

Equipment
- CO will utilize Capilano-style troughs, CN will be ponded into shallow crowder sections (one per river) at the upper end of the earthen channels used for their final rearing (see below).
- trough loadings of 54,000 fry/trough require 4 troughs for each of the river stocks of 225K CO, or 8 troughs in total.
- Based on the calculation procedure used in the July 31 memo, CN start-up sections require $12m^3$ of volume for each stock.
- suggested dimensions for the start-up sections are:

Wall height	=	1.3m
Water depth	=	0.75m
Raceway width	=	2.5m
Raceway length	=	6.5m

- each of the sections should be capable of being partitioned with a fry-proof screen into halves.

/4

Flows - Capilano-style troughs require flows of 120/240 lpm start/end; therefore, each river CO stock requires 480/960 lpm start/end (960/1930 lpm total).

- start-up raceway requirements were calculated as per the July 31 memo. Each river CN stock requires 145/493 lpm start/end (290/986 lpm total).

- source would routinely be well water, but a full surface backup is requested for emergencies.

- period of early rearing would be February 9-June 24 for CO and January 15-May 5 for CN (see July 31 memo).

Final Rearing (CN only, 2g to 5g)

Equipment- channel type could be concrete or earthen, but must be amenable to crowding and transfer of fish into tank trucks (ie, crowder screens, concrete sumps at lower end), at least for the Salmon River stock. If significant cost savings can be achieved using Aqua-breeder raceways, these also may be considered for the pilot only.

- sizings calculations as per the July 31 memo give maximum volume requirements of $70m^3$ for each river stock of 180K 5g fry. If the start-up raceways are double-used in final rearing, the net volume requirement would be $58m^3$ for each stock ($116m^3$ total).

- recommended dimensions are:

Channel Type	Reference Prototype	Wetted Cross-section	Water Depth	Net Length[a]
Earthen	Chilliwack STHD	$5m^2$	0.8m	12m
Concrete	as per start-up raceway	2	0.8	29

[a]For each stock

/5

Flows - start/end flow demands would be 493/947 lpm for each stock (986/1894 lpm total), using the 'Bio-load' rates as set in the July 31 memo.

- source would be well water only, until surface water temperature met that of the well (ie, last two weeks of June); thereafter, complete turnover to the surface supply may be desirable.

- duration of final rearing would be March 31-June 29.

Adult Holding

Equipment - double-use of the CN rearing channels would allow the following numbers to be held in each of the two channels:

Species	Rearing Volume	Avg. Fish Size	Adult Loading	No. of Adults
CN	$70m^3$	5kg	$32kg/m^3$	448
CO	70	3	32	747

As only 75 CN and 320 CO adults are required from each river to fulfill the egg targets, the rearing channels would be more than adequate for the purpose.

- use of the rearing channels will require either higher walls or the provision of bounce-panels to retain jumpers

Flows - holding flows would be less than those required for rearing:

Species	Max. Wt. Fish Held	Adult Loading	Holding Flow	(Max. Rearing Flow)
CN	375kg	1.2kg/LPM	450 LPM	(1894LPM)
CO	960	1.2	1152	

- in of recent disease analyses and logistical findings, source should be well water with emergency surface backup. Periods of flows would be July 15-October 1 for CN and October 1-December 15 for CO (see July 31 memo).

Support Items:

1. Aerator capable of achieving 102-103% N_2 and 95% O_2 for well water (D. MacKinlay will provide specifications).
2. Inches-type crew residence/office trailer.
3. Incubation trailer with tray wash sinks, three CWT marking stations and storage space.
4. Back-up generator for power supply.
5. Both wells developed and each with pump, to provide well/pump backup.
6. Remote alarm system to both residence trailer and pager.
7. Quinsam-type transport tanks.
8. Walk-in freezer of suggested total volume of 22m^2 (bag volume alone is 10.4m^3 for 173 bags; additional circulation space around stacks and aisle space is required). If there is commercial freezer storage nearby, three standard chest freezers on-site would be acceptable (2-3 weeks supply). It is emphasized that, due to the facility's remoteness from larger hatcheries capable of providing logistical support, bulk freezer storage of some type should be provided to cover the 90-day maximum feed period. (Calculations were made as per the July 31 memo).
9. A continuous-use settling lagoon, proportioned to the pilot facility size with respect to the maximum lagoon area available for a full-size facility, is requested. Operations staff will be responsible for implementing an effluent monitoring program.
10. Temporary predator fencing around channels and troughs; additionally, due to snow loads, trough area to be covered.

11. No formal off-site adult trapping structures are requested at this time, as it is felt the pilot's objectives can be met using a temporary adult fence on the Salmon, and a seining program on the Eagle. Adult holding and juvenile rearing requirements are presently uncertain; netpens will be attempted initially.

SUMMARY:

Table 2 provides a pilot strategy summary; Table 3 summarizes the projected water demand by month, purpose, species, and stock.

FULL-SCALE FACILITY DESIGN

To provide for Engineering's contingency planning with respect to potential additional funding, and in the absence of any firm targets set by the Fraser River GWG, the following approach will be taken in developing 'shelf items':

1) If minor additional funds become available, the pilot will be housed within a permanent incubation/support building capable of operation at full scale.

2) Further minor funding would go to providing concrete raceways of appropriate size and placement for inclusion in the full-scale facility, rather than temporary rearing channels located outside of the full-scale facility area.

3) A major injection of funds would go to the complete construction of the full-scale facility within Phase I. The full-scale level, in the continuing absence of firm GWG targets, is defined to be the 'large' facility, as outlined in the July 31 memo.

Your comments are invited.

B.G. Shepherd

BGS/mmm

Att.

c.c. F.K.	Sandercock	D.	Harding	R.	Harrison
T.	Perry	A.F.	Lill	B.	Pearce
C.N.	MacKinnon	J.	McNally	R.	Morley
G.	Bérézay	W.	Peterson	J.	Barnetson
		R.	Dickson	S.	Samis

TABLE 1. Production Objectives for Eagle Pilot.

STOCK	EGGS	%	EMERGENT FRY	%	FINGERLINGS	%[a]	RELEASED FRY	%[b]	TOTAL RETURN	FEMALE DONORS[c]	TOTAL DONORS[d]
EAGLE											
Chinook	250K	90	225K	90	202.5K	80	180K	1.62	4050	46	73
Coho	250K	90	225K	-	-	90	202.5K	1.22	3050	100	160
SALMON											
Chinook	250K	90	225K	90	202.5K	80	180K	1.62	4050	46	73
Coho	250K	90	225K	-	-	90	202.5K	1.22	3050	100	160

*

[a] Survival from emergent fry to released fish

[b] Survival from egg to adult

[c] Assumed average fecundities of 5500 CN, 2500 CO

[d] Assumed egg-take ratio of 3:5, male:female

TABLE 2. Rearing Strategy for Eagle Pilot.

		EAGLE RIVER		SALMON RIVER		TOTAL
		CHINOOK	COHO	CHINOOK	COHO	
INCUBATION	Eggs	250K	250K	250K	250K	1000K
	Heath Trays	50	30	50	30	160
	Stacks	6	4	6	4	10
	Flow in lpm (Flush)	90(114)	60(76)	90(114)	60(76)	300(380)
	Period-from	Sep 15	Oct 27	Sep 7	Oct 27	-
	-to	Feb 19	Mar 21	Feb 4	Mar 21	-
EARLY REARING	Fry	225K	225K	225K	225K	900K
	Troughs		4		4	8
	Raceways	1		1		2
	Flow in lpm-start	145	480	145	480	290/960
	-end	493	960	493	960	986/1920
	Period-from	Feb 4	Feb 9	Jun 15	Feb 9	-
	-to	May 5	Jun 24	Apr 20	Jun 24	-
FINAL REARING	Fingerlings	202.5K	202.5K	202.5K	202.5K	810K
	Raceways	1		1		2
	Flow in lpm-start	493		493		986
	-end	947		947		1894
	Period-from	Apr 20		Mar 31		-
	-to	Jun 29		Jun 19		-

TABLE 3. Water Demand Table for Eagle Pilot (in lpm).

		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
HEATH TRAYS	CO	120	120	120							120	120	120
	CN	180	180							180	180	180	180
CAPILANO TROUGHS	CO		1000	1300	1600	1800	1920						
REARING CHANNELS	CN	200	450	700	986	1500	1894						
ADULT HOLDING	CO									200	1152	1152	200
	CN							200	450	450	200		
TOTAL	CO	120	1120	1420	1600	1800	1920			200	1272	1272	320
TOTAL	CN	380	630	700	986	1500	1894	200	450	630	380	180	180
GRAND TOTAL		500	1750	2120	2586	3300	3814	200	450	830	1652	1452	500

ATTACHMENT 1. MINIMUM SIZES OF TAG GROUPS FOR EAGLE/SALMON PILOT FACILITY (CALCULATIONS DONE BY T. PERRY).

A. ASSUMPTIONS:

Species	Release Size(g)	Survival Rel./Smolt(%)	Survival Smolt/Adult(%)	C/E	Escapement Sample Rate(%)
CN	5	100	2.25	6/1	50
	2	20	2.25	6/1	50
CO	2	10	15.0	3/1	50

B. STATISTICAL CALCULATIONS:

Species	Size	*P_{90}, $K_{1.25}$	P_{80}, $K_{1.50}$	P_{90}, $K_{1.50}$	P_{80}, $K_{1.25}$
CO	2g	75,000	10,000	25,000	35,000
CN	2g	380,000	55,000	120,000	170,000
	5g	80,000	10,000	25,000	35,000

* P = probability in % of detecting K

K = performance difference between groups

(eg - P_{90}, $K_{1.25}$ = 90% confidence in detecting 25% difference between group returns)

C. TAG GROUP SIZES, CONSIDERING LOGISTICS: (one age class only).

Species	Stock	Size	Release Point	No. of Fry Marked: Ideal	No. of Fry Marked: Practical	Practical No. of Eggs
CN	Eagle	5g	No Eval'n	80,000	50,000	70,000
	Salmon	2g	No Eval'n	380,000	120,000	167,000
		5g	No Eval'n	80,000	50,000	70,000
CO	Eagle	2g	Upper Watershed	75,000	35,000	50,000
			Lower Watershed		35,000	50,000
	Salmon	2g	Upper Watershed	75,000	35,000	50,000
			Lower Watershed		35,000	50,000
					TOTAL	507,000

APPENDIX 1c. EXPERIMENTAL PILOT PROPOSAL

TO

F.K. Sandercock, Chief
SEP Enhancement Operations
A.F. Lill, Chief
SEP Engineering
R. Harrison, Chairman
Fraser River GWG

FROM
DE

B.G. Shepherd
New Projects Coordinator
SEP Enhancement Operations

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE
5903-85-T85

YOUR FILE/VOTRE RÉFÉRENCE

DATE
September 14, 1983.

SUBJECT
OBJET

PROPOSED TARGETS FOR THOMPSON PILOT HATCHERIES

Background

For the Thompson region to date, SEP has completed a pilot facility on the Eagle River which is now beginning broodstock collection, and will have three other pilots ready for operation in the fall of 1984 on the Clearwater, Nicola and Shuswap systems. The Eagle facility was funded from Phase I of SEP, while the other three facilities are part of a Special Employment Initiative Program (SEIP now ERI). Each pilot was designed to ask a few specific questions regarding inland enhancement strategies; it was hoped that their combined results would provide overviews of more general worth with respect to outplanting and imprinting strategies, etc. Targets for these facilities were based on the statistical number of tags required (Table 1).

Planning for the continuation of SEP has resulted in the so-called Transitional Plan, which emphasizes reconnaissance, feasibility, and pilot projects, with some expansion of existing facilities. An integral part of this plan was the immediate expansion to the above four facilities in order..."to arrest the serious declines in chinook and also coho stocks on the Fraser." (p 500, Annex II, Addendum A, March 1, 1983). However, Enhancement Operations views the immediate expansion to production levels (see proposed targets in Table 1) as very risky, until adult returns resulting from the existing pilots are known. The Fraser GWG recommended not to proceed with large-scale chinook enhancement for this reason, and because of a desire to increase escapements through management actions, and an uncertainty as to the value of enhancing stocks that may contribute mainly to the Alaskan fisheries (see Harrison-Swan memo of July 26, 1983; file 5830-85-F107). In any event, the capital funds allocated to construction of the expansions may not be adequate to achieve the proposed higher targets (A.F. Lill, pers. comm.).

In summary, then, the proposed expansion targets are regarded as not feasible on several fronts. Yet in terms of not prematurely foreclosing on any options, it seems to me to be desirable to continue our initiative on Fraser chinook and coho in particular, and on definition of upriver culture techniques in general.

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The Purpose of This Memo

I would like to propose a compromise; a set of targets based on the expansion of each pilot operation, to provide a more rounded experimental program that minimizes the possibility of site-specific characteristics confounding the results. In addition, testing of several strategies in the same year on a stock will guard against complete failure of a return, should certain coastal strategies be inappropriate to the upriver situation.

I emphasize that expansion results in a better pilot, rather than transformation into a production facility. A key point to be made is that, if we go to larger pilots, their operation will be more costly than the "marginal additional cost above the present pilot operations" identified in the Transitional Plan Submission. For example, application of coded-wire tags costs 10¢/fish; this translates to an additional $ 200,000 annually required for the expanded pilot program as proposed below. In addition, more intensive juvenile rearing and adult tag-recovery surveys also require funding. It is also worth noting that the funding and responsibility for the operation of the present ERI pilots remains unresolved.

Outline of Approach

Targetting within this memo has been approached in a stepwise fashion as follows:

1) What questions regarding upriver enhancment strategies need to be answered?

2) What are the experimental requirements of the program modules needed to answer those questions?

3) What stocks can the existing sites deal with, and what are their broodstock potentials?

4) What are the physical constraints at each site?

5) Considering the above items, what would the targets be for each expanded pilot?

(1) Major Questions Regarding Upriver Enhancement Strategies:

i) To what degree is the present rearing habitat underutilized? The general consensus from the Fraser GWG was that rearing capacity was in excess of present levels of utilization by the existing stocks. Bioreconnaissance studies done by BCFW and consultants for the New Projects Unit over the last two years do indicate empty habitat suitable for rearing. Gross quantifications of rearing capability were made, and will be used later in this memo to define some upper limits. However, it is pointed out that the habitat

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may be vacated of necessity, because of the prolonged downstream migration that Thompson juveniles face. Rearing in the Thompson and Fraser mainstems is at present a 'black box' entity. Moreover, recent studies of Ceratomyxa shasta infectivity in the lower Fraser have indicated that outmigrants may have to fit through a very narrow timing window. The productivity of juvenile releases into apparently underutilized areas of the Thompson therefore deserves a close look, both in terms of post-release juvenile distribution and survival, and of juvenile-adult survival.

ii) What release methods must be used to maximize juvenile rearing in chosen areas and survival to adult? Time and size release experimentation is required. As a general guide, Bilton's work at coastal facilities would indicate that size of fish at release has much less effect on survival to adult than does the timing of release. For the Thompson, there is additional complexity in that rearing and downstream migration success must be separated and evaluated.

iii) What methods must be used to minimize adult straying? Methods of release to ensure imprinting to return sites must be investigated. In general, Lister's review would indicate that much higher straying rates can be expected where the returning fish passes the hatchery prior to the release site (ie, upstream outplants). Size at release, time of release, and holding period are other potentially important factors requiring evaluation for both upstream and downstream outplants.

iv) Do geographic differences require different enhancement techniques? The uncertainty as to whether coastal data will apply inland has been mentioned previously. However, even within the Thompson region there is a marked disparity in climate between the North and South Thompson. In addition, the South Thompson requires fish to migrate through a highly complex lake system.

v) How can hatchery effluent be controlled or treated? This is an important technological question for the Interior Drybelt systems. Either we avoid producing effluent during the crucial periods of the year by early outplanting of the fish (as proposed for the Eagle), or we find ways of treating or disposing of it (eg, overland spray irrigation at Nicola).

2) Experimental Modules for Definition of Upriver Enhancement Strategies: The following program modules were developed in consultation with T. Perry, and are based on preferred minimum numbers required to provide statistically-valid answers to the questions posed in the previous section:

i) Gross Strategies for Release. At a minimum, one chinook and one coho stock per geographically-distinct area (two would be preferred) should be subjected in the same year to four strategies, as follow--

Species	Release Period	Fish Size	No. of Tags	No. of Eggs[b]
Chinook	First Spring	2g	100K	150K
	First Spring	5g	80K	125K
	First Fall	5g	80K	125K
	Second Spring	10-15g[a]	50K	100K
			310K	500K
Coho	First Spring	2g	100K	150K
	First Fall	5g	75K	120K
	First Fall[c]	10g	75K	110K
	Second Spring	10-20g[a]	25K	50K
			275K	430K

[a] preferred size underlined (correspond to wild smolt eggs)

[b] survival rates used are ~10% more conservative than biostandards, to ensure that tag group numbers are obtained.

[c] this group optional.

ii) Fine-tuning of Release Timings. Where smolt-size fish are being released during the wild migration period, the release should be split into five lots. Spring releases of 5g sub-1 and 10-15g sub-2 chinook, and 10-20g yearling coho should be examined in this fashion for both satellited and hatchery-return stocks in each geographically distinct region--

Species	Release Size	Release Timing	No. of Tags	No. of Eggs
Chinook	5g (sub-1)	4 wk early	25-50K[a]	40-80K
		2 wk early	25-50K[a]	40-80K
		at peak	25-50K[a]	40-80K
		2 wk late	25-50K[a]	40-80K
		4 wk late	25-50K[a]	40-80K
			125-250K	200-400K
	10g+ (sub-2)	5 lots (as above)	25-50K (X 5)	50-100K (X 5)
			125-250K	250-500K

Coho	10g+ (sub-2)	5 lots (as above)	25K (X5)	45K (X5)
			125K	225K

[a] preferred number underlined.

iii) Maximization of Rearing in Release Areas. Where fish are released at times and sizes meant to encourage instream rearing, allowance should be made for various experimental groups to investigate details of release methodology (eg, upstream versus downstream dump sites, point versus scatter releases, etc.). Some of these items may be best evaluated by instream survey during the juvenile rearing period, which would require additional fin clips or marks that would be recognizable without sacrifice of the juveniles. If four tag lots per stock were arbitrarily allowed for this purpose, numbers would be as follow--

Species	Release Size (Time)	No. of Tags	No. of Eggs
Chinook	2g (Spring)	100Kx4 = 400K	150Kx4 = 600K
	5g (Fall)	80Kx4 = 320K	125Kx4 = 500K
Coho	2g (Spring)	100Kx4 = 400K	150Kx4 = 600K
	5g (Fall)	75Kx4 = 300K	120Kx4 = 480K
	10g (Fall)	75Kx4 = 300K	110Kx4 = 440K

These studies should interface with the rearing capacity determinations outlined in Section 3.

iv) Strategies to Ensure Imprinting. Artificial rearing of juveniles may be required to ensure homing of adults to satellite streams. In each geographic area, both an upstream and a downstream stock of each species should be subjected to various durations of instream artificial rearing. Suggested numbers are--

Species	Release Size (Time)	Imprinting Period	No. of Tags	No. of Eggs
Chinook	2g[a]	none	100K	150K
	(Spring)	1 day	100K	150K
		1 week	100K	150K
			300K	450K
	5g	none	50K	80K
	(Spring)	1 day	50K	80K
		1 week	50K	80K
		1 month	50K	80K
			400K	320K
Coho	2g[a]	none	100K	150K
	(Spring)	1 day	100K	150K
		1 week	100K	150K
			300K	450K
	5g+[a]	none	75K	120K
	(Fall)	1 day	75K	120K
		1 week	75K	120K
			225K	360K
	10g+	none	25K	50K
	(Spring)	1 day	25K	50K
		1 week	25K	50K
		1 month	25K	50K
			100K	200K

[a] optional (see text comments following).

Priority should be given to evaluating imprinting of potential smolt releases. However where point releases of premigrants are considered, some acclimation prior to release may promote natural rearing within the system. The latter may be best handled using unique marks recognizable on live juveniles.

(3) Determination of Rearing Capacities:

Biological baseline studies done to date by BCFW and consultants have used various methods to predict fry stocking capacities for most of the systems of interest in this region (Table 2). Shuswap surveys are being done in 1983 by BCFW. These predicted capacities are highly theoretical; the acid test of their accuracy would be to load selected small-to-medium sized streams to saturation in each geographically distinct area, with post-stocking assessment of juvenile production. In addition, densities could be varied by reach within certain streams; for each stream and species so treated, six 100K tag groups (high, medium and low densities in both upper and lower sections of the watershed) would be required for 2g fish.

(4) Broodstock Potentials of Enhanceable Systems:

Table lists the major stocks in the region that were recommended for enhancement by the Fraser GWG (memo of February 27, 1980; file 5830-13-1). Proposed targets in Table 3 have been adjusted from that original memo by halving the large mainstem chinook and all coho targets (B. Pearce, pers. comm., May 14, 1982).

(5) Site Constraints:

Site investigations to date (see Table 4) indicate that some of the sites may be better suited physically to certain experimental approaches than others. For example, temperature manipulation is critical for time-and-size experimentation: the Clearwater and Nicola sites show the most potential for temperature manipulation followed by Eagle, while the Shuswap site is not yet defined.

Although construction costing has not been done to date, the maximum possible without requiring a TB Submission (ie, a minor project) is now $1M. This apparently is in addition to any existing investment, thus the Shuswap facility would be at or under $1M and the other sites could total $1.5M. As a rough guide, this would limit the Shuswap facility to something slightly larger than Tenderfoot ($0.75M estimated total; adult returns of 10K chinook, 15K coho and 2K steelhead; 3800 kg of juveniles released) and the other facilities to something slightly smaller than Inch's ($2M estimated total; adult returns of 114K chum and 25K coho; 9000 kg of juveniles released).

(6) Putting the Pieces Together:

Using the information contained in the previous section, it is predicted that the annual capacity of the expanded facilities would be 5000 kg for Shuswap and 7000 kg for the others. The demands of the proposed experimental program alone (Table 5) are far in excess of these projected capacities. This suggests that we must priorize our studies and stretch the program beyond one year. In terms of priorities, gross time and size studies are considered

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to be first, imprinting strategies second, detailed timing third, and maximization of rearing fourth. It should be noted that some aspects of rearing could be investigated concurrent with the time and size studies, and that the imprinting and detailed timing modules can nest together well (as per the 1983 Quesnel program).

Targetting should remain flexible for these facilities; sample approaches have been outlined for each facility in Tables 6-8, but it is emphasized that there are a multitude of equally workable (and perhaps more feasible) combinations possible. To achieve this flexibility, the design of the facilities should revolve around a basic lot size of 200K which could remain separable through to the release point. To meet the cost constraints, this will require that much of the separation during rearing will have to be obtained via screening within a common container, rather than via separate containers. It is important to identify this consequence; although disease surveys to date have not lturned up tributary-unique diseases that could have major impact on the other stocks of each area, our sampling is incomplete. Therefore, such an approach will be a calculated risk, and may result in extensive retrofits when more data become available.

The rationale resulting in the suggested targets as outlined in Tables 6-8 are discussed by facility below--

i) <u>The North Thompson area facility at Clearwater (Table 6)</u>.

Of the six chinook and eight coho major stocks (11 systems) recommended for enhancement by the GWG (Table 3), it is suggested that an expanded pilot facility deal with all but the Barriere River coho, and Louis Creek and North Thompson Mainstem chinook and coho stocks. It is presumed that existing Special Projects Division (SPD) initiatives will continue on the first two systems. It is emphasized that the existence of an SPD project on a system should not necessarily result in non-consideration for these pilots; there are opportunities for cooperative programs that would allow simultaneous comparison of stocks reared both on-site and off-site. For example, Dunn Creek and Lemieux Creek coho have been included here to allow comparison of homing of satellited fish versus fish reared on-site by the CITC project. In terms of pilot efforts, the North Thompson Mainstem stocks have been avoided due to the logistical difficulties that their monitoring would present.

Both chinook and coho of the Clearwater River are proposed as hatchery-release stocks (rearing beyond the 10g size might be achievable in the Clearwater River in a modified sidechannel or in pens). Their limits in terms of broodstock availability and GWG targets are relatively high, while rearing capacity below the lake is considered poor. The Clearwater stocks therefore would be emphasized in terms of 'smolt' time and size experimentation. The high broodstock and GWG limits versus the low rearing potential similarly resulted in the selection of Mahood River chinook and Lion Creek coho for 'smolt' time and size experimentation upstream

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of the hatchery. Finn Creek is usable for chinook premigrant outplants, both to check on rearing capacity predictions and to evaluate upstream imprinting techniques. Raft River is of special interest for both chinook and coho, mainly due to its proximity to the hatchery site; it is considered most suited to a rearing capacity check for premigrant chinook and rearing/imprinting of premigrant coho. Coho time and size releases at Clearwater were matched to upstream (Blue River) and downstream (Dunn Creek)releases in the same year.

In general, the facility as proposed would deal with approximately 2.8M eggs, resulting in up to 1.6M juveniles released, and total adult production of 19K chinook and 18K coho. The facility should have the potential to separate the juveniles into 14 lots.

ii) The South Thompson area--Eagle and Shuswap facilities (Table 7). Save for the South Thompson mainstem chinooks, the six major chinook and six major coho stocks recommended by the GWG for enhancement (Table 3) are dealt with between the two facilities.

The Eagle facility (Table 7A) emphasizes Eagle, Salmon, and Adams chinook and coho stocks, as the others are constrained by broodstock availability or GWG targets to below the useful level for release experimentation. It should be noted that the use of Adams stock may be argued against by the IPFSC or other interest group; if it is preferred, South Thompson mainstem chinook stock could be substituted for Adams stocks. Outplanting limits to the Perry, Crazy and Southpass systems would be tested, and build-up of stocks in the Seymour River would be initiated. Tappen and Trinity Creeks have been identified as having some rearing potential for coho (Table 2) but have not been included in the present plants; they should be kept in mind as possible alternatives, but may be better handled via SPD. As proposed, the Eagle facility would handle total numbers of eggs and juveniles (2.8M and 1.7M, respectively) that are similar to those proposed for Clearwater; however, coho receive more emphasis at Eagle, resulting in total adult production of 13K chinook and 30K coho. As for Clearwater, physical separation of up to 14 lots should be aimed for.

The Shuswap Falls facility (Table 7B), on the other hand, would concentrate effort on the two major mainstem chinook stocks of the Middle and Lower Shuswap Rivers. As rearing capacity studies of the Middle Shuswap area are not yet complete, the proposed outplant levels for the Middle Shuswap above the dam and for the Lower Shuswap River, Wap Creek, and Bessette Creek are subject to further adjustment. The facility as proposed would require a capacity of up to 1.9M eggs and 1.2M juveniles released, with separation of up to 10 lots possible. Total adult production is tentatively projected at 16K chinook and 6K coho.

iii) The Lower Thompson area facility at Spius Creek (Table 8). Of the four major chinook and four major coho stocks recommended by the GWG for enhancement, all but Thompson mainstem chinooks would be utilized. In addition, three minor stocks--Spius Creek chinook and Maka and Guichon Creek[a] coho--are proposed for the pilot facility, in order to improve broodstock availability for experimentation and perform checks of rearing capacity. The Thompson mainstem is avoided, due to logistical difficulties in broodstock separation and collection as well as in monitoring. It should be noted that the Spius coho limit suggested by the GWG is exceeded in order to take maximum advantage of hatchery returns in the monitoring of time and size experiments.

In general, the facility should be sized to carry up to 12 separable lots, comprising 2.3M eggs and 1.4M juveniles released. Projected total adult production would be in the order of 13K chinook and 23K coho.

SUMMARY

The preceeding may seem an overly circuitous and complex approach to targetting for these facilities, especially in light of the very similar target levels produced for the different program combinations--

Facility	Capital Limit (kg)	Maximum Suggested Capacity (kg)	No. of Stocks	Maximum No. of Eggs	Maximum No. of Juv. Rel.	Total Adult Production
Clearwater	7000	6975	9	2.8M	1.6M	37K
Eagle	7000	7075	12	2.9M	1.8M	43K
Spius	7000	7125	10	2.4M	1.4M	36K
Shuswap	5000	4700	6	1.9M	1.2M	22K

However, I feel that it is necessary that the development of the expanded-pilot concept and its targetting rationale be thoroughly documented, understood, and commited to by all groups prior to undertaking more detailed planning and design. If anyone has problems with the concept as developed here, your rapid feedback would be most appreciated.

[a] Broodstock may have to be taken from the Nicola River.

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BGS/mmm

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Table 1. Prior rationale and targets for Thompson area pilots.

Project	Purpose	Species	Stocks	(Release Size)	Eggs	Adults[a]	Adults[a] from All Systems
	PILOT AS PRESENTLY CONSTRUCTED				Number of		TRANSITIONAL PLAN TARGETS
Clearwater	Upstream and	CN	Clearwater	(5g)	110K	1.8K	25K
	downstream CN and CO		Raft	(5g)	110K	1.8K	
	release strategies; fall CO		Finn	(5g)	110K	1.8K	
	outplant;		Lemieux	(5g)	110K	1.8K	
	familiarization with	CO	Lion	(5g)	105K	2.3K	18K
	systems		Dunn	(5g)	105K	2.3K	
Eagle	Summer outplants to	CN	Eagle	(5g)	125K	2.0K	18K
	underutilized areas;		Salmon	(5g)	125K	2.0K	
	upstream and downstream CO			(2g)	250K	4.1K	
	and downstream CN release strat-	CO	Eagle	(2g)	2x125K[b]	3.1K	31K
	egies; effluent treatment		Salmon	(2g)	2x125K[b]	3.1K	
Nicola	Effluent control; solar	CN	Coldwater	(5g)	110K	1.8K	17K
	heating; outplanting		Spius	(5g)	110K	1.8K	
	to underutilized areas;	CO	Coldwater	(5g)	105K	2.3K	9K
	familiarization with						
	systems	ST	-	-	-	-	2K
Shuswap	Spring outplanting to	CN	Shuswap	(2g)	110K	1.8K	26K
	area upstream of dam	CO	-	-	-	-	5K

[a] Total adult production.

[b] Divided into upper and lower watershed plants (uniquely marked).

Table 2. Suggested rearing capacities for Thompson area systems.

AREA	SYSTEM	PREDICTED FRY STOCKING CAPACITY	REFERENCES	REMARKS OF METHODS USED
NORTH THOMPSON	Louis Cr	500K (CO) 1032K (CO)	Ptolemy (1982)	FHIS approach; 2g CO and CN per EOSC survival standards.
	Lion Cr	0 (CO)	Whelan et al (1982)	Marshall approach; smolts ÷ 10% to give nos. o 2g fry; premigrant CN releases not recommended on basis of natural emigration from headwater areas.
	Blue R	280K (CO)		
	N. Thompson R	300K (CO)		
	Finn Cr	80K (CN+CO)[a]/150K(CO)[b]	Stewart et al (1983)/ Whelan et al (1982)	FHIS approach; 0.5 fish/m^2 (maximum)/see remarks above.
	Raft R	565K (CN+CO)[a]/288K(CO)[b]		
	Lemieux Cr	83K (CN+CO)[a]		
	Joseph Cr	190K (CN+CO)		
	Dunn Cr	40K (CO) /385K (CO)		
	McTaggart Cr	6K (CO)		
	N. Barriere R	122K (CO)		
	E. Barriere R	500K (CO+CN)[a]		
	Harper Cr	7K (CO)		
	Fennell Cr	240K (CO)		
SOUTH THOMPSON	Eagle R	3160K (CO)	Whelan et al (1982)	Marshall approach; smolts ÷ 10% to give nos. of 2g fry; premigrant CN releases not recommended on basis of natural emigration from headwater areas.
	Salmon R	1430K (CO)		
	Adams R	280K (CO)		
	S. Thompson R	760K (CO)		
	Seymour R	84K (CN)[a]	Sebastian (1983)	FHIS and Marshall approaches; 5g CN and fall outplant of CN.

Table 2. (continued)

AREA	SYSTEM	PREDICTED FRY STOCKING CAPACITY	REFERENCES	REMARKS ON METHODS USED
SOUTH THOMPSON	Perry R	114K (CN)[a] 25K (CO)	(See previous page)	
	Crazy Cr	45K (CO)[b]		
	South Pass Cr	7K (CO)		
	Tappen Cr	25K (CO)		
	Trinity Cr	75K (CO)		
LOWER THOMPSON	Nicola R	370K (CN)	Sebastian (1982)	FHIS and Marshall approaches; 2 - 3g CN and 5g CO.
	Maka Cr	23K (CO)		
	Coldwater R	240K (CN) 423K (CO)		
	Spius Cr	72K (CN)		
	Guichon Cr	60K (CO)		
	Deadman Cr	450K (CN)	Sebastian (1982); Tredger (1980)	FHIS and Marshall approaches; 2 - 3g CN.

[a] accessible and inaccessible sections combined.

[b] inaccessible section only.

Table 3. Broodstock potentials and GWG targets for major stocks of the Thompson region recommended for enhancement by the Fraser GWG.

		CHINOOK				COHO			
		Proposed	Average	Broodstock Limits[c]		Proposed	Average	Broodstock Limits[c]	
Area	System	Increment[a]	Escapement[b]	No. of Females	No. of Eggs	Increment[a]	Escapement[b]	No. of Females	No. of Eggs
NORTH THOMPSON	Mainstem	15K	1840	350	2100K	-	818	150	1125K
	Clearwater R	15K	1790	340	2040K	9K	971	180	450K
	Mahood R	5K	275	50	300K	-	17	-	-
	Finn Cr	8K	515	100	600K	-	52	-	-
	Louis Cr	2K	94	20	120K	13K	1843	350	875K
	Raft R	3K	203	30	180K	3K	411	80	200K
	Barriere R	-	23	-	-	4K	752	140	350K
	Blue R	-	18	-	-	4K	369	70	175K
	Dunn Cr	-	-	-	-	6K	416	80	200K
	Lemieux Cr	-	20	-	-	5K	571	110	275K
	Lion Cr	-	21	-	-	10K	1006	190	475K
SOUTH THOMPSON	Mainstem	40K	4773	900	5400K	-	-	-	-
	Middle Shuswap R	8K	495	90	540K	-	410	-	-
	Lower Shuswap R	75K	8490	1600	9600K	3K	192	40	100K
	Eagle R	7K	401	80	400K	17K	1819	340	850K
	Salmon R	5K	266	50	250K	12K	1409	270	675K
	Adams R	24K	1320	250	1500K	3K	365	70	175K
	Wap Cr	-	-	-	-	2K	216	40	100K
	Bessette Cr	-	29	-	-	4K	471	90	225K
LOWER THOMPSON	Mainstem	25K	2417	460	2760K	-	192	-	-
	Nicola R	28K	2950	560	3360K	4K	367	70	175K
	Coldwater R	14K	611	120	720K	6K	518	100	250K
	Deadman Cr	3K	152	30	90K	1K	52	10	25K
	Spius Cr	-	343	70	400K	3K	364	70	175K

[a] total adult production.

[b] 1971-1980 averages from Fraser *et al* (1982).

[c] 30% of average escapement; 3:5 M:F; CN fecundity 6K except Eagle and Salmon 5K and Deadman 3K; CO fecundity 2.5K for all stocks.

Table 4. Possible site constraints for expanded Thompson facilities.

Facility	Water Quality and Quantity	Temperature Manipulation	Adequate Land	$[a]
Clearwater	2 wells - OK Dutch Lk - NO Clearwater R - OK	YES - wells similar but higher temp than river through winter; both sources feasible as pumped supplies	YES	1M
Eagle	Well #1 - OK Well #2 - OK? (metals) Crazy Cr - OK Eagle R - OK? (disease)	(YES) - well #1 higher temp than river through winter; well #2 may approach river temps in prolonged pumping; all sources pumped except Crazy Cr (preferred sfc source).	YES	1M
Nicola	2 wells - OK Spius Cr - OK? (silt, permit)	YES - wells higher temp than river through winter (?); all sources pumped for incubation, maybe gravity for rearing; solar heating expt.	YES	1M
Shuswap	existing wells - NO (inadequate quantity) Shuswap R - OK? (silt, BCH cooperation)	? - only proven source to date is dam (gravity)/river (pumped)	?	1M

[a] Maximum possible without TB Submission.

Table 5. Summary of tagging requirements of experimental modules for each geographically-distinct area.

Module	Species	Size	No. of Eggs	Nos. Released	kg Released	kg / Module Minimum	kg / Module Preferred
GROSS TIME & SIZE	CN	2-10g+	500K	310K	1500+	1500	3000[a]
	CO	2-10g+	320K	200K	825	825	3150[b]
DETAILED TIMING	CN	5g	200K	125K	625	625	1350[c]
		10g+	250K	125K	1250+	1250	2500[c]
	CO	10g+	180K	125K	1250+	1250	2500[c]
MAXIMIZE REARING	CN	2g	600K	400K	800	800	800
		5g	500K	320K	1600	0	1600
	CO	2g	600K	400K	800	800	800
		5g	480K	300K	1500	1500	1500
		10g	440K	300K	3000	0	3000
IMPRINTING STRATEGIES	CN	2g	450K	300K	600	0	600
		5g	320K	200K	1000	1000	1000
	CO	2g	450K	300K	600	0	600
		5g+	360K	225K	1125	1125	1125
		10g+	200K	100K	1000	0	1000
TOTAL	CN		2820K	1780K		5175	10850
	CO		3090K	2000K		5425	12525
GRAND TOTAL			5910K	3780K		10600	23375

[a] Two stocks/area.

[b] Two stocks/area, plus 10g in first fall (750 kg/stock).

[c] Tag lots doubled in size.

Table 6. Development of targets (all but suggested capacity numbers expressed in kg of juveniles released) for a 7000-kg expanded pilot facility at Clearwater to service the North Thompson area.

SPECIES	STOCK	(SIZE FOR CALC OF LIMITS)[a]	BROOD STOCK LIMIT	MODIFIED GWG LIMIT	REARING CAPACITY LIMIT	SUGGESTED FACILITY PROGRAM YR 1	(PURPOSE)	YR 2	(PURPOSE)	YR 3+	SUGGESTED FACILITY CAPACITY No. of Eggs YR 1	No. of Eggs YR 2	No. of Juv Rel YR 1	No. of Juv Rel YR 2	No. of Adults
CHINOOK	CLEARWATER	(5g)	7300	5000	0?	1500	(time & size; HY rel.)[b]	1250	(5g timing, HY rel.)		500K	400K	310K	250K	
	MAHOOD	(5g)	1100	1700	0?	1500	(time & size, US rel.)	1000	(5g imprinting)		500K	300K	310K	200K	
	FINN	(2g)	900	2100	200	200	(2g US cap. check)	600	(2g imprinting)		300K	800K	100K	300K	
	RAFT	(2g)	300	800	400	400	(2g US cap. check)	400	(per YR 1)	Repeat yrs 1 and 2 high-	500K	500K	200K	200K	
	SUBTOTAL					3600		3250		priority items OR	1800K	2000K	920K	950K	~19K
COHO	CLEARWATER	(2g)	6100	1300	0?	825	(time & size, HY rel.)[b]	1250	(1g+ timing, HY rel.)		300K	200K	200K	100K	
	RAFT	(5g)	700	500	1500	0		1125	(5g US imprinting)	study lower-priority items	0	400K	0	225K	
	BLUE	(5g)	600	700	1500	825	(time & size, US rel.)	0		OR	300K	0	200K	0	
	DUNN[c]	(5g)	700	1000	250	825	(time & size, DS rel.)	0		redirect	300K	0	200K	0	
	LEMIEUX[c]	(5g)	1000	800	400	400	(5g DS cap. check)	0		program	100K	0	80K	0	
	LION	(2g)	6400	1300	0	0		1250	(-10g+ timing, US rel.)		0	200K	0	100K	
	SUBTOTAL					2875		3625			1000K	800K	680K	425K	~ 18K
GRAND TOTAL						6475		6875			2800K	2800K	1600K	1375K	~ 37K

[a] EOSC biostandards used to convert targets to weight of juveniles released.

[b] Reared beyond 10g in river sidechannel/pens?

[c] Cooperative program with CITC Project may be possible to evaluate offsite vs onsite imprinting.

Table 7A. Development of targets for a 7000-kg expanded pilot facility on the Eagle River (all but suggested capacity numbers expressed in kg of juveniles released) to service the South Thompson area.

SPECIES	STOCK	(SIZE FOR CALC OF LIMITS)[a]	BROOD STOCK LIMIT	MODIFIED GWG LIMIT	REARING CAPACITY LIMIT	SUGGESTED FACILITY PROGRAM YR 1	(PURPOSE)	YR 2	(PURPOSE)	YR 3+	SUGGESTED FACILITY (CAPACITY) No. of Eggs YR 1	No. of Eggs YR 2	No. of Juv. Rel. YR 1	No. of Juv. Rel. YR 2	No. of Adults
CHINOOK	EAGLE	(5g)	)1500	2400	0	1500	(time & size, HY rel.)	1250	(10g+ timing, HY rel.)	Repeat	500K)	600K	310K)	375K	
	PERRY	(2g)	)	–	500	0		500	(2g imprinting, cap. check)	YRS	0)		0)		
	SALMON	(5g)	900	1700	0	1000	(5g imprinting)	800	(2g cap. check)	1 and 2	300K	300K	200K	400K	
	ADAMS	(5g)	5400	8000	0	1500	(time & size, DS rel.)	1000	(5g DS imprinting)	high-priority	500K	300K	310K	200K	
	SEYMOUR	(2g)	100	–	400	100	(build stock)	100	(per YR 1)	items	50K	50K	50K	50K	
	SUBTOTAL					4100		3650		OR	1350K	1250K	870K	1025K	~13K
COHO	EAGLE	(5g)	)3100	2833	6300	825	(time & size, HY rel.)	1250	(10g+ timing, HY rel.)	)	400K	300K	260K	185K	
	PERRY	(5g)	)	–	100	100	(5g cap. check)	100	(per YR 1)	Study)					
	CRAZY	(5g)	)	–	200	200	(5g cap. check)	200	(per YR 1)	lower-priority)					
	SOUTHPASS	(5g)	100	–	50	50	(5g cap. check)	100	(5g cap. check)	items	25K	50K	20K	20K	
	SALMON	(5g)	2500	2000	2900	825	(time & size DS rel.)	1125	(5g+ DS imprinting)	OR	300K	400K	200K	225K	
	ADAMS	(5g)	600	500	600	600	(2g imprinting, cap. check)	600	(2g imprinting, cap. check)		750K	750K	300K	300K	
	SEYMOUR	(5g)	50	–	400	50		50		Redirect	25K	25K	20K	10K	
	SUBTOTAL					2650		3425		program	1500K	1525K	790K	740K	~30K
GRAND TOTAL						6725		7075			2850K	2775K	1660K	1765K	~43K

[a] EOSC biostandards used to convert targets to weight of juveniles released.

Table 7B. Development of targets for a 5000-kg pilot facility on the Middle Shuswap River (all but suggested capacity numbers expressed in kg of juveniles released) to service the South Thompson area.

SPECIES	STOCK	(SIZE FOR CALC OF LIMITS)[a]	BROOD STOCK LIMIT	MODIFIED GWG LIMIT	REARING CAPACITY LIMIT	SUGGESTED FACILITY PROGRAM YR 1	(PURPOSE)	YR 2	(PURPOSE)	YR 3+	SUGGESTED FACILITY CAPACITY No. of Eggs YR 1	No. of Eggs YR 2	No. of Juv. Rel. YR 1	No. of Juv. Rel. YR 2	No. of Adults
CHINOOK	M. SHUSWAP	(5g)	)2000	)2700	?	1500	(time & size, HY rel.)	1250	(10g+ timing)	Repeat	500K	250K	310K	125K	
	ABOVE DAM	(2g)	)	)		500	(2g cap. check)	500	(2g cap. check)	YRS 1 and 2	400K	400K	250K	250K	
	L. SHUSWAP	(5g)	34600	25000	?	1500	(time & size, DS rel.)	1625	(5g DS imprinting & timing)	high-priority	700K	500K	435K	325K	
	SUBTOTAL					3500		3375		items	1600K	1150K	995K	700K	~ 16K
										OR					
COHO	WAP	(5g)	400	400	?	400	(5g cap. check)	400	(per YR 1)	Study	100K	100K	80K	80K	
	BESSETTE[b]	(5g)	800	700	?	400	(5g cap. check)	400	(per YR 1)	lower-priority	100K	100K	80K	80K	
	L. SHUSWAP	(5g)	400	400	?	400	(5g cap. check)	400	(per YR 1)	items	100K	100K	80K	80K	
	SUBTOTAL					1200		1200		OR	300K	300K	240K	240K	6K
GRAND TOTAL						4700		4575		Redirect program	1900K	1450K	1235K	940K	22K

[a] EOSC biostandards used to convert targets to weight of juveniles released.

[b] Cooperative program with SPD?

Table 8. Development of targets (all but suggested capacity numbers expressed in kg of juveniles released) for a 7000-kg expanded pilot facility on Spius Creek to service the Lower Thompson area.

SPECIES	STOCK	(SIZE FOR CALC OF LIMITS)[a]	BROOD STOCK LIMIT	MODIFIED GWG LIMIT	REARING CAPACITY LIMIT	SUGGESTED FACILITY PROGRAM: YR 1	(PURPOSE)	YR 2	(PURPOSE)	YR 3+	SUGGESTED FACILITY CAPACITY: No. of Eggs YR 1	No. of Eggs YR 2	No. of Juv. Rel. YR 1	No. of Juv. Rel. YR 2	No. of Adults
CHINOOK	NICOLA	(2g)	5200	7500	800	625	(5g timing)	1000	(5g imprinting)	Repeat YRS	200K	300K	125K	200K	
	SPIUS	(5g)	1440	0	200	1500	(time & size, HY rel.)	1250	(10g+ timing, HY)	1 and 2	500K	250K	310K	125K	
	COLDWATER	(2g)	1100	3800	500	1500	(time & size, DS rel.)	600	(2g imprinting US)	high-priority	500K	450K	310K	300K	
	DEADMAN	(2g)	200	800	900	200	(2g build stock)	200	(2g build stock)	items	200K	200K	100K	100K	
	SUBTOTAL					3825		3050		OR	1400K	1200K	845K	725K	13K
COHO	NICOLA	(20g)	2700	600	0	1250	(10g+ timing)	1125	(5g+ imprinting, US/DS rel.)	Study lower-	200K	400K	125K	225K	
	COLDWATER	(5g)	900	1000	2100	825	(time & size, US rel.)	1125	(5g+ imprinting)	priority	300K	400K	200K	225K	
	DEADMAN	(20g)	400	400	0	400	(meet limits)	0		items	50K	0	20K	0	
	SPIUS	(20g)	2700	400	0	825	(time & size HY rel.)	1250	(10g+ timing, HY rel.)	OR	300K	200K	200K	125K	
	MAKA	(5g)	?	-	100	0		100	(5g cap. check)		0	50K	0	20K	
	GUICHON	(5g)	?	-	300	0		300	(5g cap. check)	Redirect	0	100K	0	60K	
	SUBTOTAL					3300		3900		program	850K	1150K	545K	655K	23K
GRAND TOTAL						7125		6950			2250K	2350K	1390K	1380K	36K

[a] EOSC biostandards used to convert targets to weight of juveniles released.

APPENDIX 1d. GROSS SIZING OF EXPERIMENTAL PLAN

TO / À

B.G. Shepherd
New Projects Coordinator
Facility Operations

FROM / DE

D.D. MacKinlay
Design Biologist
New Projects Unit

SECURITY - CLASSIFICATION - DE SÉCURITÉ	
OUR FILE/NOTRE RÉFÉRENCE	
YOUR FILE/VOTRE RÉFÉRENCE	5830-85-T85
DATE	October 7, 1983

SUBJECT / OBJET: FEASIBILITY AND SIZING FOR PROPOSED EXPANDED THOMPSON PILOTS

This memo is a follow-up to your memo to Sandercock, Lill and Harrison of September 14, 1983 on this file. In it you proposed experimental designs and fish-capacity targets for the four pilot facilities under construction in the Thompson River system. This memo uses that experimental plan to determine what size of facility is required at each site. The general feasibility of the experimental programs is briefly discussed.

Design memos have already been written on each of these facilities (for Clearwater: Shepherd and MacKinlay to McNally and Peterson, Feb 22, 1983 on file 5903-85-C261; for Eagle: Sandercock, Shepherd and MacKinlay to Lill, McNally and Peterson, July 31, 1981 on file 5903-85-E7; for Shuswap: MacKinlay to Shepherd, June 8, 1983 and Shepherd and MacKinlay to McNally, Jan 20, 1983 on file 5903-85-S160; and for Spius: Sandercock, Shepherd and MacKinlay to McNally, Neilson and Rowland, April 25, 1983 on file 5903-85-N110) and the discussion on fish culture technique and event timing presented in those memo still holds true. Only the container and flow sizing changes with the change in targets.

1. Pilot Sizing

Based mainly on Tables 6 to 8 in the Shepherd proposal memo, Tables 1 to 4 here give the requirements in terms of fish culture (incubation and rearing) containers for the four pilots.

The critieria used in the calculations are given in Table 5. Standard culture techniques for coho and chinook are assumed -- that is, incubation in Heath trays, start-up rearing in Capilano-style troughs and final rearing in rectangular concrete raceways.

The maximum requirements for each facility, not considering such things as handling more than one stock in a Heath stack or trough line, double-use of troughs for final rearing of small lots of fish or overlap in flow of containers, are as follows:

Pilot	Heath Stacks	Trough Lines	Raceway Volume	Maximum Flow
Clearwater	64	26	337 m^3	6240 LPM
Eagle	55	24	401 m^3	6031 LPM
Shuswap	47	17	281 m^3	10482 LPM
Spius	50	23	431 m^3	8417 LPM

The highest flows for Clearwater occur during initial rearing because many of the stocks are released at 2 grams and therefore do not require concrete raceway rearing. The very high flows for Shuswap are based on the possibility that river water or its temperature equivalent (up to 14°C) could be used for rearing. This is most probably an overestimate of requirements but no better estimate can be made until a source for this pilot is discovered and characterized.

Table 6 makes a gross estimate of freezer requirements for storage of feed for the four pilots. Criteria used were: 1. maximum fish biomass assumed to occur for all stocks at the same time 2. maximum feeding applied over a 3 month period. These calculation assumptions both lead to over-estimations of probable actual requirements but at least show their general magnitude.

2. Experimental Module Feasibility

It is important in these facilities for fish groups to be separable into relatively small lots in containers. This is no problem for incubation and initial rearing which allow separation into lots of from 40K to 100K due to the small capacities of Heath stacks and Capilano troughs. Final rearing requirements range from 4 m^3 to 109 m^3 for particular groups of fish in the experimental plan. Using a cross-section of 1 m deep by 3 m wide, a number of different raceway lengths were evaluated to come up with a 'standard' raceway which could be used at all four facilities. Thirty meter long raceways divisible into five or six sections were the best configuration for handling both small and large lots of fish with the minimum mixing of groups within one raceway. Numbers of such (30 m x 3 m x 1 m) raceways required for the pilots are: Clearwater = 5; Eagle = 5 Shuswap = 4 Spius = 6. Rearing requirements for the very small groups can be met using Capilano troughs. However for stocks which require, for instance, 27 m^3 rearing space, it would be better to use two sections of a large raceway rather than a dozen troughs.

It should be understood that any plans for the Shuswap Pilot must be considered tentative until a proven source of water supply is found. The temperature profile of the river would limit the experimental options available due to delayed development and rearing event timing (see MacKinlay to Shepherd memo, June 8, 1983 on file 5903-85-S160 for detailed timing calculations).

The constant temperature regimes of the other sites may also limit the range of outplant options available. The relatively warm temperatures (7 to 9 C°) available allow, for instance, 5 gram spring release of chinook (see design memos for detailed timing summaries). Some the time and size experiments require simultaneous release of 2 and 5 gram fish in the spring, which is probably the most difficult scenario to achieve from a fish culture event timing viewpoint. Delay of growth can really only be effected through reduction of ration. A number of computer simulations were run using Stauffers growth equation to estimate what reduction in ration was required to delay growth such that 2 gram and 5 gram fish could be released at the same time. A reduction from 0.9 to 0.5 of the recommended ration produced an average delay of about one month in growth, whereas a delay of about two months would be required to synchronize 2 g and 5 g fish. A reduction of ration below 0.5 of the recommended level was not considered, due to possible side effects of low feeding rates. However it would be possible to accelerate the development of the 5 gram fish by one month by heating incubation water to 2°C above ambient. Therefore a combination of accelerating one group while delaying the other could feasibly produce 5 g and 2 g fish for concurrent release.

3. Facility Proposal

The present incubation rooms at Spius, Clearwater and Eagle have enough space for over 50 stacks of Heath trays or over 100 stacks double high. This is more than sufficient for the needs of any of the expanded pilots. Heater/re-aeration systems should be installed in each of the incubation rooms. A system like the one installed at Chehalis could produce a 2°C increment for over 300 LPM of flow, the equivalent of about 18 stacks of Heath Trays. This is one complete bank of troughs (both sides) off one header tank according to the layouts of the pilot incubation rooms. This is more than sufficient to meet the time-and-size experiment needs. Such a system should cost 10-15 thousand dollars. Partial recirculation of heated water during incubation could decrease the operations cost and increase the heating capacity of such a system.

The buildings at Eagle and Clearwater are of adequate size for the expanded pilots and probably of adequate size for 5 - 6 million egg production facilities in the future, therefore do not require expansion of the building perimeter. What is required is closing off the open area under the roof to incorporate the needed workshop, office and lab space. A suggested layout plan is shown in Figure 1. This layout can easily accommodate expansion if so required in the future. The only missing item is a freezer. Freezers for pilots should be freestanding to allow for potential expansion, to better utilize space within the building layout, to allow location near to rearing containers and because freezers come as self supported structures which cost very little in extra exterior cladding to make into separate buildings. The Spius Creek hatchery building is already a complete package and requires no alteration to meet the expanded pilot requirements, other than relocating the freezer as a freestanding structure and using the freezer space in the building for storage off the incubation room. This is necessary because the expanded pilot requires a larger freezer (35 m^2) than is provided in the present building (20 m^2). A storage room would allow the operator to remove the Heath stacks from the incubation room, move a couple of Capilano troughs in and use the same space (already supply and drain plumbed) for a tagging room. This would be a great advantage considering the tremendous amount of tagging required for the expanded pilot. The Shuswap building should be built to match the layouts of the Spius or Eagle (fully enclosed) buildings, with a separated freezer.

Capilano troughs are useful for getting good initiation of feeding of swim-up fry and for rearing-to-term small lots of fish. They are particularly well suited to pilot facilities such as these. Each facility should be supplied with 20 - 26 lines of troughs with lines arranged in pairs for space efficiency.

Each facility should be provided with six concrete, rectangular rearing raceways, each 30 m long and 3 m wide with a potential water depth of 1 m

(1.2 m wall height). Each raceway should be able to be divided into five or six sections by fry proof screens. Flows to each raceway should be able to be adjusted anywhere from 500 LPM up to 1500 LPM. Raceways should also be arranged in pairs with vehicle access between pairs for ease in handling and transporting fish and food. Maximum flow demand for each facility should be about 12,000 LPM, with all troughs running and raceways starting up.

Considerations should be given to provision of good covered storage areas at all sites, residences and crew quarters. Also bearing in mind the original source of funding for the pilots and the tentative funding of the SEP, public access and displays should be an integral part of these facilities.

D.D. MacKinlay

cc F.K. Sandercock
C.W. MacKinnon
G. Berezay
J.D. Buxton
J.W.C. McNally
G.O. Neilson
W. Peterson
A. Rowland

TABLE 1 CONTAINER SIZING SUMMARY FOR EXPANDED CLEARWATER PILOT FACILITY

Species	Stock	Eggs	Heath Incubation Trays	Heath Incubation Stacks	Heath Incubation Flow	Initial Rearing Troughs	Initial Rearing Lines	Initial Rearing Flow	Final Rearing Space	Final Rearing Flow
		#K	#	#	LPM	#	#	LPM	m^3	LPM
Year 1										
CN	Clearwater	500	100	13	247	8	4	960	100	1745
	Mahood	500	100	13	247	8	4	960	100	1745
	Finn	300	60	8	152	5	3	720	-	-
	Raft	500	100	13	247	8	4	960	-	-
CO	Clearwater	300	36	5	95	5	3	720	-	-
	Blue	300	36	5	95	5	3	720	55	878
	Dunn	300	36	5	95	5	3	720	55	878
	Lemieux	100	12	2	38	2	1	240	27	431
	Total	2800		64	1216		25	6000	337	5677
Year 2										
CN	Clearwater	400	80	10	190	7	4	960	84	1454
	Mahood	300	60	8	152	5	3	720	67	1163
	Finn	800	160	20	380	13	7	1680	-	-
	Raft	500	100	13	247	8	4	960	-	-
CO	Clearwater	200	24	3	57	4	2	480	-	-
	Raft	400	48	6	114	7	4	960	75	1210
	Lion	200	24	3	47	4	2	480	74	1169
	Total	2800		63	1197		26	6240	300	4996

- maximum requirements are underlined

TABLE 2 CONTAINER SIZING SUMMARY FOR EXPANDED EAGLE PILOT FACILITY

Species	Stock	Eggs	Heath Incubation			Initial Rearing			Final Rearing	
			Trays	Stacks	Flow	Troughs	Lines	Flow	Space	Flow
		#K	#	#	LPM	#	#	LPM	m^3	LPM
Year 1										
CN	Eagle	500	100	13	247	8	4	960	100	1547
	Salmon	300	60	8	152	5	3	720	67	1031
	Adams	500	100	13	247	8	4	960	100	1547
	Seymour	50	10	2	38	1	1	240	-	-
CO	Eagle	400	48	6	114	7	4	960	75	1072
	South Pass	25	3	1	19	1	1	240	4	48
	Salmon	300	36	5	95	5	3	720	55	786
	Adams	375	45	6	114	6	3	720	-	-
	Seymour	25	3	1	19	1	1	240	-	-
	Total	2475		55	1045		24	5760	401	6031
Year 2										
CN	Eagle	600	120	15	285	10	5	1200	84	1598
	Salmon	300	60	8	152	5	3	720	-	-
	Adams	300	60	8	152	5	3	720	67	1031
	Seymour	50	10	2	38	1	1	240	-	-
CO	Eagle	300	36	5	95	5	3	720	104	1477
	South Pass	50	6	1	19	1	1	240	7	96
	Salmon	400	48	6	114	7	4	960	75	1072
	Adams	375	45	6	114	6	3	720	-	-
	Seymour	25	3	1	19	1	1	240	-	-
	Total	2400		52	988		22	5280	337	5274

- maximum requirements are underlined

TABLE 3 CONTAINER SIZING FOR EXPANDED MIDDLE SHUSWAP PILOT FACILITY

Species	Stock	Eggs	Heath Incubation			Initial Rearing			Final Rearing	
			Trays	Stacks	Flow	Troughs	Lines	Flow	Space	Flow
		#K	#	#	LPM	#	#	LPM	m^3	LPM
Year 1										
CN	Middle	900	180	23	437	15	8	1920	100	3846
	Lower	700	140	18	342	12	6	1440	100	3846
CO	Wap	100	12	2	38	2	1	240	27	930
	Bessette	100	12	2	38	2	1	240	27	930
	Lower	100	12	2	38	2	1	240	27	930
	Total	1900		47	893		17	4080	281	10482
Year 2										
CN	Middle	650	130	17	323	11	6	1440	74	2841
	Lower	500	100	13	247	8	4	960	109	4167
CO	Wap	100	12	2	38	2	1	240	27	930
	Bessette	100	12	2	38	2	1	240	27	930
	Lower	100	12	2	38	2	1	240	27	930
	Total	1450		36	684		13	3120	264	9798

- maximum requirements are underlined

TABLE 4 CONTAINER SIZING FOR EXPANDED SPIUS PILOT FACILITY

Species	Stock	Eggs	Heath Incubation Trays	Heath Incubation Stacks	Heath Incubation Flow	Initial Rearing Troughs	Initial Rearing Lines	Initial Rearing Flow	Final Rearing Space	Final Rearing Flow
		#K	#	#	LPM	#	#	LPM	m^3	LPM
Year 1										
CN	Nicola	200	40	5	95	4	2	480	42	845
	Spius	500	100	13	247	8	4	960	100	2027
	Coldwater	500	100	13	247	8	4	960	100	2027
	Deadman	200	40	5	95	4	2	480	-	-
CO	Nicola	200	24	3	57	4	2	480	74	1344
	Coldwater	300	36	4	95	5	3	720	55	1019
	Deadman	50	6	1	19	1	1	240	20	377
	Spius	300	36	5	95	5	3	720	40	778
	Total	2250		50	950		21	5040	431	8417
Year 2										
CN	Nicola	300	60	8	152	5	3	720	67	1351
	Spius	250	50	7	133	4	2	480	74	1506
	Coldwater	450	90	12	228	8	4	960	-	-
	Deadman	200	40	5	95	4	2	480	-	-
CO	Nicola	400	48	6	114	7	4	960	75	1389
	Coldwater	400	48	6	114	7	4	960	75	1389
	Spius	200	24	3	57	4	2	480	74	1344
	Maka	50	6	1	19	1	1	240	7	108
	Cowichan	100	12	2	38	2	1	240	20	323
	Total	2350		50	950		23	5520	392	7410

- maximum requirements are underlined

TABLE 5 CRITERIA USED IN CALCULATION OF CONTAINER SIZING

1. Incubation - based on egg number as outlined in Shepherd memo.

Trays	-	5,000 CN/tray
	-	8,500 CO/tray
Stacks	-	8 trays/stack
Flow	-	19 LPM maximum flow/stack

2. Initial Rearing - based on survival of 90% from egg to ponded fry

Troughs	-	57,000 fry/trough
Lines	-	2 troughs/line
Flow	-	240 LPM maximum flow/line

3. Final Rearing - Only those stocks reared past 2 gram size, as per Shepherd memo

Ration	-	0.9 OMP for CN	Correction Factor	-	1.35
	-	0.75 OMP for CO	Percent Saturation	-	95

*Volume Loading

- 15 Kg/m³ for 5 gram fish
- 17 Kg/m³ for 10 gram fish
- 21 Kg/m³ for 20 gram fish

Temperature

-	Clearwater	8°C
-	Eagle	7.2°C
-	Shuswap	14°C
-	Spius	9°C

*Flow Loading

	-	Clearwater	CN	(5g)	0.86
(Kg/LPM)			CO	(5g)	0.93
				(10g)	1.07
	-	Eagle	CN	(5g)	0.97
				(10g)	1.09
			CO	(5g)	1.05
				(10g)	1.20
	-	Shuswap	CN	(5g)	0.39
				(10g)	0.44
			CO	(5g)	0.43
	-	Spius	CN	(5g)	0.74
				(10g)	0.83
			CO	(5g)	0.81
				(10g)	0.93
				(20g)	1.06

* Values derived using LOAD RATE model

TABLE 6 PROJECTED FEED STORAGE REQUIREMENTS FOR THE EXPANDED THOMPSON PILOT FACILITIES

Facility	Maximum Biomass	Rearing Temperature	Feed Rate[a]	Daily Feed	3 Month Feed	Bags[b]	Area of Freezer[c]
	Kg	°C	%	Kg	Kg	#	m^2
Clearwater	6875	8	2.89	198.7	17882	894	28(32)[d]
Eagle	7075	7.2	2.54	179.7	16173	809	26(30)
Shuswap	4700	10	3.56	167.3	15059	753	24(28)
Spius	7125	9	3.24	230.9	20777	1039	33(37)
Total	25775			776.6	69891	3495	111(115)

a according to OMP schedule

b 20 Kg per bag

c 32 bags per square meter of floor space

d includes 4 m^2 for aisle space

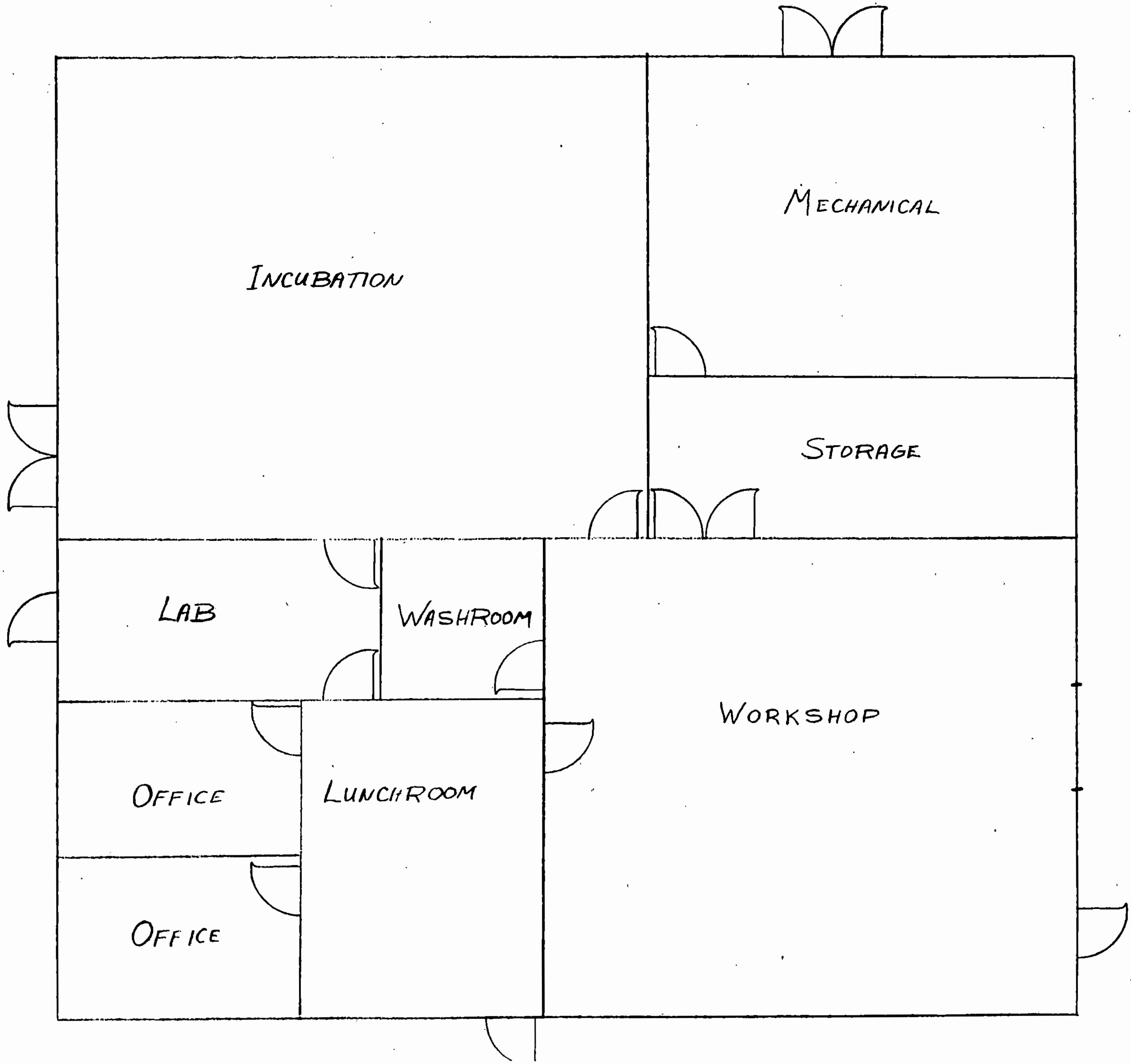

FIGURE 1 Proposed Layout for Expanded Eagle and Clearwater Pilots

APPENDIX 1e. DETAILED FLOWS FOR EXPERIMENTAL PLAN

J. McNally Sr. Implementation Engineer SEP Engineering	SECURITY - CLASSIFICATION - DE SÉCURITÉ
	OUR FILE/NOTRE RÉFÉRENCE 5903-85-E7
FROM DE B.G. Shepherd New Projects Coordinator SEP Facility Operations	YOUR FILE/VOTRE RÉFÉRENCE
	DATE February 3, 1984.

SUBJECT
OBJET WATER DEMAND CURVES FOR EAGLE PILOT FACILITY EXPANSION

As per your verbal request, this memo amplifies on the information contained in D. MacKinlay's memo of October 7, 1983 (File 5830-85-T85), as to the biological requirements for expansion of the existing Eagle facility. Please note that all requirements given are total; capacity presently built into the existing pilot has not been subtracted.

In addition, projected production-scale requirements also have been reworked in this memo to match the targets proposed in the Transition Plan.

OBJECTIVES OF EXPANDED PILOT

A detailed rationale for expansion of the Eagle pilot, as well as three other Central Interior pilots, is contained in my memo of September 14, 1983 (File 5830-85-E7). In summary, expansion is meant to result in each pilot operation being better able to deliver a more-rounded experimental program that minimizes the possibility of site-specific factors confounding the results. In addition, testing of several strategies in the same year at each facility will guard against complete failure of a return if an inappropriate strategy is tested. The targets proposed for the Eagle expanded pilot are 2.8M eggs and 1.7M juveniles pecies mix and number of stocks per species will vary each year; the only guidelines are that chinook (CN) and coho (CO) from the Eagle, Salmon, Adams and South Thompson mainstem systems could be used, and that physical separation of up to 14 lots is possible.

Because such a flexible experimental program is proposed, water demand can only be approximated for the expanded pilot. The approach used in this memo is to calculate the water demand curves for the experimental layouts proposed for the first two years of operation in my September 14 memo (see also Table 1), as well as an 'extreme' case.

BIOLOGICAL REQUIREMENTS

Unless stated otherwise, D. MacKinlay's memo of October 7 is used as a basis for the following outline. Table 1 gives a revised version of his container sizing summary for the Eagle expansion.

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Table 1. Container sizing summary for first two years of operation of expanded Eagle pilot facility.

Species	Stock	Eggs	Heath Incubation Trays	Heath Incubation Stacks	Heath Incubation Flow	Initial Rearing Units[a]	Initial Rearing Lines	Initial Rearing Flow	Final Rearing Space	Final Rearing Flow
		#K	#	#	LPM	#	#	LPM	m^3	LPM
Year 1										
CN	Eagle	500	100	13	195	450k 8	4	960	96	1547
	Salmon	300	60	8	120	270k 4	2	480	64	1031
	Adams	500	100	13	195	450k 6	3	720	96	1547
	Seymour	50	10	2	30	45k 1	1	240	-	-
		1350				1215 19	10			
CO	Eagle	400	48	6	90	[illegible] 6	3	720	72	965
	South Pass	25	3	1	15	22.5 1	1	240	4	43
	Salmon	300	36	5	75	270 4	2	480	53	707
	Adams	375	45	6	90	337.5 6	3	720	-	-
	Seymour	25	3	1	15	22.5 1	1	240	-	-
		1125				1012.5 18	10			
	Total	2475		<u>55</u>[a]	<u>825</u>	2227.5 37	<u>20</u>	<u>4800</u>	<u>385</u>	<u>5840</u>
Year 2										
CN	Eagle	600	120	15	285	10	5	1200	80	1598
	Salmon	300	60	8	120	4	2	480	-	-
	Adams	300	60	8	120	4	2	480	64	1031
	Seymour	50	10	2	30	1	1	240	-	-
CO	Eagle	300	36	5	75	4	2	480	99	1329
	South Pass	50	6	1	15	1	1	240	7	86
	Salmon	400	48	6	90	6	3	720	72	965
	Adams	375	45	6	90	6	3	720	-	-
	Seymour	25	3	1	15	1	1	240	-	-
		1150								
	Total	2400		52	780		20	4800	320	5009

[a]Maximum requirements are underlined

[b] One unit = capacity equivalent of one Capilano-style trough.

INCUBATION:

<u>Equipment</u> - Eight-tray vertical stacks, exclusively. (the use of bulk incubators would decrease the number of separate lots possible). Tray loadings are 5000 CN eggs/tray and 8500 CO eggs/tray. Using the species mixes proposed for the first two years of operation (Table 1), 55 stacks are required.

- To improve flexibility for time-and-size experiments, provision of heated water to one bank of stacks is suggested. Electrical heating, reaeration, and perhaps re-use of water was suggested by MacKinlay; it may be more productive to test a small heat-pump system for this purpose.

- The provision of surface water supply (preferably gravity-feed from Crazy Creek) also would add further flexibility to the operation, as well as provide an element of security in back-up.

<u>Flows</u> - Using routine and flush flows of 15 and 19 LPM/stack, maximum flows would be 825 and 1045 LPM, respectively. x 55

- The period of incubation would span September 5-February 25 for chinook, and October 25-March 15 for coho (Table 2).

- This analysis assumes that groundwater[a] has been used exclusively; the use of warmer or cooler sources as proposed in the previous equipment section could change timings considerably.

INITIAL REARING, PONDING TO 2g:

<u>Equipment</u> - A number of revisions are required since D. MacKinlay's October 7 memo, which recommended 24 lines of Capilano-style troughs (ie, 48 troughs in total).

1) The number of lines was reduced to 20, to improve logistics while still retaining a high degree of flexibility as to the number of test lots possible.

2) A review of intermediate rearing criteria was undertaken by the Managers' Advisory Committee, resulting in two recommendations that affect the Eagle expansion: (i) loading density for chinook should be reduced to 40K fry/trough, but coho loading would continue unchanged at 55K fry/trough; (ii) testing of a larger starter unit, side-by-side with Capilano-style troughs.

- Suggested dimensions for the larger starting unit are: 1.2m width, 0.9m depth, 1.2m wall height, and 12m length (ie, one unit would replace four troughs). In order to maintain the same number of stock separations as were possible with

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[a]Constant 7.5°C, with mid-winter aeration losses producing a decline to 7.0°C December-January. (D. Harvey, pers. comm.).

Table 2. Projected incubation and rearing timings[a] for Eagle pilot expansion (By five-day period).

CHINOOK	Start[b]	Peak[b]	End[b]
Spawning Date[c]	Sep 5	Sep 30	Oct 15
Date Eyeed (280 ATU)	Oct 15	Nov 5	Nov 20
Hatch Date (520 ATU)	Nov 15	Dec 10	Dec 25
Ponding Date (980 ATU)	Jan 20	Feb 15	Feb 25
Date to 2g[d]	Apr 1	Apr 25	May 5
Date to 5g[d]	May 30	Jun 25	Jul 5
COHO			
Spawning Date	Oct 25	Nov 15	Dec 1
Date Eyed (220 ATU)	Nov 25	Dec 15	Jan 1
Hatch Date(480 ATU)	Jan 1	Jan 20	Feb 5
Ponding Date (780 ATU)	Feb 10	Mar 1	Mar 15
Date to 2g[d]	May 15	Jun 5	Jun 20
Date to 5g[d]	Jul 15	Aug 1	Aug 15

[a] Assuming groundwater at constant 7.5 °C, save for 7.0°C due to cooling during aeration December-January (D.Harvey, pers. comm.).

[b] In order to calculate water demand, an arbitrary breakout of 25%:50%:25% has been assumed for the Start:Peak:End segments of each species.

[c] Taken from DFO spawning file summary contained in Sandercock et al memo of July 31, 1981 (File 5903-85-E7) on biological criteria of Eagle facility.

[d] Using GROWTH 5 program; 0.4g ponding, 0.9R (CN) or 0.60R (CO), and temperatures as per footnote 'a'.

the troughs, each unit is to be divided into four sections using divider screens. The units should be fully interchangeable with Capilano-style troughs, to facilitate replacement should the units prove unsuitable.

- These revisions translate to 6 lines of Capilano troughs (ie, 12 troughs) and 7 starter units (replacing 28 troughs). Using the species proportions from Table 1 and the loading densities, this translates to a total rearing capacity of 1.8M fry. This total falls short of the projected 2.5M fry that will have to be ponded (assuming 90% survival to ponding), and thus will require careful container management by the hatchery staff.

<u>Flows</u>

- Flow loadings are 120 LPM (at start)-240 LPM (at end) for each line of two Capilano-style troughs, and double that (240-480 LPM) for each of the larger starter units. This results in a total maximum flow demand of 4800 LPM.
- Initial rearing is projected to span January 20-May 5 for chinook, and February 10-June 20 for coho (Table 2).
- The above projections assume the exclusive use of groundwater. As discussed in the previous section, the addition of a surface water supply is encouraged.

FINAL REARING

<u>Equipment</u>

- Six rectangular rearing raceways with suggested dimensions of 3m width, 1.3m wall height, 1.0m water depth and 30m length would provide 540m^3 of rearing volume, which would provide a desirable excess beyond the 385m^3 needed for the first two years of proposed studies.
- If, in following years, rearing was taken to the 5g stage, 540m^3 would support 8500 kg at 15.7kg/m^3 (value from BIO-LOAD model), or 1.7M juveniles. However, if rearing was taken to 20g (21.5kg/m^3 using "LOAD RATE"), only 0.6M juveniles (11,600kg) could be carried through to release.

<u>Flows</u>

- Using BIO-LOAD predictions (Table 3), the flows required will vary slightly with the strategy followed (Table 4). Estimating conservatively, maximum flows for rearing beyond 2g would range from 4500 LPM at start-up through to 8200 LPM at release. In contrast, the two-year study plan as outlined in my September 4 memo requires maximum flows of 5000-5840 LPM (Table 1).
- The period of rearing, however, will vary considerably with the experimental strategy followed (Table 5). It is not possible to define an end point at this time; at a minimum, the facility should have the capability of providing the

Table 3. BIO-LOAD flow and volume loading rate predictions for Eagle expanded pilot (all at 7.5°C).

SP	O_2 Level	Ration Level	Loading Criteria	Size of Fish 2g	5g	10g	20g	25g
CN	95%	90%	kg/LPM	0.79	0.92	1.04		
			kg/m^3	13.0	15.7	18.0		
CO	95%	60%	kg/LPM	0.90	1.11	1.29	1.51	1.59
			kg/m^3	13.0	15.7	18.0	21.5	23.2

Table 4. Flows required for various final rearing strategies at Eagle expanded pilot, assuming volume of 540m^3 available.

Strategy	Species (Size)	Total No.	kg Carried	LPM Required	
Start-up	CN (2g)	3510K	7020	8900	(full rearing
	CO (2g)	3510K	7020	7800	capacity)
	CN (2g)	2016K	4032	5100	(full incuba-
	CO (2g)	2016K	4032	4500	tion capactiy)
CN only, Fall-term	CN (5g)	1700K	8500	7800	
	(10g)	972K	9720	8200	
CO only, Fall Release	CO (5g)	1700K	8500	7700	
	(10g)	972K	9720	7500	
CO only, Fall-term	(20g)	581K	11,600	7700	
	(25g)	250K	12,500	7900	

Table 5. Duration of rearing required for various final (post-2g) rearing strategies at Eagle expanded pilot (GROWTH 5 model predictions, assumptions listed in Table 2).

Species	Release Size	Maximum Duration of Rearing
CN	5g	Apr 1 - Jul 5
CO	5g	May 15 - Aug 15
	10g	May 15 - Nov 5
	20g	May 15 - Mar 1
	25g	May 15 - Apr 5

Table 6. Seasonal water demand (in LPM) for the Eagle expanded pilot.

A. YEAR ONE OF PROPOSED STUDIES:

PURPOSE	SP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INCUBATION	CN	540	405	-	-	-	-	-	135	405	540	540	540
	CO	285	285	70	-	-	-	-	-	-	70	215	285
	TOT	825	690	70	0	0	0	0	135	405	610	755	825
REARING TO 2g	CN	600	2000	2640	1920	660	-	-	-	-	-	-	-
	CO	-	360	2160	2160	2160	1680	-	-	-	-	-	-
	TOT	600	2360	4800	4080	2820	1680	0	0	0	0	0	0
REARING 2g+	CN	-	-	-	700	3000	4300	1950	-	-	-	-	-
	CO	-	-	-	-	500	2500	3500	3500	-	-	-	-
	TOT	0	0	0	700	3500	6800	5450	3500	0	0	0	0
ADULT HOLDING	CN	-	-	-	-	-	-	-	920	920	920	-	-
	CO	-	-	-	-	-	-	-	-	-	375	375	375
	TOT	0	0	0	0	0	0	0	920	920	1295	375	375
MONTHLY TOTAL	CN	1140	2405	2640	2620	3660	4300	1950	1055	1325	1460	540	540
	CO	285	645	2230	2160	2660	4180	3500	3500	0	445	490	660
	TOT	1425	3050	4870	4780	6320	8480	5450	4555	1325	1905	1030	1200

(Table 6. cont'd).

B. YEAR TWO OF PROPOSED STUDIES:

PURPOSE	SP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INCUBATION	CN	540	405	-	-	-	-		135	405	540	540	540
	CO	285	285	70	-	0	-	-	-	-	70	215	285
	TOT	825	690	70	0	0	0	0	135	405	610	755	825
REARING TO 2g	CN	600	2000	2640	1920	660	-	-	-	-	-	-	-
	CO	-	360	2160	2160	2160	1680	-	-	-	-	-	-
	TOT	600	2360	4800	4080	2820	1680	0	0	0	0	0	0
REARING 2g+	CN	-	-	-	700	3000	4300	1950	-	-	-	-	-
	CO	-	-	-	-	500	2500	3500	3500	500	500	500	-
	TOT	0	0	0	700	3500	6800	5450	3500	500	500	500	-
ADULT HOLDING	CN	-	-	-	-	-	-	-	920	920	920	-	-
	CO	-	-	-	-	-	-	-	-	-	375	375	375
	TOT	0	0	0	0	0	0	0	920	920	1295	375	375
MONTHLY TOTAL	CN	1140	2405	2640	2620	3660	4300	1950	1055	1325	1460	540	540
	CO	285	645	2230	2160	2660	4180	3500	3500	500	945	1090	660
	TOT	1425	3050	4870	~~4870~~ 4780	6320	8480	5450	4555	1825	2405	1630	1200

(Table 6 cont'd).

C. 'EXTREME' CASE:

PURPOSE	SP	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INCUBATION	CN	540	405	-	-	-	-	-	135	405	540	540	540
	CO	285	285	70	-	-	-	-	-	-	70	215	285
	TOT	825	690	70	0	0	0	0	135	405	610	755	825
REARING TO 2g	CN	600	2000	2640	2640	2640	2640	-	-	-	-	-	-
	CO	-	360	2160	2160	2160	2160	-	-	-	-	-	-
	TOT	600	2360	4800	4800	4800	4800	0	0	0	0	0	0
REARING 2g+	CN	-	-	-	-	3000	4300	1950	-	-	-	-	-
	CO	6500	6500	6500	6500	500	3500	6000	6500	6500	6500	6500	6500
	TOT	6500	6500	6500	6500	3500	7800	7950	6500	6500	6500	6500	6500
ADULT HOLDING	CN	-	-	-	-	-	-	-	920	920	920	-	-
	CO	-	-	-	-	-	-	-	-	-	375	375	375
	TOT	0	0	0	0	0	0	0	920	920	1295	375	375
MONTHLY TOTAL	CN	1140	2405	2640	2640	5640	6940	1950	1055	1325	1325	540	540
	CO	6875	7145	8730	8660	2660	5660	6000	6500	6500	6945	7090	7160
	TOT	7925	9550	11370	11300	8300	12600	7950	7555	7825	8270	7630	7700

Table 7. Rough sizing guidelines for a future Eagle production facility.

	ITEM	CN	CO	TOT
TARGETS	- Total Adult Production	26K	41K	67K
	- Egg-Adult Survival Rate[a]	1.62%	2.16%	
	- Total Eggs Required	1.6M	1.9M	3.5M
	- Total 2g Fry Produced	1.4M	1.2M	2.6M
	- Total 5g Fry Produced	1.2M	1.0M	2.2M
EQUIPMENT	- No. of 8-Tray Incubator Stacks	41	29	70
	- No. of Initial Rearing Units[b]	36	33	40[c]
	- No. of 1x3x30 m Raceways	3.7 ($324m^3$)	4.8 ($390m^3$)	8.5
FLOWS	- Incubation	615	435	1050
	- Initial Rearing	4320	4080	[illegible] 8406
	- Final Rearing (to 5g)	6520	4500	11020

[a] Assuming 5g release for both species

[b] Volume equivalent of one Capilano-style trough = one unit

[c] Maximum set at pilot level

maximum rearing flow at any point between May and November.

- Water source has again been presumed to be solely groundwater, but a surface supply is recommended as in previous sections.

ADULT HOLDING:

<u>Equipment</u> - It is assumed that adult holding of satellited stocks would be done within the donor systems, but that double-use of the raceways for Eagle River broodstock is probable.

<u>Flows</u> - Using flow and volume capacities of 8200 LPM and 540m^3 established for rearing, loading criteria of 1.2kg/LPM and 32kg/m^3, and average adult weights of 5kg for chinook and 3kg for coho, up to 2,000 chinook or 3300 coho could be held in the raceways if no rearing was done.

- In comparison, <u>total</u> broodstock requirements[a] for the proposed two-year study program would be 475 chinook and 1200 coho. With this same study plan, only 220 chinook and 150 coho would be needed from the Eagle, which would require 920 LPM and 34m^3 for chinook, followed by 375 LPM and 14m^3 for coho.

- The spawning periods for each species have only minimal overlap. For the Eagle system, chinook could be held between mid-August and early October, while coho could span the early October to December period.

SUPPORT ITEMS:

This subject requires a separate meeting with all involved, in order to develop a priorized listing of items including: storage, on-site residence(s), security, freezer, aeration, public washrooms, display areas, paving, egg-take area, off-site adult collection, effluent treatment, etc. I am given to understand that Engineering will be providing a tentative overall layout and costing of major support items shortly. I suggest that a meeting be called upon receipt of these plans.

WATER DEMAND:

Tables 6A-6C summarize the approximate water demands as required for the first two years of the proposed experimental operation, as well as an [redacted] Although the first two examples have the same maximum water demand (8480 LPM in June), the 'extreme' would require 33% more water at maximum demand (12,600 LPM).

SIZING OF FUTURE PRODUCTION FACILITY:

Total adult production targets were set at 18,000 CN and 31,000 CO for

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[a] Assuming fecundities of 5500 CN and 2500 CO, sex ratio of 1F:0.6M, and pre-spawning mortality of 25%.

an Eagle production facility during planning of the SEP Transition phase; these targets are additive to the existing pilot production of 1M eggs. Table 7 outlines the <u>total</u> requirements of the further expansion needed to meet these suggested production targets, assuming a 5g release strategy for both species. Requirements, of course, would increase again if longer-term rearing was undertaken, but selection of such a strategy is dependent on the results of the pilot.

Bruce Shepherd
B.G. Shepherd

BGS/mmm

c.c. F.K. Sandercock
C.N. MacKinnon
G.F. Bérézay
D. Harvey
W. Peterson

APPENDIX 2. GWG TARGET PROPOSAL MEMO

Government of Canada | Gouvernement du Canada

MEMORANDUM | NOTE DE SERVICE

TO / À: Distribution

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE: 5830-13-1

YOUR FILE/VOTRE RÉFÉRENCE

FROM / DE: R. Harrison
Co-Chairman
Fraser River, Northern B. C. & Yukon GWG

DATE: February 27, 1980

SUBJECT / OBJET: Proposed Enhancement Targets and Strategy for Fraser River Chinook, Coho, and Chum Salmon and Steelhead Trout.

1. Introduction

The Fraser River, Northern B. C. & Yukon Geographical Working Group (GWG) has developed a tentative plan for the enhancement and management of Fraser River chinook, coho and chum salmon and steelhead trout. This plan includes substantial increases in the production of all species through artificial enhancement and through greater spawning escapements to take advantage of presently underutilized spawning and rearing areas. It must be stressed that the enhancement levels proposed here are tentative and are subject to change pending development of a strategy for sockeye and pink salmon. However, it is expected that the magnitude of any changes would, in most cases, be relatively small.

In developing production levels for artificial enhancement of chinook and coho both migration timing through the lower Fraser River and present natural spawning populations were taken into consideration. In the case of chum salmon the level of enhancement for individual stocks was based on the predicted size of that stock at full utilization of the natural spawning grounds. Steelhead enhancement levels are presented as desired returns of adults to individual tributaries. As some steelhead runs will be threatened by overfishing due to heavy exploitation of enhanced salmon runs, the total steelhead production levels required can be determined only after the plan for enhancing and managing salmon is finalized. In general, no attempt has been made to assign individual stocks to particular enhancement facilities. The actual assignment of stocks to facilities on the basis of technical, engineering and economic considerations has been left to SEP.

There are numerous streams supporting relatively small numbers of fish that have not been included in this proposal. The total number of salmonids utilizing these small streams is relatively low compared with the number found in streams selected for enhancement. However, the importance of these smaller stocks is often much greater than their size would suggest, particularly when they are located close to areas of human settlement. Many such streams may be suitable candidates for assessment through the Public Involvement Program or Small Projects, etc. Some may indirectly benefit as a result of straying of adjacent enhanced stocks. If there is no enhancement effort on these stocks or they do not benefit from straying it is anticipated that some may be faced with extinction.

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The phasing in of enhancement facilities is important as it has an effect on the manageability of stocks and species that overlap in migration timing. For the same species it is highly desireable that all stocks with similar timing not only be enhanced to the same relative degree but also be phased into production at the same time to avoid overexploitation of unenhanced stocks or overescapements of enhanced stocks.

2. Chinook Salmon

The average spawning escapement of Fraser River chinook salmon is about 66,000 and the total stock has been tentatively estimated at approximately 600,000. The migration timing through the lower Fraser River is very extended (Fig. 1) with chinook entering the river from March through October. As indicated in Fig. 1 the timing of individual stocks can be broadly separated into early, middle and late timing segments. The early and middle-timing segments are comprised of numerous stocks while the late-timing run is thought to consist solely of the Harrison River stock.

The enhancement plan for chinook involves increased production through greater escapements and by artificial means. The extent of increases through additional spawners is difficult to quantify because of the paucity of information on spawning and rearing capacities. The proposed increases through artificial enhancement facilities total 1,006,000 for the entire Fraser River system. Table 1 lists the proposed increases for individual streams grouped by migration timing and geographical areas. There are numerous streams supporting chinook salmon that have not been included in this proposal. They represent 40 percent of the total number of chinook spawning streams but only three percent of current total production.

a) Early Timing Chinook

The early-timing chinook run is comprised of the small run of Birkenhead River chinook (now being enhanced) all stocks spawning north of Prince George and a few spawning to the south of Prince George (Westroad, Cottonwood). Early-timing is defined as having a main migratory period through the lower Fraser prior to July 1. The average escapement (1969-78) of the early run is 13,000 while the total catch in all areas is estimated to be 104,000. It is estimated the currently underutilized spawning areas could support at least 70,000 additional early chinook spawners.

Because the migration timing of early run chinook salmon through Area 29 does not coincide to any extent with that of other salmonid species and commercial fisheries can be specifically targeted on them, the early run provides an excellent enhancement opportunity that should be developed immediately. However, in order to obtain a balanced production within this timing segment and minimize loss of natural runs through overfishing it is important that as many stocks as possible be enhanced and that enhancement proceed as far as is practicable, simultaneously on all stocks selected.

The stocks recommended for enhancement and the suggested levels are listed in Table 1. For the early-timing run as a whole the GWG is proposing an increase of 198,000 fish (catch plus escapement).

cont'd 3

(3)

b) Middle-Timing Chinook

The middle-timing chinook stock is comprised of the Quesnel Sub-District escapement (Quesnel, Chilcotin-Chilko-Taseko Rivers) that is not included in the early-timing stock, the Thompson River watershed escapement and the lower Fraser River escapement (excluding the Harrison River "white" chinook) that migrate through Area 29 after July 1. The middle-timing stock has an average (1969-78) escapement of approximately 35,000 and a total catch of 280,000. It is estimated that currently underutilized spawning areas within middle-timing chinook streams could support an additional 100,000 chinook spawners.

There are no Area 29 target fisheries for middle-timing chinook salmon. Management control of the Fraser River is exercised by the International Pacific Salmon Fisheries Commission (IPFSC) during the period of the middle-timing chinook spawning migration (approximately July 1 to September 30). The IPSFC manage the river for sockeye and pink salmon. Chinook salmon captured during IPSFC control are caught incidentally to sockeye and pink. Enhancement of middle-timing chinook should increase the incidental chinook catch in Area 29 during the IPSFC control period. No target fisheries on middle-timing chinook should occur until all designated middle-timing stocks have been enhanced and are of sufficient strength to support additional exploitation.

Table 1 shows the stocks proposed for enhancement and the associated increments. The total proposed increment for this timing segment is 673,000 chinook. Because of our inability to control the Area 29 commercial fishery during the time that middle-timing chinooks are migrating through this area the GWG recommends that enhancement of middle-timing chinooks be given lower priority than that of early or late timing chinooks.

c) Late-Timing Chinook

The late-timing run is considered to be comprised entirely of the white-fleshed Harrison River chinook. These fish occur in substantial numbers in the Area 29 commercial catch in mid-August and comprise the greater portion of the catch in September and October. The Harrison River supports an average (1969-78) escapement of 18,000 chinook while the total catch in all areas is estimated at 144,000. It is estimated that there is sufficient unutilized spawning gravel in the Harrison River to support an additional 35,000 chinook spawners.

The peak migratory period for Harrison River chinooks through the lower Fraser is relatively discrete from the migration of other chinook stocks although they do coincide with coho, early chums, pink, late sockeye and steelhead. Because of their large size they can be fished with large meshed nets which would minimize the incidental coho catch. The chum salmon run is relatively small at this time and may be protected to some extent by enhancement. The peak migration of Thompson and Chilcotin steelhead is about mid-October thus these fish could be subject to severe overfishing if the late-timing chinook run is increased substantially during this period. However, by focussing enhancement on the early-timing segment of the Harrison chinook stock and enhancing the Thompson and Chilcotin steelhead the impacts should be minimized.

cont'd 4

(4)

The GWG proposes that the Harrison River chinook stock be enhanced by 135,000 adults with enhancement aimed at the early portion of this run to minimize the adverse effect on chum salmon and steelhead trout.

3. <u>Coho Salmon</u>

The estimated average (1969-78) spawning escapement of coho salmon to the Fraser River is 64,000 while the total stock is in the order of 250,000 assuming a catch to escapement ratio of 3:1. As indicated in Fig. 2 coho migrate through the lower Fraser from August to November with a peak about the beginning of October. There is currently insufficient information available to separate individual stocks into specific timing segments. The migration timing of coho coincides with that of late sockeye, pink, late chinook, early chum and steelhead. At the present time coho are not commercially fished deliberately in the Fraser River area; the entire catch is taken incidentally to that of other species.

The enhancement strategy for coho involves increases in production through greater escapements as well as by artificial means. Based on rough estimates of the gross spawning area an additional 150,000 coho spawners could be accommodated. However, in many areas rearing capacity will probably be limiting before the spawning grounds are filled to capacity.

Because many of the coho stocks in the Fraser River are in poor condition and because of the overlap in timing with other species, enhancement plans for other species with similar timing must also take coho into consideration. The broad geographical spawning distribution of coho is also a problem if all coho stocks are to be enhanced at a similar rate as it will necessarily involve many individual facilities or extensive satelliting from central facilities.

In the lower Fraser River there are several facilities either under construction (Chilliwack) or planned for the near future (Chehalis, Stave) which will enhance coho, chums and steelhead. In order to minimize the impact on unenhanced coho and steelhead stocks it will be necessary to keep exploitation rates at current levels until production is available from all facilities in both the upper and lower Fraser. This may result in substantial overescapements and hatchery rack harvesting until a balanced increase is achieved. To minimize this effect it is recommended that coho production from the lower Fraser facilities be initially held at a relatively low level. In the meantime it is essential that a comprehensive facility plan be formulated that allows each stock to be enhanced at the rates proposed in Table 2.

The proposed enhancement increment for coho is 913,000 at full production (Table 1). As most of the production is from relatively small stocks this may present serious problems from a benefit-cost point of view. However, the GWG urges SEP to take a close look at the feasibility of small projects on individual streams wherever possible rather than trying to achieve all production from a few large central hatcheries.

There are many small coho spawning streams that have not been included in this proposal. Together they include 50 percent of the known coho spawning streams but only 5 percent of the current total coho production. Many may be suitable candidates for Public Involvement Programs, etc.

cont'd 5

and October with a peak in mid-October (Fig. 1). This run coincides in timing with coho, pinks, early chums, late sockeye and Harrison River chinook. Most summer run steelhead spawn in the Chilko-Chilcotin and Thompson River systems which have current escapements in the order of 400-500 and 6,000 fish, A smaller summer run, spawning in the Coquihalla and Silverhope Rivers, migrates through the lower Fraser from May to July.

The winter run of steelhead starts to show up in abundance in December and coincides with the late portion of the chum run. Winter run steelhead are confined to streams in the lower Fraser Valley, the largest being the run to the Chilliwack River.

a) Mid-Fraser Stocks

The mid-Fraser steelhead stocks are particularly vulnerable to overfishing during commercial openings for salmon during late September and October 29 any enhancement plans for these salmon stocks must also consider steelhead.

Table 3 lists the proposed enhancement plan for mid-Fraser steelhead. The total enhancement increment in terms of adults returning to the river is 2,000 for the Chilko/Chilcotin and 12,000 to the Thompson River. Depending upon the final salmon increments selected there may be a need to provide even greater levels of enhancement to these two systems.

b) Lower Fraser Stocks

The late-timing steelhead stocks are relatively discrete in their migration timing although there could be some conflict with late-timing chums if the latter are enhanced substantially and fished commercially in the river. They are a very important sport fish and in order to reverse the recent downward trend of many stocks and restore sport fishing potentials a steelhead enhancement program has been proposed. Table 4 lists the selected stocks and levels for enhancement. The total proposed increase in adults returning to the streams is about 18,000 of which the Vedder-Chilliwack would account for nearly half.

CONCLUSIONS

The GWG concludes that SEP must develop a facility plan for the enhancement of Fraser River salmonids, that examines the economics of enhancement from a broad point of view taking all stocks into consideration. Some facilities may show unfavourable benefit/cost ratios when examined individually. However, because of the need to simultaneously enhance stocks with similar migration timing a comprehensive enhancement facility plan might include both large and small facilities. It is important that a situation does not occur whereby a few facilities with highly favourable benefit/cost ratios are constructed first leaving the unfavourable ones for phase II or never. This situation would result in overexploitation of unenhanced stocks possibly leading to their extinction. The necessity of phasing in all stocks with similar timing at the same rate cannot be over-emphasized. Management of enhanced production is dependent on this concept.

RECOMMENDATIONS

The Fraser River, Northern B. C. and Yukon GWG makes the following

4. Chum Salmon

Fraser River chum salmon have an average total stock of 905,000, a commercial catch of 462,000 and a spawning ground escapement of 443,000. The average exploitation rate is approximately 50 percent. An estimated two thirds of the spawners utilize three major tributaries: the Harrison, Vedder-Chilliwack and Stave Rivers. The Harrison River alone supports 40 percent of the spawners on the average. Most of the remaining spawners have been attributed to the mainstem of the Fraser while smaller numbers utilize more than thirty other tributaries. In most years the spawning grounds are underutilized.

The long term management and enhancement plan involves increases in production through larger escapements to the spawning grounds and through artificial enhancement. To achieve increases in the spawning populations the GWG recommends an initial reduction of the commercial fishery in Johnstone Strait and the Fraser River. As artificially-produced chum salmon begin to be phased in it is suggested that the level of exploitation not be increased until it is evident that the natural spawning grounds are being filled to capacity. Eventually the combined runs of natural and enhanced chums will support a higher level of exploitation that will still allow an optimum number of fish to reach the spawning grounds.

The recommended plan for artificially increasing Fraser River chum salmon consists of a total increase (catch plus escapement) of 700,000 fish involving six different stocks (Chehalis, Squakum, Harrison, Vedder, Stave and Nicomen and tributaries including Inches Creek) (Table 2). The level of enhancement for each stock was derived by allocating a portion of the 700,000 total on the basis of the relative number of natural spawners each system was estimated to be able to support. In this way each system would theoretically be in balance with all the others and a single exploitation rate (67 percent) could be used to optimize escapements to all areas. It is assumed that the same enhancement technology would be used for all stocks (i.e. fed fry with an egg-to-adult survival of 1.44 percent). Enhancement methods resulting in lower egg-to-adult survivals would require greater escapements and therefore somewhat lower exploitation rates.

In addition to major enhancement of these six stocks there are a number of opportunities for "low level technology" in enhancement of some stocks by such methods as side channel improvement, gravel placement, etc. The GWG strongly supports enhancement projects of this nature. However, it is requested that proposals be sent to the GWG for approval prior to implementation.

One of the costs of this enhancement program will be the loss of production (even extinction) of unenhanced stocks due to overfishing. The largest stock is the mainstem spawning population with an average estimated escapement of 126,000 fish. There is, however, some doubt about the validity of escapement estimates for this population and it may actually be considerably lower. In addition, there are a number of small stocks with have not been included.

5. Steelhead Trout

There are two major runs of steelhead into the Fraser River, a summer run and a winter run. The summer run passes through the lower Fraser mainly in September

cont'd 6

(7)

recommendations regarding the enhancement of Fraser River Salmonids:

1. that enhancement of individual stocks of chinook coho, chum and steelhead take place according to the levels indicated in the attached tables. Alternately, all stocks with similar migration timing (e.g. all early chinook stocks) may be proportionately enhanced to an alternate level after consultation and approval of the GWG.

2. that all salmonid stocks with similar timing be phased into production at the same time, as far as is practical.

3. that immediate emphasis be given to enhancing early-timing chinook. This may require a mixture of large and small facilities to include as many stocks as possible.

4. that enhancement of late-timing chinook (Harrison River) coincide with enhancement of mid-Fraser steelhead. If enhancement of Harrison River chinooks precedes that of steelhead then production should initially be kept relatively low and the early portion of the run should be enhanced.

5. that a comprehensive facility plan for all Fraser River coho and middle-timing chinook be developed.

R. Harrison

Distribution

H. Swan	GWG members:	J. Cartwright
A. Lill		J. Barnetson
A. Wood		O. Sweitzer
R. Palmer		J. Leggett
J. McNally		D. Aurel
F. Fraser		P. Caverhill
B. Shepherd		R. Bell-Irving
D. Wilson		G. Zealand
D. Marshall		B. Pearce

Figure 1. Relationship between Racial Migration Timing of Chinook Salmon Stocks and Other Salmon Species through the Lower Fraser River Fishery (Area 29).

	5 Year (1974 - 1978) Mean Escapement
Chinook Salmon	
Early Timing Stocks	
Birkenhead River	360
Bowron River	1,190
McGregor River	690
Slim Creek	1,280
Upper Fraser River	1,940
Other Upper Fraser Tributaries	1,360
Nechako River	1,930
Stuart R. and Tributaries	700
Westroad and Cottonwood Rivers	1,570
Salmon and Willow Rivers	480
Total	**11,500**
Middle Timing Stocks	
Quesnel and Horsefly Rivers	1,340
Chilco and Taseko Rivers	7,900
Clearwater River	2,250
N. Thompson River	1,800
Other NTR Tributaries	830
Shuswap River	10,480
Adams River	1,470
S. Thompson River	4,700
Other STR Tributaries	980
Nicola River and Tributaries	4,270
Thompson River and Tributaries	1,830
Misc. Fraser Tributaries	750
Misc. Harrison Tributaries	490
Pitt and Chilliwack Rivers	660
Total	**39,750**
Late Timing Stock	
Harrison River	19,500
Sockeye Salmon	
Pink Salmon	
Chum Salmon	
Coho Salmon	
Steelhead	

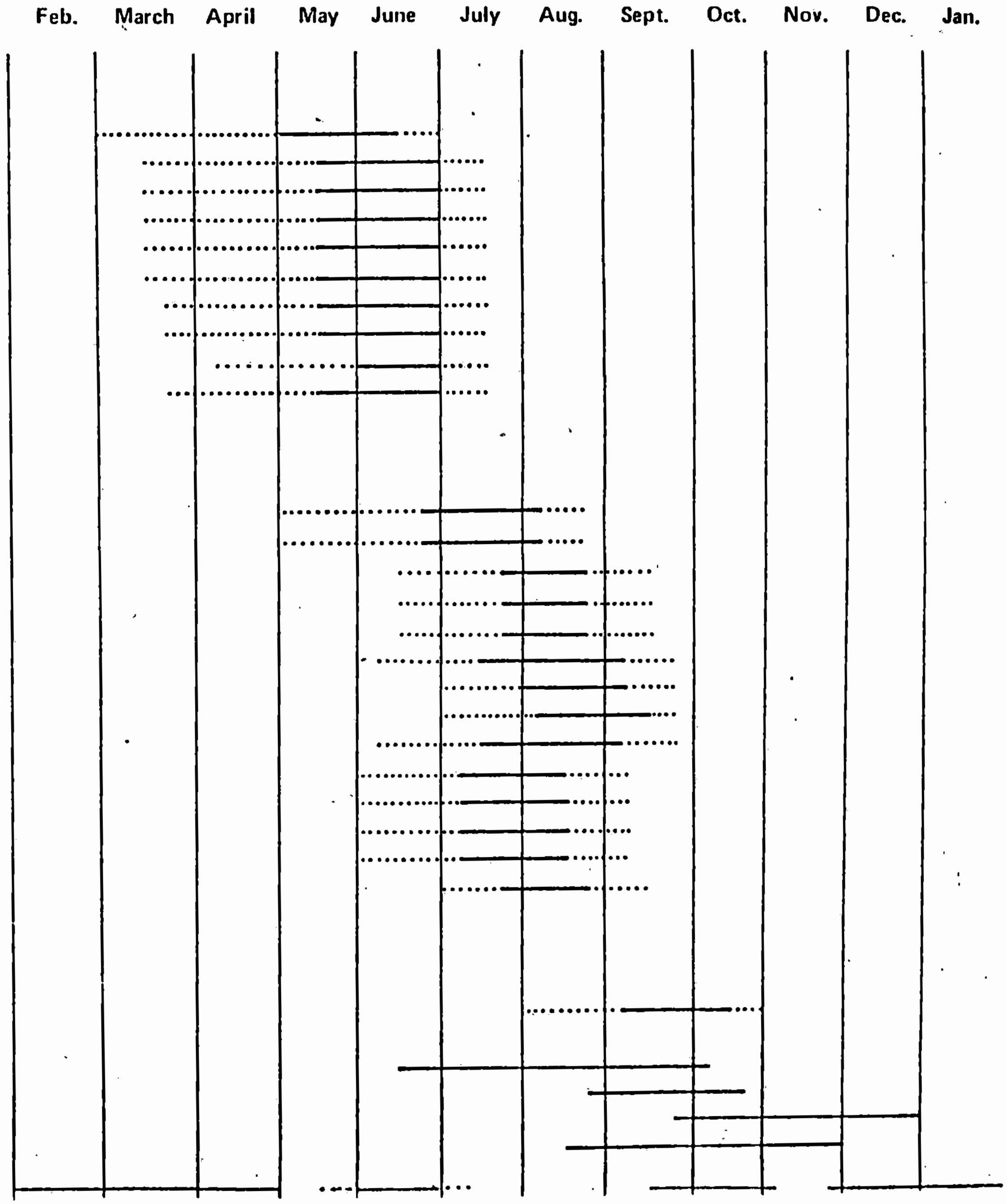

Figure 2. Relationship between Racial Timing of Coho Salmon Stocks and Other Salmon Species through the Lower Fraser River Fishery (Area 29).

	5 Year (1974 - 1978) Mean Escapement
Coho	
Stocks Above Hope	
N. Thompson River and Tributaries	7,600
S. Thompson River and Tributaries	5,270
Thompson River and Tributaries	1,530
Misc. Fraser River Tributaries	2,420
Total	16,820
Stocks: Steveston to Hope, N. Side	
Tributaries above Lillooet Lake	7,890
Harrison River and Tributaries	7,510
Misc. Fraser River Tributaries:	
Hope to Mission Bridge	3,210
Mission to Steveston	3,100
Upper Pitt River	7,000
Total	28,710
Stocks: Steveston to Hope, S. Side	
Chilliwack-Vedder R. and Tributaries	11,230
Misc. Fraser River Tributaries:	
Hope to Mission Bridge	1,380
Mission to Steveston	6,050
Total	18,660
Sockeye	
Pink	
Chum	
Chinook	
Steelhead	

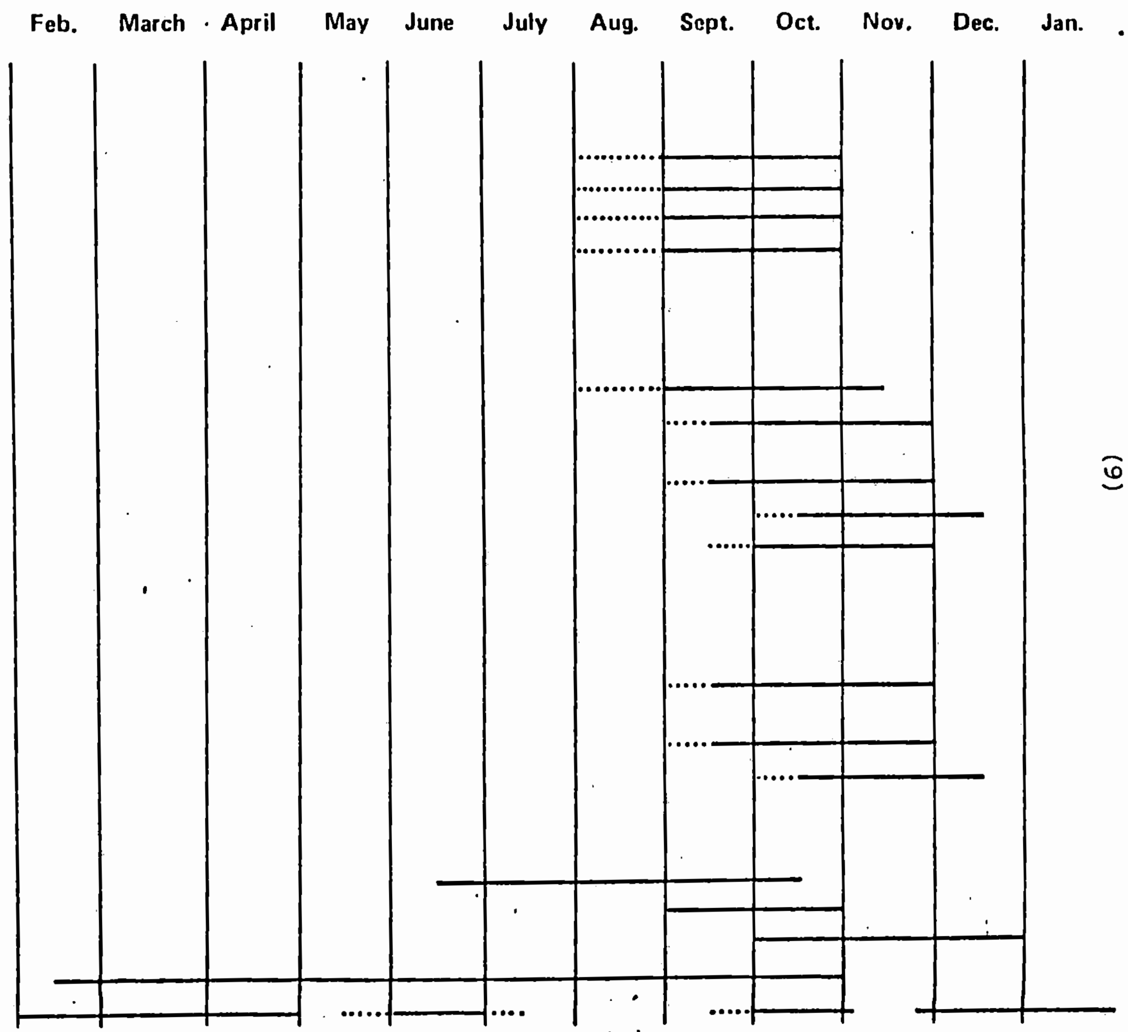

Table 1

CURRENT STOCK AND PROPOSED ENHANCEMENT COMPONENT OF SELECTED STOCKS OF FRASER RIVER CHINOOK AND COHO

I. CHINOOK SALMON

A. Early Timing Stocks

Upper Fraser River	Current Stock	Proposed Enhancement Increment
Bowron River	11,250	23,000
McGregor River	6,750	14,000
Tête Jaune	19,350	39,000
Slim Creek	11,700	24,000
Torpy River	3,150	6,000
Holmes (Beaver) River	2,500	5,000
Salmon River	2,250	5,000
Stuart River	4,950	10,000
Nechako River	19,350	39,000
Westroad River	12,150	25,000
Cottonwood River	900	2,000
Birkenhead River[1]	3,000	6,000
	97,300	198,000

1) tributary to Lillooet Lake (lower Fraser River)

B. Middle Timing Stocks

Central Fraser River	Current Stock	Proposed Enhancement Increment
Quesnel River	10,350	19,000
Chilko River	72,000	130,000
Little Chilcotin River	7,200	13,000
Taseko River*	4,500	8,000
Bridge River*	2,700	5,000
Portage River*	2,250	4,000
Nahatlatch River	900	2,000
	99,900	181,000

* also coho salmon

Lower Fraser River	Current Stock	Proposed Enhancement Increment
Chilliwack River*	450	1,000
Pitt River*	4,500	8,000
	4,950	9,000

* also coho salmon

(11)

North Thompson River	Current Stock	Proposed Enhancement Increment
North Thompson River*	18,000	33,000
Clearwater River	18,900	34,000
Mahood Creek	2,700	5,000
Finn Creek *	4,500	8,000
Louis Creek*	900	2,000
Raft River	1,800	3,000
	46,800	85,000

* also coho salmon

South Thompson River		
South Thompson River	44,100	80,000
Middle Shuswap River*	4,500	8,000
Lower Shuswap River*	84,150	152,000
Eagle River *	3,600	7,000
Salmon River*	2,250	5,000
Adams River	13,050	24,000
	151,650	276,000

* also coho salmon

Lower Thompson River		
Thompson River*	27,000	49,000
Nicola River *	31,050	56,000
Coldwater River*	7,650	14,000
Deadman River	1,800	3,000
	67,500	122,000

* also coho salmon

C. Late Timing Stock

Harrison River	135,000	135,000

II. COHO SALMON

North Thompson River		
Barriere River	1,600	7,000
Blue River	1,600	7,000

(12)

North Thompson River, cont'd	Current Stock	Proposed Enhancement Increment
Clearwater River*	4,000	18,000
Dunn Creek	2,400	11,000
Lemieux	2,000	9,000
Lion*	4,800	21,000
Louis*	5,000	26,000
Raft	1,200	5,000
	22,600	104,000

* also chinook salmon

South Thompson River		
Lower Shuswap*	1,200	5,000
Wap Creek	1,000	4,000
Eagle River*	7,600	33,000
Salmon River*	5,200	23,000
Adams River*	1,200	5,000
Bessette Creek	1,600	7,000
	17,800	77,000

* also chinook salmon

Lower Thompson / Central Fraser River		
Nicola River*	1,600	7,000
Coldwater River*	2,600	11,000
Spius Creek*	1,200	5,000
Deadman River*	200	1,000
Bridge River*	1,800	8,000
Gates River	3,000	13,000
Nahatlatch*	1,800	8,000
Kawkawa	1,800	8,000
Portage*	1,400	6,000
	15,400	67,000

* also chinook salmon

North Side Lower Fraser River Hope to Mission		
Harrison River*	6,400	28,000
Big Silver Creek	2,800	12,000
Chehalis River	4,800	22,000
Coho Creek	4,800	22,000
Weaver Creek	6,000	26,000
Siddle (Bell's) Creek	3,400	15,000
Hicks Creek	3,000	13,000
Maria Slough	600	3,000

(13)

North Side Lower Fraser River Hope to Mission, cont'd

	Current Stock	Proposed Enhancement Increment
Nicomen Slough	2,000	9,000
Norrish Slough	1,000	4,000
Squakum Creek	800	4,000
	35,600	158,000

1) proposed Central Hatchery site
* also chinook salmon

North Side Lower Fraser River Mission to Mouth

Stave River[1]	800	4,000
Salmon River	10,000	44,000
North/South Allouette River	3,200	14,000
Coquitlam River	1,200	5,000
Kanaka Creek	400	2,000
MacIntyre Creek	1,000	4,000
Silverdale Creek	800	4,000
Widgeon (Silver) Creek	3,600	16,000
Whonnock River	1,000	4,000
	22,000	97,000

1) proposed Hatchery site

Lillooet River

Birkenhead River*	8,800	39,000
Lillooet River	5,600	25,000
Pool Creek	800	4,000
Railroad Creek	800	4,000
Ryan Creek	800	4,000
Salmon Slough	3,400	15,000
	20,200	91,000

* also chinook salmon

Pitt River*	38,000	167,000

* also chinook salmon

South Side Lower Fraser River Hope to Mouth

Chilliwack River[1]*	8,000	34,000
Chilliwack tributaries	11,200	74,000
Dunville Creek	1,200	5,000
Elk Creek	1,600	7,000
Kelly (Clayburn) Creek	2,000	9,000

(14)

South Side Lower Fraser River Hope to Mouth, cont'd

	Current Stock	Proposed Enhancement Increment
Beaver (Nathan) Creek	4,000	18,000
West Creek	1,200	5,000
	29,200	152,000

1) Central Hatchery
* also chinook salmon

III. ALLOCATION OF PRODUCTION

	Current Stock	Current Catch	Proposed Enhance.	Total Product.	Enhanced Catch	Enhanced Escape.	Required Escape.	Surplus[1)] Escape.
Early Chinook	97,300	86,489	198,000	295,300	262,488	32,811	15,700	17,111
Middle Chinook	370,800	329,600	673,000	1,043,800	927,822	115,978	57,817	58,161
Late Chinook	135,000	120,000	135,000	270,000	240,000	30,000	18,333	11,667
Total Chinook	603,100	536,089	1,006,000	1,609,100	1,430,311	178,789	91,850	86,939
Coho	200,800	150,600	913,000	1,063,600	797,700	265,900	57,410	208,490

1) Surplus escapement to service underutilized spawning areas; an additional 76,000 Early Timing Chinook spawners; 100,000 Middle Timing Chinook spawners; 35,000 Late Timing Chinook spawners and 151,000 Coho spawners.

TABLE 2 AVERAGE STOCK SIZES, ESCAPEMENTS AND COMMERCIAL CATCHES FOR MAJOR FRASER RIVER CHUM SALMON STOCKS AFTER ENHANCEMENT

	STOCK SIZE			REQUIRED ESCAPEMENT*			COMMERCIAL CATCH		
	Natural	Enhanced	Combined	Natural	Enhanced	Combined	Natural	Enhanced	Combined
Chehalis	200,000	122,000	322,000	100,000	5,600	105,600	100,000	116,400	216,400
Squakum	30,000	18,000	48,000	15,000	800	15,800	15,000	17,200	32,200
Harrison	350,000	215,000	565,000	175,000	10,000	185,000	175,000	205,000	380,000
Vedder	300,000	185,000	485,000	150,000	8,600	158,600	150,000	176,400	326,400
Stave	200,000	122,000	322,000	100,000	5,600	105,600	100,000	116,400	216,400
Nicomen & tributaries	60,000	38,000	98,000	30,000	1,800	31,800	30,000	36,200	66,200
Total	1,140,000	700,000	1,840,000	570,000	32,400	602,400	570,000	667,660	1,237,600

* Assumes egg-to-adult survival of 1.44% for enhanced fish; 50:50 sex ratio.

Table 3 (16)

Proposed Steelhead Enhancement Goals for the Thompson and Chilko/Chilcotin Rivers

Production goals (summer steelhead adults returned to Thompson River), production system and enhancement strategy for Thompson River steelhead, and for Chilko-Chilcotin.

Thompson River

System	Strategy	Ultimate Production Goal (Adults to River)
Deadman River	Habitat improvement	1,000
	Rearing ponds	1,000
Bonaparte River	Colonization Habitat improvement	2,000
	Hatchery	2,000
	Falls Removal Plus Habitat Improvement	1,000
Nuaitch Creek Skuhun Creek Shakan Creek	Habitat improvement Rearing to Smolts On site Native involvement	1,000
Spius Creek	Fish culture Stream restoration	2,000
Nicola River Coldwater River	As yet unidentified. Water storage and controlled releases critical.	2,000

Total ultimate production - 12,000 additional adults to river.

Major production facility not included but may be required.

Chilko/Chilcotin River

Little Chilcotin	Colonization	500
Taseko River System	Lake rearing	1,500

TOTAL PRODUCTION - 2,000 additional adults to river. Major production facility not included, but may be required.

TABLE 4 Proposed Enhanced Production Levels of Steelhead in the Lower Fraser Valley.

Stock		Smolts	Adults to River
Alouette River		20,000	800-1,000
Coquihalla River	summer:	30-40,000	1,000
	winter:	12,000	500
Coquitlam River		12,000	500
Chehalis River	summer:	85,000	3,500
	winter:	35,000	1,500
Inches Creek		12,000	500
Kanaka Creek		12,000	500
Lillooet/Birkenhead River		25,000	1,000
Nathan Creek		12,000	500
Norrish Creek		12,000	500
Widgeon Creek		12,000	500
Ruby Creek		12,000	500
Silverhope River	summer:	12,000	500
	winter:	6,000	250
Stave River		12,000 ?	500 ?
Sumas River		12,000	500
Vedder-Chilliwack River		150,000	7-9,000
TOTAL		483,000	20,550-22,750

***

Province of British Columbia — Ministry of Recreation and Conservation — Fish and Wildlife Branch

MEMORANDUM

To: Hugh Sparrow

Date: February 7, 1980

SUBJECT: Steelhead/Cutthroat in Federal Production Facilities - Region II

Introduction

This will clarify our requirements for steelhead/cutthroat in Federal hatcheries in this region. For any new facility, our feeling is that we should request capacity for the two species. Our job, initially, is to consider whether these species would be feasible when considering biology and potential angling benefits. On a first look at a Federal facility we may reject the idea of either species or both. There's no point in producing anything where no angling will occur or where there is strong knowledge that there would be biological problems. Once we have decided to ask for fish and provide some goal numbers and rationale, it should be up to Federal expertise (and ours?) to determine site capability. Goal numbers rationale and comments are provided below for proposed Federal Facilities in this region. (Comments regarding steelhead and cutthroat in existing Federal Facilities, ie. Capilano, will be dealt with separately.)

Federal Facilities

1) Inches Creek (Nicomen Slough)

Species: CT, SH

Species Priority: CT

Distribution & Angling (present/historical): CT are present throughout Nicomen Slough and downstream into the Fraser River. A considerable amount of fishing still occurs in the slough despite depressed numbers of CT and salmon. Historically (20 years ago), Nicomen Slough was highly regarded for CT. Anglability in the slough would be good (bank and small boat). SH are found in Suicide Creek in small numbers compared to the past. Angling is limited to the lower several miles of stream.

Benefits: Better angling for more anglers in a presently depressed angling area. Close to Vancouver population.

Production Goal: CT - 8000 smolts to produce 2000 adults.
SH - 12000 smolts to produce 500 adults.

Stock Origin: CT to come from slough, slough tribs. or Fraser River. SH from Suicide Creek or nearest other source on Fraser north side (ie. Chehalis River).

Stocking Sites: CT - 3-4 sites along slough. SH - Suicide Creek below falls.

Problems: Proposed dam and water use from Suicide Creek may degrade steelhead angling.

2) Chehalis/Harrison River

Species: CT, SH

Species Priority: probably equal.

Species Distribution & Angling (present/historical): Harrison River area has been noted over years for cutthroat angling. Fish and angler numbers are presently depressed. CT are found as the dominant trout species throughout the Harrison watershed. Steelhead in the Chehalis River system, a Harrison tributary, number 200-300 adult fish. This is suspected to be down considerably from historical numbers. Restoration of winter run steelhead and the introduction of summer steelhead are possibilities.

Benefits: Better angling, more angler days, close to Vancouver for SH & CT.

Production Goal: CT - 20000 smolts to produce 5000 adults.
SH - 12,000 smolts (WRSH) to produce 500 adults.
12,000 smolts (SRSH) to produce 500 adults.

Stock Origin: CT from Harrison system (river). SH from Chehalis and Coquihalla

Stocking Sites: CT - Harrison River
SH - Chehalis and its tributary the Statlu. Possibly also Harrison Lake tribs. with WRSH, ie. Cogburn, Big Silver.

Problems: Introduction of summer steelhead must be considered critically.

3) Stave River

Species: CT and SH.

Species Priority: CT

Species Distribution & Angling (present/historical): Cutthroat trout and steelhead are present. Steelhead numbers are probably extremely low. Angling for cutthroat occurs in Stave February through May.

Benefits: Increased angling for CT especially, would generate greater angler days than at present. Good anglability (bank and boat). Benefits down Fraser through bar fisheries.

Production Goal: CT - 4000-6000 adults from about 40,000 smolts returning to Fraser and Stave Rivers.

Stock Origin: CT - Harrison River, Stave or Fraser River.
SH - would have to come from some local area stream, ie. Alouette, Chehalis.

4) Birkenhead

Species: SH and CT.

Species Priority: Both (but priority leans toward SH).

Species Distribution & Angling (present/historical):

Steelhead - Small numbers of steelhead are present in the Lillooet River below Lillooet Lake from December through May. The Birkenhead River has a very small run of steelhead of 7-12 lbs. that appear april through mid-May (scale readings tend to confirm these fish). The Birkenhead also has runs of Rainbow and Dolly Varden which enter the river with sockeye in late August. Size of the DV and RBT in the run increases until mid-October to the end of November when rainbows are 2-7 lbs. and Dollies are 2-4 lbs. It is felt (scale readings) that the rainbows are lake resident fish.

Cutthroat - Larger adults are present throughout the system, including the upper Lillooet, generally in the period February through March. Birkenhead cutthroat are not numerous and the greatest numbers appear below Lillooet Lake. Also, it is not known if these fish are sea-run, lake resident or a mixture.

Angling for both species, particularly in the Lillooet River below Lillooet Lake is increasing.

Benefits: Better angling opportunity. More angler days. The area from below Lillooet Lake will increase in angler use in the future especially if access up Harrison Lake (down Lillooet Lake) becomes more of an all season reality. The Duffey Lake road, linking the cariboo via Lillooet, with the Lower Mainland is in a constant process of upgrading and will become a paved all weather-highway in the near future. Enhanced SH/CT would be used by anglers from the Fraser River mouth upstream and into the Lillooet/Birkenhead.

Production Goal: 1000 adult SH (25,000 smolts) distributed throughout the Lillooet system and Birkenhead River. 3000 cutthroat (12,000 smolts) similarly distributed (ie. stock 50% of steelhead in Birkenhead and remainder at other sites on Lillooet. Probably most of cutthroat at sites on Lillooet).

Stock Origin: Brood availability - may be difficult to obtain 10-15 females and 5-8 male SH from the Lillooet system. (This will have to be explored further). Cutthroat probably are no problem. Alternate sources of steelhead could be Sloquet (spring) Creek at the N.W. end of Harrison Lake or Cogburn Creek and Big Silver on Harrison Lake east side. These would be the closest potentially viable sources of SH.

Problems: Possibly the Birkenhead River native food fishery for chinooks in the spring and summer may intercept some spring steelhead.

5) Vedder/Chilliwack

Species: SH & CT.

Species Priority: SH

Details are already worked out and construction is well underway. It should be emphasized that rearing adult holding is to separately accommodate early, middle and late components of the Vedder SH run and the capacity for 2 additional, as yet unspecified, stocks.

6) Cheakamus

Species Priority: SH

Benefits: Cheakamus River steelhead angling has declined in recent years. As more restrictive regulations are applied to other regional streams pressure is focused on the Squamish and Cheakamus Rivers. Some degree of enhancement will be necessary if the system is to provide a similar or better angling success than what is available now. Other enhancement opportunities throughout the system are limited. Benefits will come from greater angler success and a more equitable distribution of anglers throughout the Squamish system. (Poor angling in the Cheakamus has caused a shift in pressure to the Squamish River.

Production Goal: 500-1000 adults from 12-24,000 smolts.

Stock Origin: Cheakamus (easily obtained by angling).

It should be noted that production goal figures for the various federal facilities may have to be adjusted due to rearing conditions (ie. production of 2 years instead of 1 year smolts). Calculations have been based on smolt to adult survivals for cutthroat and steelhead of 25% and 4% respectively.

Peter A. Caverhill

Peter A. Caverhill
Fisheries Biologist

PAC/rc

c.c. - Dave Narver
- Vic Swiatkiewicz
- Robin Harrison

APPENDIX 3. WATER QUALITY MEMOS

a. Effluent Treatment Requirements

b. Well #PW-E1 Water Quality Evaluation

c. Well #PW-E2 Water Quality Evaluation

d. Chinook Mortality Problems

APPENDIX 3a. EFFLUENT TREATMENT REQUIREMENTS

TO
A

B.G. Shepherd
A/New Projects Coordinator
E.S.B.

FROM
DE

Ted Perry
Bio Program Coordinator
E.S.B.

SECURITY - CLASSIFICATION - DE SECURITE
OUR FILE/NOTRE RÉFÉRENCE 5903-85-E7
YOUR FILE/VOTRE RÉFÉRENCE
DATE May 25, 1981.

SUBJECT
OBJET **RE: EAGLE RIVER PILOT - EFFLUENT TREATMENT:**

A phosphorus budget has been calculated for the proposed Eagle River Pilot hatchery assuming production of "90-day" chinook smolts and 2g coho fry. This budget, based on P in OMP and in fish flesh, is used to estimate total P load, incremental P concentrations in the hatchery effluent and incremental P concentrations in the Eagle River (Tables 1-3). The assumptions for the calculations follow the tables. These estimates are then used to evaluate treatment technology options. Please note that all load and concentration estimates are conservative. (That is, they are a maximum). This is implied since:

- P input is limited by P concentration in the feed
- some P will remain in pond sludge and may be disposed by means other than direct discharge
- rearing pond flows are low relative to rearing biomass
- the calculations assume all fish of a species will be on hand to a single release date - sequential plants would reduce the maximum P discharge levels
- Eagle River flows in June when rearing loads will peak are expected to be considerably (2-4 x) higher than flows recorded August 26, 1980 (The August 26 reading of $5.8 m^3 s^{-1}$ has to be used since it is the only datum available).

P Concentrations in the Effluent

Maximum incremental concentrations of P in the effluent are estimated at approximately 0.3mg/l (Table 2). Reliability of this estimate may be judged from the following:

a) Available data (UML March 1979) for P concentrations

B.C. hatcheries 0-0.15mg/l

U.S. hatcheries 0-0.26mg/l

B.C. hatcheries (cleaning) $\leq$ 1.43mg/l

b) Calculations based on published relationships between P-loads and feed rate (kg P discharged/day)

	CO	CN
Liao	1.83	1.08
UMA	0.56	0.33
Eagle estimate	1.13	0.62

Incremental P Concentration in Eagle River

Phosphorus concentrations in Eagle River downstream of the discharge point, assuming complete mixing at $5.8m^3 s^{-1}$ river flow, will increase by 0.003mg/l due to CN rearing and by 0.004mg/l due to CO rearing. These concentrations are maxima since they reflect rearing conditions just prior to release. They are expected to be overestimates since Eagle River flow will probably exceed $5.8m^3 s^{-1}$ in June.

Treatment Technology

The basic issue is how much effluent P must be removed in order to reduce impact on Eagle River and to determine which technology can do the job. Phosphorus levels in the Eagle are generally low compared to the predicted output from the hatchery.

Eagle River Total P Concentration (mg/l	Frequency
below detection (0.002)	1
0.002	3
0.003	2
0.004	1
0.008	1
0.027	1

/3

The high readings were obtained in November (0.008mg/l) and during the April freshet (0.027mg/l). For the sake of argument, levels in June are assumed to be 0.003mg/l.

Given this background level, the hatchery effluent would triple Eagle River P concentrations [(0.003 natural + 0.003 CN + 0.004 CO) ÷ 0.003 = 3.3] . If the objective of effluent treatment were to limit effluent impact to increasing P levels by 50% or less, that is maximum incremental P concentrations of 1.5mg/l, then 80% of the effluent P must be removed [(7mg/l - 1.5mg/l) ÷ 7mg/l].

Calculation of the required P removal efficiency, in this case 80%, is necessary for evaluating treatment methods. The definition of acceptable P increases over background levels significantly effects the performance demanded of effluent treatment facilities. For example, if a 50% increase is not acceptable to HP or PCB, then removal efficiency must be greater than 80%.

Given that 80% removal of P is required, most available technology is inappropriate.

Technology	P Removal*	Waste Type
Sand filters	-	
Biofilters	up to 33% OP	Hatchery
Sweco concentrators	17% TP	Hatchery
Lagoon/duckweed harvest	56-81% ?	Domestic
Sorption	99% ?	Domestic
Activated sludge	25% OP	Hatchery

*Data from UML report on Treatment Technology, March, 1979. OP = orthophosphate
TP = total phosphate
? = not specified

Only stabilization lagoons combined with macrophyte harvesting and sorption techniques have the required removal efficiency. However, these data are for sewage treatment dealing with wastes at much higher concentrations than found in hatchery effluents - efficiency will be lower for treatment of hatchery effluents. Considering weather extremes, seasonality of operation and low nutrient levels it is unlikely that duckweed or other harvestable plants offer a viable solution. Sorption is expensive. All solids must be removed by pretreatment to prevent fouling of the sorption column (activated alumina). Capital and annual operating costs would probable exceed $5,000,000 and $50,000 respectively.

Summary

Sorption is the only method which might significantly reduce P levels in the Eagle River hatchery effluent but costs are unacceptably high and application to hatchery waste water has not been tested.

Ted

Ted Perry

TP/mmm

Att:

TABLE 1: Estimate of phosphorus discharge from Eagle River pilot hatchery for duration of rearing.

Species	Release Biomass (kg wet wt.)	P Content Fish (g P/kg wet wt.)	Total Biomass-P (kg)	Feed (kg wet wt.)	P Content OMP (g P/kg wet wt.)	Total P Fed (kg)	P Discharged (kg)
CN	2700	3.364	9	4050	12.25	50	41
CO	4700	3.364	16	7050	12.25	86	70

TABLE 2: Estimate of maximum incremental phosphorus concentration in Eagle River pilot hatchery effluent.

Species	Release Biomass (kg)	Final Feed Rate (% b.w./day)	Max. Daily Ration (kg)	Max. Daily P Fed (kg)	Max. Daily P Retained (kg)	Max. Daily P Discharged (kg)	Max. Flow (LPM)	Max. Daily Effluent Volume During Feeding (m^3)	Max. Δ P Conc. in Effluent (mg/l)
CN	2700	2.3	62	0.76	0.14	0.62	2665	1900	0.33
CO	4700	2.4	113	1.38	0.25	1.13	4880	3500	0.32

TABLE 3: Estimate of maximum incremental phosphorus concentration in Eagle River due to Eagle River pilot hatchery effluent.

Species	Max. Daily Effluent Flow ($m^3 s^{-1}$)	Eagle River Flow ($m^3 s^{-1}$)	Eagle River Dilution Factor	Max. Δ P in Eagle River (mg/l)
CN	0.044	5.8 (Aug 26/80)	132	0.003
CO	0.081	5.8 "	72	0.004

9/

Assumption

Calculations assume OMP diet at 30% moisture content

Conversion rate 1.5 : 1 on wet wt. basis

For calculation of max. P concentration in effluent feeding is assumed to occur over 12 hours. The "max. P concentration" is the average expected concentration over the 12 hour feeding period.

****

APPENDIX 3b. WELL #PW-E1 WATER QUALITY EVALUATION

TO / À: B.G. Shepherd
A/New Projects Coordinator
E.S.B.

FROM / DE: Don D. MacKinlay
Design Biologist
E.S.B.

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE: 5830-13-16

YOUR FILE/VOTRE RÉFÉRENCE

DATE: May 20, 1980

SUBJECT / OBJET: WATER QUALITY-CRAZY CREEK PUMP-TEST; MARCH 16-20, 1980

Thomas Well Drilling drilled, developed and pump-tested wells on the proposed Crazy Creek hatchery site near Taft B.C. during March 1980 under the supervision of Pacific Hydrology Consultants. Sigma Resource Consultants provided on-site water quality testing during the pump-test of well CR1 and sent water samples to the EPS-EMS Cypress Creek Laboratory for more thorough analysis. This memo summarizes the data from the Pacific Hydrology, Sigma and Cypress Creek reports, and interprets the findings with respect to suitability of the water for fish culture.

Well CR1 was drilled through water bearing gravel to bedrock at a diameter of 25 cm to a depth of 34 meters. The well was developed by surging and bailing after a 10.7 meter screen was set in place between 22.7m and 33.2m. Static water level at the time of pump-testing was 5.2m below the top of the well casing. The well was tested at a rate of 300 LPM. Pacific Hydrology suggested that a 40cm diameter well could produce up to 9600 LPM. The aquifer is most likely recharged from Crazy Creek but extended pumping may result in infiltration from Eagle River.

There were two break-downs during the pump-test. The first occurred during the third day and lasted 5.5 hours. The second occurred after 90 hours of accumulated pumping and terminated the pump-test since both the Thomas and Sigma people on site felt that no significant change in conditions were expected.

Figure 1 shows the location of the sampling sites with respect to the Taft railroad siding and highway. Table 1 summarizes water quality parameters important to fish culture. Table 2 summarizes the field data collected by Sigma.

1. Groundwater Quality

Generally the water from well CR1 is quite attractive as a potential source of hatchery water. At the time of sampling the temperature was 4 to 5°C above the surface water temperature; well within the acceptable incubation range. Temperatures increased slightly with pumping which may suggest

.../2

that recharge is from a large warm source but evidence for this is not at all conclusive.

Potential problem areas include gas saturation, water softness and nitrate and metal concentrations. Dissolved oxygen is too low and total dissolved gases are too high for fish culture. An aeration/strippping facility will definitely be required to correct these conditions. Alkalinity, pH and hardness are in the low range of acceptability. Conductivity, calcium and filtrable residue (dissolved solids) are below recommended levels. This characterizes the water as moderately soft. Soft water has been associated with several disease conditions in hatchery salmonids (Alderdice, pers. comm.). Changes in design criteria, operational strategy or water treatment may be required in the future, when more is known about the relationship between disease and soft water.

High nitrate concentrations are often associated with algal blooms in rearing ponds during the summer, but lack of other nutrients (especially phosphorus) would limit such occurrence here and no problems are anticipated. Zinc concentrations are above the recommended maximum for soft waters. Though the level decreases with pumping, the situation is still marginal and should be investigated further to determine whether there is contamination from a point source or whether high zinc concentration is indeed a characteristic of the entire aquifer. High aluminum and copper concentrations were found in the first sample set after pumping started but did not re-occur and are interpreted as contamination from well development of surface sources. One very high titanium value is interpreted as a mistaken readout by the laboratory auto-analyser.

2. Surface Water Quality

Both Crazy Creek and Eagle River are characterized by:

a. Excess total gas pressure - requires a stripping facility before use.
b. Marginally acceptable ionic strength (low alkalinity, filtrable residue, conductivity hardness and calcium) which is even softer than the well-water - see comments on ground-water softness.
c. Low winter temperature - unsuitable for incubation.
d. Slightly high nitrate concentrations - no problem anticipated.

Ongoing water quality sampling and temperature monitoring at Crazy Creek is being carried out and a summary report will be available in the near future.

Recommendations:

1. Further ground-water testing, especially for metals, temperature and water hardness group (alkalinity, conductivity, filtrable residue, calcium, hardness).

2. Inclusion of aeration/stripping facility in any design.

Don D. MacKinlay

Don MacKinlay

DMcK:ib

SITE: CRAZY CREEK

DATE SAMPLED: Apr. 16-20/80

'IPLER: SIGMA

TABLE 1. Water quality criteria of samples. Circled values indicate unsuitability for fish culture.

PARAMETER	VALUES (mg/l) RECOMMENDED	TOXIC	SITE VALUES (from PEI or Field test)						
			1.5 HRS	24 HRS	48 HRS	72.5 HRS		CRAZY CREEK	EAGLE RIVER
Temperature (°C)	>2°-7°; <18°-25°		7.0	7.1	7.3	7.4		2.0	3.1
pH	6.5-8.5	<5; >9 Field / Lab	6.5 / 6.4	6.4 / 6.4	6.4 / 6.5	6.6 / 6.5		6.9 / 7.2	6.8 / 7.3
D. Oxygen (mg/l)	>6-8		4.3	4.1	4.0	4.2		13.2	13.0
(% satn.)	100%		36.9	35.8	33.7	35.5		97.1	98.5
D. Gases-Total	<103%	>110%	92.0	93.7	94.3	94.2		102.2	102.6
$-N_2$ + Ar	≤100%		106.6	109.1	110.5	109.8		103.6	103.7
Acidity			—	—	—	—		—	—
Alkalinity-Total	20-300		28.2	29.7	30.7	31.0		23.3	20.9
Ammonia (total)	{<.002 incubating; <.005 rearing	>.08	<.0050	<.0050	<.0050	<.0050		<.0050	<.0050
CO_2 (free total)	2-5	>20	—	—	—	—		—	—
Chloride	<170	>400	1.60	2.12	1.75	1.79		1.68	<.50
Chlorine	<.002	>.006	—	—	—	—		—	—
Ttl. Carb. Res.	<.003		—	—	—	—		—	—
Colour	<15 TCU		<5	<5	<5	<5		5	<5
Conductivity	150-2,000	Field / LAB	58 / 82.5	59 / 88.0	55 / 87.8	57 / 90.4		28 / 75.7	40 / 56.2
-nide	<.005		—	—	—	—		—	—
uride	<1.5	>2.3	—	—	—	—		—	—
Hardness ($CaCO_3$)	20-400		35.8	36.5	38.0	38.9		28.0	26.0
$_2S$	<.002	>.004	—	—	—	—		—	—
Nitrogen (N)	≤100% satr.		—	—	—	—		—	—
itrite (NO_2)	<.012	>.2	<.0050	<.0050	.0098	<.0050		<.0050	<.0050
Nitrate (NO_3)	<.12		0.324	0.387	.155	.245		.309	.179
O_2 + NO_3	<.13		—	—	—	—		—	—
Pest-Herbicides	0		—	—	—	—		—	—
Phosphate (total)	<.05		<.0050	<.0050	<.0050	<.0050		.0050	<.0050
Residue-Total	<2000.		—	—	—	—		—	—
-filterable	70-400		58	63	64	64		55	44
-non-filterable	{3 incubating; 25 rearing		<5	<5	<5	<5		<5	<5
Silica (SiO_2)	<10-60		5.59	5.57	5.48	5.65		5.58	3.33
ulfate (SO_4)	<90		7.70	8.20	8.25	7.90		9.70	5.25
Sulfide	<.002		—	—	—	—		—	—
aste/Odour	odour free, unaffected taste		—	—	—	—		—	—
minerals	500-1000	[illegible]	—	—	—	—		—	—
bidity	1-60 TTU	1000.	1.9	<1.0	<1.0	<1.0		<1.0	<1.0

WELL CR1

SITE: CRAZY CREEK TABLE 1(cont'd). Water Quality criteria of samples.
DATE SAMPLED: Ap16-20/80 Circled values indicate unsuitability for fish culture.

SAMPLER: SIGMA

ELEMENT	VALUES (mg/l) RECOMMENDED	TOXIC	SITE VALUES (from PEI tests)						
aluminum	<.1	5	.118	<.09	---	---→		---	---→
As-arsenic	<.5	1	<.15	---	---	---→		---	---→
Ba-barium	1. (domestic water)		.0079	.0056	.0058	.0060		0.0096	.0136
Ca-calcium	>20	>300	11.3	11.6	12.1	12.4		9.60	7.76
Cd-cadmium	<.0004(soft); <.003(hard)		.0022	.0011	<.0010	---→		---	---→
Co-cobalt			<.015	---	---	---→		---	---→
Cr-Chromium	<.01 hexavalent <.05 trivalent		<.015	---	---	---→		0.022	<.015
Cu-copper	<.006 soft <.03 hard		.0066	.0026	.0026	.0028		<.0010	---→
Fe-iron	<.3		.128	.026	.038	.019		0.092	.012
Hg-mercury	<.00005	>.0002	<.00020	---	---	---→		---	---→
K -potassium		50	1.26	1.23	1.28	1.28		0.935	.8522
Mg-magnesium	<10	100	1.83	1.84	1.89	1.92		0.98	1.62
Mn-manganese	<1. /<.005	>15	.0093	<.003	.0032	<.003		.0048	<.003
Mo-molybdenum			<.15	---	---	---→		---	---→
Na-sodium		20 [illegible] 500 [illegible]	1.86	1.9	2.12	2.32		1.63	1.02
Ni-nickel	<.01 of the 96h LC50		<.08	---	---	---→		---	---→
P hosphorus	<.0001 for Saltwater		<.3	---	---	---→		---	---→
Pb lead	<.01/<.03		<.0010	---	---	---→		---	---→
Sb-antimony			<.08	---	---	---→		---	---→
Se-selenium	<.001 of the 96h LC50	2.5	<.15	---	---	---→		---	---→
Si-silicon	10-60		5.85	5.58	5.78	5.77		3.79	3.5
Sn-tin			<.2	---	---	---→		---	---→
Sr-strontium			.0655	.0664	.0699	.0712		.0561	.0369
Ti-titanium			<.0085	---	---→	17.0		<.0085	---→
V -vanadium			<.05	---	---	---→		---	---→
Zn-zinc	<.005 soft <2 hard		.0174	.0141	.0066	.0080		<.0010	---→
			1.5 HRS	24 HRS	48 HRS	72.5 HRS		CRAZY CREEK	EAGLE RIVER

WELL CR1

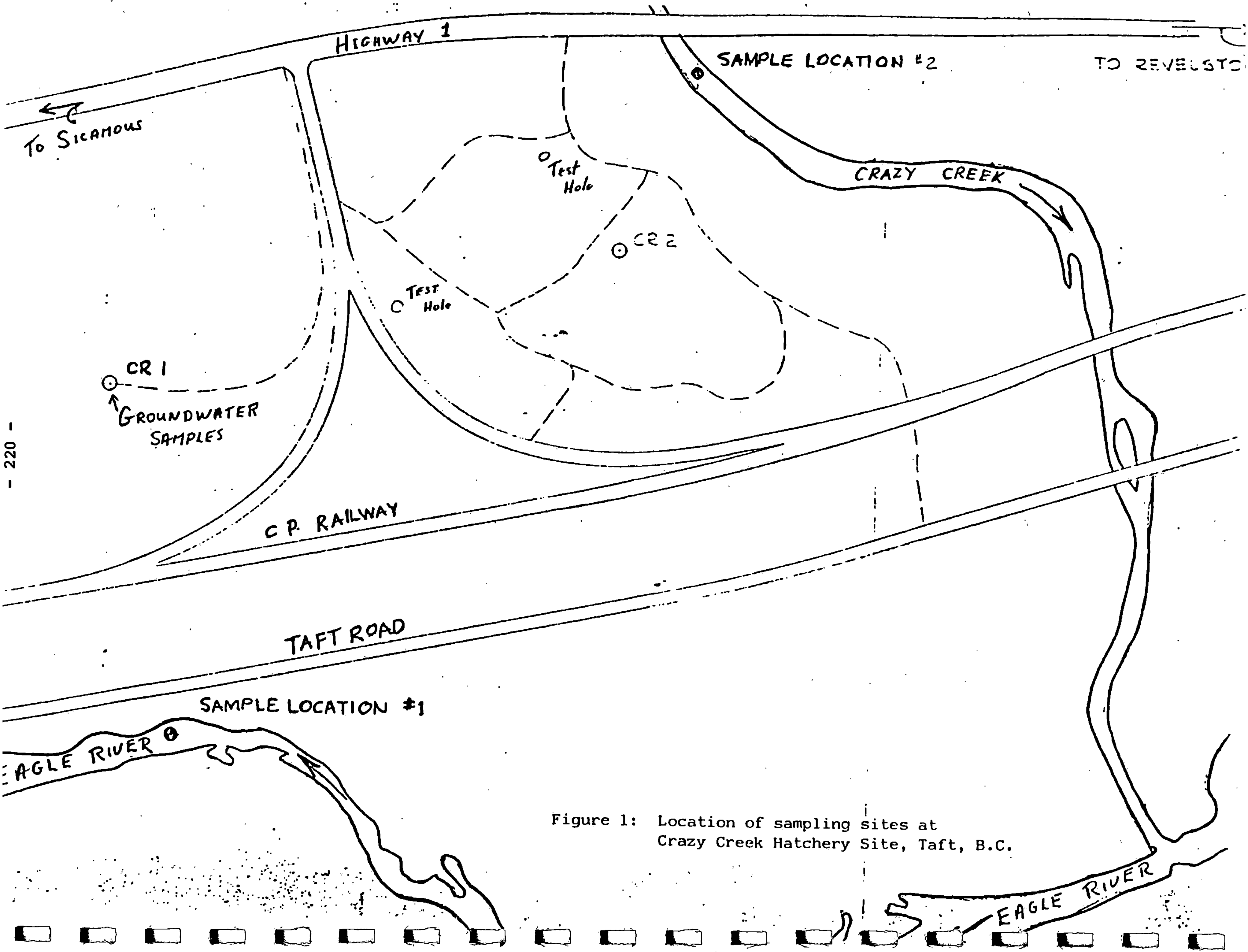

Figure 1: Location of sampling sites at Crazy Creek Hatchery Site, Taft, B.C.

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

March 26, 1980 File: 265E

Mr Bruce Shepherd
Department of Fisheries and Oceans
1090 West Pender Street
Vancouver, BC
V6E 2P1

Dear Mr Shepherd:

CRAZY CREEK PUMPTEST: WATER QUALITY FIELD RESULTS

Samples were collected and water quality analysis performed from March 16 - 20 during a pump test of well #1 at the Crazy Creek hatchery site (designated CR1). The field results are presented in the attached table. The work was done according to our proposal of August 1979, "Water Quality Analysis of Selected Salmonid Enhancement Projects". Additional information and comments are listed below.

Sample Collection

Well water samples for field and laboratory analysis were collected at the well head.

The aquifer is most likely recharged from Crazy Creek. However, extended pumping, could also result in infiltration from Eagle River. Therefore, depth integrated samples were taken from both Crazy Creek and Eagle River. Eagle River was sampled downstream of Crazy Creek close to well CR1 (see attached site plan).

Water Quality Analysis

The instruments were calibrated daily and operated satisfactorily throughout the test. The well was pumped at approximately 750 gpm (US). The pump test was shut down 5.5 hours on March 18 due to mechanical problems. The effects of the shut-down on water quality was considered minimal, therefore the pump test was continued and the time assumed to be accumulative. The pump broke down at 90

...../2

hours on the final day eliminating the 96 hours sampling, however, no significant changes in water quality were anticipated.

Based on the field analysis, the water quality of well CR1 seems good. All parameters remained essentially unchanged throughout the pump test. The temperature increased slightly from 7.0 to 7.4^{o}C. The TGP pressure increased from 92% to 94.3% during the first 48 hours. The results are listed in the attached table.

Ryznar Stability Index

The Ryznar Stability Index ranged from 11.7 to 12.0 for well CR1. With reference to case histories (see attached Figure 1) the well water is expected to be corrosive.

We trust that the work done is in accordance with your expectations. If the above discussion raises any further questions, please do not hesitate to call us.

Yours truly
SIGMA RESOURCE CONSULTANTS LTD

Reider Zapf-Gilje

R ZAPF-GILJE

Encls

RZ-G:jl

FIELD RESULTS: CRAZY CREEK PUMP TEST

WATER SOURCE	CR1	CR1	CR1	CR1	CR1	CRAZY CREEK	EAGLE RIVER
Date, March 1980	16	17	18[A]	19	20[B]	18[C]	18[D]
Time of Day	1300	1130	1700	1730		1230	1400
Accumulative Pumping Time, (hours)	1.5	24	48	72.5		47	47
Temperature, ^oC	7.0	7.1	7.3	7.4		2.0	3.1
Conductivity, µmhos/cm	58[E]	59	55	57		28	40
pH	6.5	6.4	6.4	6.6		6.9	6.8
ORP, mV	175	105	130	160		110	145
[illegible], mm Hg	-61	-48	-43	-44		17	20
TGP, %	92.0	93.7	94.3	94.2		102.2	102.6
S_{N_2+Ar} %	106.6	109.1	110.5	109.8		103.6	103.7
DO, mg/l	4.3	4.1	4.0	4.2		13.2	13.0
S_{O_2}	36.9	35.8	33.7	35.5		97.1	98.5
Atmospheric Pressure, mm Hg	725	715	745	743		745	745
Ryznar Stability Index, I_s	12.0	12.0	11.9	11.7		12.4	12.1

A) Pump was shut down from 1040 to 1610 due to mechanical problems.

B) Pump broke down at 1100 hours.

C) Depth integrated river samples were collected approximately 50 m downstream of Crazy Creek bridge.

D) Depth integrated samples of Eagle River were collected at the riverbend south of well CR1 approximately 20 m from Taft Road.

E) Conductivity was measured at in situ water temperatures.

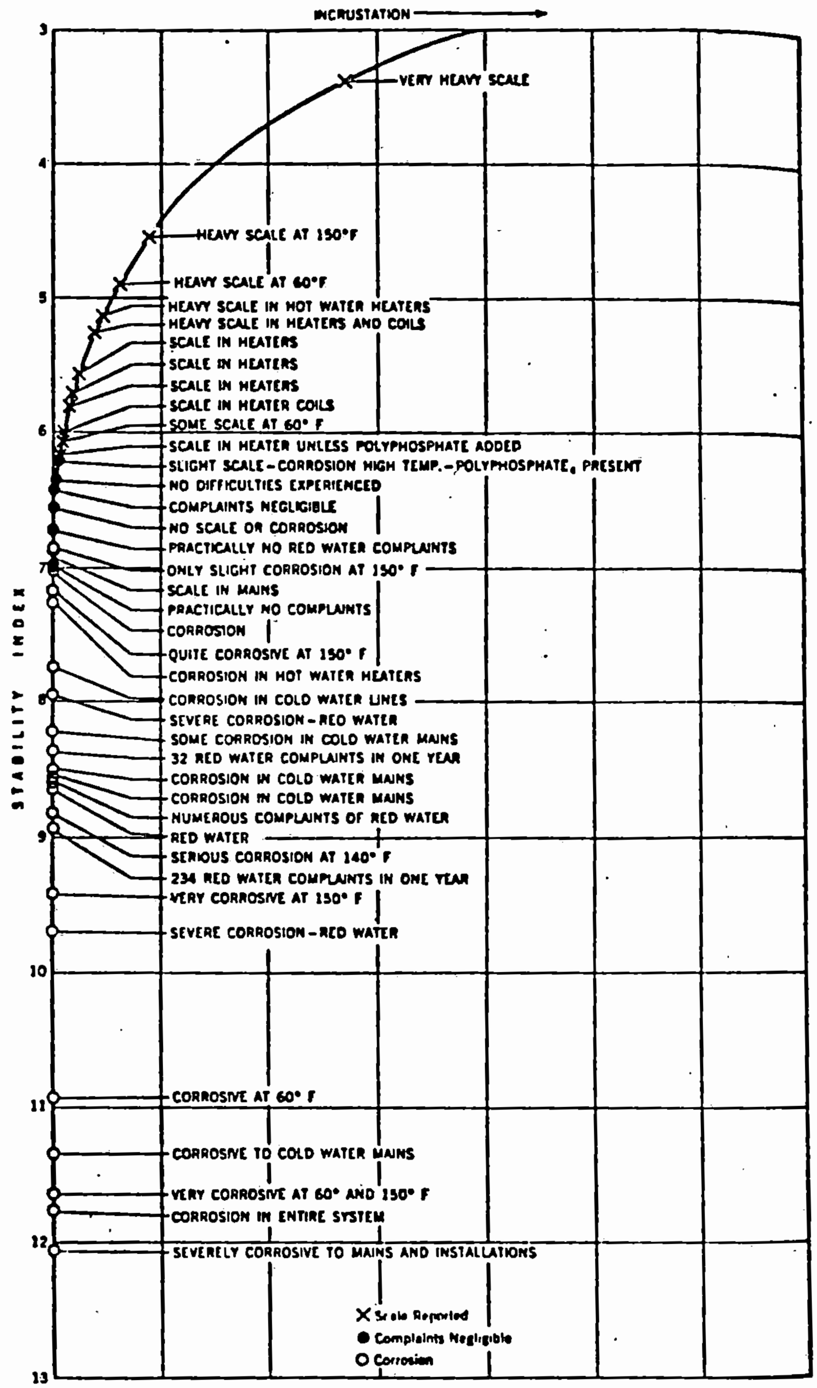

Figure 127[543] Case Histories of Using the Stability Index

APPENDIX 3c. WELL #PW-E2 WATER QUALITY EVALUATION

TO
A

B.G. Shepherd
New Projects Coordinator
SEP Enhancement Operations

FROM
DE

D.D. MacKinlay
Design Biologist, New Projects Unit
SEP Enhancement Operations

SECURITY - CLASSIFICATION - DE SÉCURITÉ	
OUR FILE/NOTRE RÉFÉRENCE	5830-13-16
YOUR FILE/VOTRE RÉFÉRENCE	
DATE	July 13, 1983.

SUBJECT
OBJET
QUALITY OF WATER FROM WELL NO. PW-E2 AT EAGLE RIVER HATCHERY SITE

1. Background

This memo reports on results of pump-testing and water quality sampling and analysis of Well PW-E2 located on the Eagle River Hatchery site (see Figure 1) at Taft, British Columbia. SEP Engineering contracted Piteau and Associates Geotechnical Consultants to supervise drilling, developing and testing of this second production well at the Eagle Hatchery to complement Well PW-E1 which was developed in 1980. SEP Facilities Operations (New Projects and Fraser River Units) were to evaluate the suitability for fish culture of the water from the well.

2. Methods

A.C. Drillers of Keremeos carried out drilling (cabletool, 390 mm casing) and development (surging and bailing) of Well PW-E2 from March 14 to May 4, 1983. Aquaflow Testing and Equipment Ltd. carried out step drawdown (4620 LPM, 5658 LPM, 6666 LPM and 7056 LPM for 1/2 hr each) and continuous rate (6790 LPM for 94 hrs) pump-tests from May 6 to May 11, 1983.

Water quality samples were taken by SEP Facility Operations personnel once during well development on April 5 (D.D. MacKinlay) and at the 7, 24, 72 and 94 hour marks of the continuous rate pump-test (G. Bérézay). The April 5 sampling consisted of on site determination of dissolved oxygen (Hach kit to nearest 0.5 mg/l), pH (Hach Brom cresol kit to nearest 0.1 units within range), temperature (fourteen inch mercury reference thermometer to nearest 0.1^{o}C), taste and smell (human nose can detect levels of 0.02 ppm for H_2S). The May 7-11 samplings consisted of on site determination of dissolved oxygen (standard Winkler titration to nearest 0.1 mg/l), pH (Orion pH meter, accurate to 0.05 units), temperature (mercury reference thermometer), total gas pressure (Novatech tensiometer model 300 B accurate to ± 7 mm Hg), barometric pressure (Thommen 2000 aneroid barometer) and smell.

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Each sampling included collection and preservation of a sample series for "Hatchery analysis" by the EPS/DFO Water Quality Laboratory at Cypress Creek. Each series consisted of a 100 ml plastic bottle sample with 1 ml nitric acid preservative for ICAP metals determination, a 100 ml plastic bottle sample with 5 ml nitric dichromate preservative for mercury determination and a 2 liter plastic bottle with no preservative for nutrients and residues determination. The pump-test crew took extra samples (2 liter bottles only) at the 2 and 11 hr marks of the pump-test. All water samples were kept on ice in a cooler and arrived at the laboratory for analysis within 48 hrs after sampling.

3. Results

Well PW-E2 encounters three distinct strata of sediments. From the surface to 8.5 m deep is a layer of coarse gravel not completely saturated (static water level is about 0.5 m below the surface). This is a high velocity alluvial fan deposit from Crazy Creek. There is a low velocity alluvial fan deposit below this which is made up of a medium grain brown sand. Below this, to the bottom of the well (41.5 m) is a distinctly different grey medium sand. D. MacKinlay inspected the well log samples on April 5, 1983 (during well development) and saw that the line of demarcation between these two layers was at about 23.5 m. The sample above was brown sand, the one below was grey sand. In the 23.5 m sample was a layer of about 100 mm of brown mud, which the driller suggested represented a clay boundary between the two layers. The groundwater hydrologist's report ("Second Stage Groundwater Development for the Eagle River Hatchery", by Piteau and Associates, June, 1983) states on page 5 that the fan deposit ends at 20.1 m but the diagram in Appendix A-1 in that report indicates that the brown sand continues until 26.6 m. Figure 3 shows the suspected stratigraphy of the area around Well PW-E2, in cross section. The area around Well PW-E1 would be higher up the right slope than PW-E2, with the well only reaching into the top fan deposits.

Well screens of 254 mm diameter were placed between 19.6 m and 25.9 m (80 slot screen) and between 31.8 m and 39.6 m (150 slot screen), with gravel packing between the 390 mm hole and the 254 mm casing. See Figure 2 for a diagram of the finished well setup. The groundwater hydrologist's conclusions are given in Appendix 1.

Water quality parameter values from Well PW-E2 are summarized in Table 1. Values which exceed recommended fish culture limits are circled in black. These values are gas pressures (oxygen is too low, nitrogen is too high), nutrients (nitrate, phosphate and hydrogen sulfide) and toxic heavy metals (chromium, copper, iron, manganese and zinc). A definite trend in decrease of almost all dissolved chemical species (except some metals) occurred over the period of the pump-test. Water temperature decreased over the pumping period, from 9.7°C at 7 hrs. to 8.6°C at 94 hrs.

The first sampling (April 5) was taken during well development, resulting in unrepresentively high turbidity and, therefore, high ICAP metals values (Al, Cu, Fe, etc.) extracted from the sediments.

4. Discussion

Four water sources have been sampled for possible use at the Eagle Hatchery. These are PW-E2, PW-E1, Eagle River at Taft and Crazy Creek. The water quality parameter values for samples taken of these sources are summarized in Table 1 to 4, respectively. There is a general trend from good quality water (low in toxic metals and nitrogen gas, high in oxygen) to poorer quality (reverse factors) from Crazy Creek through Eagle River to PW-E1 then PW-E2. Crazy Creek and, to a lesser extent, Eagle River, are the surface sources for the aquifers. As the water seeps into the ground it dissolves material from the sediments, accounting for increased conductivity and eratic high values of toxic heavy metals. Soil microbial activity deletes the oxygen from the water and increased pressure increases dissolved nitrogen.

Heavy metal toxicity is partly dependent on presence of other ionic species in the water, such that metals are more toxic if dissolved solids values are low. Our criteria for metals are based on worst case situations (extremely low hardness, conductivity and pH). In this case, the high ionic content of the well waters should help to mitigate toxic effects of the heavy metals, however, favourable rearing conditions cannot be guaranteed.

It can be expected that, over long term pumping, the characteristics of Well PW-E2 should become more like those of PW-E1 and the surface sources. This effect will be advantageous with respect to water quality but disadvantageous with respect to temperature.

The response of the fish during the pilot hatchery operation should help to elucidate the quality of the water from these aquifers, with their eratic heavy metal concentrations, for fish culture.

D.D. MacKinlay

DDMACK/mmm

Attachments (6)

c.c. F.K. Sandercock
C.N. MacKinnon
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TABLE I WATER QUALITY VALUES FOR EAGLE WELL #2 1983
(BELOW DETECTION LIMITS=0)

PARAM.	RECOMM.	TOXIC	PUMP TEST APR05/83 EAGLE WELL #2	MAY07/83 2 HRS WELL #2	MAY07/83 7 HRS WELL #2	MAY07/83 11 HRS WELL #2	MAY08/83 24 HRS WELL #2	MAY09/83 48 HRS WELL #2	MAY10/83 72 HRS WELL #2	MAY11/83 96 HRS WELL#2
ALK.TOT	20-300		63	58.5	57.5	58	57	55	56	55
AMMON.	<.002	>.08	.033	.02	.019	.018	.021	.022	.017	.014
CO2	2-5	>20								
CHLOR.	<170	>400	5.5	3.7	3.5	3.4	3.2	3.1	2.9	3
COLOR	<15									
COND.FLD	150-2000									
COND.LAB	""		239	208	202	198	191	183	179	177
DO-PPM	>6-8	<4	3.25		2.4		2.3	2.1	1.7	1.6
DO-%SAT	100%				22.27		21.08	19.18	14.76	14.26
DGAS.TOT	<103%	>110%			98.32		96.5	96.65	95.57	95.31
DGAS.NIT	100%				118.5		116.5	117.2	117	116.8
HARDNESS	20-400		92.9		72.5		68.6	67.7	66.5	65.1
H2S	<.002	>.004	PRESENT	PRESENT	PRESENT	PRESENT				
NITRITE	<.012	.2	0	0	0	0	0	0	0	0
NITRATE	<.12		0	.02	.06	.03	.09	.41	.06	.04
PH-FLD	6.8-8.5	<5,>9	8.3		8.75		7.75	7.7	7.45	7.25
PH-LAB	""	""	8.2	7.8	7.7	7.7	7.6	7.6	7.6	7.5
PHOSPH.	<.05		.229	.025	.007	.021	.079	.022	.019	.02
RESID.TOT	<2000									
RESID.FIL	70-400		148	120	124	127	123	115	111	119
RESID.N.F	<3		143	0	0	0	0	0	0	8
SALIN.										
SILICA	<10-60		5.9	6	5.9	5.9	5.9	5.4	5.2	5.1
SULFATE	<90		38.5	32.4	31.2	30.4	28.4	27.1	24.9	23.9
TASTE	OK		BAD							
T.D.SOL	500-1000	15000								
TEMP.	4-19C	<2,>25	9.5		9.7		9.2	9.2	8.7	8.6
TURBID	1-60	>1000	34	.1	.1	.1	.1	.1	.1	0
METALS--										
AL	<.1	>5	.95		0		0	.05	0	0
AS	<.5	>1	0		0		0	0	0	0
BA	<1		.042		.023		.022	.022	.021	.021
CA	4-150	>300	26.5		24.2		22.9	22.5	22.1	21.7
CD	<.0004		0		0		0	0	0	0
CO			0		0		0	0	0	0
CR	<.01		0		0		0	.024	.015	.022
CU	<.006		.061		.001		0	.006	0	0
FE	<.3		4.17		.095		.049	.079	.053	.039
HG	<.00005	>.0002	0		0		0	0	0	.0002
K		>50	3.42		1.81		1.72	2.19	2.22	1.99
MG	<10	>100	3.3		2.8		2.7	2.6	2.6	2.6
MN	<.05	>15	.119		.056		.052	.059	.104	.07
MO			0		0		0	0	0	0
NA		>500	15		11.9		10.9	10.1	10	9.1
NI			0		0		0	0	0	0
P			.1		0		0	0	0	0
PB	<.01		.003		0		0	0	0	0
SB			0		0		0	0	0	0
SE		>2.5	0		0		0	0	0	0
SI	<10-60		6.7		5.7		5.6	5.6	5.6	5.6
SN			0		0		0	0	0	0
SR			.193		.168		.16	.155	.152	.149
TI			.047		0		0	.002	0	0
V			0		0		0	0	0	0
ZN	<.005		.008		.03		0	.012	.01	.004

TABLE 2 WATER QUALITY VALUES FOR EAGLE WELL #1 1980/83
(BELOW DETECTION LIMITS=0)

			PUMP TEST				
			MAR16/80	MAR17/80	MAR18/80	MAR19/80	AUG04/82
			1.5 HRS	24 HRS	48 HRS	72.5 HRS	EAGLE
PARAM.	RECOMM.	TOXIC	WELL #1	WELL #1	WELL #1	WELL #1	WELL #1
ALK.TOT	20-300		28.2	29.7	30.7	31	34
AMMON.	<.002	>.08	0	0	0	0	.008
CO2	2-5	>20					
CHLOR.	<170	>400	1.6	2.12	1.75	1.79	7.5
COLOR	<15		0	0	0	0	
COND.FLD	150-2000		58	59	55	57	
COND.LAB	" "		82.5	88	87.8	90.4	114
DO-PPM	>6-8	<4	4.3	4.1	4	4.2	
DO-%SAT	100%		36.9	35.8	33.7	35.5	
DGAS.TOT	<103%	>110%	92	93.7	94.3	94.2	
DGAS.NIT	100%		106.6	109.1	110.5	109.8	
HARDNESS	20-400		35.8	36.5	38	38.9	54.4
H2S	<.002	>.004					
NITRITE	<.012	.2	0	0	0	0	0
NITRATE	<.12		.324	.387	.155	.245	.12
PH-FLD	6.8-8.5	<5,>9	6.5	6.4	6.4	6.6	
PH-LAB	" "	" "	6.4	6.4	6.5	6.5	6.7
PHOSPH.	<.05		0	0	0	0	0
RESID.TOT	<2000						
RESID.FIL	70-400		58	63	64	64	76
RESID.N.F	<3		0	0	0	0	17
SALIN.							
SILICA	<10-60		5.59	5.57	5.48	5.65	5.4
SULFATE	<90		7.7	8.2	8.25	7.9	9.5
TASTE	OK						
T.D.SOL	500-1000	15000					
TEMP.	4-18C	<2.>25	7	7.1	7.3	7.4	
TURBID	1-60	>1000	1.9	0	0	0	2.7
METALS--							
AL	<.1	>5	.118	0	0	0	0
AS	<.5	>1	0	0	0	0	0
BA	<1		.0079	.0056	.0058	.006	.006
CA	4-150	>300	11.3	11.6	12.1	12.4	13.8
CD	<.0004		.0022	.0011	0	0	.0007
CO			0	0	0	0	.007
CR	<.01		0	0	0	0	0
CU	<.006		.0066	.0026	.0026	.0028	.006
FE	<.3		.128	.026	.038	.019	6.38
HG	<.00005	>.0002	0	0	0	0	0
K		>50	1.26	1.23	1.28	1.28	1.5
MG	<10	>100	1.83	1.84	1.89	1.92	2
MN	<.05	>15	.0093	0	.0032	0	.017
MO			0	0	0	0	0
NA		>500	1.86	1.9	2.12	2.22	2.7
NI			0	0	0	0	0
P			0	0	0	0	0
PB	<.01		0	0	0	0	0
SB			0	0	0	0	0
SE		>2.5	0	0	0	0	0
SI	<10-60		5.85	5.58	5.73	5.77	5.7
SN			0	0	0	0	0
SR			.0655	.0664	.0699	.0712	.079
TI			0	0	0	17	0
V			0	0	0	0	0
ZN	<.005		.0174	.0141	.0066	.008	.003

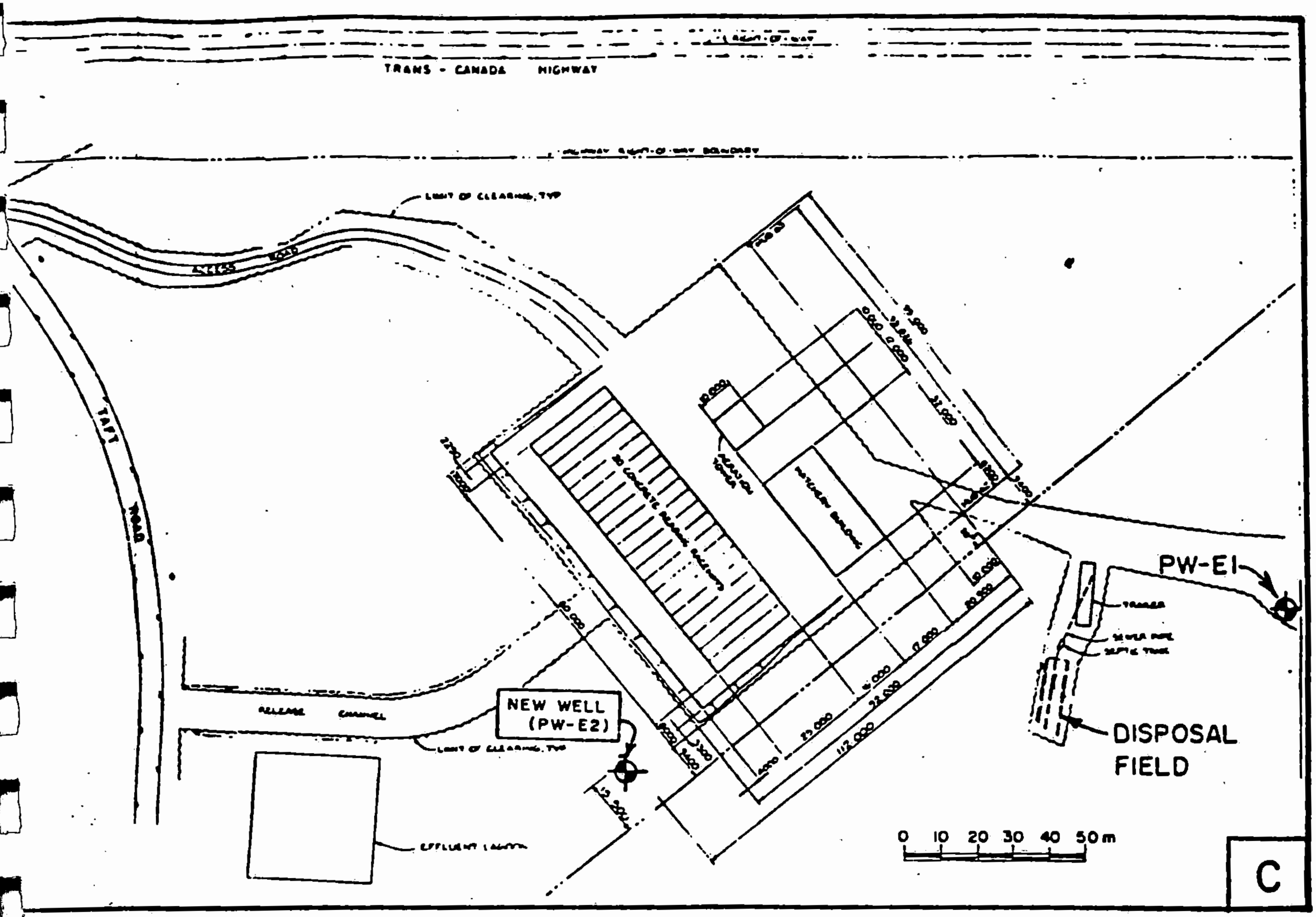
TABLE 3 WATER QUALITY VALUES FOR EAGLE RIVER 1980/83
(BELOW DETECTION LIMITS=0)

PARAM.	RECOMM.	TOXIC	MAR18/80 EAGLE RIVER	AUG15/81 EAGLE RIVER	SEP24/81 EAGLE RIVER	MAY09/83 EAGLE RIVER
ALK.TOT	20-300		23.3	24.3	23.4	19.5
AMMON.	<.002	>.08	0	.0072	.021	.006
CO2	2-5	>20				
CHLOR.	<170	>400	1.68	.85	.53	.6
COLOR	<15		5			
COND.FLD	150-2000					
COND.LAB	"		75.7	70	65	55.7
DO-PPM	>6-8	<4	13.2			
DO-%SAT	100%		97.1			
DGAS.TOT	<103%	>110%	102.2			
DGAS.NIT	100%		103.6			
HARDNESS	20-400		28	28.3	26.9	23.5
H2S	<.002	>.004				
NITRITE	<.012	.2	0	0	0	0
NITRATE	<.12		.309	.169	.061	.19
PH-FLD	6.8-8.5	<5,>9	6.9			
PH-LAB	"	"	7.2	7.6	7.6	7.3
PHOSPH.	<.05		.005	.0061	.01	.008
RESID.TOT	<2000					
RESID.FIL	70-400		55	49	51	40
RESID.N.F	<3		0	0	0	8
SALIN.			0			
SILICA	<10-60		5.58	3.27	3.2	2.6
SULFATE	<90		9.7	8.8	7.3	6.5
TASTE	OK					
T.D.SOL	500-1000	15000				
TEMP.	4-18C	<2,>25	2			8.2
TURBID	1-60	>1000	0	0	0	.5
METALS--						
AL	<.1	>5	0	0	0	.07
AS	<.5	>1	0	0	0	0
BA	<1		.0096	.009	.0088	.008
CA	4-150	>300	9.6	9.23	8.78	7.5
CD	<.0004		0	0	0	0
CO			0	0	0	0
CR	<.01		.022	0	0	0
CU	<.006		0	0	0	0
FE	<.3		.092	.0746	.0796	.063
HG	<.00005	>.0002	0	0	0	0
K		>50	.935	.846	.848	.8
MG	<10	>100	.98	1.28	1.22	1
MN	<.05	>15	.0048	.003	.0029	0
MO			0	0	0	0
NA		>500	1.63	1.26	1.27	1.1
NI			0	0	0	0
P			0	0	0	0
PB	<.01		0	0	0	0
SB			0	0	0	0
SE		>2.5	0	0	0	0
SI	<10-60		3.79	3.34	2.97	3.2
SN			0	0	0	0
SR			.0561	.047	.047	.04
TI			0	.009	.0095	0
V			0	0	0	0
ZN	<.005		0	.0013	.0013	0

TABLE 4 WATER QUALITY VALUES FOR CRAZY CREEK 1979/82
(BELOW DETECTION LIMITS=0)

PARAM.	RECOMM.	TOXIC	AUG22/79 CRAZY CREEK	NOV29/79 CRAZY CREEK	MAR18/80 CRAZY CREEK	APR17/80 CRAZY CREEK	JUL21/80 CRAZY CREEK	JUL25/82 CRAZY CREEK	AUG22/82 CRAZY CREEK	SEP13/82 CRAZY CREEK	OCT15/82 CRAZY CREEK
ALK.TOT	20-300		22.9	24.3	20.9	14.5	17	15	18.5	17	21
AMMON.	<.002	>.08	0	0	0	0	0	0	0	0	0
CO2	2-5	>20									
CHLOR.	<170	>400	0	.5	0	0	0	0	0	.6	0
COLOR	<15		0	0	0	15					
COND.FLD	150-2000				40						
COND.LAB	" "		61.2	66.9	56.2	37.4	43.7	37	45.8	40.4	48.1
DO-PPM	>6-8	<4			13						
DO-%SAT	100%				98.5						
DGAS.TOT	<103%	>110%			102.6						
DGAS.NIT	100%				103.7						
HARDNESS	20-400		16.9	28.4	26	18.5	19.4	16.1	19.1	17.6	20.6
H2S	<.002	>.004									
NITRITE	<.012	.2	0	0	0	0	0	.006	0	0	0
NITRATE	<.12		.119	.208	.179	.209	.0776	.09	.17	.09	.12
PH-FLD	6.8-8.5	<5,>9			6.8						
PH-LAB	" "	" "	7.5	7.4	7.3	7.1	7.1		7.6	7.2	7.5
PHOSPH.	<.05		0	0	0	0	0	0	.005	0	0
RESID.TOT	<2000										
RESID.FIL	70-400		47	28.4	44	33	35	30	32	41	43
RESID.N.F	<3		0		0	0	0	5	0	0	6
SALIN.					0						
SILICA	<10-60		2.9	3.6	3.33	3.1	2.55	2.2	2.8	2.7	2.4
SULFATE	<90		5.18	6.95	5.25	3.9	3.6	3.2	5.1	4	4.8
TASTE	OK										
T.D.SOL	500-1000	15000									
TEMP.	4-18C	<2,>25									
TURBID	1-60	>1000	0	0	0	1.6	1	0	0	0	0
METALS--											
AL	<.1	>5	0	0	0	.159	0	.06	.05	.06	0
AS	<.5	>1	0	0	0	0	0	0	0	0	0
BA	<1		.0037	.0141	.0136	.0065	.015	.01	0	.011	.012
CA	4-150	>300	5.94	8.32	7.76	5.71	6	4.9	6	5.2	6.3
CD	<.0004		0	0	0	0	0	0	0	0	0
CO			0	0	0	0	0	0	0	0	0
CR	<.01		0	0	0	0	0	0	0	0	0
CU	<.006		0	0	0	0	0	0	0	0	0
FE	<.3		.018	0	.012	.095	.019	.025	.018	.042	.01
HG	<.00005	>.0002	0	0	0	0	0	0	0	0	0
K		>50	1.1	.963	.852	.718	.757		.83	.74	.89
MG	<10	>100	.492	1.55	1.62	1.04	1.05	.9	1	1	1.2
MN	<.05	>15	0	0	0	0	0	0	0	.005	.001
MO			0	0	0	0	0	0	0	.005	0
NA		>500	1.1	1.28	1.02	.635	.694	.5	0	.7	.9
NI			0	0	0	0	0	0	0	0	0
P			0	0	0	0	0	0	0	0	0
PB	<.01		0	0	0	0	0	0	0	0	0
SB			0	0	0	0	0	0	0	0	0
SE		>2.5	0	0	0	0	0	0	0	0	0
SI	<10-60		2.41	2.91	3.3	3.03	2.53	2.4	2.5	2.3	2.6
SN			0	0	0	0	0	0	0	0	0
SR			.0372	.0392	.0369	.0232	.0258	.021	.027	.023	.029
TI			0	0	0	0	0	0	0	.002	0
V			0	0	0	0	0	0	0	0	0
ZN	<.005		0	0	0	0	0	0	0	0	0

Figure 1. Location of Wells at Eagle River Hatchery site.



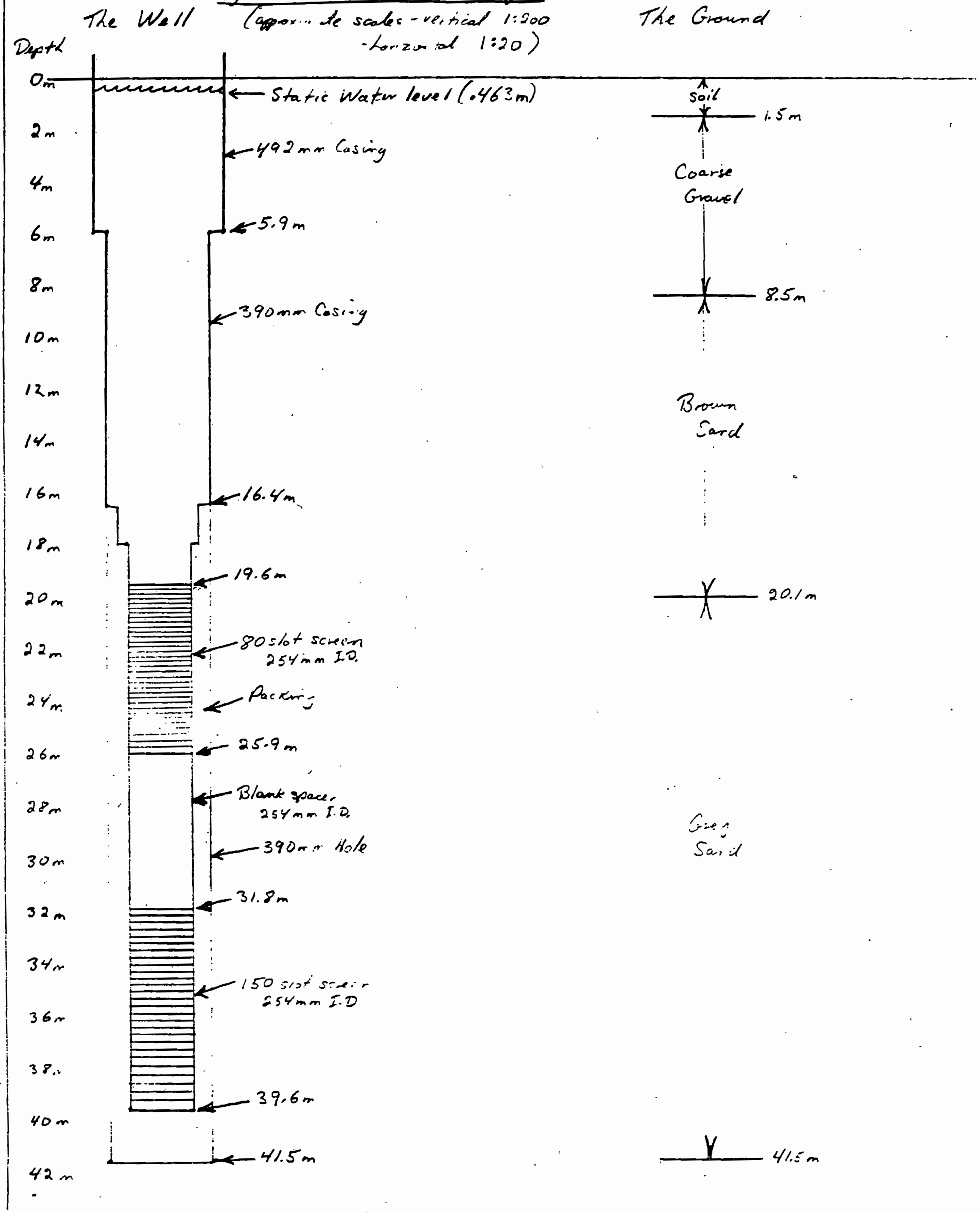
DEPARTMENT OF FISHERIES AND OCEANS CANADA	PITEAU & ASSOCIATES GEOTECHNICAL CONSULTANTS VANCOUVER CALGARY		
2nd STAGE GROUNDWATER DEVELOPMENT FOR EAGLE RIVER SALMON HATCHERY	SITE LOCATION AND SITE PLAN MAPS	BY: SS	DATE: MAY/83
		APPROVED: [signature]	DWG: 1

PROJECT Eagle River SHEET ____ OF ____

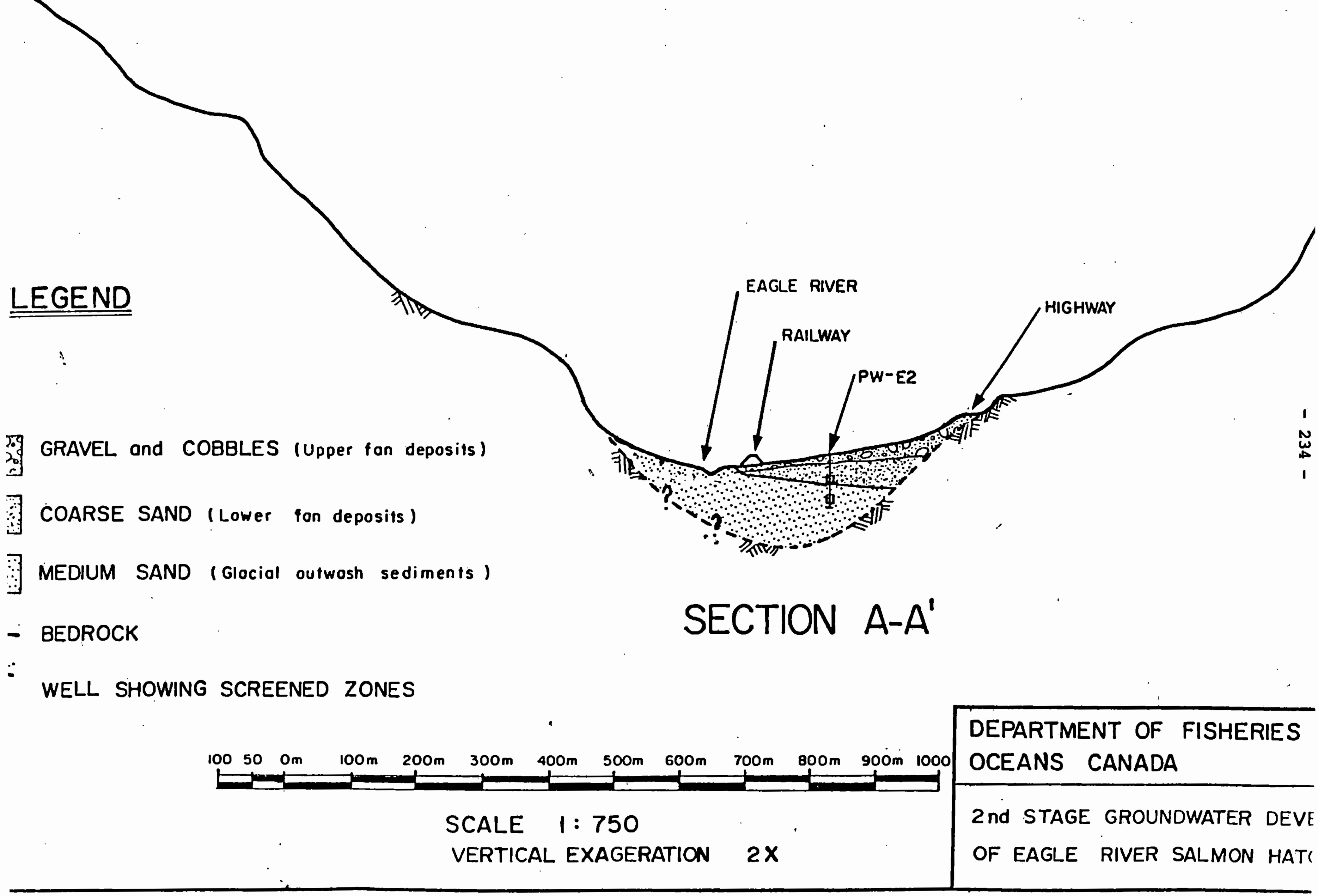
SUBJECT Well PW-E2 Profile DATE Jun. 23/83

COMPUTED BY [illegible] CHECKED BY ____

Figure 2 Well PW-E2 at Eagle



Figı . Cross-section of stratigraphy below Eagle Riv ıtchery site
(according to Piteau and Associates).



APPENDIX 3d. CHINOOK MORTALITY PROBLEMS

EAGLE RIVER HATCHERY DIE-OFF

OBSERVATIONS:

Typical symptoms : a large portion of the fry were pinheaded (30-40%), very lethargic, dark coloring, very weak and had lost most or all of their gill epithelium when the die-off reached serious propotions (> 200/day). The rest of the group was apparently unaffected, however they were relatively lethargic in comparison to now, thus I feel they were partially affected by the 'disease'.

To ensure that feeding was initiated, frozen euaphasids were added to the food. This stimulated the feeding rate very well and it appeared that all the fry were feeding readily (Table 1). This appears to be the case from January 4 to February 1. From February 8 onwards the spread in frequency becomes greater and greater. It may be possible that the actual 'effect' was occurring at this time (exposure time 37 days) for the channel #6 fry (Salmon River) and the die-off began 10 days later.

TABLE 1. GROWTH FREQUENCIES OF THE CHANNEL #6 CHINOOK FRY.

FREQ.	JAN 4	JAN11	JAN18	JAN25	FEB1	FEB8	FEB15
.15-.18	1	0	0	0	0	0	0
.19-.22	5	6	1	0	0	0	0
.23-.26	37	17	1	0	2	0	0
.27-.30	[illegible]	13	12	4	0	0	0
.31-.34	1	1	15	6	3	0	2
.35-.38	1	3	14	12	3	1	6
.39-.42			3	13	4	5	6
.43-.46			2	7	5	7	4
.47-.50			2	5	9	5	4
.51-.54				3	8	6	6
.55-.58				0	5	7	4
.59-.63				1	4	7	2
.64-.67					1	1	4
.68-.71						5	0
.72-.75						3	2
.76-.79						2	2
.80-.83						1	2
.84-.87						1	1
.88-.91						0	0
.92-.95						1	1
.96-.99							2
1-1.03							2
1.04-1.07							1
1.08-1.11							1

As of January 2,1985, cell #2 was used for rearing and since this was the only difference I consider it the cause of the problem and thus exposure time is measured from January 2,1985. I have arbitrarily used a critical die-off of more than 200 fry a day, as I felt from the data that once this range was reached, there was a significant die-off going to occur.

Prior to this time, all incubation was done on well #1 because well #2 water had a very strong hydrogen sulfide (H2S) smell to it. During the pump tests in 1984, there was a smell of H2S, but by the 96 hour sample it was undetectable by smell. We felt that by pumping the well prior to using it for rearing, we could once again 'clean' it. This procedure was carried out for several weeks by flushing the water through the cement raceways without aeration. By Jan 2,'85 we were committed to utilizing the water, even though it still had a detectable smell to it.

A short term experiment, exposing one Heath stack of four trays of chinook alevins and both, coho alevins and eggs to well #2 and similarily well #1 waters, indicated that there were no short term effects due to the H2S. The exposure time was from Dec 18'84 to Jan 14,'85 (28 days) at which time the smell was greatly reduced. It was not possible at that time to measure the levels of H2S that were present, thus we felt that it should not cause a problem.

The die-off appears to occur at various exposure times for the chinook, but does not affect the coho, which have been exposed the same amount of time. All fry/alevins were subjected to the well 2 water from January 2,1985. Exposure time of the first group was 47 days (Table 2), at which time the increase in

TABLE 2. TABLE OF INITIATION OF DIE-OFF, EXPOSURE TIME AND SIZE FOR CHANNEL #6 CHINOOK FRY.

BROOD (ORIGIN)	INITIATION DATE OF DIE-OFF ([illegible])	DAYS OF EXPOSURE (JAN2=1)	RANGE IN SIZE (GRAMS)
SALMON CH #6	FEB 18	47	0.33 - 1.09 WT.=0.6 S.D.=0.22
SALMON CH #5	MAR 2	60	0.22 - 1.31 WT.=.5[illegible] S.D.=0.27
EAGLE CH #2	MAR 6	64	0.41 - 2.08 WT.=1.1 S.D.=0.32
EAGLE CH #3	MAR 4	62	0.33 - 1.62 WT.=1.01 S.D.=0.30
EAGLE CH #4	MAR 11	67	0.48 - 1.40 WT.=0.90 S.D.0.26
[illegible]	MAR 30	89	0.36 - 2.42 WT.=0.95 S.D.=[illegible].53

mortality (> 200/day) occured in channel #6. Channels 2,3 and 5 were affected at about the same time (see figure) with exposures of 60-64 days. Channels #5 and 6 are Salmon River stock, channels #2, 3 and 4 are Eagle River stock and the Shushwap River stock was held in Capilano style troughs and was exposed for 88 days before the critical die-off period was iniated.

The main consistencies that occur are that the Salmon River stocks were beging to die-off at about 0.60 grams and the Eagle River stock at 1.0 gram. Die-off of the Shushwap stock occured at .95 grams, but the range in size was much greater than for the other stocks and the exposure time was approximately 26 days longer (88 days).

The main difference this year is the use of the new well (WELL 2) and the new concrete raceways. The raceways are of a typical design and the concrete work was completed in August of '84, thus they were allowed to cure for 6 months, which we assume is long enough to insure that there would not be any deterimental effects to the fry. This is substantiated by the fact that no abnormal chemical traces were detected in the raceway waters. During the pump tests of the new well, the concentration of heavy metals etc. was similar to other groundwater systems and appeared suitable for hatchery use. Hydrogen sulfide was present during the first 72 hours but was undetectable at 96 hours (smell). The well was ready for use in the early winter of 1984 and we began pumping it several weeks prior to use in rearing to insure that it was 'clean'. The hydrogen sulfide smell was more pronounced during this period than at any other time, thus I fixed some samples and had them analysed. The levels were below detection limits (50 ug/L). After aeration the H2S smell was less pronounced and as mentioned, we felt it should cause no problems.

By mid January the smell was virtually undetectable by smell and again we felt it was of no concern. It is still present in this water source, as it is detectable in the aeration tower, but no where near the levels that it was originally. Only rarely can it be detected at the raceways, thus it was assumed that after January 14/85 the fry were exposed to very low levels, if at all.

HEAVY METAL CONTAMINATION:

The die-off symptoms were very severe in that all the gill epithelia was sloughed off of the gill arch. It is not likely that it is a bacterial or viral condition because none could be detected until bacterial gill infections occurred secondarily and if it was a disease the gill epithelia would have been affected contagiously rather than uniformily. Thus I felt that heavy metal contamination must be the cause, as some zinc and copper are detectable in the raw waters from both wells (Table 3).

Table 3. Chemical analysis data for Eagle wells 1 & 2, and Shushwap well # 5.

WELL DATE	2 RAW N28/84	2 RAW MR18/85	2 RAW A23/85	2 RAW M17/85	SHUSHWAP M14/85	1 RAW A25/85	1 RAW M17/85	RACE#6 MR18/85	ALUM #4 MR18/85
PH	7.4	7.11	7.4	7.5	7.9	6.7	6.27	7.02	7.12
ALKAL	53.2		54.5	55.1	121	36.4			
COND	165		148	150	310	103			
SULF	18					9			
CL-	2.4			2.8	1.5	2.4			
AL	0	0	0	.08	.06	0	0	0	0
CU	.005	0	.007	0	0	.008	0	0	0
FE	.025	.111	.031	.03	.119	.01	0	.027	.030
K	1.82	1.9		.075		1.61			
MN	.053	.032	.023	.02	.034	0	0	.023	.030
NA	6.1	5.3	5.6	4.85	6.7	3.2	2.8	4.4	4.65
CA	20.2	21	21.3		47.7	14.2		19	18.2
ZN	0	.013	.005	.0025	0	.007	.002	0	0
HARD	63.8	63	63.8	65.5	146	44.1	45	57.2	55.5
NH4+				0	0	0			
TL -28 WELL #2 ART. 2-4				7	2-10		1	0	0
H2S TOXIC COND. 1.44-1.92				2.1	.24-1.2		.88	0	0

Zinc and copper can be detected in the two water sources, but they tend to be there intermittly. Low level analysis for cadmium, aluminum, mercury and lead were negative, however aluminum was present in the last water sample of well #2 at .08 ug/l. Zinc and copper are found in both sources but they fluctuate from nondetectable levels to levels of 0.013 for well #2 and 0.008 in well #1 (Table 3). They are below detection limits in the mixed waters and occured only once in the raceways. There are substantial levels in the food particulate matter and this sample may have been contaminated as it was taken from the upper end of the raceway.

Interestinly, the bio-rings used in the well #2 pods are a rich brown color. Scrapings of this material indicate that most of it is iron, which does occur in the well water, but also it was high in copper (0.402 ug/ml), manganese (0.025 ug/ml) and zinc (0.225 ug/ml). Analysis of the sludge in the ponds showed no trace of copper, but manganese and zinc were present (0.276 and 0.248 ug/ml, respectively) and iron at 0.292 ug/ml.

The levels of heavy metals in combination with a water hardness of 50 -65 ug/ml (PPM), pH near 7 and an alkalinity of about 50 should not constitute even a long term, sublethal effect to the fry. It should definetely not cause the severe case of gill hyperplasia that occured (Pers Com. Dr. John Sprague). He, Dr. Velsen, Dr. Alderdice, Jon Jensen and Gary Hoskins cannot account for any conditions that could do this. They conclude as well that it must be an enviromental problem and it is unlikely that it is nutritional, or caused by fish culture. Gary feels it is more like the drop out disease that occured at Quinsam when it stated up its chinook program, however it differs in that there is a 30 - 40 % loss due to gill hyperplasia and that the drop out occurs at different sizes. The Quinsam problem occured at the 50 mm (about 1.30 g) whereas at Eagle the drop out occurs at .6 and 1.0 grams. It does not fit the typical drop out symptoms but he also feels that it is not due to the metals found or the food.

They collectively agree that emphasis should be placed on measuring H_2S at, at least 5 ppbs and as well measure the nitrite immediately, as it will very likely be formed by nitrifying bacteria associated with the sulfur bacteria.

Analysises of the food shows levels of 215 to 250 ug/g zinc and 14.5 to 21.1 ug/g copper. Other foods show zinc ranges from about 130 to 180 ug/g and similar levels of copper. Food allowed to soak in a beaker of water for 1 hour had zinc levels of 0.081 ug/ml. I also placed food in a coffee filter and poured some well water through it for analysis. The zinc levels were 0.026 and 0.039 ug/ml for 1/16 and 3/32 OMP, respectively. The 1/16 OMP had a zinc level of 215 ug/g and the 3/32 OMP had a zinc level of 250 ug/g.

Fish tissue analysis showed zinc levels of 22.7 to 33.2 ug/g wet and data from a review by Spear indicate that normal tissue levels are 4 to 20 ug/g wet. Wild fry tissue samples will be available later for comparisson.

Aluminimum Toxicity:

Aluminum in water has a very complex behaviour. It will form a variety of toxic complexes with water, hydroxide, flouride, silicate and sulfate which are all present in the #2 and even in the #1 wells. Its solubility increases from a pH of 5.5 to the upper end of the scale. At a pH of 7 to 8 100% of the aluminum is dissolved and thus in its toxic state. Tests carried on rainbow trout fry at 0.514 PPM and a pH of 7.5 to 8, showed that after 6 days food consumption was greatly reduced and showed darker coloration. After 10 days there was a noticeable reduction of the fright recation and gill hyperlasia occurred in about 50% of the fish. After 45 days all of the fry had some gill hyperplasia. These symptoms were very similar to those experienced at Eagle. Growth was reduced by about 40% of the controls and it was evident that continued exposure would cause much higher mortalities.

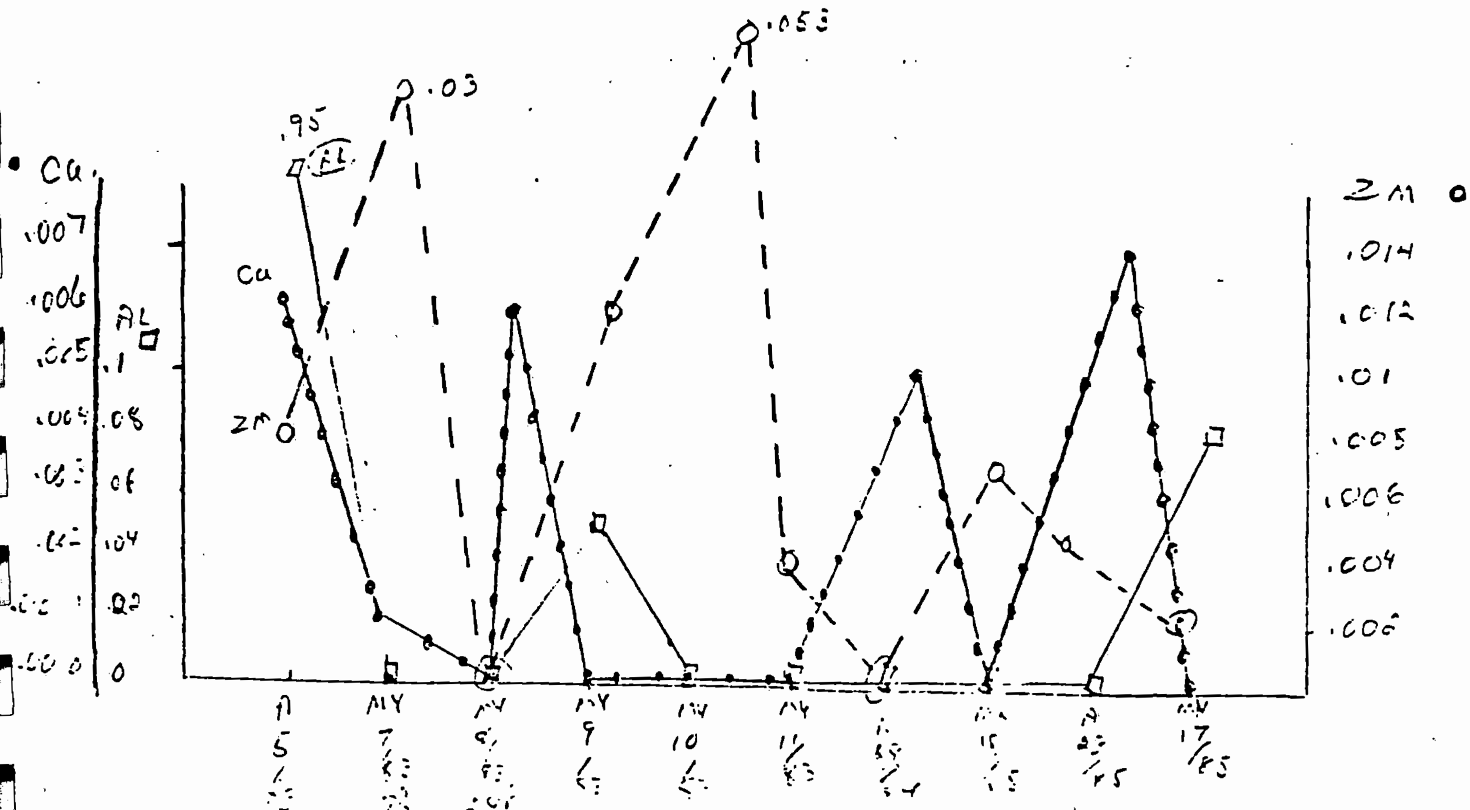
Surviving fish were placed in 'clean' water and quickly recovered, except for the gill hyperplasia. Growth and normal behaviour over a period of 16 days and no additional mortalities occurred. It would seem that fry released to nontoxic water would have a good chance of surviving.

Tests carried out at 0.052 PPM aluminum showed no symptoms but it is conceviable that at some intermediary point between 0.052 and 0.514 PPM aluminum, there would be some effect. It is also possible that chinook salmon are much less tolerant of aluminum toxicity than rainbow trout, but this is not known for certain.

The effect of any of the toxic metals is very hard to determine as they tend to flucatate radically (Fig 2). There is never any constant level of a metal over time, whether hours or months, thus the problem may be due to a combination of the metals acting together or that the erratic highs are such that, that there is always a toxic level acting on the fry. All of the metals will cause similar reactions but as mentioned earlier, the levels present should not be severe enough to cause the problem.

The other plausible explaination is that the samples were contaminated. During the pump tests it possible that some of the piping was galvinized and contributed to the zinc levels. How aluminum could get into the samples is unknown. It is possible that the fluctuating levels during 1984 and 1985 could because I used a handy bucket that could have been used for feeding the fry and the food had fairly levels of the metals. If the buckets were not allowed to flush long enough the sample could have been contaminated. I will take more controlled water samples to determine if this could have happened.

Figure 2. Metal levels in PPM (ug/ml)



If sampling procedure is ruled out for the cause of the fluctuating levels then it leaves the problem very complex. If contamination is found to be possible then we can rule out the metals as the cause of the 'disiase' and then I would suspect that hydrogen sulfide is the next possible problem.

HYDROGEN SULFIDE

I ignored H2S as a problem as the short test using well #2 water during hatching and incubation was considered to be no problem. At the time we were unable to measure H2S below 50 ug/l (PPB), and we did not consider it would be a problem (if it is the problem). Work by Chris Warfield has allowed this range to be lowered to 5 ug/l. The results are not very quantitative yet, due to measurement problems at these low levels. It is apparently due to the ionization strengths in these small volumes. Esentially we have increased the samlple volume from 250 ml to 1000 ml, increasing the amount of reagant proportionally.

The results are in a range of +/- 3 or 4 ug/l, but they are a great improvement over the previous measurements. We are now in a position of being able to measure the samples at levels that are toxic to fish. However it appears that the hydrogen sulfide is removed by aeration as it does not show up in the mixed, aerated water. If this is so we are back to square one.

The toxic form of H2S is the undissociated form. The HS- form is considered to be relatively nontoxic. At a pH of 4.1 H2S is 100% undissociated and 50% at pH of 7 and 10% at pH of 9. The mixed waters at Eagle have a pH of 7.5 thus the H2S levels measured will be about 45-50% toxic H2S. Well #2 water raw is about 7 ug/l and 3-4 ug/l after aeration. This means that the fry or eggs could be exposed to 1.5-2 ug/l which is the border line level of the long term or chronic toxic level. It is possible to smell the H2S in the rearing ponds occassionaly, thus it may be present at levels of 2 ug/l as this the level that the nose can detect in the air.

The primary biochemical alteration caused by H2S, is the inhibition of cytochrome oxidase, a necessary step in the final transfer of electrons in the ATP cycle in the mitochondria. This inhibition prevents the formation of ATP in the cell thus the cell does not have enough energy to survive if enough of the cycle is stopped. At a pH of 8 and at 20° C, fathead minnows in 100 ug/l H2S have 15% of their cytochrome oxidase enzymes blocked in 5 minutes and 39% at 30 minutes in the gills. At this level respiration ceased at 18-23 minutes. It appears that at these temperature and pH conditions, a reduction of cytochrome oxidase of about 30% will cause the gill cells to reduce their respiratoy ability to a level that causes the gill muscles to fatigue and are unable to irragate the gill epithelia.

This reduction in aerobic capacity and primarily the blocking of the electron transport system results in a build up of metabolic waste products, causing fatal metabolic acidosis. That is, a lowering of the blood pH, which can cause death or 'corrision' of the basement membranes of the fine capillary walls. This condition could cause a further reduction in the aerobic caopacity of the fry and thus it should theoretically cause the gill epithelial cells to die and slough off.

An excellent study of Bluegills by Oseid and Smith (1972), for long terms (126 & 148 days) in 0.4 - 6.7 ug/l H_2S at a pH of 7.8 21°C was carried out. They found that the eggs were more resistant to the H_2S than fry. Generally the gill irrigation rate was increased by 39%, due to these relatively low levels of H_2S. This indicates that the oxygen uptake rate was decreased and as well growth was decreased up to 33% and as well the swimming ability was also reduced. The physical capabilities of the fry were reduced when H_2S levels were above 1.5 ug/l. At a pH of 7.8 the level of undissociated H_2S would only be about 25% H_2S or .4 ug/l.

Fathead minnows have a 96 h LC50 of 18-21 ug/l and at 9.3 ug/l for 79 days, survival was reduced to 61% vs control of 93%. Survival was only 6% as compared to 65% for the controls after 191 days. Growth over 121 days was decreased by 33% at 20 ug/l (for the survivers), while there was no affect at 7 ug/l. Generaly growth was reduced at 8-9.34 ug/l for chronic tests.

Similar tests on rainbow trout fry showed that they were much more susceptible to H_2S than the Fathead minnow. 20 day exposures at H_2S levels over 6.8 ug/l caused 100% mortality and growth was radically reduced from levels of 2.7 to 6.8 ug/l. The 96 hr LC 50 level was 13 ug/l and 5.6 ug/l for 17 days. If the fertilized eggs were subjected to 2.5 ug/l or greater then there were incubation problems. If the eggs were not exposed until the eyed stage then the critical levels were slightly higher. It appears that the eggs are more susceptible to harm prior to eyeing and thus it would be best to avoid any exposure until ponding. These tests were carried out at a pH of 7.5 thus the amount of undissociated H_2S was about 40-45% Kof the total quoted above.

Their tests also showed that the no effect level was much lower than the LTC (lethal toxic concentration). That is the fry will be experiencing deterimental effects at levels of less than 4 or 5 ug/l H_2S.

APPENDIX 4. SURVIVAL BIOSTANDARDS

FROM: Lill, A.F. and Tautz (chrmn) 1983 MS.

Opportunities for salmonid enhancement

projects in B.C. and the Yukon.

Report of Enhancement Opportunities

Subcommittee, SEP, DFO.

NHANCEMENT OPPORTUNITIES SUB-COMMITTEE C SURVIVAL/CAPACITY 4/6
IO-ENGINEERING STANDARDS 4 COHO

ECH	PROD AREA	FECUNDITY	DESCRIPTION	OUTPUT SIZE	EGG/FRY %	FRY/SMOLT %	SMOLT/ADULT %	EGG/ADULT %	ADULT/ UNIT	KG JUV. / 1000 ADULT	REMARKS
W OR P CO C	All	2500	Natural	0.5 g	15	8	15	0.18	$6/100m^2$ 218/km		Flow control 2X survival
X	All	- " -	Incubation Box - no Rearing	0.5 g	80	8	15	0.96	$480/50^k$ incubation box	78	
Y R	- " -	- " -	Hatchery spring release	2 g	90	10	15	1.35	-	200	
Y	- " -	- " -	Hatchery fall release	5 g	90	80 HY X 20 WILD	15	2.16	-	167	
(	- " -	- " -	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.

APPENDIX 5. MODELS USED IN DESIGN

a. Load Rate Model

b. Growth Model

c. Aeration Model

APPENDIX 5a. LOAD RATE MODEL

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. Barometric pressure defaults to 760 mmHg. If this value is suitable, simply press <Return>. If not, enter the appropriate value.
If food rate is greater than 100%, it will automatically be reduced to 100% for the calculations.
Also, 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 (GRAMS) (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>
```

APPENDIX 5b. 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)

Screen #2 Input the data as prompted (for more information see program particulars). If you ask for a 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 last weight for progressive growth. To re-enter any value, simply type <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 progam 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. This table is very close, but not identical to the NEW O.M.P. maximum ration guide (Table 2).

With the proper input data the program proceeds to calculate the

GROWTH MODEL

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).

It should be noted that the predicted food conversion can be 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 dependant 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).

A more complete description of the Stauffer model (1973) and the Fish and Wildlife model (Iwama and Tautz, 1981) is given in Appendix 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 expressed in grams of O.M.P. per 100 grams of fish per day (or percentage of body weight)*

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

* estimated quantity of food that fish will consume if held at constant water temperature and fed two times per day, seven days per week based on laboratory experiments with coho fingerlings.

GROWTH MODEL

GROWTH MODEL Screen #1

*** GROWTH MODEL ***

CHOOSE OPTION #

(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	SPECIFIC GROWTH RATE	FEED RATE (% DRY / DAY
0	5.000	.0166	1.9959
5	5.427	.0162	1.9521
10	5.878	.0158	1.8911
15	6.353	.0154	1.8428
20	6.852	.015	1.7969
25	7.377	.0146	1.7532
30	7.928	.0143	1.7116

HARDCOPY ? <Y/N>
TITLE =
ANOTHER RUN ? <Y/N>

FIGURE 7. Fraction of the maximum specific growth rate as a function of the ration level; values shown have been calculated for 10 gm fish at a water temperature of 10°C. The maintenance ration "Fmax" yields maximum growth (1.0). The relationship has been described by a sine curve.

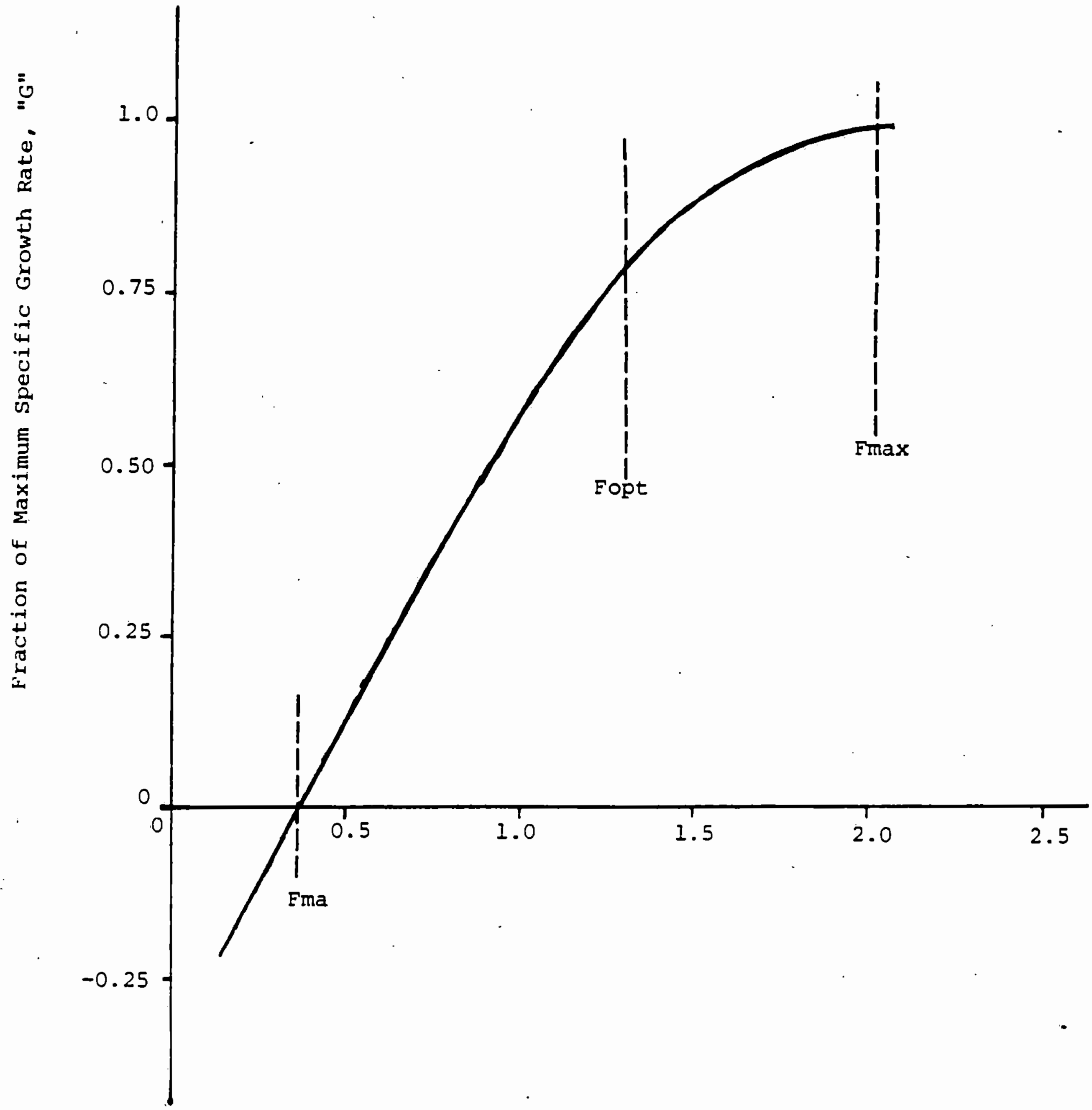


FIGURE 8. Specific growth rate x 100 for 1 gm fish at the maximum ration as a function of water temperature. The relationship is described by a polynomial.

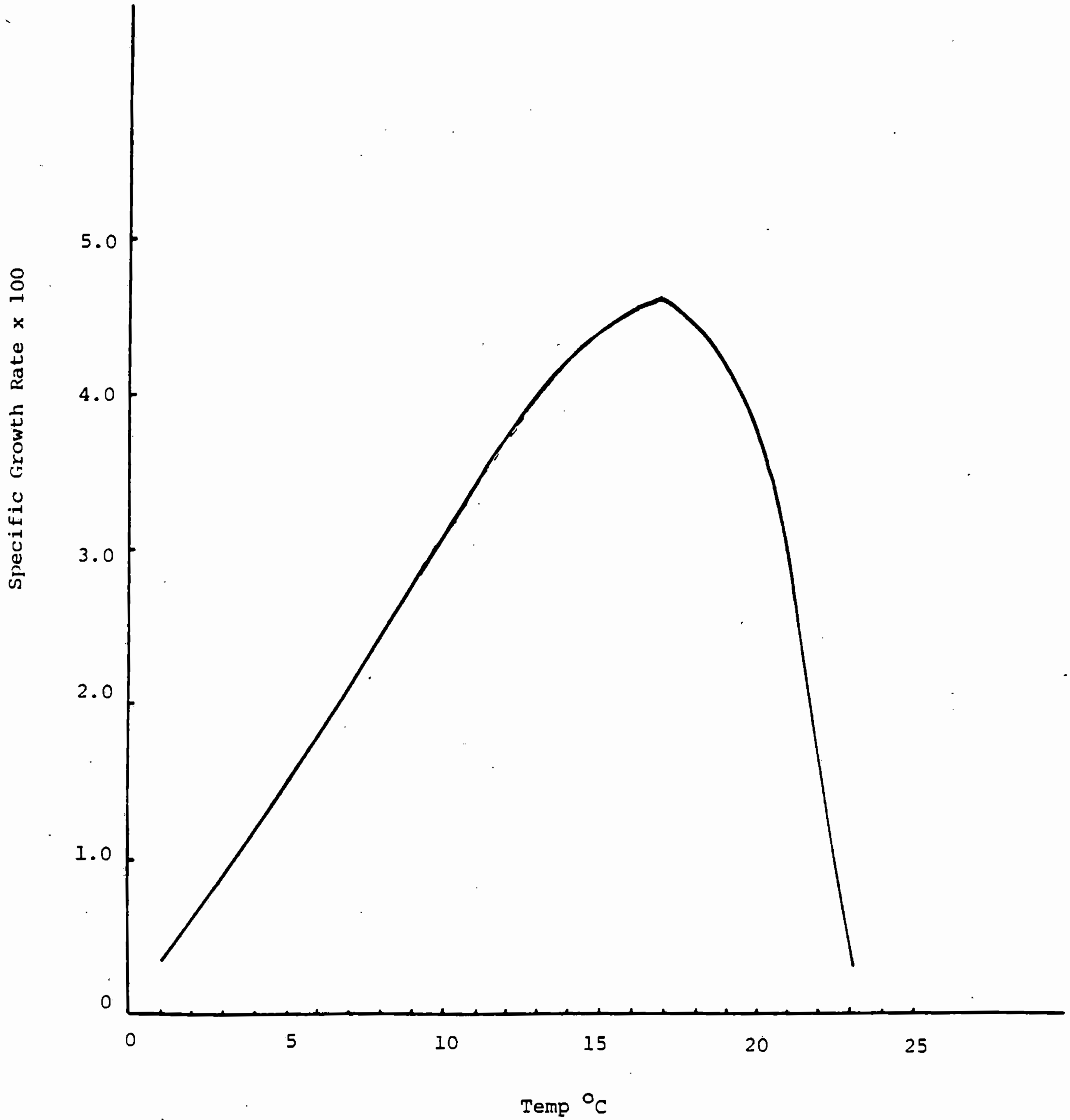
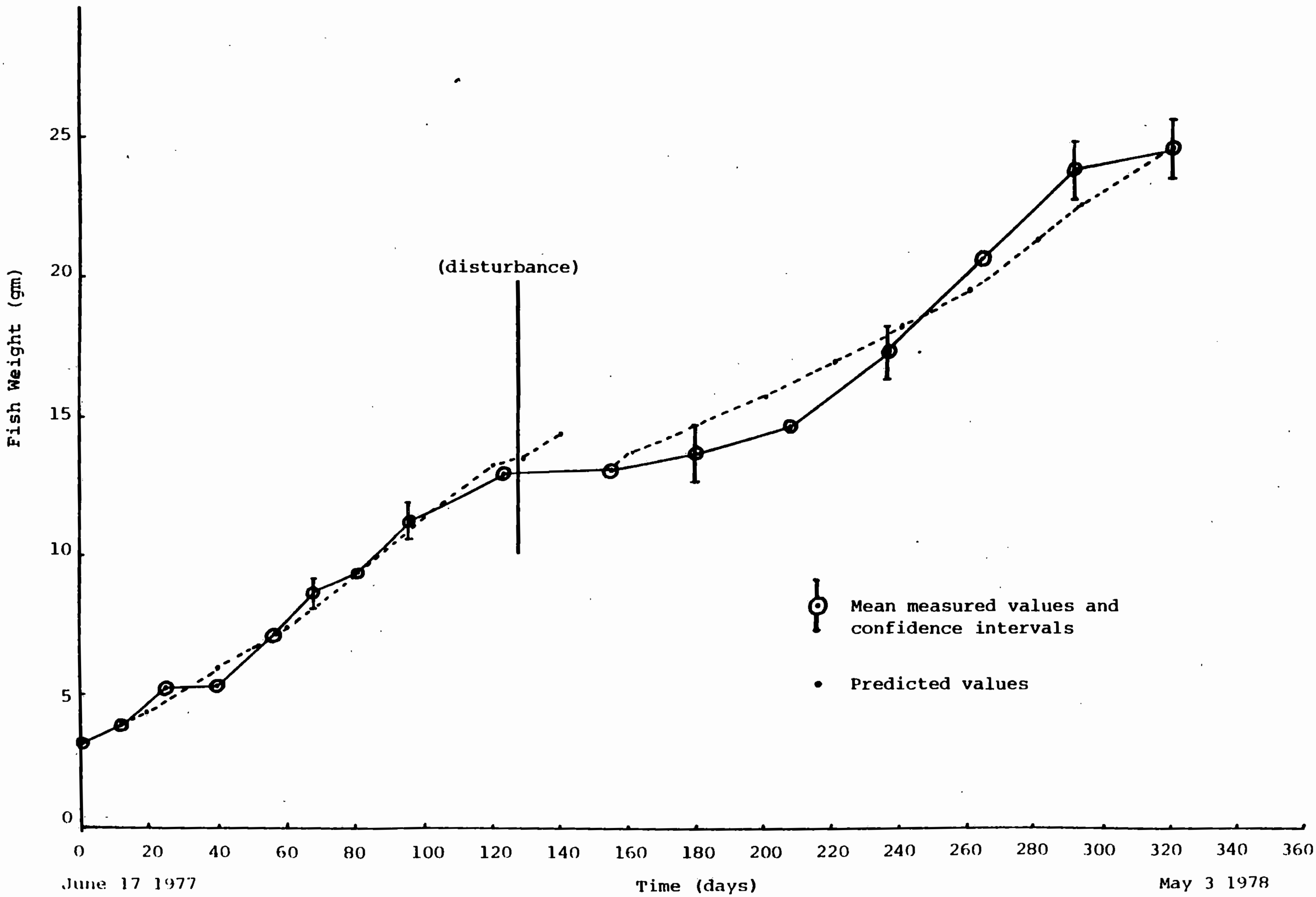


FIGURE 9 Comparison of predicted and measured growth at reduced ration levels. Ninety-five percent confidence intervals of selected measured values are shown.



APPENDIX 5c. AERATION MODEL

PURPOSE	This program calculates the changes of oxygen or nitrogen saturation in water as it flows through the levels of an aeration tower. The aeration constant of the screening material must be known and can be calculated from an existing system using the program AERATION CONSTANT.	
NOTE	This program is valid for bio-rings and other aeration substrate materials, provided that they are arranged in similar units, with constant distances between them.	
INPUT	Gas (Oxygen or Nitrogen)	Screen 1
	Inflow concentration (% saturation)	Screen 2
	Number of screens	"
	Distance between screens (cm)	"
	Type of screens (optional label)	"
	Aeration constant	"
OUTPUT	Saturation of gas at each screen level	

AERATION MODEL

Screen 1

```
              AERATION MODEL

          MCLEAN & BOREHAM 1980


CHOOSE OPTION :   1

 1 OXYGEN (O2)
 2 NITROGEN (N2)
```

Choose the gas (oxygen or nitrogen) which is to be used in calculations. This affects only the format of the questions, not the calculations.

Screen 2 (sample screen)

```
              AERATION MODEL

          MCLEAN & BOREHAM 1980

ENTER :

 INFLOW O2 CONC. (% SAT)         = 50
 NUMBER OF SCREENS               = 5
 DISTANCE BETWEEN SCREENS (CM)   = 3
 SCREEN TYPE (OPTIONAL)          = ST
 AERATION CONSTANT               = .3
```

Input data as requested. Screen type is an optional entry, which can be any length. To erase an entry in this position type </>.

AERATION MODEL

Screen 3 (sample screen)

```
SCREEN #        O2  (% SAT)
........        ...........
   0             50
   1             55.44
   2             60.29
   3             64.62
   4             68.47
   5             71.9


HARDCOPY <Y/N>
REVIEW DATA AGAIN <Y/N>
SELECT #
 1 LIST TABLE AGAIN
 2 ANOTHER RUN
 3 RETURN TO MENU
```

This screen presents a table of the changes in saturation across the screens.

HARDCOPY will generate a printed copy of the data as entered and the resultant table.

REVIEW DATA AGAIN will show the data as entered, but will not give you access to it for changes.

LIST TABLE AGAIN puts you back to screen 3.

ANOTHER RUN gives you the choice of using the same gas again. If you choose <Y> for yes, you will be returned to screen 2 with all previously entered data still shown. You can re-enter any value by pressing <Return>. To change an entry, type the new value over the old.

APPENDIX 6. MANAGER'S COMMENTS

SEP FACILITY DESIGN REVIEW
June/July 1985

FACILITY NAME: Eagle River Hatchery

MANAGER: Dick Harvey

ASSISTANT MANAGER:

OVERVIEW:

The Eagle River hatchery is located on the Eagle River approximately 70 km east of Salmon Arm. The Eagle River is part of the Thompson-Fraser system, connected through the Shuswap Lakes. This hatchery was completed in the fall of 1982 and was planned so that it can either be expanded to deal with all South Thompson stocks, or modified to shift its emphasis to other species, or stock mixes.

The facility is totally satisfactory, it fills the needs of what it was designed for and is a good experimental hatchery.

A. FACILITY OPERATIONS/STRUCTURES

Adult Capture:

No permanent fishway or fences were constructed. This is fine at this time but will be required under facility expansion. Two temporary fences have now been built on the Eagle and Salmon rivers.

Adult Transport:

Use of 5 ton truck with two 500 gallon tanks or 1 ton truck with a 250 or 500 gallon tank. This system is adequate.

Adult Sorting:

Not required. The aluminum raceways are used for sorting and is suitable at this time, with expansion a sorting facility would be required.

Adult Holding:

The aluminum raceways (70 x 6 x 4 feet) are good, mortalities are almost nil. The divider screens and container lids were not initially provided and were built by staff. The concrete raceways are not used as the aluminum raceways work well and are all that's needed at this time.

Egg Take Area:

Built temporary shelters and modified bleeding racks, permanent structures are not needed.

FACILITY NAME: Eagle River Hatchery

Incubation:

Very Good. All equipment required was initially provided and is fine. Up to 5 million eggs are incubated in heath trays.

Wash/Pick Area:

Tables for egg picking were made; no problem.

Rearing:

4 Aluminum Raceways - fry are held til 2 grams as designed, each container holds 175,000 fry. The raceways are hard to keep clean, they must be vacuumed once every two days. The drains are also inadequate, a larger horizontal drain rather than a vertical drain is needed to improve drainage. Temporary divider screens were made as they were not provided.

6 Large Concrete Raceways - The flow is not enough to keep the raceway clean, they must be vacuumed every day. The inadequate flow is not an engineering fault, the flows supplied were requested as part of the biological design criteria.

The stop logs that were provided had bowed, so our own had to be made. The inflow water to the raceway is also designed poorly. The water should plunge into the raceway, but it has been designed to enter into the bottom.

8 Concrete Intermediate Rearing Containers measuring 40 x 4 x 4 feet are used to hold fry to 2 grams. They are housed in the intermediate rearing building along with 8 Capilano troughs. The building provides snow cover and helps ponding times to be attained.

The fry are hand fed, automatic feeders are not needed at this time. Capital was provided for purchase of feeders when required.

Fry Marking:

Very good. A separate room was provided for fin clipping and tagging 800,000 coho and chinook.

Fry Transport/Release:

No tanks were supplied, bought surplus dairy tanks: 1,000 gal., two 500 gal., 300 gal., and 100 gal. tanks with capital supplied by Engineering.

FACILITY NAME: Eagle River Hatchery

Predation Control:

Otters, Herons and King Fishers - netting will be provided to deter predators.

B. BUILDINGS AND SERVICES

Main Office Building:

Excellent, no problems; good lighting, work areas and overall environment.

Building Storage:

Very good.

Labs:

The wet and dry labs are excellent.

Workshop:

The workshop design is very good and well equipped (capital supplied by Engineering).

Freezer:

Access and capacity are good.

Alarms:

The alarm system is excellent, the alarms are located where required (ponds, incubation room, aeration tower).

Warehouse and Storage Yard:

The warehouse has yet to be built and will house vehicles, boats and other equipment.

Accommodation:

The trailer provided is adequate for standby crew at this time.

Fencing:

A chain link security fence is required around the entire complex because of location next to highway and animal intrusion.

FACILITY NAME: Eagle River Hatchery

Site Access:

The access road is still not finished. Rocks and boulders need removal and fill is required.

Landscaping:

No beautification work required but the site roads should have been completed, it is still very rough.

Public Facilities:

None provided, some displays have been built by staff but proper signage as well as public washrooms will be required at a later date (capital is provided).

Power Supply:

Three phase power supplied is adequate.

C. WATER SUPPLY

Quality and Treatment:

The hatchery totally relys on ground water from two wells to raise 2.5 million chinook and coho fingerlings.

#2 well water quality problems are being worked on.

Treatment - no filtration is required
- aeration tower works fine
- hatchery effluent settles in a swamp and the wastes go to the surrounding land.

Quantity:

#1 well capacity is 720 gal/min
#2 well capacity is 1,700 gal/min

There is enough water to produce what is requested however additional water is needed to run everything at once; i.e. have enough water to run the aluminum raceways and the large concrete raceways together but not incubation and the concrete intermediate rearing containers, as they all draw the same water.

FACILITY NAME: Eagle River Hatchery

Intake Structure:

None at present, in the future an intake at Crazy Creek could possibly provide surface water.

Pumps:

No backup pump provided and is required. Two standby generators - one for well #1 and one for well #2 supply backup power.

Supply Lines and Fittings:

Are excellent.

A proper culvert or fishway is needed for the hatchery outflow to Eagle River. The culvert presently in place from the hatchery to the Eagle river is inadequate.

Monitoring Systems (control, meters):

No problems. Each pump has a flow meter and works well.

D. SUMMARY OF MODIFICATIONS/CONSTRUCTION

1984-1985 Expansion:
- 6 concrete raceways
- well #2 developed and pumped
- new aeration tower
- offices, crews office and lunchroom
- extended incubation room - used for tagging
- wet lab
- intermediate rearing developed

COMMENT SOURCES

1) Dick Harvey, current hatchery manager; phone interview.
2) SEP, Annual Report, 1983.