KLONDIKE AREA CENTRAL INCUBATION/OUTPLANT FACILITY CRE - 05 - 97 FEASIBILITY STUDY PROGRESS REPORT

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ABSTRACT

This report represents the second phase of a feasibility study to explore the development of a chinook salmon incubation facility in northern Yukon. A primary site has been identified near Dawson City. This phase of the study concentrates on the use of tailings ponds, in conjunction with an infiltration well near the Klondike River, to provide suitable water for the facility.

Results from water quality evaluations have proven to be satisfactory. Water temperature fluctuation data from the ponds in question and the Klondike River (for one season only) tend to confirm the hypothesis that desirable water temperatures will be available early enough in the season so that temporal concerns (with respect to fish development stages) can be adequately addressed. Total water volume was determined for all ponds through bathymetric measurements. Land zoning and acquisition matters were addressed through the City of Dawson, and are not anticipated to be a limiting factor regarding the development of this facility.

Basic facility design options, based on a combination of water use and water heating, were also investigated. While it is premature to endorse a specific design, some combination of the various designs discussed in this report will likely prove to be most suitable for a Dawson area hatchery facility. Some form of water recirculation or re-use system, at least during incubation, may be recommended.

Studies requiring completion prior to final site selection include continued water quality evaluations, zoning requirements follow-up, infrastructure development (access, power), early pond ice cover break-up, water source development and effluent disposal methods.

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I. INTRODUCTION

During 1997 a study was initiated investigating the feasibility of developing a small scale chinook salmon incubation/outplant facility in the Dawson City region. Part I of the study, completed in the fall of 1997 (Petkovich and Ricks, 1997), identified two potential sites for establishing a facility. One of the sites identified is in a tailings ponds region, located on the north side of the North Klondike Highway within the City of Dawson's boundary. It was conceived that the ponds, in combination with an infiltration well adjacent to the Klondike River, could provide water of suitable quality for the facility. Incorporating two sources of water into the outplant facility design will allow for greater control and variability of water temperatures. This is highly desirable, if not mandatory, as various developmental stages of chinook salmon eggs and fry require varying water temperatures, particularly if temporal constraints are incorporated into the growth design. A specific site, consisting of seven ponds adjacent to the Klondike River (Figure 1), was investigated further for water quality, temperatures, volumes, flows and land zoning. These investigations are presented here.

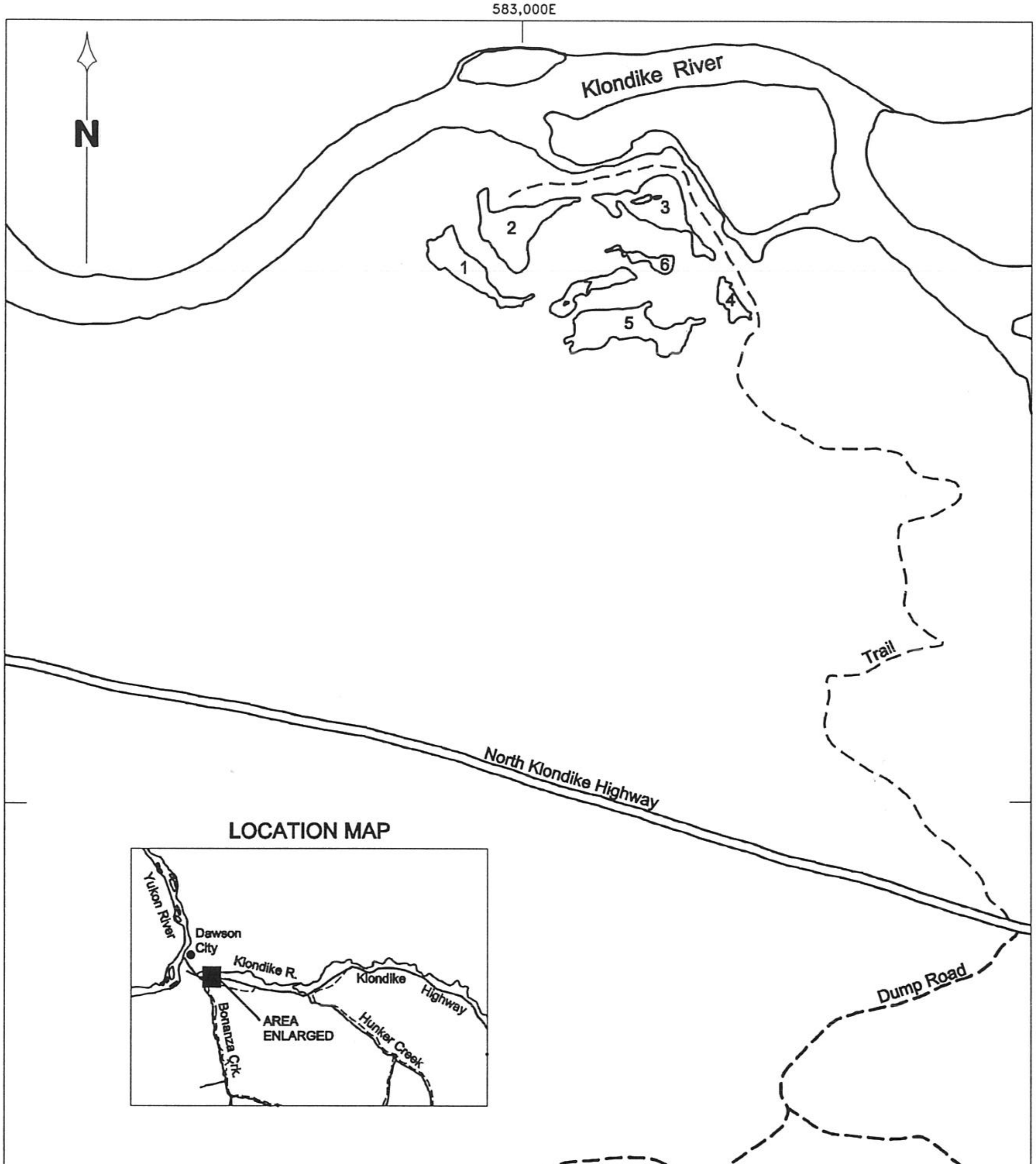

Figure 1: Tailings Ponds Site

0 100 200 300 400 500

metres

KLONDIKE AREA CENTRAL INCUBATION
OUTPLANT FACILITY
SITE PLAN

Duncan Contracting Dawson City, Yukon

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II. WATER TEMPERATURE PROFILES

Water temperature profiles of the ponds and Klondike River are important in developing a final facility design. The rate of fish development and growth is directly correlated to water temperature. Ideally, the spring water temperatures of the ponds and/or Klondike River (Tailings Ponds Site - Figure 1) will naturally attain temperatures suitable for ponding and first feeding of swim-up fry. Water temperature must achieve a minimum of 4 - 5°C (naturally or artificially) in order to avoid problems of initiating feeding response in newly ponded salmonids[1,2,3].

For Yukon River chinook salmon that have been incubated at a constant 6 °C water temperature, ponding/first feeding usually occurs at 1,000 accumulated thermal units (ATU's)[2], although there is evidence to indicate that, at lower temperatures, the ATU's might actually be somewhat less[4]. An ATU is accrued for each degree Celsius to which the fish are exposed per day (e.g. - water temperature at 4 °C will result in 4 ATU's per day; 5 days at 4 °C will provide 20 ATU's). It was anticipated, based on 30 years of climate data for the Dawson region (Appendix 1), that pond temperatures would reach the required temperature (4 °C) for ponding/first feeding by the middle of May. As described further in this report, the ongoing feasibility study will investigate means of accelerating ice removal from the

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[1] Pers. Comm. - Lawrence Vano, Manager, Whitehorse Rapids Fish Hatchery.
[2] Personal experience of the authors.
[3] Iwama, G. K. 1989. In: Intensive Fish Production, Animal Science 480, University of British Columbia, Vancouver, B. C.
[4] Pacific Salmon Life Histories. Groot, C. and Margolis, L., Eds. UBC Press, Vancouver.

ponds in the spring in an attempt to stimulate water temperature increases in the ponds, to accommodate the ponding of fry from the incubation facility by late April/early May.

If ambient water temperatures of 4 °C or greater are available at the time of ponding/first feeding, it may be feasible to design a facility that operates using a "flow through" water system. This would eliminate or minimize the need to heat water (which increases operational costs), or incorporate water reuse/recirculation and heat recovery systems (which increases equipment/construction costs).

Temperature Recording: 1998

The recording of water temperatures in the tailing ponds and the Klondike River was initiated in February 1998. A total of 5 Optic Stowaway® Temperature dataloggers (Onset Computer Corporation™) were placed, respectively, in tailing ponds #1, #2, #3, #5 and the Klondike River. These computerized sensors are designed to continuously record water temperature fluctuations over an extended period of time. They provide a computer generated graph format printout of temperatures taken approximately hourly over the entire duration of their placement. In addition, instantaneous water temperatures were recorded twice during water sample collections, once in February and once in March, using the temperature probe associated with an Oxyguard® Handy MK II dissolved oxygen meter.

Temperatures obtained from the dataloggers to date indicate, as anticipated, that the ponds attain 4 °C by the middle of May, with two of the ponds (#2 & #3) attaining 4 °C by late April/early May (see Appendix 2). Of the four ponds where temperature readings were taken, pond #3 is situated in closest proximity to the Klondike River. The water temperature of the Klondike River also attained 4 °C by the middle of May, and had reached 10 °C by early June, 1998.

Although a statistical analysis has not been applied to the data, it appears that pond water temperatures are associated with increasing air temperatures during the spring. Comparison of 1998 air temperature data to the 30 year average (see chart in Appendix 3) indicates that average air temperatures in 1998 were higher throughout much of April. Temperatures through late April to mid-May, however, were about average or below.

From these data, it may be concluded that 4 °C water could be accessed by early May. Therefore, a hatchery system designed to use ambient water temperatures for rearing should manipulate ATU's during the incubation stage in such a way that first feeding (ponding) occurs in early May. If necessary some water heating could occur cost-effectively during the incubation stage of development.

During incubation relatively small volumes of water are required (when compared to the rearing stage). As demonstrated further in the report, only a slight increase in temperature (1-2 °C), if any, may be necessary to achieve the required ATU's by late April/early May. Additionally, as there is no solid waste produced by the fish (i.e. no feeding) during the incubation stage, the water can be re-used or recirculated with a minimum of additional equipment required.

III. WATER QUALITY PROFILES

Prior to this study, comprehensive water quality analyses had not been performed on water in the tailings ponds. One previous water quality analysis, performed on Klondike River water in this area, indicated elevated levels of aluminum and iron. As a precaution, water quality sampling for a variety of parameters was conducted as part of this phase of the feasibility study.

Two comprehensive water quality analyses were performed on each of the 7 ponds under investigation, as well as from the Klondike River. The results of those two analyses are located in Appendix 4. Inductively coupled plasma (ICP) scans for total metals were conducted on the water samples, by Analytical Service Laboratories Ltd. in Vancouver, B. C. In addition to ICP scans, all samples were analyzed specifically (with greater sensitivity) for arsenic, mercury and aluminum. Methodologies utilized for the analysis of the samples can be found in Appendix 5. The results of all analyses were relatively consistent with respect to total metal concentrations, and were within the water quality parameter ranges recommended for use in fish culture[5].

Concern had been expressed regarding aluminum levels in water samples taken from the Klondike River in previous years. It is recommended that the concentration of aluminum hydroxide complexes in water not exceed 0.1 mg/l (ppm) for use in fish culture[5]. One previous water sample on the Klondike River[6] (December 10, 1996 - Environment Canada) indicated an aluminum concentration in excess of 0.3 mg/l; however, it is typical of rivers with a significant amount of silt present, to show elevated levels of aluminum[5]. In these situations, much of the aluminum present is likely to occur in a non-toxic form. All current water samples from this study (tailings ponds and Klondike River sample sites) indicate that aluminum is present in levels well below 0.1 mg/l, and should not present any concerns for use in fish culture.

Water quality parameters analyzed on site included temperature, pH, conductivity and dissolved oxygen (Table 1). Water temperatures ranged from 0.0 °C to 0.5 °C in the Klondike River and near the surface of the ponds. Measurements taken deeper in the ponds (3.5 - 4.0 m) indicated water temperatures of up to 1.6 °C, indicating that some heat is retained in the ponds through the winter, or alternatively, a source of relatively warmer groundwater flows into the ponds.

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[5] Sigma Environmental Consultants Ltd. October, 1983. Department of Fisheries and Oceans Summary of Water Quality Criteria for Salmonid Hatcheries. SECL 8067.
[6] Petkovich and Ricks. 1997. Klondike Area Central Incubation/Outplant Facility: Water Quality Evaluation.

The pH of the ponds ranged from 6.5 to 7.8. The lower pH values may reflect minimal water exchange and/or the degradation of organic matter in the pond. Conductivity ranged from 240 to 260 µmho/cm. The dissolved oxygen content of the ponds ranged from a low of 0.1 ppm in tailings pond #5, to a high of 5.7 ppm in tailings pond #6.

Table 1: Tailings Ponds (TP1-7) And Klondike River (KR2). Onsite Water Quality Data - March 16, 1998

Parameter ↓	TP1	TP2	TP3	TP4	TP5	TP6	TP7	KR2
Temp @ 5'	0.0 °C	0.3 °C	0.5 °C	0.1 °C	0.2 °C	0.0 °C	0.1 °C	0.2 °C
Temp @ 12'-14'	0.3 °C	1.2 °C	0.7 °C	0.2 °C	1.6 °C	0.1 °C	0.3 °C	---
D. O.* @ 5' (ppm)	4.0	5.3	5.0	5.3	5.7	5.7	5.2	10.7
D. O. @ 14' (ppm)	3.0	0.2	4.7	2.7	0.1	4.5	3.3	---
pH˙	7.8	6.5	7.4	6.8	7.3	7.2	7.7	7.4
Conductivity°	240	240	240	240	240	260	260	240

* D. O. = Dissolved Oxygen (parts per million - ppm)

˙ pH = Hydrogen Ion Concentration

° Conductivity (µmho/cm)

The low oxygen levels found in most of the ponds during this investigation are not a concern regarding the potential for fish propagation in this area. Dissolved oxygen values were determined in March, when levels were likely to be at or near their lowest, due to minimal or zero photosynthesis (due to ice and snow cover blockage), no entraining of air from wind action (due to ice cover) and the utilization of most oxygen present through the aerobic decomposition of organic material at the bottom of the ponds. Knowledge of D.O. levels could give some insight as to water exchange between the ponds and the Klondike River. For example, if D.O. levels were found to be at or near saturation (maximum amount per given temperature), this would provide a strong indication that there is substantial water exchange between the pond(s) and the Klondike River during all or part of the winter. In some of the ponds, water flow was observed but D.O. levels were low, possibly indicating that the water exchange may only be from pond to pond, or from groundwater sources, which are typically low in D.O.[7] Based on the relatively low D. O. levels encountered, it was concluded that no substantial flow into the ponds, occurs during the winter.

Regarding the requirements for oxygen, virtually all fish culture facilities provide some sort of oxygenation/aeration, either through simple passive aeration upon entry into the facility, or through more elaborate means, such as the injection of pure oxygen. Passive aeration of water is, at a minimum, standard procedure, and recommended for several reasons, including 1) the need to bring the oxygen saturation level up to 100%, 2) to remove carbon dioxide and 3) to remove any excess nitrogen gas. Excess nitrogen gas in water is of primary concern in hatcheries using well water[7]. If the high nitrogen levels that are commonly associated with well water are left untreated, a severe pathological condition caused by gas supersaturation in the water (Gas Bubble Disease) can develop in the fish. This condition is potentially very serious, and can be debilitating,

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[7] Soderberg, R. W. 1995. Flowing Water Fish Culture. CRC Press, Inc. Boca Raton, Florida.

or even fatal, to all fish. Small fish, such as the size targeted by this facility, are particularly susceptible[8].

Even if D.O. levels had been high in the ponds and/or if water is to be taken directly from the Klondike River, where D.O. is at or close to saturation, an aeration system is highly recommended for the facility design, as the water will be pumped and may be heated. Both activities increase the chance of gas supersaturation problems, as discussed previously. Additionally, if D.O. levels are found to be at zero, this could indicate a potential hydrogen sulfide (H_2S) problem. H_2S is a soluble and highly toxic gas produced by the anaerobic (absence of oxygen) bacterial degradation of organic matter. However, since D.O. levels were above zero in all ponds (at least near the surface) and no H_2S odour was detected, it is unlikely there will be any problems associated with it. Any negligible amount of H_2S that might be present would be stripped out during the recommended aeration process.

For the reasons stated above, virtually any hatchery should incorporate an aeration system regardless of the level of dissolved oxygen encountered in the source water. It is anticipated that a bulk aerator, similar to the one designed and installed in the Whitehorse Rapids Fish Hatchery, Whitehorse, Yukon, will be recommended for the Dawson salmon incubation facility. An aerator of this design passively increases dissolved oxygen levels

[8] Stofkopf, M. K. 1993. Fish Medicine. W. B. Saunders Company. Philadelphia, Pennsylvania.

to saturation while reducing or removing carbon dioxide and nitrogen gas. At the Whitehorse Rapids Fish Hatchery, well water enters the facility at zero ppm D.O., and is increased to 12 ppm, simply by passing it through the bulk aerator. At 6 °C (hatchery water temperature), 12 ppm represents almost 100% saturation[9], which is highly desirable.

IV. FACILITY DESIGN OPTIONS

A. Flow Through (Without Water Heating)

Fish hatcheries typically rely on mechanical systems (pumps, filters, heaters, etc.) to operate. The more complex the system, the greater the likelihood that the facility will experience problems, in addition to the increased costs associated with installation, operation and maintenance. Ideally, a facility can be designed so that the water enters, makes a single pass through the incubators and tanks, and is then discharged. However, as discussed earlier (and in detail in the Part I report[10]), water temperature is a critical parameter for any fish culture operation. Temperatures must be within a specific range in order to appropriately accommodate all growth stages of the fish. As mentioned previously, one of the critical stages of fish development occurs when the endogenous feeding process (nutrition provided through its own yolk supply) converts to exogenous

[9] Noga, Edward J. 1996. Fish Disease: Diagnosis and Treatment. Mosby-Year Book, Inc. St. Louis.
[10] Petkovich and Ricks. 1997. Klondike Area Central Incubation/Outplant Facility: Water Quality Evaluation.

feeding (nutrition obtained through active feeding). For chinook salmon, this occurs at approximately 1,000 ATU's (Accumulated Thermal Units). Once the salmon have accumulated approximately 1,000 ATU's of development, a minimum of 4 - 5 °C water must be available to them in order to successfully "trigger" this feeding reflex.

The tailings ponds site may provide water of suitable temperatures to allow for incubation, development and rearing of the salmon on ambient water temperatures (no heating). One strategy for accumulating the necessary ATU's by early May would be to utilize water supplied by an infiltration well (situated near the Klondike River) mixed with water from the tailings ponds, allowing incubation water temperatures during August and September to be maintained between 8 - 10 °C (a recommended temperature for the successful incubation of chinook salmon eggs[11]). This would allow ATU's to be compiled early in the incubation cycle and then the incubation temperatures could be allowed to drop through the fall and winter.

Two possible scenarios, relating to ambient temperature profiles and development of ATU's, are presented in Tables 2 and 3. The actual temperature profile will be determined throughout the ongoing feasibility study. It is anticipated, however, that 1,000 ATU's will be attained by late April/early May. Although one or two ponds may reach 4 °C by early

[11] Sigma Environmental Consultants Ltd. October, 1983. Department of Fisheries and Oceans Summary of Water Quality Criteria for Salmonid Hatcheries. SECL 8067.

May, it is recognized that with accelerated ice removal from the ponds, 4 °C water should be available from year to year when it is needed. By accessing water from two sources (infiltration well and ponds), water temperatures during the earlier incubation stage (August - October) can be manipulated to a certain extent through mixing, so that the total number of Thermal Units developed will reach 1,000 by late April, coinciding with the availability of 4 °C pond water (naturally occurring or assisted via ice removal) necessary for initiating first feeding.

Table 2: Thermal Unit Accumulation Estimated For Ambient Water Temperatures (Some Water Re-Use To Maintain Winter Incubation Temperatures At 2 °C).

Month	Number Days	Temp. in °C	Thermal Units	ATU's
August	31	8	248	248
September	30	7	210	458
October	31	4	124	582
November	30	2	60	642
December	31	2	62	704
January	31	2	62	766
February	28	2	56	822
March	31	2	62	884
April	30	2	60	944
May	31	5	155	1099
June	30	8	240	1339

Table 3: Thermal Unit Accumulation Estimated For Ambient Water Temperatures.

Month	Number Days	Temp. in °C	Thermal Units	ATU's
August	31	10	310	310
September	30	10	300	610
October	31	5	155	765
November	30	2	60	825
December	31	1	31	856
January	31	1	31	887
February	28	1	28	915
March	31	1	31	946
April	30	1	30	976
May	31	5	155	1131
June	30	8	240	1371

Based on the pond temperature information obtained during this investigation, it may not be necessary to provide extrinsic heating to the water in order to obtain the required size (minimum 1 gram) for tagging. The Whitehorse Rapids Fish Hatchery. produces chinook fry in excess of 1.0 gram within 70 days of ponding. Water temperature at the hatchery is consistent at 6.0 °C. Therefore, a facility operating in the Klondike region should be able to produce fry in excess of 1.0 gram by July. Fry could be tagged and released at this time, or held longer (September) until they reach a larger size, depending on the specific objectives of the facility and the outmigrant timing of the wild juveniles.

B. Direct Heating

The need to provide water at specific temperatures to ensure adequate fish growth for a specific period of time was discussed in the first report. As a brief review, the extent and rate of fish growth is almost entirely dependent on water temperature, assuming that other essential components (oxygen, feed) are available. In order to ensure that fish reach their target size by a certain time, so that the natural growth pattern is followed as closely as possible, and so that the fish are large enough to be coded wire tagged (CWT) prior to release, adequate water temperatures must be provided during all phases of their life cycle. If water of optimal temperature is not provided, the fish may fail to initiate feeding, and even if they do, will grow very slowly. This may result in them having to be maintained in the hatchery an additional year prior to release, in order to ensure that they reach a size that gives them a reasonable chance of survival in the wild. Although the number of fish proposed for rearing is small, a substantial amount of water will still be required for rearing. Water is expensive to heat, and a flow through fish culture facility requiring heated water is not recommended for the Klondike facility. The energy demand of directly heating water at the various life stages is shown in Table 4.

C. Water Re-use

The term "water re-use", as it relates to a fish culture facility, denotes using the water more than once with, unlike recirculation, little or no treatment of the water between uses. This can be effective for conserving temperature when used during egg incubation. During this phase of development, especially up to the eyed stage, a very small amount of metabolic waste material is produced by the eggs, requiring minimal or no treatment of the water prior to subsequent use. Water used in this manner, up to approximately 4 cycles, works well for egg incubation and will maintain (or possibly increase marginally) its temperature. This process should be limited to the egg stage of development. Fish that have hatched will begin to excrete metabolic waste products into the water, and water treatment of some kind will be required.

Table 4: Typical Energy Consumption (Kw) Of A Fish Culture Facility Incubating And Rearing Up To 300,000 Fish Using Either A Flow Through (1 Pass), Water Re-Use Design (4 Pass), Or Water Re-Use With Heat Recovery (Heat Exchanger). Energy Consumption Based On A Flow Loading Rate Of 0.6 Kg Fish/Litre/Min. And An Increase In Temperature (ΔT), From Ambient, Of 4 °C

		Energy Demand (Kw) - Continuous		
Stage Of Development	Water Demand (L/Hour)	Flow Through	4 Pass Water Reuse	Water Re-use/ Heat Recovery
Incubation	4,500	21	5.25	0.525
0.5 gram	15,000	70	17.5	1.75
1.0 gram	30,000	140	35	3.50

Water re-use facilities can also be designed to heat water using a heat exchanger to further conserve energy. A heat exchanger is a specialized piece of equipment that acts on the counter-current flow principal. It is designed to passively transfer heat from the warmer outgoing water to the colder incoming water. This is accomplished by forcing the two water sources through very narrow spaces with large surface areas. The two water sources come in very close contact with each other, separated only by a very thin, highly conductive metal plate, and most of the heat from the warmer water is transferred to the cooler water on the opposite side. Efficiency is typically around 90%[12], assuming initial installation and maintenance of an appropriately sized unit. In order for this system to work effectively, there must be an ample temperature differential between the two water components in order for an adequate heat transfer to take place. The smaller the temperature differential, the less efficient the process.

D. Recirculation (The REBF Module)

The REBF in REBF module stands for <u>RE</u>circulation with <u>B</u>io<u>F</u>iltration. It is a complete, specialized recirculation system designed by Aquabiotech, Inc., in Coaticook, Quebec. This concept is a total system designed to provide complete biofiltration in an almost total recirculation (up to 99.9%) environment.

Generally speaking, aquaculture recirculating systems (recirculation) are fish production systems in which the water is utilized by the fish more than once, with some degree of waste treatment or removal and water renovation applied between successive uses. Recirculating systems are usually measured, or identified, by the percent volume of make-up water added to the system (or exchanged) on a daily basis. For example, a recirculating system that replaces approximately 2 cubic meters of fresh water daily in a 20 cubic meter volume operation would be considered a 90% recirculation system (90% of the water at any given time is being recirculated - 2 parts out of 20 parts, or 10%, is new). Recirculating systems are

[12] Alfa - Laval, Toronto, Ontario (A leading heat exchanger manufacturer).

used to compensate for some limiting factor, such as water availability, water discharge restrictions or temperature concerns. Invariably, a completely closed recirculation system (100% recirculation) is much more difficult to maintain than one that allows some amount of fresh water into it on a continuous basis.

There are potential problems associated with a closed, or predominantly closed, fish culture recirculation system. Primarily, it is expensive to purchase and install, and it allows for the accumulation of metabolic waste products, feed by-products and other undesirable water quality changes produced by uneaten feed and feces, including ammonia and carbon dioxide intensification, pH depression, increased turbidity and high oxygen demand. However, most of these water quality concerns can be effectively dealt with using existing technology. Of primary concern are 1) the build-up of suspended solids {turbidity}, and 2) the concentration of ammonia, a naturally occurring waste product of food metabolism by fish. New technology has made it possible to solve these problems, and recirculation aquaculture systems are currently being viewed much more favorably than they have been in the recent past.

Ammonia is usually considered the single water quality parameter of most concern for potentially causing the most problems in fish being raised in a recirculation system. Ammonia is a normal by-product of protein utilization in fish, and is continually excreted from the fish, primarily via the gills, and to a much lesser extent, the kidneys[13]. Ammonia, particularly in its un-ionized form, is toxic to fish. In a flow-through, or single water use, system, ammonia accumulation is not a concern. However, it is allowed to accrue if the water is re-used. Biofiltration is the process whereby specific but naturally occurring bacteria (*Nitrosomonas sp.* and *Nitrobacter sp.*) are introduced and allowed to colonize at some physical point within the system. Through natural biological processes, these bacteria convert the ammonia first to nitrite and then to nitrate. Nitrate is substantially (approximately 2000 times) less toxic to fish than ammonia[14]. For practical purposes, it is considered to be non-toxic to fish. Biofiltration, therefore, biologically "filters" the water by converting toxic ammonia to non-toxic, or very mildly toxic nitrate ion, through natural biological activity. The water containing the nitrate ion can then be discharged to the outside environment, providing necessary nutrients to nitrogen using plants. The biofiltration unit is the "heart" of the new technology fish culture recirculation system.

Another notable concern that is exacerbated by water recirculation in a fish culture environment is the effluent, or waste water, which will contain a build-up of suspended solids; uneaten feed and feces. Accumulation of these wastes can initiate chemical changes in the water, as well as cause physical and mechanical complications. Specialized sediment removal

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[13] Moyle, P. B. and Cech, J. J., Jr. 1988. Fishes: An Introduction to Ichthyology. Prentice-Hall, Inc. Englewood Cliffs, New Jersey.
[14] Andrews, C., Exell, A. and Carrington, N. 1988. The Manual of Fish Health. Tetra Press. Morris Plains, N. J.

tanks and high efficiency filters are devices that are built into modern recirculation systems, and are designed to capture almost all waste material. The waste material filtered out can be isolated and concentrated, and dealt with through a settling pond or a wetland environment, or compiled and physically removed from the facility. Mechanical sediment filters and specially designed sediment traps on fish tanks constitute mandatory components of any technologically sound recirculation system. It is possible to actually improve the water quality (depending on the quality of the original water) of a recirculating fish culture operation through a technologically advanced recirculation system.

In this project, the primary rationale for a system that functions with a very high percentage of recirculated water is the elevation and maintenance of water temperature. Once a large volume of water is heated to the desired temperature, it is relatively easy (and relatively inexpensive) to maintain that temperature at just below ambient room temperature, requiring that only a very small percentage of fresh, cold water be continuously added to the system. For example, in a fish culture operation requiring a total of 30 cubic meters of water, such as may be proposed here, a 99.9% recirculation system would, in theory, require the addition of only 30 litres per day of fresh make-up water, or about 1.25 litres (1,200 ml) per hour. The REBF Module that is being described here has been successfully operated with 7 °C water[15]. It would be relatively inexpensive to

[15] Personal communication, Hélène Drouin, President, Aquabiotech

maintain water at this temperature, once it has reached this temperature, with a high proportion (95% - 99%) of recirculated water. Additional information regarding the REBF Module can be found in Appendix 6. A cost generalization for this system cannot be accomplished until the precise size and nature of the proposed facility has been finalized.

In a well designed and maintained recirculating system that is neither overstocked nor overfed, most aspects of water quality can be precisely controlled. Water quality parameters such as dissolved oxygen, bacterial loading, ammonia, nitrite, nitrate, carbon dioxide, pH and temperature can be monitored and adjusted. A primary advantage to developing a recirculation facility is that it increases the number of locations where it can be situated, as the water demand for fish culture is very low.

V. TAILINGS PONDS - PHYSICAL PARAMETERS

A. Ice Cover Removal

As part of this investigation, the use of tailings ponds has been explored as a possible source of relatively warmer water in the spring and again in the fall. The tailings ponds under investigation are shown in Figure 1.

All ponds were measured for ice cover thickness in 1998. On all ponds, the ice thickness was approximately 50 cm (20") in February. By the second measurement in March, the ice had increased in thickness by only a few centimeters.

The fact that relatively thin ice was encountered on all ponds indicates that it will likely break up early in the spring. It also means that whatever methods are employed to accelerate the break-up may be more effective.

Break-up of the ponds, as anticipated, began in late April to early May (1998). Weather data for the month of April indicates that the mean daily temperature for the region is above 0 °C by the middle of April, with the daily maximum (30 year average) being above 0 °C by April 1 (Appendix 1). Therefore, it may be possible to accelerate ice removal from the ponds beginning in early April. By the end of April, the mean air temperature for the region is above 4 °C. If ice is removed from the ponds by the middle of April, it may be possible to ensure that ambient water temperature in a given pond reaches 4 °C (minimum required ponding temperature) by late April. An incubation scenario utilizing ambient water temperature should target ATU development such that the ponding stage of development occurs by late April/early May.

B. Maximum and Average Depth of Ponds

There are seven ponds associated with the site under investigation. Bathymetry was performed on six of these ponds. Pond #6 was not sampled for depth due to its small size. It had been visually evaluated the previous summer and was not considered to have a serviceable water volume.

Bathymetry was performed by establishing transect lines running roughly perpendicular to the longitudinal axis of each pond. These transects were established at 10 meter intervals, and depth measurements were taken at 10 meter intervals along each transect, using an electronic depth sounder. Depth reading values were confirmed periodically with the use of a graduated long line. Lake bathymetry developed from the transects are appended (Appendix 7). From the bathymetry investigations, the standing water volume of each pond was determined. Ponds ranged in volume from an estimated 2,700 cubic meters to 17,800 cubic meters. Maximum and average depths, and volumes for each pond measured are presented in Table 5. None of the ponds exceeded 6.1 metres (20 feet) in depth, with respective mean depths ranging from 1.7 metres to 3.7 metres.

Table 5: Tailings Ponds Water Depths And Estimated Volumes (M^3)

POND → CRITERIA ↓	POND #1	POND #2	POND #3	POND #4	POND #5	POND #7
Maximum Depth	20' (6.1 m)	19' (5.8 m)	12' (3.6 m)	14' (4.3 m)	17' (5.2 m)	12' (3.6 m)
Mean Depth	12.36' (3.7 m)	10.35' (3.1 m)	7.27' (2.2 m)	9.88' (3.0 m)	11.28' (3.4 m)	5.73' (1.7m)
Estimated Volume (m^3)	13,000	15,000	11,000	2,700	17,800	3,900

Maximum water demand in a flow-through situation (300,000 fish @ 2.0 grams per fish and flow loading of 0.6 Kg/litre/minute) would be 60,000 litres/hour, or 60 cubic metres per hour (m^3/hour). Therefore, complete water exchange from the ponds, assuming all water is derived from any given pond at one time, is estimated as follows:

POND ➡	POND #1	POND #2	POND #3	POND #4	POND #5	POND #7
complete exchange (days)	9.0	10.4	7.6	1.9	12.3	2.7

Recharge rates of the ponds have yet to be determined, and will be related to the water demand/exchange rates. Water gauges have been made and will be placed in three of the ponds in order to monitor water level fluctuations over an extended period.

C. Determination of Water Flow; Rate and Direction

Water flows in the ponds were investigated during water sample collection and bathymetry work. Flagging tape attached to a pole was lowered into each hole drilled through the ice. With assistance of an underwater lamp, it was determined that flow in the ponds was not detectable with the method employed. Flow was observed, however, on tailings ponds 1 and 3 at the narrowest sections of the ponds. The fact that dissolved oxygen levels measured in the ponds were depressed relative to the Klondike River levels indicates that water exchange through the ponds from the River during the winter is minimal, or does not occur. The source of the observed water flow is likely from groundwater that is usually associated with low dissolved oxygen. Low dissolved oxygen levels were measured in several of the ponds in which water was flowing.

Water flow characteristics in the ponds will likely vary greatly with seasonal changes in river and groundwater levels in the area. Accordingly, water flow observations should continue throughout the spring and summer during scheduled site visits.

The primary emphasis for this portion of the investigation is scheduled for the spring/summer, after the ice cover is gone. It is much simpler to determine the presence of flow in a waterbody without ice cover.

VI. POTENTIAL FACILITY SITES

The two potential sites for the location of an incubation/outplant facility, the tailings ponds area site and the former Dawson City well site, were identified in the phase 1 report[16].

The tailings ponds site is currently (April, 1998) zoned Country Residential. While this zoning does not allow for aquaculture use, Mr. Jim Kincaid, Dawson City Manager, indicated that, given advanced notification, zoning changes needed to accommodate this project should not pose any serious problems.

The second potential site, also identified in the first report, is the former City well site. According to Mr. Kincaid, it is currently zoned as Hinterland. In the document entitled City of Dawson Zoning and Historical Control - Bylaw 97 - 25; Draft No. 4, October 23/97, under Section IV - 20, the

[16] Petkovich, D. and Ricks, W. R. 1997. Klondike Area Central Incubation/Outplant Facility - Water Quality Evaluation

category "Fish Farming and Hatchery" is already listed under Discretionary Uses for an area that is zoned Hinterland. Mr. Kincaid did not anticipate zoning changes scheduled for this particular site.

Mr. Kincaid is aware of this proposed project, and he is supportive of the concept. He does not feel at this time that the availability of either site will pose a serious problem. A letter has been forwarded to the City of Dawson to formally advise the City of the proponents' intention of potentially developing a facility at the tailings pond site (Appendix 8).

VII. RECOMMENDED INVESTIGATIONS

A. Continued Seasonal Temperature Monitoring

Of primary importance is the continued monitoring of the Klondike River and associated tailings ponds water temperatures, in the vicinity of the tailings ponds site currently under investigation. Knowledge of these temperature profiles is important to the formation of decisions regarding the suitability of this site for the production of chinook fry under natural (or near natural) conditions (ambient water temperatures). Ultimately, this will greatly influence the facility design. If ambient water temperature profiles necessary for the successful incubation and rearing of chinook salmon are not available, the facility will have to incorporate a means to provide heated water in the most cost-effective manner with respect to both capital and operational reparations.

B. Early Spring Ice Break-Up Experimentation

It may be possible to induce premature ice cover removal from the tailings ponds in order to initiate an earlier water warming phase than would normally occur. Mean daily air temperatures are well above 0 °C by late April in the Dawson area, whereas the pond ice does not ordinarily break up naturally until mid to late May. By allowing the sun and warmer ambient air access to the pond water earlier than usual, it may be possible to increase the pond water temperatures substantially, providing naturally occurring elevated water temperatures that would coincide with fry ponding when they are needed. Preliminary work on this concept has already begun on one pond. Snow was removed from a portion of the pond, and a strip of black construction paper was anchored to the ice surface in an attempt to produce a concentrated heat absorbing area that would induce early ice cover break-up.

C. Spring Pond Water Drawdown/Recharge/Volume Investigation

After ice out occurs on the ponds, it is proposed to pump water from certain ponds in an attempt to determine drawdown and recharge profiles, i.e., the sustainable water volume production for each pond tested. This information is necessary so that, in the likely event certain ponds meet fish culture temperature requirements, a determination can be made regarding the availability of the required amount of water for a particular fish growth phase. Pump sizes used for this aspect would accommodate the anticipated hatchery water usage for that phase of the life cycle at that time of the year. As there appears to be some flow in the ponds throughout the winter, it is likely that recharge rates will be adequate for the needs of the proposed facility. Anecdotal information (provided by a resident of the tailings pond area) indicated that continuous pumping on one of the smaller ponds did result in a lower water level.

D. Perform Additional Comprehensive Water Quality Evaluations

While unlikely, it is possible that the water quality of the ponds and the Klondike River might change over the course of the summer. Accordingly, additional comprehensive water quality analyses, as were done during late winter of this year, should be performed during other seasons as well.

E. Follow-Up Site Investigation Regarding Zoning

Site zoning inquiries have been made, and the information obtained to date is documented earlier in this report. Zoning investigation will continue to the extent possible until a specific site has been selected. Once the site has been selected, a formal request for zoning changes, if deemed necessary, will be made.

A letter of interest has been sent to Dawson City Manager Jim Kincaid (Appendix 8) on his recommendation, formally advising him and Dawson City Council of the intended use of one of the two potential sites identified. Mr. Kincaid indicated that such a gesture would facilitate any future zoning changes that might be required to accommodate the project.

F. Infrastructure Development

Once a site has been selected, the cost of road and power development will be determined. Road access needs to be year round and, depending on final facility design, it is likely that three phase power will be required.

G. Water Source Development

Once a site and facility design (flow through, water re-use, recirculation) are designated, the most suitable water source(s) and means of accessing the water will be determined. Water will likely come from two sources: an infiltration well adjacent the Klondike River to access filtered River water, and water taken directly from one of the tailings ponds. The infiltration well may consist of a hole (3-5 metres depth) with encasement developed by a backhoe, or an actual shallow well developed (10-20 metres depth) using well drilling equipment. The most suitable well type and associated cost will be determined in consultation with professional well developers who are familiar with this type of enterprise (Aquatech, Midnight Sun Drilling Co.). As previously mentioned, the amount of water the facility will require will ultimately depend on a final facility design, which in turn will dictate the capacity of pump(s) and extent of plumbing required.

H. Investigate Effluent Disposal Methods And Permits

Depending on the specific system design of the facility, a given volume and quality of effluent will be produced, and will possibly require some treatment prior to discharge to receiving waters. The volume of water to be used at the facility, and the fact that the quality of that water will be altered, dictates that a water use licence be obtained. Application for a water use licence requires a completed facility design. Once the design is finalized, an application for a water use licence will be made. It is likely that only a type "B" licence will be required. A type "B" licence requires minimal environmental review and will likely have some water quality monitoring as a condition of the licence.

I. Investigate Use Of Tailings Ponds As Early Grow-Out Ponds

It may be possible, depending on water temperature and recharge regimes, to utilize one or more of the adjacent tailings ponds as a grow-out pond for juvenile chinook. This could save on pumping costs and artificial water heating strategies.

J. Facility Design

Parameters upon which the final facility design will be based include, but are not necessarily limited to, the following:

a. site availability and selection (zoning, access, cost, permit restrictions, effluent concerns)
b. water availability, volume and access costs
c. water quality
d. water temperature available/required through certain time periods
e. anticipated funding for infrastructure, facility, equipment, operation and maintenance
f. potential for tourism/interpretive applications

A final design will incorporate the above and other considerations, and will mimic as closely as possible, if possible, the natural conditions under which the Dawson area chinook salmon eggs and fry actualize their life cycle.

The facility design will be developed to accommodate the objectives of the program. Design will include building development (type, size, construction cost). Engineering work will include geotechnical, foundation and/or slab design, structure, septic requirements and design, electrical, plumbing and heating components, and any associated specialized fish culture constituents, such as recirculation, biofiltration and aeration components.

K. Determine The Best Method Of Water Temperature Increase (Ponds, Recirculation, Direct Heat, Heat Exchanger, Water Reuse)

Once the required water temperature increase is determined, the various methods for obtaining this result will be explored so that the most efficient and effective technology can be identified and incorporated into the system design. In order to minimize the complexity of the facility and its operation, a design based on direct flow-through and ambient water temperatures will be the goal. However, if this is not achievable, designs employing water re-use or recirculation, combined with heat recovery technology, will be examined in more detail. The costs associated with installing and utilizing these technologies will also be determined.

L. Cost Determination - Capital And Operational

All capital costs (buildings and equipment) will be determined and presented. Monthly and yearly operating costs will be determined and presented as a proforma monthly/yearly cash flow statement. Operating cost estimates will capture all operating expenses (salaries, utilities, feed, maintenance, consumables, etc.) including egg collection, tagging and fry release.

M. Funding Sources - Capital And Operational

As this facility will not generate its own annual income, sources of capital funding, as well as financing the program on an annual basis, will be investigated.

N. Consideration Of Duplicating Natural Incubation/Growth Temperature Parameters Of Klondike River Chinook Salmon

Concern has been expressed by the Yukon River Panel that diligent attention should be paid to the duplication of natural Klondike River incubation and grow-out water temperatures, to the extent possible and practical. To date, this investigation has focused on providing for a one year production cycle, which would include the collection of gametes during the summer spawning run, and release of appropriately sized fry just prior to the subsequent spawning the following summer. This is the general pattern of operation with the Whitehorse Rapids Fish Hatchery in Whitehorse, as it has been demonstrated that substantial numbers of fry begin their outmigration from the upper Yukon River after only one year in fresh water (1+).

The Department of Fisheries and Oceans (DFO) Whitehorse has very little information regarding the physiology and behaviour of chinook fry in the Klondike River, or in the Dawson area generally. Local information sources indicate that the overall water temperatures in the Klondike River, and the Yukon River in the Dawson area, may be notably lower than those of the upper Yukon River and its tributaries in the Whitehorse area. If this is the case, Klondike River chinook fry may be spending an additional year in fresh water in order to achieve the physical size and physiological development required for the onset of downstream migration. Obviously, if this were the case, a one-year hatchery cycle would fail to provide a valid duplication of naturally occurring conditions. An investigation into this concern has been initiated through consultation with DFO records of scale analysis of scale samples collected from adult broodstock in the Klondike River. Limited available evidence to date has not indicated that the Klondike River chinook fry undergo an increased freshwater residency period as compared to the upper Yukon River chinook fry.

It may be worthwhile to conduct a limited chinook fry trapping/collection program. Size classes of captured fry may provide additional information relating to the freshwater residency period of Klondike River chinook fry.

O. Explore And Address Possible Fish Health Concerns Re: Use Of Klondike River Water.

It is highly probable that Klondike River water will be an important component of the proposed facility. Consequently, the quality of that water as it relates to fish health becomes of significance. Specific diseases that might be present in this system need to be identified so that appropriate preventative measures may be taken to avoid introduction of these organisms into a fish culture facility relying on this water.

It is recommended that some biological screening for specific fish diseases, such as those listed under Schedule II (Certifiable Diseases) of the Fish Health Protection Regulations[17], be undertaken. The recommended time to do this is during the normal summer spawning event, as fish are readily available and, due to the stress of spawning, any diseases endemic to the system will be readily demonstrable in the salmon. Tissue samples can be collected by qualified personnel and sent to the Pacific Biological Station (DFO) in Nanaimo, B. C., for evaluation.

P. Conduct A Pilot Project With Klondike River Chinook In The Klondike River, To Determine The ATU's Required To Attain Various Stages Of Development, So That More Precise Growth Estimates May Be Established.

A small project of this type would be of considerable value, so that the final hatchery design could provide for all strategies needed to ensure that a targeted number of fish reach the desired size at the chosen time.

[17] Department of Fisheries and Oceans. 1984. Fish Health Protection Regulations: manual of compliance. Misc. Spec. Publ. 31 (Revised): 32 p.

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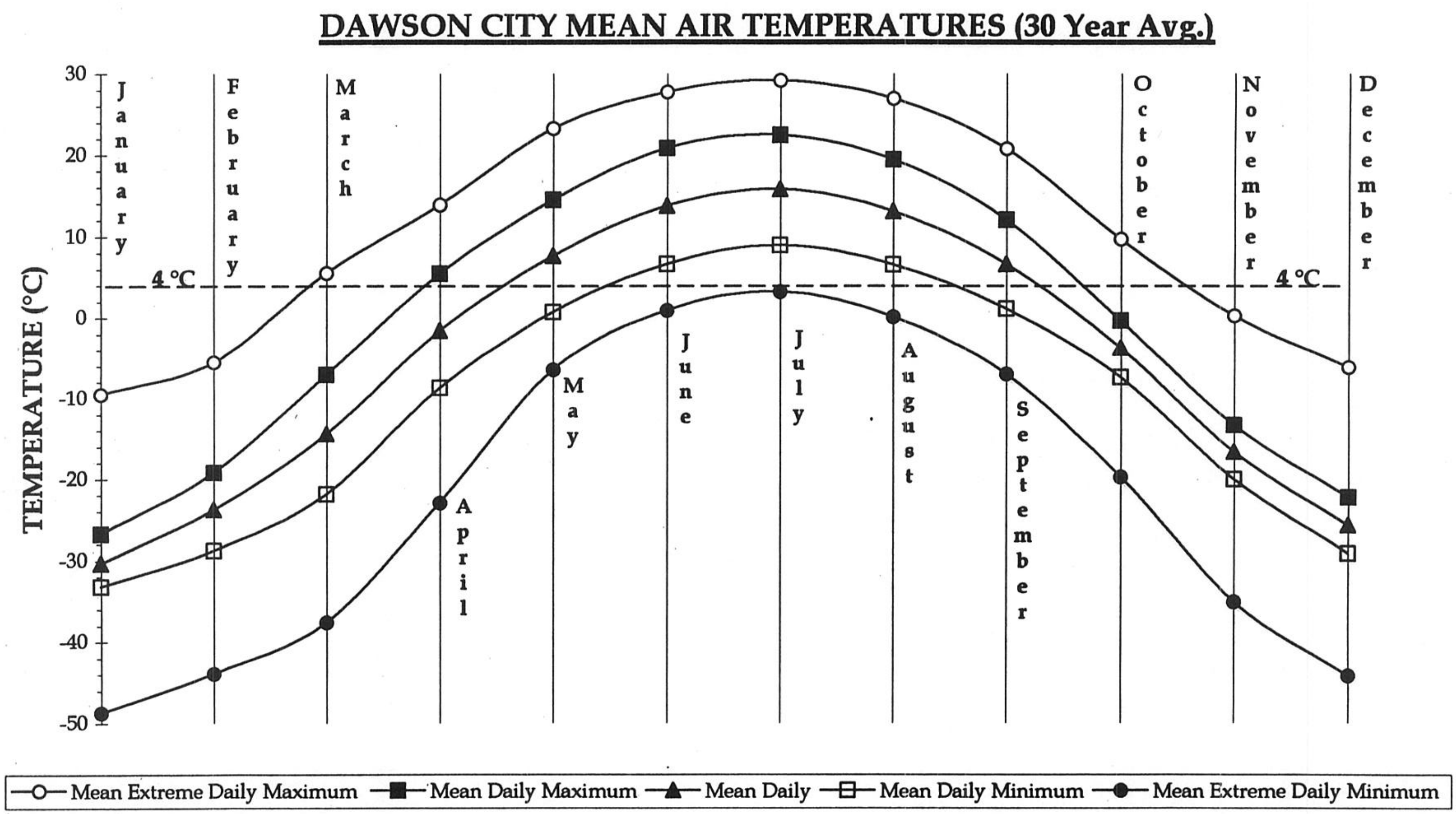
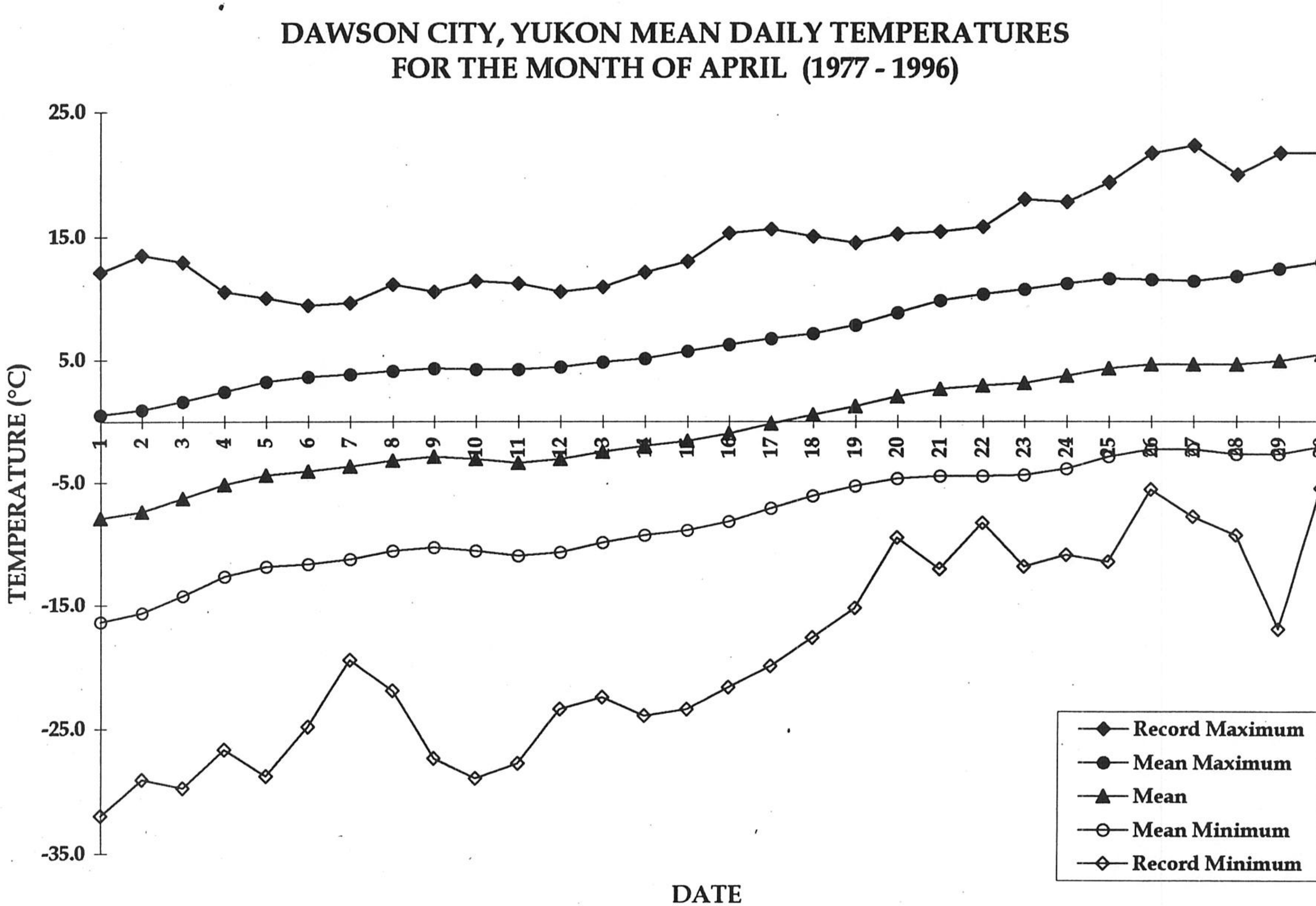
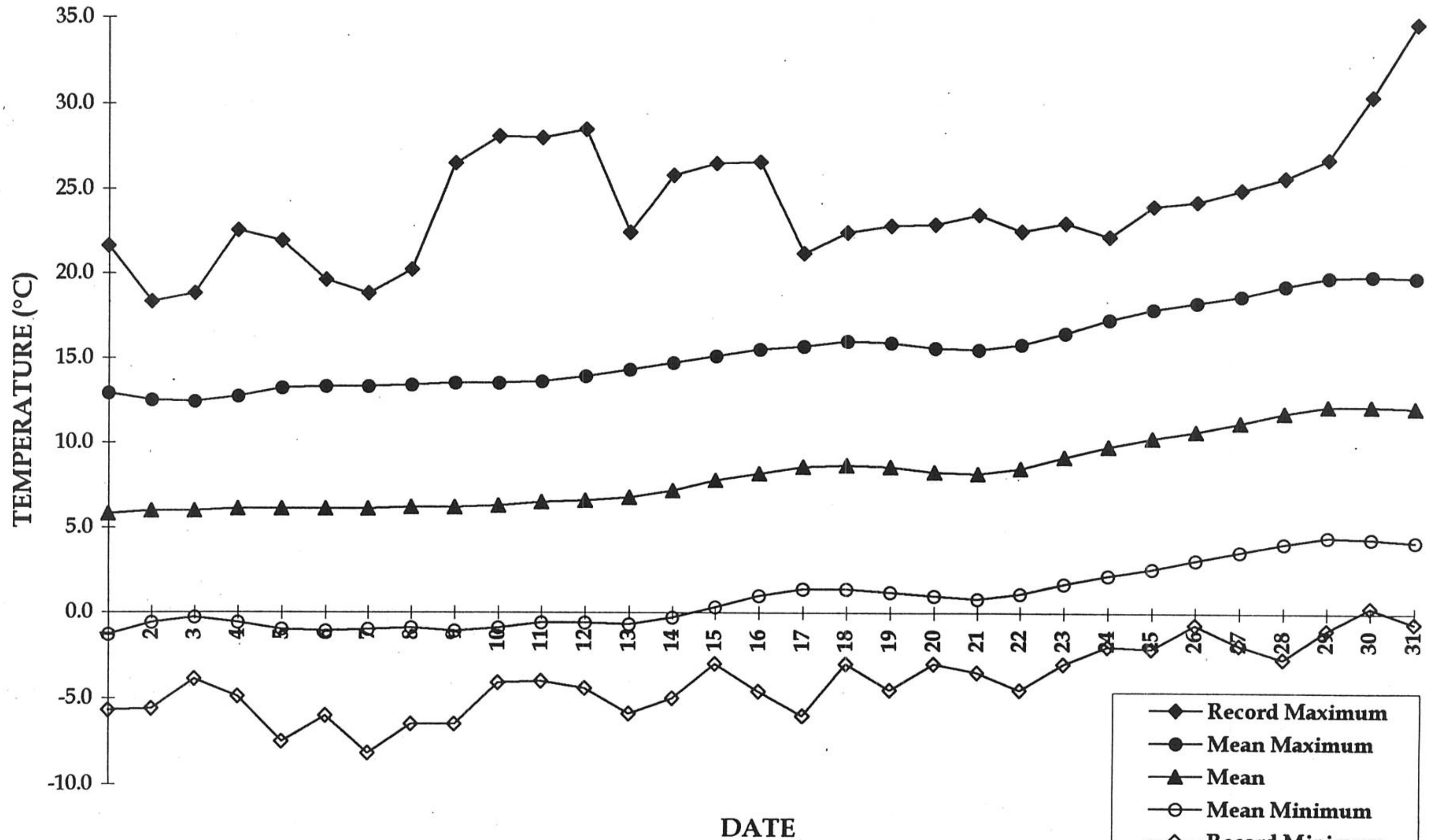
IX. APPENDICES

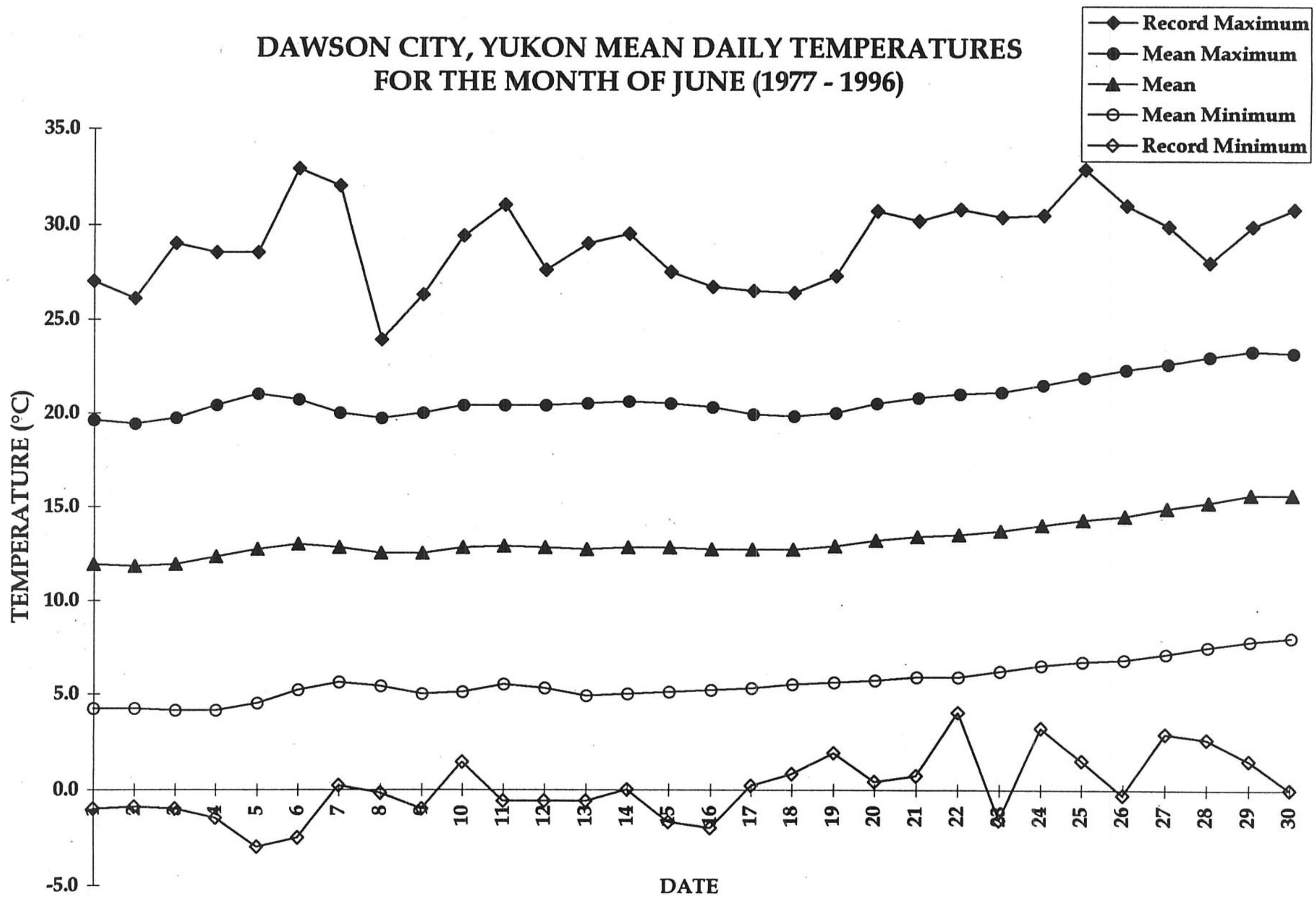
Appendix 1: Climate Data; Dawson City, Yukon Region - 30 Year Average.


DAWSON CITY MEAN AIR TEMPERATURES (30 Year Avg.)
TEMPERATURE (°C)
30
20
10
0
-10
-20
-30
-40
-50
4 °C
4 °C
January
February
March
April
May
June
July
August
September
October
November
December
Mean Extreme Daily Maximum
Mean Daily Maximum
Mean Daily
Mean Daily Minimum
Mean Extreme Daily Minimum

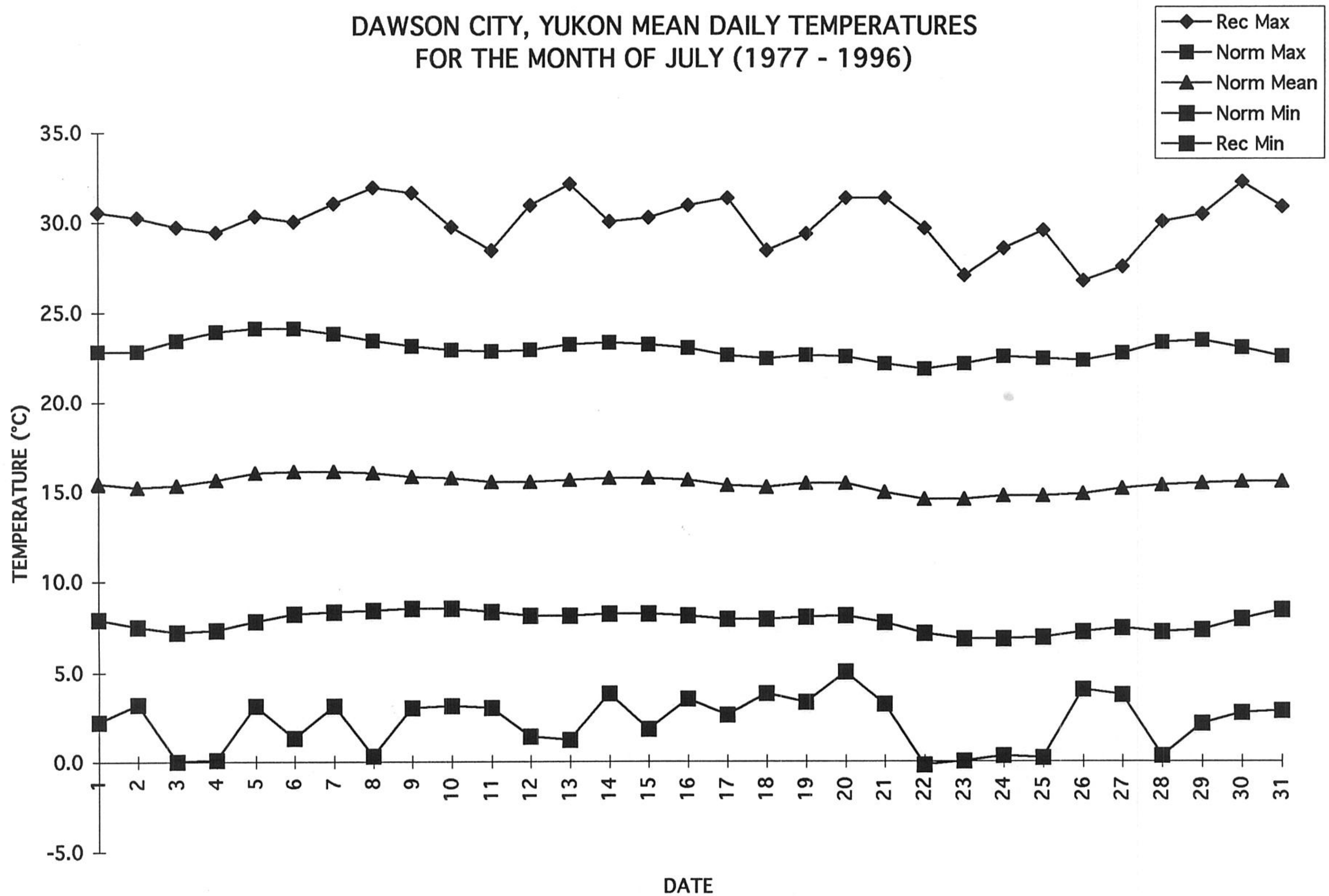

DAWSON CITY, YUKON MEAN DAILY TEMPERATURES
FOR THE MONTH OF APRIL (1977 - 1996)
25.0
15.0
5.0
-5.0
-15.0
-25.0
-35.0
TEMPERATURE (°C)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
DATE
Record Maximum
Mean Maximum
Mean
Mean Minimum
Record Minimum

DAWSON CITY, YUKON MEAN DAILY TEMPERATURES FOR THE MONTH OF MAY (1977 - 1996)

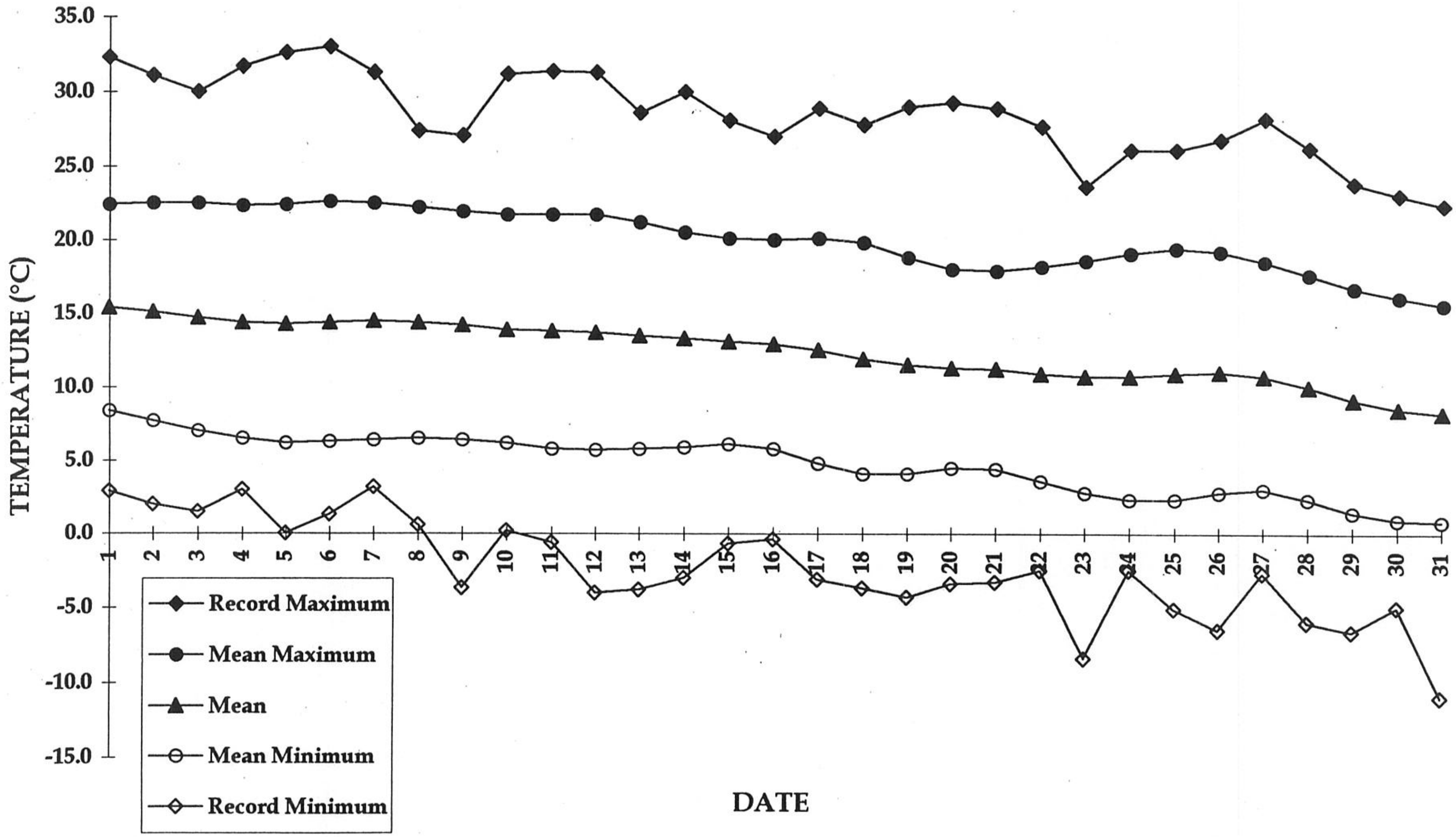


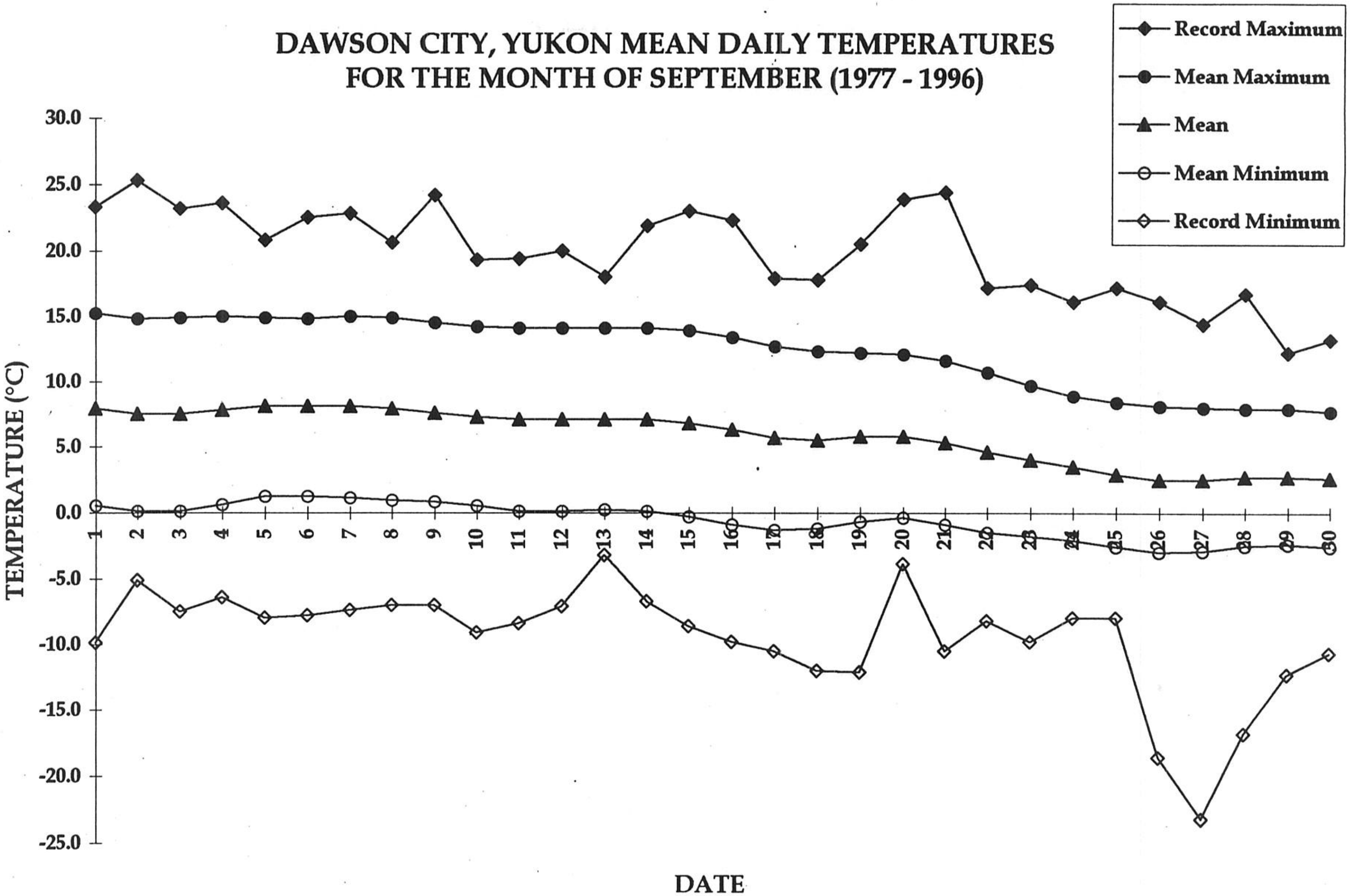


DAWSON CITY, YUKON MEAN DAILY TEMPERATURES
FOR THE MONTH OF JUNE (1977 - 1996)
Record Maximum
Mean Maximum
Mean
Mean Minimum
Record Minimum
TEMPERATURE (°C)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
DATE


DAWSON CITY, YUKON MEAN DAILY TEMPERATURES
FOR THE MONTH OF JULY (1977 - 1996)
Rec Max
Norm Max
Norm Mean
Norm Min
Rec Min
TEMPERATURE (°C)
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
DATE

DAWSON CITY, YUKON MEAN DAILY TEMPERATURES FOR THE MONTH OF AUGUST (1977 - 1996)




DAWSON CITY, YUKON MEAN DAILY TEMPERATURES
FOR THE MONTH OF SEPTEMBER (1977 - 1996)
Record Maximum
Mean Maximum
Mean
Mean Minimum
Record Minimum
TEMPERATURE (°C)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
1
2
3
4
5
6
7
8
9
10
11
12
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28
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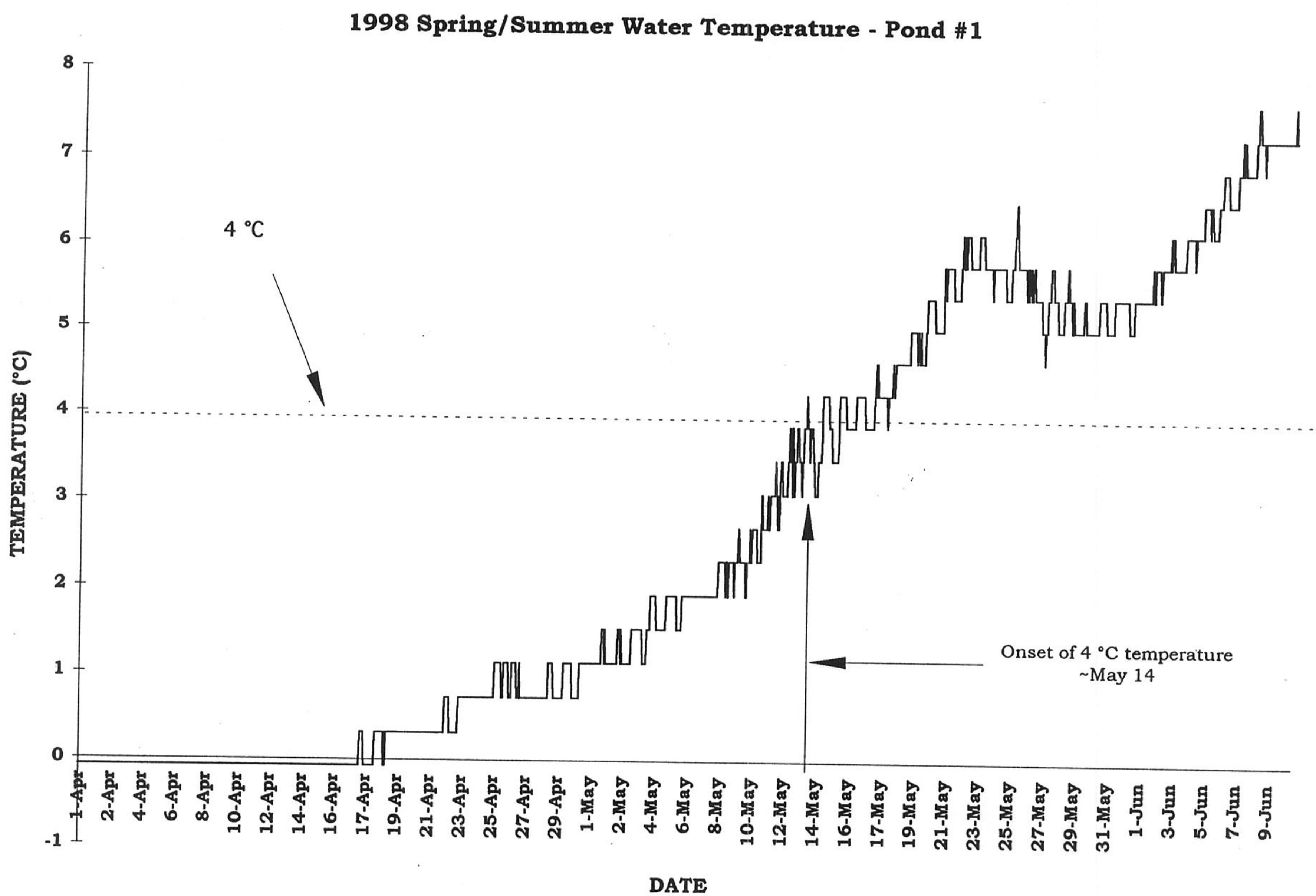
30
DATE

Appendix 2: Temperature Information; Tailings Ponds and Klondike River - Tailings Ponds Site


1998 Spring/Summer Water Temperature - Pond #1
TEMPERATURE (°C)
DATE
4 °C
Onset of 4 °C temperature
~May 14
8
7
6
5
4
3
2
1
0
-1
1-Apr
2-Apr
4-Apr
6-Apr
8-Apr
10-Apr
12-Apr
14-Apr
16-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
2-May
4-May
6-May
8-May
10-May
12-May
14-May
16-May
17-May
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29-May
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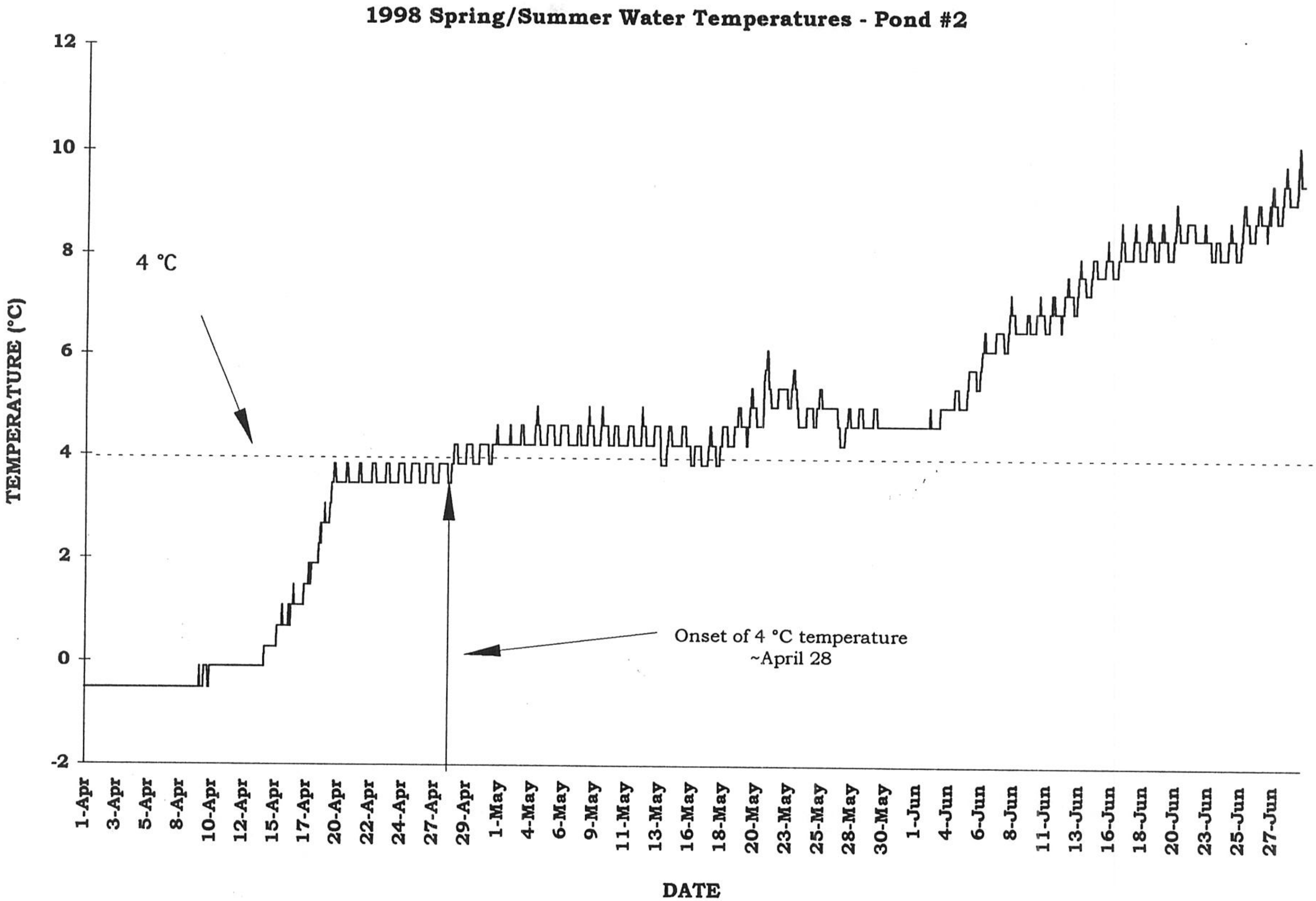
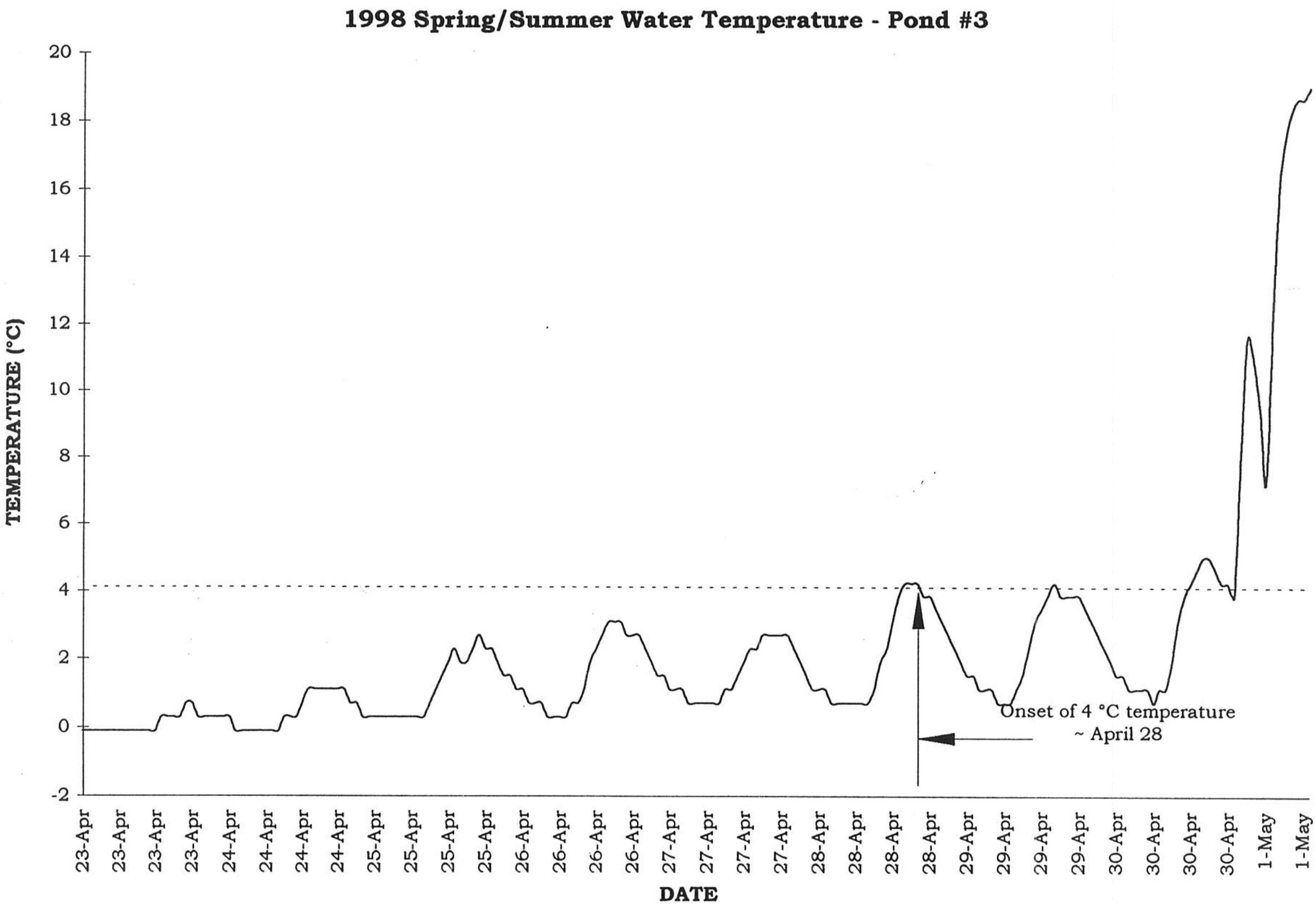
1-Jun
3-Jun
5-Jun
7-Jun
9-Jun



1998 Spring/Summer Water Temperatures - Pond #2
TEMPERATURE (°C)
12
10
8
6
4
2
0
-2
4 °C
Onset of 4 °C temperature
~April 28
1-Apr
3-Apr
5-Apr
8-Apr
10-Apr
12-Apr
15-Apr
17-Apr
20-Apr
22-Apr
24-Apr
27-Apr
29-Apr
1-May
4-May
6-May
9-May
11-May
13-May
16-May
18-May
20-May
23-May
25-May
28-May
30-May
1-Jun
4-Jun
6-Jun
8-Jun
11-Jun
13-Jun
16-Jun
18-Jun
20-Jun
23-Jun
25-Jun
27-Jun
DATE


1998 Spring/Summer Water Temperature - Pond #3
TEMPERATURE (°C)
20
18
16
14
12
10
8
6
4
2
0
-2
Onset of 4 °C temperature
~ April 28
23-Apr
23-Apr
23-Apr
23-Apr
24-Apr
24-Apr
24-Apr
24-Apr
25-Apr
25-Apr
25-Apr
25-Apr
26-Apr
26-Apr
26-Apr
26-Apr
27-Apr
27-Apr
27-Apr
27-Apr
28-Apr
28-Apr
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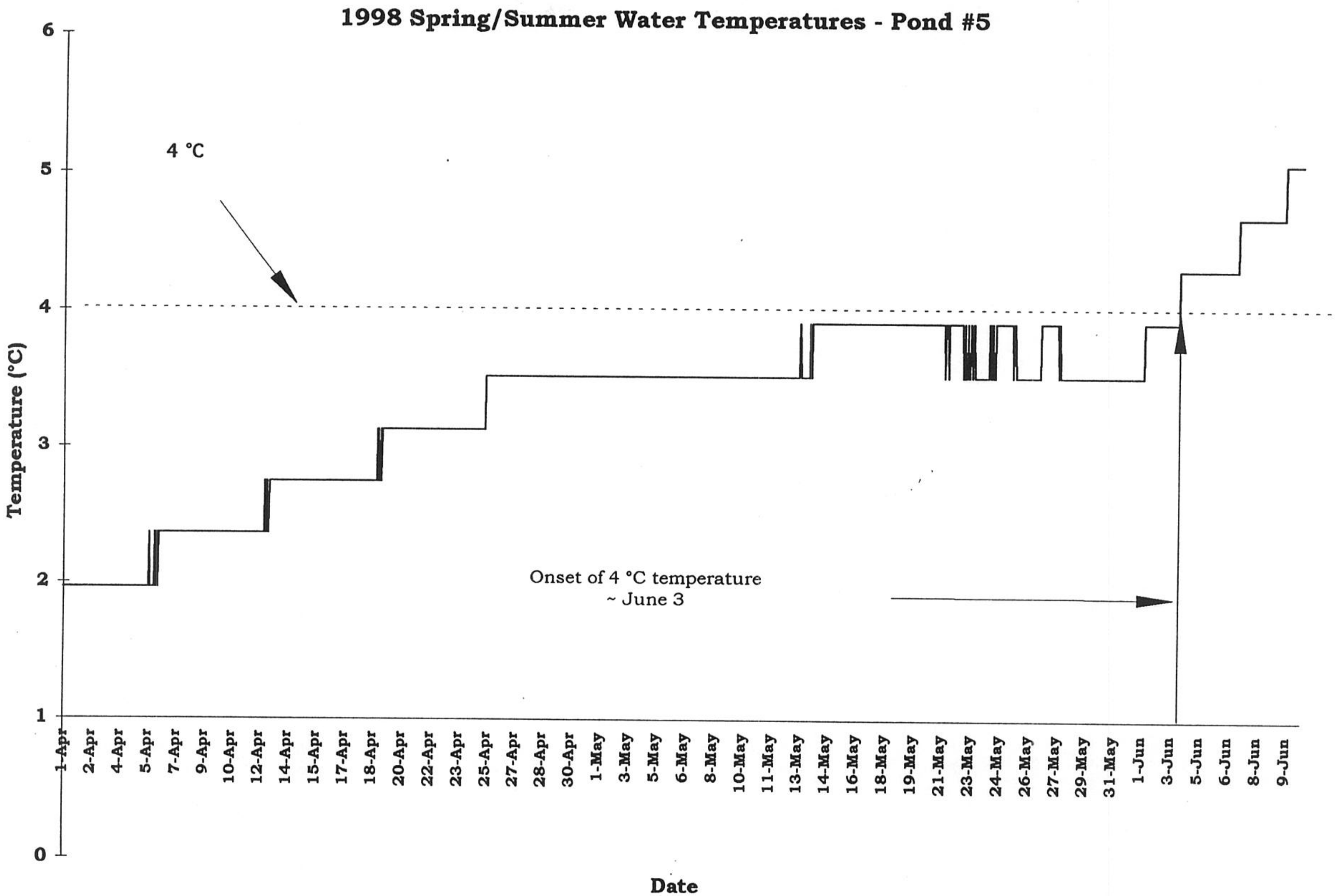
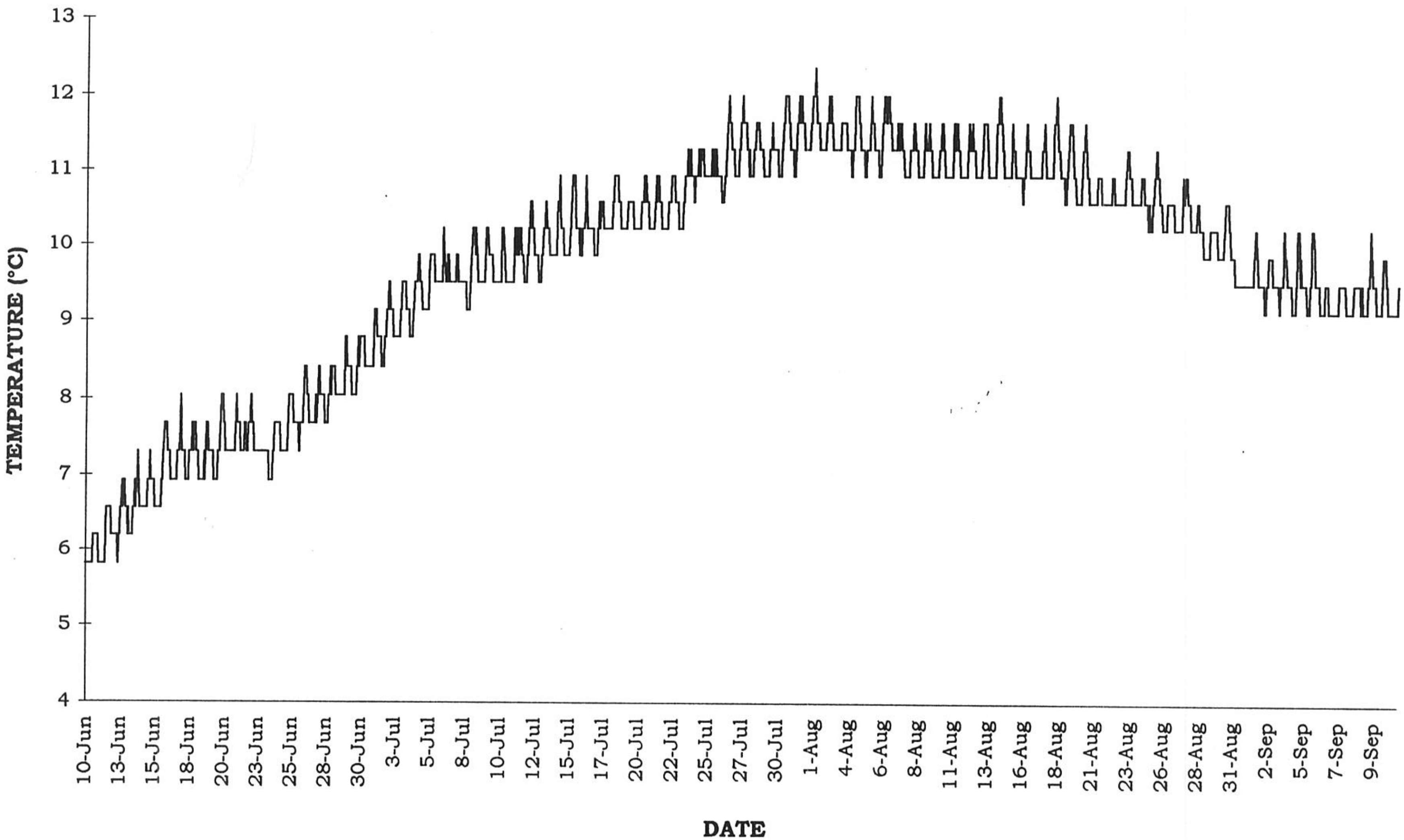
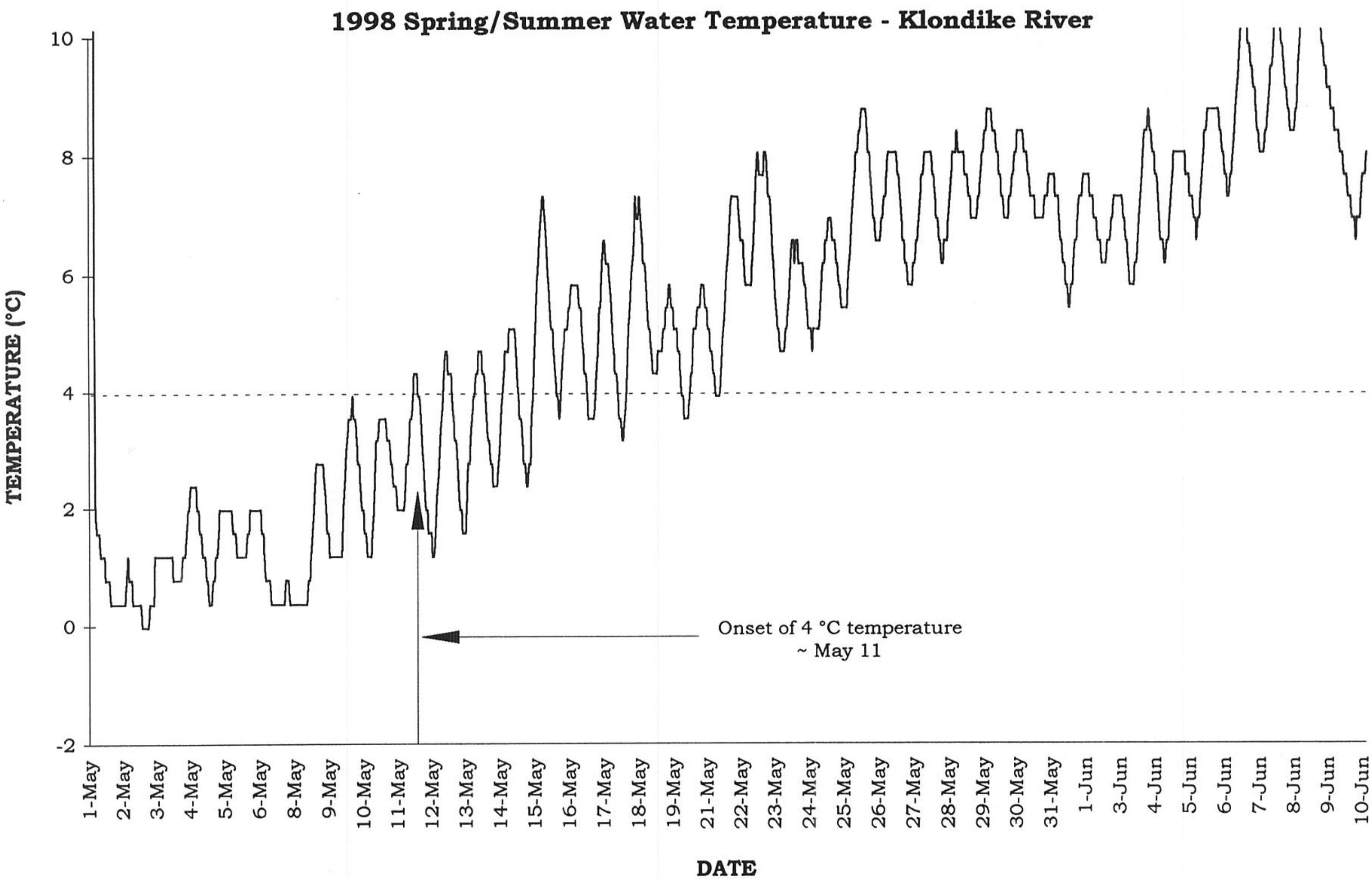
30-Apr
30-Apr
1-May
1-May
DATE


1998 Spring/Summer Water Temperatures - Pond #5
Temperature (°C)
0
1
2
3
4
5
6
4 °C
Onset of 4 °C temperature
~ June 3
1-Apr
2-Apr
4-Apr
5-Apr
7-Apr
9-Apr
10-Apr
12-Apr
14-Apr
15-Apr
17-Apr
18-Apr
20-Apr
22-Apr
23-Apr
25-Apr
27-Apr
28-Apr
30-Apr
1-May
3-May
5-May
6-May
8-May
10-May
11-May
13-May
14-May
16-May
18-May
19-May
21-May
23-May
24-May
26-May
27-May
29-May
31-May
1-Jun
3-Jun
5-Jun
6-Jun
8-Jun
9-Jun
Date

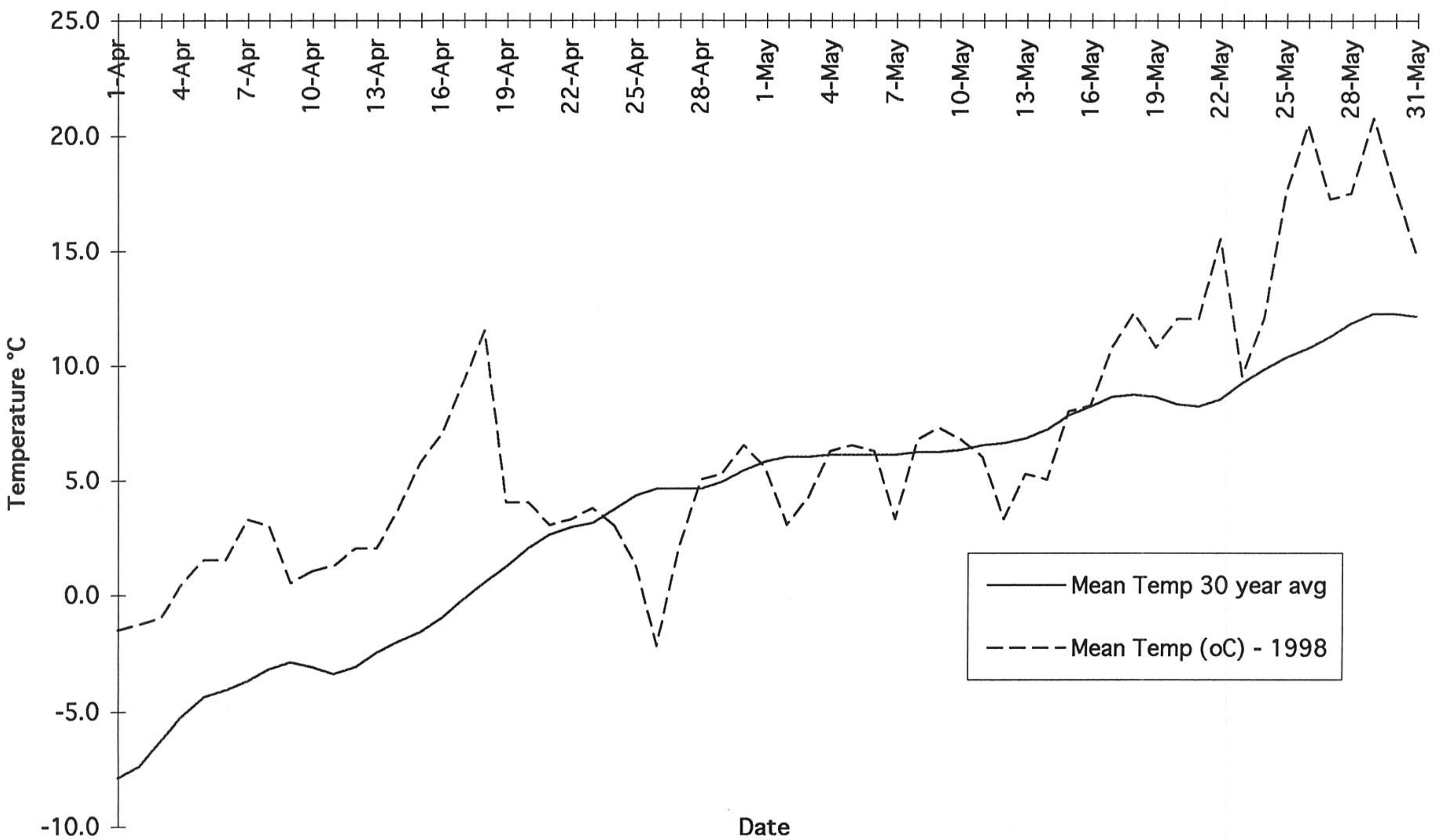
1998 Summer/Fall Water Temperature - Pond #5




1998 Spring/Summer Water Temperature - Klondike River
TEMPERATURE (°C)
10
8
6
4
2
0
-2
Onset of 4 °C temperature
~ May 11
1-May
2-May
3-May
4-May
5-May
6-May
8-May
9-May
10-May
11-May
12-May
13-May
14-May
15-May
16-May
17-May
18-May
19-May
21-May
22-May
23-May
24-May
25-May
26-May
27-May
28-May
29-May
30-May
31-May
1-Jun
3-Jun
4-Jun
5-Jun
6-Jun
7-Jun
8-Jun
9-Jun
10-Jun
DATE

Appendix 3: Comparison Of 1998 Air Temperatures To 30 Year Average - Dawson City, Yukon

Dawson City Mean Air Temperature Data 30 year Average vs. 1998



Appendix 4: Water Quality Analyses Data

RESULTS OF ANALYSIS - Water

File No. I2380

			TP1	TP2	TP3	TP4	TP5
			98 02 09	98 02 09	98 02 09	98 02 09	98 02 09
Physical Tests							
Conductivity		(umhos/cm)	285	283	279	283	284
Total Metals							
Aluminum	T-Al		0.018	<0.005	<0.005	<0.005	0.005
Antimony	T-Sb		<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	T-As		0.0001	<0.0001	0.0001	0.0003	0.0001
Barium	T-Ba		0.06	0.06	0.05	0.06	0.06
Beryllium	T-Be		<0.005	<0.005	<0.005	<0.005	<0.005
Bismuth	T-Bi		<0.1	<0.1	<0.1	<0.1	<0.1
Boron	T-B		<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd		<0.01	<0.01	<0.01	<0.01	<0.01
Calcium	T-Ca		37.5	38.0	36.1	36.5	37.7
Chromium	T-Cr		<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	T-Co		<0.01	<0.01	<0.01	<0.01	<0.01
Copper	T-Cu		<0.01	<0.01	<0.01	<0.01	<0.01
Iron	T-Fe		<0.03	<0.03	<0.03	<0.03	<0.03
Lead	T-Pb		<0.05	<0.05	<0.05	<0.05	<0.05
Lithium	T-Li		<0.01	<0.01	<0.01	<0.01	<0.01
Magnesium	T-Mg		11.0	11.1	10.6	10.8	11.0
Manganese	T-Mn		<0.005	<0.005	0.010	0.007	<0.005
Mercury	T-Hg		<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo		<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni		<0.02	<0.02	<0.02	<0.02	<0.02
Phosphorus	T-P		<0.3	<0.3	<0.3	<0.3	<0.3
Potassium	T-K		<2	<2	<2	<2	<2
Selenium	T-Se		<0.2	<0.2	<0.2	<0.2	<0.2
Silicon	T-Si		2.94	2.95	2.85	2.84	2.92
Silver	T-Ag		<0.01	<0.01	<0.01	<0.01	<0.01
Sodium	T-Na		2	2	2	2	2
Strontium	T-Sr		0.201	0.203	0.193	0.197	0.202
Thallium	T-Tl		<0.1	<0.1	<0.1	<0.1	<0.1
Tin	T-Sn		<0.03	<0.03	<0.03	<0.03	<0.03
Titanium	T-Ti		<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	T-V		<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn		<0.005	<0.005	<0.005	<0.005	<0.005

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water

File No. I2380

			TP6	TP7	KR1
			98 02 09	98 02 09	98 02 09
Physical Tests					
Conductivity		(umhos/cm)	284	286	282
Total Metals					
Aluminum	T-Al		<0.005	<0.005	<0.005
Antimony	T-Sb		<0.2	<0.2	<0.2
Arsenic	T-As		0.0004	<0.0001	<0.0001
Barium	T-Ba		0.06	0.06	0.07
Beryllium	T-Be		<0.005	<0.005	<0.005
Bismuth	T-Bi		<0.1	<0.1	<0.1
Boron	T-B		<0.1	<0.1	<0.1
Cadmium	T-Cd		<0.01	<0.01	<0.01
Calcium	T-Ca		38.1	37.3	36.8
Chromium	T-Cr		<0.01	<0.01	<0.01
Cobalt	T-Co		<0.01	<0.01	<0.01
Copper	T-Cu		<0.01	<0.01	<0.01
Iron	T-Fe		<0.03	<0.03	<0.03
Lead	T-Pb		<0.05	<0.05	<0.05
Lithium	T-Li		<0.01	<0.01	<0.01
Magnesium	T-Mg		11.1	11.0	10.7
Manganese	T-Mn		<0.005	<0.005	0.005
Mercury	T-Hg		<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo		<0.03	<0.03	<0.03
Nickel	T-Ni		<0.02	<0.02	<0.02
Phosphorus	T-P		<0.3	<0.3	<0.3
Potassium	T-K		<2	<2	<2
Selenium	T-Se		<0.2	<0.2	<0.2
Silicon	T-Si		2.94	2.90	3.01
Silver	T-Ag		<0.01	<0.01	<0.01
Sodium	T-Na		2	2	2
Strontium	T-Sr		0.203	0.200	0.201
Thallium	T-Tl		<0.1	<0.1	<0.1
Tin	T-Sn		<0.03	<0.03	<0.03
Titanium	T-Ti		<0.01	<0.01	<0.01
Vanadium	T-V		<0.03	<0.03	<0.03
Zinc	T-Zn		<0.005	<0.005	<0.005

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water File No. J3376

		TP1	TP2	TP3	TP4	TP5
		98 03 16	98 03 16	98 03 16	98 03 16	98 03 16
Total Metals						
Aluminum	T-Al	<0.005	<0.005	<0.005	<0.005	<0.005
Antimony	T-Sb	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic	T-As	<0.2	<0.2	<0.2	<0.2	<0.2
Barium	T-Ba	0.06	0.06	0.06	0.06	0.06
Beryllium	T-Be	<0.005	<0.005	<0.005	<0.005	<0.005
Bismuth	T-Bi	<0.1	<0.1	<0.1	<0.1	<0.1
Boron	T-B	<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	<0.01	<0.01	<0.01	<0.01	<0.01
Calcium	T-Ca	38.5	38.3	37.7	38.6	38.9
Chromium	T-Cr	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	T-Co	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	T-Cu	<0.01	<0.01	<0.01	<0.01	<0.01
Iron	T-Fe	<0.03	<0.03	<0.03	<0.03	<0.03
Lead	T-Pb	<0.05	<0.05	<0.05	<0.05	<0.05
Lithium	T-Li	<0.01	<0.01	<0.01	<0.01	<0.01
Magnesium	T-Mg	11.3	11.3	11.1	11.3	11.3
Manganese	T-Mn	<0.005	<0.005	<0.005	0.006	<0.005
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	<0.03	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni	<0.02	<0.02	<0.02	<0.02	<0.02
Phosphorus	T-P	<0.3	<0.3	<0.3	<0.3	<0.3
Potassium	T-K	<2	<2	<2	<2	<2
Selenium	T-Se	<0.2	<0.2	<0.2	<0.2	<0.2
Silicon	T-Si	2.95	2.92	2.88	2.92	2.94
Silver	T-Ag	<0.01	<0.01	<0.01	<0.01	<0.01
Sodium	T-Na	2	2	2	2	2
Strontium	T-Sr	0.210	0.209	0.206	0.210	0.211
Thallium	T-Tl	<0.2	<0.2	<0.2	<0.2	<0.2
Tin	T-Sn	<0.03	<0.03	<0.03	<0.03	<0.03
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	<0.005	0.012	<0.005	<0.005	<0.005

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

RESULTS OF ANALYSIS - Water

File No. J3376

		TP6	TP7	KR1	KR2
		98 03 16	98 03 16	98 03 16	98 03 16
Total Metals					
Aluminum	T-Al	<0.005	<0.005	<0.005	<0.005
Antimony	T-Sb	<0.2	<0.2	<0.2	<0.2
Arsenic	T-As	<0.2	<0.2	<0.2	<0.2
Barium	T-Ba	0.06	0.06	0.06	0.06
Beryllium	T-Be	<0.005	<0.005	<0.005	<0.005
Bismuth	T-Bi	<0.1	<0.1	<0.1	<0.1
Boron	T-B	<0.1	<0.1	<0.1	<0.1
Cadmium	T-Cd	<0.01	<0.01	<0.01	<0.01
Calcium	T-Ca	38.3	38.6	38.3	36.7
Chromium	T-Cr	<0.01	<0.01	<0.01	<0.01
Cobalt	T-Co	<0.01	<0.01	<0.01	<0.01
Copper	T-Cu	<0.01	<0.01	<0.01	<0.01
Iron	T-Fe	<0.03	<0.03	<0.03	<0.03
Lead	T-Pb	<0.05	<0.05	<0.05	<0.05
Lithium	T-Li	<0.01	<0.01	<0.01	<0.01
Magnesium	T-Mg	11.2	11.3	11.1	10.6
Manganese	T-Mn	0.006	<0.005	0.005	0.006
Mercury	T-Hg	<0.00005	<0.00005	<0.00005	<0.00005
Molybdenum	T-Mo	<0.03	<0.03	<0.03	<0.03
Nickel	T-Ni	<0.02	<0.02	<0.02	<0.02
Phosphorus	T-P	<0.3	<0.3	<0.3	<0.3
Potassium	T-K	<2	<2	<2	<2
Selenium	T-Se	<0.2	<0.2	<0.2	<0.2
Silicon	T-Si	2.91	2.92	3.01	2.91
Silver	T-Ag	<0.01	<0.01	<0.01	<0.01
Sodium	T-Na	2	2	3	2
Strontium	T-Sr	0.208	0.209	0.212	0.204
Thallium	T-Tl	<0.2	<0.2	<0.2	<0.2
Tin	T-Sn	<0.03	<0.03	<0.03	<0.03
Titanium	T-Ti	<0.01	<0.01	<0.01	<0.01
Vanadium	T-V	<0.03	<0.03	<0.03	<0.03
Zinc	T-Zn	<0.005	<0.005	<0.005	<0.005

Results are expressed as milligrams per litre except where noted.
< = Less than the detection limit indicated.

Appendix 5: Water Quality Analyses Methodology

Appendix 5: Water Quality Analyses Methodology

Outlines of the methodologies utilized for the analysis of the samples submitted are as follows:

Metals in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion or filtration (EPA Method 3005), followed by instrumental analysis by atomic absorption spectrophotometry (EPA Method 7000), inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010), and/or inductively coupled plasma - mass spectrometry (EPA Method 6020).

Mercury in Water

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" 19th Edition 1995 published by the American Public Health Association. A cold-oxidation procedure involving bromine monochloride is used, followed by instrumental analysis by cold-vapour atomic absorption spectrophotometry (CVAAS).

End of Report

Appendix 6: <u>RE</u>circulation with <u>B</u>io<u>F</u>iltration (REBF) Module; Promotional Literature

Now
AQUACULTURISTS

You can totally control your aquaculture environment with superior **Water Recirculating Units** from AQUABIOTECH.

Designed to maintain extra high water quality these Water Recirculation Modules are ideal for research, Educational Laboratories and intensive fry and juvenile production.

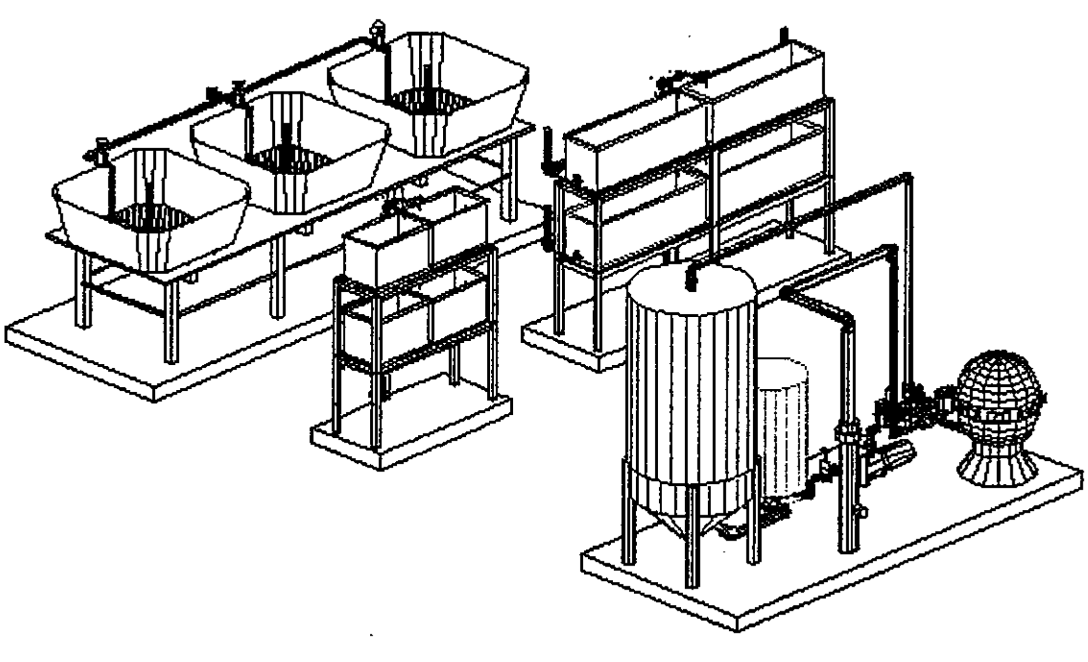
1. The REBF Module

The REBF Module for REcirculation with BioFiltration Module consists of all the equipment needed for recirculating and purifying 99.9% of a given volume of water (1 to 100 m^3). It includes:

- Trickling biofilter complete with :
  - active nitrifying bacteria ;
  - selected nutrients ;
  - comprehensive instructions for a reliable inoculation;
- High quality Sand Filters;
- Sediment traps that remove more than 90% solids right from the fish tanks ;
- Superior quality pump & associated plumbing, including:
  - Pressure-relief Valve ;
  - Oxygen Saturator ;
- Built-in Security Package (level switches, oxygen diffusers, etc.)
- Instruction manual providing advises and useful tips on :
  - general maintenance ;
  - raising healthy fish in closed systems ;
- Optional three consecutive days on site technical support to get you started on the right track ;
- A period of 5 hours of free consultation through our 888 number.

> *« Our company has raised Walleye in recirculated water for 5 years. This year we used a 7 m^3 REBF Unit to grow our larvae. I can assert without hesitation that we are very satisfied with this new tool. It is much superior in terms of performance and ease of maintenance to our previous system. Our water is of excellent quality, even when we add turbidity to the water. The high level of recirculation allows the water temperature to rise to 20 °C during the day, without any heating. »*
>
> **Marco Blanchet, P.D.G., Station Piscicole 3 Lacs, P.Québec, Canada.**

Figure 1: Smaller scale REBF Module with various fish tanks



2. Main advantages of the REBF

These modules are especially designed for larval and fingerling production. The designers have given the emphasis on water quality, so important during these tender stages. This REBF technology was tested for 4 years within Aquabiotech's pilot plant, rearing from 2 to 5 tons of healthy Atlantic salmon smolts yearly. Providing good management procedures, salmon fingerlings grow extremely well in these units and develop perfect fins.

A closer look at the unit reveals the following points :

Sediment-traps that remove 90% solids right from tanks.

When installed within smaller rearing tanks (1-2 m in diameter) this passive device concentrates and removes more than 90% feces and uneaten feeds in less than a minute. There is no need to flush this black water on a continuous basis ! You simply open a valve for about 10-20 seconds morning and evening. This device allows for a very high level of recirculation. About 50 liters of black water per tank is wasted to drain daily.

100% water is sand filtered to remove the fine solids

During first feeding, powdered feeds do not settle readily, and degrade rapidly. High in proteins, these fines represent a BOD load of approximately 50% by weight. If left within the circuit, these solids generate turbid water. They also increase the organic load within the biofilter. Bioreactors with a mixed function (i.e. removing solids and nitrification) will develop an important population of heterotrophic bacteria that feed on organic mater. Having a generation time of ≈20-30 minutes, these faster growing bacteria will gradually displace nitrifying bacteria (generation time : ≈ 24 hours), and eventually reduce the efficiency of nitrification at low concentrations[1]. Sand filtration, on the other hand, generates crystal-clear water. Our recirculated water qualifies as drinking water (Canadian Health Standards) in terms of color, turbidity and suspended matter.

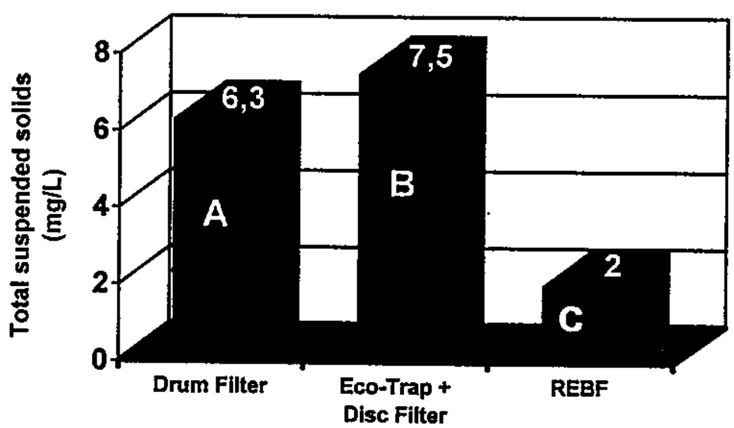


Figure 2: Suspended solid levels with the REBF in comparison with systems operating with various Drum Filters .

[1] Hélène Drouin, President of Aquabiotech, has done Ph.D. research (microbiology) on optimization of nitrification in biofilters for aquaculture.

Low operating and maintenance costs

Because REBF requires 100 times less water than a re-use water system operating at 90% recirculation (table 1), operating costs are very less.

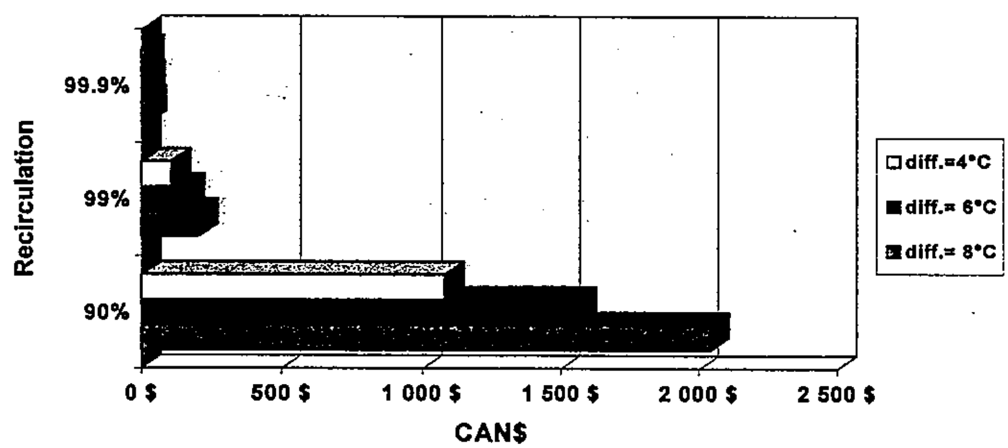
Table 1 : Effect of recirculation level (%) on the Water Residence Time in a 60 m^3 Unit.

Recirculation %	Make-up water per day (m^3)	Water Residence Time
0	2060	42 min
90	206	7 hours
99	20,6	2,9 days
99,9	2.1	29 days

- **Trivial heating and cooling costs**

  At 99.9% recirculation, generally no direct heating is required; the water simply circulates at about 1°C less than the ambient temperature. In most cases, the unit has to be cooled down with make-up water. Where sea-water is to be made, salt costs are reduced considerably. In the Laval University Laboratory (one of our client) where 30 m^3 of salt water is re-used, it was estimated that over $10,000 a month in salt costs are being saved with the REBF in comparison with a popular re-use water system on the market.

Figure 3: Monthly cost of heating 60 m3 of rearing water at 3 temperature differentials and recirculation levels



- **Easy-maintenance sand filter**

  The high efficiency sand filters selected for the REBF are designed for easy maintenance. Their Posi-lock™ system allows rapid and complete access to the sand for efficient cleaning. Depending on the feeding rate, backwash schedule will vary from once weekly to twice daily. A backwash requires about 2 minutes; you simply use gravity fed water right from your hatchery head tank ; there is no need to waste your system's water. The sand filter also comes with a pressure relieve valve that allows bypass flow when required.

- **Virtually no-maintenance biofilter**

  The large hydraulic load across our trickling bio-reactor keeps the bio-film thin and active for an efficient diffusion of ammonia and oxygen. It eliminates the need for back-washing.

- **No need to add an expensive oxygen diffusion device.**

The centrifugal pump provides the required head for the efficient diffusion of pure oxygen through our passive oxygen saturator.

Highly reliable system

Three safety elements :
- digital sensors for water level
- pressure relief valve
- automatic injection of pure oxygen within each tank in case of flow failure

« At the Laboratoire régional des sciences aquatiques (LARSA) of Laval University we provide facilities for researchers conducting fundamental and applied research in aquatic and marine science. We have operated 23 REBF Units for two years now.
The flexibility and reliability of these units allow us to reproduce the required conditions, whether they are optimal (typical of aquaculture environment) or extreme (in terms of temperature, pH, alkalinity, salinity or turbidity). We have always succeeded in maintaining these conditions with the required precision. ...Our water quality remains stable and excellent...These units require little maintenance and we appreciate the excellent technical support provided by the company Aquabiotech.»

Serge Higgins, Operation Manager, LARSA

A biofilter that removes excess CO_2 and picks up oxygen

Nitrification requires 4.5 mg O_2 for each mg of ammonia (NH_4). For a module receiving 12 kg of feed per day, the ammonia produced is approximately 380 g per day. This corresponds to an oxygen demand of 1.7 kg O_2 per day per biofilter. Because of our multi-functional trickling biofilter, there is no need to supply this oxygen. The bacteria will pick it up from the contact between air and the media, and the water will reach between 80 and 90% saturation at the biofilter's outlet. The bioreactor also acts as a very efficient degassing column, preventing CO_2 from accumulating within the system.

A readily performing bio-reactor upon its linkage to well-loaded fish tanks.

The unique method for biofilter inoculation you will learn is based upon extensive post-graduate research work. You will generate optimal conditions for growing nitrifying bacteria, and let them proliferate until the biofilter demonstrates it is ready to accept your predicted fish load. Once activated, the biofilter does not require the addition of sustaining bacteria, and keeps on maintaining excellent water quality for years on.

Table 2 : Water quality in various Water Recirculation Systems

	Striped bass	Tilapia	Trout	Tilapia	Trout	Atlantic Salmon (Aquabiotech)
% recirculation	unknown	unknown	91	unknown	90	99,8
System volume (m^3)	9	20	15	160	20	60
Nitrite (mg $N\text{-}NO_2$ / L)	0,52±0,32	1,62±1,1	0,02-0,12	0,7±1,3	0,04-0,21	0,11±0.04
Total ammonia (mg $N\text{-}NH_4$ / L)	0,80±0,52	0,62±0,37	0,5-1,5	1,3±1,9		0,28±0,08
CO_2 (mg / L)		>50	33		17-32	10,9±0,6

A : Easter & al., 1996 ; B : Twarowska, 1996 ; C : Honeyfield and Watten, 1996 ; D : DelosReyes and Malone, 1996 ; E : Heinen et al., 1996 ; F : Aquabiotech inc., 1996.

Excellent after-sales service

Beside providing general maintenance information, we will provide you with useful tips on how to :
- economically and safely control your pH without a pH controller ;
- safely apply prophylactic treatments on your fish in a closed system ;
- store and restart your biofilter

And, of course, we provide consulting service for planning your hatchery or laboratory, and adapt the REBF to your specific needs.

AQUABIOTECH - The Company and the Team

Of all Canadian firms specialising in re-used water systems, AQUABIOTECH is currently the only one to have validated a method for inoculating nitrifying biofilters for cold water culture. This method provides the required conditions for generating a readily performing bio-reactor upon its linkage to well-loaded fish tanks. AQUABIOTECH is staffed by a team of competent technicians and engineers led by Tony Pouliot, Ph.D. and Hélène Drouin, Ph.D candidate. Both Tony and Hélène are trained researchers; he is a specialist in fish nutrition and physiology, and she has done Ph.D. research in the microbiology of nitrification. They bring to the Company a solid background in intensive aquaculture, having had more than 15 years of experience in this field. The AQUABIOTECH installation consists of a 10,500 square feet pilot farm which includes wet and dry laboratories, a work shop, and a demonstration area.

Conclusion

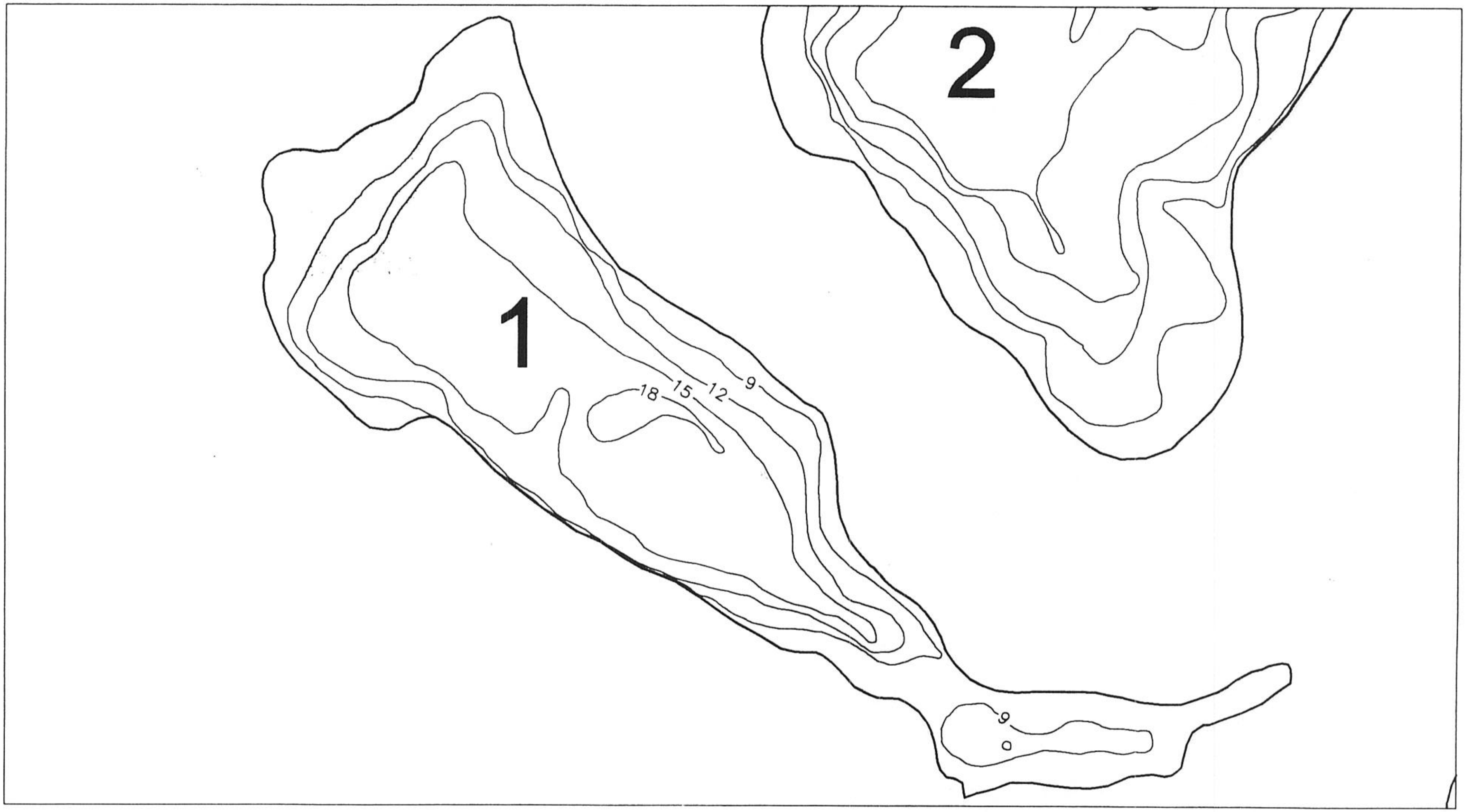
REBF is a cost-effective technology that provides :

- High quality water for the most sensitive stage of salmon culture ;
- A recirculation level (99,9%) that allows maximum operational economy with minimal maintenance ;
- A proven technology with an excellent technical support.

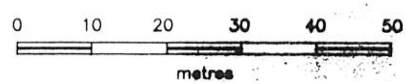
« For the past two years, I have used Aquabiotech's recirculated aquaculture systems at the Laval Univeristy's Aquatic Sciences Laboratory. Our work has involved the culture of warm and cool-water fish species at a variety of life stages-from egg incubation to adult fish rearing. I have found that these systems are easy to operate, provide an extremely stable environment for fish culture and require minimal maintenance. »

Grant Vandenberg BSc. Agr., MSc., PhD student
Dept of Animal Science, Université Laval

Appendix 7: Tailings Ponds Bathymetry; Tailings Ponds Site



Bathymetry isobaths in feet



KLONDIKE AREA CENTRAL INCUBATION OUTPLANT FACILITY POND 1 BATHYMETRY		
Duncan Contracting Dawson City, Yukon		
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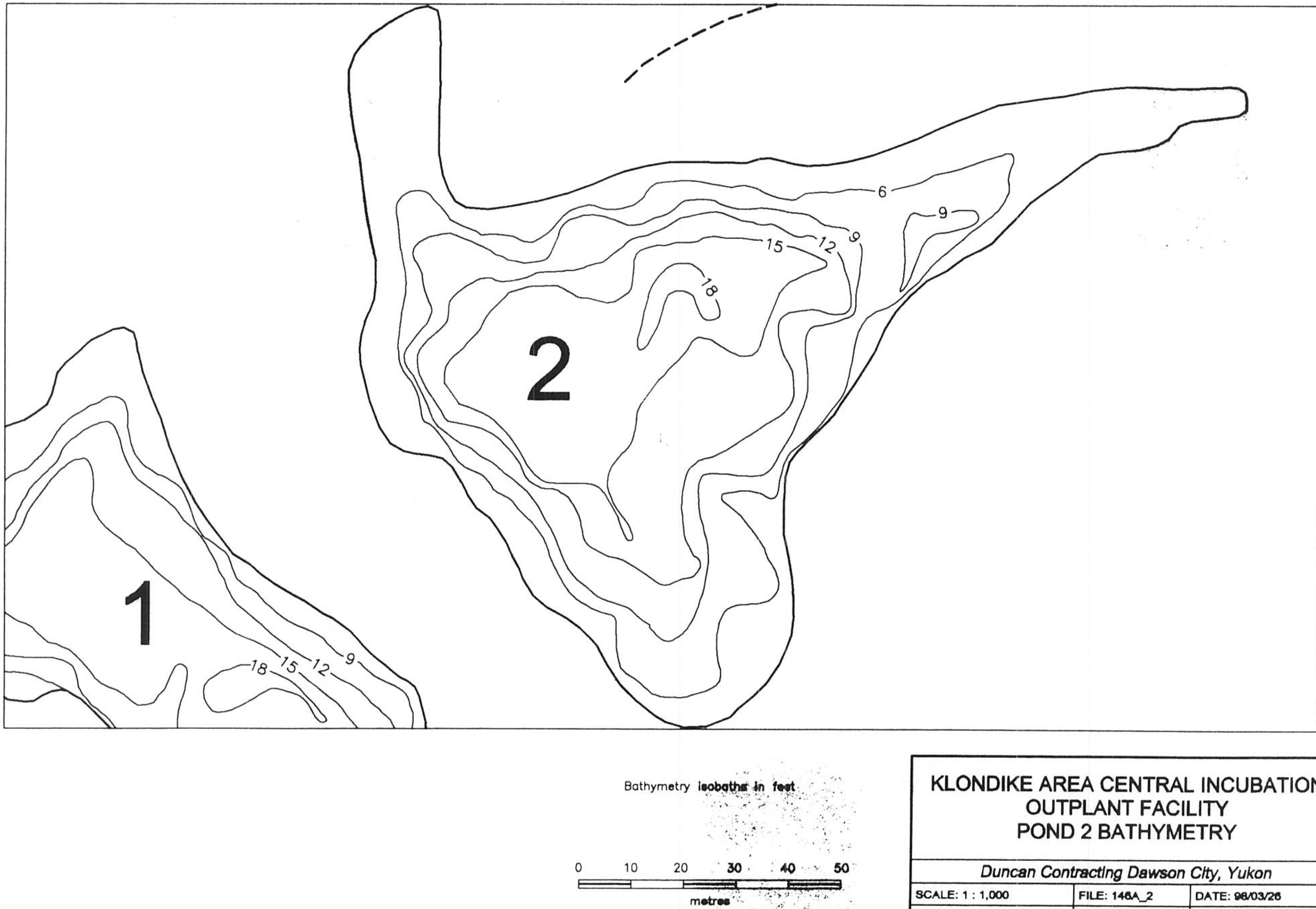
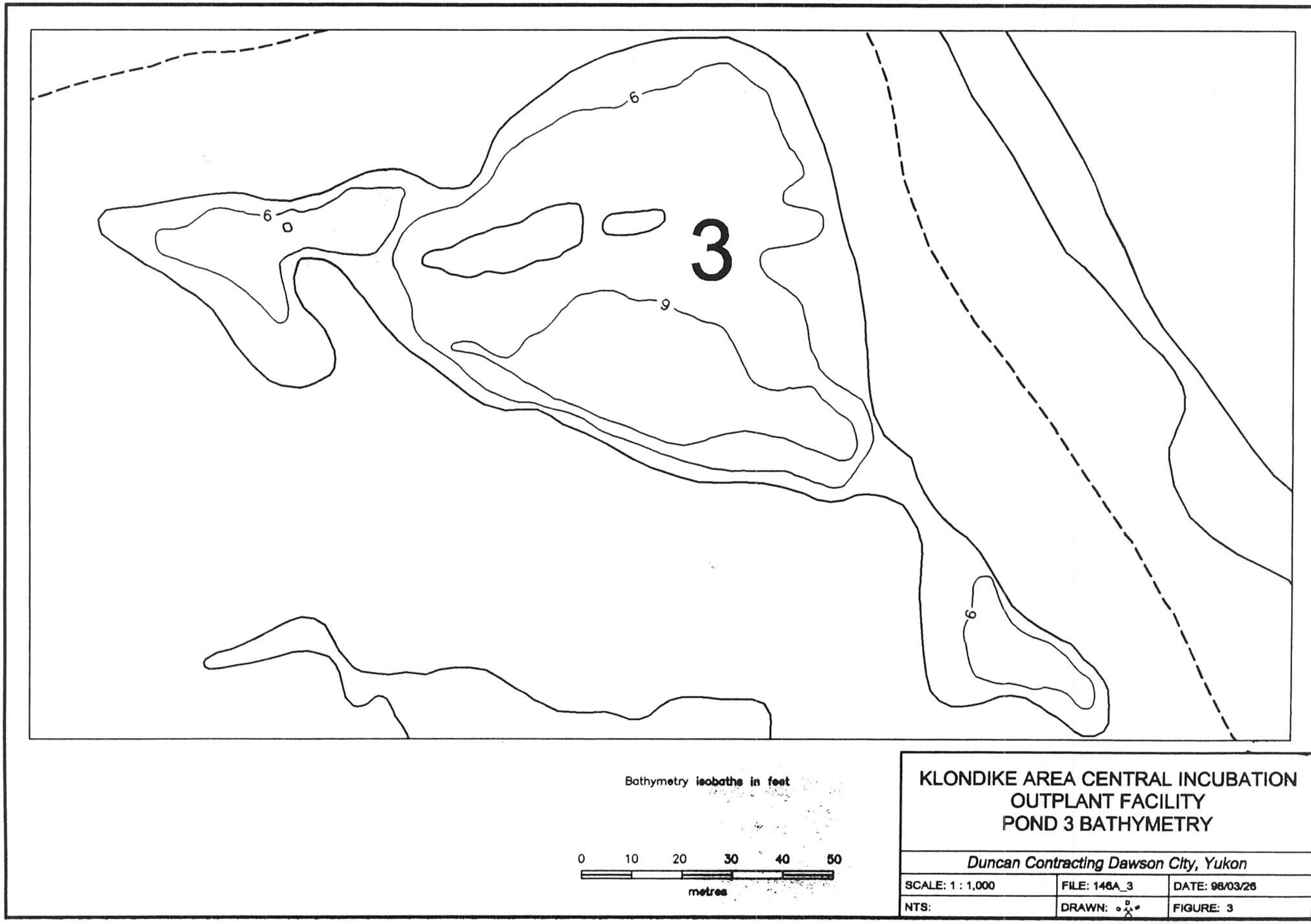
NTS:	DRAWN:	FIGURE: 1



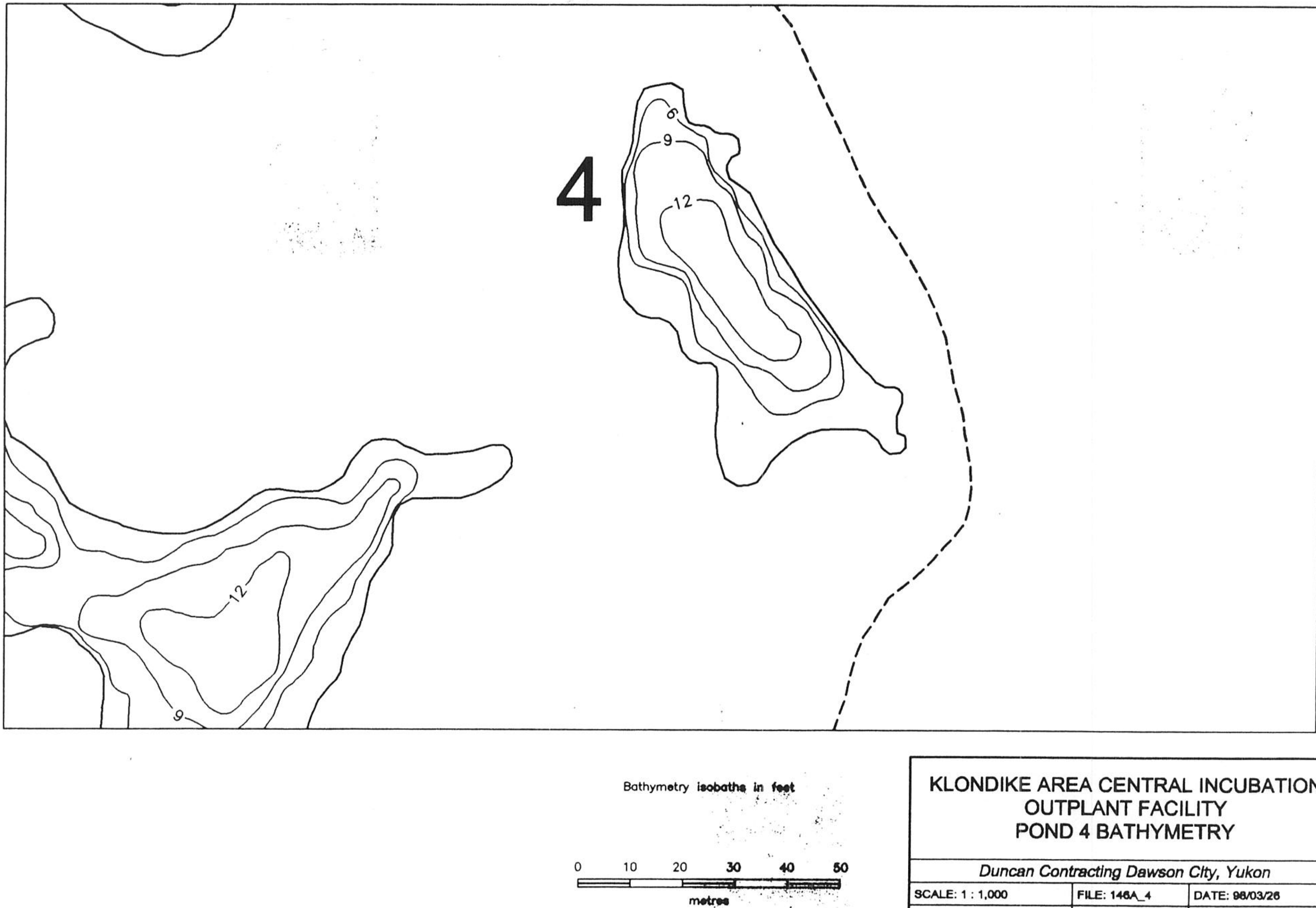
KLONDIKE AREA CENTRAL INCUBATION OUTPLANT FACILITY POND 2 BATHYMETRY

Duncan Contracting Dawson City, Yukon

SCALE: 1 : 1,000	FILE: 146A_2	DATE: 98/03/26
NTS:	DRAWN:	FIGURE: 2



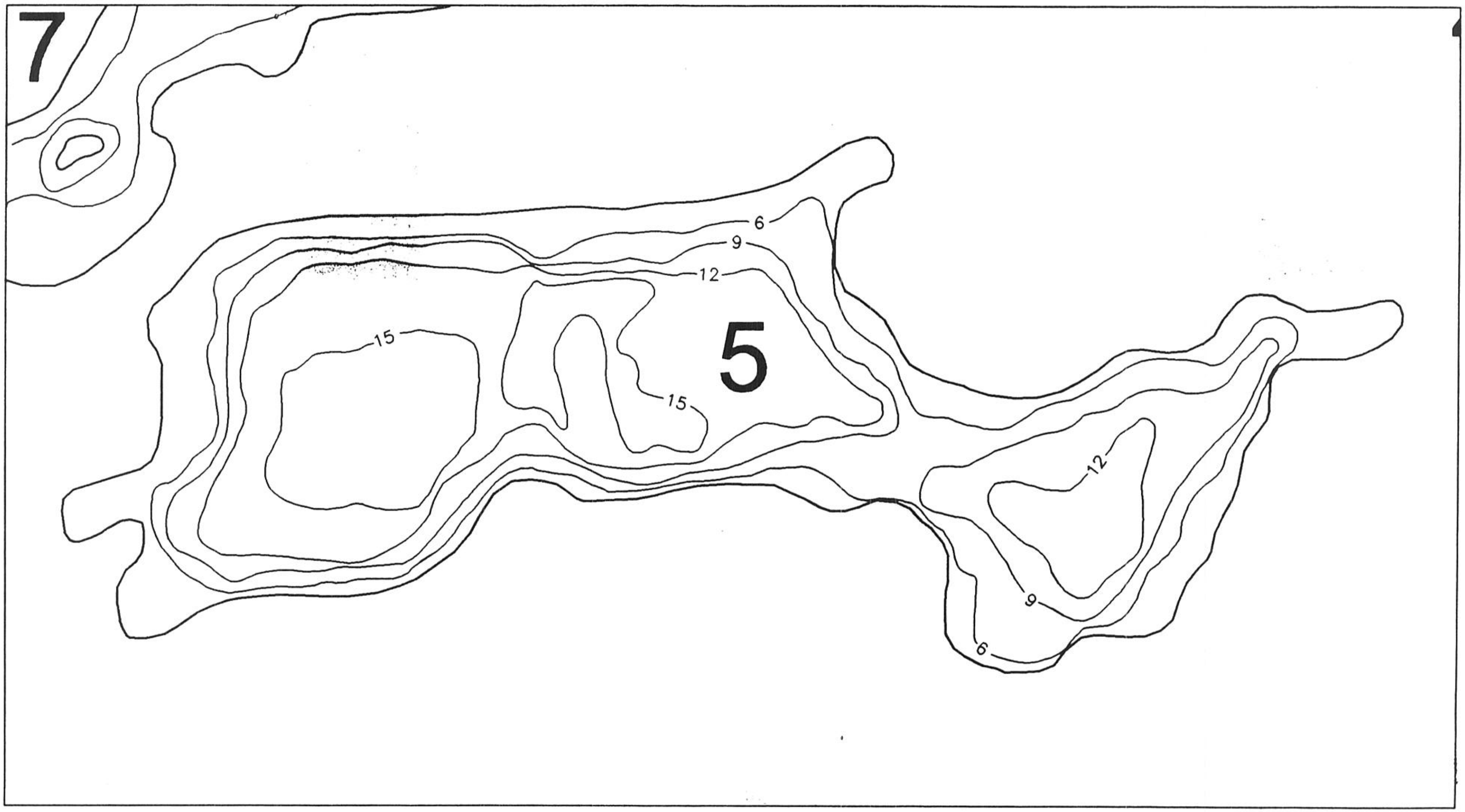
KLONDIKE AREA CENTRAL INCUBATION OUTPLANT FACILITY POND 3 BATHYMETRY		
Duncan Contracting Dawson City, Yukon		
SCALE: 1 : 1,000	FILE: 146A_3	DATE: 96/03/26
NTS:	DRAWN:	FIGURE: 3



KLONDIKE AREA CENTRAL INCUBATION
OUTPLANT FACILITY
POND 4 BATHYMETRY

Duncan Contracting Dawson City, Yukon

SCALE: 1 : 1,000	FILE: 146A_4	DATE: 98/03/26
NTS:	DRAWN:	FIGURE: 4



Bathymetry isobaths in feet

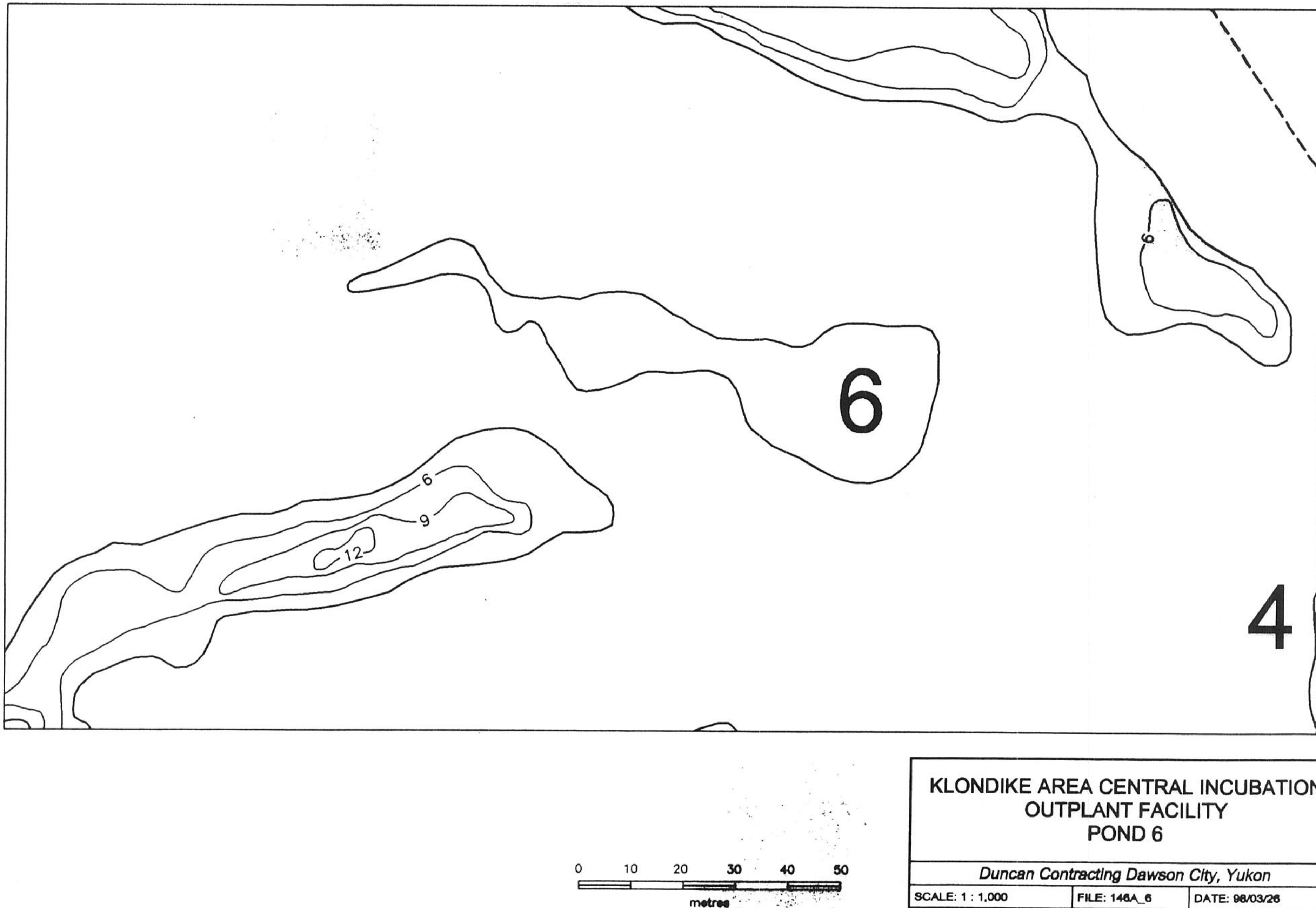
0 10 20 30 40 50

metres

KLONDIKE AREA CENTRAL INCUBATION OUTPLANT FACILITY
POND 5 BATHYMETRY

Duncan Contracting Dawson City, Yukon

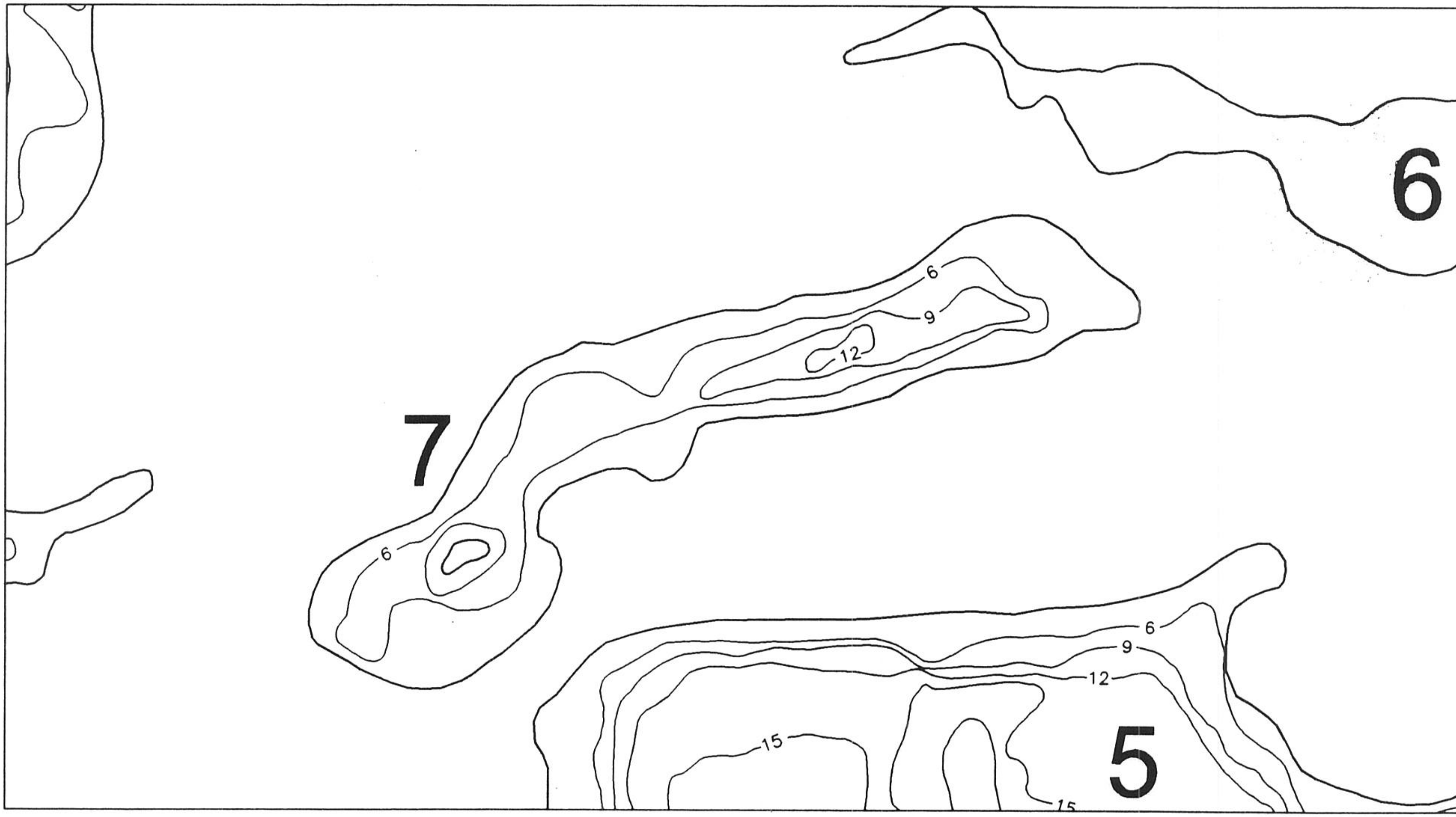
SCALE: 1 : 1,000	FILE: 146A_5	DATE: 98/03/26
NTS:	DRAWN:	FIGURE: 5



KLONDIKE AREA CENTRAL INCUBATION
OUTPLANT FACILITY
POND 6

Duncan Contracting Dawson City, Yukon

SCALE: 1 : 1,000	FILE: 146A_6	DATE: 96/03/26
NTS:	DRAWN:	FIGURE: 6



Bathymetry isobaths in feet

0 10 20 30 40 50
metres

KLONDIKE AREA CENTRAL INCUBATION OUTPLANT FACILITY POND 7 BATHYMETRY		
Duncan Contracting Dawson City, Yukon		
SCALE: 1 : 1,000	FILE: 146A_7	DATE: 98/03/26
NTS:	DRAWN:	FIGURE: 7

Appendix 8: Letter of Confirmation Re: Zoning of Potential Facility Site; Mr. Jim Kincaid, City Manager, Dawson City, Yukon

W. R. RICKS CONSULTING
BOX 5392
WHITEHORSE, YUKON Y1A 4Z2
PHONE/FAX: 867 633 5970

March 24, 1998

Mr. Jim Kincaid
City Manager, Dawson City
Box 308
Dawson City, Yukon
Y0B 1G0

Dear Sir:

As you are aware, there is currently a feasibility study underway which will involve the design of a chinook salmon incubation facility. This project is the result of a joint proposal by the Yukon River Commercial Fishing Association and the Tr'on dëk Hwech'in First Nation. Mr. Jake Duncan (Duncan Contracting) is the primary contractor for the project, and he has retained Mr. David Petkovich (DNA Enterprises) and myself to investigate the hatchery feasibility portion of the project. Of primary importance is the location of a suitable site for the facility. At the present time, the tailings ponds site we have previously discussed (see enclosed map) is still a contender, due to the availability, quality, and anticipated temperature of the water in the area.

We have discussed this situation previously on several occasions. I am writing now to clarify and comment on our conversation of Tuesday, March 17, regarding the zoning of the tailings ponds area that we have been discussing as the possible site

At your recommendation, I spoke with Mr. Ian Robertson of Inukshuk Planning and Development in Whitehorse, regarding the potential re-zoning of this site as part of the Thé Cho Residential Development Plan. However, I discovered that the area of interest to us just outside of the boundary of the Thé Cho Residential Development Plan, and therefore will not be subject to recommendations by Mr. Robertson regarding its zoning status.

According to Ms. Elizabeth Connellan of your office, the site in question is curently zoned Country Residential (CR).

Therefore, referring back to your initial discussion with Mr. David Petkovich in the fall of 1997, I am submitting this letter to formally and respectfully advise you that we are considering the tailings ponds area referred to herein as a possible site for construction and operation of a government funded, non-profit chinook salmon incubation and rearing facility for stock restoration and enhancement purposes. We feel that the presence and operation of this type of facility will benefit not only the salmon stock in the Dawson area, but may also provide the potential for a tourism/interpretive attraction.

We appreciate your support of this concept to date. We hope to be able to recommend a final site for this project in the latter part of this year, once that portion of feasibility study is completed. If you require additional information at this time, please contact me at your convenience.

Sincerely,

W. R. Ricks

cc/Dawson City Council
cc/Dawson City Mayor