REVIEW OF THE BIOLOGICAL DESIGN CRITERIA

FOR THE

SHUSWAP RIVER SALMONID ENHANCEMENT FACILITY

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INTRODUCTION

PURPOSE OF REPORT

The New Projects Unit of the Facility 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 Territory. This responsibility includes site reconnaissance, enhancement and operational strategy selection, and conceptual design and review of detailed facility design and construction. For each project, selected staff from the appropriate geographic operations unit (North Coast, South Coast, or Fraser River, Northern B.C. and Yukon) are involved in the development through the coordinating efforts of the New Projects Unit, and take over responsibility for operation of the facility upon completion of construction.

The purpose of this report is to consolidate and update the biological criteria for the Shuswap River hatchery and to relate these to the production capabilities of the as-built facility. This review was prepared after two years of pilot operation, such that the projected performance from the design memos could be updated based on actual performance. The expanded Pilot, or Experimental facility, at Shuswap was constructed in 1986 using different water sources than the Pilot, so comparison of some timings may not be very valid.

The review is mainly intended to inform interested parties as to why the facility was planned and built the way it was and how it was expected to operate. Changes in priorities, methods and resources no doubt will result in changes in operational strategies and adaptation of the structures provided to serve new needs in the future.

PROJECT HISTORY

The Shuswap River Salmonid Enhancement Facility is located on the west bank of the Shuswap River in W.J. Tolley Park, a 4 ha parcel of land owned by the North Okanagan Regional District. The park is named after Mr. Tolley, a farmer in the area who owned the island until 1980. The facility is 1 km downstream of the B.C. Hydro Wilsey Dam at Shuswap Falls near the town of Lumby, B.C. (Figure 1). The altitude of the site is approximately 425 m above sea level.

Wilsey Dam is a 26 m high concrete arch dam spanning the Shuswap River canyon where Brenda Falls was once located. The dam and powerhouse were put into service for the West Canadian Hydro Co. in 1928. The two penstocks draw 18.7K LPM of water from the river, producing 6 MW of electrical power.

The hatchery is situated on an island on an elevated gravel pad fill area. A flood channel is located on the west side of the facility and the main river channel on the east. A gravel road and a bridge from the west bank over the flood channel allows vehicle access to the property.

General reconnaissance was carried out throughout the Thompson River system from 1978-1981 to identify potential hatchery sites. This resulted in a number of bio-baseline studies of adult and juvenile salmonids in the Thompson/Shuswap watershed being contracted out (Bowman and Stewart, 1984; Fee and Jong, 1984; Sebastion, 1983). Four facilities have recently been built to serve salmonid stocks of the Thompson tributaries: Clearwater (at Clearwater) for North Thompson stocks, Eagle (at Taft) for Eagle and Salmon stocks, Spius (at Canford) for Nicola stocks and Shuswap (at Shuswap Falls) for Shuswap stocks. These facilities have been collectively known as the Central Interior Pilots.

The Shuswap Falls area was originally selected for a potential hatchery site for a number of reasons, including:

* a. potential for gravity flow supply from Wilsey Dam;
b. nearness to a major road for convenient access;
c. nearness to line power for pumps and other electricals;
c. location at the upper limit of salmon migration of a major run of chinook;
d. nearness to the town of Lumby, precluding the need for an on-site residence.

Plans to use penstock water or water directly from the dam headpond were not realized, partly because of the lack of a large enough site for a facility and partly because of the high cost of buying water from B.C. Hydro. Since the river water temperatures were not entirely suitable for a salmon hatchery, a search was made for well water.

Groundwater exploration in the area (Aquaterre Consultants 1983, 1984) revealed that the bedrock which formed the falls and supported the dam extended for some distance downstream. No substantial aquifer was found until downstream of the canyon, starting in the area of the island making up W.J. Tolley Park. A Pilot hatchery was built on the fifth well drilled (after

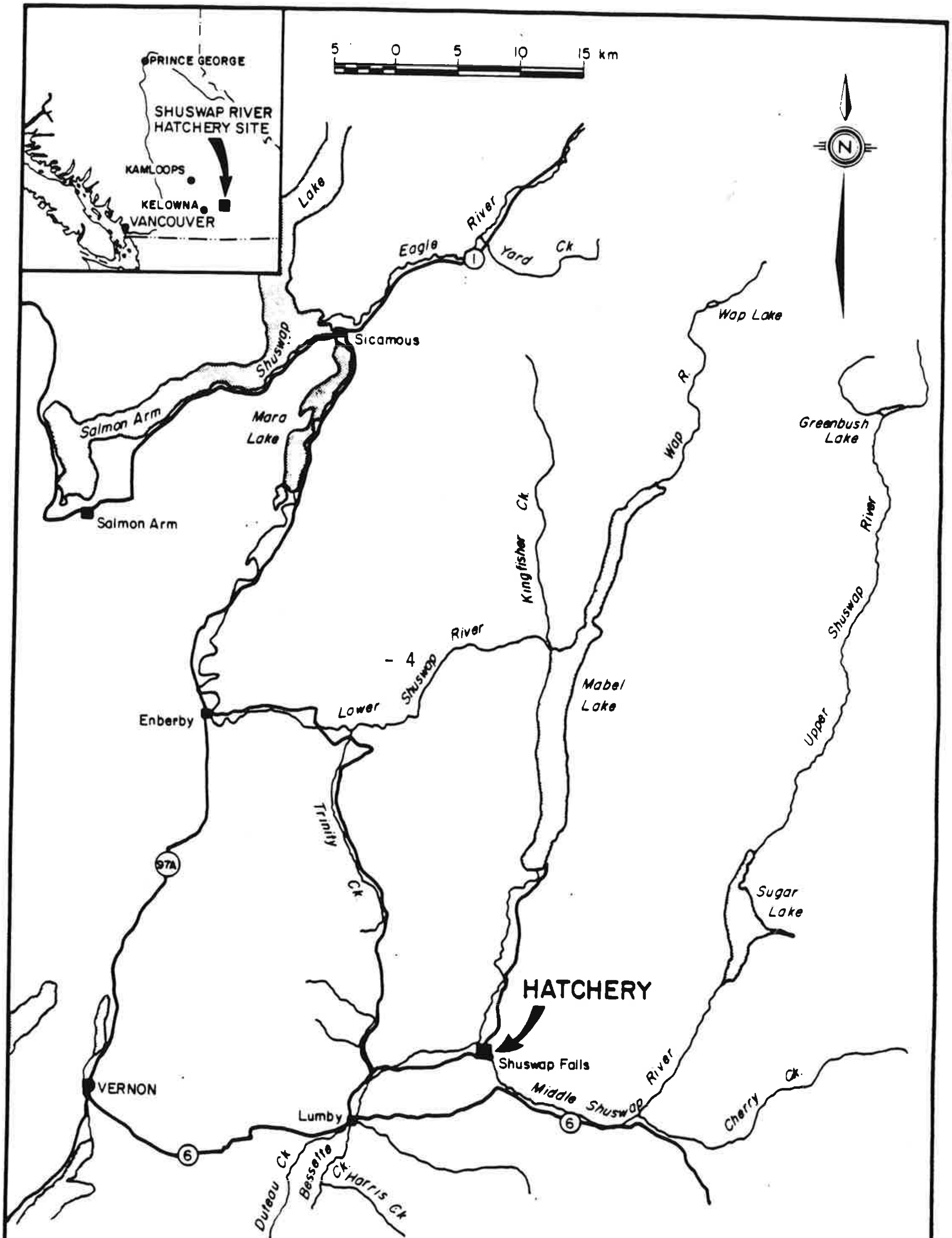


Figure I Shuswap River Hatchery and Donor Stream Location Map three dry wells and one with very limited yield), but acceptable quality and quantity of water were not found until the sixth well.

The facilities constructed at Shuswap (Figure 2) have been a product of the amount and kind of funding provided. There was no money set aside in Phase I of SEP for construction of facilities in the B.C. Interior, other than on the Quesnel River. A special employment initiative (the so-called Senator's Package) was created in 1983 to help declining chinook stocks from interior streams, while providing some local economic stimulus. Projects were quickly put together for the Spius, Eagle, Shuswap, Clearwater and Stuart sites. These were designed as pilot facilities, sized to handle a few hundred thousand eggs to provide tag groups of fry to test release strategies.

The constraints of the Senator's Package were that local labour and materials be used as much as possible. This resulted, for instance, in the buildings being built of wooden frames with metal cladding rather than the usual concrete block, making them much less expensive to construct than previous hatchery buildings.

Another constraint of the Senator's Package was that construction of each project had to result in an operable facility with the money provided. Because the total amount of money was small and distributed among five projects, the facilities provided were minimal. Therefore, production from each was not great enough to be of significant economic benefit. The approach taken was to construct a working facility that was amenable to future expansion, such that later funding would allow refurbishing the existing minimal structures and expanding to more reasonable, larger size. The test results of the first, small-scale Pilots were to be nested to give the maximum understanding of apropriate outplanting strategies from the limited numbers of fish being released. Expansion would allow duplication of release strategies at more than one facility, to help determine how specific return results are for different watersheds.

Of the five Central Interior sites, Shuswap was the smallest pilot built. A small, portable building, which had been used at the Adams River 1982 "Salute to the Sockeye" to demonstrate the plans for Interior Pilot facilities, was erected on the banks of the flood channel in W.J. Tolley Park. An aeration tower was built over Well #5, which was the best performing well at that time. This pilot was dismantled once the construction of the full sized facility was completed on the island.

Following the Senator's Package, funding came from the SEP Transition Plan, which included money for initiatives to begin to address the problem of declining stocks of Fraser River chinook and coho salmon. Unlike SEP Phase I, where projects (like Quesnel) had to pass Treasury Board scrutiny in terms of benefit:cost analysis, the Transition projects were charged with starting a chinook and coho rehabilitation and enhancement initiative for inland stocks. This was interpreted and used by the Enhancement Operations group of SEP as an opportunity to conduct studies designed to define enhancement techniques most appropriate for Interior B.C. hatcheries. This was acceptable to Treasury Board becakuse the expected costs for the expansions were below the $1.0 million maximum limit for capital projects which did not require economic review.

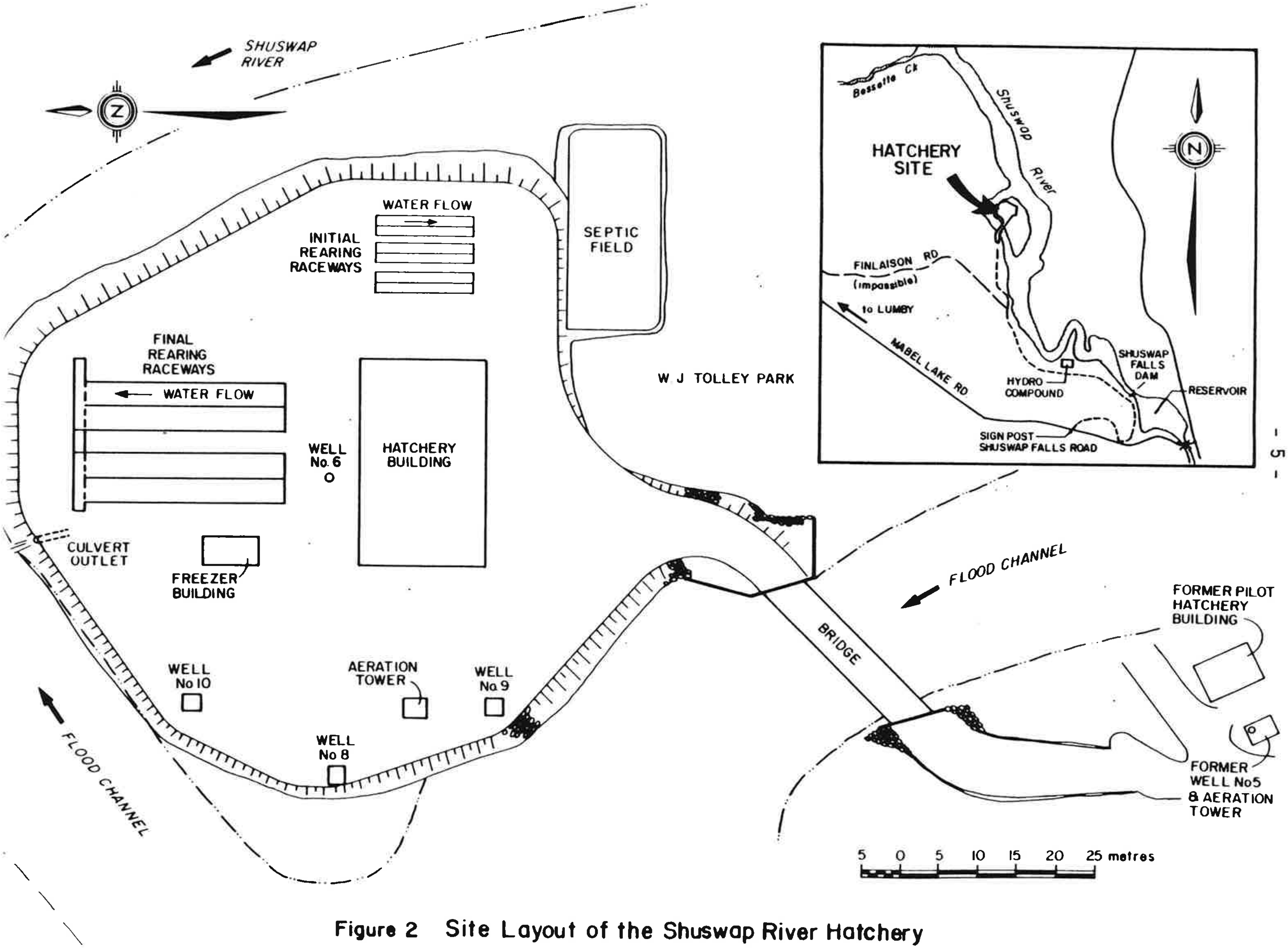


Figure 2 Site Layout of the Shuswap River Hatchery

In this vein, the objectives of facilities on the Thompson River tributaries were revamped to provide relatively complete experimental programs to test a number of enhancement strategies for chinook and coho. The facilities thus moved from 'pilot' to 'experimental' status, being too big to be considered pilots, but without the specific adult return goals associated with 'production' facilities. The credibility of the SEP is linked to proper assessment of these techniques before launching into full production at these facilities.

For Shuswap, this meant that the Experimental facility was constructed from scratch, since the Pilot was located over an unsuitable well and was not constructed in a way that could be properly expanded. The new construction included site fill, bridge, raceways, wells, building and river intake.

Construction of the Pilot hatchery was completed in 1984, and the Experimental facility was completed in 1986, after two years of Pilot operation.

PRODUCTION OBJECTIVES

Project Stages

A number of different stages in the development of an enhancement facility at the Shuswap River site have been proposed, designed or constructed, as follows:

- Pilot as-designed - the original pilot plan based on 110K eggs from one stock (Appendix 1a).
- Pilot as-built - the facility constructed to provide fish culture capability for the Pilot target.
- Experimental as-proposed - the requirements of the integrated experimental design proposed to test a number of enhancement strategies (Appendix 1b, 1c, 1d).
- Experimental as-designed - the capacity of the 'downsized' requests for structures to meet the experimental requirements (Appendix 1e, 1f, 1g).
- Experimental as-built - the capacity of the structures actually provided by the end of the construction of the pilot expansion (Appendix 1g).
- Ultimate site capacity - the limitations of the site in terms of water and space available.
- Ultimate Geographic Working Group (GWG) target - stock handling requirement based on translation of the original recommendations for area streams to be serviced (Appendix 2) into facility handling requirements as per SEP survival biostandards (Appendix 3).

This report compares these different concepts for the Shuswap facility, focusing on the present situation of carrying on the experimental program with the structures provided by the end of facility construction. The words Pilot, Experimental and Ultimate have been capitalized throughout this report when referring to those specific stages of the project development.

General Targets

The Fraser River Geographic Working Group (GWG) authored a memo in 1980 which recommended enhancement targets for the main Fraser River stocks of salmon and anadromous trout (Appendix 2). This document formed the basis for sizing most major Fraser River enhancement projects (e.g. Inch, Chehalis, Chilliwack, Quesnel) in Phase I of SEP.

The Central Interior Pilots have not been bound by the targets set out in the GWG memo because initially, as small scale Pilot facilities, their expected adult production was insignificant in relation to the GWG recommendations. Presently, as Experimental facilities, their purpose is not as much adult production as to evaluate different means of accomplishing Interior stream enhancement.

The actual structures provided and constructed are supposed to be based on the biological criteria set out in the design memos (Appendix 1), but at Shuswap, the Engineering group provided combinations of structures that did not match very closely the structures requested (Appendix 1g).

A comparison of production targets (translated to equivalents in eggs) for the various concepts of the Shuswap River facility is given in Table 1.

Table 1. Summary of Container Capacities for the Shuswap River Facility.

	Eggs (#K)	Incubator Stacks (#)	Capilano Troughs (#)	Final Rearing (m3)	Maximum Flow (LPM)
PILOT					
As-Designed	110	3	4	-	240
As-Built	260	6	4	-	750
EXPERIMENTAL					
As-Requested	1900	47	40	540	9100
As-Built	1680CN or 2856CO	42	34	360	7187
ULTIMATE					
Site Limited	4320CN or 7344CO	108	42	540	26000
GWG Target	11189	268	243	2385	50000

Notes - Assumes no rearing past 5 g.
- Capilano trough figures represent actual troughs or their equivalents in large starter units.
- Site limited maximum flow assumes 10K LPM groundwater and 16K LPM surface water

Experimental Plan

The plan for sizing the original Pilot was to provide enough incubation and rearing capacity for one group of tagged chinook to test outplanting of fry into the headwaters above Wilsey Dam. The number of fry to be released (110K) was based on an estimate of the number of validly tagged juveniles required to obtain sufficient returning adults to generate statistically significant survival values. The Pilot releases were also to provide a first-cut at the numbers required to fill the unutilized upstream rearing capacity.

The release strategy was changed to outplanting into the lower river, with upriver releases delayed until either the hatchery production capacity was increased or the escapement to the lower river increased to the optimum value.

The Experimental stage was designed to address specific questions regarding the applicability of various enhancement strategies to Central Interior conditions. The main purpose was to determine what release methods would maximize juvenile utilization of natural rearing habitat and survival to adult, while minimizing adult straying. A modular approach was taken to the design of the individual experimental programs for each facility, as there may be differences in optimal enhancement strategy between different geographical areas within the Central Interior. The modules were set up to include the following variations in releases for each species (refer to Appendix 1b for detailed lot size requirements for each experimental module):

- 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, to some extent, imprinting, with evaluation by assessment of coded-wire tagged (CWT) adult returns.

- time of release; gross timing as above and fine tuned using separate releases up to 4 wk on either side of the peak natural downstream migration. This would also test survival, again evaluated by CWT detection in adult returns.

- location of release; upstream versus downstream of facility and single point versus scattered locations. Imprinting, habitat utilization and perhaps survival, would be evaluated by studying rearing distributions of marked fish.

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

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

Chinook Objectives

Initial Pilot plans (Appendix 1a) called for incubation of a total of 110K eggs from the Lower Shuswap chinook stock at the Shuswap facility (Table 2). Biostandard estimates predicted a total return of 649 adults (catch plus escapement) from this program. Fry were to be planted at 2 g into the Middle Shuswap River above B.C. Hydro's Wilsey Dam (Figure 1).

The Experimental program plans and Ultimate GWG production targets include both the Lower and Middle Shuswap chinook stocks. The 1984-85 operation serviced Lower Shuswap stock only, while in 1985-86 both Lower and Middle chinook stocks were included.

Actual egg to fry survivals of 96.6% in the 1984-85 Pilot operation were substantially higher than biostandard survivals (90%). Similarly, the expected biostandard swim-up to 2 g fry survival of 90% was exceeded during the 1984-85 operation (97%).

Chinook survivals in 1985-86 were 96.6% from egg to fry, exceeding the biostandard of 90%. Similarly, fry survivals from swim-up to release at 3-5 g were also very high (98.8%).

No disease was encountered at the facility during the Pilot operation. Mortalities were attributable only to fry jumpout and pinheading.

The actual Pilot operation in 1984 collected 133.6K eggs from the Middle Shuswap stock (Table 2). The operation was expanded in 1985 to include 153.5K Middle Shuswap and 106.9K Lower Shuswap eggs. These should result in adult returns of 1732 and 2487 based on an egg to adult survival biostandard of 1.62%.

The Experimental plan as originally proposed called for the incubation of 1600K chinook eggs during Year 1 and 1150 eggs during Year 2. The 1986-87 targets include incubation of 1100K Lower Shuswap and 500K Middle Shuswap eggs, for a predicted adult return of 25920 fish (catch plus escapement).

The total target of 160K chinook adults originally set by the GWG could not be accommodated by full expansion of the Shuswap facility to its site limited Ultimate capacity. The number of incubation and rearing containers that could be provided falls short, and would suffice only if the large target for the Lower Shuswap (152K adults) is downsized substantially.

Table 2. Chinook Production Objectives at the Shuswap River Facility.

	Eggs (#K)	Swim-up Fry (#K)	Fingerlings (2g) (#K)	Smolts (5 g) (#K)	Total Adult Return
PILOT					
Planned Stock					
Lower Shuswap	110	99	89	-	649
1984-85 Operation					
Lower Shuswap	134	129	125	119	2164
1985-1986 Operation					
Lower Shuswap	107	105	-	105	1732
Middle Shuswap	154	147	-	147	2487
Total	261	252	-	251	4219
EXPERIMENTAL					
Plan Year 1					
Lower Shuswap	700	630	567	504	11340
Middle Shuswap	900	810	729	648	14580
Total	1600	1440	1296	1152	25920
Plan Year 2					
Lower Shuswap	500	450	405	360	8100
Middle Shuswap	650	585	527	468	10530
Total	1150	1035	932	828	18630
1986-1987 Plans					
Lower Shuswap	1100	-	-	880	17820
Middle Shuswap	500	-	-	400	8100
Total	1600	1035	932	828	25920
ULTIMATE GWG Target					
Lower Shuswap	9383	8445	7600	6756	152000
Middle Shuswap	494	444	400	356	8000
Total	9877	8889	8000	7112	160000

Notes - Survival rates: egg to swim-up, 90%; swim-up to fingerlings, 90%; swim-up to smolt, 80%; egg to adult, 1.62% for 5 g release, 0.57% for 2 g release.
- Figures for the operation are based on actual survivals to release
- The 1984-85 and 1985-86 operations did not rear all fish to 5 g, some were released at a smaller size.

Coho Objectives

Initial Pilot plans (Appendix 1a) did not include coho production at the Shuswap Pilot facility and they were not included in the Pilot operation (Table 3).

Experimental plans (Appendix 1d) originally called for coho production from three stocks (Wap, Bessette and Lower Shuswap). The 1986-87 plans target the Lower Shuswap stock only (200K eggs). If this target is met, the predicted adult return would be 4320 fish with a 6 g release.

The total GWG target of 16,000 returning adults for systems the facility would service is well within the facility's Ultimate site limitation capacity for incubation and rearing, as long as chinook are not simultaneously reared to the GWG recommended levels. The requirements for the GWG coho target production are only approximately one half of the incubation space currently on site.

Table 3. Coho Production Objectives at the Shuswap River Facility.

	Eggs (#K)	Swim-up Fry (#K)	Fingerlings (2g) (#K)	Smolts (20 g) (#K)	Total Adult Return
PILOT					
Planned Stocks					
-no coho					
1984-1985 Operation					
-no coho					
1985-1986 Operation					
-no coho					
EXPERIMENTAL					
Plan Year 1					
Wap	100	90	81	68	10130
Bessette	100	90	81	68	10130
Lower Shuswap	100	90	81	68	10130
Total	300	270	243	203	30390
Plan Year 2					
Wap	100	90	81	68	10130
Bessette	100	90	81	68	10130
Lower Shuswap	100	90	81	68	10130
Total	300	270	243	203	30390
1986-87 Plans					
Lower Shuswap	200	180	162	-	4320
ULTIMATE					
GWG Target (2 g option)					
Wap	328	295	266	-	4000
Bessette	574	517	465	-	7000
Lower Shuswap	410	369	332	-	5000
Total	1312	1181	1063	-	16000
GWG Target (25 g option)					
Wap	39	35	32	26	4000
Bessette	69	62	56	47	7000
Lower Shuswap	49	44	40	33	5000
Total	157	141	127	106	16000

Notes - Survival rates: egg to swim-up, 90%; swim-up to fingerlings, 90%; swim-up to smolt, 75%; egg to adult, 1.22% for 2g release, 2.16 % for 5 g release, 10.13% for 20 g release.

FACILITY DESCRIPTION

ADULT HOLDING

Biological Characteristics

Broodstock holding requirements for the design of the Shuswap Pilot facility were forecast using Fraser River biostandard averages of adult weight and fecundity (Tables 4 and 5). Weights for chinook broodstock were not recorded during the Pilot operation, so the biostandard assumptions cannot be checked.

In 1984, Middle Shuswap stock males had a mean postorbital-hypural length (POHL) of 62.9 +/- 7.5 cm while females were 71.5 +/- 4.7 cm. In 1985, POHL was 62.0 +/- 10.3 cm for males and 65.5 +/- 6.2 cm for females.

To date, Middle Shuswap broodstock have been spawned immediately upon capture or held at the Eagle River facility, and have not been held at the Shuswap facility.

The Shuswap facility was designed assuming a pre-spawning mortality of 25% of the broodstock collected. Despite the fact that the actual mortality experienced during adult holding in 1984 and 1985 was negligible, the 25% figure was maintained in the calculations as a safeguard against disease or other problems in the future.

The design memos (Appendix 1) were based on the assumption that a 0.6:1 male to female sex ratio would be used during egg takes. During the 1984 Pilot operation, male to female ratios were 0.58:1, while during 1985 they were 1:1. For all projections in this report, the calculations have been done assuming a sex ratio of 1:1. This ratio accommodates genetic concerns that as large a gene pool as possible be maintained for hatchery stocks.

The design memos (Appendix 1) used fecundity estimates of 6000 eggs for chinook. Egg-take fecundities for chinook recorded in 1984 averaged 5800 and in 1985 averaged 5365. These represent those taken from green fish only, not fish that were ripe and running at the time of egg takes (G. Conway, pers. comm.). An average of 5600 eggs has been applied to all projections, based on the two years' data.

Table 4. Adult Chinook Holding Requirements at the Shuswap River Facility.

	Eggs (#K)	Donors Female	Donors Total	Biomass (kg)	Volume Required (m3)	Flow Required (LPM)
PILOT						
Planned Stocks						
Lower Shuswap	110	20	40	200	6	167
1984-1985 Operation						
Lower Shuswap	134	31	49	245	8	204
1985-1986 Operation						
Lower Shuswap	154	22	44	220	7	183
Middle Shuswap	107	42	84	420	13	350
Total	160	64	128	640	20	533
EXPERIMENTAL						
Plan Year 1						
Lower Shuswap	700	125	250	1250	39	1042
Middle Shuswap	900	161	322	1610	50	1342
Total	1600	286	572	2860	89	2383
Plan Year 2						
Lower Shuswap	500	90	180	900	28	750
Middle Shuswap	650	116	232	1160	36	967
Total	1150	206	412	2060	64	1717
1986-1987 Plans						
Lower Shuswap	1100	196	392	1960	61	1633
Middle Shuswap	500	90	180	900	28	750
Total	1600	286	572	2860	89	2383
ULTIMATE						
GWG Target						
Lower Shuswap	9383	1676	3352	16761	524	13968
Middle Shuswap	494	89	178	890	28	742
Total	9877	1765	3530	17650	552	14708
Chinook Only						
As-Built Capacity	1680	300	600	3000	94	2500
Site Limited Capacity	4320	772	1544	7720	241	6433

Notes - values for the 1984-1986 operation represent actual numbers of fish used. These were were spawned at the capture location.
- Fecundity, 5600; Mean adult weight, 5 kg; Sex ratio, 1:1
- Load rates are 32 kg/m3 and 1.2 kg/LPM
- As-Built and Site Limited Ultimate figures are derived from the limitations imposed by incubation space.

Table 5. Adult Coho Holding Requirements at the Shuswap River Facility.

	Eggs (#K)	Donors Female	Donors Total	Biomass (kg)	Volume Required (m3)	Flow Required (LPM)
PILOT						
Planned Stocks						
-no coho						
1984-1985 Operation						
-no coho						
1985-1986 Operation						
-no coho						
EXPERIMENTAL						
Plan Year 1						
Wap	100	40	80	240	8	200
Bessette	100	40	80	240	8	200
Lower Shuswap	100	40	80	240	8	200
Total	300	120	240	720	22	600
Plan Year 2						
Wap	100	40	80	240	8	200
Bessette	100	40	80	240	8	200
Lower Shuswap	100	40	80	240	8	200
Total	300	120	240	720	22	600
1986-1987 Plans						
Lower Shuswap	200	80	160	480	15	400
ULTIMATE						
GWG Target (25 g option)						
Wap	328	131	262	786	25	655
Bessette	574	230	460	1380	43	1150
Lower Shuswap	410	164	328	984	31	820
Total	1312	525	1050	3150	98	2625
GWG Target (20 g option)						
Wap	39	16	32	96	3	80
Bessette	69	28	56	168	5	140
Lower Shuswap	49	20	40	120	4	100
Total	157	64	128	384	12	320
Coho Only						
As-built Capacity	2856	1142	2284	6852	214	5710
Site Limited Capacity	7344	2938	5876	17628	551	14690

Notes - As-Built and Site Limited Ultimate capacities are derived from the limitations imposed by incubation space.
- load rates are 32 kg/m3 and 1.2 kg/LPM.
- Fecundity, 2500; Mean adult weight, 3 kg; Sex ratio 1:1

Capture and Holding Facilities

During broodstock collection in 1984, adult chinook were captured by angling deep pools in the Lower Shuswap River during September over a 2-3 wk period. Fish were held in a net at the angling location, then carried one at a time in a water filled innertube up a 20 m bank and a further 75 m to the transport vehicle. The fish were transported approximately 80 km to the Eagle River Facility in a 1400 L fibreglass tank on a 1.0 ton flatbed truck. Transport time was estimated to have been 1-2 hr. Upon arrival at the Eagle River Facility, fish were transferred to aluminum raceways (1.8 m wide by 21.0 m long by 1.0 m high) and held to maturity in 7.5oC groundwater. The fish were held until ripe for up to 3 wk at the Eagle Facility. The eggs and sperm were stripped from the fish at Eagle and transported in coolers to the Shuswap Pilot, where the eggs were fertilized.

In 1985, difficulties were encountered during the broodstock collection period. An attempt was made to capture chinook by means of a broomstick fence and trap constructed across the Middle Shuswap River about 2 km downstream from the Pilot site. It was thought that chinook salmon spawners may have been holding in Mabel Lake and would move upstream onto the spawning grounds in mid-September. The fence was erected in early September but by September 20 no fish had been trapped. It was discovered that most broodstock were already in holding areas upstream, and must have passed by the fence prior to construction.

Chinook salmon began to spawn in the Middle Shuswap River on September 15 in 1985. When no fish were caught in the fence trap by September 23, an attempt was made to capture broodstock with tangle nets. Flows in the river proved to be too slow for this method. A 50 m adult beach seine was borrowed from the Eagle River Facility and on September 24 seining was initiated. Two productive sites to seine broodstock were identified, one immediately upstream of the riffle in front of the hatchery and the other at the tail of a large pool near the mouth of Bessette Creek. Most fish were seined from these two sites. After capture and before spawning, Middle Shuswap adults were held in pens measuring 1.0 m by 1.0 m by 3.0 m, constructed with wooden frames and covered with mesh. These were inadequate and some fish escaped by damaging the pens, while six other fish were apparently stolen.

Initially, sufficient Middle Shuswap female chinook were caught to supply the target of 250K eggs. However, approximately one-half escaped or were stolen, which prompted the collection of approximately 100K chinook eggs from the Lower Shuswap River. Most of the broodstock from the Lower Shuswap River were collected by DFO Field Services Branch using a beach seine during a tagging operation in a long run upstream from the Cook Creek campsite. Fish were spawned immediately on the river and eggs and sperm transported back to the Pilot hatchery in coolers with an average transit time of 2.5 hr. Eggs were fertilized upon arrival at the Pilot facility.

Most chinook broodstock from the Middle Shuswap River were caught between September 24 and October 2, 1985. Chinook broodstock from the Lower Shuswap River were caught October 4 to 10, 1985.

Chinook salmon typically spawn from September 15 to September 30 in the Middle Shuswap River, and from October 1 to October 20 in the Lower Shuswap River.

After these dates there are very few unspawned fish available (Brown et al., 1979).

Difficulties are anticipated for broodstock collection in the future, especially for Lower Shuswap coho requirements. On spawning grounds, the stock is thinly distributed and the river is large. Angling for green adults is suggested (G. Conway, pers. comm.).

* stock? origin

It is assumed that in the future if green fish are captured during broodstock collection activity, they will be held to maturity at the hatchery, rather than in net pens at the capture location. This is recommended in light of the escape and theft problem experienced during the Pilot operation.

The concrete raceways now on site can be used for holding. Temperature regulation during holding is possible by running a hose from the incubation room to the raceways to supply 800 LPM of river water.

Chinook Holding

Table 4 lists the adult chinook holding requirements for the Shuswap River facility based on the various design memos and the actual 1984-85 brood statistics.

The Experimental plan design memo (Appendix 1d) assumed the adult holding of the satellited stocks would be done within the donor systems and that the raceways would be used for the Middle Shuswap River broodstock only.

The design memo also stated that early chinook holding would be done using well water, as the river water temperature exceeds 15°C in summer. Also, the memo predicted a critical time would be in July and August when chinook adult holding was required and all the containers would be filled to capacity for rearing.

The existing raceways now on site could hold 11520 kg of adults, which would satisfy all the target options except the GWG targets which called for 17650 kg of adults.

Coho Holding

Adult coho holding requirements for the Shuswap River facility are listed in Table 5 for the various stages of the hatchery design.

The design memos (Appendix 1) used a fecundity of 2500 and a sex ratio of 0.6:1.0 (males to females) to calculate the number of donor coho adults required for the Shuswap facility. Further, like that for chinook, the sex ratio for coho has been increased to 1:1 to maintain a large gene pool. The 2500 assumed fecundity figure has been applied to the targeted stocks.

As there is no major overlap in the holding requirements of adult chinook and coho, the raceways can be devoted to accommodate either species when needed.

Table 5 indicates that there is more than ample space to hold the adult coho required to meet any coho target set for the Shuswap facility. The Experimental plan maximum target equates to use of only one-third of one raceway. The GWG 2 g rearing option could be met using only one raceway to hold adults.

Brood Stock Availability

According to the spawning records (Brown et al., 1979), coho broodstock from Bessette Creek and Wap Creek may be difficult to obtain (Table 6). Recent escapements to Bessette Creek have averaged only 29 fish and the maximum for 1981-1985 is only 50, less than the 80 fish requirement to meet the objectives of the Experimental Plan. The 1986-1987 plans are likely achievable, providing the 1986 returns are not at minimum.

Event Timing

The design memo timings assumed that the well water temperature would be 9°C year round and that incubation and rearing would be carried out on well water only. These assumptions have proven to be correct to date.

The design memo correctly predicted the major events in chinook culture at Shuswap during the 1984-1985 and 1985-1986 operational years, except that adult holding was projected to occur in July, rather than late September (Table 7). This occurred because only ripe fish on spawning grounds have been taken, not green fish upon arrival.

The ATU projected for the development of chinook eggs to swim-up has been bracketed by the range of ATU at each stage during the actual operation. Most fish however, have been ponded at over 1000 ATU.

No coho culture has been done at Shuswap, so operational timings cannot be compared to those projected.

Table 6. Broodstock Limitations in Donor Streams.

Stocks	Escapements (1981-1985) Max.	Mean	Min.	Adult Requirements Experimental Program Year 1	Year 2	1986-1987
Chinook						
Lower Shuswap	10000	5800	2200	250	180	392
Middle Shuswap	900	580	300	322	232	180
Coho						
Wap	250	161	80	80	80	-
Bessette	50	29	10	80	80	-
Lower Shuswap	500	310	200	80	80	160

Notes - fecundities as noted in Tables 4 and 5
- egg requirements as in Tables 4 and 5
- 1:1 sex ratio assumed except for operational year 1984-1985
- escapement data obtained from Farwell (pers. comm.)
- Bessette Creek coho run has declined since a 1965 high of 2500.

Table 7. Event Timing at the Shuswap Facility

1. DATES

Species	Adult Holding & Egg Takes	Incubation	Ponding	Size (2g)	Release
Chinook					
Projected:	Jul18-Oct31	Sep21-Feb19	Jan10-Feb19	Mar10-May19	Apr29-Jul 8
Actual:	Sep24-Oct10	Sep24-Feb10	Jan14-Feb10	Apr 1-Apr16	May 1-May20a
Coho					
Projected:	Oct16-Nov30	Oct31-Feb27	Jan26-Feb27	Apr 4-May 4	May30-Jun28
Actual:	no coho				

2. ACCUMULATED THERMAL UNITS (ATU's):

	Eyed	Hatch	Ponding
Chinook - projected	280	520	980
- actual	252-351	492-576	970-1197
Coho - projected	220	480	780
- actual - no coho			

Note a - Most fish have been released at a size smaller than 5 g at Shuswap

INCUBATION

Vertical Tray Incubators

Eight-tray vertical incubator stacks (Figure 3) are used for incubation of chinook, coho and steelhead at most SEP facilities. Each eight-tray stack is 81 cm high by 62 cm wide by 63 cm deep. Each incubator tray has a screen lined insert for holding the eggs with inside measurements of 35 cm by 30 cm by 4 cm high and an egg holding volume of about 4 L.

Each stack is routinely run at 10-15 LPM, but flush flows of 19 LPM have been allowed for in the plumbing design. During 1984, only seven of the eight trays were used in each stack, with the top tray unused in an attempt to reduce air bubbles. During 1985 all eight trays were used in each stack. Each stack received a flow of 13-15 LPM during in the two-year Pilot operation. Flush flows were not used.

At the start of 1984 operations, the Shuswap Pilot facility had only three stacks (24 trays fully operational). This number was increased to six stacks (48 trays) in 1985 to accommodate the larger egg take.

The Experimental design memo requested a total of 47 stacks and the provision of heated water to one bank of stacks. No heated water has been supplied and only 42 eight-tray stacks were initially installed in two batteries in the incubation room. One battery consists of two lines of nine stacks set back to back, two stacks high. The second battery is only one stack high. The six stacks from the Pilot were placed above one group of nine in the second battery.

In the as-built facility, 108 eight-tray stacks could be accommodated in the incubation room, bringing the Ultimate building capacity to 864 trays.

Each battery of 36 stacks (area of 18 only) takes up about 7.7 m^2 of floor space. The aisles between batteries are approximately 1.5 m wide.

A single header supply line feeds water to each of the upper and lower groups of stacks. Since the only water supply was groundwater, no means of regulating incubation water temperature existed at the Pilot. The as-built Experimental facility is capable of delivering 800 LPM of river water to the incubation room, which allows for some temperature manipulation.

Eggs and sperm have been taken from fish at the capture location or from adults held at the Eagle River Hatchery during past operations, and transported in iced coolers to the Pilot hatchery. At Shuswap, eggs have been fertilized by the dry method at Shuswap, moved to their permanent stack and treated with Ovidine the following day.

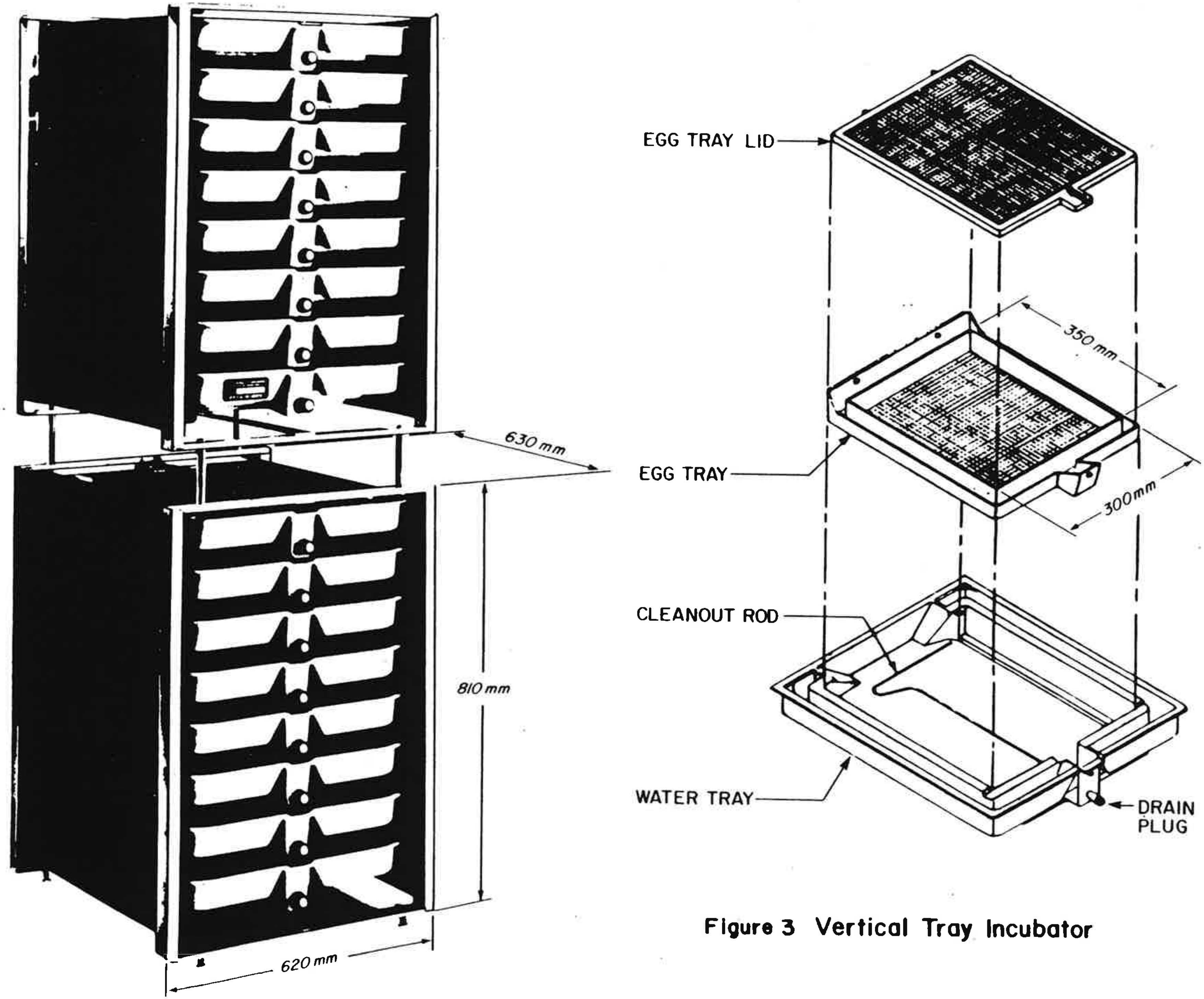


Figure 3 Vertical Tray Incubator

Chinook Incubation

Loading rates for chinook were estimated at 5000 eggs per tray for hatchery design purposes. In 1985-86 nearly 8000 eggs per tray of Lower Shuswap chinook were incubated during operation. This was necessary to accommodate the large egg take. Attempts were made during the Pilot operation to limit the loading to one female's eggs per tray.

The Pilot design memo (Appendix 1a) indicated a requirement for three stacks to incubate 110K chinook and the Experimental design memo (Appendix 1d) requested 41 stacks of trays for incubation of chinook eggs. Chinook eggs were incubated in three stacks (24 trays) during 1984-85 (Table 9). During the 1985-86 operation six stacks (48 trays) were used.

The 42 stacks provided in the as-built facility contain sufficient incubation space for 1680K chinook eggs, if this were the only species enhanced and all eight trays in the each stack were used. The Ultimate capacity of the Shuswap facility to incubate exclusively chinook would be 4320K eggs in 108 stacks. This is less than one-half the incubation space required to meet the GWG target but is sufficient to meet all the other target options.

Unless tray loadings were increased, the Experimental Plan Year 1 and proposed 1986-87 targets for both chinook and coho could not be met by the current incubation capacity of the as-built facility. Chinook objectives alone would require 41 of the 42 stacks on-site.

Shuswap chinook have been ponded at approximately 970-1197 ATU, compared to the coast-wide average of 900-1000 ATU to swim-up used in design.

Shuswap chinook incubation in 1984-85 spanned the first egg-take October 1 to the last ponding on January 27, 1985. In 1985-86, incubation occurred from September 24 to February 10 with the last ponding of Lower Shuswap fry.

Survivals of Shuswap chinook to ponding were 96% and 97% respectively in the 1984-85 and 1985-86 operations. This is substantially higher than the egg-fry hatchery survival biostandard of 90%, used in the project design.

Considering the comparatively high incubator tray loadings and egg survivals experienced in 1985-86, incubation capacities outlined in Table 8 may be lower than is actually possible. However, pilot survivals often exceed those obtained during routine production, thus capacities have been left at the more conservative level.

Table 8. Chinook Incubation Requirements at the Shuswap River Facility.

	Eggs (#K)	Eggs per Tray (#)	Trays (#)	Stacks (#)	FLOW Normal (LPM)	FLOW Flush (LPM)
PILOT Planned Stocks						
Lower Shuswap	110	5000	22	3	45	57
1984-1985 Operation						
Lower Shuswap	134	6000	21	3	45	-
1985-1986 Operation						
Lower Shuswap	107	8000	16	2	30	-
Middle Shuswap	154	5000	32	4	60	-
Total	261		48	6	90	-
EXPERIMENTAL						
Plan Year 1						
Lower Shuswap	700	5000	140	18	270	342
Middle Shuswap	900	5000	180	23	345	437
Total	1600		320	41	615	779
Plan Year 2						
Lower Shuswap	500	5000	100	13	195	247
Middle Shuswap	650	5000	130	17	255	323
Total	1150		230	30	450	570
1986-1987 Plans						
Lower Shuswap	1100	5000	220	28	420	532
Middle Shuswap	500	5000	100	13	195	247
Total	1600		320	41	615	779
ULTIMATE						
GWG Target						
Lower Shuswap	9383	5000	1877	235	3525	4465
Middle Shuswap	494	5000	99	13	195	247
Total	9877		1976	248	3720	4712
Chinook only						
As-Built Capacity	1680	5000	336	42	630	798
Site Limited Capacity	4320	5000	864	108	1620	2052

Notes - Chinook load rate normally 5000 eggs per tray
- Flows are 15 LPM normal and 19 LPM flush
- Eight trays per stack, except 1984-85 when seven trays were used

Coho Incubation

The Experimental plan design memo requested six stacks of trays for use by three stocks of coho. The as-built facility contains 42 stacks, which translates to a total incubation capacity of 2,856K coho eggs if this was the only species enhanced and all eight trays per stack were used at the 8500 eggs per tray loading rate.

For the 1986-87 plans, three stacks would be required to meet the 200K egg target (1 stock). Including chinook, this is a total requirement of 44 stacks, two more than were provided on site, requiring either higher tray loadings or provision of two more stacks.

The Ultimate site limited capacity of the Shuswap facility to incubate coho exclusively is 7344K eggs. The requirement of the GWG target would be a maximum of 19.5 stacks for coho, leaving 88.5 stacks available for chinook if the ultimate incubation space at the facility was provided.

Table 9. Coho Incubation Requirements at the Shuswap River Facility.

	Eggs (#K)	Eggs per Tray (#)	Trays (#)	Stacks (#)	FLOW Normal (LPM)	FLOW Flush (LPM)
PILOT						
Planned Stocks						
-no coho						
1984-1985 Operation						
-no coho						
1985-1986 Operation						
-no coho						
EXPERIMENTAL						
Plan Year 1						
Wap	100	8500	12	1.5	23	29
Bessette	100	8500	12	1.5	23	29
Lower Shuswap	100	8500	12	1.5	23	29
Total	300		36	4.5	69	86
Plan Year 2						
Wap	100	8500	12	1.5	23	29
Bessette	100	8500	12	1.5	23	29
Lower Shuswap	100	8500	12	1.5	23	29
Total	300		36	4.5	69	86
1986-1987 Plans						
Lower Shuswap	200	8500	24	3	45	57
ULTIMATE						
GWG Target (2 g option)						
Wap	328	8500	39	5	75	95
Bessette	574	8500	68	8.5	128	162
Lower Shuswap	410	8500	48	6	90	114
Total	1312		155	19.5	293	371
GWG Target (25 g option)						
Wap	39	8500	4.5	1	15	19
Bessette	69	8500	8	1	15	19
Lower Shuswap	49	8500	6	1	15	19
Total	157		18.5	3	45	57
Coho only						
As-built Capacity	2856		336	42	630	798
Site Limited Capacity	7344		864	108	1620	2052

Notes - Coho tray loadings usually 8500/tray
- Normal flow 15 LPM, flush flow 19 LPM
- Eight trays per stack

REARING

Capilano Troughs

Capilano troughs (Figure 4) are used in most SEP facilities for the start-up rearing of 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 m3 of water, depending on overflow setting and bottom slope. A 0.4 m section separated by a tail screen limits the volume of water available for rearing to approximately 2.2 m3. The Capilano troughs used at Shuswap are made of welded aluminum with support struts.

The troughs are set in lines of two, such that one water supply feeds both troughs in a series. The first trough is set 300 mm above ground and the second 100 mm above ground. This allows overspill from the first trough to fall 200 mm into the second trough, providing some re-aeration. The troughs are supplied with adjustable style legs and bolted to the concrete floor of the building.

Two troughs were requested and provided inside the Pilot building, with another two being added on outside the building for the second year of the Pilot. This was because the purpose of the Pilot changed from providing 2 g outplants above the dam to the release of larger fish into the river downstream.

Up to 22 lines of troughs (44 troughs) were requested for the Experimental facility, but this was later downsized to six lines in combination with eight initial rearing raceways. In the as-built facility, five lines of Capilano troughs (10 troughs) are housed in a fully enclosed rearing room adjacent to the incubation room. The four troughs from the Pilot were not used and were in storage at the time of writing.

Typically, the flow to each line of troughs starts at 120 LPM for newly ponded fry and increases to a maximum of 240 LPM when fry reach 1.5 g. This method was used during both years of the Pilot operation, resulting in a maximum flow requirement of 480 LPM.

Loading densities assumed during the design of the facility were 40K chinook and 57K coho per Capilano trough. Pilot loadings originally were assumed at 57K for chinook also. Loadings were 23-38K chinook per trough at the start of initial rearing in 1984-85. In 1985-86, the large number of fish at the facility necessitated loading the four Capilano troughs on site with from 64K to 78K fish at the start of initial rearing.

Temporary covers made of plywood and netting were placed on each of the two troughs housed outside during the Pilot project. Permanent covers may not have to be provided in future operations, as the troughs are enclosed in the rearing room.

The technique for rearing fish in Capilano troughs normally involves crowding newly ponded fry into the upstream end by placing a screen about one third the distance from the inlet. This crowding helps initiate the feeding response in young fish. Once the fish are feeding, the rearing space made available is

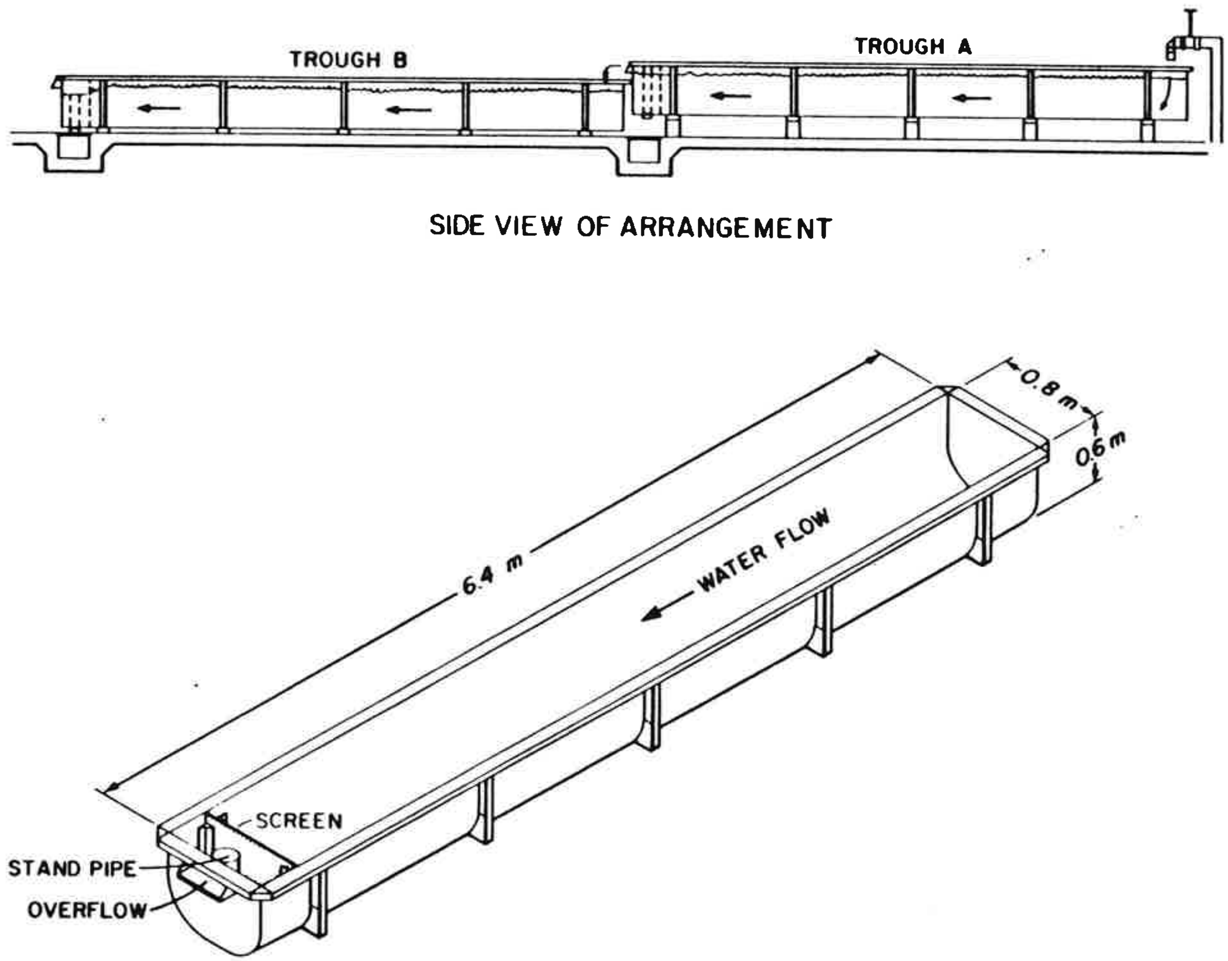


Figure 4 Capilano Style Rearing Trough

increased by repositioning or removing the screens. In 1984-85, screens were employed to initially crowd fry into the lower or downstream third of the troughs for a period of two weeks. After initiation of feeding, the crowding screens were removed and feeding frequency was reduced. Screens were used in 1985-86 to separate each trough into two or three compartments.

During the Pilot, the fish in the Capilano troughs were fed daily over an eight hour period at an initial rate of twice per hour and a final rate of once per hour. Oregon Moist Pellet (OMP) was presented to the fish at a rate of approximately 60-70% of the rate recommended by the manufacturer. The feed rate was determined mainly by the amount of food the fish would accept at any one feeding to minimize waste.

Each trough was cleaned twice per day, once in the morning and again in the afternoon at the end of the work day. Troughs were partially drained during cleaning and waste material was swept out with brushes. To reduce the potential for spread of disease, each line was cleaned with its own brush.

Initial Rearing Raceways

An intermediate-sized rearing unit between Capilano troughs and conventional rearing raceways was designed for the Interior Pilot facilities. This was to allow for start-up rearing of larger groups of fish than would fit in a single Capilano trough and thus cut down on the manpower required for early rearing. These initial rearing raceways (also called large starter units) were designed to be equivalent in overall dimensions and flow to two lines of Capilano troughs such that if the new units were not found to be acceptable at some future date, troughs could be directly substituted in place of the larger, initial rearing raceways.

No initial rearing raceways were requested for the Pilot. For the full-sized Experimental facility, the equivalent of 20 Capilano trough lines were requested, or 12 troughs and seven initial rearing raceways. This request was later adjusted to six troughs and eight initial rearing raceways to accommodate downsizing. Six initial rearing raceways were provided in the as-built facility . In combination with the 10 Capilano troughs placed in the rearing room, the equivalent of 17 lines of Capilano troughs has been provided.

The initial rearing raceways at Shuswap (Figure 5) measure 13.2 m long by 1.2 m wide by 1.2 m deep with a normal operating depth of 0.8 m. The rearing volume of each raceway is approximately 13 m^3, after allowing for fish and water control features at the ends of the raceways and freeboard to prevent fry jump-out. Each raceway can be screened into four compartments, each approximately 3.0 m long containing 3.0 m^3 of rearing space, enough for 20K fed fry.

The initial rearing raceways at the Shuswap facility are constructed of steel reinforced concrete. Walls are 150 mm thick and the units are mounted on a 150 mm thick concrete slab. The bottom slope is 1%.

Similar to Capilano troughs, these raceways are arranged in pairs side by side, such that one riser pipe splits into two valved spigots to feed the two

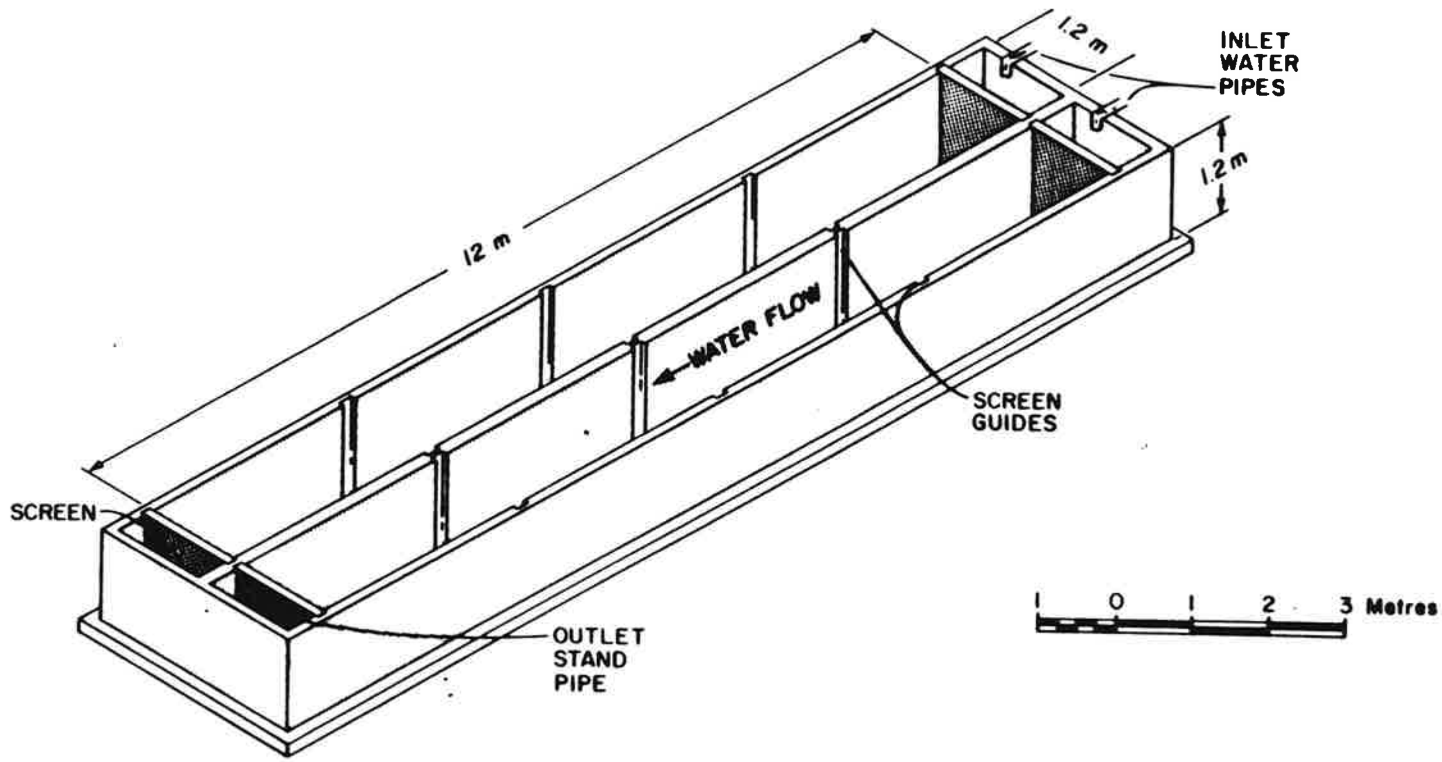


Figure 5 Initial Rearing Raceways at the Shuswap River Facility

eways. The flow is single pass and does not go through two raceways in ies, as does the flow for Capilano troughs.

er from any of the four wells can be supplied via the aeration tower ough a 300 mm diameter mainline and piped via 100 mm diameter lines to the d of each raceway. Drainage is accomplished through 150 mm diameter lets. All the initial rearing raceways were equipped with low flow alarms.

ign flows to each initial rearing raceway are equivalent to the amount uired to supply two Capilano troughs lines (initial and final flows of 240 480 LPM per raceway, respectively). Peak flows to all initial rearing eways combined would be approximately 2880 LPM.

ding and cleaning routines used for these raceways closely resemble those ployed for Capilano troughs.

Final Rearing Raceways

he bulk of the final rearing at the Shuswap facility is expected to be done the final concrete rearing raceways (Figure 6). No final rearing was nned for the Pilot. A total of four units, placed in pairs side by side, e provided in the Experimental as-built facility.

n raceway measures 28.7 m long by 3 m wide by 1.4 m high and likely will be led to a depth of 1.2 m during operation. Allowing for water and fish trol features at the end of the raceway, the usable volume of water is roximately 90 m3 for each raceway, or 360 m3 total. This is less than the m3 requested for the full-sized Experimental facility (Appendix 1d) but e than the 150 m3 requested for the downsized Experimental plan (Appendix .

ision is available to allow screening of each raceway into four partments, each 6.25 m long containing 22.5 m3 of rearing space.

raceway exterior walls are 200 mm thick reinforced concrete, while the der walls between pairs are 150 mm thick. The raceways sit on a 200 mm k concrete slab set at a slope of 0.3%.

ated well water is supplied to each raceway via a 400 mm diameter mainline 150 mm diameter supply pipes controlled with gate valves. The raceways n into a transport channel then to a 900 mm diameter drainpipe which dumps water into the downstream end of the island's flood channel. All the ways are equipped with low flow alarms.

flow requirement to operate all four raceways at 2000 LPM each would ed the current well output of 7187 LPM. Therefore, the operation of the ainers will have to be carefully managed to control flow demands and not ed well output.

feeding will have to be done by hand, since automatic feeders were not ided.

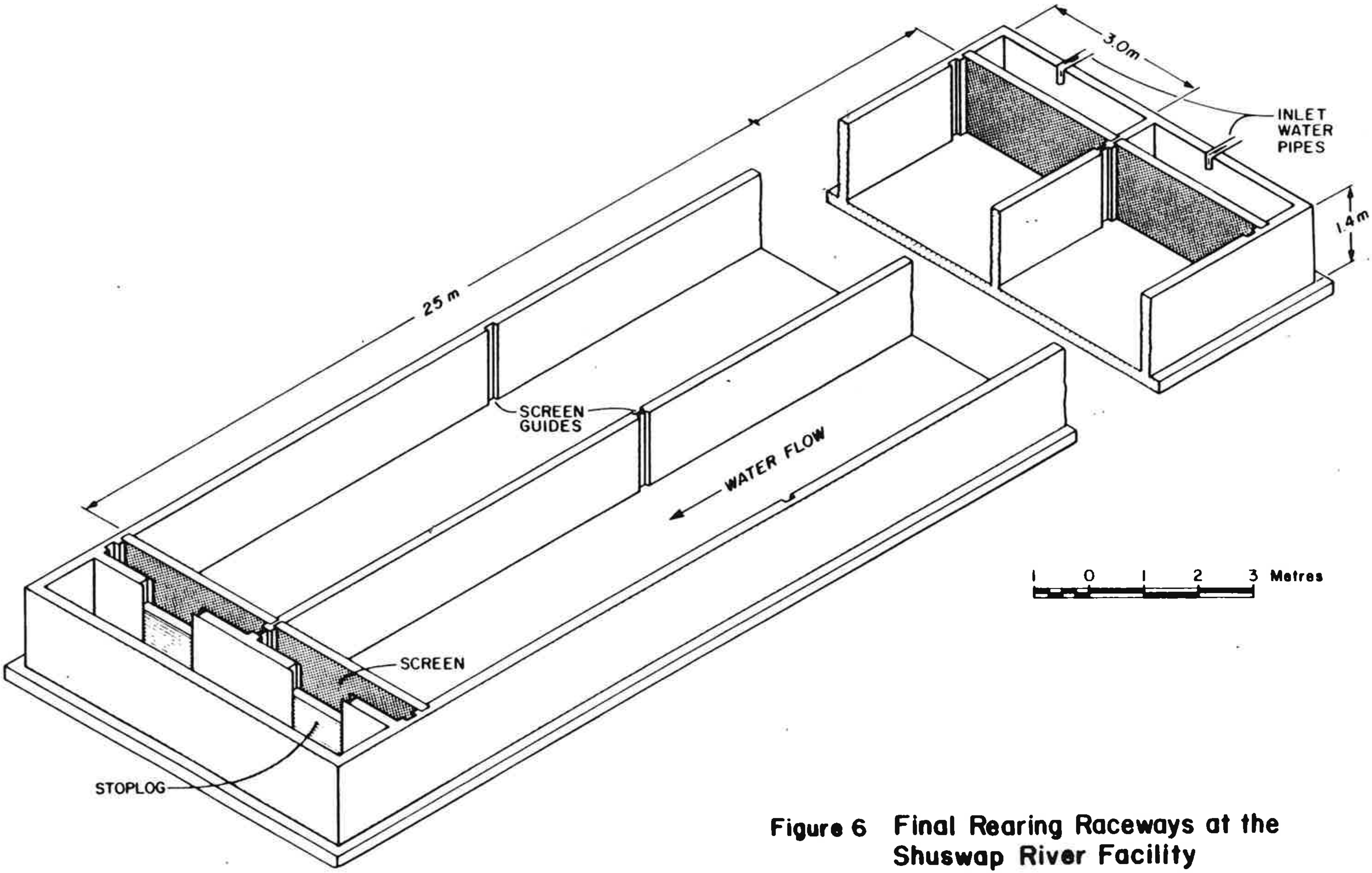


Figure 6 Final Rearing Raceways at the Shuswap River Facility

Chinook Initial Rearing

Year 1 of the Experimental Plan would require 17 lines of troughs or their equivalent and Year 2 would require 13 lines. The program proposed for 1986-87 would require 18 lines to meet chinook objectives alone. If the target egg collections are met, careful container management will be required by slightly increasing loading rates or moving ponded fish earlier. To meet the maximum objectives of the Experimental program (Year 1) with the containers on site, chinook load rates would need to be increased to 50K fry per trough. This should be approached cautiously, but evidence from the Pilot operation indicates that it would be possible.

The design memo (Appendix 1d) requested that a surface water back-up of at least 250 LPM per line of Capilano troughs and 500 LPM per initial rearing raceway be supplied because it was expected that these containers would be used in the future for rearing on surface water during summer, when water temperatures are quite high. This was not provided for at the as-built facility.

The requirements to meet the GWG target for chinook far surpass the ultimate capacity of the facility. The Lower Shuswap stock target alone would require the equivalent of 105 lines of troughs, but if such large numbers of fish were to be raised, they would probably be ponded directly into the top end of the final rearing raceways at swim-up.

Coho Initial Rearing

Experimental plans for both Year 1 and Year 2 called for use of six troughs (three lines) each year (Table 11). Coho have not yet been enhanced at the Shuswap facility, but are planned for inclusion in 1986-87 when the target of 180K swim-up fry will require three troughs.

The 25 g option for coho in the GWG target would require only three troughs, while the 2 g option would require 21 troughs. The differences reflect the much lower bio-standard survival for smaller-size releases. If coho are released at a smaller size, more must be included in the operation to achieve a set adult return target.

The Experimental design memo (Appendix 1d) raised a number of points concerning coho initial rearing and the effect of water temperature. If coho incubation were delayed using surface water, the temperature of the mix would have to be increased up to over 6°C before ponding to ensure a good initial feeding response. Also, if coho incubation is delayed such that swim-up does not occur until mid-March, the initial rearing containers can be double-used during years when coho are not released in the spring as 2 g or 5 g fry.

Table 10. Chinook Initial Rearing Requirements at the Shuswap River Facility.

	Fry (#K)	Capilano Troughs (#)	Trough Lines (#)	FLOWS Start (LPM)	FLOWS End (LPM)
PILOT					
Planned Stocks					
Lower Shuswap	110	2	1	120	240
1984-1985 Operation					
Lower Shuswap	129	4	2	240	480
1985-1986 Operation					
Lower Shuswap	105	1.5	-	-	-
Middle Shuswap	147	2.5	-	-	-
Total	252	4	2	240	480
EXPERIMENTAL					
Plan Year 1					
Lower Shuswap	810	20	10	1200	2400
Middle Shuswap	630	16	8	960	1920
Total	1440	36	18	2160	4320
Plan Year 2					
Lower Shuswap	585	15	7.5	900	1800
Middle Shuswap	450	11	5.5	660	1320
Total	1035	26	13	1560	3120
1986-1987 Plans					
Lower Shuswap	990	25	12.5	1500	3000
Middle Shuswap	450	11	5.5	660	1320
Total	1440	36	18	2160	4320
ULTIMATE					
GWG Target					
Lower Shuswap	8444	211	105.5	12660	25320
Middle Shuswap	444	11	5.5	660	1320
Total	8888	222	111	13320	26640
Chinook Only					
As-Built Capacity	1360	34	17	2040	4080
Site Limited Capacity	1680	42	21	2520	5040

Notes - Chinook load rates are 40K fry per Capilano trough
- Pilot requirements were based on 57K fry per trough
- Flow starts at 120 LPM per line, ends at 240 LPM per line
- Each large starter unit is equivalent to four Capilano troughs (two lines)

Table 11. Coho Initial Rearing Requirements at the Shuswap River Facility

	Fry (#K)	Capilano Troughs (#)	Trough Lines (#)	FLOWS Start (LPM)	FLOWS End (LPM)
PILOT					
Planned Stocks					
-no coho					
1984-1985 Operation					
-no coho					
1985-1986 Operation					
-no coho					
EXPERIMENTAL					
Plan Year 1					
Wap	90	2	1	120	240
Bessette	90	2	1	120	240
Lower Shuswap	90	2	1	120	240
Total	270	6	3	360	720
Plan Year 2					
Wap	90	2	1	120	240
Bessette	90	2	1	120	240
Lower Shuswap	90	2	1	120	240
Total	270	6	3	360	720
1986-1987 Plans					
Lower Shuswap	180	3	1.5	180	360
ULTIMATE					
GWG Target (2 g option)					
Wap	295	5	2.5	300	600
Bessette	516	9	4.5	540	1080
Lower Shuswap	369	7	3.5	420	840
Total	1180	21	10.5	1260	2520
GWG Target (25 g option)					
Wap	36	1	.5	60	120
Bessette	62	1	.5	60	120
Lower Shuswap	44	1	..5	60	120
Total	142	3	1.5	180	360
Coho Only					
As-built Capacity	1938	34	17	2040	4080
Site Limited Capacity	2394	42	21	2520	5040

Notes - Aluminum raceways and initial rearing raceways are each considered to be equivalent to four Capilano troughs (two lines)
- load rate is 57K coho fry per Capilano trough
- flows start at 120 LPM per line, end at 240 LPM per line

Final Rearing

Final rearing requirements for chinook and coho for the various stages of the Shuswap facility are summarized in Tables 12 and 13.

There was no final rearing requirement associated with the Pilot plans for the Shuswap facility, as chinook fry were to be released at 2 g. However, due to a change in the Pilot's objective, extended rearing of 52K chinook fryto 5 g was done at the Pilot facility in two Capilano troughs in 1984-85.

In 1985-86, with construction of the hatchery building, fry were moved to the Capilano troughs in the new rearing room in early to mid-February. They were then transferred to the initial rearing raceways outside at a size of 1.5 g on March 18-19. Five of the six initial rearing raceways were used, but not to capacity, and screens were employed to separate groups of fish. Flow to each initial rearing raceway was maintained at 450 LPM. Although all wells were operational, only Well #8 was used to supply all five containers. In 1985-86, only 45.5K Middle Shuswap fry and 14K Lower Shuswap fry were reared to 5 g. The remainder were released at 4.0 g or smaller.

The Experimental Plan memo (Appendix 1d) requested 434 m3 of volume to rear the required number of chinook and coho to 5 g and suggested five rectangular rearing raceways with dimensions of 30 m long, 3 m wide and 1.3 m high walls would be sufficient. The memo also suggested that Shuswap stocks could be reared to larger sizes in net pens in the river adjacent to the site, in the Wilsey Dam headpond, or near the outlets of Mabel or Sugar Lakes.

The Experimental Plan memo stated that rearing chinook to 10 g and coho to 20 g would require at least 720 m3 of space during summer before chinook are released, and that this demand could be met by construction of eight final rearing raceways, supplemented by the use of seven initial rearing raceways and six lines of Capilano troughs, for a total of 840 m3 of final rearing volume. The as-built capacity of all containers is about 460 m3.

The memo predicted that the use of river water for rearing during summer would double the flow required compared to groundwater, due to the higher temperature of the surface supply.

The GWG objectives for chinook production could not be met by the Ultimate site capacity, even if all rearing containers were used solely for this species.

Table 12. Chinook Final Rearing Requirements at the Shuswap River Facility.

	Maximum Size (g)	Total Released (#K)	Maximum Biomass (kg)	Maximum Flow (LPM)	Maximum Volume (m3)
PILOT					
Planned Stocks				no final rearing	
Lower Shuswap	2	89			
1984-1985 Operation				all fish reared in	
Lower Shuswap	3 to 5	119		Capilano troughs	
1985-1986 Operation					
Lower Shuswap	3 to 5	104.5		all fish reared in	
Middle Shuswap		146.5		initial raceways	
Total					251
EXPERIMENTAL					
Plan Year 1					
Lower Shuswap	5	504	2520	3390	161
Middle Shuswap	5	648	3240	4360	207
Total		1152	5760	7750	368
Plan Year 2					
Lower Shuswap	5	360	1800	2425	115
Middle Shuswap	5	468	2340	3150	150
Total		828	4140	5575	265
Ten gram Rearing Option					
Lower Shuswap	10	473	4730	15590	339
Middle Shuswap	10	608	6080	12130	264
Total		1081	10810	27720	603
1986-1987 Plans					
Lower Shuswap	5	880	4400	5946	281
Middle Shuswap	5	400	2000	2703	128
Total		1280	6400	8649	409
ULTIMATE					
GWG Target					
Lower Shuswap	5	6756	33780	45650	2158
Middle Shuswap	5	356	1780	2400	113
Total		7112	35560	48050	2271

Notes - volume and flow loadings determined by Load Rate Model (Appendix 5a) using the following values: - temperature 9°C - ration 0.9 OMP - correction factor 1.35 - 95% DO saturation

Table 13. Coho Final Rearing Requirements at the Shuswap River Facility.

	Maximum Size (g)	Total Released (#K)	Maximum Biomass (kg)	Maximum Flow (LPM)	Maximum Volume (m3)
PILOT					
Planned Stocks					
-no coho					
1984-1985 Operation					
-no coho					
1985-1986 Operation					
-no coho					
EXPERIMENTAL					
Plan Year 1					
Wap	20	68	1360	1280	64
Bessette	20	68	1360	1280	64
Lower Shuswap	20	68	1360	1280	64
Total		204	4080	3840	192
Plan Year 2					
Wap	5	72	360	445	22
Bessette	5	72	360	445	22
Lower Shuswap	5	72	360	445	22
Total		216	1080	1335	66
1986-1987 Plans					
Lower Shuswap	6	160	960	1107	58
ULTIMATE					
GWG Target (2 g option)					
Wap					
Bessette		-no final rearing			
Lower Shuswap					
GWG Target (25 g option)					
Wap	25	27	675	580	29
Bessette	25	47	1175	1010	50
Lower Shuswap	25	33	825	710	35
Total		107	2675	2300	114

Notes - volume and flow loadings determined by Load Rate Model (Appendix 5a) using the following values:
- temperature 8oC
- ration 0.7 OMP
- metabolic correction 1.35
- 95% DO saturation

Release Strategies

In 1985, all fry were released at a size of 4-6 g back to the Lower Shuswap River. Release locations included the outlet of Mabel Lake, the Cook Creek campsite and the Trinity Valley Bridge. Release dates spanned April 27 to May 26.

In 1986, Lower Shuswap fry were released only at the Cook Creek campsite. On April 28, 41K fry were released at a size of approximately 3.5 g, while on May 29 the remainder (approximately 65K) were released at 4 g.

Middle Shuswap fry were released in the river adjacent to the facility in 1986. On April 28, 71K fry were released at 4 g, while in late May the remainder (approximately 80K) fry were released at 6 g.

For transport to the release locations, two 900 L aluminum transport tanks mounted on pick-up trucks have been used. Tanks have been supplied with oxygen from a portable cylinder using airstones and monitored by a YSI DO meter to maintain 10-12 ppm of oxygen during transport.

Some fry stocking estimates have been compiled for the Shuswap area. Griffiths (MS 1979) felt that the Middle Shuswap River had ample rearing capacity for the progeny of 1000 female chinook. Fee and Jong (1984) estimated that 670 adult chinook would be optimum to fully seed rearing habitat below Shuswap Falls.

Fee and Jong (MS 1984) further estimated Bessette Creek and Middle Shuswap capacities at 112.5K and 36K coho fry, respectively. The Middle Shuswap was estimated to be able to accommodate 190K 2 g chinook fry upstream of Shuswap Falls and 168K 2 g fry downstream of the falls.

FLOW DEMAND

A summary of the rearing requirements for Year 1 of the Experimental program is presented in Table 14. The rearing requirement summary was used to develop estimates of the maximum required flow demand to meet the objectives of the Experimental program (Table 15, Figure 7).

If all containers (Capilano troughs, initial and final raceways) were filled to capacity for final rearing simultaneously, the combined water demand would be 12080 LPM. The Experimental design memo projected that maximum flows for final rearing past 2 g could peak at 12000 LPM. The current output capacity of the four wells at Shuswap is, however, only 7187 LPM. In addition, the 800 LPM of surface water supplied to the incubation room could be diverted by surface hose to the rearing area. This would increase the water supply to 7987 LPM. It has been estimated that the aquifer at the Shuswap hatchery could produce a maximum of about 12800 LPM (Aquaterre, 1984).

The Experimental design memo (Appendix 1d) stated that for the "worst case" situation, where river water would be used to rear chinook to 10 g and coho to 20 g in containers, the flow of river water required through the summer could peak at 38000 LPM. The memo requested that in negotiations with B.C. Hydro, a flow of 42000 LPM should be discussed, to allow for full back-up of the well supply during the time of maximum river water demand.

With the exception of the post-release period when no water was required, the period of lowest water demand in the Pilot operation occurred during incubation. Peak flows were required in mid-April, immediately prior to the start of releases when the fry were reared in the initial rearing raceways.

Minimum flows for the Experimental Program would occur in July and December, when the only requirement would be the early stages of adult holding and incubation, respectively.

The flow demands projected in Table 15 are slightly higher than what was predicted in the Experimental design memo (Appendix 1d). Modifications reflect changes in adult holding requirements, based on the lower fecundities found during operation for chinook.

The flow demand table indicates that the current water supply at Shuswap could be taxed by high demands for the full-scale Experimental program during March, April and May when final rearing is in progress. A similar situation may develop if 1986-87 target egg collections are achieved.

Table 14. Experimental Rearing Requirements at the Shuswap River Facility.

SPECIES	CHINOOK				COHO			
Stock Portion	Early	Middle	Late	Total	Early	Middle	Late	Total
ADULT HOLDING								
adults	143	286	143	572				240
in space (m3)	22	45	22	89				22
at flow (LPM)	596	1191	596	2383				600
from	July 18							
to			Oct 31					
INCUBATION								
eggs (#K)	400	800	400	1600	75	150	75	300
in trays	80	160	80	320	9	18	9	36
in stacks	10	21	10	41	2	3	1	6
at flow (LPM)	150	315	150	615	30	45	15	90
from	Sep 21	Oct 1	Oct 31		Oct 31	Nov 15	Nov 30	
to	Jan 10	Jan 20	Feb 19		Jan 26	Feb 12	Feb 27	
INITIAL REARING								
fry (#K)	360	720	360	1500	68	135	67	270
in troughs	9	18	9	36	2	3	1	6
in lines	5	9	4	18	1	2	-	3
at flow (start)	600	1080	480	2160	120	240	-	360
to end (LPM)	1200	2160	960	4320	240	480	-	720
from	Jan 10	Jan 20	Feb 19		Jan 26	Feb 12	Feb 27	
to	Mar 10	Mar 20	Apr 19		Apr 4	Apr 9	May 4	
FINAL REARING								
fingerlings (#K)	324	648	324	1300	61	121	61	243
in space (m3)	92	184	92	368	17	33	16	66
at flow (start)	1013	2026	1012	4051	179	357	178	714
to end (LPM)	1938	3876	1937	7751	960	1920	960	3840
from	Mar 10	Mar 20	Apr 19		Apr 4	Apr 9	May 4	
to	Apr 29	May 9	Jun 18		May 30	Jun 13	Jun 23	
Produces								
Smolts (#K)	288	576	288	1200	54	108	54	216

Notes - requirements as outlined in Year 1 of the Experimental program
- loading rates as outlined in earlier tables

Table 15. Projected Flow Demand at the Shuswap River Facility for Year 1 of the Experimental Program. (flows in LPM)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
ADULT HOLDING												
Chinook							1000	2000	2380	2380		
Coho										600	600	
Total							1000	2000	2380	2980	600	
INCUBATION												
Chinook	615	150							150	615	615	615
Coho	90	60								30	90	90
Total	705	210							150	645	645	645
INITIAL REARING	(to 2 g)											
Chinook	2000	3600	4200	900								
Coho	120	450	600	720	240							
Total	2120	4080	4800	1620	240							
FINAL REARING	(2 g+)											
Chinook			3500	6000	7751	2000						
Coho				1000	1335	1335						
Total			3500	7000	9086	3335						
TOTALS												
Chinook	2615	3750	7700	6900	7751	2000	1000	2000	2530	3025	1305	705
Coho	210	510	600	1720	1575	1335	-	-	-	630	690	90
GRAND TOTAL	2825	4260	8300	8620	8326	3335	1000	2000	2530	3655	1305	705
WORST CASE EXAMPLE (Chinook to 10 g; Coho to 20 g, both on river water)												
FINAL REARING												
Chinook	-	-	3500	6000	8000	15000	25000	28000	-	-	-	-
Coho	4000	4000	4000	5000	1500	3000	4800	4800	4000	4000	4000	4000
Total	4000	4000	7500	11000	9500	18000	29800	32800	4000	4000	4000	4000
WORST CASE GRAND TOTAL	6825	8290	8300	12620	9740	18000	30800	33800	6530	7655	5305	4705

Note - worst case example is based on rearing at hatchery, not in net pens

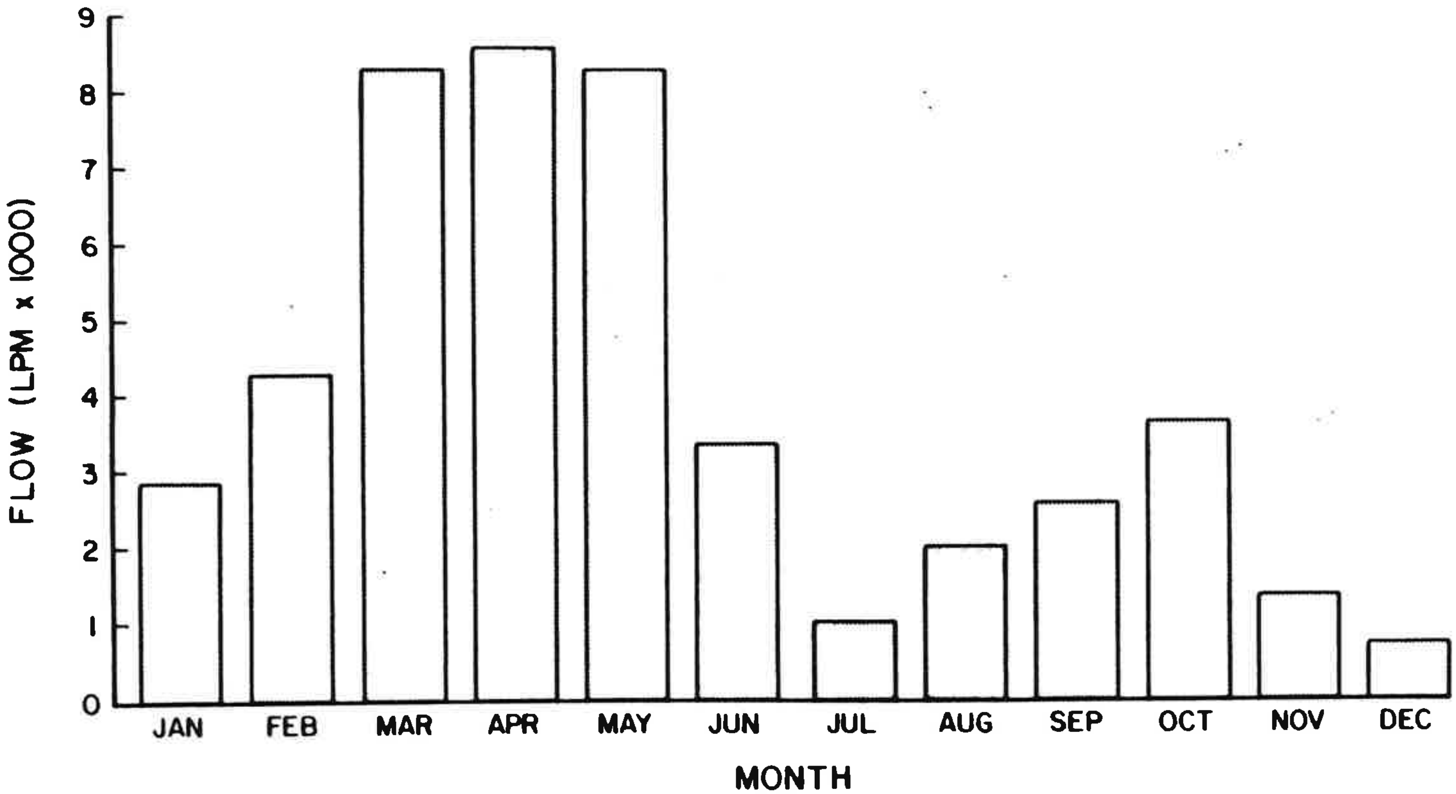


Figure 7 Monthly Flow Demand for Shuswap Experimental Year 1

WATER SUPPLY

WATER QUANTITY

Well Water

For the Pilot water supply, only Well #5 was used. At present, Wells #6, #8, #9 and #10 are in use at the Shuswap Facility. The water characteristics indicate that the wells tap the same aquifer.

The first pump tests on wells drilled to a productive aquifer at Shuswap were conducted in March 1983. Well #5 was tested for 29 hrs at a screen depth of 28 m and a rate of 760 LPM (200 US gpm). Well #4 was tested for 48 hrs at a screen depth of 12 m and a pump rate of 795 LPM (210 USgpm) (Aquaterre, 1983).

For the Pilot operation, Well #5 was used as its temperature was considered more suitable for the desired fish development and growth timing. Well #5 was supplied with a 10 hp pump with a capacity of 750 LPM for the Pilot operation.

Groundwater exploration at the site continued with pumptests on Wells #6, #8 and #9 between March 11-15, 1984. Well #8 was pumped for 48 hrs at a rate of 3028 LPM (800 USgpm). Well #9 was tested for 24 hrs at 2400 LPM (640 USgpm), while Well #6 was tested for 22 hrs at a rate of 960 LPM (254 USgpm). Well #10 was pump tested May 21-22, 1985 (Aquaterre, 1984). All four of these new wells are located near the site of the Experimental facility (Figure 2). Wells #4 and #5, located near the Pilot facility, are no longer in operation and have been capped. Well characteristics of the producing Shuswap wells are presented in Table 16.

Table 16. Well Characteristics at the Shuswap Facility

Well	Casing Diameter (mm)	Screen Locations (m depth)	Pump hp and Type	Maximum Safe Estimated Yield (LPM)
#6	200	25.65	10 submersible	757
#8	200	24.85	32 submersible	3030
#9	200	25.35	18 submersible	1510
#10	200	25.35	26 submersible	1890
Total				7187

Emergency power for all pumps is supplied by a genset located in the mechanical room . Well #6 is connected by a 100 mm diameter supply pipe to the aeration tower. Supply lines for Wells #8, #9 and #10 are 150 mm diameter. Pumps #8, #9 and #10 are equipped with pressure gauges, #6 is not. All have low water probes for automatic shutdown. The flow meters for pumps #8, #9 and #10 are vertical upflow type.

The current total output of the wells is about 5000 LPM less than the yield requested in the design memos and is not adequate to supply all containers on site during final rearing. If all the initial and final rearing raceways were run at flows of 480 LPM and 2000 LPM, respectively, 10880 LPM would be required. If all components of the facility were run at maximum requirements simultaneously, the flow demand would be 12878 LPM. This includes all initial and final rearing containers and the incubation room. Therefore, operations in 1986-87 will therefore necessitate careful container and water distribution management. Provision of at least two additional wells or a large capacity surface water source would be needed to run the facility at full capacity.

Surface Water

The as-built facility is capable of supplying 800 LPM of river water to the incubation room only. The water is pumped from an infiltration gallery near the river by a 6 hp pump to a river water manifold in the incubation room. The infiltration gallery is located to the east of the hatchery site past the toe of the fill area and passes water through a 100 mm diameter pipeline to the hatchery.

The Shuswap River was monitored by Water Survey of Canada (Stn. No. 08LC003) from 1913 to 1973. Mean annual flow was 49.8 m^3/s with a maximum daily discharge of 552 m^3/s on May 28, 1928 and a minimum daily discharge of 0.57 m^3/s on April 27, 1929 (Water Survey of Canada, 1980). The system has been regulated by dams at the Sugar Lake outlet and near the hatchery since 1940.

WATER QUALITY

Well Water

Water quality analysis results from the Shuswap wells are compared to the recommended values for intensive fish culture (Sigma Resource Consultants, MS 1983) in Table 17.

The two wells monitored in March 1983 for the initial Pilot operation (Wells #4 and #5) seemed to be tapping different aquifers. Well #5 produced water of higher mineral content and temperature (8.9oC) that was virtually anoxic (0.4 mg/L oxygen), with detectable ammonia (0.008 mg/L total) and high nitrite (0.099 mg/L) levels. Well #4 produced cooler (7.1oC) water, quite high in dissolved oxygen (8.5 mg/L) with higher nitrate (0.15 to 0.17 mg/L) and detectable nitrite (0.007 mg/L) levels. One of the four samples from Well #4 produced barely detectable levels of chromium (0.013 mg/L) and zinc (0.005 mg/L). The Well #4 aquifer seemed to be more directly influenced by the river while the Well #5 aquifer appeared to contain much "older" groundwater. The waters from both wells were classified as marginal for use as hatchery supplies (Appendix 3).

During operation of the Pilot, there was some concern regarding the amount of iron in the water, which was quite high (up to 0.2 mg/L) but not over the recommended limit of 0.3 mg/L. The iron had little effect on incubation or rearing results. At the eyed stage, eggs had a light coat of rust, but from first shock to hatch, they were disturbed enough by picking that the build-up did not re-occur. Some Shuswap chinook eggs were transferred to the Eagle facility to guard against potential high mortalities caused by the iron precipitate but the eggs at the Shuswap Pilot survived much better than those sent to Eagle, because of water quality problems with the Eagle well water.

In March 1984 pump tests of Wells #6, #8 and #9 water quality for all three wells was similar and probably from the same aquifer. The water quality of these three wells combined the best aspects of the two wells tested previously. There were no anomalous high heavy metal concentrations like Well #4 had exhibited, and no ammonia was detected. Marginally high levels of nitrate (up to 0.2 mg/L) detected in Well #8, and of phosphate (0.2 mg/L) in Well #6 indicated the aeration tower should be shaded to prevent algae growth. The three wells were classified as generally suitable for salmonid culture, with the exception of dissolved gases, which could be corrected by aeration.

Well #10 was pumptested in May 1985 and water quality was comparable to the results from Wells #6, #8 and #9, with one exception. Zinc concentration was slightly above the recommended level (0.01 mg/L versus 0.005 mg/L) in one of the three samples. In general, Well #10 seemed to be tapping the same aquifer as the other three wells and was felt to be suitable for intensive culture of salmonids.

Table 17 . Water Quality Values for the Shuswap Wells.
(Below detection limits = 0)

PARAMETER	(1983->) RECOMMENDED LEVELS	MAR21 1600HR WELL#4	MAR22 0830HR WELL#4	MAR22 1600HR WELL#4	MAR23 1030HR WELL#4	MAR19 1500HR WELL#5	MAR20 0830HR WELL#5	MAR20 1200HR WELL#5
Alkalinity-Tot	20-300	50	50	51	51	78	88	80
Ammonia-Tot	<.002	0	0	0	0	.007	.008	.009
Chloride	<170	.9	.9	.8	.9	.8	.9	.9
Conductivity-fld	150-2000	68	69	69	68	120	132	132
- lab	150-2000	118	117	117	117	179	209	214
Dis.Oxygen(ppm)	6-8	8.9	8	8.3	8.1	.5	.3	.4
Oxygen Saturat.	100%	76	68.9	72.1	70.7	4.5	2.6	3.6
Dis.Tot.Gas	<103%	105.3	102.3	103.2	102.5	90.6	90.4	89.4
Dis.Nitrogen	100%	113.1	114	111.5	111	113.5	113.7	112.2
Hardness	20-400	55.1	53.8	55.1	57.7	89.8	94.6	97.7
Nitrite	<.012	.012	.007	0	0	.099	.017	.011
Nitrate	<.12	.17	.15	.16	.15	.04	.07	.04
pH-FIELD	6.8-8.5	7.15	7.2	7.1	7.1	7.8	7.7	7.7
pH-LAB	6.8-8.5	7.5	7.5	7.4	7.4	7.8	8	8
Phosphate	<.05	0	.005	.007	.007	.022	.022	.022
Res.Filtrable	70-400	84	79	80	72	127	137	136
Res.Nonfilt.	<3	0	0	0	0	0	0	0
Silica	<10-60	3.3	3.4	3.4	3.4	5.9	5.9	5.9
Sulphate	<90	8	7.4	7.1	6.9	15.3	16.7	17
Temperature	4-18C	6.7	7	7.1	7.1	8.9	8.85	8.9
Turbidity	1-60	.1	.1	.2	.2	.8	.8	.8
METALS--								
Al	<.1	0	0	0	0	0	0	0
As	<.5	0	0	0	0	0	0	0
Ba	<1	.009	.008	.009	.009	.016	.018	.018
Ca	4-150	18.6	18.2	18.6	19.5	29.1	30.9	31.9
Cd	<.0004	0	0	0	0	0	0	0
Co		0	0	0	0	0	0	0
Cr	<.01	0	0	.013	0	0	0	0
Cu	<.006	0	0	0	0	0	0	0
Fe	<.3	.01	.006	.038	0	.157	.205	.209
Hg	<.00005	0	0	0	0	0	0	0
K	<50	.78	.78	.81	.79	1.6	1.67	1.69
Mg	<10	2.1	2	2	2.1	4	4.1	4.2
Mn	<.05	0	0	.003	0	.038	.045	.046
Mo		0	0	0	0	.02	0	0
Na	<500	1.2	1.1	1.1	1.2	3.3	3.9	4
P		0	0	0	0	0	0	0
Pb	<.01	0	0	0	0	0	0	0
Se	<2.5	0	0	0	0	0	0	0
Si	<10-60	3.1	3.1	3.2	3.4	5.9	5.5	5.6
Sn		0	0	0	0	0	0	0
Sr		.079	.079	.081	.084	.203	.203	.208
V		0	0	0	0	0	0	0
Zn	<.005	0	0	.005	0	0	0	0

Notes - underlined values indicate results in excess of recommended limits
- all values in mg/L unless otherwise noted

Table 17 (con't). Water Quality Values for the Shuswap Wells.
(Below detection limit = 0)

PARAMETER	RECOMMENDED LEVELS	MAR15/84 1230HRS WELL#6	MAR15/84 2130HRS WELL#6	MAR16/84 0800HRS WELL#6	MAR11/84 1100HRS WELL#8	MAR11/84 2100HRS WELL#8	MAR12/84 0900HRS WELL#8	MAR12/84 2100HRS WELL#8	MAR13/84 0900HRS WELL#8
Alkalinity-Tot	20-300	60	57	57	61	61	63.5	69	76
Ammonia-Tot	<.002	0	0	0	0	0	0	0	0
Chloride	<170	.6	.6	.6	.7	.6	.6	.8	1.1
Conductivity-fld	150-2000	98	97	94	93	101	107	116	133
- lab	150-2000	139.4	141	138	138.4	139.4	147	172	196
Dis.Oxygen(ppm)	>6-8	6.4	7.8	7.3	5.4	5.6	5.8	5.6	5.3
Oxygen Saturat.	100%	56.9	69.4	65	49.2	51	52.8	51	48.3
Dis.Tot.Gas	<103%	93.1	98.2	97.5	95.7	95.5	95.8	96.3	96.2
Dis.Nitrogen	100%	102.8	105.9	106.2	108.1	107.3	107.1	108.3	108.9
Hardness	20-400	65.2	66.1	65.3	67.6	68.2	72.1	81.8	93.6
Nitrite	<.012	0	0	0	0	0	0	0	0
Nitrate	<.12	.11	0	.11	.1	.11	.15	.18	.21
pH-FIELD	6.8-8.5	7.1	7.2	7.2	6.3	6.7	6.5	6.4	6.5
pH-LAB	6.8-8.5	8	7.8	7.8	8	8	8	7.9	7.8
Phosphate	<.05	.003	.003	.024	.003	.003	.003	.002	.002
Res.Filtrable	70-400	94	96	97	92	94	97	107	126
Res.Nonfilt.	<3	0	0	0	0	0	0	0	0
Silica	<10-60								
Sulphate	<90	7.7	7.8	7.6	7.5	7.6	9.8	11.6	15.2
Temperature	4-18C	8.4	8.2	8.2	8.8	8.7	8.7	8.7	8.7
Turbidity	1-60								
METALS—									
Al	<.1	0	0	0	0	0	0	0	0
As	<.5	0	0	0	0	0	0	0	0
Ba	<1	.007	.006	.006	.008	.008	.009	.007	.007
Ca	4-150	22.2	22.5	22.3	23.1	23.3	24.7	28	32
Cd	<.0004	0	0	0	0	0	0	0	0
Co		0	0	0	0	0	0	0	0
Cr	<.01	0	0	0	0	0	0	0	0
Cu	<.006	0	0	0	0	0	0	0	0
Fe	<.3	.016	.016	.016	.019	.009	.008	.009	.006
Hg	<.00005	0	0	0	0	0	0	0	0
K	<50	1.06	.92	.94	1.01	1.03	1.05	1.06	1.12
Mg	<10	2.3	2.3	2.3	2.4	2.4	2.5	2.8	3.3
Mn	<.05	.004	.001	0	0	0	0	0	0
Mo		0	0	0	0	0	0	0	0
Na	<500	1.6	1.7	1.6	1.5	1.4	1.4	1.4	1.5
P		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
Si	<10-60	3.9	4	4	4.3	4.3	4.3	4.3	4.3
Sn		0	0	0	0	0	0	0	0
Sr		.096	.1	.098	.097	.098	.105	.119	.138
V		0	0	0	0	0	0	0	0
Zn	<.005	.002	.003	0	0	0	0	0	0

Notes - underlined values indicate results in excess of recommended limits
- all values in mg/L unless otherwise noted

Table 17 (con't). Water Quality Values for the Shuswap Wells.
(Below detection limits = 0)

PARAMETER	RECOMMENDED LEVELS	MAR13/84 1900HRS WELL#9	MAR14/84 0500HRS WELL#9	MAR14/84 1700HRS WELL#9	MAY21/85 1900HRS WELL#10	MAY22/85 0500HRS WELL#10	MAY22/85 1700HRS WELL#10
Alkalinity	20-300	57	62.5	69	64.6	69.8	71.7
Ammonia	<.002	0	0	0	0	0	0
Chloride	<170	.7	.8	.8	1	1.1	.8
Conductivity-fld	150-2000	98	106	118	109	110	114
- lab	150-2000	135	155	173	168	170	175
Dis.Oxygen(ppm)	>6-8	6.5	6.5	6.5	4.4	4.4	4.5
Oxygen Sarurat.	100%	58.8	59.2	58.8	40.4	40.4	41.3
Dis.Tot.Gas	<103%	97	96.5	96.6	95.6	94.6	95.2
Dis.Nitrogen	100%	107	106.4	106.7	110.6	109.5	109.8
Hardness	20-400	64.6	72.5	80.6	83.3	85.3	89.2
Nitrite	<.012	0	0	0	0	0	0
Nitrate	<.12	.13	.15	.17	.085	.086	.094
pH-FIELD	6.8-8.5	7.1	7.5	7.1	7.5	7.54	7.4
pH-LAB	6.8-8.5	7.9	7.9	8	7.3	7.6	7.8
Phosphate	<.05	.002	.002	.002	0	0	0
Res.Filtrable	70-400	93	108	116	98	99	104
Res.Nonfilt.	<3	0	0	0	0	0	0
Silica	<10-60						
Sulphate	<90	7.6	10.1	12.6	11	11	12
Temperature	4-18C	8.6	8.6	8.7	8.8	8.5	9
Turbidity	1-60				.3	.3	.18
METALS--							
Al	<.1	0	0	0	0	0	0
As	<.5	0	0	0	0	0	0
Ba	<1	.001	.007	.01	.011	.011	.012
Ca	4-150	22.1	24.8	27.6	28.8	29.4	30.8
Cd	<.0004	0	0	0	0	0	0
Co		0	0	0	0	0	0
Cr	<.01	0	0	0	0	0	0
Cu	<.006	0	0	0	0	0	0
Fe	<.3	.01	.006	.006	.01	.008	0
Hg	<.00005	0	0	0	0	0	0
K	<50	1	1.05	1.08	.9	.97	1.04
Mg	<10	2.2	2.5	2.8	2.8	2.8	3
Mn	<.05	0	0	.001	.002	0	0
Mo		0	0	0	0	0	0
Na	<500	1.3	1.4	1.4	1.5	1.5	1.5
P		0	0	0	0	0	0
Pb	<.01	0	0	0	0	0	0
Se	<2.5	0	0	0	0	0	0
Si	<10-60	4.1	4.1	4.1	3.7	3.6	3.8
Sn		0	0	0	.02	.03	.04
Sr		.095	.105	.117	.115	.119	.123
V		0	0	0	0	0	0
Zn	<.005	0	0	0	0	.01	0

Notes - underlined values indicate results in excess of recommended limits
- all values in mg/L unless otherwise noted

Surface Water

Surface water quality was monitored in the area has been conducted since 1982 (Table 18). That year, sampling was done at four different locations; three at Wilsey Dam and one at the hatchery site. At the dam, samples were taken at the surface of the head pond above the dam, inside the powerhouse from Penstock #1 (13.7 m depth) and from Penstock #2 (7.6 m depth).

Ammonia was detected in one sample at Penstock #1 (0.019 mg/L) and once in the forebay (0.006 mg/L) but was not detected in the other samples. Calculation of the un-ionized portion of the total ammonia (upon which the recommended value is based) showed that levels were well within the range recommended for salmonid culture. All other values were within the recommended limits for fish culture. One of three samples from Penstock #1 showed a high chromium value (0.368 mg/L), all other metal concentrations were acceptable and recommended nitrate levels were exceeded in one sample from the headpond (2.11 mg/L). On two occasions total dissolved gas levels exceeded the recommended level of 103%. Aeration of surface water may therefore be required if used for hatchery operations.

River water quality was sampled again in March 1984 at the hatchery location. High levels of dissolved gases were detected (up to 106.5% dissolved nitrogen), and the recommended levels of nitrate were exceeded marginally (0.13 mg/L). All other results were acceptable.

Concurrent with sampling during the May, 1985 Well #10 pumptests, the river was sampled during a spring freshet. Results were similar to those of earlier samples, but some parameters were different. This water had lower alkalinity, sulphate and conductivity compared to the previous samples. Field pH values were slightly acidic and turbidity values were considerably higher, no doubt attributable to freshet. Phosphate levels (0.115 mg/L) during freshet were well outside the recommended limits, and high enough to accelerate algal fouling. Ammonia (0.010 mg/L) also exceeded that recommended. Both total dissolved gas (106.3%) and dissolved nitrogen (109.1%) were above the recommended limits. Levels of aluminum (0.61 mg/L), iron (0.82 mg/L), zinc (0.007 mg/L) and manganese (0.064) also were above the recommended limits.

The river water is characterized as moderately soft (total alkalinity 42-50 mg/L, conductivity 102-136 umhos/cm, hardness 49-65, mg/L) and slightly alkaline (pH 7.4-8.4), and would be suitable for intensive culture of salmonids with aeration. The situation would be improved if use of surface water was avoided during freshets.

Table 18. Water Quality Values for the Shuswap River
(Below detection limits = 0)

PARAMETER	RECOMMENDED LEVELS	BESSETTE CREEK JULY25/82	WILSEY DAM FOREBAY APR4/84	WILSEY DAM FOREBAY APR29/84	WILSEY DAM FOREBAY JUNE2/84	PEN45#1 MAR31/82	PEN25#2 MAR31/82	HEADPOND OCT26/82
Alkalinity-Tot	20-300	70.5	42	44	42	51	50	45
Ammonia	<.002	<0.005	<0.005	.006	<0.005	0	0	0
Chloride	<170	-	<0.5	-	.8	.7	.9	0
Conductivity-fld	150-2000	174	104.6	107.6	102.2			
- lab	150-2000					123.9	122.8	103
Dis.Oxygen(ppm)	>6-8	8						
Oxygen Saturat.	100%					82.54	87.55	79.37
Dis.Tot.Gas	<103%	>110%				102.27	100.67	104.13
Dis.Nitrogen	100%					106.21	105.51	110.74
Hardness	20-400	80.9	4.85		49.2	53	52.9	50.1
Nitrite	<.012	.009	<.005	<.005	<.005	0	0	0
Nitrate	<.12	.1	.08	.07	.18	.08	.13	.03
pH-FIELD	6.8-8.5	7.4	7.8	7.4	7.5			7.75
pH-LAB	6.8-8.5					7.9	7.8	7.8
Phosphate	<.05			.005	.018	.005	0	.006
Res.Filtrable	70-400	134	74	74	76	53	52.9	50.3
Res.Nonfilt.	<3	<5	<5	24				
Silica	<10-60					3.5	3.4	2.8
Sulphate	<90		6.4	6.7	6	8.3	8.4	6.8
Temperature	4-18C	18				2	3	9
Turbidity	1-60		.2	.1	4.6	.2	.2	.1
METALS								
Al	<.1	.16	<.05		.14	0	0	0
As	<.5					0	0	0
Ba	<1					.009	.009	.009
Ca	4-150					17.4	17.4	17.1
Cd	<.0004	<0.0005	<.002	<.005	<.002	0	0	0
Co						0	0	0
Cr	<.01	<0.005				.368	0	0
Cu	<.006	<0.001				0	0	0
Fe	<.3	.363				.043	.037	.042
Hg	<.00005	<.0002	<.00005	<.00005		0	0	0
K	<50		.9	.79	.81	1.02	.85	.79
Mg	<10					2.3	2.2	1.8
Mn	<.05	.037				.003	.003	0
Mo						0	0	0
Na	<500					1.3	1.3	1.2
P						0	0	0
Pb	<.01	<0.001	<.02	<.001	<.02	0	0	0
Se	<2.5	<0.05				0	0	0
Si	<10-60					3.1	3.1	2.6
Sn						0	0	0
Sr						.079	.08	.075
V						0	0	0
Zn	<.005	<0.002				0	0	.004

Notes - underlined values indicate results in excess of recommended limits
-all values in mg/L unless otherwise noted

Table 18 (con't). Water Quality Values for the Shuswap River
(Below detection limits = 0)

PARAMETER	RECOMMENDED LEVELS	PEN45#1 OCT26/82	PEN25#2 OCT26/82	PEN45#1AT FEB08/83	RIVER ISLAND AT MAR22/83	RIVER ISLAND AT MAR12/84	RIVER ISLAND MAR14/84	RIVER 0600 MAY22/85
Alkalinity-Tot	20-300	45	45	48	47.5	55	56	34.3
Ammonia-Tot	<.002	0	0	.019	0	0	0	.01
Chloride	<170	0	0	.6	.8	.6	.9	.09
Conductivity-fld	150-2000					79	78	54
- lab	150-2000	104	104	129	107	131.8	136	83
Dis.Oxygen(ppm)	>6-8				12.1	13.6	13.2	10.9
Oxygen Saturat.	100%	75.37	80.87		95.7	106.5	103.8	100
Dis.Tot.Gas	<103%	102.43	101.05		105	101.7	101.4	106.3
Dis.Nitrogen	100%	109.65	106.45		107.5	106.5	103.8	109.1
Hardness	20-400	50.3	49.3	60.4	49.9	63.3	65.4	44.9
Nitrite	<.012	0	0	0	.005	0	0	0
Nitrate	<.12	.03	.02	2.11	.11	.12	.13	.115
pH-FIELD	6.8-8.5	8	8.25		7.35	6.85	6.8	6.85
pH-LAB	6.8-8.5	7.8	7.8	7.7	7.8	7.7	7.6	7.4
Phosphate	<.05	.007	.006	.01	.008	.005	.008	.115
Res.Filtrable	70-400	50.3	49.3	90	79	90	102	56
Res.Nonfilt.	<3			0	0	0	0	106
Silica	<10-60	2.8	2.8	3.5	3.3			
Sulphate	<90	6.7	6.7	7.8	6.7	9.1	8.9	5
Temperature	4-18C	13	10		3.7	2.95	2.6	8.5
Turbidity	1-60	.1	.1	.1	.5			33
METALS								
Al	<.1	0	0	0	0	.06	.1	.46
As	<.5	0	0	0	0	0	0	0
Ba	<1	.009	.009	.009	.009	.011	.007	.019
Ca	4-150	17.1	16.7	20.8	16.6	20.8	21.2	14.1
Cd	<.0004	0	0	0	0	0	0	0
Co		0	0	0	0	0	0	0
Cr	<.01	0	0	0	0	0	0	0
Cu	<.006	0	0	.003	0	0	0	0
Fe	<.3	.026	.027	.028	.04	.065	.113	.45
Hg	<.00005	0	0	0	0	0	0	0
K	<50	.81	.79	.8	.79	1.05	1.09	1
Mg	<10	1.8	1.8	2	2	2.6	2.8	1.5
Mn	<.05	.004	.003	.003	.005	.006	.009	.015
Mo		0	0	0	0	0	0	0
Na	<500	1.2	1.1	1.2	1.1	1.4	1.4	.9
P		0	0	0	0	0	0	0
Pb	<.01	0	0	0	0	0	0	0
Se	<2.5	0	0	0	0	0	0	0
Si	<10-60	2.6	2.6	3.1	3.1	3.7	3.8	4.2
Sn		0	0	0	0	0	0	.01
Sr		.073	.072	.007	.072	.095	.098	.062
V		0	0	0	0	0	0	0
Zn	<.005	0	0	.002	0	0	0	.007

Notes - underlined values indicate results in excess of recommended limits
-all values in mg/L unless otherwise noted

WATER TEMPERATURE

Water temperatures collected from the Shuswap wells and the Shuswap River are summarized in Table 19.

Well Water

During their pump tests, the water from Well #4 was 7°C, while that from Well #5 was 9°C. Due to the greater influence of the river on Well #4, it was decided to use Well #5 for the Pilot operation in order to provide a greater flexibility in rearing strategy. Water temperatures in Well #5 were recorded with a Ryan thermograph from July to mid December, 1983 by DFO. During this period, the temperature ranged from 8.3°C to 10.9°C with the highest mean monthly temperature (10.7°C) occurring in September. Monitoring of pumped water from Well #5 from March 1984 to the end of the Pilot phase indicated a constant temperature of 9°C.

During pump tests in March 1983 and 1984, water temperatures averaged 7.0, 8.9, 8.2, 8.7 and 8.6°C in Wells 4, 5, 6, 8 and 9, respectively. These differences are probably related to the distances of each well from the recharge source, the Shuswap River. Long term high yield pumping could alter the apparent high temperature profiles of these wells.

Surface Water

Water Survey of Canada (1977) has recorded spot temperatures in the middle Shuswap River since 1949. Based on these spot temperatures, the average monthly temperature in the middle Shuswap River would be lowest in January at about 1.0°C and highest in July and August at about 15°C. In 1982, DFO installed a Ryan thermograph in the Shuswap River. Temperatures increased from 2.0°C at the end of March to 12.0°C in early June.

Temperatures behind Wilsey Dam were monitored in late 1982 and early 1983 by DFO. Ryan thermographs recorded temperatures near the surface (1.0 m) and at 8.0 m depth. Temperatures were similar at the two depths, the deeper water being slightly warmer (1.0°C) than surface water over winter.

Table 19. Summary of Water Temperatures Recorded at the Shuswap Facility.

SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Well #5[a]												
Min						8.3	8.3	9.2	10.0	9.5	9.5	9.5
Mean						8.6	8.8	10.1	10.7	9.8	9.8	9.5
Max						8.9	9.5	10.8	10.9	10.4	10.4	9.5
Shuswap River at Lumby[b]												
Min	0.0	0.0	1.0	1.8	3.5	6.5	9.5	10.0	9.0	9.0	0.0	1.0
Mean	0.7	0.7	2.6	4.8	7.2	11.2	14.6	13.8	14.1	9.0	3.6	3.0
Max	2.0	1.5	6.5	8.3	11.8	13.5	17.0	18.5	16.5	13.5	5.5	4.5
Wilsey Dam (1.0 m depth)[c]												
Min	0.2	0.5	0.5	2.0	4.0	8.0	10.0			5.0	0.5	0.2
Mean	0.5	1.0	2.0	4.0	8.0	11.0	12.0			6.5	3.0	1.0
Max	1.0	2.0	4.0	8.0	12.5	14.5	14.5			8.0	6.0	2.5
Wilsey Dam (8.0 m depth)[c]												
Min	0.5	1.0	1.5	4.0	5.5	9.5				6.0	0.5	0.5
Mean	1.5	2.5	3.5	6.0	9.0	12.0				7.5	3.5	1.5
Max	2.5	3.5	6.0	9.0	13.5	14.0				9.0	7.0	3.0

[a] from Shuswap Pilot Hatchery records
[b] from Water Survey of Canada, 1977
[c] from MacKinlay, MS 1984

SUPPORT STRUCTURES

Hatchery Building

The as-built hatchery building layout (Figure 8) was designed specifically to accommodate expansion to a production level greater than that required to meet the Experimental needs. It has an overall size of 17 m by 24 m (408 m2) and contains an incubation room, a tagging room, a mechanical room, a storage room, a workshop, two offices, a lab, a lunchroom, separate men's and women's washrooms and an entrance lobby. A comparison of the floor space provided with that of other recent SEP facilities is given in Table 20.

Table 20. Building Component Sizes - Shuswap Compared to Other Recently Constructed SEP Facilities (m2)

Facility	Egg Capacity (M)	Office Area	Lab. Area	Work shop Area	Storage Area	Lunch Room Area	Lobby Area	Wash Room Area
Shuswap	2.3	27	10	61	22	11	11	12
Clearwater	4.5	42	26	72	72	23	10	28
Eagle	6	41	26	72	40	23	11	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 (excluding Shuswap)		40	32	99	68	21	11	21

The incubation room, measuring 9.9 m by 8.5 m (84 m2), has the capacity for three complete banks of incubator tray stacks, capable of holding a total of 108 eight-tray stacks. It is plumbed to supply well or river water. The incubation room also contains two large stainless steel sinks for tray cleaning.

The rearing room measures 8.5 m x 13.5 m (115 m2) and contains five lines of Capilano troughs. The room is plumbed to receive well water only.

The mechanical room, measuring 5.2 m by 6.8 m (35 m2), contains the emergency power genset, aeration tower control panel, electrical panels and three domestic water supply tanks.

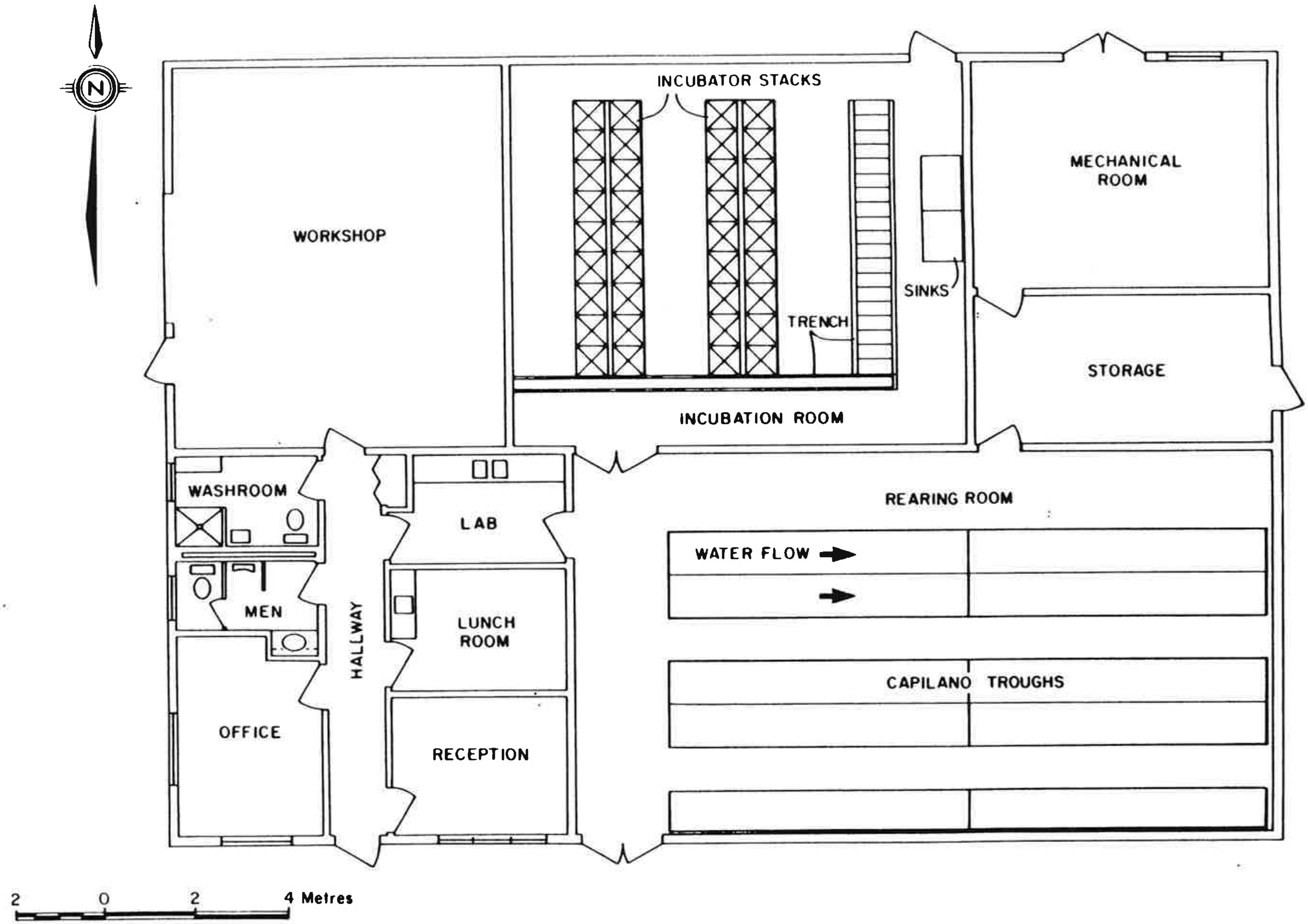


Figure 8 Shuswap River Hatchery Building Layout

The storage room measures 3.3 m by 6.8 m (22 m^2) and is used to store items such as raingear, a snow blower and power washer.

The workshop, measuring 8.4 m by 8.6 m (72 m^2), has both an overhead roll-up door and man door access. Power equipment housed here includes two household freezers, a radial arm saw, portable generator, welder and drill press. The workshop area should be supplied with circuits higher than 15 amp as these are now tripped with the operation of the power tools.

The two offices measure 4.1 m by 3.2 m (13 m^2) and 3.2 m by 4.5 m (14 m^2), respectively. One office is used as a reception area and contains a couch; the other is used for administrative purposes and contains one desk.

The lab, measuring 2.5 m by 4.0 m (10 m2), contains a full-length laboratory workbench with a double sink with cupboards below and a dissection microscope.

The lunchroom, measuring 2.8 m by 4.0 m (11 m2), contains a table, three chairs, cupboards, a sink and a fridge.

Separate men's and women's (wheelchair) washrooms are provided, the latter contains a shower.

The lobby (actually a hallway) measures 1.3 m by 8.3 m (11 m^2). This area is not used for any specific purpose at present, but could serve as a location for public information displays in the future. It houses the process alarm cabinets (intrusion, fire, low water and low aeration) which are linked to a dialer.

Crew Residence

No crew residence was provided at the facility. Security is currently provided by hatchery personnel who live next to the site.

Fishway

There is no fishway at the facility at present, but one could be constructed to the Shuswap River. At its nearest point to the facility, the distance to the river is 100 m. The elevation difference between the hatchery pad and the river is approximately 4 m.

Freezer Building

The freezer building is located to the west of the concrete raceways (Figure 1) and is used for fish feed storage. The building measures 3.7 m wide by 9.3 m long, with the first 1.8 m of length from the entrance doorway used as the cooler. This gives 28 m^2 of freezer and 6.5 m^2 of cooler space. The freezer could reasonably accommodate approximately 500 bags (11,500 kg) of fish food.

Effluent Area

Effluent water from the Capilano troughs and incubation room empties into a 375 mm diameter line, which connects to the main 900 mm diameter raceway drain pipe which discharges to the normally-dry river flood channel to the north of the raceways.

The existing area will provide adequate drainage for the facility during Experimental operations, but may have to be formalized with provision of a separate sludge lagoon for cleaning wastes in the future.

Pump Houses

There are three pump houses enclosing each of the wells #8 and #9 and #10 at the as-built facility. Well #6 does not have a pumphouse and is controlled directly from the mechanical room. Each pumphouse is equipped with the necessary valves and electric controls for the pumps, as well as a bypass valve used to clear out the wells and lines upon start-up.

Site Fencing

There is no site fencing at the Shuswap hatchery. At least token fencing should be erected to discourage the curious during off hours.

The access road is secured by a wooden swing gate at property line, which can be easily bypassed on foot. A culvert is needed to drain run-off under the access road. Meltwater currently runs over the road during spring.

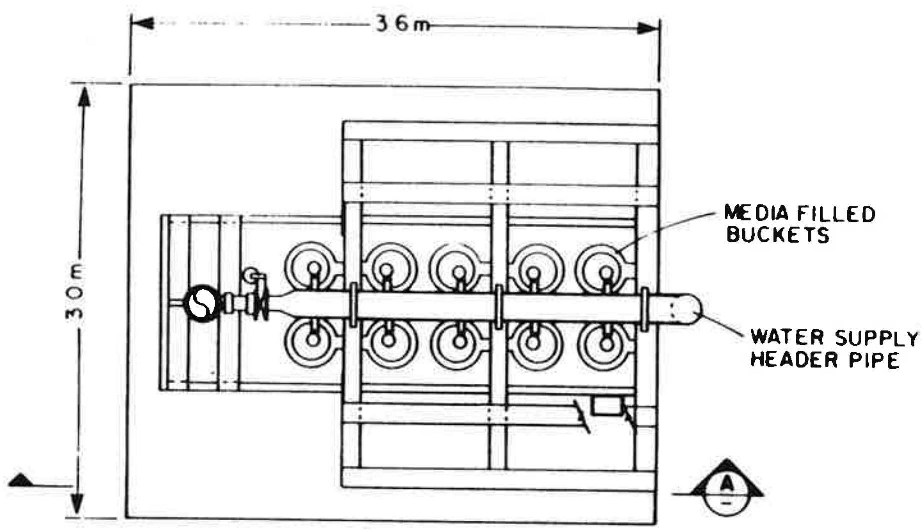
Aeration Towers

The aeration tower (Figure 9) serves two purposes: aeration and stripping of well water to improve gas characteristics, and supplying sufficient head to ensure distribution throughout the hatchery facility. The number of buckets it contains was determined by entering raw well water gas pressures into the Aeration Model (Appendix 5).

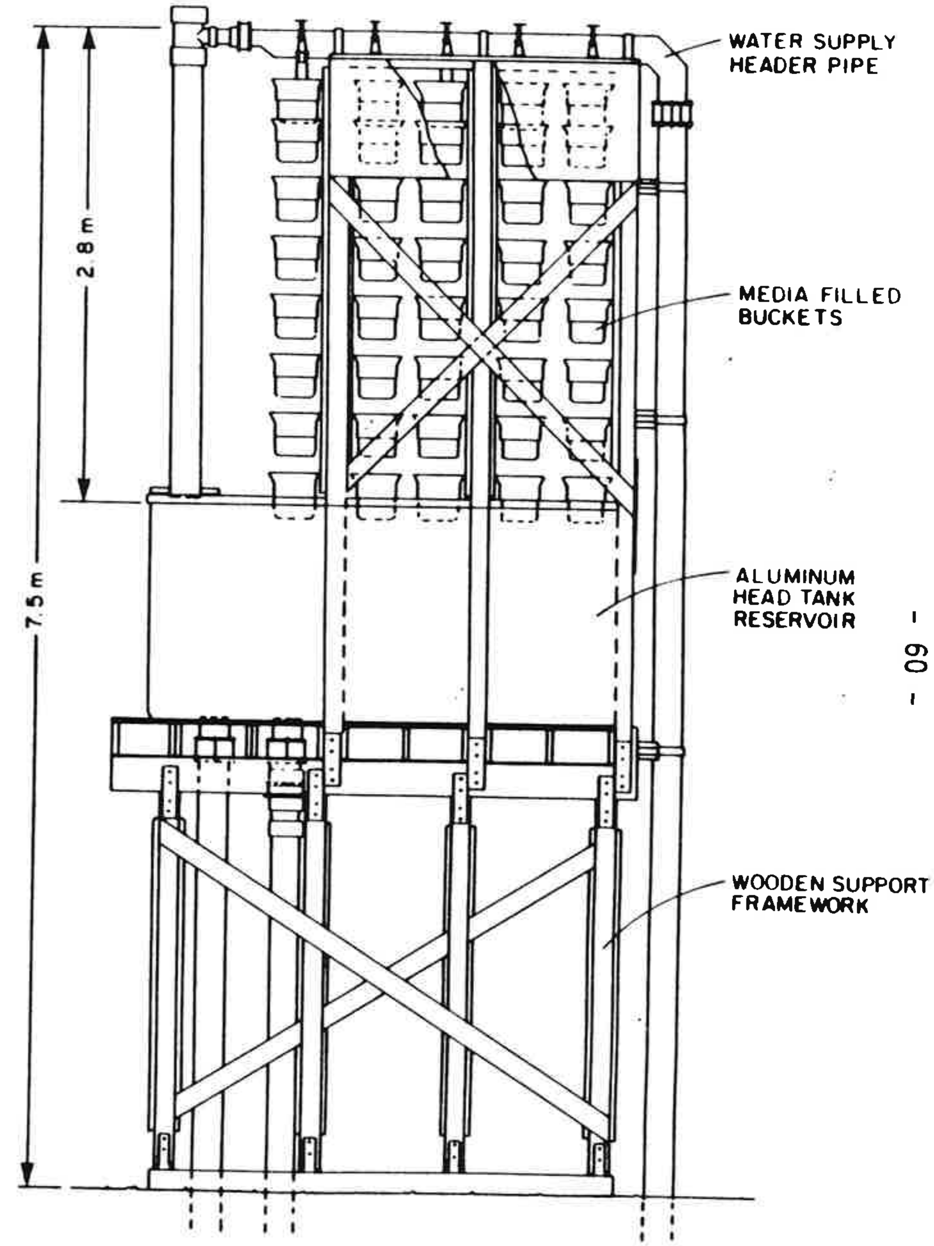
The original aeration tower constructed for the Pilot facility was located near the Pilot building. It was sheathed in plywood and had some vertical staggered ventilation strips. That structure has now been removed. The new tower is situated to the west of the hatchery building with the three pump houses clustered near it. The tower contains two rows of five aeration bucket columns, each column with eight buckets filled with media. Water is supplied to the columns by a 200 mm diameter aluminum header pipe.

The structure is wooden and supported by wooden posts and cross bracing from below. It is anchored to a concrete pad by corrosion proof steel column bases.

The aluminum reservoir in the tower has a usable volume 5.4 m3 and supplies aerated water via two 200 mm supply lines to all facilities on-site. It was



PLAN



SECTION A

Figure 9 Shuswap River Aeration Tower Details originally used at the Eagle River facility until a new tower was built there in 1984.

This tower was designed as a temporary structure which will serve the immediate needs of the Experimental facility but which will have to be replaced if the facility is expanded.

CONCLUSIONS

The Shuswap River Salmonid Enhancement Facility was constructed to test production strategies for chinook and coho salmon enhancement in the Shuswap River area of the B.C. central interior. It is therefore more important for this facility to test a number of different rearing and outplanting options than it is to attempt to produce large quantities of fish by committing to a few set strategies. Rehabilitation of local stocks to levels that will significantly benefit the various fisheries has to be approached cautiously, given the current lack of knowledge.

Expansion and construction of the Shuswap hatchery from the original small scale pilot to the as-built facility has resulted in considerable increase in the capacity for handling fish and servicing the experimental needs for target stocks of coho and chinook. Expansion was originally proposed to provide the facility with incubation and container space to handle 1.9 million eggs and 1.3 million juveniles. The as-built facility however, cannot accommodate these numbers, and a variety of components would require expansion to meet these objectives. This means that fewer experiments can be done in any one year.

Most limiting is the fact that the as-built facility can only provide 7187 LPM of groundwater and 800 LPM of river water (the latter to the incubation room only). This is insufficient flow to supply the containers currently on site if all were operating simultaneously. Therefore, the provision of more flow should be rated as the number one priority at Shuswap for future development. As the aquifer has been assessed as having a 12,800 LPM maximum capacity, river water is probably the most readily available alternate source.

Adult collection methods for chinook need to be improved, since the staff experienced brood stock acquisition problems during the Pilot operation. Difficulties are also anticipated for the collection of Lower Shuswap coho. One solution would be fence construction on the lower Shuswap, but the river is large and this approach may be difficult. A more realistic method may be to angle brood stock from holding areas early in the runs and hold them to maturity at the hatchery (G. Conway, pers. comm.).

In 1984, adult chinook were held at the Eagle River hatchery for up to three weeks in 9°C wellwater. That season, pinheading and drop-out were a problem, but not in 1985-1986, when the Shuswap fish were captured ripe and spawned at the capture location. Perhaps holding the fish in cold well water may cause unnatural egg development and pinheading. If these problems re-occur when adults are held on well water at Shuswap, this should be further investigated.

The site has good expansion potential, in that the property fill area can be extended, creating more area for additional initial and final rearing raceways. The provision of sufficient flow will be the limiting factor in determining the Ultimate size and enhancement production from this facility.

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ACKNOWLEDGEMENTS

The Shuswap River Facility project design team was composed of the following individuals:

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APPENDICES

APPENDIX 1. DESIGN MEMOS

Government of Canada   Gouvernement du Canada

APPENDIX 1a. Pilot Design Memo

SECURITY · CLASSIFICATION · DE SÉCURITÉ	
OUR FILE / NOTRE RÉFÉRENCE	5903-85-S160
YOUR FILE / VOTRE RÉFÉRENCE	
DATE	January 20, 1983.

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Sr. Implementation Engineer
SEP Engineering

B.G. Shepherd
New Projects Coordinator
D.D. MacKinlay
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SEP Operations

SUBJECT / OBJET **SHUSWAP RIVER PILOT PROJECT**

Table 1 gives the general container requirements for a pilot facility to handle 110,000 chinook salmon of the Shuswap River for outplanting at 2 gram size into the Middle Shuswap River above the Wilsey Dam near Lumby, British Columbia.

Due to the small size of this facility, and the imcompleteness of water temperature and water quality data to date, no attempt has been made to try to incorporate the pilot into a full scale facility design. For a facility this small, the reusable metal building approach would probably be most suitable, perhaps combining the two Kelly Closures from Adams and Finn.

Part of the building should be designed for bench-top work for fish sampling and record keeping, lab analysis and report writing, and should be lighted and heated as a office/lab. Small hose bibs should be provided about the facility for washdown, tagging, and sampling work. A fridge and freezer (10 ~ cu ft) are also required for storage of feed, chemicals, and fish samples.

Since the water quality characteristics of the source water are not yet known, provision should be made to aerate all water before distribution, including that going to hose bibs.

We hope this information is sufficient to serve preliminary engineering design needs. If there are any questions please contact us anytime.

B.G. Shepherd

D.D. MacKinlay

DDMACK/mmm

Att. (1)

c.c. F.K. Sandercock

Table 1. Container Requirements for Shuswap River Pilot Project.

Production	Eggs	110K
	Fry	99K
	Outplanted Fry	89K
	Adult Return	1.8K
Incubation	Trays	22
	Stacks	3
	Regular Flow (LPM)	45
	Flush Flow (LPM)	57
Rearing	Troughs	2
	Lines	1
	Start Flow (LPM)	120
	End Flow (LPM)	240

Criteria

Fish: chinook salmon; outplant at 2 gram size.

Survivals: 90% eggs to fry; 90% fry to outplant; 2% outplant to adult.

Containers: 5K eggs/tray, 8 trays/stack, 15 LPM/stack (19 LPM flush).

57K fry/trough, 2 troughs/line, flows:120 LPM (start), 240 LPM (end).

Appendix 1b. Experimental Pilot Proposal

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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 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] (Spring)	none	100K	150K
		1 day	100K	150K
		1 week	100K	150K
			300K	450K
	5g (Spring)	none	50K	80K
		1 day	50K	80K
		1 week	50K	80K
		1 month	50K	80K
			400K	320K
Coho	2g[a] (Spring)	none	100K	150K
		1 day	100K	150K
		1 week	100K	150K
			300K	450K
	5g+[a] (Fall)	none	75K	120K
		1 day	75K	120K
		1 week	75K	120K
			225K	360K
	10g+ (Spring)	none	25K	50K
		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.

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(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 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) <u>The South Thompson area--Eagle and Shuswap facilities (Table 7)</u>. 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) <u>The Lower Thompson area facility at Spius Creek (Table 8)</u>. 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

c.c. C.N. MacKinnon
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Table 1. Prior rationale and targets for Thompson area pilots.

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

Area	System	CHINOOK Proposed Increment[a]	CHINOOK Average Escapement[b]	CHINOOK Broodstock Limits[c] No. of Females	CHINOOK Broodstock Limits[c] No. of Eggs	COHO Proposed Increment[a]	COHO Average Escapement[b]	COHO Broodstock Limits[c] No. of Females	COHO Broodstock Limits[c] 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	500K	500K	200K	200K	
	SUBTOTAL					3600		3250		and 2 high-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-	0	400K	0	225K	
	BLUE	(5g)	600	700	1500	825	(time & size, US rel.)	0		priority items 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 1c. Gross Sizing of Experimental Phase

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SECURITY · CLASSIFICATION · DE SECURITE
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.

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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 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	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
[illegible]										
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 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	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/m^3 for 5 gram fish
- 17 Kg/m^3 for 10 gram fish
- 21 Kg/m^3 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

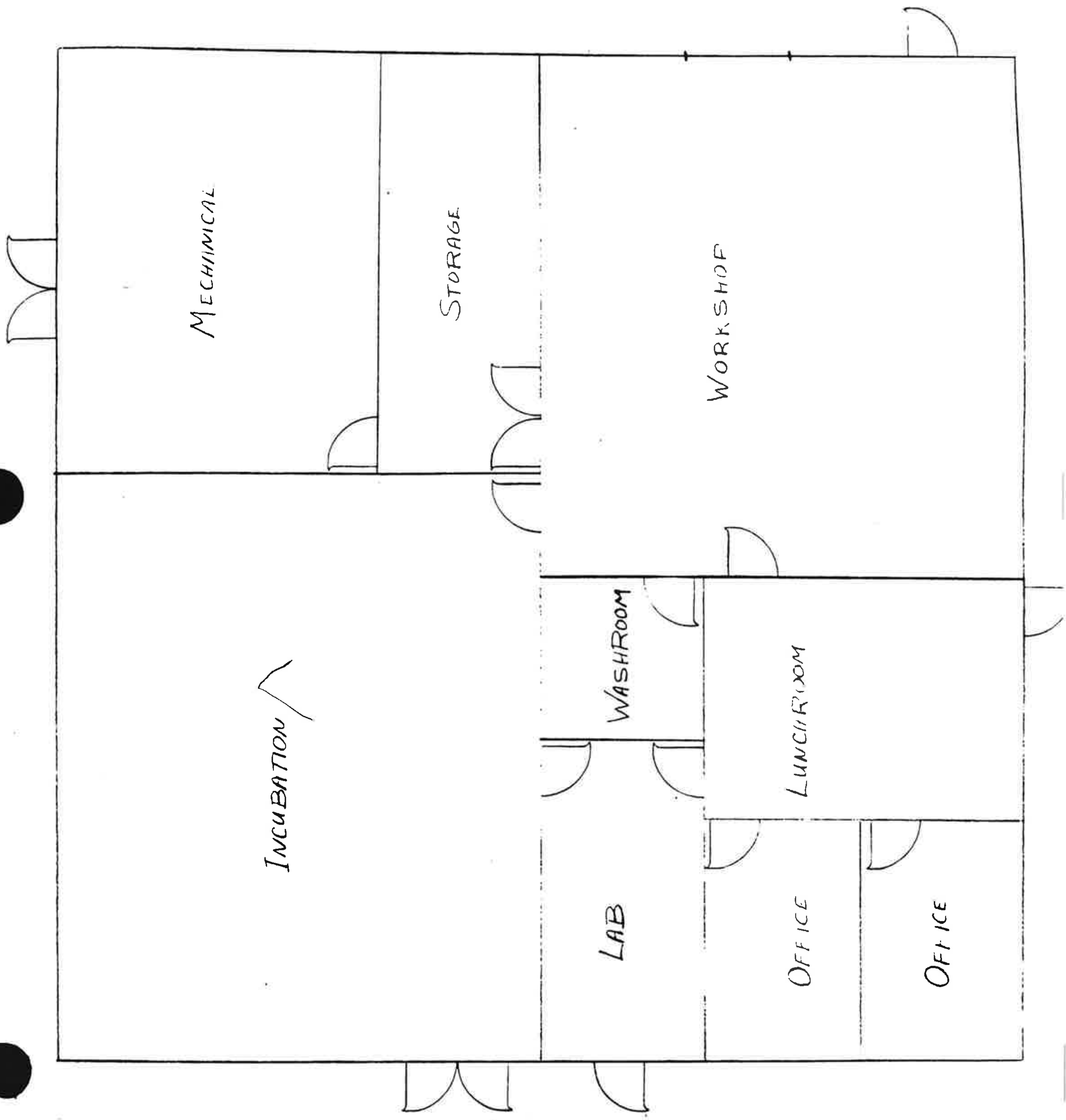
* Values derived using LOAD RATE model

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



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APPENDIX 1d. Detailed Flow for Experimental Plan

TO / À:
B. B. Shepherd
New Projects Coordinator
S.E.P.

FROM / DE:
Don D. MacKinlay
Design Biologist
S.E.P.

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE: 5830-85-T85

YOUR FILE/VOTRE RÉFÉRENCE:

DATE: September 24, 1984

SUBJECT / OBJET: WATER DEMAND FOR EXPANDED SHUSWAP PILOT FACILITY

As per your verbal request, this memo adds to the computations in my memo to you of October 7, 1983 (on this file) on the biological requirements for expansion of the Shuswap pilot facility.

OBJECTIVES

A detailed rationale for expansion of the Shuswap pilot is contained in your memo of September 4, 1983 (on this file). In summary, expansion is meant to provide an experimental program that tests several operational strategies each year. This should guard against failure of adult returns if an inappropriate strategy is tested. The maximum targets proposed for the Shuswap expanded pilot are 1.9M eggs and 1.3M juveniles (Table 1). Species mix and number of stocks per species will vary each year within the guidelines that chinook (CN) from the Middle and Lower Shuswap River and coho (CO) from Wap and Bessette Creeks and the Lower Shuswap River be used. Separation into several fish culture lots is also required.

Because a flexible experimental program has been proposed, water demand can only be approximated for the expanded pilot. This memo presents the maximum water demand for the operation as laid out by you for the first two years of operation (CN and CO reared to 5 g), as well as the demand for an 'extreme' case (CN to 10 g, CO to 20 g).

In summary, this memo proposes a facility with 48 stacks of Heath trays, six lines of Capilano troughs, seven large initial rearing troughs and five rearing raceways (each 30 m long by 3 m wide by 1.3 m deep). Provision should be made to add three more final rearing raceways without replumbing.

BIOLOGICAL REQUIREMENTS

Unless stated otherwise, my memo of October 7 is used as a basis for the following outline.

ADULT HOLDING

Equipment

- Requirements are given in Table 2. Three of the final rearing raceways (two for CN, one for CO) would provide enough holding facilities for all the stocks to be handled at the Shuswap Pilot.

- Total broodstock requirements for the proposed two year study are 512 chinook and 192 coho. This assumes broodstock fecundities of 6000 for chinook and 2500 for coho and a sex ratio of 1F:0.6M.

- If either a pre-spawning mortality of 25% or a more genetically balanced (according to Dr. B. Riddel) sex ratio of 1:1 were used, broodstock requirements would be raised to 640 CN and 240 CO.

- It is expected that adult holding of the satellited stocks would be done within the donor systems, but that the final rearing raceways would be used for the Middle Shuswap River broodstock.

Flows

- Maximum flow required is about 4000 LPM (Table 2).

- The flow and volume capacities of 10000 LPM and 450 cu.m. provided for rearing would allow for holding 1200 kg of adults, using loading criteria of 1.2 kg/LPM and 32 kg/cu.m. Assuming an average adult weight of 5 kg for chinook and 3 kg for coho, up to 2880 chinook or 4000 coho could be held in the raceways if no rearing occurred at the same time.

Timing

- Chinook would be held between late July and mid October, while coho holding would span from mid October to the end of November (Table 3). These estimates are based on the spawning timing reported by the fishery officers (Table 4).

- Early chinook holding would probably have to be on well water since the river water temperatures exceed 15°C in the summer (Table 5).

- The spawning periods for the two species overlap in late October (Table 4), requiring concurrent holding.

- Overlap between adult holding and rearing would occur if rearing were to continue through the summer and fall. The critical time would be in July and August when chinook adult holding was required and all the rearing containers would be filled to capacity. Unless some rearing was carried out off site (such as in net pens in the river or lakes), separate adult holding containers would have to be built. These would require the dimensions and flows outlined in Table 2. Water supply should be both well and river water.

INCUBATION

Equipment

- Eight-tray vertical stacks are to be used exclusively (bulk incubators would decrease the number of separate lots possible). Tray loadings are 5000 CN eggs per tray and 8500 CO eggs per tray. Using the species mixes proposed for the first two years of operation (Table 1), 47 stacks are required (Table 6).

- To improve flexibility for time-and-size of release experiments, provision of heated water to one bank of stacks is suggested. The advantages of this option are discussed under Timing, below.

Flows

- Using routine and flush flows of 15 and 19 LPM per stack, maximum flows would be 705 and 893 LPM, respectively (Table 6).

- Although surface water is too cold for incubation during the winter (Table 5) for the operation strategies planned, an emergency back-up supply to incubation would be desirable in case of loss of the pumped well water supply.

Timing

- The period of incubation would be from September to February for chinook and from October to February for coho (Table 3). This assumes that groundwater is used for incubation (essential) and that the groundwater temperature profile is that shown in Table 5 (9°C all year). Since the wells on site have not been monitored at operational pumping rates over the expected incubation period, changes from the predicted timings are possible.

- It may be advantageous to cool some of the coho incubation water with surface water during the winter. Even if early spawned coho were incubated exclusively on surface water, swim-up would not occur until mid June the following year (at an average temperature of 3.5'C for the whole period) (Table 7). This option would only be suitable if coho were to be reared for a full year (to 20 g). However, if water temperatures were adjusted to only delay coho swim-up until mid March (requiring an average temperature of 5.7'C for the period), fry could still be released at 2 g in May, 5 g in July or 10 g in September. In this case, double use could be made of the initial rearing containers because chinook would have already been moved to final rearing.

- Conversely, heating of the incubation water for chinook would gain some timing advantage through acceleration of egg development (Table 8). This would allow time to grow larger chinook (to 10 g) in time to meet the natural fry migration by early May.

INITIAL REARING -Ponding to 2g.

Equipment

- An arbitrary limit of 20 lines of troughs has been set for the Interior pilot facilities. This falls short of the 22 lines required for Shuswap (Table 9), based on the loading criteria of 55K CO or 40K CN per trough at ponding. It is expected that this shortfall can be made up by careful management of the timing of ponding and transfer of different groups of fry of the two species by the operator (see the second item under Timing, below).

- If the experimental large initial rearing units planned for other pilots are used at Shuswap, a good combination would be to have seven large troughs and six lines of normal size troughs (equivalent to 20 normal lines). This number ensures that enough flexibility is maintained to handle both large and small groups of fish. The large units are assumed to be 1.2m wide, 1.2m deep with 0.9m water depth and 12 m long.

Flow

- Flow requirements per normal line of two Capilano troughs are 120 LPM at ponding and 240 LPM at fry transfer. Flows per line would be doubled if the large starter units are used. This results in a total maximum flow demand of 4800 LPM for initial rearing (regardless of container) (Table 9).

- Back-up surface supply of at least 250 LPM per line of conventional troughs (500 LPM per large starter unit) is recommended. This is about the limit that the standard drain plumbing from Capilano troughs can handle. Greater flow than the normal 240 LPM per line is requested because it is expected that these containers will be used in the future for rearing on surface water during the summer, when water temperatures are quite high.

Timing

- Initial rearing is expected to span from January to March for chinook and from January to April for coho (Table 3). These timing estimates are based on rearing on well water at 9°C.

- River water is too cold to initiate rearing until May (Table 5), well after all stocks would be ponded. If coho incubation were delayed using surface water, the temperature of the mix would have to be gradually increased up to over 6°C during the weeks before ponding to ensure a good initial feeding response.

- If coho incubation is delayed such that swim-up does not occur until mid March, double use can be made of the initial rearing containers, alleviating the problem mentioned above of having too many fish for too few containers. This option is only suitable in later years when coho are not to be released in the spring as 2 g or 5 g fry.

FINAL REARING

Equipment

- Rearing chinook and coho to 5 g will require 434 cu.m of volume (Table 10). Five rectangular rearing raceways with dimensions of 3 m wide, 1.3 m high walls (water to 1.0 m deep) and 30 m long would provide sufficient (450 cu.m.) rearing volume for this outplant strategy.

- The Shuswap stocks could be reared to larger sizes in net pens in the Shuswap River adjacent to the project site, in the dam head pond, or near the outlets of Mabel or Sugar Lakes.

- Rearing chinook to 10 g and coho to 20 g requires at least 720 cu.m of space at the most critical time during the summer before the chinook have been released. This would be met by building eight final rearing raceways (720 cu.m). Final rearing could also be carried out in the seven large initial rearing raceways (90 cu.m) and the six lines of Capilano troughs (30 cu.m) for a total of 840 cu.m available.

Flows

- The 9100 LPM required to rear both chinook and coho to 5 g (Table 10) would be met by allowing 2000 LPM per raceway to five rearing raceways. With a total of eight raceways being built to meet future demands, flow demand for well water would be 16000 LPM.

- Water source has been assumed to be groundwater, but a back-up surface supply is recommended. Rearing on river water during the summer would require greater flows (4000 LPM versus 2000 LPM per raceway) than using well water, due to the higher water temperatures

Timing

- Chinook final rearing commences in March and goes until the beginning of July (or the end of August if reared to 10 g) (Table 3). The natural migration of chinook from the Middle Shuswap is in mid April to early May (Federenko and Pearce, 1982). Release of 5 g smolts at that time would require some heating of incubation water to accelerate embryo development. This may not be necessary since chinook in the Shuswap/Thompson system seem to rear in the lakes during the early part of the summer and migrate out as large smolts in August.

- Coho final rearing commences in early April and goes until June for 5 g releases, August for 10 g releases and until the following spring for 20 g releases.

- Delayed incubation of coho, as outlined above, would still allow coho to outplanted as fry in the summer and fall or reared to smolt size (20 g) by the following spring.

SUPPORT ITEMS

The usual support structures are required at the Shuswap Expansion. The details should be worked out in a bio-engineering consultation meeting but the general requirements will be something like the following list:

- Aeration tower
- Laboratory (wet)
- Workshop
- Storage (large outdoor, volatiles and indoor)
- Offices (2 private, 1 common)
- Lunch room
- Wash rooms (male and female)
- Sleeping quarters
- Freezer (probably free standing)
- Adult handling/spawning facility
- Site security fencing

The same building layout as at the Spius Creek pilot is recommended for the Shuswap pilot, since the functions and scales of the pilots are the same and the Spius layout is efficient, sufficient and inexpensive to build.

WATER DEMAND

The Flow Schematic in Figure 1 summarizes the maximum flows required to be plumbed to each container line for both well and river water. All containers require well water supplies if the experimental plan goals are to be reached. River water is considered mainly as a back-up for the expanded pilot.

The timing of the well water flows required was determined from the Event Timing (Table 3) by breaking the runs of each species into three groups and assuming that 25% of the run was in each of the 'Early' and 'Late' groups and 50% was in the 'Peak' group. This resulted in a Strategy Summary (Table 12) which shows how many containers and how much flow is used by which group during what period. This table was used to determine the maximum flow demand for each month (Table 13).

The maximum well water demand for the pilot facility as planned is for about 12000 LPM during April and May when five final raceways and seven lines of initial rearing containers are operating. This is more than the maximum of 8620 LPM shown in the Water Demand Table (Table 13) because, in normal operation, flows are set at standard maximum levels for each container (2000 LPM for final rearing, 240 LPM for initial rearing) and kept there regardless of whether the BIO-LOAD model says that less flow is needed (e.g. when some fry have been removed for outplants). This is good, safe, fish culture practice.

A note from G. Neilson suggests that the well field at the Shuswap pilot site could produce about 12800 LPM (double the output of 6400 LPM from the existing wells #5, #8, #9 and one more new one). This is just enough to meet the expected requirements of the facility for well water.

The flow of river water required for a 'worst case' condition of rearing both coho and chinook through the summer is given at the bottom of the Water Demand Table (Table 13). The maximum water demand in this case would be almost 35000 LPM. If the initial rearing containers were also used for rearing during this period, maximum demand could be over the system capacity of 38000 LPM. In this light, a value of about 42000 LPM (0.7 cms) should be requested in the B.C. Hydro negotiations.

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Table 1. Juvenile Production Objectives for the Shuswap Pilot Expansion.

Species	Stock	Eggs Taken (#K)	Fry Ponded (#K)	Two Gram Size (#K)	Five Gram Size (#K)	Twenty Gram Size (#K)
YEAR ONE						
Chinook	Middle	900	810	729	648	
	Lower	700	630	567	504	
Coho	Wap	100	90	81	72	68
	Bessette	100	90	81	72	68
	Lower	100	90	81	72	68
	Total	1900	1710	1539	1368	204
YEAR TWO						
Chinook	Middle	650	585	527	468	
	Lower	500	450	405	360	
Coho	Wap	100	90	81	72	68
	Bessette	100	90	81	72	68
	Lower	100	90	81	72	68
	Total	1450	1305	1175	1044	204

** The following survival rates were used for the calculations:

Species	Egg to Fry	Fry to 2g	Fry to 5g	Fry to 20g
Chinook	90%	90%	80%	
Coho	90%	90%	80%	75%

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Table 2. Adult Holding Requirements for the Shuswap Pilot Expansion.

Species	Stock	Eggs Taken (#K)	Adults Required Total (#)	+25% (#)	Donors' Weight (kg)	Volume (cu.m)	Flow (LPM)
YEAR ONE							
Chinook	Middle	900	288	360	1800	56.3	1500
	Lower	700	224	280	1400	43.8	1170
Coho	Wap	100	64	80	240	7.5	200
	Bessette	100	64	80	240	7.5	200
	Lower	100	64	80	240	7.5	200
	Total	1900	644	805	3920	122.6	3270
YEAR TWO							
Chinook	Middle	650	208	260	1300	40.6	1080
	Lower	500	160	200	1000	31.3	835
Coho	Wap	100	64	80	240	7.5	200
	Bessette	100	64	80	240	7.5	200
	Lower	100	64	80	240	7.5	200
	Total	1450	560	700	3020	94.4	2515

** The following assumptions wer made in the calculations:

Fecundity of 5000 for chinook and 2500 for coho
Weight per adult of 5 kg for chinook and 3 kg for coho
Sex Ratio of 1.0 female to 0.6 males, or 1.0 female to 1.6 total donors
Pre-spawn mortality of 25%;
Volume loading of 32 kg/cu m;
Flow loading of 1.2 kg/LPM

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Table 3. Projected Event Timing for the Shuswap Pilot Expansion.

EVENT	Start	Peak	End
CHINOOK			
Adult Holding	Jul 18	Sep 1	Oct 31
Spawning Date	Sep 21	Oct 1	Oct 31
Eyed Date (280 ATU)	Oct 22	Nov 1	Dec 1
Hatch Date (520 ATU)	Nov 20	Dec 1	Jan 1
Ponded Date (980 ATU)	Jan 10	Jan 20	Feb 19
Reared to - 2g size	Mar 10	Mar 30	May 19
- 5g size	Apr 29	May 9	Jul 8
- 10g size	Jun 18	Jun 28	Aug 27
COHO			
Adult Holding	Oct 16	Nov 1	Nov 30
Spawning Date	Oct 31	Nov 15	Nov 30
Eyed Date (220 ATU)	Nov 25	Dec 10	Dec 25
Hatch Date (480 ATU)	Dec 23	Jan 9	Jan 24
Ponded Date (780 ATU)	Jan 26	Feb 12	Feb 27
Reared to - 2g size	Apr 4	Apr 19	May 4
- 5g size	May 30	Jun 13	Jun 28
- 10g size	Jul 23	Aug 7	Aug 22
- 20g size	Sep 26	Oct 11	Oct 26

** The above timings assume that the well water temperatures at the Shuswap Pilot will be 9'C all year long and that incubation and rearing are carried out on well water only.

Table 4. Spawner Timing in the Shuswap Pilot Broodstock Streams.

Species	Stock	Arrive	Start	Peak	End
Chinook	Middle Shuswap	M.Jul	M.Sep	L.Sep	M.Oct
	Lower Shuswap	M.Jul	E.Oct	E.Oct	E.Nov
Coho	Wap Creek	Oct	E.Nov	M.Nov	Dec
	Bessette Creek	M.Oct	L.Oct	E.Nov	Dec
	Lower Shuswap	E.Oct	E.Nov	M.Nov	L.Nov

Data is from the DFO Stream Spawning files, summarized in Brown et al., 1979. Berry and Kahl (1982) also summarized these files but misinterpreted the notation in the Stream reports (read 'E.' as 'end' rather than 'early' and therefore many of their timing tables are incorrect.

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Table 5. Mean Monthly Temperatures Data for the River and Wells at the Shuswap Pilot Site.

	DFO Thermograph Data				Contract Monitor Data			
	Well	River			Well	River		
	Mean	Low	High	Mean	Mean	Low	High	Mean
Jan		0.3	1.2	0.8				
Feb		0.5	3.5	1.5		0	2.0	1.0
Mar		0.5	6.0	3.5	9	3.0	5.0	4.0
Apr		2.0	9.0	5.0	9	4.0	5.0	4.1
May		3.8	13.5	7.5	9	6.0	10.5	7.0
Jun	8.6	8.0	14.5	9.5	9	7.0	12.0	9.5
Jul	8.8	10.0	14.5	13.0	9	10.0	17.0	14.0
Aug	10.1				9	14.0	16.0	15.0
Sep	10.7							
Oct	9.8	5.0	8.8	7.0				
Nov	9.5	0.5	6.8	3.5				
Dec		0.3	3.3	1.5				

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Table 6. Incubation Requirements for the Shuswap Pilot Expansion.

Species	Stock	Eggs Taken (#K)	Heath Trays (#)	Incubator Stacks (#)	Regular Flow (LPM)	Flush Flow (LPM)
YEAR ONE						
Chinook	Middle	900	180	23	345	437
	Lower	700	140	18	270	342
Coho	Wap	100	12	2	30	38
	Bessette	100	12	2	30	38
	Lower	100	12	2	30	38
	Total	1900	620	47	705	893
YEAR TWO						
Chinook	Middle	650	130	17	255	323
	Lower	500	100	13	195	247
Coho	Wap	100	12	2	30	38
	Bessette	100	12	2	30	38
	Lower	100	12	2	30	38
	Total	1450	266	36	540	684

** Assumptions:

Eggs per tray - 5000 for chinook and 8500 for coho
Eight trays per stack
Flow of 15 LPM regular and 19 LPM flush per stack

Table 7. Coho Incubation Timing Using Shuswap River Water.

Period To	Mean Monthly Temperature	ATU's for Month	Cummulative ATU's
Nov 30	3.5	105	105
Dec 31	1.5	47	154
Jan 30	1.0	30	184
Feb 28	1.3	36	220 ** eyed
Mar 31	3.5	109	329
Apr 30	4.5	135	464 ** hatched
May 31	7.0	217	681
Jun 12	8.0	96	787 ** swim-up

Temperatures are derived from the data in Table 5.
Spawning date is assumed to be October 31.

Table 8. Chinook Ponding Timing Using Heated Incubation Water.

Incubation Temperature	Days to Swim-up	Swim-up Date	Days Saved
9	109	Jan 20	0
10	98	Jan 9	11
11	89	Dec 31	20
12	82	Dec 24	27
13	75	Dec 17	34
14	70	Dec 12	39
15	65	Dec 7	44

Swim-up is assumed to occur at 980 ATU

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Table 9. Initial Rearing Requirements for the Shuswap Pilot Expansion.

Species	Stock	Fry Ponded (#K)	Capilano Troughs (#)	Trough Lines (#)	Start Flow (LPM)	End Flow (LPM)
YEAR ONE						
Chinook	Middle	810	21	11	1320	2640
	Lower	630	16	8	960	1920
Coho	Wap	90	2	1	120	240
	Bessette	90	2	1	120	240
	Lower	90	2	1	120	240
	Total	729	43	22	2640	5280
YEAR TWO						
Chinook	Middle	585	15	8	900	1800
	Lower	450	12	6	720	1440
Coho	Wap	90	2	1	120	240
	Bessette	90	2	1	120	240
	Lower	90	2	1	120	240
	Total	1305	33	17	2040	4080

** Assumptions:

Fry per trough - 40K for chinook, 55K for coho
Two troughs per line
Flow per line - 120 LPM to start, increasing to 240 LPM

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Table 10. Final Rearing Requirements for the Shuswap Pilot Expansion.

Species	Stock	2g Fry Ponded (#K)	Released Smolts (#K)	Smolt Size (g)	Volume (cu.m.)	Flow Start (LPM)	Flow End (LPM)
YEAR ONE							
Chinook	Middle	729	648	5	207	2278	4360
	Lower	567	504	5	161	1772	3390
Coho	Wap	81	68	20	64	238	1280
	Bessette	81	68	20	64	238	1280
	Lower	81	68	20	64	238	1280
	Total	1539	1356		560	4764	11590
YEAR TWO							
Chinook	Middle	527	468	5	150	1647	3150
	Lower	405	360	5	115	1266	2425
Coho	Wap	81	72	5	22	238	445
	Bessette	81	72	5	22	238	445
	Lower	81	72	5	22	238	445
	Total	1175	1044		331	3627	6910
TEN GRAM REARING							
Chinook	Middle	729	608	10	339	2278	15590
	Lower	567	473	10	264	1772	12130
Coho	Wap	81	70	10	39	238	1590
	Bessette	81	70	10	39	238	1590
	Lower	81	70	10	39	238	1590
	Total	1539	1291		720	4764	32490

Assumptions are given in Table 11.
Ten gram chinook and coho are assumed to start rearing on well water but be reared on river water (at 15'C) during the summer.

Table 11. Loading Calculations for the Shuswap Pilot Expansion.

Species	Size (g)	Flow Loading (kg/LPM)	Volume Loading (kg/cu.m)
Chinook			
	2	0.64	13.01
	5	0.74	15.65
	10	0.83	17.95
(15'C)	10	0.39	17.95
Coho			
	2	0.68	13.01
	5	0.81	15.65
	10	0.92	17.65
	20	1.06	21.48
(15'C)	10	0.44	17.95

Assumptions (from the LOAD RATE model):

Temperature of 9'C; Ration of 0.9(CN) and 0.75(CN) of OMP max. Metabolic Correction of 1.35; DO inflow of 95% of saturation;

Table 12. Operation Strategy Summary for the Shuswap Pilot Expansion.

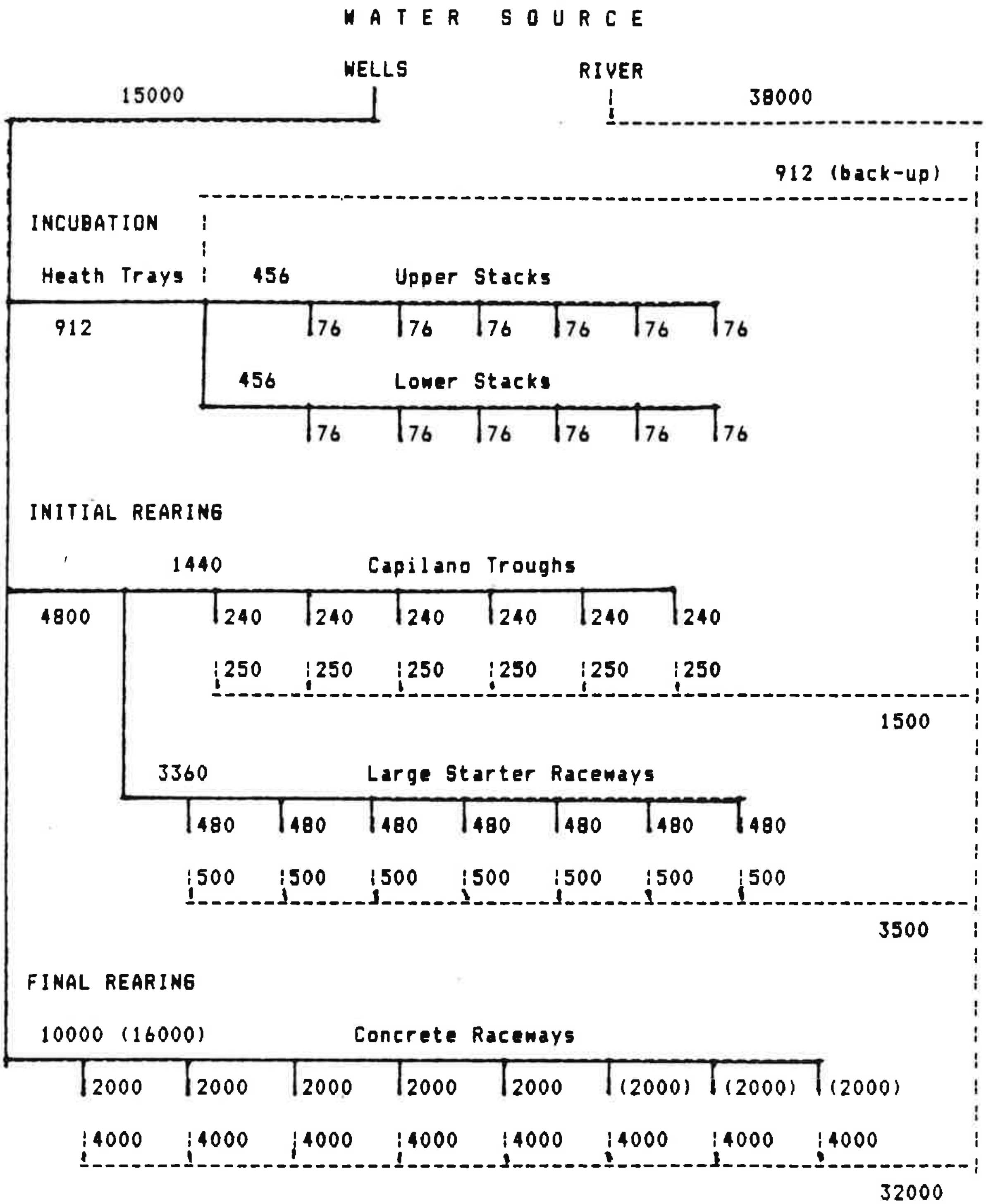
Species	CHINOOK				COHO			
Stock Portion	Early	Middle	Late	Total	Early	Middle	Late	Total
ADULT HOLDING								
Adults(#)	160	320	160	640	60	120	60	240
in Space(cu.m)	25	50	25	100	6	12	6	24
at Flow(LPM)	670	1300	670	2640	150	300	150	600
from	Jul18				Oct16			
to			Oct31				Nov30	
INCUBATION								
Eggs(#K)	400	800	400	1.6M	75	150	75	300
in Trays(#)	80	160	80	320	9	18	9	36
in Stacks(#)	10	21	10	41	2	3	1	6
at Flow(LPM)	150	315	150	615	30	45	15	90
from	Sep21	Oct 1	Oct31		Oct31	Nov15	Nov30	
to	Jan10	Jan20	Feb19		Jan26	Feb12	Feb27	
INITIAL REARING								
Fry(#K)	360	720	360	1.5M	68	135	67	270
in Troughs(#)	9	18	9	36	2	3	1	6
in Lines(#)	5	9	4	18	1	2	-	3
Start Flow(LPM)	600	1080	480	2160	120	240	-	360
End Flow(LPM)	1200	2160	960	4320	240	480	-	720
from	Jan10	Jan20	Feb19		Jan26	Feb12	Feb27	
to	Mar10	Mar20	Apr19		Apr 4	Apr 9	May 4	
FINAL REARING								
Fingerlings(#K)	324	648	324	1.3M	61	121	61	243
in Space(cu.m)	92	184	92	368	17	33	16	66
Start Flow(LPM)	1013	2026	1012	4051	179	357	178	714
End Flow(LPM)	1938	3876	1937	7751	960	1920	960	3840
from	Mar10	Mar20	Apr19		Apr 4	Apr 9	May 4	
to	Apr29	May 9	Jun18		May30	Jun13	Jun23	
Produces Smolts(#K)	288	576	288	1.2M	54	108	54	216

Table 13. Water Demand for the Shuswap Pilot Expansion

PURPOSE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INCUBATION												
CN	615	150							150	615	615	615
CO	90	60								30	90	90
Tot	705	210							150	645	645	645
INITIAL REARING (to 2g)												
CN	2000	3600	4200	900								
CO	120	450	600	720	240							
Tot	2120	4080	4800	1620	240							
FINAL REARING (2g+)												
CN			3500	6000	7751	2000						
CO				1000	1335	1335						
Tot			3500	7000	9086	3335						
ADULT HOLDING												
CN							1000	2000	2640	2640		
CO										600	600	
Tot							1000	2000	2640	3240	600	
SPECIES TOTALS												
CN	2615	3750	7700	6900	7751	2000	1000	2000	2790	3255	615	615
CO	210	510	600	1720	1575	1335	-	-	-	630	690	90
GRAND TOTAL	2825	4260	8300	8620	8326	3335	1000	2000	2790	3855	1305	705
WORST CASE (Chinook to 10g, Coho to 20g, both on river water)												
FINAL REARING												
CN			3500	6000	8000	15000	25000	28000				
CO	4000	4000	4000	5000	1500	3000	4800	4800	4000	4000	4000	4000
Total	4000	4000	7500	11000	9500	18000	29800	32800	4000	4000	4000	4000
WORST CASE GRAND TOTAL	6825	8290	8300	12620	9740	18000	30800	33800	6790	7855	5305	4705

Figure 1. Flow Schematic for the Shuswap Pilot Expansion

(** NUMBERS REPRESENT FLOW IN LITERS PER MINUTE **)



APPENDIX 1e. Downsizing of the Pilot Expansion

J. McNally, Sr. Implementation Engineer
W. Leung, Sr. Project Engineer
SEP Engineering

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE
5830-85-T85
5830-85-S160

YOUR FILE/VOTRE RÉFÉRENCE

FROM
DE

[redacted]
New Projects Coordinator
SEP Facility Operations

DATE
November 29, 1984.

SUBJECT
OBJET
DOWNSIZING OF SHUSWAP PILOT EXPANSION

To recap our discussion of November 28, 1984 regarding the Shuswap pilot expansion, my understanding of the problems you face is as follows:

A facility of the size proposed in my memo of September 14, 1983 and D. MacKinlay's memos of October 7, 1983 and September 24, 1984 (all on file 5830-85-T85) is projected to cost about twice what the available budget is . In addition, the maximum amount of gravity-feed surface water that can be provided using the existing pipe on the BCH Dam is 17,000 LPM, which is half of that required for MacKinlay's extreme-case projection. Accordingly, major savings in both costs and water are required. Costs are relatively higher than at the other pilots because of the gravity-feed pipeline, and because site preparation and access costs have not been absorbed by a pre-existing pilot.

Because the Central Interior pilots are commited to maximum experimental flexibility and not to specific production targets, such downsizing can be relatively easily accommodated. This will mean that fewer studies could be carried out simultaneously at Shuswap, but as long as the reduction does not jeopardize the minimum size of any basic program 'module', the overall program objectives can still be satisfied over time.

I have re-examined the minimum and preferred module sizes, and stocks involved, for the Shuswap facility (Table 1), and downsizing of the Shuswap facility to a 1M egg facility of the Stage I Eagle type should not jeopardize any of these basic modules, although there are constraints placed on the number of study combinations that could be undertaken in any one year (increasing capacity to 1.2M eggs would make a greater number of study combinations possible). The Middle and Lower Shuswap stocks cannot be dealt with simultaneously at this smaller size, and the Middle Shuswap stocks probably are more properly dealt with at this facility if a choice must be made.

Elimination of Lower Shuswap chinook and coho from the facility would result in about a 40% decrease in incubation and rearing flow and volume requirements. An additional 40% decrease in final rearing flow and volume requirements may be possible if Middle Shuswap stocks are reared in net pens in the river (preferably in the BCH Dam forebay).

/2

In terms of final rearing containers, four separate raceways, each capable of being divided into 3-4 compartments with screens, should give adequate experimental flexibility .

I am also given to understand that, even if downsizing to the 1M egg size occurs, funds are still insufficient to provide the gravity-feed surface water supply line as part of the first stage, and the facility will have to be fully pumped. Although this situation is similar to what has happened at several other facilities I find it discomforting, especially considering our various recent problems with wells. If there is any way in which a surface water supply can be incorporated, I would urge its inclusion.

The numbers (Table 1) represent a simplistic first cut at the problem. I will have D. MacKinlay examine this approach in more detail, and Don will provide reworked design requirements and water demand as soon as possible.

A final note re construction scheduling. You have suggested--and I certainly agree--that we not commit to operating the expanded pilot until in the fall of 1985. I think all of us would appreciate the longer planning and preparation time that this would give us. This would mean that the existing pilot would have to be run for a second year or be shut down; C. MacKinnon may wish to comment further.

B.G. Shepherd

BGS/mmm

c.c. F.K. Sandercock
C.N. MacKinnon
G.F. Bérézay
D.D. MacKinlay
D. Buxton

Table 1. Summary of numbers of eggs and stocks required to undertake experimental study 'modules' at Shuswap facility.[a]

Study Module	Sp	No. of Eggs (No. of Stocks) Minimum	Preferred	
Gross Time & Size	CN	500K (1)	1000K (2)	
	CO	320K (1)	640K (2)	
	TOT	820K (2)	1640K (4)	
Detailed Timing	CN	250K (1)	500K (1)	(10g + module)
	CO	180K (1)	360K (1)	
	TOT	430K (2)	860K (2)	
Maximize Rearing	CN	600K (1)	600K (1)	(2g module)
	CO	600K (1)	600K (1)	(2g module)
	TOT	1200K (2)	1200K (2)	
Imprinting Strategies	CN	450K (1)	450K (1)	(2g module)
	CO	450K (1)	450K (1)	(2g module)
	TOT	900K (2)	900K (2)	
Rearing Cap. Checks:				
- U/S Dam	CN	400K (1)	400K (1)	(2g)
- Wap	CO	100K (1)	100K (1)	(5g)
- Bessette	CO	100K (1)	100K (1)	(5g)

[a] Taken from Shepherd memo of September 14, 1983, on file 5830-85-T85.

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APPENDIX 1f. Detailed Downsizing

B. G. Shepherd
New Projects Coordinator
S.E.P.

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

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE 5830-85-T85

YOUR FILE/VOTRE RÉFÉRENCE

DATE January 18, 1985

SUBJECT / OBJET **DOWNSIZING OF THE SHUSWAP EXPANDED PILOT**

This memo discusses reduction in size of the Shuswap Expanded Pilot facility in order to meet the site water supply constraints, as requested by you in your memo to J. McNally, November 29, 1984 on this file.

My memo to you of September 24, 1984 set out the biological criteria required for an expanded pilot facility at the Shuswap site near Shuswap Falls. The major items requested were as follows:

- 48 stacks of Heath trays
- 6 lines of Capilano troughs (12 troughs)
- 7 large starter raceways
- 5 final rearing raceways (30mL)
- 15K LPM of well water
- 25K LPM of surface water

Engineering is working on a first cut conceptual design as follows:

- 36 Heath stacks (180 stack capacity)
- 10 Capilano troughs (single, under cover)
- 0 large starter raceways
- 4 final rearing raceways (24mL)
- well water capacity
  - 4.6K LPM presently
  - 6.5K LPM with one more well
  - ~10K LPM, maximum aquifer capacity
- surface water
  - none in first construction phase
  - 17K LPM, maximum pipe capacity

As can be seen, the provided components bear little resemblance to those requested. What needS to be considered in designing the Expanded Pilot are:

1. the requirements of the experimental modules
2. the ultimate capacity of the facility

These are discussed below.

EXPERIMENTAL REQUIREMENTS

The key to fitting all the experimental modules into a pilot facility which is within the budget for the first stage of construction is to be able to adjust the timing of different groups such that double use of rearing containers can be made. Timing adjustment is also essential to produce the correct size of fish at the appropriate time for most of the experimental modules. The following discussion assumes that the pilot facility will have such an ability.

Flows

Comparing the present site capacities (4.6K LPM) with the requested flows, there is almost enough well water available to satisfy the incubation (912 LPM) and initital rearing (4.8K LPM) requirements of the pilot plan. The limiting flow requirement is for final rearing.

I have re-examined your proposed experimental modules (memo to Sandercock, Lill and Harrison of September 14, 1983) in some detail and have determined that only about 500K chinook need to be reared to the 5 g+ stage each year. This requires about two raceways (500K * 5 g / 15.65 Kg/cu.m = 159 cu.m; /0.74 Kg/LPM = 3400 LPM). If, at the same time, coho are in the initial rearing containers (due to delayed development during incubation), their requirements would be less than 1K LPM. The total (4120 LPM) is within the flow capacity of the present wells.

To accomplish the timing adjustments as mentioned above, cold, river water needs to be made available at least during incubation and initial rearing. Since only coho need to be delayed significantly during incubation, a provision of cold water equal to their total requirement (90 LPM) would be an acceptable minimum. All the coho require only 720 LPM for initial rearing, so a provision of 400 LPM of river water would be an acceptable minimum for adjusting rearing temperatures. This could be provided by a 100 USgpm pump with a small intake out in the river.

Containers

It can be assumed that incubation space is not limiting. The number of Capilano troughs, large starter units and final rearing raceways available depends only on priorization of expenditures.

Since only two large chinook stocks and three small coho stocks are planned for the Expanded Pilot, three lines (of six requested) of Capilano troughs would be an acceptable minimum to be in place after the first stage of construction. A large number of capilano troughs is of less use at this pilot than the equivalent in large starter units, since the starter units can be better used for rearing to larger sizes in lieu of final rearing raceways. The entire requirement of eight starter units should be provided, since this stage of rearing is the most important part of the pilot operation.

As mentioned under 'Flow', two final rearing raceways would be enough to meet the pilot requirements if some event timing manipulation were done. Without those raceways, about two thirds of the chinook could be reared to the 5 g size in the large starter units, not considering the conflict with coho being reared at the same time.

Therefore, the adjusted minimum requirements for the Shuswap pilot are as follows:

- 48 stacks of Heath trays
- 3 lines of Capilano troughs
- 8 large starter units
- 2 final rearing raceways (25mL)
- 4.6K LPM of well water
- 400 LPM of river water

Flow Demand

A revised flow demand for the down-sized Shuswap Expanded Pilot is shown in Table 1. The changes mentioned above have been incorporated into this table, including reduced final rearing flow and timing adjustment of coho incubation and subsequent rearing.

The coho timing can be delayed by one month by incubating them on 6.5[C water during incubation. This would require 30-40% of the flow to be cold surface water to cool the 9[C well water.

Overlap of container flows has been taken into account in the flow demand table. For example, in March, when some of the chinook fry are transferred from initial rearing (3800 LPM) to final rearing (1000 LPM), only the higher value is added to the grand total flow.

ULTIMATE FACILITY CAPACITY

The main limiting factors at the Shuswap site are the flows potentially available from the wells (10K LPM) and river (17K LPM). These can be used to determine the maximum potential requirements for fish culture facilities and the ultimate size and capacity of the facility. Since chinook require more flow and containers per fish than coho, capacities will be expressed in terms of chinook eggs.

If rearing were to continue to the 5 g smolt stage, the 17K LPM of river water could sustain a maximum of about 2.5M smolts (4.0M eggs). This would require eleven 24mL or nine 30mL raceways (800 cu.m).

If rearing only went to the 2 g stage, the 10K LPM of well water could sustain a maximum of 3.2M fry (3.6M eggs). This would require 20 large starter units, each with 160K fry ponded to it. Some augmentation of flow with river water could raise initial rearing capacity to the 4.0M egg mark with minor decrease in growth rates due to lower temperatures.

Incubation space and flow requirements for the 4.0M egg maximum rearing capacity are 100 stacks of Heath trays and 1500 LPM, respectively. However the Eagle style of building proposed for this site has a capacity for 180 stacks of Heath trays, equivalent to 7.2M eggs. This is obviously oversized for the limited flows available at this site. The Spius style of building, which has an egg capacity of 4.2M eggs (104 Heath stacks), would be a much more appropriate size for the Shuswap project. The Spius building can be considered the minimum acceptable size for a hatchery building which still contains enough of the main components for a fish culture operation (workshop, lab, offices, mechanical room, storage).

Therefore the ultimate size of the Shuswap River Salmonid Enhancement Facility should be characterized as follows:

- 100 Heath stacks (Spius hatchery building)
- 6 lines Capilano troughs (= 3 large starters)
- 20 large starter units
- 10 final rearing raceways (27mL)
- 10K LPM of well water
- 17K LPM of river water

PRIORIZATION

The most important components of the Shuswap Expanded Pilot are those directly related to fish culture. Because of the regional climate, the biological/operations group feel that it is essential that the initial rearing containers be sheltered. Since the initial rearing containers are the key to the operation of the pilot, if only one major structure can be afforded at this time at the Shuswap site, it should be the rearing building. Temporary incubation could be incorporated into a corner of it and a rented trailer could serve as office/lab.

I would priorize the construction of items at the Expanded Shuswap Pilot as follows:

0. site fill, access road, pumps, aeration
1. 8 starter units and building pad
2. rearing building shell
3. 3 lines of Cap. troughs (in building)
4. temporary pumped river supply
5. hatchery building, complete shell
6. 2 final rearing raceways
7. hatchery building completion
8. 3 more Cap. trough lines
9. 2 more final rearing raceways
10. more wells, gravity surface supply
11. rearing building completion
12. crew residence
13. final rearing raceway completion
14. adult handling facility
15. sludge lagoon

The SEP OPS group should have a meeting as soon as possible to agree on or adjust these priorities and communicate them to Engineering.

Don D. MacKinlay

c.c. F.K. Sandercock, C.N. MacKinnnon, G.F. Berezay, J.D. Buxton, A.F. Lill, J.W. McNally, Y.W. Leung, A. Machel

Table 1. Revised Water Demand for the Shuswap Pilot Expansion

PURPOSE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
INCUBATION												
CN	615	150							150	615	615	615
CO	90	90	60							30	90	90
Tot	705	240	60						150	645	645	645
INITIAL REARING (to 2g)												
CN	2000	3600	3800	900								
CO		120	450	720	720	240						
Tot	2000	3720	4250	1620	720	240						
FINAL REARING (2g+)												
CN			1000	2000	3400	2000						
CO					500	1000	1335					
Tot			1000	2000	3900	3000	1335					
ADULT HOLDING												
CN							1000	2000	2640	2640		
CO										600	600	
Tot							1000	2000	2640	3240	600	
GRAND TOTAL	2705	3960	4310	3620	4120	3240	2335	2000	2790	3855	1305	705

B. G. Shepherd
New Projects Coordinator
S.E.P.

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

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE 5830-85-T85

YOUR FILE/VOTRE RÉFÉRENCE

DATE July 21, 1985.

SUBJECT OBJET **SHUSWAP PILOT: AS-DESIGNED versus REQUESTED**

This memo compares the description of the facilities to be provided (as-designed) by the fall of 1986 (as outlined by Wai Leung in his memo to you of July 18, 1985) to the facilities requested to fulfill the experimental requirements of the Shuswap Pilot.

The design of this pilot should have been based on two previous memos: the first gave the requirements to meet the experimental program as originally outlined by you; and the second described the minimal facilities required to handle a truncated range of experimental options.

WATER SUPPLY

The 7K LPM available from the four main wells at the Shuswap site are only half of the requested 15K for the full size pilot but are greater than the 4.6K required to meet the minimal demands of the down-sized pilot. However, the 7K LPM provided are not enough to adequately supply the four large raceways being constructed, if they are all operated at once (at 1800 LPM each they require 7200 LPM total). Continuous use of the maximum groundwater capacity may also lead to a decrease in the total yield from the wells, as has happened at many facilities. This provision of too many containers for the water available will probably result in chronic water shortage problems at this pilot. The operator should be advised that the design allows for only two of the large raceways to be supplied with adequate flows when the other rearing units are in operation, as will be the normal situation.

The 800 LPM of river water to be provided (supplied to the incubation room only) exceeds the minimum of 400 LPM requested for a down-sized pilot. It obviously is insufficient to make any significant contribution to rearing or as a back-up supply. The pilot operator should understand that there is no back-up supply available.

AERATION

The old Eagle aeration tower is to be used, which consists of 10 segmented columns, each with one distribution system and 6 standard aerator pots. This seven segment system should be adequate to bring the approximately 40% oxygen well water up to 95% of saturation and reduce nitrogen supersaturation. The 10 columns will be able to accommodate the 7K LPM, at the normal flow rate of 700-900 LPM per column.

FISH CULTURE CONTAINERS

The following table summarizes the main fish culture container requirements for performing the release strategy experiments compared to the facility being built at the Shuswap Pilot:

	Full-Sized Experiment	Down-Sized Experiment	As-Designed Facility
Tray Stacks	48	48	54
Trough Lines	6	3	5
Large Starters	7	8	6
Raceways (25m long)	6	2	4

This table shows that sufficient incubation capacity will be provided but that final rearing is only sufficient for the down-sized pilot and initial rearing capacity is insufficient for either option.

Due to the nature of the experimental plan, emphasis was to be placed on initial rearing. The total initial rearing capacity required for the full-size and down-size pilots were calculated to be the equivalent of 20 and 19 Capilano trough lines, respectively, whereas only the equivalent of 17 lines will be provided. It would have been preferable to build more large starter units in lieu of the extra large raceways that are being provided. With the presently designed setup, the facility operator may be forced into a situation where coho have to be ponded directly into the large raceways, a practice that has not been tested at DFO facilities, to my knowledge.

The operator should be advised that incubaton timing for the coho to be reared through the second winter should be delayed (using cold surface water) to swim-up after the bulk of the chinook 2g fry releases have been carried out. This strategy was taken into account in assessing the design requirements of the down-sized pilot, therefore, will probably not be sufficient to alleviate the problem of insufficient initial rearing capacity.

Since both water and small-sized rearing space will be in short supply at the Shuswap Pilot, the experimental objectives should be reduced by about 25%. Dropping the coho over-winter rearing component in favor of fall releases would save the most water, while reducing the proportion of early fry releases would save the most initial rearing space.

I therefore suggest that the operator be given relatively modest egg-take targets and a simple release strategy plan to follow for the first year of operation, to reduce the impact of problems encountered while the bugs are being ironed out and the facility capacity and performance are being assessed.

Don D. MacKinlay

c.c. F.K. Sandercock
C.N. MacKinnon
G.F. Berezay

APPENDIX 2. GWG TARGET PROPOSAL MEMO

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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).

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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.

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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. Coho Salmon

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.

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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

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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	

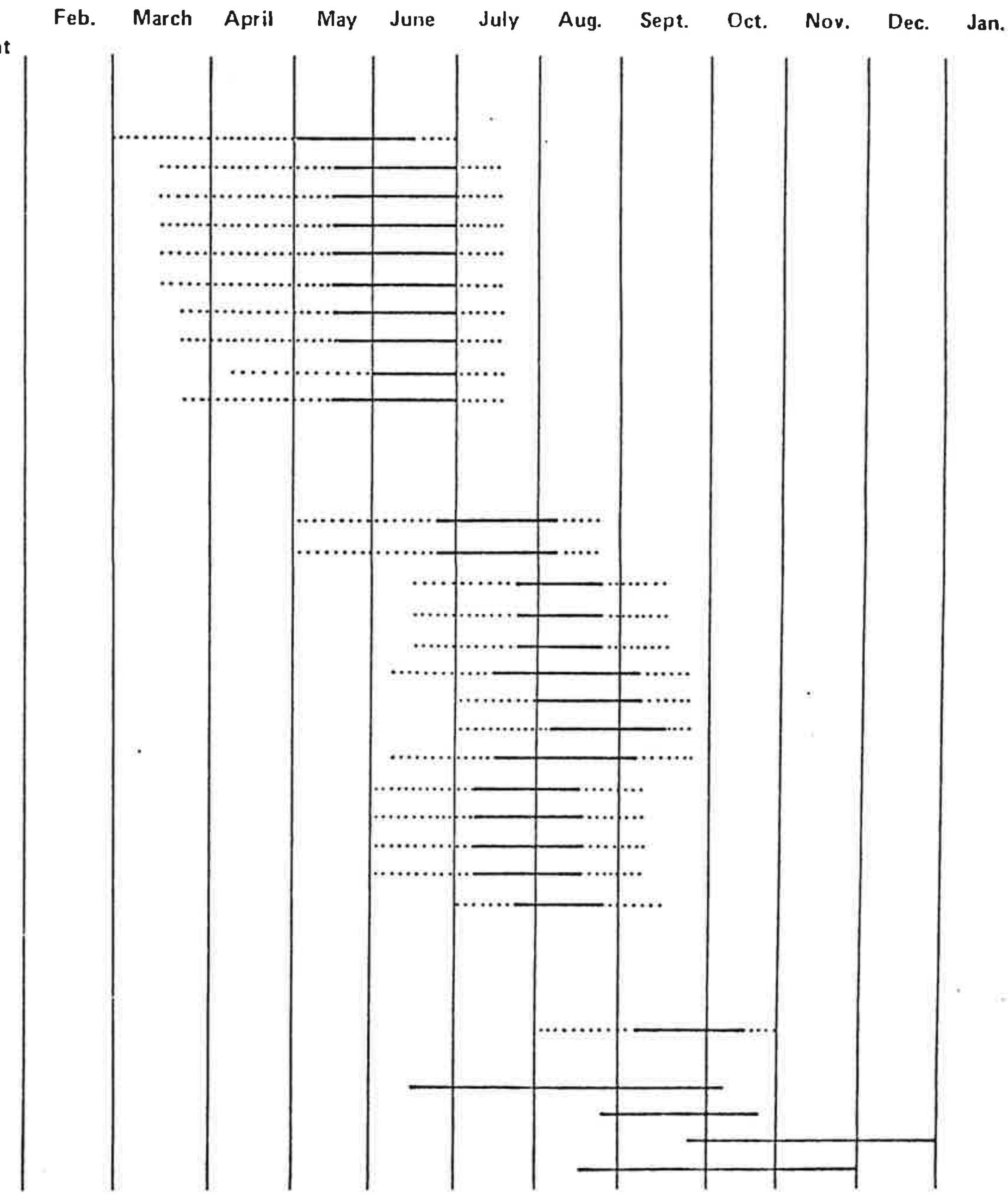


Figure 2. Relationship between Racial Timing of Coho Salmon Stocks and Other Salmon Species through the Lower Fraser River Fishery (Area 29).

	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	

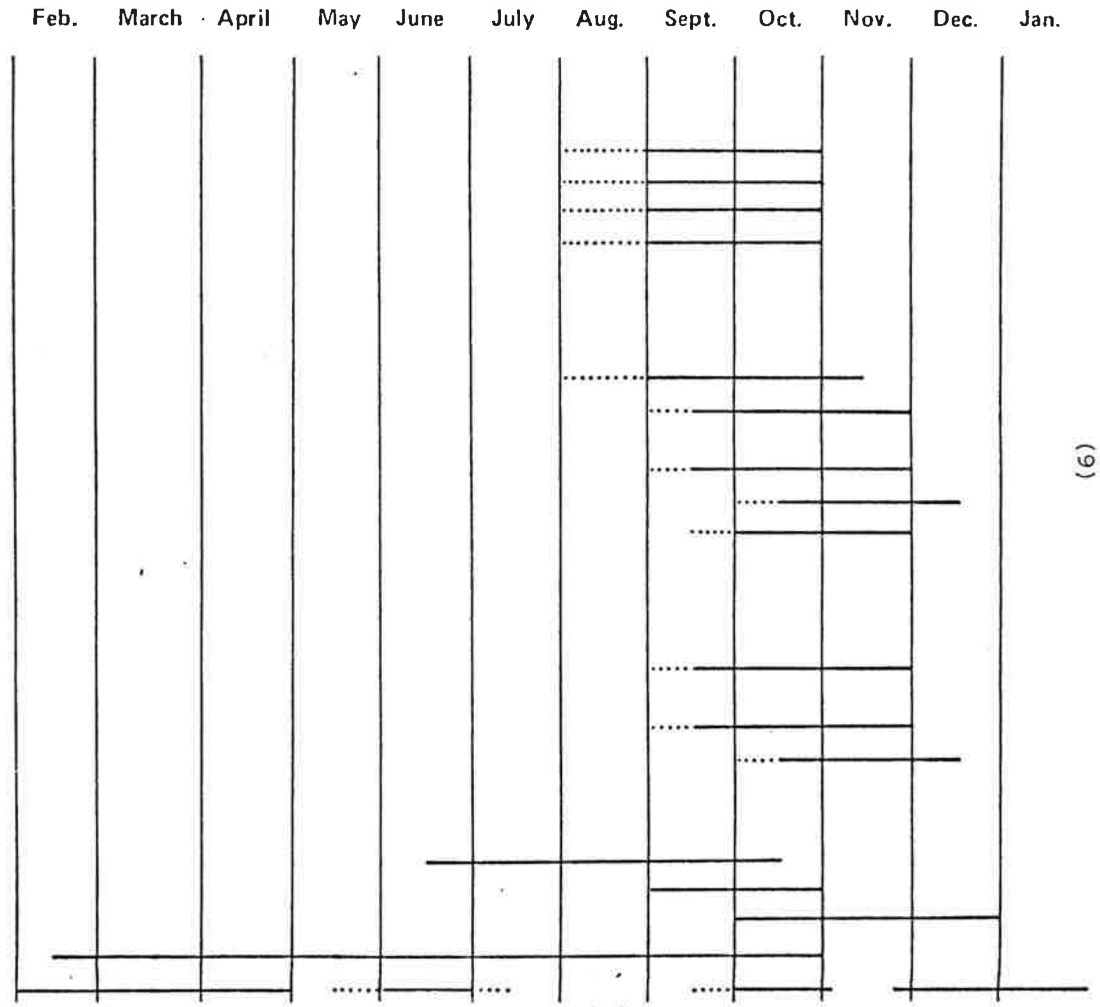


Table 1 CURRENT STOCK AND PROPOSED ENHANCEMENT COMPONENT OF SELECTED STOCKS OF FRASER RIVER CHINOOK AND COHO

I. CHINOOK SALMON

A. Early Timing Stocks

Upper Fraser River	Current Stock	Increase 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

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

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

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.

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. SURVIVAL BIOSTANDARDS

FROM: Lill, A.F., A. Tautz, B.G. Shepherd, J.R. Willd, D.E. Marshall, W. Schouwenburg, and B. Tutty. 1983 MS. Opportunities for salmonid enhancement projects in B.C. and the Yukon. Report of the Enhancement Opportunities Subcommittee of the Salmonid Enhancment Program, DFO, Vancouver. 160 p.

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.

ECH	PROD AREA	FECUNDITY	DESCRIPTION	OUTPUT SIZE	EGG/FRY %	FRY/SMOLT %	SMOLT/ADULT %	EGG/ADULT %	ADULT/ UNIT	KG JUV. 1000 ADULT
W OR P CO C	All	2500	Natural	0.5 g	15	8	15	0.18	6/100m^2 218/km	
X	All	- " -	Incubation Box - no Rearing	0.5 g	80	8	15	0.96	480/50^k incubation box	78
IY R	- " -	- " -	Hatchery spring release	2 g	90	10	15	1.35	-	200
IY	- " -	- " -	Hatchery fall release	5 g	90	80 HY X 20 WILD	15	2.16	-	167
IY	- " -	- " -	Hatchery smolt release	20 g	90	75	15	10.13	-	133

APPENDIX b. Coho salmon

APPENDIX 4. WATER QUALITY MEMOS

Government of Canada / Gouvernement du Canada

APPENDIX 4a. Quality of River and Wells #4 and #5

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

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

SECURITY - CLASSIFICATION - DE SÉCURITÉ	
OUR FILE/NOTRE RÉFÉRENCE	
YOUR FILE/VOTRE RÉFÉRENCE	
DATE	May 2, 1983.

SUBJECT / OBJET **WATER QUALITY AT SHUSWAP FALLS PILOT SITE**

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

1. Surface Water

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

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

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

2. Groundwater Quality

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

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

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

Recommendations

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

D.D. MacKinlay

DDMACK/mmm

Attachments

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

PARAM.	RECOMM.	TOXIC	PEN45#1 MAR31/82	PEN25#2 MAR31/82	HEADPOND OCT26/82	PEN45#1 OCT26/82	PEN25#2 OCT26/82	PEN45#1 FEB8/83	RIVER 09:00 MAR22/83
ALK.TOT	20-300		51	50	45	45	45	48	47.5
AMMON.	<.002	>.08	0	0	0	0	0	.019	0
CO2	2-5	>20							
CHLOR.	<170	>400	.7	.9	0	0	0	.6	.8
COLOR	<15		0	0					0
COND.FLD	150-2000								57
COND.LAB	**		123.9	122.8	103	104	104	129	107
DO-PPM	>6-8	<4							12.1
DO-%SAT	100%		82.54	87.55	79.37	75.37	80.87		95.7
DGAS.TOT	<103%	>110%	102.27	100.67	104.13	102.43	101.05		105
DGAS.NIT	100%		106.21	105.51	110.74	109.65	106.45		107.5
HARDNESS	20-400		53	52.9	50.1	50.3	49.3	60.4	49.9
H2S	<.002	>.004							
NITRITE	<.012	.2	0	0	0	0	0	0	.005
NITRATE	<.12		.08	.13	.03	.03	.02	2.11	.11
PH-FLD	6.8-8.5	<5,>9			7.75	8	8.25		7.35
PH-LAB	**	**	7.9	7.8	7.8	7.8	7.8	7.7	7.8
PHOSPH.	<.05		.005	0	.006	.007	.006	.01	.008
RESID.TOT	<2000								
RESID.FIL	70-400		53	52.9	50.3	50.3	49.3	90	79
RESID.N.F	<3							0	0
SALIN.									0
SILICA	<10-60		3.5	3.4	2.8	2.8	2.8	3.5	3.3
SULFATE	<90		8.3	8.4	6.8	6.7	6.7	7.8	6.7
TASTE	OK								
T.D.SOL	500-1000	15000							
TEMP.	4-18C	<2,>25	2	3	9	13	10		3.7
TURBID	1-60	>1000	.2	.2	.1	.1	.1	.1	.5
METALS—									
AL	<.1	>5	0	0	0	0	0	0	0
AS	<.5	>1	0	0	0	0	0	0	0
BA	<1		.009	.009	.009	.009	.008	.009	.009
CA	4-150	>300	17.4	17.4	17.1	17.1	16.7	20.8	16.6
CD	<.0004		0	0	0	0	0	0	0
CO			0	0	0	0	0	0	0
CR	<.01		.368	0	0	0	0	0	0
CU	<.006		0	0	0	0	0	.003	0
FE	<.3		.043	.037	.042	.026	.027	.028	.04
HG	<.00005	>.0002	0	0	0	0	0	0	0
K		>50	1.02	.85	.79	.81	.79	.8	.79
MG	<10	>100	2.3	2.2	1.8	1.8	1.8	2	2
MN	<.05	>15	.003	.003	0	.004	.003	.003	.005
MO			0	0	0	0	0	0	0
NA		>500	1.3	1.3	1.2	1.2	1.1	1.2	1.1
NI			0	0	0	0	0	0	0
P			0	0	0	0	0	0	0
PB	<.01		0	0	0	0	0	0	0
SB			0	0	0	0	0	0	0
SE		>2.5	0	0	0	0	0	0	0
SI	<10-60		3.1	3.1	2.6	2.6	2.6	3.1	3.1
SN			0	0	0	0	0	0	0
SR			.079	.08	.075	.073	.072	.007	.072
TI			0	0	0	0	0	0	0
V			0	0	0	0	0	0	0
ZN	<.005		0	0	.004	0	0	.002	0

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

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

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

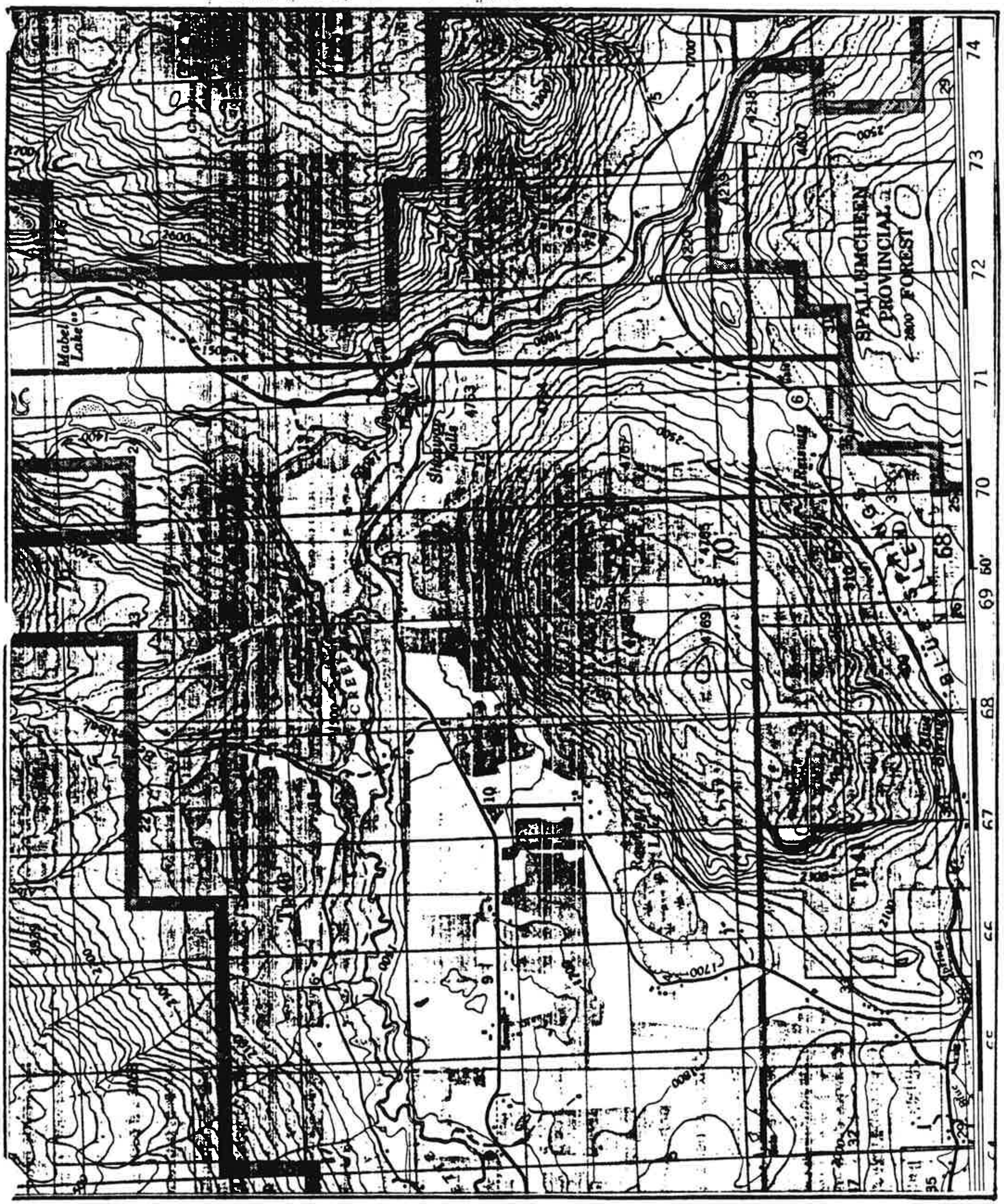


Figure 2. Shuswap River temperatures, intake chamber, 1982.

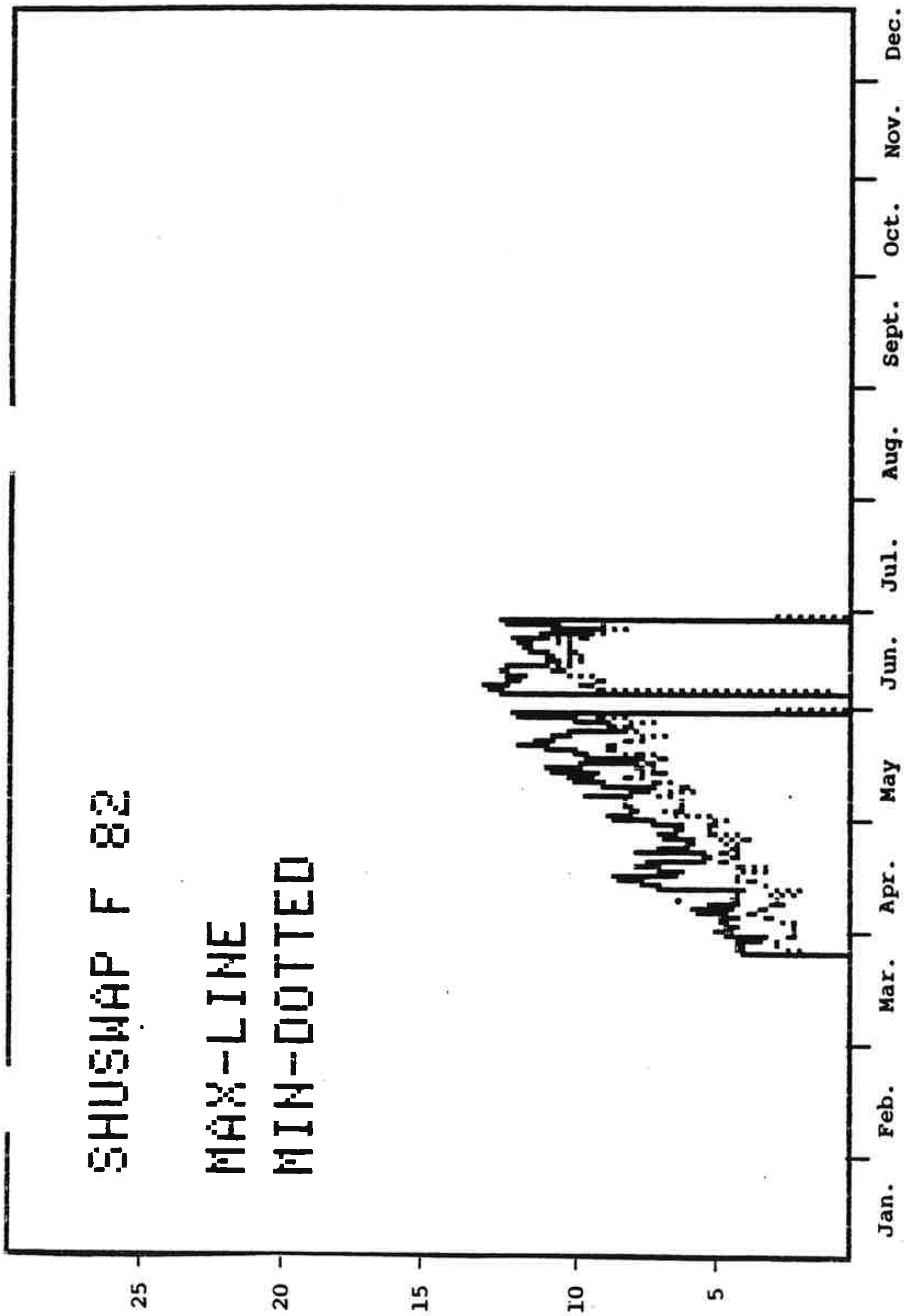


Figure 3. Shuswap River temperatures, 3 ft. deep 1982.

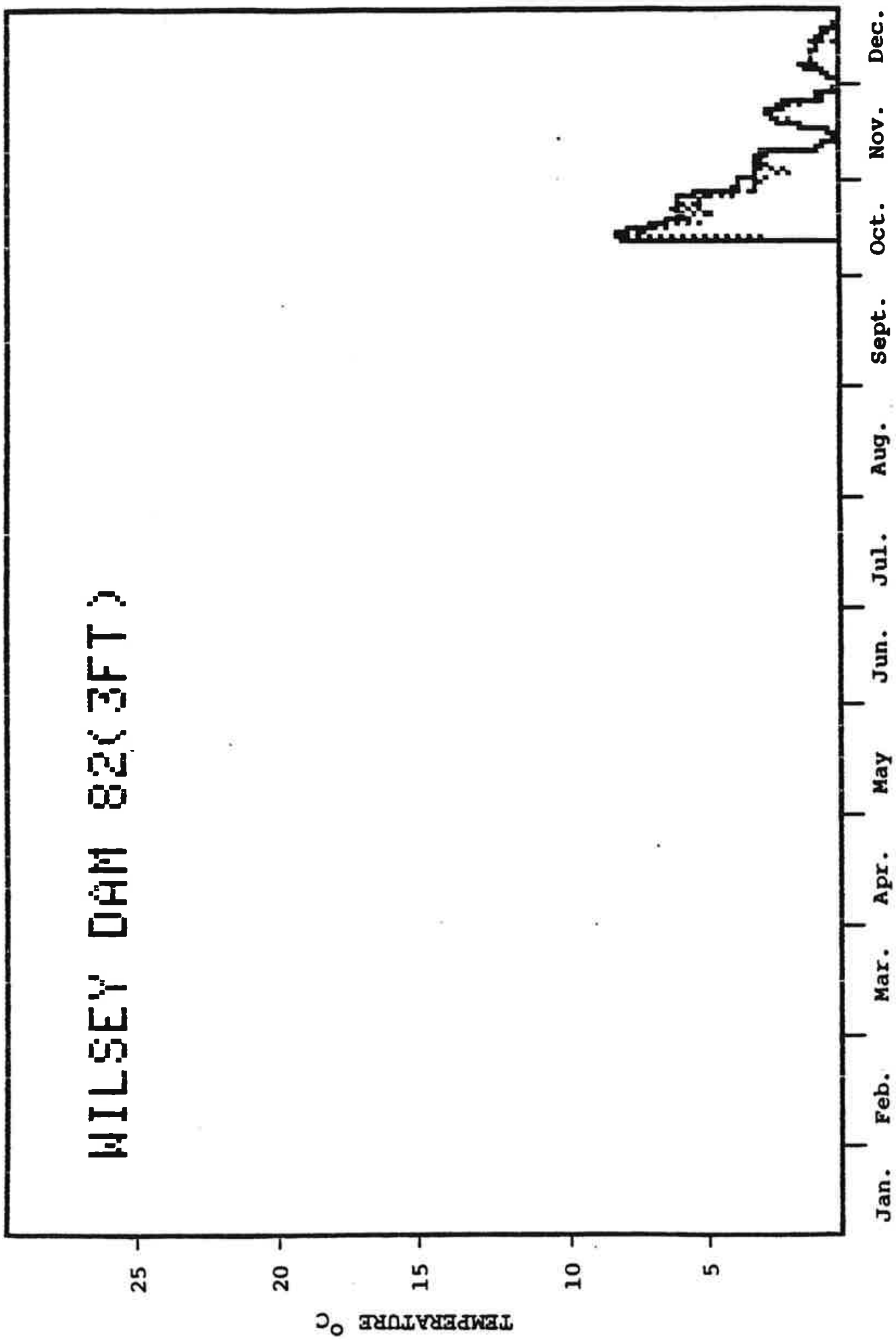


Figure 4. Shuswap River temperatures, 27 ft. deep 1982.

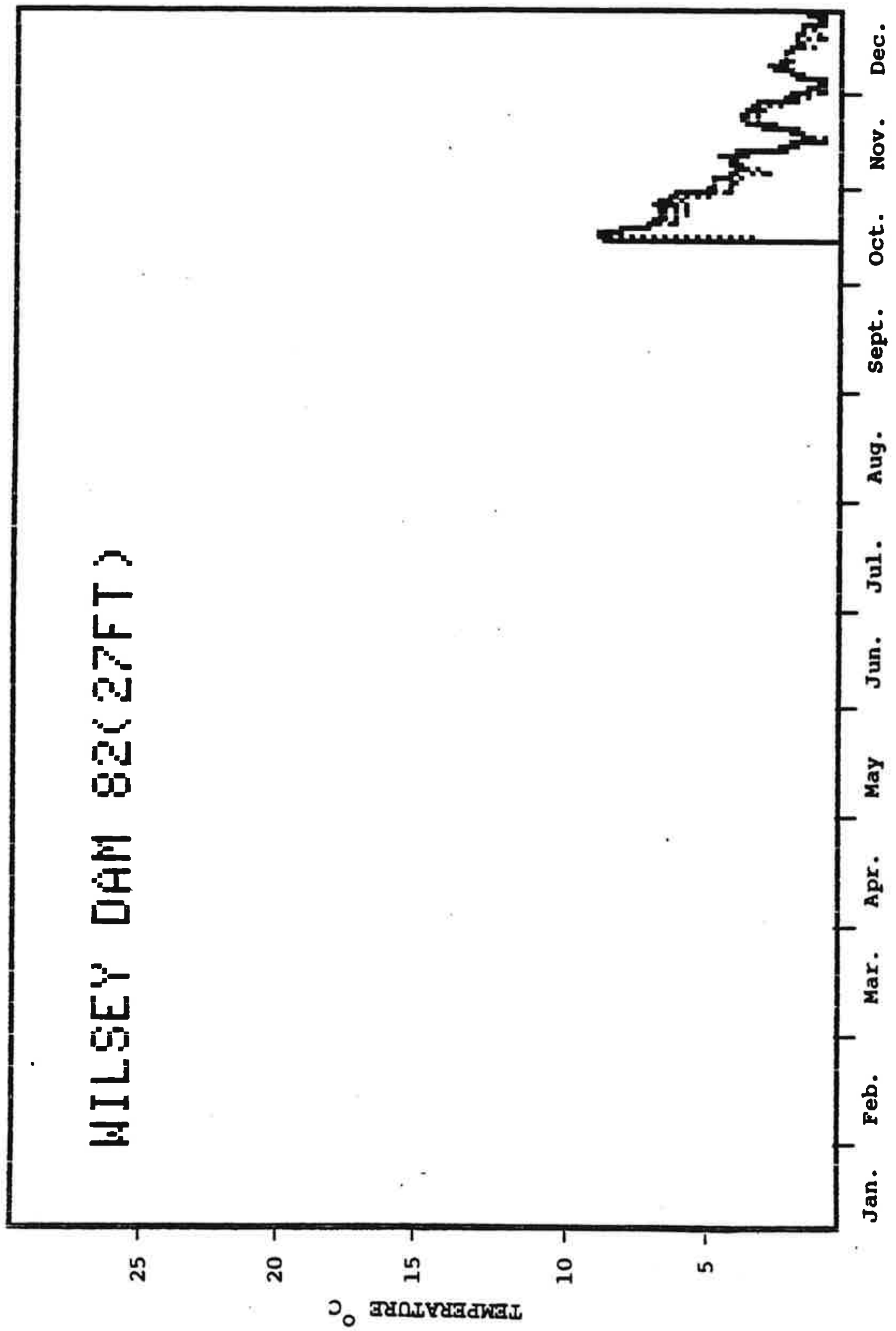
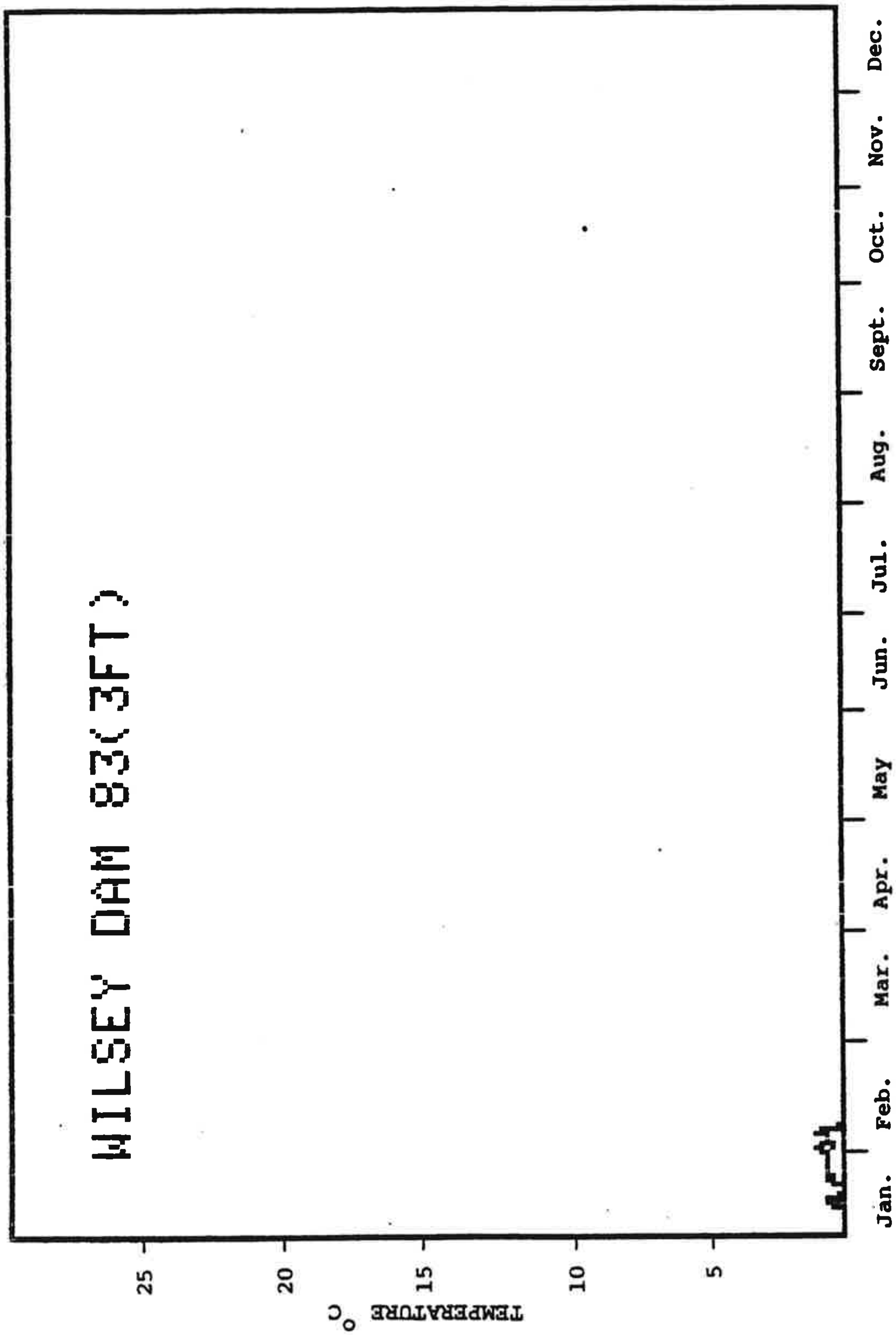


Figure 5. Shuswap River temperatures, 3 ft. deep 1983.



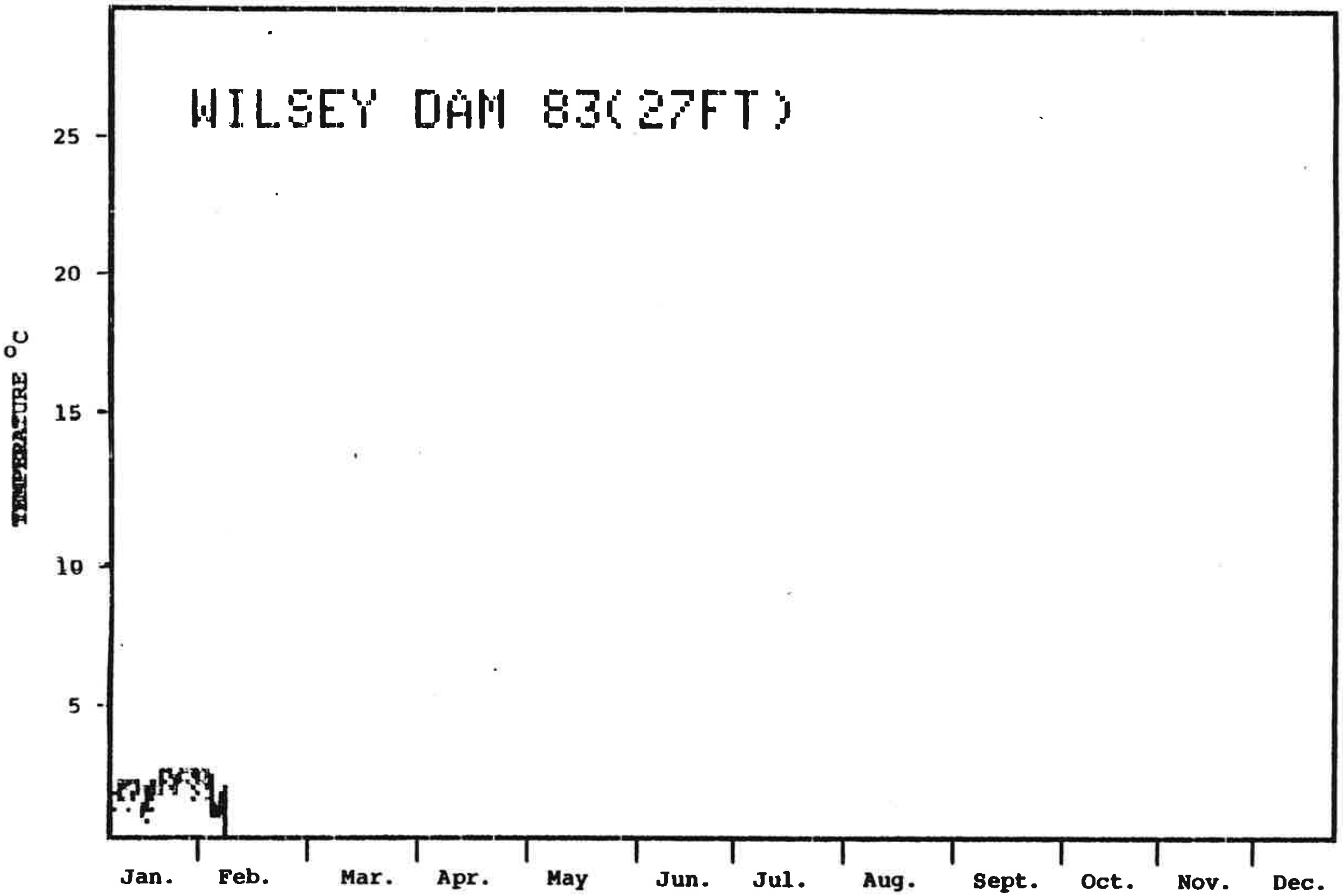
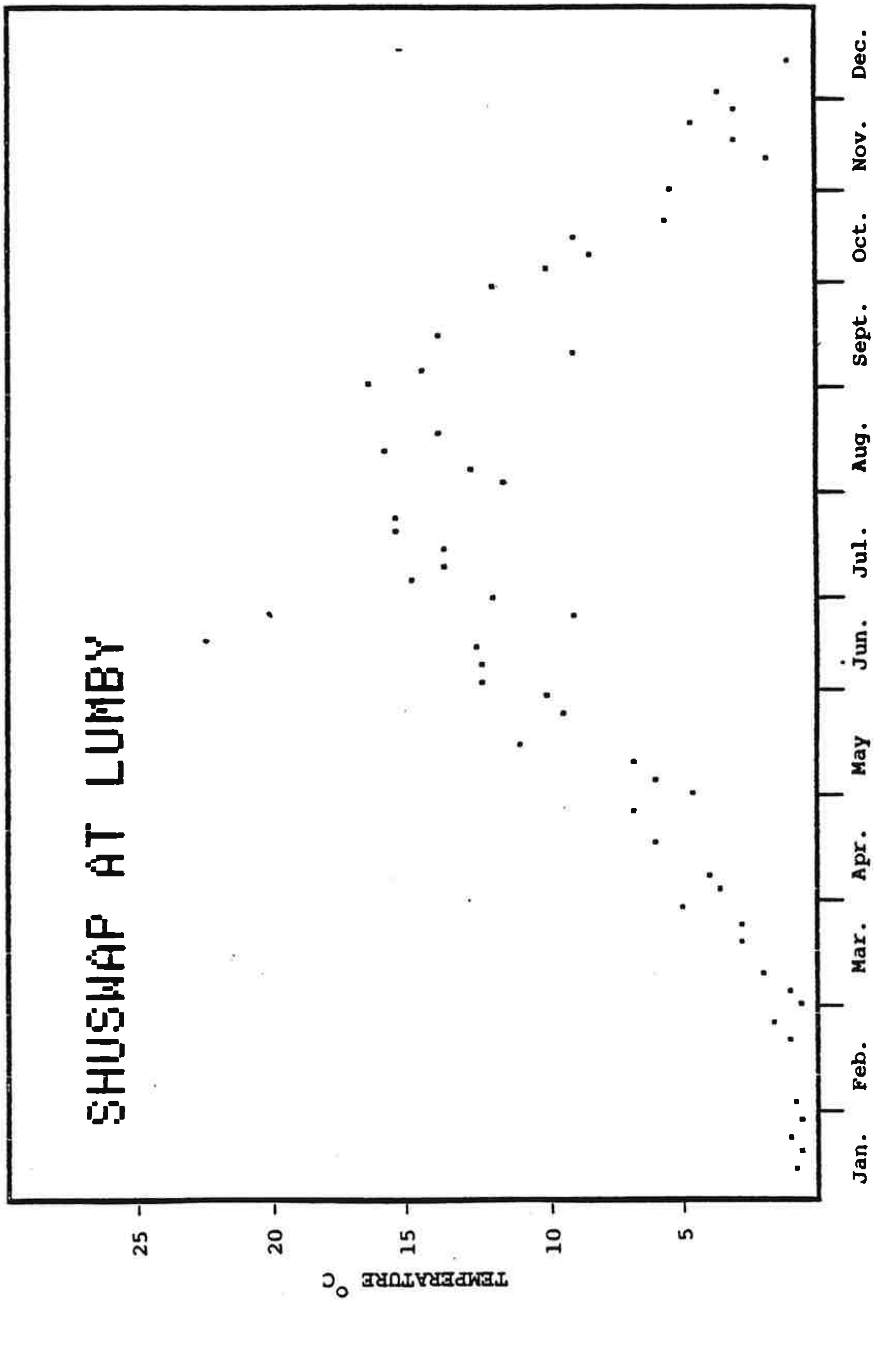


Figure 6. Shuswap River temperatures, 27 ft. deep 1983.

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



Appendix I. SIGMA Sampling report

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

March 29, 1983

File: 8055V

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

Dear Bruce:

SHUSWAP RIVER WATER QUALITY FIELD DATA

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

1. SAMPLE COLLECTION AND ANALYSIS

General

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

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

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

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

where is data? sigma to contract 365 to this Apr 1983

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

Temperature

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

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

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

Ryznar and Langlier Stability Indices

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

2. DISCUSSION OF WATER QUALITY

General

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

Well #5

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

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

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

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

Well #4

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

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

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

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

Shuswap River

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

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

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

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

Yours truly
SIGMA ENVIRONMENTAL CONSULTANTS LTD

DAVID W GRAHAM, MASc, P Eng

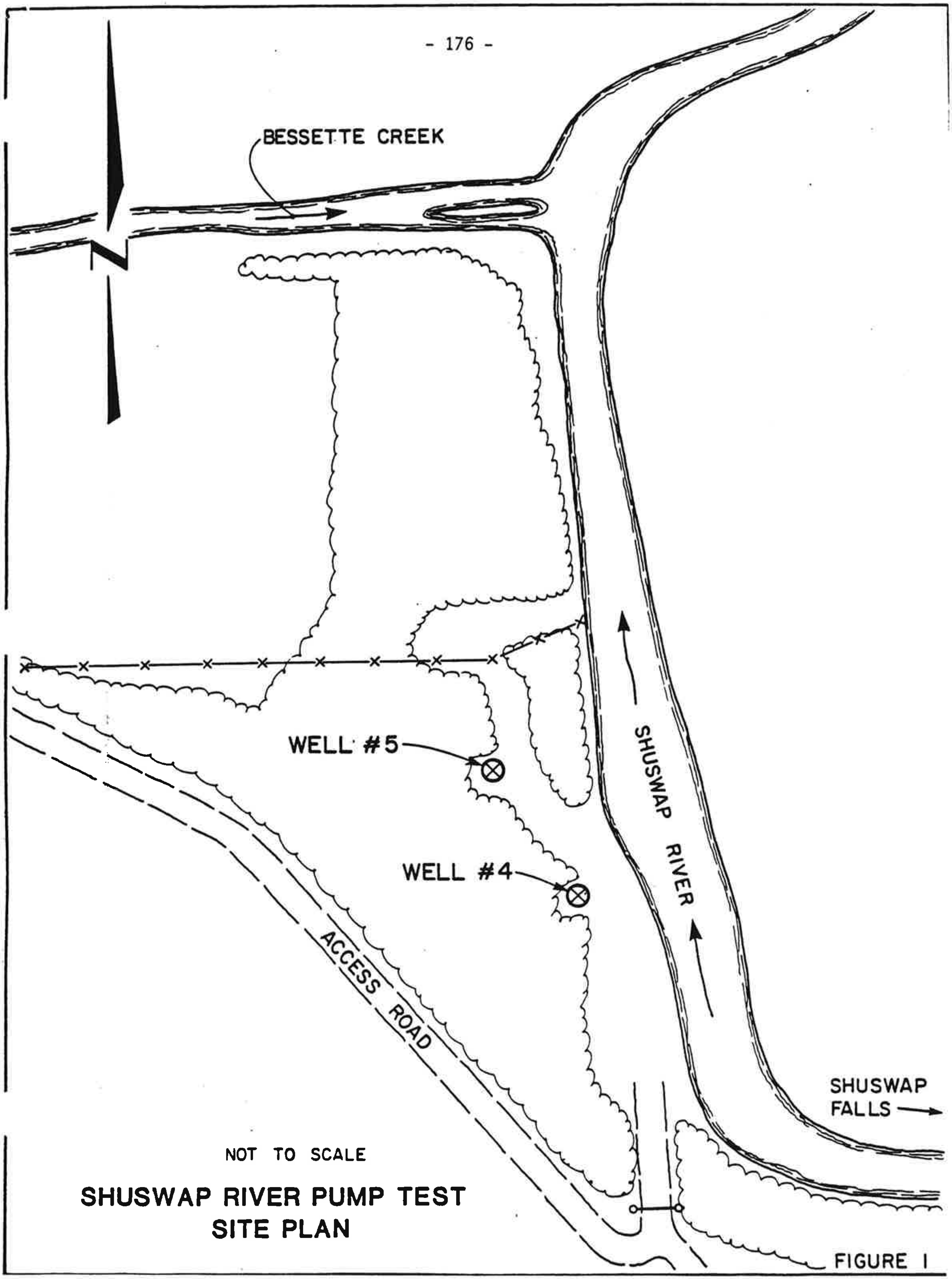
DWG:ejw-27

File: 8055V

FIELD RESULTS: SHUSWAP RIVER PUMP TESTS

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

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



SHUSWAP RIVER PUMP TEST
SITE PLAN

FIGURE 1

Appendix II. Sigma Water Temperature Monitoring.

MEMORANDUM File: 8055V

To: Bruce Shepherd, Department of Fisheries and Oceans

From: David Graham, Sigma Environmental Consultants Ltd

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

Date: April 18, 1983

Please find below the relevant temperature data you requested.

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

DAVID W GRAHAM

DWG

DWG:ejw-18

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

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

Appendix IVa. Aeration Requirements for Various Input Values.

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

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

Appendix IVb. Aeration Requirements for Various Input Values

INITIAL O2 CONC. (% SAT) = 2.6
NUMBER OF SCREENS = 10
SCREEN DISTANCE (CM) = 20.3
AERATION CONSTANT = .35
SCREEN TYPE = PACKED COLUMN

SCREEN #	O2 (% SAT)
0	2.6
1	31.35
2	51.61
3	65.89
4	75.96
5	83.05
6	88.06
7	91.58
8	94.07
9	95.82
10	97.05

Appenxid IVc. Aeration Requirements for Various Input Values.

INITIAL O2 CONC. (% SAT) = 72
NUMBER OF SCREENS = 10
SCREEN DISTANCE (CM) = 20.3
AERATION CONSTANT = .35
SCREEN TYPE = PACKED COLUMN

SCREEN #	O2 (% SAT)
0	72
1	80.26
2	86.09
3	90.19
4	93.09
5	95.13
6	96.57
7	97.58
8	98.29
9	98.8
10	99.15

Appendix IVd. Aeration Requirements for Various Input Values.

INITIAL N2 CONC. (% SAT) = 113.5
NUMBER OF SCREENS = 10
SCREEN DISTANCE (CM) = 20.3
AERATION CONSTANT = .3
SCREEN TYPE = PACKED COLUMN

SCREEN #	N2 (% SAT)
....	....
0	113.5
1	110
2	107.41
3	105.49
4	104.07
5	103.02
6	102.23
7	101.66
8	101.23
9	100.91
10	100.67

Appendix IVe. Aeration Requirements for Various Input Values.

INITIAL N2 CONC. (% SAT) = 110
NUMBER OF SCREENS = 10
SCREEN DISTANCE (CM) = 20.3
AERATION CONSTANT = .3
SCREEN TYPE = PACKED COLUMN

SCREEN #	N2 (% SAT)
0	110
1	107.41
2	105.49
3	104.07
4	103.01
5	102.23
6	101.65
7	101.23
8	100.91
9	100.67
10	100.5

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APPENDIX 4b. Further notes on Pilot Well Selection

TO / À: 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	5903-85-2130
YOUR FILE/VOTRE RÉFÉRENCE	
DATE	June 8, 1983.

SUBJECT / OBJET: FURTHER ON WELL SELECTION FOR SHUSWAP PILOT

In my memo to you May 5, 1983 on file 5830-13-16 in regards to the water quality of the water from two wells pumptested near the Shuswap Falls between March 19 to March 23, 1983, I recommended that water from either the river or from Well #4 (now called Well #1) be used for the pilot hatchery. After reading the Groundwater Hydrologists report (Shuswap Falls Pilot Project, Aquaterre Consultants Inc., April 1983) and assessing the effect of projected temperatures on fish development and growth timing, I wish to reverse that recommendation and recommend instead that Well #5 (now called Well #2) be used for the hatchery supply. Although Well #2 is not of as good quality as the river or Well #1 (the reason it was not preferred in the previous memo), it is further away from and less likely to be closely hydrologically associated with the river than Well #1. The problem is that the river water is too cold for normal hatchery operation.

Data collected on temperatures of the Shuswap River were presented in the previous memo. Monthly averages are summarized in Table 1. Since our knowledge of groundwater temperatures from the area are limited to the spot checks from Well #1 (7 °C) and Well #2 (9 °C) during the pumptest, temperature estimates had to be generated mathematically. To produce the 'Delayed' set of monthly averages in Table 1, I took a 7 month running mean of surface water temperatures to smooth out the curve a bit, then simulated a 5 month delay (such that August became January, for instance). This manipulation put the groundwater temperature at about 8 °C during mid March - the time of the pumptest. For an estimate of an even stabler groundwater environment, I compared the mean annual temperature of the Lumby area from the Canadian Climate Normals 1951-1981 (Volume 1, Temperature) and the average temperature of the monthly averages from Table 1. Both these values were 6.7, so I used that for the third set of calculations. Figure 1 shows the relationship of the three sources graphically.

I calculated developmental timing using my ATU program on the TI 59 and growth timing using my GROWTH TIMING program on the APPLE, both of which use Fourier Curve estimates for temperature for each 5 day iteration. Timing results are shown in Table 2.

/2

Chinook salmon could not be planted out until August if river water were used as the source. Fish on the 'Delayed' or 'Constant' groundwater could be planted out in April or May, or later, at a larger size. Much greater flexibility in rearing strategies would be obtained if a groundwater source not closely associated with the river were used for the pilot.

D.D. MacKinlay

DDMACK/mmm

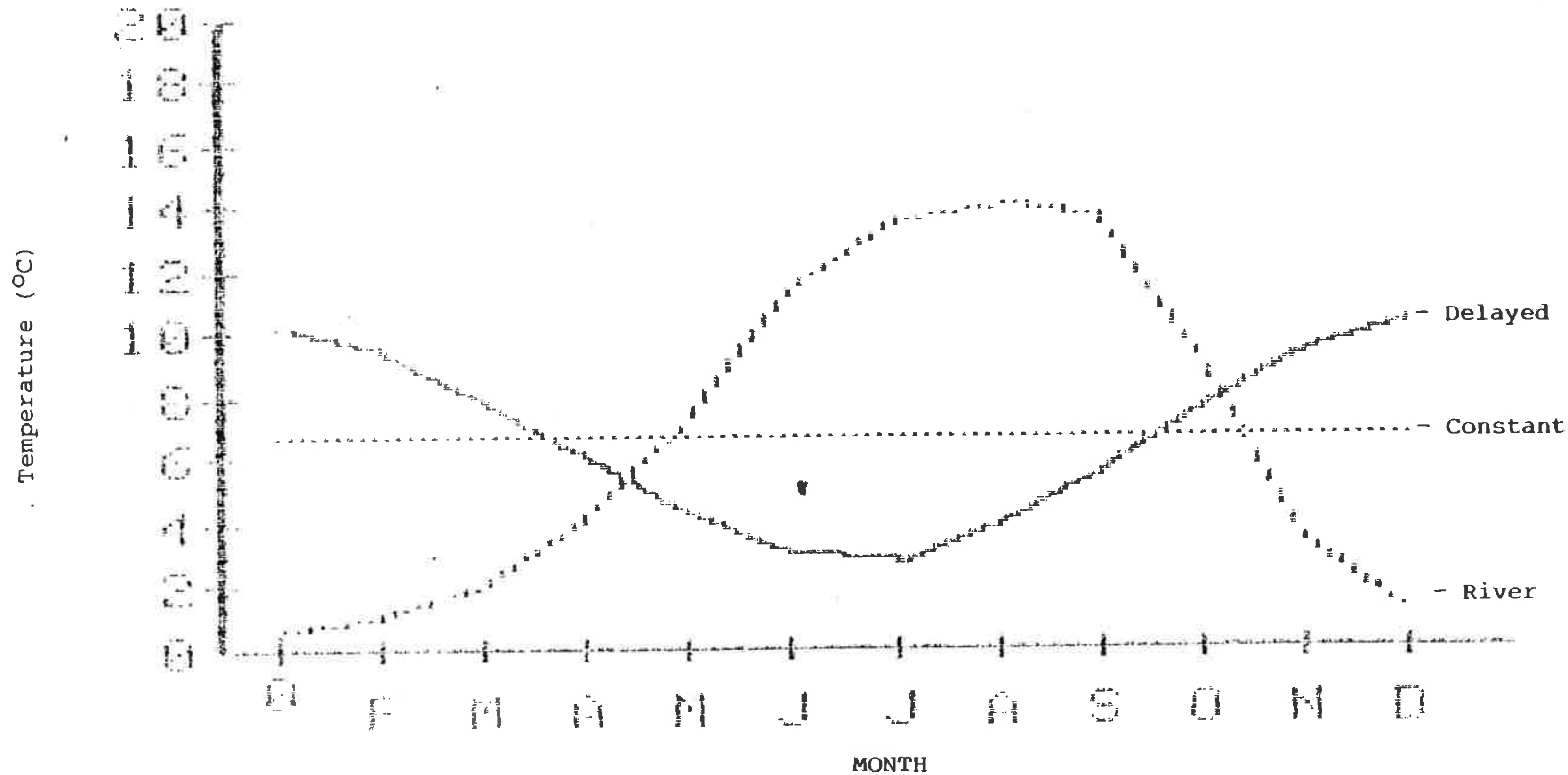
Table 1. Summary of Projected Temperatures from Shuswap Project Site.

Month	Average Monthly Temperatures		
	Source → River	Delayed	Constant
January	.5	10.2	6.7
February	1.0	9.4	6.7
March	2.0	7.8	6.7
April	4.1	6.0	6.7
May	7.1	4.3	6.7
June	11.3	3.0	6.7
July	13.5	2.7	6.7
August	14.0	3.9	6.7
September	13.5	5.6	6.7
October	9.0	7.6	6.7
November	3.3	9.4	6.7
December	1.0	10.4	6.7
Average	6.7	6.7	6.7

Table 2. Event Timing Summary for Shuswap Project Based on Different Source Temperatures.

Event	River	Delayed	Constant
Spawning	Sep 27	Sep 27	Sep 27
Eyed	Nov 1	Nov 6	Nov 11
Hatch	Mar 26	Dec 1	Dec 16
Swimup	Jun 14	Jan 15	Feb 24
2 gram	Jul 24	Mar 11	May 15
5 gram	Aug 23	May 30	Jul 24

Figure 1. Comparison of projected temperatures of water soures for Shuswap Pilot.



Appendix la. Fish Growth at River Temperatures
- Assumptions.

Graph 1b. Growth on River water source between June 14 (swim-up date) and November 11.

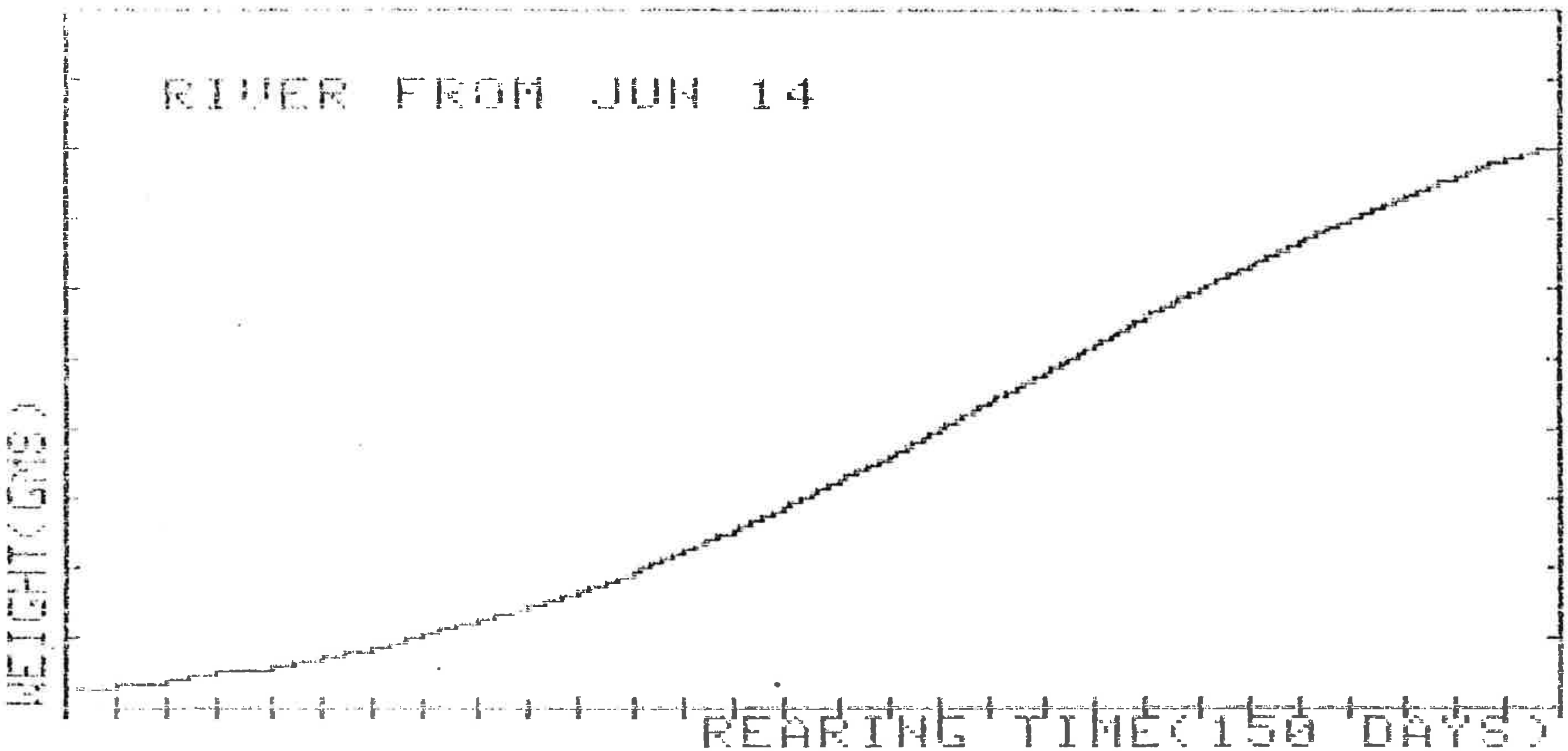


Table 1c. Fish Growth on River water source between June 14 (swim-up date) and November 11.

Period	Date	Temp.	Weight
[illegible]	[illegible]	[illegible]	[illegible]

Appendix 2a. Growth on 'Delayed' water sources between Jan 15 (swim-up date) and Jun 15.

[illegible]

Graph 2b. Growth on 'Delayed water source between Jan 15 (swim-up date) and Jun 15.

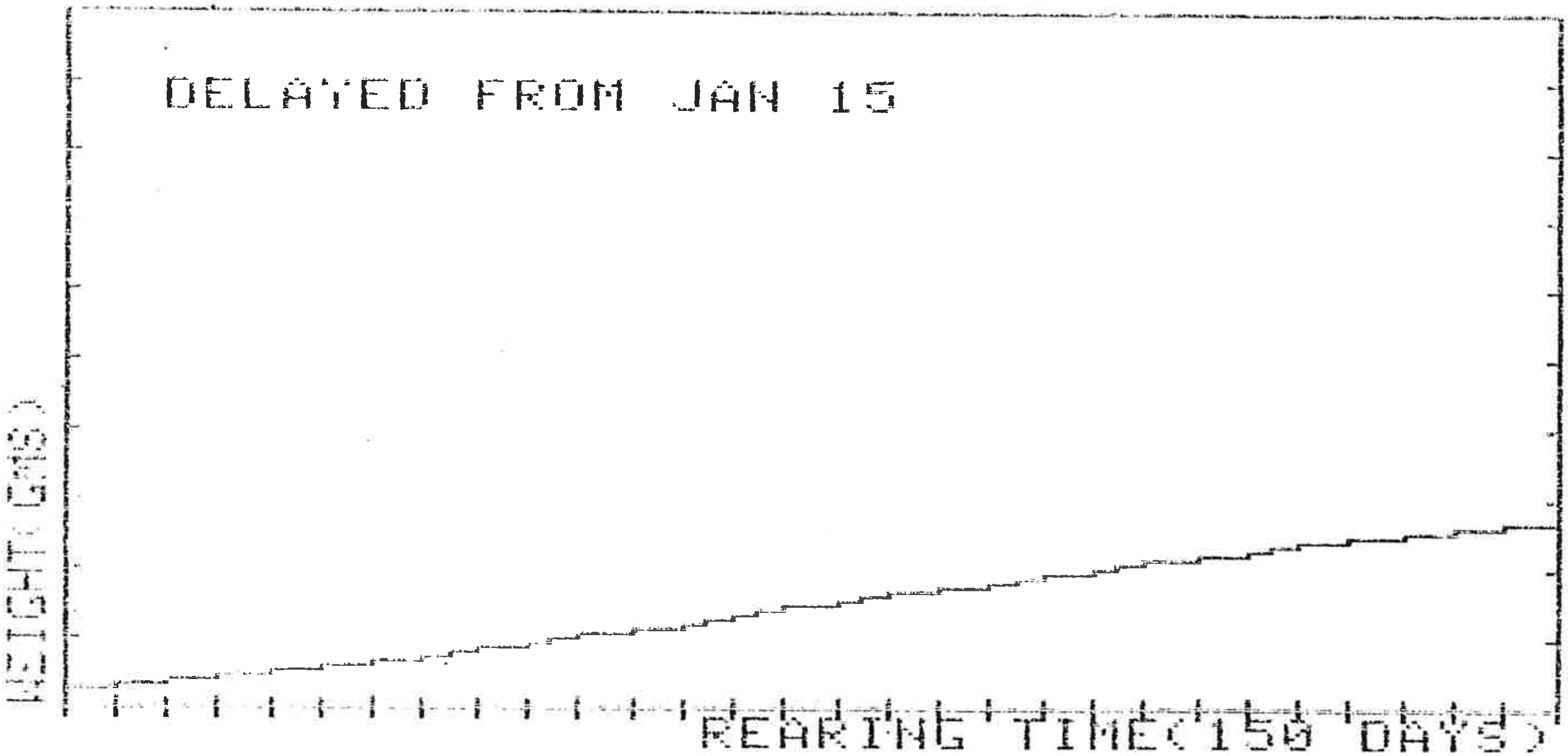


Table 2c. Growth on 'Delayed' water sources between Jan 15 (swim-up date) and Jun 15.

Period	Date	Temp.	Weight
[illegible]	[illegible]	[illegible]	[illegible]

Appendix 3a. Growth on Constant water source between Feb 24 (swim-up date) and Jul 24.

Graph 3b. Growth on Constant water source between Feb. 24
(swim-up date) and Jul 24.

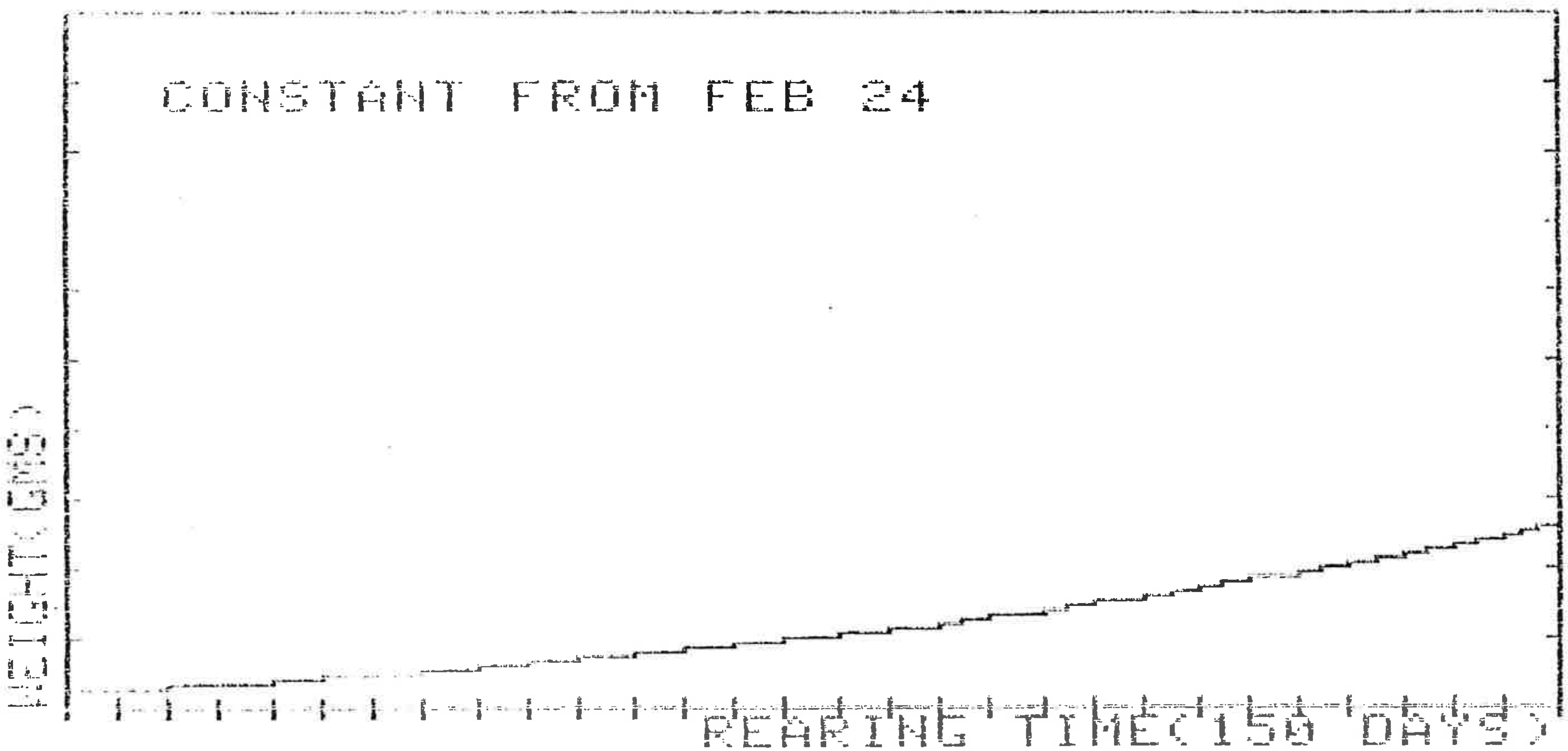


Table 3c. Growth on Constant water source between Feb. 24
(swim-up date) and Jul 24.

Period	Date	Temp.	Weight
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	30	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	80	[illegible]	[illegible]
[illegible]	85	[illegible]	[illegible]
[illegible]	90	[illegible]	[illegible]
[illegible]	95	[illegible]	[illegible]
[illegible]	100	[illegible]	[illegible]
[illegible]	105	[illegible]	[illegible]
[illegible]	110	5.74888275	3.57963526
[illegible]	115	5.44172469	[illegible]
[illegible]	120	5.14086261	3.98168176
[illegible]	125	4.84855812	[illegible]
[illegible]	130	4.56701351	4.34557098
[illegible]	135	[illegible]	[illegible]
[illegible]	140	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	150	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

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TO / À: B. G. Shepherd
New Projects Coordinator
S.E.P.

FROM / DE: Don D. MacKinlay
Design Biologist
S.E.P.

SECURITY - CLASSIFICATION - DE SÉCURITÉ:

OUR FILE/NOTRE RÉFÉRENCE: 5830-13-16

YOUR FILE/VOTRE RÉFÉRENCE:

DATE: April 19, 1984.

SUBJECT / OBJET: **Groundwater Quality of Shuswap Wells #6, #8 and #9.**

This memo reports on the water quality of the water drawn from Wells #6, #8 and #9 at the Shuswap Pilot Hatchery site near Lumby, B. C. during pump tests carried out there from March 11 to March 15, 1984. On site sampling and field analysis was contracted to Envirocon Limited and laboratory analyses were done at the DFO/EPS Water Quality Laboratory in West Vancouver.

The water from the three new wells is very similar and probably comes from the same aquifer. The quality seems to combine the best aspects of the two previous wells tested on this site, Wells #4 and #5 (see Table 1; and my memo to you of May 2, 1983 on this file).

The total and nitrogen gas pressures were lower (less than 100% and less than 109%, respectively), oxygen was higher (up to 69%), there was no ammonia and there were no anomalous high heavy metal detections compared to the previous wells. The water still requires aeration but not as much as does the water from Well #5 (which is being used for the Pilot). The hardness parameters (conductivity, hardness, calcium, total alkalinity, filtrable residue) are all within good ranges for fish culture. The water temperature (8.2°C to 8.8°C) is very good for a March sampling, indicating a reverse temperature curve compared to the ambient river water. This should prove advantageous for fish culture.

There were two on-site low readings of pH (6.3 and 6.4 in Well #8) but these were not reflected in the laboratory analysis of the same samples, therefore may have been due to instrument malfunction. Marginally high levels of nutrients (nitrate and phosphate) indicate that the aeration tower should probably be covered to shade from sunlight which may cause algal blooming but otherwise are not a serious problem.

Generally, the water from these wells is of excellent quality for fish culture, as long as it is aerated first.

Don D. MacKinlay

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

PARAM.	RECOMM.	TOXIC	OCT27/82 RIVER HEADPOND	MAR30/82 RIVER PEN1 45'	OCT27/82 RIVER PEN1 45'	FEB08/83 RIVER PEN1 45'	MAR30/82 RIVER PEN2 25'	OCT27/82 RIVER PEN2 25'	MAR22/83 RIVER AT ISLAND	MAR12/84 RIVER AT ISLAND	MAR14/84 RIVER AT ISLAND
ALK.TOT	20-300		45	51	45	48	50	45	47.5	55	56
AMMON.	<.002	>.08	0	0	0	.019	0	0	0	0	0
CO2	2-5	>20									
CHLOR.	<170	>400	0	.7	0	.6	.9	0	.8	.6	.9
COLOR	<15										
COND.FLD	150-2000								57	79	78
COND.LAB	"		103	123.9	104	129	122.8	104	107	131.8	136
DO-PPM	>6-8	<4		12			11		12.1	13.6	13.2
D0-%SAT	100%		79.37	87.6	75.37		82.5	80.87	95.7	106.5	103.8
DGAS.TOT	<103%	>110%	104.13	102.3	102.43		100.7	101.05	105	101.7	101.4
DGAS.NIT	100%		110.74	106.2	109.65		105.5	106.45	107.5	106.5	103.8
HARDNESS	20-400		50.3	53	50.3	60.4	52.9	49.3	49.9	63.3	65.4
H2S	<.002	>.004									
NITRITE	<.012	.2	0	0	0	0	0	0	.005	0	0
NITRATE	<.12		.03	.08	.03	2.11	.13	.02	.11	.12	.13
PH-FLD	6.8-8.5	<5,>9	7.75		8			8.25	7.35	6.85	6.8
PH-LAB	"	"	7.8	7.9	7.8	7.7	7.8	7.8	7.8	7.7	7.6
PHOSPH.	<.05		.006	.005	.007	.01	0	.006	.008	.005	.008
RESID.TOT	<2000										
RESID.FIL	70-400		70	83	77	90	84	71	79	90	102
RESID.N.F	<3		0	0	0	0	0	0	0	0	0
SALIN.									0		
SILICA	<10-60		2.8	3.5	2.8	3.5	3.4	2.8	3.3		
SULFATE	<90		6.8	8.3	6.7	7.8	8.4	6.7	6.7	9.1	8.9
TASTE	OK										
T.D.SOL	500-1000	15000									
TEMP.	4-18C	<2,>25	9	2	13		3	10	3.7	2.95	2.6
TURBID	1-60	>1000	0	.2	.1	.1	.2	.1	.5		
METALS--											
AL	<.1	>5	0	0	0	0	0	0	0	.06	.1
AS	<.5	>1	0	0	0	0	0	0	0	0	0
BA	<1		.009	.009	.009	.009	.009	.008	.009	.011	.007
CA	4-150	>300	17.1	17.4	17.1	20.8	17.4	16.7	16.6	20.8	21.2
CD	<.0004		0	0	0	0	0	0	0	0	0
CO			0	0	0	0	0	0	0	0	0
CR	<.01		0	.368	0	0	0	0	0	0	0
CU	<.006		0	0	0	.003	0	0	0	0	0
FE	<.3		.042	.043	.026	.028	.037	.027	.04	.065	.113
HG	<.00005	>.0002	0	0	0	0	0	0	0	0	0
K		>50	.79	1.02	.81	.8	.85	.79	.79	1.05	1.09
MG	<10	>100	1.8	2.3	1.8	2	2.2	1.8	2	2.6	2.8
MN	<.05	>15	.005	.003	.004	.003	.003	.003	.005	.006	.009
MO			0	0	0	0	0	0	0	0	0
NA		>500	1.2	1.3	1.2	1.2	1.3	1.1	1.1	1.4	1.4
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		2.6	3.1	2.6	3.1	3.1	2.6	3.1	3.7	3.8
SN			0	0	0	0	0	0	0	0	0
SR			.075	.079	.073	.007	.08	.072	.072	.095	.098
TI			0	0	0	0	0	0	0	0	.003
V			0	0	0	0	0	0	0	0	0
ZN	<.005		.004	0	0	.002	0	0	0	0	0

TABLE 1 WATER QUALITY VALUES FOR SHUSWAP-(continued)
(BELOW DETECTION LIMITS=0)

PARAM.	RECOMM.	TOXIC	MAR21/83 1600 HR WELL #4	MAR22/83 0830 HR WELL #4	MAR22/83 1600 HR WELL #4	MAR23/83 1030 HR WELL #4	MAR19/83 1500 HR WELL #5	MAR20/83 0830 HR WELL #5	MAR20/83 1200 HR WELL #5
ALK.TOT	20-300		50	50	51	51	78	88	90
AMMON.	<.002	>.08	0	0	0	0	.007	.008	.009
CO2	2-5	>20							
CHLOR.	<170	>400	.9	.9	.8	.9	.8	.9	.9
COLOR	<15		0	0	0	0	0	0	0
COND.FLD	150-2000		68	69	69	68	120	132	132
COND.LAB	"		118	117	117	117	179	209	214
DO-PPM	>6-8	<4	8.9	8	8.3	8.1	.5	.3	.4
D0-%SAT	100%		76	68.9	72.1	70.7	4.5	2.6	3.6
DGAS.TOT	<103%	>110%	105.3	102.3	103.2	102.5	90.6	90.4	89.4
DGAS.NIT	100%		113.1	114	111.5	111	113.5	113.7	112.2
HARDNESS	20-400		55.1	53.8	55.1	57.7	89.8	94.6	97.7
H2S	<.002	>.004							
NITRITE	<.012	.2	.012	.007	0	0	.099	.017	.011
NITRATE	<.12		.17	.15	.16	.15	.04	.07	.04
PH-FLD	6.8-8.5	<5,>9	7.15	7.2	7.1	7.1	7.8	7.7	7.7
PH-LAB	"	"	7.5	7.5	7.4	7.4	7.8	8	8
PHOSPH.	<.05		0	.005	.007	.007	.022	.022	.022
RESID.TOT	<2000								
RESID.FIL	70-400		84	79	80	72	127	137	136
RESID.N.F	<3		0	0	0	0	0	0	0
SALIN.			0	0	0	0	0	0	0
SILICA	<10-60		3.3	3.4	3.4	3.4	5.9	5.9	5.9
SULFATE	<90		8	7.4	7.1	6.9	15.3	16.7	17
TASTE	OK								
T.D.SOL	500-1000	15000							
TEMP.	4-18C	<2,>25	6.7	7	7.1	7.1	8.9	8.85	8.9
TURBID	1-60	>1000	.1	.1	.2	.2	.8	.8	.8
METALS--									
AL	<.1	>5	0	0	0	0	0	0	0
AS	<.5	>1	0	0	0	0	0	0	0
BA	<1		.009	.008	.009	.009	.016	.018	.018
CA	4-150	>300	18.6	18.2	18.6	19.5	29.1	30.9	31.9
CD	<.0004		0	0	0	0	0	0	0
CO			0	0	0	0	0	0	0
CR	<.01		0	0	.013	0	0	0	0
CU	<.006		0	0	0	0	0	0	0
FE	<.3		.01	.006	.038	0	.157	.205	.209
HG	<.00005	>.0002	0	0	0	0	0	0	0
K		>50	.78	.78	.81	.79	1.6	1.67	1.69
MG	<10	>100	2.1	2	2	2.1	4	4.1	4.2
MN	<.05	>15	0	0	.003	0	.038	.045	.046
MO			0	0	0	0	.02	0	0
NA		>500	1.2	1.1	1.1	1.2	3.3	3.9	4
NI			0	0	0	0	0	0	0
P			0	0	0	0	0	0	0
PB	<.01		0	0	0	0	0	0	0
SB			0	0	0	0	0	0	0
SE		>2.5	0	0	0	0	0	0	0
SI	<10-60		3.1	3.1	3.2	3.4	5.9	5.5	5.6
SN			0	0	.01	0	0	0	0
SR			.079	.079	.081	.084	.203	.203	.208
TI			0	0	0	0	0	0	0
V			0	0	0	0	0	0	0
ZN	<.005		0	0	.005	0	0	0	0

TABLE 1 WATER QUALITY VALUES FOR SHUSWAP-(continued)
(BELOW DETECTION LIMITS=0)

PARAM.	RECOMM.	TOXIC	MAR15/84 1230 HRS WELL #6	MAR15/84 2130 HRS WELL #6	MAR16/84 0800 HRS WELL #6	MAR11/84 1100 HRS WELL #8	MAR11/84 2100 HRS WELL #8	MAR12/84 0900 HRS WELL #8	MAR12/84 2100 HRS WELL #8	MAR13/84 0900 HRS WELL #8	MAR13/84 1900 HRS WELL #9	MAR14/84 0500 HRS WELL #9	MAR14/84 1700 HRS WELL #9
ALK.TOT	20-300		60	57	57	61	61	63.5	69	76	57	62.5	69
AMMON.	<.002	>.08	0	0	0	0	0	0	0	0	0	0	0
CO2	2-5	>20											
CHLOR.	<170	>400	.6	.6	.6	.7	.6	.6	.8	1.1	.7	.8	.8
COLOR	<15												
COND.FLD	150-2000		98	97	94	93	101	107	116	133	98	106	118
COND.LAB	"		139.4	141	138	138.4	139.4	147	172	196	135	155	173
DO-PPM	>6-8	<4	6.4	7.8	7.3	5.4	5.6	5.8	5.6	5.3	6.5	6.5	6.5
D0-%SAT	100%		56.9	69.4	65	49.2	51	52.8	51	48.3	58.8	59.2	58.8
DGAS.TOT	<103%	>110%	93.1	98.2	97.5	95.7	95.5	95.8	96.3	96.2	97	96.5	96.6
DGAS.NIT	100%		102.8	105.9	106.2	108.1	107.3	107.1	108.3	108.9	107	106.4	106.7
HARDNESS	20-400		65.2	66.1	65.3	67.6	68.2	72.1	81.8	93.6	64.6	72.5	80.6
H2S	<.002	>.004											
NITRITE	<.012	.2	0	0	0	0	0	0	0	0	0	0	0
NITRATE	<.12		.11	0	.11	.1	.11	.15	.18	.21	.13	.15	.17
PH-FLD	6.8-8.5	<5,>9	7.1	7.2	7.2	6.3	6.7	6.5	6.4	6.5	7.1	7.5	7.1
PH-LAB	"	"	8	7.8	7.8	8	8	8	7.9	7.8	7.9	7.9	8
PHOSPH.	<.05		.003	.003	.024	.003	.003	.003	.002	.002	.002	.002	.002
RESID.TOT	<2000												
RESID.FIL	70-400		94	96	97	92	94	97	107	126	93	108	116
RESID.N.F	<3		0	0	0	0	0	0	0	0	0	0	0
SALIN.													
SILICA	<10-60												
SULFATE	<90		7.7	7.8	7.6	7.5	7.6	9.8	11.6	15.2	7.6	10.1	12.6
TASTE	OK												
T.D.SOL	500-1000	15000											
TEMP.	4-18C	<2,>25	8.4	8.2	8.2	8.8	8.7	8.7	8.7	8.7	8.6	8.6	8.7
TURBID	1-60	>1000											
METALS--													
AL	<.1	>5	0	0	0	0	0	0	0	0	0	0	0
AS	<.5	>1	0	0	0	0	0	0	0	0	0	0	0
BA	<1		.007	.006	.006	.008	.008	.009	.007	.007	.001	.007	.01
CA	4-150	>300	22.2	22.5	22.3	23.1	23.3	24.7	28	32	22.1	24.8	27.6
CD	<.0004		0	0	0	0	0	0	0	0	0	0	0
CO			0	0	0	0	0	0	0	0	0	0	0
CR	<.01		0	0	0	0	0	0	0	0	0	0	0
CU	<.006		0	0	0	0	0	0	0	0	0	0	0
FE	<.3		.016	.016	.016	.019	.009	.008	.009	.006	.01	.006	.006
HG	<.00005	>.0002	0	0	0	0	0	0	0	0	0	0	0
K		>50	1.06	.92	.94	1.01	1.03	1.05	1.06	1.12	1	1.05	1.08
MG	<10	>100	2.3	2.3	2.3	2.4	2.4	2.5	2.8	3.3	2.2	2.5	2.8
MN	<.05	>15	.004	.001	0	0	0	0	0	0	0	0	.001
MO			0	0	0	0	0	0	0	0	0	0	0
NA		>500	1.6	1.7	1.6	1.5	1.4	1.4	1.4	1.5	1.3	1.4	1.4
NI			0	0	0	0	0	0	0	0	0	0	0
P			0	0	0	0	0	0	0	0	0	0	0
PB	<.01		0	0	0	0	0	0	0	0	0	0	0
SB			0	0	0	0	0	0	0	0	0	0	0
SE		>2.5	0	0	0	0	0	0	0	0	0	0	0
SI	<10-60		3.9	4	4	4.3	4.3	4.3	4.3	4.3	4.1	4.1	4.1
SN			0	0	0	0	0	0	0	0	0	0	0
SR			.096	.1	.098	.097	.098	.105	.119	.138	.095	.105	.117
TI			0	0	0	0	0	0	0	0	0	0	0
V			0	0	0	0	0	0	0	0	0	0	0
ZN	<.005		.002	.003	0	0	0	0	0	0	0	0	0

1919/WP 1739

DATA REPORT

ON-SITE WATER QUALITY SAMPLING AND ANALYSIS AT SHUSWAP FALLS SALMON ENHANCEMENT PROJECT SITE, MARCH, 1984

(DSS File No. 045B FP576-3-0265)

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1.0 INTRODUCTION

In partial fulfillment of a contract with the Department of Fisheries and Oceans (DFO) Envirocon Limited conducted water quality sampling and analyses at the Shuswap Falls salmon enhancement project site. This work was conducted between March 11 and March 16, 1984 as part of the well development and pump testing of three wells conducted by Aqua-Terr Consultants Ltd. and Aqua-Flo Testing and Equipment Ltd. This report presents the results of all on-site water quality analyses conducted at wells # 6, 8 and 9 at the Shuswap Falls site as well as data obtained for the Shuswap River and well # 5. Analytical results of water quality analyses conducted at the EPS-DFO Cypress Creek Laboratory, which will be submitted directly to the Scientific Authority, are complimentary to the results reported here.

2.0 METHODS

Wells #6, 8 and 9 at the Shuswap Falls salmon enhancement project site were pump tested for 48 hours, 24 hours and 24 hours, respectively, between March 11 and March 16, 1984. The pumping of the wells was conducted by Aqua-Flo Testing and Equipment Ltd. while supervision of the pump testing procedure was undertaken by Aqua-Terr Consultants Ltd. On-site analyses were conducted and laboratory samples collected two hours after the commencement of pumping and at subsequent twelve hour intervals from the commencement of pumping at each well.

Well water for water quality analyses and sample collection was obtained during each pump test from a back pressure valve located upstream of the end of the discharge pipe (Plate 1, 2). No air was entrained in the water collected. The water was run through a short length of hose into a narrow necked carboy. The narrow opening of the carboy and a constant flow of water minimized contact between the pumped well water and the atmosphere.

Water temperature, dissolved oxygen concentration, total gas pressure, pH and conductivity were all measured in the carboy. Water samples for the DFO hatchery series of water quality analyses were collected directly from the hose leading from the back pressure valve. Air entrainment into the samples was minimized as much as possible while these samples were being collected. Additional water temperature data for the well water was obtained using a Ryan Peabody thermograph. The thermograph was placed in the pool created by the pump discharge and recorded water temperature for the duration of each pump test.

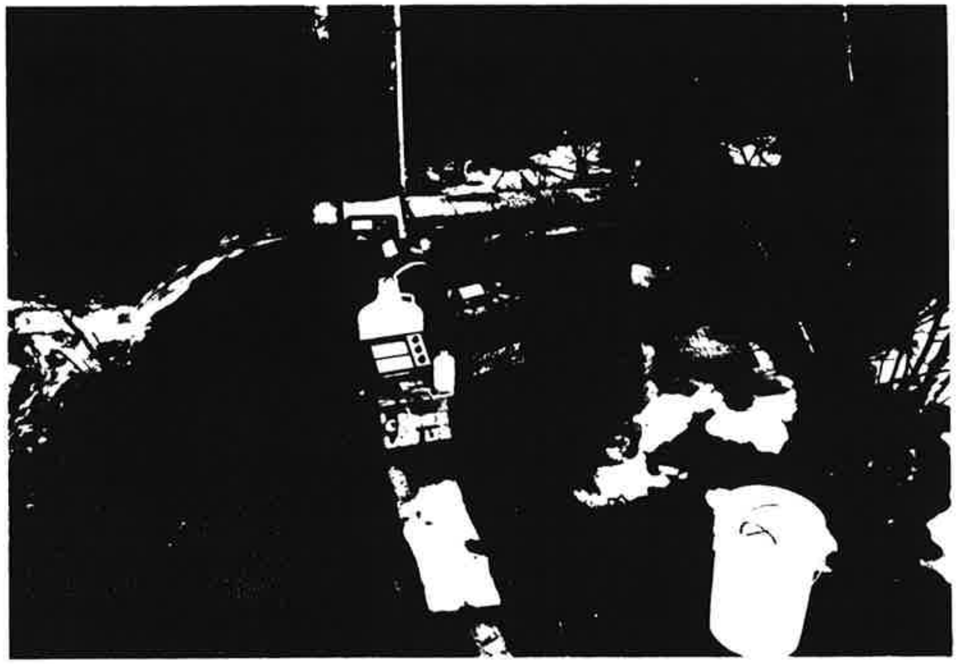

PLATE 1. Pump test discharge at Shuswap Falls project site showing instruments used for the on-site analysis, the carbuoy in which measurements were taken and the back pressure hose which supplied sample water

PLATE 2. Pumping equipment in place on the head of well #6, Shuswap Falls project site

Water quality samples were also collected and on-site analyses conducted in the Middle Shuswap River on March 12 and March 13. Sampling and analyses were conducted adjacent to the project site approximately 100 m upstream of where the pump discharge flow entered the river. The March 13 sample was collected to provide an indication of changes in river water quality associated with increased turbidity due to heavy rains which occurred the night of March 12/13.

Water quality samples were collected and water temperature, dissolved oxygen concentration, total gas pressure and conductivity were also measured in the pilot hatchery rearing troughs at the project site on March 16 at the request of Mr. G. Neilson. Water supply to these troughs from Well #5 had been pumped for one to two hours prior to sample collection and water quality measurement. These samples were submitted to the EPS-DFO laboratory approximately 69 hours after being collected. This delay was unavoidable due to the hour at which the samples were collected and the fact that the water quality laboratory was closed on March 17 and 18. These samples were frozen to preserve them until they were submitted to the water quality laboratory on March 19.

Schedules of sample collection, shipping and delivery for all the samples submitted to the EPS-DFO Water Quality Laboratory are detailed in Appendix I.

2.1 Analytical Methods

The analytical methods used were those described in Standard Methods for the Examination of Water and Wastewater (American Public Health Association, 1976) with the exception of the measurement of total gas pressure. Total gas pressure was measured using a Novatech Designs Model 300 B Gas Tensionometer, according to the manufacturers recommended methods of operation. A handheld altimeter and the tensionometer were used to measure local barometric pressure at each sampling time as required for the calculation of total dissolved gas saturation. The altimeter was calibrated using barometric pressure data obtained at the Kelowna airport. Total dissolved gas saturation and dissolved oxygen concentration data were used to calculate dissolved nitrogen and argon concentrations and saturations. Data used to determine the dissolved gas results are presented in Appendix 2. The equations used for these calculations were previously presented in the data report describing water quality sampling conducted by Envirocon Limited in September, 1983.

Dissolved oxygen concentration measurements were made using YSI Model 54A and Model 57 dissolved oxygen meters which were calibrated using the manufacturers recommended methods before each series of measurements.

An Orion Model 407A electronic pH meter with a single combination electrode was used for all pH measurements. The meter was calibrated on site and manually adjusted for water temperature.

A YSI Model 33 Salinity/Conductivity/Temperature meter which was manually compensated for water temperature was used for all measurements of conductivity.

Water temperatures were measured using a calibrated mercury thermometer.

3.0 RESULTS

Well #8 was pumped from 0900 hours March 11 to 0900 hours March 13 at a constant rate of approximately 800 U.S. GPM. During the pump test on-site analyses were conducted and water samples collected at 2, 12, 24, 36 and 48 hour intervals (Table 1).

After 48 hours of pumping, conductivity and pH in the well water measured 133 umho/cm and 6.5, respectively (Table 1). The dissolved oxygen concentration was 5.3 mg/l and nitrogen and argon concentration was 19.2 mg/l (Table 1). Total gas saturation was 96.2% with an oxygen saturation of 48.3% and a nitrogen and argon saturation of 108.9% (Table 1). The water temperature was 8.7°C. Parameter levels were relatively stable with little change from levels earlier in the test, with the exception of conductivity which increased gradually from 93 umho/cm at the 2 hour interval of the test (Table 1). No hydrogen sulfide odour was detected during the test period and the water was clear at all times.

Well #9 was pump tested for 24 hours at a constant rate of approximately 640 U.S. GPM commencing at 1700 hours March 13. On-site analyses were conducted and water samples collected at the 2, 12 and 24 hour intervals.

At the 24 hour interval of the pump test, conductivity of the well water was 118 umho/cm and pH was 7.1 (Table 2). The dissolved oxygen concentration was 6.5 mg/l and the dissolved nitrogen and argon concentration was 17.0 mg/l (Table 2). Total gas saturation was 96.6% while oxygen saturation was 58.8% and nitrogen and argon saturation was 106.7% (Table 2). Water temperature was 8.7°C. These parameter levels were relatively constant throughout the pump test period with only a small increase in conductivity between the two hour interval and the end of the test. The pH result obtained at the 12 hour interval

TABLE 1
Water Quality Data Collected at Shuswap Falls Project Site, Well 8, During a 48 Hour Pump Test Conducted March 11 to 13, 1984

Parameter	Interval After Pumping Began[1]				
	2 hrs.	12 hrs.	24 hrs.	36 hrs.	48 hrs.
Total gas saturation (%)	95.7	95.5	95.8	96.3	96.2
Dissolved N_2 and Ar (mg/l)	19.0	18.9	18.9	19.1	19.2
Dissolved N_2 and Ar (%)	108.1	107.3	107.1	108.3	108.9
Dissolved O_2 (mg/l)	5.4	5.6	5.8	5.6	5.3[2]
Dissolved O_2 (%)	49.2	51.0	52.8	51.0	48.3[2]
Temperature (°C)	8.8	8.7	8.7	8.7	8.7
pH (rel. units)	6.3	6.7	6.5	6.4	6.5
Conductivity (umho/cm)[2]	93	101	107	116	133

1 Water quality samples were collected for complete analysis each time on-site analyses were conducted. Well water was pumped at a rate of approximately 800 U.S. GPM for the duration of the test.

2 Values represent the mean of duplicate sample data.

TABLE 2
Water Quality Data Collected at Shuswap Falls Project Site, Well 9, During a 24 Hour Pump Test Conducted March 13 to 14, 1984

Parameter	Interval after Pumping Began[1]		
	2 hrs.	12 hrs.	24 hrs.
Total gas saturation (%)	97.0	96.5	96.6
Dissolved N_2 and Ar (mg/l)	17.1	17.0	17.0
Dissolved N_2 and Ar (%)	107.0	106.4	106.7
Dissolved O_2 (mg/l)[2]	6.5	6.5	6.5
Dissolved O_2 (%)[2]	58.8	59.2	58.8
Temperature (^{o}C)	8.6	8.6	8.7
pH (rel. units)	7.1	7.5[3]	7.1
Conductivity (umho/cm)	98	106	118

1 Water quality samples were collected for complete analysis each time that on-site analysis were conducted. Well water was pumped at a rate of approximately 640 U.S. GPM for the duration of the test.

2 Values represent the mean of duplicate sample data.

3 Meter instability makes this value questionable.

is questionable due to meter difficulties encountered at that time. No hydrogen sulfide odour was detected during the test period and the water was clear at all times.

While the levels of the parameters measured on-site were similar in most cases for both well #8 and well #9 some differences were apparent. The most significant is the difference in pH from that measured in well #8 (6.5) to that measured in well #9 (7.1). Data for dissolved gases indicate slightly lower oxygen levels and higher nitrogen and argon levels in well #8 relative to those in well #9. Conductivity levels for well #9 fall within the range observed in water from well #8 while water temperatures vary by only 0.1 to 0.2°C between wells.

Well #6 was pumped for 22 hours to a constant rate of approximately 254 U.S. GPM, beginning at 1030 hours March 14. Sampling was conducted at the two hour, eleven hour and twenty one hour intervals. The last water samples were collected and on-site analyses conducted earlier than usual to insure that the samples could be submitted to the EPS-DFO Water Quality Laboratory within the required time.

After 24 hours of pumping, conductivity and pH in the well water were 94 and 7.2, respectively (Table 3). The dissolved oxygen concentration was 7.3 mg/l and the dissolved nitrogen and argon concentration was 19.1 mg/l (Table 3). Total gas saturation was 97.5% while dissolved oxygen saturation was 65.0% and nitrogen and argon saturation was 106.2% (Table 3). Water temperature was 8.2°C. Total gas saturation and dissolved oxygen and dissolved nitrogen and argon concentrations and saturations increased from earlier values and conductivity dropped slightly. The water was clear at all times and no hydrogen sulfide odour was detected during the test period.

TABLE 3
Water Quality Data Collected at Shuswap Falls Project Site, Well 6, During a 22 Hour Pump Test Conducted March 15 to 16, 1984

Parameter	Interval after Pumping Began[1] 2 hrs.	11 hrs.	21 hrs.
Total gas saturation (%)	93.1	98.2	97.5
Dissolved N_2 and Ar (mg/l)	18.5	19.1	19.1
Dissolved N_2 and Ar (%)	102.8	105.9	106.2
Dissolved O_2 (mg/l)[2]	6.4	7.8	7.3
Dissolved O_2 (%)[2]	56.9	69.4	65.0
Temperature (°C)	8.4	8.2	8.2
pH (rel. units)	7.1	7.2	7.2
Conductivity (umho/cm)	98	97	94

1 Water quality samples were collected for complete analysis each time on-site analysis were conducted. Well water was pumped at a rate of approximately 254 U.S. GPM for the duration of the test.

2 Values represent the mean of dulpicate sample data.

The levels of the measured parameters in well #6 were generally similar to those measured in wells #8 and 9. Total gas saturation and dissolved oxygen and dissolved nitrogen and argon concentrations were slightly higher or equal to the upper end of the range of values measured in wells #8 and 9. Conductivity levels fell within the range of values measured in wells #8 and 9 while pH remained similar to that measured in well #9. Water temperature was 0.2 to 0.6°C lower in wells #8 and 9 than in well #6.

The levels of the parameters measured for each of the three wells were generally suitable for salmonid culture with the exception of dissolved gases which would require some aeration to raise the dissolved oxygen saturation. Conductivity and pH were within the ranges acceptable for salmonid culture although the pH measured at well #8 was low compared to recommended levels (Sigma, 1979). Water temperatures in all three wells were satisfactory. Water treatment in the form of aeration would be necessary for all three wells to lower the dissolved nitrogen saturation and raise the dissolved oxygen saturation to levels acceptable for salmonid culture.

Water samples were collected in the middle Shuswap River at 1015 hours, March 12 and at 0930 hours, March 13. On-site analyses were also conducted at these times. On March 12 conductivity measured 79 umho/cm and pH measured 6.85 (Table 4). The dissolved oxygen concentration was 13.6 mg/l and the dissolved nitrogen and argon concentration was 20.3 mg/l (Table 4). Total gas saturation, dissolved oxygen saturation and dissolved nitrogen and argon saturation measured 101.7%, 106.5% and 100.3%, respectively (Table 4). Water temperature was 2.95°C (Table 4). The levels of these parameters were almost unchanged when measured on March 13 with the exception of water temperature which decreased to 2.6°C and dissolved oxygen saturation which decreased to 103.8% (Table 4).

TABLE 4
Water Quality Data Collected in the Middle Shuswap River Near the Shuswap Falls Project Site, March 12 and 13, 1984

Parameter	12 March	13 March
Total gas saturation (%)	101.7	101.4
Dissolved N_2 and Ar (mg/l)	20.3	20.4
Dissolved N_2 and Ar (%)	100.3	100.8
Dissolved O_2 (mg/l)[2]	13.6	13.2
Dissolved O_2 (%)[2]	106.5	103.8
Temperature (°C)	2.95	2.6
pH (rel. units)	6.85	6.8
Conductivity (umho/cm)	79	78

1 Water quality sampling was conducted approximately 100 m upstream of where the pump test flow was entering the river.

2 Values represent the mean of duplicate sample data.

Sampling of the water supply to the pilot hatchery after it had been aerated was conducted at Mr. G. Neilson's request on March 16. Conductivity measured 170 umho/cm (Table 5), which is higher than was encountered in wells #6, 8 and 9. The dissolved oxygen concentration was 10.5 mg/l and the dissolved nitrogen and argon concentration was 18.0 mg/l (Table 5). Total gas saturation was 101.0% while dissolved oxygen saturation and dissolved nitrogen and argon saturation were 95.6% and 102.0%, respectively (Table 5). Water temperature measured 8.8°C (Table 5).

TABLE 5
Water Quality Data Collected at the Shuswap Falls Project Site, Pilot Hatchery Rearing Troughs, March 16, 1984[1]

Parameter	
Total gas saturation (%)	101.0
Dissolved N_2 and Ar (mg/l)	18.0
Dissolved N_2 and Ar (%)	102.0
Dissolved O_2 (mg/l)	10.5
Dissolved O_2 (%)	95.6
Temperature (^{o}C)	8.8
Conductivity (umho/cm)	170

1 Well water from well #5, pumped for approximately two hours prior to sample collection and on-site measurements.

4.0 REFERENCES CITED

American Public Health Association. 1976. Standard methods for the examination of water and wastewater. American Public Health Association, American Water Works Association, Water Pollution Control Federation. Washington.

Sigma Resource Consultants Ltd. 1979. Summary of water quality criteria for salmonid hatcheries. Prepared for the Department of Fisheries and Oceans. Vancouver.

APPENDIX I

Collection, Shipping and Delivery Schedules for DFO Water Quality Samples Collected

APPENDIX I
Collection, Shipping and Delivery Schedules for DFO Water Quality Samples Collected at the Shuswap Falls Project Site, March 11-16, 1984

Site	Time Sampled[1] (1984)	Time Samples Shipped from Field (1984)	Time Samples Delivered to Lab. (1984)	Sample Identification
Well No. 8 Shuswap River	1100 hrs, March 11 (1) 2100 hrs, March 11 (2) 0900 hrs, March 12 (3) 1100 hrs, March 12 (4)	2100 hrs, March 12, from Vernon via bus	0900 hrs, March 13	Shuswap Falls samples 1-4 DFO Lab No. 840337-1-4
Well No. 8 Shuswap River Well No. 9	2100 hrs, March 12 (1)[2] 0900 hrs, March 13 (2)[2] 0930 hrs, March 13 (3)[2] 0500 hrs, March 14 (4) 1900 hrs, March 13 (5)	2100 hrs, March 13, from Vernon via bus	1300 hrs, March 15	Shuswap Falls samples 1-5 DFO Lab No. 840352-1-5
Well No. 6 Well No. 9	1230 hrs, March 15 (1) 1700 hrs, March 14 (2)	2100 hrs, March 15, from Vernon via bus	0900 hrs, March 16	Shuswap Falls samples 1-2 DFO Lab No. 840355-1-2
Well No. 6	2130 hrs, March 15 (1) 0800 hrs, March 16 (2)	0945 hrs, March 16 via air cargo	1230 hrs, March 16	Shuswap Falls samples 1-2 DFO Lab No. 840357-1-2
Hatchery Trough	1100 hrs, March 16 (1)	with technician, March 16	0830 March 19	Shuswap Falls DFO Lab No. 840361-1

1 Bracketed number refers to DFO Lab No. subsample.

2 Samples submitted to DFO laboratory later than 48 hr. requirement due to transit delays.

APPENDIX 2

Data Used to Determine Dissolved Gas Saturation and Concentration Data

TABLE A2.1
Field and Calculated Dissolved Gas Data For Shuswap Falls Project Site, Well 8, March 11-13, 1984

Time After Pumping Began (hr)	Field Data: Water Temperature (°C)	Barom. Pressure (mm Hg)	Diss. O_2 (mg/l)	Tensionometer Reading (mm Hg)	Calculated Data: PH_2O (mm Hg)	Bunsen Coeff.	Total Gas Sat. (%)	N_2 and Ar Sat. (%)	O_2 Sat. (%)	N_2 and Ar. Conc. (mg/l)
2.0	8.8	724	5.4	-031	8.494	0.0392	95.7	108.1	49.2	19.0
12.0	8.7	720	5.6	-032	8.437	0.0392	95.5	107.3	51.0	18.9
24.0	8.7	716	5.8	-030	8.437	0.0392	95.8	107.1	52.8	18.9
36.0	8.7	716	5.6	-026	8.437	0.0392	96.3	108.3	51.0	19.1
48.0	8.7	716	5.3	-027	8.437	0.0392	96.2	108.9	48.3	19.2

TABLE A2.2
Field and Calculated Dissolved Gas Data For
Shuswap Falls Project Site, Well No. 9, March 13-14, 1984

Time After Pumping Began (hr)	Field Data: Water Temperature (°C)	Barom. Pressure (mm Hg)	Diss. O_2 (mg/l)	Tensionometer Reading (mm Hg)	Calculated Data: PH_2O (mm Hg)	Bunsen Coeff.	Total Gas Sat. (%)	N_2 and Ar Sat. (%)	O_2 Sat. (%)	N_2 and Ar. Conc. (mg/l)
2.0	8.6	712	6.5 6.4	-021	8.380	0.0392	97.0	107.0	59.2 58.3	17.1
12.0	8.6	716	6.5 6.5	-025	8.380	0.0392	96.5	106.4	59.2 59.2	17.0
24.0	8.7	718	6.4 6.5	-024	8.437	0.0392	96.6	106.7	58.3 59.2	17.0

TABLE A2.3
Field and Calculated Dissolved Gas Data For Shuswap Falls Project Site, Well No. 6, March 14-15, 1984

Time After Pumping Began (hr)	Field Data: Water Temperature (°C)	Field Data: Barom. Pressure (mm Hg)	Field Data: Diss. O_2 (mg/l)	Field Data: Tensionometer Reading (mm Hg)	Calculated Data: PH_2O (mm Hg)	Calculated Data: Bunsen Coeff.	Calculated Data: Total Gas Sat. (%)	Calculated Data: N_2 and Ar Sat. (%)	Calculated Data: O_2 Sat. (%)	Calculated Data: N_2 and Ar. Conc. (mg/l)
2.0	8.4	719	6.4 6.3	-049	8.267	0.0401	93.1	102.8	57.0 56.1	18.5
11.0	8.2	721	7.9 7.7	-013	8.155	0.0401	98.2	105.9	70.3 68.5	19.1
21.0	8.2	724	7.3	-018	8.155	0.0401	97.5	106.2	65.0	19.1

envirocon

TABLE A2.4
Field and Calculated Dissolved Gas Data For The Middle Shuswap River Near The Shuswap Falls Project Site, March 12 and 13, 1984

	Field Data				Calculated Data					
Date (1984)	Water Temperature (°C)	Barom. Pressure (mm Hg)	Diss. O_2 (mg/l)	Tensionometer Reading (mm Hg)	PH_2O (mm Hg)	Bunsen Coeff.	Total Gas Sat. (%)	N_2 and Ar Sat. (%)	O_2 Sat. (%)	N_2 and Ar. Conc. (mg/l)
March 12	2.95	715	13.6 -	012	5.685	0.0455	101.7	100.3	106.5 -	20.3
March 13	2.6	716	13.1 13.4	010	5.525	0.0455	101.4	100.8	102.6 104.9	20.4

TABLE A2.5
Field and Calculated Dissolved Gas Data For Shuswap Falls Project Site, Pilot Hatchery Rearing Trough, 16 March 1984

Date (1984)	Water Temperature (°C)	Barom. Pressure (mm Hg)	Diss. O_2 (mg/l)	Tensionometer Reading (mm Hg)	PH_2O (mm Hg)	Bunsen Coeff.	Total Gas Sat. (%)	N_2 and Ar Sat. (%)	O_2 Sat. (%)	N_2 and Ar. Conc. (mg/l)
	Field Data				Measured Data					
March 16	8.8	724	10.5	004	8.494	0.0392	101.0	102.0	95.6	18.0

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APPENDIX 4d. Quality of Well #10

TO / À

B. G. Shepherd
New Projects Coordinator
S.E.P.

FROM / DE

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

SECURITY - CLASSIFICATION - DE SÉCURITÉ

OUR FILE/NOTRE RÉFÉRENCE: 5830-13-16

YOUR FILE/VOTRE RÉFÉRENCE

DATE: July 11, 1985

SUBJECT / OBJET: **WATER QUALITY OF SHUSWAP WELL #10**

Please find attached the final report from Gary Birch of Aquatic Resources Limited on the water quality sampling and analysis of Well #10 at the Shuswap River Hatchery site.

In summary, this well is essentially identical in quality to Wells #6, #8 and #9, which were discussed in my memo to you of April 19, 1984, on this file. All these wells can be considered very suitable for fish culture.

The trace iron concentration and high nutrient levels may cause some container staining and algal fouling, as Mr. Birch suggests, but the extent cannot be known until the facility is in operation. Some provision for filtration of incubation water may be required if the iron concentration increases in the future, as it appears to have done in Well #5, but simple retro-fit should be possible. The high nutrients suggest that an enclosed aeration tower be used at this site.

Don D. MacKinlay

c.c. F.K. Sandercock
C.N. MacKinnon
G.F. Berezay
G. Conway
J.W. McNally
W.Y. Leung
A. Machel

FINAL REPORT ON

WATER QUALITY DATA COLLECTED AT THE SHUSWAP HATCHERY SITE, MAY 21 to 22, 1985

by G.J. Birch

D.S.S. FILE 01SB.FP501-5-SP1008
CONTRACT SERIAL NUMBER 0SB84-00774

Prepared for the
DEPARTMENT OF FISHERIES AND OCEANS
SALMONID ENHANCEMENT PROGRAM
New Projects Unit

Prepared by
AQUATIC RESOURCES LIMITED
Vancouver, B.C.

JULY 8, 1985

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INTRODUCTION

This project was designed to provide the New Projects Unit of the Salmonid Enhancement Program (SEP) with baseline water quality information to aid in determining the suitability of selected water sources as potential enhancement facility supplies. This report will deal with water quality measurements collected during a pump test of well #10 at the Shuswap Hatchery site which was conducted over a 24 hour period during May 21 to 22, 1985. The report should be considered as an addendum to a review of previously collected groundwater and surface water data (Envirocon MS 1985).

SITE LOCATION

The Shuswap Hatchery site is located on the west bank of the Shuswap River immediately downstream of Shuswap Falls and the B.C. Hydro Wilsey Dam. The gazetted location of the site is latitude 50°, longitude 118°, and quadrant SW (Anon. 1966). The watershed code is 03-5400 (Shera and Grant 1980). The altitude of the site is approximately 1400 ft (427 m) above sea level.

The hatchery gravel pad is situated on an island with a flood channel located on the west side and the main river channel on the east. Flow into the flood channel has been diverted by a berm placed upstream of the site. Road access was available around the berm at the time of the sampling, however an access bridge from the west bank is currently under construction. Well #10 is located on the north end of the property along the edge of the pad. Well #8 is the closest previously tested well, and is located just to the southwest.

METHODS

LOGISTICS

The site was accessed by truck from Vancouver, B.C. The access route from the nearest town, Lumby, is via Mabel Valley Road towards Shuswap Falls. Shuswap Falls Road leads off the main road to the hatchery site. The crew camped on-site to facilitate easier maintenance of the sampling schedule. Alternative routing includes scheduled commercial flights to Kelowna or Kamloops airports, car rental, and residence at a hotel in Lumby.

SAMPLING SCHEDULE

The sampling period was to extend for the 24 hours of pump testing. Longer testing was deemed unnecessary since indications were that the same aquifer as previously sampled in adjacent wells was being pumped. Water quality measurements and samples were taken at 2, 12, and 24 hours after pumping began. Since the river was dirty and in flood, additional sampling of the river water at a site next to the hatchery pad was conducted just after the 12 hour well sampling. Table 1 below lists the pertinent collection and lab delivery schedule information.

Table 1: Collection and Lab Delivery Schedule

Sample	Method of Shipment	Laboratory Number	Collection Date & Time	Delivery Date & Time
Well #10 2 hr	Personal delivery	850210 #1	85-05-21 1900 hr	85-05-23 1135 hr
Well #10 12 hr	Personal delivery	850210 #2	85-05-22 0500 hr	85-05-23 1135 hr
Shuswap River	Personal delivery	850210 #3	85-05-22 0600 hr	85-05-23 1135 hr
Well #10 24 hr	Personal delivery	850210 #4	85-05-22 1700 hr	85-05-23 1135 hr

SAMPLING PROCEDURES

During the sampling period, notes were kept of general changes in air temperature, barometric pressure and weather conditions. For each water sample set, sampling took about 30-40 minutes and spanned the hour.

For well sampling, water was drawn from a tap welded on close to the well head. It should be noted that previous samples have apparently been taken at a pressure line (C. Dunwoody, pers. comm.) which, during this test, was located about 10 m from the well head. Samples taken at this distance may have been contaminated during passage through the pump line. A plastic tube fed water from the tap to a 15 liter bucket which was allowed to continuously overflow. All measurements were taken in the bucket.

It was also observed that the driller was using a lead based pipe lubricant which could contaminate the samples, although no high levels of lead contamination were subsequently noted. Consideration should, however, be given during future pump testing to the substances being used by the pump test crews which may contribute to unusually high metals values.

At the start of each test period, air temperature and barometric pressure were noted. Water temperature was taken and the tensionometer probe inserted in the water following zeroing. While the tensionometer stabilized, pH, conductivity, and dissolved oxygen were measured. The tensionometer reading was then taken and the barometric pressure checked for any change. The tensionometer was then allowed to restabilize in air, while water samples were collected for dissolved oxygen Winkler titrations, and nutrients, metals and mercury analyses. Water collection techniques followed those described by MacKinlay (1984) and APHA Standard Methods (Anon. 1975). Water samples for oxygen determinations were preserved for later titration (Strickland and Parsons 1968).

River water was sampled at a site next to the hatchery pad. Sampling procedures were comparable to those for well water. Water samples for oxygen determination were collected with a Van Dorn bottle.

EQUIPMENT

The techniques used to collect water samples and to measure in situ temperature, pH, conductivity, dissolved oxygen and gas saturation followed those described by MacKinlay (1984). Specific field equipment models and their measurement accuracies are listed in table 2.

Table 2: Water sampling equipment and accuracy for different measurements.

Measurement	Equipment Proposed	Accuracy
Temperature	-ASTM mercury reference thermometer,	±0.05°C
pH	-Fisher pH/Temp. Meter Model 119,	±0.05pH
Dissolved Oxygen	-YSI Model 51A Oxygen/ Temp. Meter, -Winkler titration,	±0.1 mg/l ±<0.01 mg/l
Salinity/ Conductivity	-YSI Model 33 SCT meter	±2.5-3.0% Cond. (umhos/cm)
Dissolved Gas Pressure	-Novatech Tensionometer Model 300C,	±2-7 mmHg
Barometric Pressure	-Lufft aneroid barometer	±0.2 mmHg

All meters were calibrated carefully. No problems were encountered with the equipment during the tests, although the pH meter required recalibration during the last measurement set.

Laboratory nutrient sample analysis techniques were documented by MacKinlay (1984). Metals samples were all analysed using Atomic Emission Spectrophotometry which employs an Inductively Coupled Argon Plasma (ICAP) excitation source. More sensitive analyses were carried out for toxic heavy metals including cadmium, copper, mercury, lead and potassium using flameless Atomic Absorption Spectrophotometry (AAS). Quality control measurements of the cation/anion balance and diluted conductance of each sample were used to check measurement accuracies. Lab analysis units, precision and detection limits are listed in table 3 (MacKinlay 1984) for reference.

Winkler titration values for dissolved oxygen were used in preference to the YSI meter values. Levels measured with the meter in the field were consistently 0.3 to 0.4 mg/l high.

RESULTS AND DISCUSSION

WEATHER

Throughout the test period, the weather was hot and sunny. The skies were generally clear, and there was an occasional slight breeze from the south to southeast. Air temperatures ranged from 16°C in the mornings to 29°C in the midafternoons. Temperatures around the well head were even higher. Barometric pressure was relatively stable, ranging from 732.6 to 735.4 mm Hg. There was a slight tendency for the barometric pressure to fall in the evening as thunder storms moved into the area. However, there were no incidences of significant change in pressure during water quality sampling periods.

GROUNDWATER QUALITY

Nutrient sample results and field measurements are listed in table 4. Values outside the recommended limits have been underlined for easy reference.

TABLE 3

LABORATORY ANALYSIS ABBREVIATIONS, UNITS, PRECISION AND DETECTION LIMITS

(After MacKinlay 1984)

Parameter Name	Table Abbreviation	Reported Units	Normal Precision	Detection Limit
Alkalinity - Total	Alk.Tot.	mg/l as $CaCO_3$	± 1.0	≥ 1.0
Ammonia - Total	Ammonia	mg/l N	± 1%	≥ 0.005
Chloride	Chloride	mg/l	± 0.1	≥ 0.5
Color	Color	Color Units	± 5 units	≥ 1.0
Conductivity	Cond.-Lab	umhos/cm	± 3%	0.0
Hardness	Hardness	mg/l as $CaCO_3$	± 5%	≥ 0.03
Nitrite	Nitrite	mg/l N	± 0.8%	≥ 0.005
Nitrate	Nitrate	mg/l N	± 2.3%	≥ 0.01
Hydrogen Ion	pH-Lab	pH Units	± 1.9%	0.0
Phosphate - Total	Phosph.	mg/l P	± 0.0	≥ 0.005
Total Residues	Resid.Tot.	mg/l	± 5%	≥ 5.0
Filterable Residues	Resid.Fil.	mg/l	± 10%	≥ 5.0
Non-filterable Residues	Resid.N.F.	mg/l	± 10%	≥ 5.0
Salinity	Salinity	$^o/_{oo}$ (ppt)	± 0.05	≥ 1.0
Silica	Silica	mg/l	± 0.04	≥ 0.5
Sulfate	Sulfate	mg/l	± 0.5	≥ 1.0
Total Dissolved Solids	T.D.Sol.	mg/l	± 10%	≥ 5.0
Turbidity	Turbidity	Formazin (FTU)	N/A	≥ 1.0
Metals —				
Aluminum	Al	mg/l		≥ 0.05
Arsenic	As	mg/l		≥ 0.05
Barium	Ba	mg/l		≥ 0.001
Calcium	Ca	mg/l		
Cadmium	Cd	mg/l		≥ 0.0005
Cobalt	Co	mg/l		≥ 0.005
Chromium	Cr	mg/l		≥ 0.005
Copper	Cu	mg/l		≥ 0.001
Iron	Fe	mg/l		≥ 0.005
Mercury	Hg	mg/l		≥ 0.0002
Potassium	K	mg/l		
Magnesium	Mg	mg/l		
Manganese	Mn	mg/l		≥ 0.001
Molybdenum	Mo	mg/l		≥ 0.005
Sodium	Na	mg/l		
Nickel	Ni	mg/l		≥ 0.02
Phosophorus	P	mg/l		≥ 0.05
Lead	Pb	mg/l		≥ 0.001
Antimony	Sb	mg/l		≥ 0.05
Selenium	Se	mg/l		≥ 0.05
Silicon	Si	mg/l		
Tin	Sn	mg/l		≥ 0.01
Strontium	Sr	mg/l		
Titanium	Ti	mg/l		≥ 0.002
Vanadium	V	mg/l		≥ 0.005
Zinc	Zn	mg/l		≥ 0.002

TABLE 4
WATER QUALITY DATA (NUTRIENTS) FOR THE SHUSWAP HATCHERY
WELL SITE 10 AND THE RIVER; MAY 21 to 22, 1985

Parameter	Recommended Level[a]	Toxic Level[a]	SAMPLE SITE AND TIME: Well #10, May 21, 1985 1900 hours	Well #10, May 22, 1985 0500 hours	Well #10, May 22, 1985 1700 hours	Shuswap River, May 22, 1985 0600 hours
Alk.Tot.	20-300		64.6	69.8	71.7	34.3
Ammonia *	<0.002	>0.08	0	0	0	0.010
CO_2	2-5	>20				
Chloride	<170	>400	1.0	1.1	0.8	0.9
Color	<15					
Cond.-Field	150-2000		109	110	114	54
Cond.-Lab.	150-2000		168	170	175	83
DO_2-ppm	>6-8	<4.0	4.4	4.4	4.5	10.9
DO_2-% Sat.	100%		40.4	40.4	41.3	100
DGas.Tot.	<103%	>110%	95.6	94.6	95.2	106.3
DGas.Nit.	100%		110.6	109.5	109.8	109.1
Hardness	20-400		83.3	85.3	89.2	44.9
H_2S	<0.002	>0.004				
Nitrite	<0.012	0.2	0	0	0	0
Nitrate	<0.12		0.085	0.086	0.094	0.115
pH-Field	6.8-8.5	<5, >9	7.5	7.54	7.4	6.85
pH-Lab	6.8-8.5	<5, >9	7.3	7.6	7.8	7.4
Phosph.	<0.05		0	0	0	0.115
Resid.Tot.	<2000					
Resid.Fil.	70-400		98	99	104	56
Resid.N.F.*	<3.0		0	0	0	106
Salinity						
Silica	<10-60					
Sulfate	<90		11	11	12	5
Taste	OK		OK	OK	OK	SILTY
T.D.Sol.	500-1000	15000				
Temperature	4-18°C	<2, >25	8.8	8.5	9.0	8.5
Turbidity	1-60	>1000	0.30	0.30	0.18	33.0

a- from Shepherd (1982), SIGMA Environmental Consultants Ltd. (MS 1983) and MacKinlay (1984)
*- Recommended level below detection limit (see Table 3)

In general, the groundwater from well #10 at the Shuswap Hatchery site is acceptable for fish culture assuming the necessary aeration and nitrogen stripping is conducted. Water from the well was moderately soft with hardness from 83.3 to 89.2 mg/l, and borderline conductivity values (109-114 umhos/cm in the field, 168-175 umhos/cm in the lab). Temperature, pH, turbidity and other nutrient parameters were within recommended limits. Nitrate levels (0.085-0.094 mg/l) may cause limited algal fouling within the planned hatchery facility.

Metals and mercury values are given in table 5. Measurements beyond recommended values are again underlined. Groundwater samples were generally low in metallic content. Calcium levels were acceptable (28.8-30.8 mg/l) reflecting the hardness values. Only the 12 hour zinc value (0.01 mg/l) was just outside the recommended value. Iron levels were (0.008-0.01 mg/l) at least a magnitude lower than values for well #5 (0.134-0.209 mg/l) (MacKinlay 1984), which is currently providing water for the pilot hatchery and is causing staining problems in that facility (G. Conway pers. comm.). Cleaning requirements should be considerably reduced in the new facility using groundwater from wells #6, 8, 9 and 10, all of which have consistently low iron levels.

The water quality values for well #10 are comparable to those reported for wells #6, 8 and 9 (MacKinlay 1984). With a few exceptions, the nutrient, metals and mercury values for well #10 are within the range of values established for these associated wells. Well #10 waters were slightly higher in conductivity, and 1 to 3 mg/l lower in dissolved oxygen levels. Dissolved nitrogen gas saturation levels were correspondingly slightly higher. Generally, pH values for well #10 were also higher (by <1 pH unit) particularly in comparison to well #8. Amongst the metals, only barium (0.011-0.012 mg/l) and calcium (28.8-30.8 mg/l) values were slightly higher, while the already mentioned zinc value was occasionally borderline, a condition which has not been previously observed in the other wells.

TABLE 5
WATER QUALITY DATA (METALS) FOR THE SHUSWAP HATCHERY
WELL SITE 10 AND THE RIVER; MAY 21 to 22, 1985

Parameter	Recommended Level[a]	Toxic Level[a]	SAMPLE SITE AND TIME			
			Well #10			Shuswap River
			May 21, 1985 1900 hours	May 22, 1985 0500 hours	May 22, 1985 1700 hours	May 22, 1985 0600 hours
Metals						
Al	<0.1	>5.0	0	0	0	<u>0.46</u>
As	<0.5	>1.0	0	0	0	0
Ba	<1.0		0.011	0.011	0.012	0.019
Ca	4-150	>300	28.8	29.4	30.8	14.1
Cd *	<0.0003		0	0	0	0
Co			0	0	0	0
Cr	<0.01		0	0	0	0
Cu	<0.002		0	0	0	0
Fe	<0.3		0.01	0.008	0	<u>0.45</u>
Hg	<0.00005	>0.0002	0	0	0	0
K		>50.0	0.9	0.97	1.04	1.0
Mg	<10.0	>100.0	2.8	2.8	3.0	1.5
Mn	<0.05	>15.0	0.002	0	0	0.015
Mo	<0.01		0	0	0	0
Na	<50.0	>500	1.5	1.5	1.5	0.9
Ni	<0.045		0	0	0	0
P			0	0	0	0
Pb	<0.004		0	0	0	0
Sb	<0.05		0	0	0	0
Se	<0.05	>2.5	0	0	0	0
Si	<10-60		3.7	3.6	3.8	4.2
Sn			0.02	0.03	0.04	0.01
Sr			0.115	0.119	0.123	0.062
Ti			0	0	0	0.022
V			0	0	0	0
Zn	<0.005		0	<u>0.01</u>	0	<u>0.007</u>

a- from Shepherd (1982), SIGMA Environmental Consultants Ltd. (MS 1983) and MacKinlay (1984)
*- Recommended level below detection limit (see Table 3)

Well water temperatures reflected some influence from the river and were suggestive of diel fluctuations. Measurements in the mornings were coolest (8.3-8.5°C), while midafternoon temperatures were as high as 9.5°C.

The water quality values for well #10 suggest that the well was drawing from the same aquifer as the surrounding wells. Well #10 is 31.4 m deep (M. Schibli pers. comm.) and therefore comparable to wells #6, 8 and 9 which are 31.7 to 32.6 m in depth (Envirocon MS 1985).

SURFACE WATER QUALITY

Since the Shuswap River was in spring flood during the test period, surface water quality measurements and samples were taken at a site next to the hatchery pad. The results are given in tables 4 and 5. Resulting parameter values are similar to those reported by Envirocon (MS 1985) and MacKinlay (1984), but the high phosphate, non-filterable residue, and metallic ion levels indicate the hatchery use of river water should probably be avoided during freshet. Aeration to control nitrogen saturation levels will be necessary if surface waters are used in fish culture.

In comparison to previous samples (MacKinlay 1984), the flood waters showed lower alkalinity (34.3 mg/l compared to 42-50 mg/l) sulphates (5 mg/l compared to 6.7-9.1 mg/l) and conductivity (54 umhos/cm in the field compared to 57-79 umhos/cm, and 83 umhos/cm in the lab compared to 103-136 umhos/cm). Hardness levels were similar, although calcium and magnesium values were slightly lower. Field pH values were slightly acidic (6.85 pH), and turbidity values (33 FTU) were much higher than previously recorded (0.1 to 4.6 FTU). Turbidity and pH values were, however, within recommended limits. Filterable residues were comparable to previous records.

Phosphate levels were up to a magnitude higher than previously reported (0.115 mg/l compared to 0.005-0.01 mg/l) and well outside the recommended limit. These levels are high enough to accelerate algal fouling. Nitrate levels were comparable to previous samples but were also high enough to contribute to algal growth in the planned facility.

The river waters also exhibited higher than recommended levels of aluminum (0.46 mg/l), iron (0.45 mg/l) and zinc (0.007 mg/l). These levels were, however, well below the toxic values (table 5). Non-filterable residue levels were also above recommended levels for both incubation (3 mg/l), and rearing and holding (25 mg/l) (SIGMA Environmental Consultants Ltd.). These levels of suspended solids could be responsible for the higher levels of heavy metals which would have been transported as absorbed pollutants in suspension. Aluminum (0.1-0.13 mg/l), zinc (0.005-0.007 mg/l) and chromium (0.368 mg/l) have previously been observed above the recommended levels in river samples (MacKinlay 1984). Chromium, however, was acceptable during this trip.

The levels of non-filterable residues were high enough to contribute to egg suffocation, gill irritation and the culture of nuisance organisms, and would necessitate extra maintenance during periods of freshet. Unfortunately, the iron levels were high enough to result in staining of containers in the hatchery which would also require extra attention.

The surface water total gas saturation level (106.3%) was above the recommended level (103%), due largely to a high nitrogen gas saturation level (109.1%). Similar nitrogen saturation levels have been previously noted, but total gas saturation levels were generally lower (100.7%-105%) (MacKinlay 1984). Nitrogen stripping will be necessary prior to hatchery use of river waters.

The surface water temperature was comparable to well water temperatures.

QUALITY CONTROL TESTS

Quality control tests of the samples indicated the presence of one or more undetected anions. All cations and major anions were, however, retested and the levels reconfirmed. Flouride levels were measured at 0.06 mg/l for each of the well samples, and at 0.05 mg/l for the river sample, neither of which are toxic. McKee and Wolf (1963) cited 2.3 mg/l flouride as toxic to fish, and 1 mg/l has been recommended as a drinking water standard.

CONCLUSIONS

Well #10 at the Shuswap Hatchery site was tested for water quality over a 24 hour pump test period. The water quality is acceptable for fish culture, although aeration will be necessary. The well water was moderately soft, and low in metallic content. Nitrate and iron content may result in algal fouling and container staining, respectively. The indication is that well #10 was drawing water from the same aquifer as associated wells #6, 8 and 9.

Surface water quality from the flooded Shuswap River suggests that river water would be acceptable as a short term backup to the wells but should be avoided during freshet periods. Nitrogen stripping would be required prior to hatchery use. The river waters were softer than the groundwater and may be slightly acidic. The higher than recommended values for phosphates, non-filterable residues, aluminum, iron and zinc suggest future sampling during freshet is in order, however all but possibly the non-filterable residue levels would be acceptable over the short term. The turbidity level was higher than previously recorded, but within the recommended range.

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PERSONAL COMMUNICATIONS

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APPENDIX 5. MODELS USED IN DESIGN

a. Load Rate Model

b. Growth Model

c. Aeration Model

FROM: Kling, A.E., C.L. Cross, W.E. McLean and C.J. West 1985 MS. A guide to the fishculture information system for hatcheries (FISH) utility programs and the Apple II microcomputer. Draft Report, SEP. 156 p.

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 program predicts the average weight at five day intervals. At the end of 30 days an option is provided for new input data and continuation of the program. Ration input must be expressed in terms of the fraction of the maximum Stauffer ration. Typical levels are shown in Table 1. 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 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. (ec. 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.

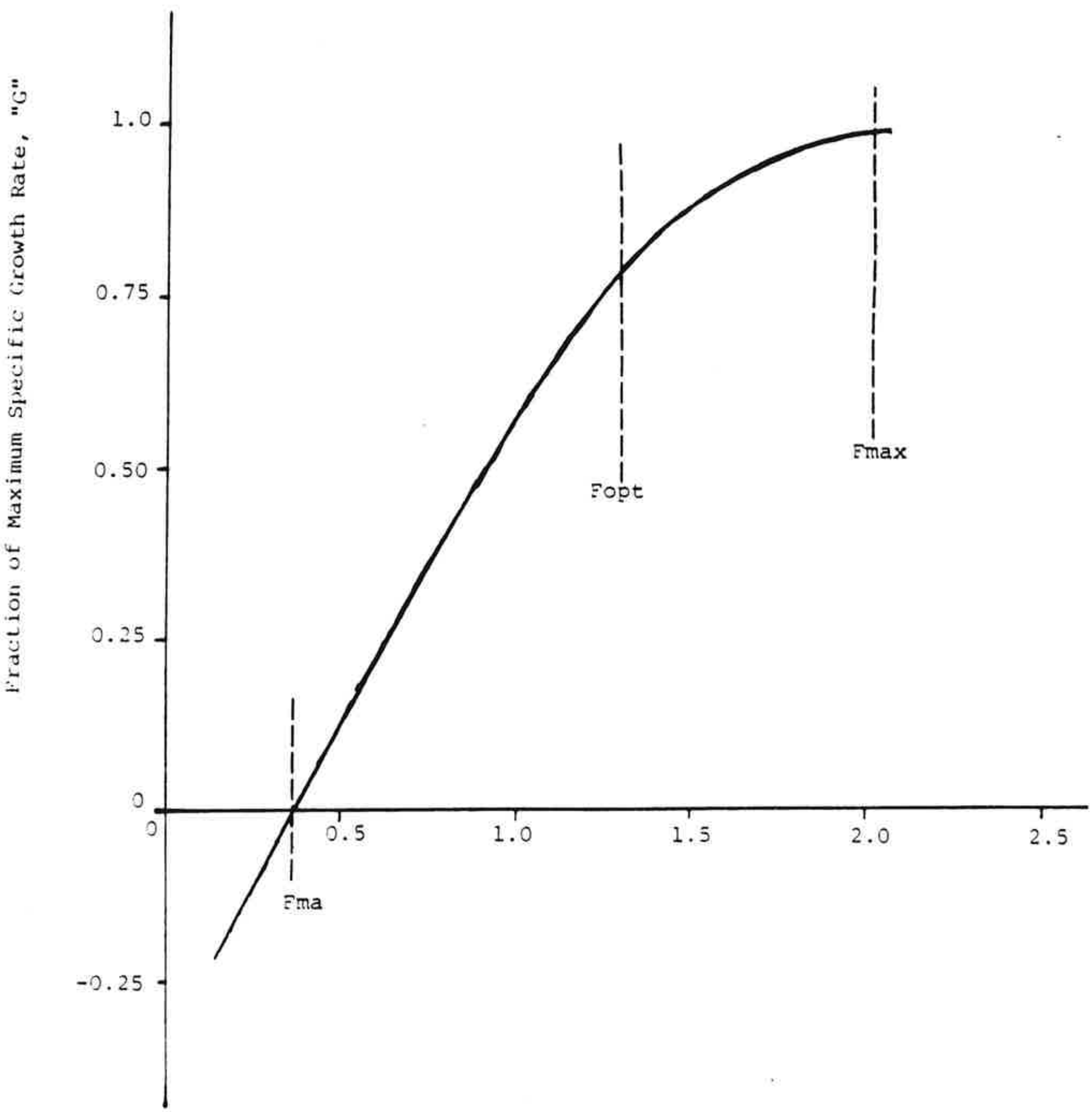


FIGURE 8. Specific growth rate x 100 for 1 gm fish at the maximum ration as a function of water temperature. The relationship is described by a polynomial.

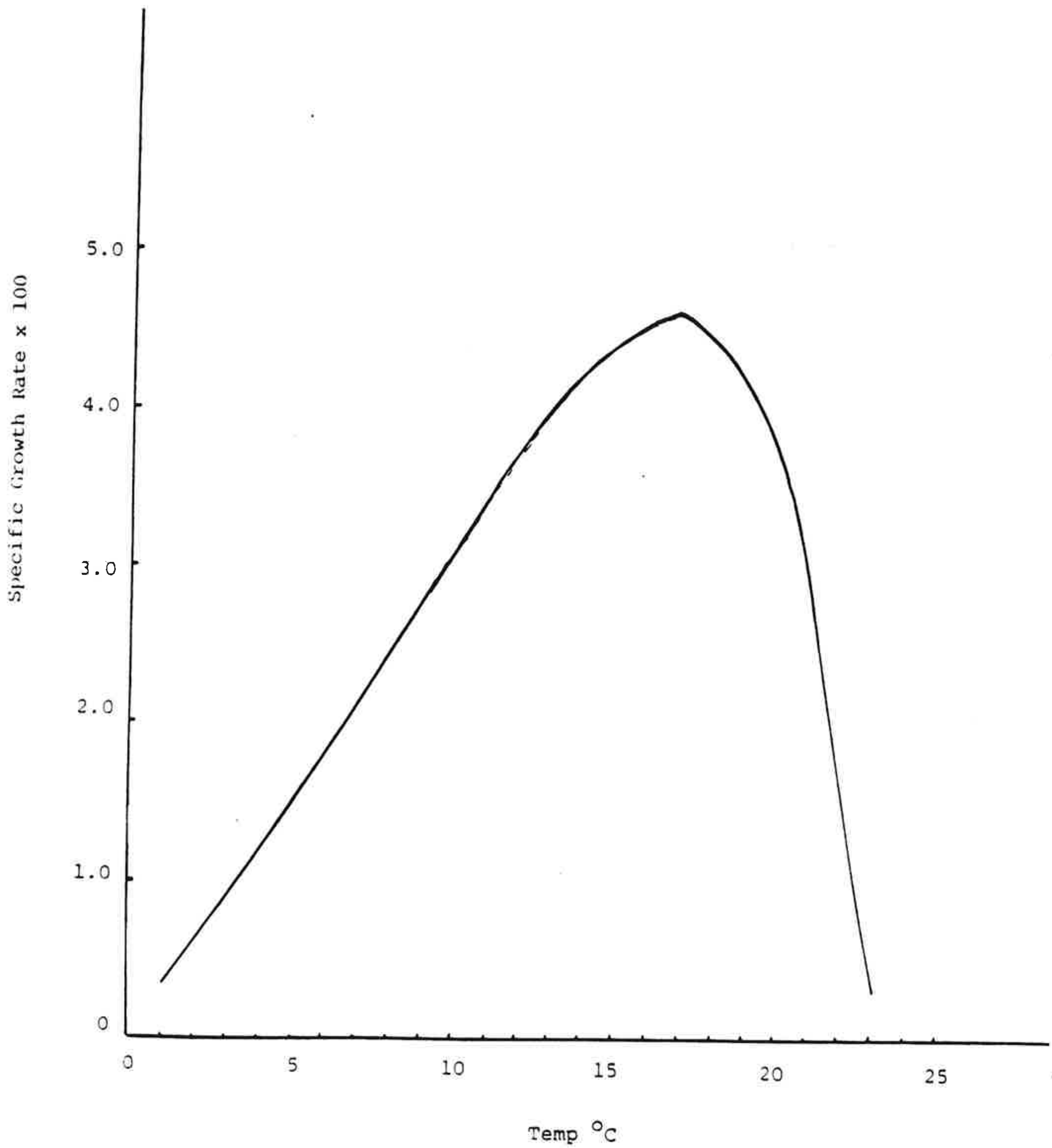
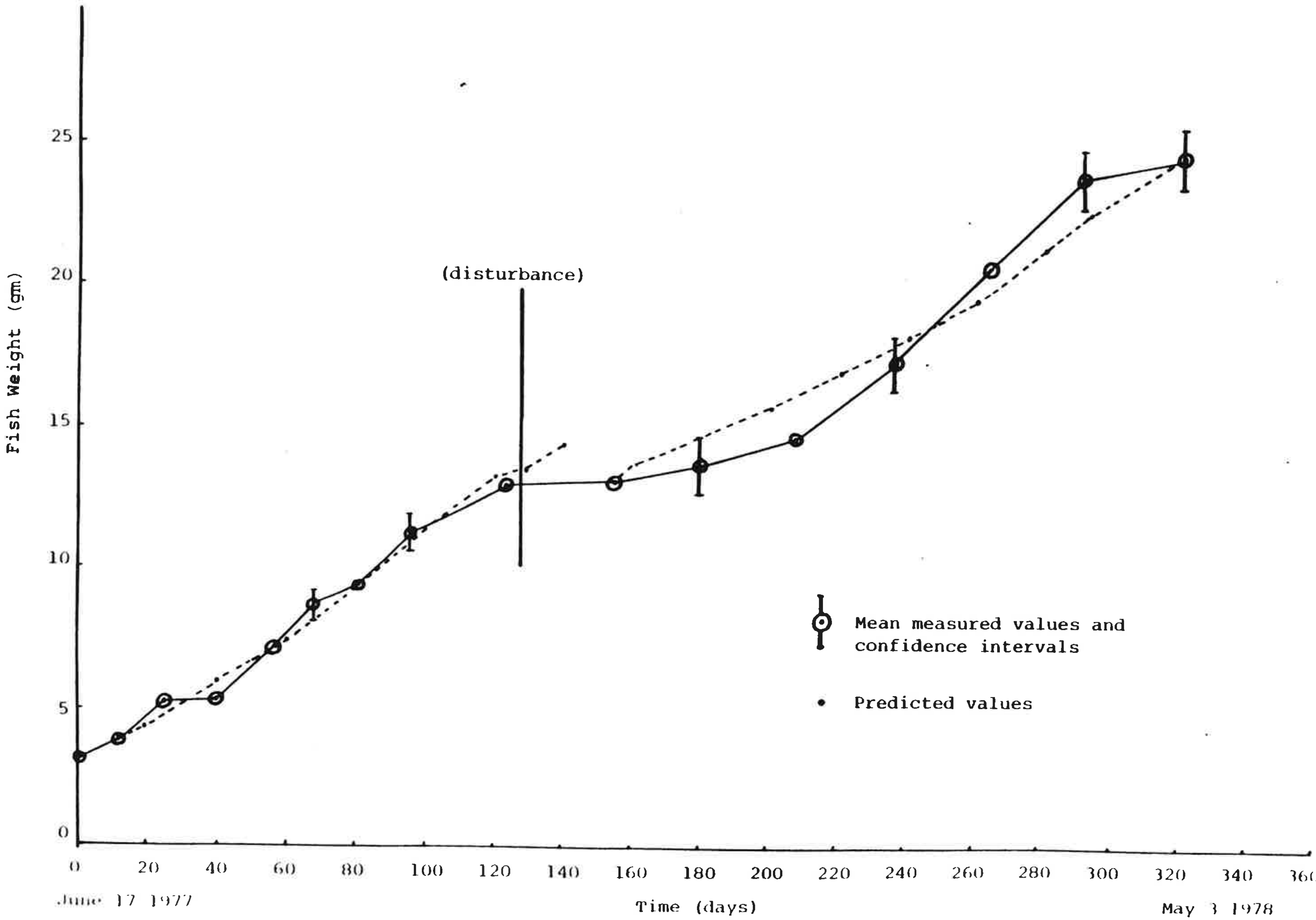


FIGURE 9 Comparison of predicted and measured growth at reduced ration levels. Ninety-five percent confidence intervals of selected measured values are shown.



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