THE 1989 SUMMER WATER TEMPERATURE AND FLOW MANAGEMENT PROJECT

NECHAKO FISHERIES CONSERVATION PROGRAM
Technical Report No. RM89-2

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Table of Contents

List of Figures

List of Tables

List of Appendices

ABSTRACT

The 1989 Nechako River Summer Water Temperature and Flow Management Project was undertaken to attempt to prevent mean daily water temperatures in the Nechako River above Stuart River (at Finmoore) from exceeding 20.0°C (68.0°F), and to control flows in the Nechako River below Cheslatta Falls and at Vanderhoof during the water temperature control period (July 20 to August 20).

In 1989, mean daily water temperatures in the Nechako River above Stuart River exceeded the temperature criterion on six days (July 28-August 1, and August 7) during the water temperature control period (July 20 to August 20), with a maximum mean daily temperature of 21.2°C (70.2°F), recorded on July 31. Prior to, and including July 28 the meteorological forecasts predicted cool conditions thus the Skins Lake Spillway release was maintained at 170 m^3/s (6,000 cfs). On July 29 the predicted water temperatures showed a substantial increase due to the meteorological forecast for the period. However, the temperature trends showed no potential to exceed 19.4°C (67.0°F). In recognition of the current instability in meteorological conditions, the Skins Lake Spillway release was increased to 453 m^3/s (16,000 cfs) as a conservative measure. The following day's forecast, July 30, predicted a cooling trend and in response to this forecast, the spillway release was reduced from 453 m^3/s (16,000 cfs) to 14.2 m^3/s (500 cfs). The forecasted conditions for July 31 predicted a warming trend to occur, and the spillway release was increased to 453 m^3/s (16,000 cfs) where it was maintained until August 2. On August 7 flow in the Nechako River below Cheslatta Falls was at or near the maximum allowable level of 283 m^3/s (10,000 cfs), and thus no further action could be taken.

Over the duration of the 1989 Summer Water Temperature and Flow Management Project, the total volume of water released was 8,255.2 m^3/s-d (291,532 cfs-d). The volume released for cooling purposes was 6,251.8 m^3/s-d (220,782 cfs-d). The average flow over the operational period (July 10 to August 20) was 196.6 m^3/s (6,943 cfs).

INTRODUCTION

Control of the Nechako River water temperature for protection of fish resources is a concern of both government agencies and Alcan Smelters and Chemicals Ltd. Each summer between 1981 and 1984, Alcan, Triton Environmental Consultants Ltd. (formerly Envirocon Pacific Ltd.), and the Department of Fisheries and Oceans (DFO) undertook a joint water temperature monitoring and control project. In 1985, no water temperature monitoring and control project was implemented as Alcan maintained a constant Skins Lake Spillway release of 283 m^3/s (10,000 cfs) providing the maximum allowable flow in the Nechako River below Cheslatta Falls for the entire period of concern. In 1986 and 1987, Triton Environmental Consultants Ltd. (Triton), on behalf of Alcan, carried out an independent water temperature and flow management project similar to the one used during the summer of 1984 (Envirocon 1985). Since 1988, Triton has carried out an analogous water temperature and flow management project (Triton 1995) under the auspices of the Nechako Fisheries Conservation Program (NFCP).

The Nechako River Summer Water Temperature and Flow Management Project currently being used was designed and developed by Triton in 1982 and has been successfully implemented by Triton since 1983. The project is comprised of an operational period (July 10 to August 20), a water temperature control period (July 20 to August 20), and a flow control period (July 10 to September 6). The objectives of the Summer Water Temperature and Flow Management Project are to attempt to prevent water temperatures in the Nechako River above the Stuart River confluence from exceeding 20.0°C (68.0°F) during the water temperature control period, and to control flows in the Nechako River below Cheslatta Falls and at

Vanderhoof during the flow control period. The latter objective includes reducing the flow in the Nechako River below Cheslatta Falls to the chinook salmon spawning flow by September 6.

The study area included in the Summer Water Temperature and Flow Management Project is shown in Figure 1. Unless otherwise stated, the location of the Nechako River above Stuart River refers to the Nechako River at Finmoore.

This report reviews the 1989 Summer Water Temperature and Flow Management Project and includes an outline of Triton's method of determining Skins Lake Spillway releases, a summary of Triton's 1989 Skins Lake Spillway release recommendations for the period July 10 to September 6 inclusive, and a summary of observed flows (July 10 to September 6) and water temperatures (July 10 to August 20) at various locations along the Nechako River. Also discussed is the volume of cooling water used in the 1989 Summer Water Temperature and Flow Management Project.

METHODS

Management of the Nechako River flows and water temperatures was accomplished using water temperature predictions based on five-day meteorological forecasts to determine scheduling of Skins Lake Spillway releases required to meet project objectives. The Summer Water Temperature and Flow Management Project is a computer based project utilizing an unsteady-state flow routing model and an unsteady-state water temperature prediction model designed to compute the conditions in the Nechako River defined by the nature of the meteorological conditions. Mathematical modelling of flows and water temperatures in the Nechako River was performed daily during the period July 10 to August 20, inclusive.

Daily operations followed the protocol defined in the Settlement Agreement (Anon. 1987), and involved collection of water temperature and river stage data from several locations in the study area, and development of five-day meteorological forecasts. Water temperatures were obtained daily from recorders maintained in the Nechako River below Cheslatta Falls (at Bert Irvine's Lodge), in the Nechako River at Fort Fraser (upstream of Nautley River), in the Nechako River above Stuart River and in the Nautley River. River stages were obtained daily from recorders maintained in the Nechako River below Cheslatta Falls, in the Nechako River at Vanderhoof and from a staff gauge in the Nautley River. Five-day meteorological forecasts were obtained from Meteorological and Environmental Planning Ltd. (MEP), a subconsultant to Triton.

River stage and minimum and maximum water temperature data were obtained daily by Triton (staff member resident in Vanderhoof) for each location identified except the Nechako River below Cheslatta Falls. Each morning, hourly water temperature and river stage data recorded by the data collection platform located at Nechako River below Cheslatta Falls were obtained via computer link to Water Survey of Canada (WSC), Vancouver. In addition, spot and corresponding recorded water temperatures were collected at each location during these daily site visits and used to adjust the recorded water temperatures. Adjustment was included to provide an ongoing check of each thermograph, and was performed in the following manner. If the spot temperature was higher than the thermograph record, the thermograph record was adjusted to agree with the observed spot temperature for that day. If the thermograph record was higher than the spot temperature, the thermograph record was not adjusted. This procedure was implemented as a conservative measure.

Skins Lake Spillway releases documented in this report are the releases requested by Triton. All Nechako River and Nautley River flow data documented in this report are preliminary data. The values presented are part of the database utilized in the daily operation of the Summer Water Temperature and Flow Management Project. These data have not been updated as it is the preliminary data that was used in real-time modelling of the Nechako River system. Therefore, values presented in this report may differ slightly from those reported by WSC.

The first 10 days of the operational period, July 10 to July 19, are utilized for system start up, for initialization of the data base required to schedule Skins Lake Spillway releases necessary to meet project water temperature objectives during the control period commencing July 20, and for increase of the flows in the Nechako River from spring flows to the minimum cooling flow of 170 m^3/s (6,000 cfs) required below Cheslatta Falls. The 1989 Skins Lake Spillway spring

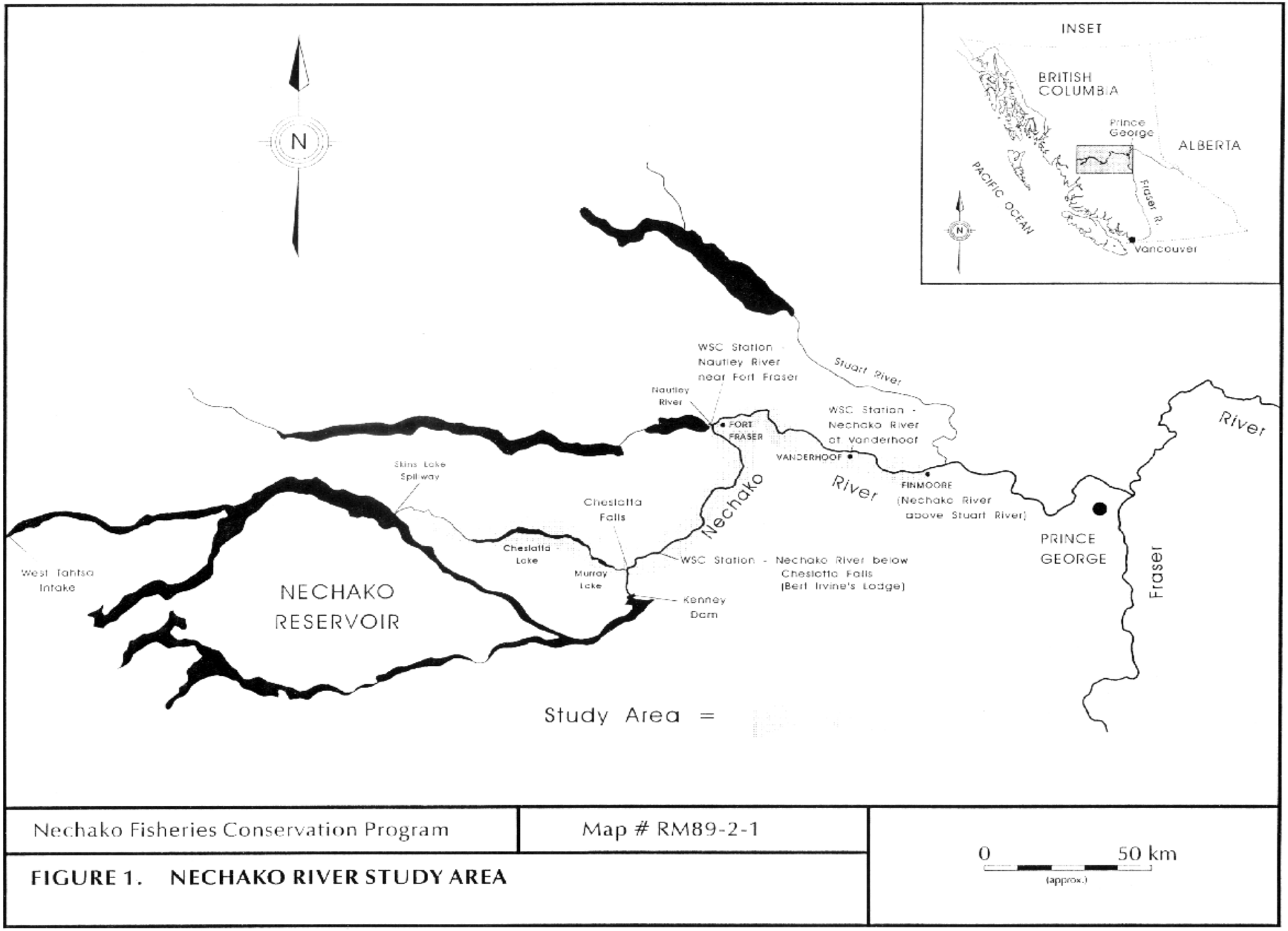


FIGURE 1. NECHAKO RIVER STUDY AREA

base release as determined by NFCP was 47.7 m³/s (1,685 cfs). Upon commencement of the operational period on July 10, the observed flow in the Nechako River below Cheslatta Falls was unavailable. The observed flow on July 11 was 47.9 m³/s (1,692 cfs). On July 11, 1989, the Skins Lake Spillway release was increased from the spring base release to 227 m³/s (8,000 cfs) to ensure flows in the Nechako River below Cheslatta Falls reached the minimum cooling flow of 170 m³/s (6,000 cfs) by July 20 (the beginning of the water temperature control period).

Throughout the operational period of the project, water temperatures in the Nechako River were calculated daily for the previous day, the current day and each of the next 4 days. These calculations were based on observed and five-day forecast meteorological data, observed water temperature and computed flow data. Forecast water temperature predictions were tabulated and reviewed daily to identify trends in water temperature changes. These trends are the same as those used in the water temperature and flow management projects since 1984 (Envirocon Ltd. 1985), and are best explained through reference to Table 1. Assuming the current day is July 16, entries corresponding to the current day's operation are represented by the letter c. Entries co and cs represent the observed and calculated water temperatures, respectively, for

Table 1
Daily Operations to Manage Water Temperatures in the Nechako River above Stuart River

Date	11-Jul	12-Jul	13-Jul	14-Jul	15-Jul	16-Jul*	17-Jul	18-Jul	19-Jul	20-Jul
Fifth Day's Predicted Water Temperature @ Date + 4 Days								a5	b5	c5
Fourth Day's Predicted Water Temperature @ Date + 3 Days							a4	b4	c4	
Third Day's Predicted Water Temperature @ Date + 2 Days						a3	b3	c3		
Second Day's Predicted Water Temperature @ Date + 1 Day					a2	b2	c2			
Current Day's Predicted Water Temperature @ Date				a1	b1	c1				
Previous Day's Calculated Water Temperature @ Date - 1 Day			as	bs	cs					
Previous Day's Observed Water Temperature @ Date - 1 Day			ao	bo	co					
Current Day's Release @ Date				ra	rb	rc				

observed trend
predicted trend
forecast trend

* The current day (e.g., the day of operation) for this example is July 16.

the previous day (July 15). Entries c1 through c5 represent predicted water temperatures computed using the current day's five-day meteorological forecast and an assumed current day's flow regime. The entry rc represents the current day Skins Lake Spillway release required to meet project objectives.

The following three trends in water temperature changes were reviewed on a day-by-day basis:

1. Observed trend; developed from observed mean daily water temperatures measured in the Nechako River above Stuart River each day (bo and co in Table 1). The difference in observed water temperatures for the previous two days is extrapolated over the next 5 days to determine the observed water temperature trend.
2. Predicted trend; developed from the predicted water temperatures for the previous day and the following five days (cs,c1,c2,c3,c4,c5, in Table 1). These data represent the predicted trend.
3. Forecast trend; developed from the difference between the current five-day and previous five-day predictions for the same calendar days (c3 and b4, c2 and b3, c1 and b2 in Table 1). Differences between forecasted data on coincident dates for the next 3 days only are averaged and added to the 5th day predicted temperature to determine the trend in forecasted temperatures.

A numerical example of how the trends are calculated is presented in Appendix A.

Each day predicted water temperatures for the five-day forecast period were checked and the three trends were calculated. If two of the three trends indicated that the water temperature in the Nechako River above Stuart River could potentially exceed 19.4°C (67.0°F) then an increase in the Skins Lake Spillway release was required. When this occurred the current day's release was revised and the flow and temperature models were rerun using the modified flow regime. Results of each day's final computer run were subsequently used to initialize water temperatures for the following day's computations. Entries in Table 1 represent each day's final cooling water release and resultant predicted water temperatures.

The following release criteria were used with the three trends identified above to determine the timing and magnitude of Skins Lake Spillway releases:

1. When two of the three trends show an increase in water temperature in the Nechako River above Stuart River, and these trends show that potentially the water temperature could exceed 19.4°C (67.0°F), increase the Skins Lake Spillway release according to criteria 2 and 3 below.
2. Operate Skins Lake Spillway such that flow in the Nechako River below Cheslatta Falls ranges between 170 m^3/s (6,000 cfs) and 283 m^3/s (10,000 cfs) as required, and flow in the Nechako River above Stuart River does not exceed 340 m^3/s (12,000 cfs). It is understood that the flow in the Nechako River below Cheslatta Falls is to be not less than 170 m^3/s (6,000 cfs) by July 20, and is to be reduced to approximately 31.2 m^3/s (1,100 cfs) by September 6.
3. At any time of release, increase Skins Lake Spillway from the current level to 453 m^3/s (16,000 cfs) directly to achieve the flow changes in the Nechako River as fast as possible.
4. During cooling periods when two of three trends in forecasted water temperatures are decreasing and these trends indicate that potentially the water temperature could drop below 19.4°C (67.0°F) within the forecast period (5 days), reduce the Skins Lake Spillway release from the current level to 14.2 m^3/s (500 cfs).

RESULTS

Predicted and observed mean daily water temperatures for the Nechako River above Stuart River, Skins Lake Spillway releases and changes in Skins Lake Spillway releases over the duration of the project operational period (July 10 to August 20) are summarized in Table 2.

Observed mean daily water temperatures in the Nechako River above Stuart River are tabulated in Table 3 and plotted in Figure 2. The maximum observed mean daily water temperature recorded dur-

Table 2
Predicted and Observed Mean Daily Water Temperatures in the Nechako River above Stuart River, July to to August 20, 1989

	JULY																					
Date	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
5th Day's Predicted Water Temperature at Date + 4 Days					19.8	20.7	19.8	19.7	20.1	19.5	19.5	18.7	18.8	18.5	18.8	18.8	18.8	18.4	18.4	18.4	18.3	18.3
4th Day's Predicted Water Temperature at Date + 3 Days				19.8	20.9	20.0	20.2	20.3	19.6	19.6	18.7	18.8	18.7	18.6	18.4	18.5	18.6	19.0	19.4	18.7	18.4	18.1
3rd Day's Predicted Water Temperature at Date + 2 Days			19.3	20.8	19.8	20.9	20.9	20.2	19.6	18.6	19.0	19.2	18.8	17.9	18.0	18.0	18.9	19.9	19.5	19.0	18.6	19.1
2nd Day's Predicted Water Temperature at Date + 1 Day		18.4	20.5	19.3	21.3	21.5	21.0	20.1	18.8	19.3	19.5	19.1	17.5	17.7	17.2	18.0	19.5	20.1	19.4	19.2	19.6	20.1
Current Day's Predicted Water Temperature at Date	17.3	19.4	19.3	20.9	21.6	21.3	21.1	19.8	20.1	19.7	19.3	18.3	17.8	17.4	17.3	18.6	19.9	20.1	19.9	20.2	20.5	21.2
Previous Day's Calculated Water Temperature at Date - 1 Day	17.3	19.1	19.9	21.1	21.5	21.2	21.0	20.4	20.2	19.7	19.0	18.3	18.0	17.4	17.6	18.6	19.9	20.2	20.3	20.5	20.7	21.3
Previous Day's Observed Water Temperature at Date - 1 Day	**N/A**	**17.8**	**19.7**	**19.7**	**20.3**	**20.4**	**20.3**	**20.2**	**19.4**	**19.1**	**19.2**	**18.9**	**18.2**	**17.9**	**17.2**	**18.3**	**18.8**	**19.4**	**20.3**	**20.1**	**20.3**	**21.2**
Current Day's Skins Lake Spillway Release at Date (m^3/s)	47.7	47.7 to 227 @ 1600 hrs	227	227	227 to 453 @ 1600 hrs	453	453	453 to 14.2 @ 1300 hrs	14.2 to 453 @ 1600 hrs	453 to 14.2 @ 1500 hrs	14.2	14.2 to 170 @ 2145 hrs	170	170	170	170	170	170	170	170 to 453 @ 1600 hrs	453 to 14.2 @ 1600 hrs	14.2 to 453 @ 1600 hrs

Table 2 (Continued)
Predicted and Observed Mean Daily Water Temperatures in the Nechako River above Stuart River, July 10 to August 20, 1989

	AUGUST																			
Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
5th Day's Predicted Water Temperature at Date + 4 Days	18.0	18.3	18.4	19.6	19.1	18.8	19.0	19.5	19.6	19.7	19.4	18.9	18.9	18.7	18.2	18.6	18.2	18.5	19.1	19.0
4th Day's Predicted Water Temperature at Date + 3 Days	18.5	18.4	19.6	19.2	18.8	18.9	19.6	20.2	20.1	19.6	18.7	18.4	18.3	18.1	18.6	17.7	17.6	18.4	18.9	19.3
3rd Day's Predicted Water Temperature at Date + 2 Days	19.2	20.1	19.5	18.7	18.8	19.6	20.4	20.5	20.0	19.2	18.4	18.0	18.0	18.6	18.4	17.2	17.4	18.7	19.5	19.5
2nd Day's Predicted Water Temperature at Date + 1 Day	20.9	20.0	18.7	18.8	19.5	20.0	20.5	20.3	19.8	19.0	18.0	17.8	18.6	19.4	18.0	17.3	18.5	19.7	19.9	
Current Day's Predicted Water Temperature at Date	21.2	19.7	19.1	19.4	19.6	20.3	20.5	20.3	19.8	18.5	18.1	18.5	19.6	19.1	18.2	18.5	19.6	19.8		
Previous Day's Calculated Water Temperature at Date - 1 Day	21.2	19.6	19.2	19.4	19.8	20.3	20.6	20.3	19.5	18.6	18.3	18.9	19.4	19.1	18.4	18.9	19.7			
Previous Day's Observed Water Temperature at Date - 1 Day	**20.7**	**19.8**	**19.2**	**19.1**	**19.4**	**19.8**	**20.2**	**20.0**	**19.4**	**18.5**	**18.3**	**18.7**	**19.4**	**18.9**	**18.6**	**18.8**	**18.9**	**19.4**	**19.4**	**18.8**
Current Day's Skins Lake Spillway Release at Date (m^3/s)	453	453 to 14.2 @ 1600 hrs	14.2	14.2 to 453 @ 1545 hrs	453	453 to 283 @ 1600 hrs	283	283 to 14.2 @ 1600 hrs	14.2	14.2	14.2 to 170 @ 1600 hrs	170	170	170	170	170	170 to 453 @ 1600 hrs	453 to 170 @ 1420 hrs	14.2	14.2 to 0 @ 1400 hrs

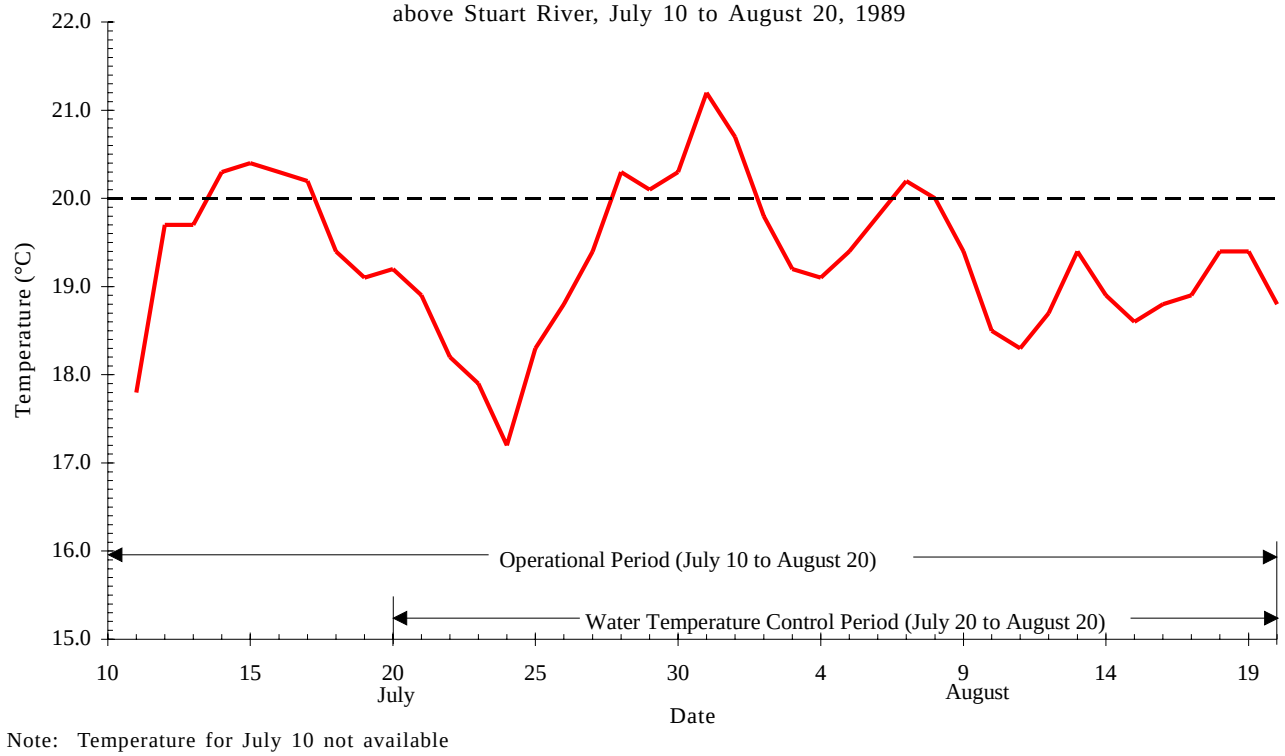
Note: Observed temperature not available for July 10

Table 3
Observed Mean Daily Water Temperatures in the Nechako River above Stuart River, July 10 to August 20, 1989

Date	Water Temperature (°C)	Date	Water Temperature (°C)
10-Jul	N/A	1-Aug	20.7
11-Jul	17.8	2-Aug	19.8
12-Jul	19.7	3-Aug	19.2
13-Jul	19.7	4-Aug	19.1
14-Jul	20.3	5-Aug	19.4
15-Jul	20.4	6-Aug	19.8
16-Jul	20.3	7-Aug	20.2
17-Jul	20.2	8-Aug	20.0
18-Jul	19.4	9-Aug	19.4
19-Jul	19.1	10-Aug	18.5
20-Jul	19.2	11-Aug	18.3
21-Jul	18.9	12-Aug	18.7
22-Jul	18.2	13-Aug	19.4
23-Jul	17.9	14-Aug	18.9
24-Jul	17.2	15-Aug	18.6
25-Jul	18.3	16-Aug	18.8
26-Jul	18.8	17-Aug	18.9
27-Jul	19.4	18-Aug	19.4
28-Jul	20.3	19-Aug	19.4
29-Jul	20.1	20-Aug	18.8
30-Jul	20.3		
31-Jul	21.2		

Note: Temperature for July 10 not available

Figure 2
Observed Mean Daily Temperatures in the Nechako River
above Stuart River, July 10 to August 20, 1989



Note: Temperature for July 10 not available

ing the control period (July 20 to August 20) was recorded as 21.2°C (70.2°F) on July 31. This was also the maximum observed mean daily water temperature recorded during the operational period (July 10 to August 20). The minimum observed mean daily water temperature recorded during the control period (July 20 to August 20) was recorded as 17.2°C (63.0°F) on July 24. This was also the minimum observed mean daily water temperature recorded during the operational period (July 10 to August 20). A summary of mean daily water temperatures recorded in the Nechako River below Cheslatta Falls, near Fort Fraser and above Stuart River, and in the Nautley River near Fort Fraser (July 10 to August 20) is presented in Appendix B.

As outlined in *Methods*, during the water temperature control period Skins Lake Spillway releases required for water temperature control were to be such that flows in the Nechako River below Cheslatta Falls were to range between 170 m^3/s (6,000 cfs) and 283 m^3/s (10,000 cfs) and flows at Vanderhoof were not to exceed 340 m^3/s (12,000 cfs).

Skins Lake Spillway releases and corresponding flows in the Nechako River below Cheslatta Falls and at Vanderhoof are plotted in Figure 3. Daily Skins Lake Spillway releases, Nautley River flows and flows in the Nechako River below Cheslatta Falls and at Vanderhoof are tabulated in Appendix C. A day-by-day record of Triton's Skins Lake Spillway release recommendations and the reasoning behind them is presented in Table 4.

During the water temperature control period, measured flows in the Nechako River below Cheslatta Falls (based on preliminary WSC data from the WSC data collection platform at Bert Irvine's Lodge) ranged between a maximum of 284 m^3/s (10,029 cfs) on August 8 and a minimum of 174 m^3/s (6,145 cfs) on July 23. Flows measured in the Nechako River at Vanderhoof ranged between a maximum of 317 m^3/s (11,195 cfs) on August 9 and a minimum of 210 m^3/s (7,416 cfs) on August 18. Following the water temperature control period, the mean daily flow in the Nechako River below Cheslatta Falls was reduced to 41.8 m^3/s (1,476 cfs) by September 6. The recorded maximum mean daily flow in the Nechako River below Cheslatta Falls exceeded the previously stated limits for flood control by 0.29%.

DISCUSSION

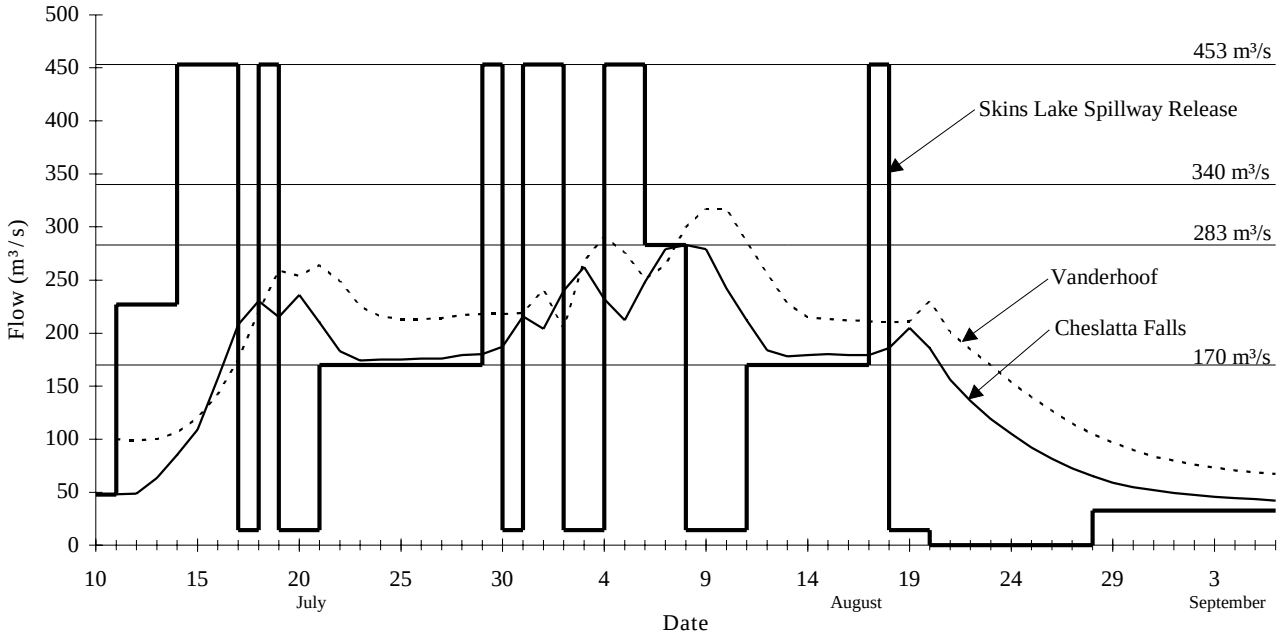
Decision criteria used to determine Skins Lake Spillway releases during the 1989 Summer Water Temperature and Flow Management Project were identical to those used during summer water temperature and flow management projects since 1984. Discussion of the 1989 Summer Water Temperature and Flow Management Project has been divided into four sections. The first section reviews the collection and use of observed field data. Types of data include water temperature, flow, and meteorological data (observed and forecast). The second section discusses occurrences of mean daily water temperatures in excess of 20.0°C (68.0°F) in the Nechako River above Stuart River. The third section discusses the volume of water used during the 1989 Summer Water Temperature and Flow Management Project. The fourth section discusses instances when judgment was exercised (based on experience gained in previous years' operation of the Summer Water Temperature and Flow Management Project) during the application of the release criteria.

Observed Data

Triton's modelling procedure is based on the premise that the best way to forecast water temperatures is to initialize computations with observed conditions. For this reason, the quality of the field data used in the modelling process directly affects the accuracy of the computed water temperatures. Therefore, data must be collected accurately and consistently to ensure that random errors are kept to a minimum. Consistency in data collection techniques will ensure any systematic errors maintain a constant bias throughout the project.

In 1989, flow data obtained from gauging stations in the Nechako River below Cheslatta Falls, in the Nechako River at Vanderhoof and in the Nautley River near Fort Fraser appeared to be of a reasonable quality. Changes in flows in the Nechako River below Cheslatta Falls and in the Nechako River at Vanderhoof responded as expected in response to changes in Skins Lake Spillway releases. The Nautley River flow regime was typical for the time of year. The ability to obtain hourly stage data from the gauging station located in the Nechako River below Cheslatta Falls proved very useful in verifying the daily predictions of the flow model and accounting for changes in the local inflow to the Cheslatta/ Murray Lakes system.

Figure 3
Skins Lake Spillway Releases and Flows in the Nechako River below Cheslatta Falls and at Vanderhoof, July 10 to September 6, 1989



Note: Flows for Nechako River below Cheslatta Falls and at Vanderhoof not available for July 10

Table 4
Rationale for Skins Lake Spillway Release Changes, July 10 to September 6, 1989

Date 1989	Old Setting (m^3/s)	New Setting (m^3/s)	Time of Change (hrs)	Reason for Changing SLS Release Setting
11-Jul	47.7	227	1600	To ensure base flow of 170 m^3/s below Cheslatta Falls by July 20
14-Jul	227	453	1600	In response to a predicted warming trend
17-Jul	453	14.2	1300	In response to a predicted cooling trend
18-Jul	14.2	453	1600	In response to a predicted warming trend
19-Jul	453	14.2	1500	In response to a predicted cooling trend
21-Jul	14.2	170	2145	To maintain base flows of 170 m^3/s
29-Jul	170	453	1600	In response to a predicted warming trend
30-Jul	453	14.2	1600	In response to a predicted cooling trend
31-Jul	14.2	453	1600	In response to a predicted warming trend
2-Aug	453	14.2	1600	In response to a predicted cooling trend
4-Aug	14.2	453	1545	In response to a predicted warming trend
6-Aug	453	283	1600	To maintain base flows of 170 m^3/s
8-Aug	283	14.2	1600	In response to a predicted cooling trend
11-Aug	14.2	170	1600	To maintain base flows of 170 m^3/s
17-Aug	170	453	1600	In response to a predicted warming trend
18-Aug	453	14.2	1420	In response to a predicted cooling trend
20-Aug	14.2	0	1400	To permit engineering and geological surveys of the plunge pool below Skins Lake Spillway.
28-Aug	0	32.6	1600	To achieve spawning flow in Nechako River below Cheslatta Falls by September 6.

As stated previously, spot and corresponding recorder (thermograph) water temperatures were collected in the Nechako River at Fort Fraser (upstream of the Nautley River), in the Nechako River above Stuart River and in the Nautley River during each site visit. The thermograph water temperatures were not consistently higher or lower than their associated spot temperatures. These data were used in adjustment of water temperatures and the method applied is that outlined previously.

Observed and forecast meteorological data were obtained daily from Meteorological and Environmental Planning Ltd. (MEP), a subconsultant to Triton. Forecast weather data obtained from MEP was developed using observed weather data from the Atmospheric Environmental Service (AES) station at Prince George Airport and from the meteorological monitoring station installed by Triton at Fort Fraser. The observed and forecast weather data received from MEP was used to estimate water temperatures in the Nechako River below Cheslatta Falls and in the Nautley River for the previous day, current day, and following four days. A listing of the observed and forecast meteorological data is provided in Appendix D. The accuracy of the forecast meteorological data has a direct effect on the accuracy of the forecast river water temperatures.

Occurrences of Water Temperatures in the Nechako River above Stuart River Exceeding Water Temperature Criterion

Mean daily water temperatures in the Nechako River above Stuart River exceeded 20.0°C (68.0°F) on six days during the water temperature control period of July 20 to August 20. Prior to the water temperature control period, mean daily water temperatures in the Nechako River above Stuart River exceeded 20.0°C (68.0°F) on July 14 to July 17, inclusive.

During the water temperature control period, the first exceedance of the temperature criterion occurred from July 28 through August 1, inclusive. A maximum mean daily temperature of 21.2°C (70.2°F) was recorded on July 31. Prior to, and including July 28 the meteorological forecasts predicted cool conditions thus the Skins Lake Spillway release was maintained at 170 m^3/s (6,000 cfs). On July 29 the predicted water temperatures showed a substantial increase due to the meteorological forecast for the period. However, the temperature trends showed no potential to exceed 19.4°C (67.0°F). In recognition of the current instability in meteorological conditions, the Skins Lake Spillway release was increased to 453 m^3/s (16,000 cfs) as a conservative measure. The following day's forecast, July 30, predicted a cooling trend and in response to this forecast, the spillway release was reduced from 453 m^3/s (16,000 cfs) to 14.2 m^3/s (500 cfs). The forecasted conditions for July 31 predicted a warming trend to occur, and the spillway release was increased to 453 m^3/s (16,000 cfs) where it was maintained until August 2. A cooling trend was predicted on August 2 and the spillway release was decreased to 14.2 m^3/s (500 cfs).

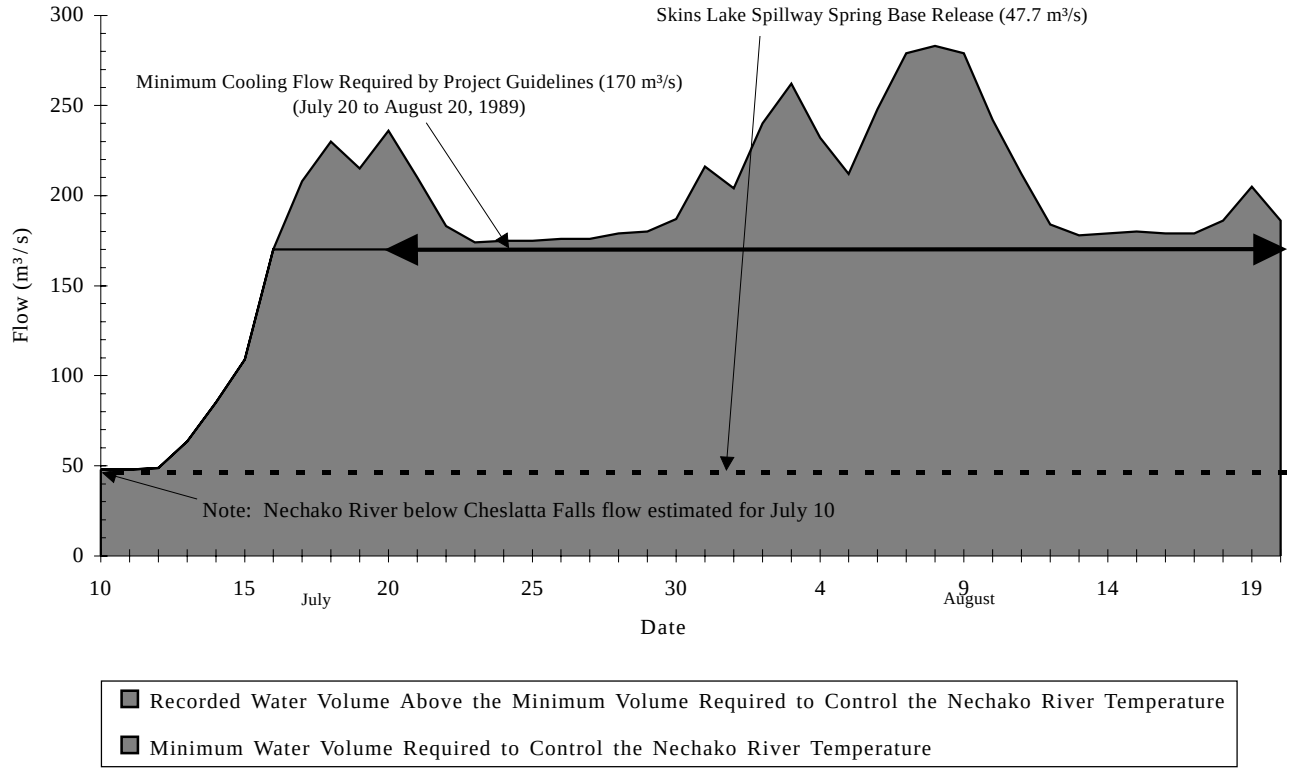
The second exceedance of the temperature criterion occurred on August 7, 1989. A maximum mean daily temperature of 20.2°C (68.4°F) was recorded. Predicted water temperatures were within range of observed values. During this period flow in the Nechako River below Cheslatta Falls was at or near the maximum allowable level of 283 m^3/s (10,000 cfs), and thus no further action could be taken.

Volume of Water Used

Figure 4 illustrates the observed flows in the Nechako River below Cheslatta Falls for the 1989 Summer Water Temperature and Flow Management Project. Also indicated is the minimum cooling flow of 170 m^3/s (6,000 cfs) in the Nechako River below Cheslatta Falls, and the Skins Lake Spillway release of 47.7 m^3/s (1,685 cfs) required as part of the "Annual Water Allocation" defined in the Settlement Agreement. Skins Lake Spillway releases in excess of 47.7 m^3/s (1,685 cfs) are considered releases used for cooling purposes.

The total volume of water released during the 1989 Summer Water Temperature and Flow Management Project was 8,255.2 m^3/s-d (291,532 cfs-d). The volume released for cooling purposes was 6,251.8 m^3/s-d (220,782 cfs-d). The average flow over the operational period (July 10 to August 20) was 196.6 m^3/s (6,943 cfs). Volume calculations are presented in Appendix E.

Figure 4
Flows in the Nechako River below Cheslatta Falls Resulting from Skins Lake Spillway Releases, July 10 to August 20, 1989



Application of the Summer Water Temperature and Flow Management Project Release Criteria

The Summer Water Temperature and Flow Management Project is very sensitive to the accuracy of meteorological forecasting. If a change in temperature direction occurs over a prolonged period of time (3 or 4 days), inaccurate meteorological forecasts may predict the reversal of the temperature direction prematurely. In these instances, it may be required to exercise judgment when applying the Summer Water Temperature and Flow Management Project release criteria used with the three water temperature trends. Experience gained in the operation of the Summer Water Temperature and Flow Management Project since 1984 has assisted in developing the judgment required to make exceptions to the release criteria during such events, which has proven to be beneficial in terms of managing downstream water temperatures.

On two occasions during the operational period of the 1989 Summer Water Temperature and Flow Management Project, judgment was applied and exceptions to the release criteria were made. This occurred when meteorological forecasts and/or the three water temperature trends did not clearly indicate which Skins Lake Spillway release should be implemented.

The first exception was made on July 29, when one of three water temperature trends indicated that the water temperature could exceed 19.4°C (67.0°F) in the Nechako River above Stuart River within the forecast period (5 days). The other two trends showed no potential to exceed 19.4°C (67.0°F). Following the release criteria under these conditions, the release from Skins Lake Spillway should have been maintained at the current release of 170 m³/s (6,000 cfs). However, the observed trend was up and it became apparent that the meteorological forecasts had been significantly under-predicting a future warming event.

Therefore, as a conservative measure, it was decided to increase the Skins Lake Spillway release from 170 m^3/s (6,000 cfs) to 453 m^3/s (16,000 cfs) until a continued cool trend was clearly established. The following day's trend analysis and meteorological forecast clearly indicated a cooling trend, thus the Skins Lake Spillway release was decreased from 453 m^3/s (16,000 cfs) to 14.2 m^3/s (500 cfs).

The second exception to the release criteria was made on August 7, when one of three water temperature trends indicated that the water temperature could exceed 19.4°C (67.0°F) in the Nechako River above Stuart River within the forecast period (5 days). Another trend showed that the water temperature could hit 19.4°C (67.0°F) and the final trend showed no potential to exceed 19.4°C (67.0°F). Following the release criteria under these conditions, the Skins Lake Spillway release should have been decreased from 283 m^3/s (10,000 cfs) to 14.2 m^3/s (500 cfs). However, the observed trend's fifth day temperature was 21.8°C (71.2°F). The predicted trend's fifth day temperature was 19.4°C (67.0°F) and the forecast trend's fifth day temperature was 19.3°C (66.8°F). Based on these considerations and to allow for a clear temperature trend to materialize, it was decided to maintain the Skins Lake Spillway release at 283 m^3/s (10,000 cfs). On August 8, two of three water temperature trends predicted cooling, and the Skins Lake Spillway release was decreased from 283 m^3/s (10,000 cfs) to 14.2 m^3/s (500 cfs).

REFERENCES

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Envirocon Limited. 1985. Review of the 1984 Nechako River Hydrothermal Monitoring and Control Program. Technical Memorandum 1941/C. Chapter 2.0, Methods. Prepared for Alcan Smelters and Chemicals Ltd.

Triton Environmental Consultants Ltd. 1995. The 1988 Summer Water Temperature and Flow Management Project. Nechako Fisheries Conservation Program Technical Report No. RM88-5.

APPENDIX A

Numerical Example of Water Temperature Trend Calculation

Appendix A
Numerical Example of Water Temperature Trend Calculation

From data for July 16 date of operation (Table A1).

1. Observed Trend

   The observed trend is up by 0.1°C from 20.3°C (J14) to 20.4°C (J15). Take the previous day's observed temperature 20.4°C (J15) and extrapolate the trend for 5 days at +0.1°C. The observed trend shows that the water temperature could potentially reach 20.4°C + 5(+0.1°C) = 20.9°C.

2. Predicted Trend

   The predicted trend is the difference between the previous day's computed water temperature (J15) and the fifth day predicted water temperature (J20). The predicted trend is down from 21.2°C to 19.5°C with the potential to reach 19.5°C.

3. Forecast Trend

   The forecast trend for the current day of July 16 is based on the first, second and third day forecasts.

July 16	21.1 - 21.0	=	up	0.1°C
July 17	20.1 - 20.2	=	down	0.1°C
July 18	19.6 - 19.6	=	unchanged	0.0°C

   Mean of 3 differences = unchanged 0.0°C

   This mean of 0.0°C is added to the fifth day predicted water temperature to give 19.5°C + (0.0°C) = 19.5°C.

   The forecast trend is constant with the potential to reach 19.5°C.

Appendix A1
Predicted and Observed Mean Daily Water Temperatures in the Nechako River above Stuart River, 1989

	JULY												
Date	10	11	12	13	14	15	16	17	18	19	20	21	22
5th Day's Predicted Water Temperature at Date + 4 Days					19.8	20.7	19.8	19.7	20.1	19.5	19.5		
4th Day's Predicted Water Temperature at Date + 3 Days				19.8	20.9	20.0	20.2	20.3	19.6	19.6			
3rd Day's Predicted Water Temperature at Date + 2 Days			19.3	20.8	19.8	20.9	20.9	20.2	19.6				
2nd Day's Predicted Water Temperature at Date + 1 Day		18.4	20.5	19.3	21.3	21.5	21.0	20.1					
Current Day's Predicted Water Temperature at Date	17.3	19.4	19.3	20.9	21.6	21.3	21.1						
Previous Day's Calculated Water Temperature at Date - 1 Day	17.3	19.1	19.9	21.1	21.5	21.2							
Previous Day's Observed Water Temperature at Date - 1 Day	N / A	17.8	19.7	19.7	20.3	20.4							
Current Day's Skins Lake Spillway Release at Date (m^3/s)	47.7	47.7 to 227 @ 1600 hrs	227	227	227 to 453 @ 1600 hrs	453	453						

Note: Observed temperature not available for July 10

APPENDIX B

Mean Daily Water Temperatures in the Nechako and Nautley Rivers, 1989

Appendix B
Mean Daily Water Temperatures in the Nechako and Nautley Rivers, 1989

Date	Nechako River Cheslatta Falls (°C)	Nechako River Fort Fraser (°C)	Nechako River above Stuart River (°C)	Nautley Fort Fraser (°C)	Date	Nechako River Cheslatta Falls (°C)	Nechako River Fort Fraser (°C)	Nechako River above Stuart River (°C)	Nautley Fort Fraser (°C)
10-Jul	16.3	18.2	N / A	16.8	1-Aug	17.9	18.8	20.7	19.5
11-Jul	15.9	18.7	17.8	16.7	2-Aug	17.7	18.4	19.8	19.0
12-Jul	16.4	19.3	19.7	17.0	3-Aug	17.7	18.5	19.2	17.9
13-Jul	17.1	19.5	19.7	16.9	4-Aug	17.7	18.7	19.1	18.7
14-Jul	17.4	19.4	20.3	18.2	5-Aug	17.7	19.1	19.4	18.8
15-Jul	17.5	19.9	20.4	18.1	6-Aug	17.6	18.9	19.8	18.9
16-Jul	16.8	18.5	20.3	18.4	7-Aug	17.6	18.8	20.2	18.9
17-Jul	16.4	18.0	20.2	18.7	8-Aug	17.6	18.7	20.0	18.9
18-Jul	16.5	17.4	19.4	18.7	9-Aug	17.3	18.4	19.4	17.8
19-Jul	16.7	18.1	19.1	18.9	10-Aug	17.0	17.8	18.5	18.5
20-Jul	16.7	17.6	19.2	18.3	11-Aug	17.2	17.8	18.3	18.3
21-Jul	16.6	17.7	18.9	17.6	12-Aug	17.2	18.4	18.7	18.7
22-Jul	16.4	16.7	18.2	17.1	13-Aug	17.3	18.9	19.4	18.9
23-Jul	16.4	16.6	17.9	17.5	14-Aug	17.4	17.9	18.9	19.4
24-Jul	16.7	16.9	17.2	17.4	15-Aug	17.3	18.5	18.6	18.5
25-Jul	17.1	18.1	18.3	18.0	16-Aug	17.4	18.5	18.8	18.6
26-Jul	N / A	19.0	18.8	19.1	17-Aug	17.3	19.0	18.9	19.4
27-Jul	17.3	18.5	19.4	18.5	18-Aug	N / A	18.7	19.4	19.7
28-Jul	17.5	18.3	20.3	18.5	19-Aug	N / A	18.5	19.4	19.4
29-Jul	17.5	19.2	20.1	18.7	20-Aug	N / A	N / A	18.8	N / A
30-Jul	17.8	19.4	20.3	19.3					
31-Jul	17.9	19.1	21.2	20.1					

Note: Temperatures not available

APPENDIX C

Mean Daily Skins Lake Spillway Releases and Flows in the Nechako and Nautley Rivers, 1989

Appendix C
Mean Daily Skins Lake Spillway Releases and Flows in the Nechako and Nautley Rivers, 1989

Date	Skins Lake Spillway Release (m^3/s)	Nechako River Cheslatta Falls (m^3/s)	Nechako River At Vanderhoof (m^3/s)	Nautley Fort Fraser (m^3/s)
10-Jul	47.7	N/A	N/A	N/A
11-Jul	47.7 to 227 @ 1600	47.9	100	34.2
12-Jul	227	48.7	99.5	35.3
13-Jul	227	63.4	99.6	34.2
14-Jul	227 to 453 @ 1600	85.4	106	35.1
15-Jul	453	109	120	34.6
16-Jul	453	157	142	34.6
17-Jul	453 to 14.2 @ 1300	208	175	34.2
18-Jul	14.2 to 453 @ 1600	230	220	33.8
19-Jul	453 to 14.2 @ 1500	215	259	33.3
20-Jul	14.2	236	254	32.9
21-Jul	14.2 to 170.0 @ 2145	210	264	32.5
22-Jul	170	183	249	30.7
23-Jul	170	174	225	29.7
24-Jul	170	175	216	29.4
25-Jul	170	175	213	29.0
26-Jul	170	176	213	29.0
27-Jul	170	176	214	29.4
28-Jul	170	179	217	29.2
29-Jul	170 to 453 @ 1600	180	218	28.7
30-Jul	453 to 14.2 @ 1600	187	218	28.4
31-Jul	14.2 to 453 @ 1600	216	219	28.1
1-Aug	453	204	241	27.7
2-Aug	453 to 14.2 @1600	240	240	27.1
3-Aug	14.2	262	268	26.4
4-Aug	14.2 to 453 @ 1545	232	291	25.8
5-Aug	453	212	276	25.2
6-Aug	453 to 283 @1600	248	251	24.6
7-Aug	283	279	264	24.0
8-Aug	283 to 14.2 @1600	284	300	23.7
9-Aug	14.2	279	317	23.7
10-Aug	14.2	242	316	23.4

Appendix C (Continued)
Mean Daily Skins Lake Spillway Releases and Flows in the Nechako and Nautley Rivers, 1989

Date	Skins Lake Spillway Release (m^3/s)	Nechako River Cheslatta Falls (m^3/s)	Nechako River At Vanderhoof (m^3/s)	Nautley Fort Fraser (m^3/s)
11-Aug	14.2 to 170 @1600	212	286	23.1
12-Aug	170	184	256	23.1
13-Aug	170	178	228	22.5
14-Aug	170	179	215	22.8
15-Aug	170	180	213	22.8
16-Aug	170	179	212	22.2
17-Aug	170 to 453 @1600	179	211	21.6
18-Aug	453 to 14.2 @ 1420	186	210	21.3
19-Aug	14.2	205	211	21.0
20-Aug	14.2 to 0 @1400	186	230	20.7
21-Aug	0	156	201	19.5
22-Aug	0	136	185	20.9
23-Aug	0	119	170	21.3
24-Aug	0	105	154	21.2
25-Aug	0	92.0	140	20.2
26-Aug	0	81.4	127	19.8
27-Aug	0	72.6	115	19.6
28-Aug	0 to 32.6 @1600	65.1	105	18.9
29-Aug	32.6	58.9	96.9	18.7
30-Aug	32.6	54.5	89.8	18.5
31-Aug	32.6	51.9	83.4	18.9
1-Sep	32.6	49.2	79.9	18.1
2-Sep	32.6	47.5	75.9	18.0
3-Sep	32.6	45.6	73.3	17.2
4-Sep	32.6	44.4	70.6	17.5
5-Sep	32.6	43.4	68.7	16.8
6-Sep	32.6	41.8	67.1	16.2

Note: Flows not available

APPENDIX D
Observed and Forecast Meteorological Data

Appendix D
Observed and Forecast Meterological Data

14.60	513.30	0.64	9.10	11.00	93.90	71.90	9 7 89
18.00	650.00	0.45	8.00	15.00	93.50	57.00	10 7 89
16.00	648.00	0.45	8.00	11.00	93.70	59.00	
16.00	650.00	0.45	7.50	5.00	94.00	57.00	
16.00	573.00	0.60	8.00	8.00	93.70	59.00	
16.00	550.00	0.70	8.50	10.00	93.20	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 10/89

18.10	619.00	0.34	6.50	17.30	93.50	49.90	10 7 89
18.00	620.00	0.20	7.50	10.00	93.90	50.00	11 7 89
18.50	615.00	0.25	8.00	6.00	94.10	50.00	
19.00	570.00	0.35	8.50	9.00	93.60	51.00	
17.50	585.00	0.55	10.00	13.00	93.60	61.00	
16.00	615.00	0.20	7.00	10.00	93.80	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 11/89

16.40	500.10	0.42	8.60	9.40	93.90	60.50	11 7 89
16.00	505.00	0.50	9.50	4.00	94.10	65.00	12 7 89
18.00	480.00	0.45	11.00	10.00	94.10	64.00	
19.00	535.00	0.55	10.50	8.00	93.90	58.00	
17.00	560.00	0.50	9.00	10.00	93.70	59.00	
15.00	590.00	0.30	8.00	13.00	93.70	63.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 12/89

17.60	630.00	0.32	9.30	4.50	94.10	62.80	12 7 89
19.50	465.00	0.55	11.00	13.00	93.90	58.00	13 7 89
19.00	560.00	0.50	10.50	10.00	93.90	58.00	
17.00	563.00	0.55	9.00	13.00	93.70	59.00	
16.00	620.00	0.35	7.50	14.00	93.60	57.00	
15.50	600.00	0.40	7.00	7.00	93.50	57.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 13/89

20.00	572.00	0.50	11.50	11.00	93.80	59.10	13 7 89
19.00	630.00	0.35	11.50	5.00	93.70	62.00	14 7 89
18.50	500.00	0.55	10.50	9.00	93.30	60.00	
17.00	540.00	0.65	9.00	13.00	93.50	59.00	
16.00	575.00	0.45	9.00	7.00	93.50	63.00	
16.50	620.00	0.30	8.50	7.00	93.30	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 14/89

17.80	592.00	0.36	11.00	7.00	93.60	67.20	14 7 89
17.00	442.00	0.70	10.00	9.00	93.30	63.00	15 7 89
16.50	517.00	0.70	9.00	10.00	93.40	61.00	
16.50	435.00	0.80	9.50	10.00	93.20	63.00	
16.50	559.00	0.40	8.50	7.00	93.30	59.00	
16.50	556.00	0.45	8.50	9.00	93.60	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 15/89

16.20	333.50	0.81	10.30	6.10	93.10	69.70	15 7 89
16.00	510.00	0.55	9.50	9.00	92.90	65.00	16 7 89
17.00	530.00	0.50	10.00	7.00	93.20	63.00	
17.00	560.00	0.40	9.00	7.00	93.50	59.00	
16.50	525.00	0.50	9.00	8.00	93.70	61.00	
17.50	550.00	0.40	8.00	9.00	93.80	54.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 16/89

15.30	444.00	0.64	7.90	9.10	93.00	64.80	16 7 89
17.00	422.00	0.70	9.00	10.00	93.30	59.00	17 7 89
17.00	530.00	0.50	9.00	7.00	93.60	59.00	
16.50	487.00	0.65	9.00	9.00	93.70	61.00	
17.50	556.00	0.50	8.00	8.00	93.50	54.00	
17.00	553.00	0.50	8.00	12.00	93.50	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 17/89

18.40	608.40	0.70	8.60	9.70	93.30	56.30	17 7 89
18.00	580.00	0.40	8.00	11.00	93.80	52.00	18 7 89
17.50	530.00	0.60	9.00	8.00	93.80	57.00	
16.00	567.00	0.50	8.50	10.00	94.00	61.00	
15.50	570.00	0.45	7.50	12.00	93.80	59.00	
16.00	610.00	0.35	7.00	10.00	93.90	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 18/89

17.80	723.40	0.40	6.30	11.80	93.80	50.80	18 7 89
18.50	620.00	0.53	7.50	10.00	93.70	49.00	19 7 89
18.50	640.00	0.50	7.50	12.00	93.30	49.00	
16.00	510.00	0.65	7.50	13.00	93.40	57.00	
15.00	630.00	0.40	6.50	11.00	93.60	57.00	
15.00	670.00	0.15	5.50	10.00	93.70	53.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 19/89

Appendix D (Continued)
Observed and Forecast Meterological Data

19.00	652.00	0.40	6.80	10.50	93.70	50.00	19 7 89
17.00	620.00	0.38	8.00	8.00	93.30	55.00	20 7 89
16.00	500.00	0.65	9.50	14.00	93.30	65.00	
14.50	570.00	0.40	7.50	11.00	93.80	63.00	
14.00	670.00	0.15	5.50	10.00	93.60	57.00	
15.00	580.00	0.50	7.00	8.00	93.40	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 20/89

15.30	501.00	0.40	7.40	7.20	93.40	61.20	20 7 89
13.60	460.00	0.68	8.30	14.00	93.60	70.00	21 7 89
14.50	550.00	0.45	7.50	11.00	93.90	63.00	
15.00	590.00	0.40	7.50	10.00	94.00	61.00	
15.00	570.00	0.40	7.00	8.00	93.70	59.00	
17.00	600.00	0.40	8.00	7.00	93.40	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 21/89

12.10	414.00	0.75	7.80	13.50	93.50	75.80	21 7 89
13.80	530.00	0.70	6.00	15.50	93.90	60.00	22 7 89
15.00	550.00	0.55	7.50	10.00	93.90	61.00	
15.50	590.00	0.40	7.00	8.00	93.80	57.00	
17.00	560.00	0.50	8.00	8.00	93.60	55.00	
16.00	500.00	0.70	8.50	10.00	93.40	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 22/89

14.40	541.00	0.68	5.30	13.50	93.90	56.60	22 7 89
12.30	410.00	0.67	6.00	6.50	93.60	65.00	23 7 89
15.50	600.00	0.45	7.00	8.00	93.70	57.00	
17.00	590.00	0.40	7.50	8.00	93.80	55.00	
16.00	520.00	0.65	8.50	10.00	93.60	61.00	
14.00	450.00	0.75	8.00	12.00	93.60	65.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 23/89

12.20	326.80	0.67	6.50	8.90	93.80	69.60	23 7 89
16.00	600.00	0.43	8.30	10.00	94.00	60.00	24 7 89
17.00	680.00	0.15	7.50	5.00	93.70	54.00	
18.00	515.00	0.50	8.50	9.00	93.50	54.00	
16.50	447.00	0.75	9.00	12.00	93.30	61.00	
14.00	467.00	0.65	8.50	13.00	93.30	69.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 24/89

Appendix D (Continued)
Observed and Forecast Meterological Data

15.80	579.00	0.53	8.40	8.90	93.90	64.60	24 7 89
17.50	660.00	0.27	7.50	5.00	93.90	52.00	25 7 89
19.00	650.00	0.35	9.00	9.00	93.50	52.00	
18.00	530.00	0.50	9.00	12.00	93.30	56.00	
14.00	464.00	0.65	8.50	13.00	93.40	69.00	
13.50	418.00	0.70	8.00	11.00	93.60	69.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 25/89

18.20	593.00	0.26	7.70	4.10	93.80	53.90	25 7 89
19.00	650.00	0.15	9.00	9.00	93.40	52.00	26 7 89
18.00	500.00	0.55	9.00	12.00	93.20	56.00	
15.00	446.00	0.70	8.50	13.00	93.50	65.00	
14.50	421.00	0.70	8.00	11.00	93.70	65.00	
15.00	480.00	0.65	8.50	8.00	93.70	65.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 26/89

20.10	650.40	0.25	7.00	11.90	93.40	48.70	26 7 89
21.00	490.00	0.65	10.00	16.00	93.30	49.00	27 7 89
18.00	443.00	0.65	9.00	14.00	93.00	56.00	
15.00	392.00	0.80	8.50	14.00	93.00	67.00	
15.00	436.00	0.70	9.00	13.00	93.20	67.00	
15.50	510.00	0.50	8.00	9.00	93.70	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 27/89

19.80	533.80	0.59	9.10	14.10	93.40	51.40	27 7 89
17.50	500.00	0.35	9.00	9.00	93.50	57.00	28 7 89
16.00	449.00	0.65	10.00	11.00	93.10	68.00	
15.00	376.00	0.80	10.00	16.00	93.20	72.00	
15.50	399.00	0.70	10.00	14.00	93.40	70.00	
16.00	469.00	0.50	9.00	10.00	93.30	63.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 28/89

16.20	656.50	0.23	6.60	4.80	93.60	56.50	28 7 89
18.00	500.00	0.50	9.00	9.50	93.20	56.00	29 7 89
18.00	445.00	0.75	10.00	11.00	93.30	60.00	
15.00	400.00	0.80	9.00	14.00	93.40	67.00	
16.00	440.00	0.70	9.00	15.00	93.50	63.00	
17.00	490.00	0.55	8.00	10.00	93.40	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 29/89

Appendix D (Continued)
Observed and Forecast Meterological Data

18.00	602.20	0.37	9.30	9.10	93.40	58.70	29 7 89
19.50	540.00	0.50	11.00	10.00	93.30	54.00	30 7 89
16.00	460.00	0.75	10.00	15.00	93.00	68.00	
15.00	380.00	0.80	9.00	16.00	93.20	67.00	
16.00	440.00	0.70	9.00	14.00	93.40	63.00	
17.00	520.00	0.45	8.00	8.00	93.50	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 30/89

20.50	603.90	0.46	10.10	10.00	93.30	53.70	30 7 89
20.50	600.00	0.36	9.50	10.00	93.10	51.00	31 7 89
18.50	480.00	0.65	9.50	8.00	92.70	56.00	
16.50	430.00	0.65	9.00	10.00	92.90	61.00	
15.00	560.00	0.40	8.50	8.50	93.10	65.00	
15.50	510.00	0.55	9.00	10.00	93.20	65.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED JUL 31/89

20.70	623.90	0.31	8.40	9.20	93.00	48.80	31 7 89
19.00	470.00	0.57	9.60	8.00	92.70	54.00	1 8 89
18.00	425.00	0.70	10.00	14.00	92.30	60.00	
16.00	560.00	0.55	9.00	15.00	92.80	63.00	
16.00	439.00	0.65	9.50	11.00	93.00	65.00	
16.00	550.00	0.45	8.50	9.00	93.20	63.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 01/89

19.30	461.70	0.54	9.90	8.40	92.70	55.80	1 8 89
16.00	290.00	0.95	11.70	12.00	92.40	76.00	2 8 89
17.00	486.00	0.75	9.50	17.00	92.80	61.00	
15.50	520.00	0.55	8.50	14.00	93.10	63.00	
15.00	550.00	0.45	8.00	11.00	93.20	63.00	
14.50	550.00	0.45	7.00	11.00	93.20	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 02/89

14.80	200.00	0.98	12.20	11.00	92.50	84.50	2 8 89
17.50	485.00	0.55	9.00	13.00	93.10	57.00	3 8 89
16.00	520.00	0.45	8.00	10.00	93.20	59.00	
15.50	550.00	0.45	8.00	8.00	93.30	61.00	
15.00	550.00	0.45	7.00	8.00	93.30	59.00	
15.00	590.00	0.40	7.00	8.00	93.50	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 03/89

Appendix D (Continued)
Observed and Forecast Meterological Data

17.60	439.00	0.60	9.10	10.70	93.00	59.10	3 8 89
18.00	570.00	0.15	9.00	9.00	93.60	56.00	4 8 89
18.00	570.00	0.25	9.00	6.00	93.40	56.00	
17.50	500.00	0.55	9.50	8.00	93.30	59.00	
16.00	530.00	0.45	8.50	9.00	93.20	61.00	
16.00	550.00	0.35	8.00	10.00	93.30	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 04/89

18.00	526.90	0.41	10.00	6.20	93.50	61.80	4 8 89
18.60	501.00	0.48	12.00	4.00	93.60	65.00	5 8 89
19.50	580.00	0.30	12.00	4.00	93.60	62.00	
19.00	481.00	0.45	11.00	8.00	93.50	60.00	
18.00	485.00	0.45	9.50	10.00	93.30	58.00	
16.00	501.00	0.45	8.50	9.00	93.30	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 05/89

19.90	595.40	0.46	12.20	5.50	93.60	64.20	5 8 89
19.50	590.00	0.28	11.00	7.00	93.90	58.00	6 8 89
20.00	590.00	0.40	10.00	8.00	93.60	53.00	
19.00	500.00	0.45	10.00	10.00	93.40	56.00	
17.50	500.00	0.45	9.50	9.00	93.20	59.00	
16.50	500.00	0.45	9.00	11.00	93.40	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 06/89

19.40	636.90	0.14	10.90	6.80	93.90	60.60	6 8 89
20.50	540.00	0.40	11.00	7.00	93.60	54.00	7 8 89
20.00	500.00	0.45	10.50	8.50	93.20	54.00	
18.50	450.00	0.60	10.00	10.00	92.80	58.00	
17.50	480.00	0.55	9.50	10.00	93.30	59.00	
18.50	510.00	0.40	9.50	9.00	93.60	56.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 07/89

20.60	636.60	0.26	9.50	5.60	93.60	53.50	7 8 89
19.80	600.00	0.35	7.50	8.00	93.20	45.00	8 8 89
18.30	460.00	0.65	10.50	11.00	92.90	60.00	
16.50	338.00	0.70	12.00	13.00	92.90	75.00	
17.50	480.00	0.45	9.50	10.00	93.10	59.00	
18.50	510.00	0.40	10.00	8.00	93.30	58.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 08/89

Appendix D (Continued)
Observed and Forecast Meterological Data

19.00	627.00	0.22	6.40	6.80	93.20	47.80	8 8 89
18.00	460.00	0.60	8.50	10.00	92.90	54.00	9 8 89
16.50	350.00	0.70	11.00	11.00	93.10	70.00	
16.50	310.00	0.70	11.00	10.00	93.40	70.00	
17.50	455.00	0.55	10.00	8.00	93.30	61.00	
18.50	510.00	0.45	9.50	7.00	93.30	56.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 09/89

16.30	490.20	0.63	5.70	12.50	93.00	52.60	9 8 89
15.00	420.00	0.70	7.00	10.00	93.40	59.00	10 8 89
16.00	460.00	0.60	8.00	10.00	93.50	59.00	
16.50	400.00	0.70	8.50	9.00	93.50	59.00	
17.50	510.00	0.50	9.00	9.00	93.30	57.00	
18.00	510.00	0.45	9.00	8.00	93.30	56.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 10/89

13.40	472.50	0.68	7.50	7.20	93.50	70.20	10 8 89
14.00	450.00	0.65	8.00	8.00	93.60	67.00	11 8 89
15.50	460.00	0.65	8.50	8.00	93.50	63.00	
15.50	405.00	0.65	8.50	9.00	93.40	63.00	
15.50	450.00	0.65	8.50	8.00	93.30	63.00	
15.50	450.00	0.65	8.50	8.00	93.30	63.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 11/89

14.40	439.00	0.53	8.10	6.00	93.60	69.00	11 8 89
16.50	450.00	0.45	10.50	5.50	93.80	68.00	12 8 89
17.00	410.00	0.65	11.00	8.00	93.60	68.00	
16.50	400.00	0.65	10.50	10.00	93.30	68.00	
15.50	475.00	0.60	9.50	10.00	93.30	67.00	
15.00	475.00	0.60	8.50	10.00	93.30	65.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 12/89

18.10	536.20	0.33	10.60	5.50	93.70	65.70	12 8 89
20.00	400.00	0.65	11.00	11.00	93.60	56.00	13 8 89
16.50	380.00	0.70	10.50	10.00	93.40	68.00	
13.50	260.00	0.80	9.00	12.00	93.30	74.00	
15.00	480.00	0.65	9.00	10.00	93.30	67.00	
17.50	542.00	0.40	9.50	8.00	93.30	59.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 13/89

Appendix D (Continued)
Observed and Forecast Meterological Data

17.80	353.50	0.60	11.50	9.60	93.70	68.40	13 8 89
13.00	280.00	0.70	9.50	5.00	93.50	79.00	14 8 89
13.50	240.00	0.80	10.00	10.00	93.30	79.00	
14.50	435.00	0.70	9.50	10.00	93.30	70.00	
16.50	490.00	0.40	9.00	8.00	93.40	61.00	
16.50	539.00	0.20	9.00	4.00	93.60	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 14/89

13.40	338.80	0.66	9.60	5.50	93.60	79.10	14 8 89
14.00	220.00	0.80	9.50	6.00	93.10	74.00	15 8 89
15.50	390.00	0.70	0.50	8.00	93.30	67.00	
16.00	580.00	0.45	8.50	9.00	93.50	63.00	
16.00	560.00	0.25	8.00	4.00	93.70	59.00	
16.00	570.00	0.15	7.00	3.00	93.80	55.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 15/89

14.40	202.50	0.80	10.60	4.50	93.20	78.30	15 8 89
15.50	440.00	0.70	10.00	8.00	93.40	70.00	16 8 89
15.50	480.00	0.50	9.00	6.00	93.50	65.00	
15.50	540.00	0.25	8.00	3.00	93.60	61.00	
16.00	570.00	0.15	7.00	5.00	93.40	55.00	
15.50	490.00	0.35	8.00	8.00	93.30	61.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 16/89

17.10	514.80	0.53	10.00	9.20	93.30	65.00	16 8 89
18.00	510.00	0.45	10.00	9.00	93.30	60.00	17 8 89
17.00	520.00	0.35	9.00	3.00	93.60	59.00	
16.00	540.00	0.35	8.00	5.00	93.30	59.00	
15.50	480.00	0.45	8.00	9.00	92.80	61.00	
15.00	510.00	0.55	8.50	10.00	93.00	65.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 17/89

18.10	549.00	0.48	9.80	7.60	93.30	59.30	17 8 89
18.00	500.00	0.45	10.00	5.00	93.60	60.00	18 8 89
17.00	540.00	0.38	9.50	7.00	93.20	61.00	
16.00	480.00	0.50	9.50	9.00	93.00	65.00	
15.50	450.00	0.65	9.00	10.00	93.00	65.00	
15.00	480.00	0.60	9.00	9.00	93.30	67.00	
ATEMP(C)	RAD(LY)	CC(TTHS)	DPT(C)	SPD(KH)	SPR(KPA)	RH(%)	DD MM YY

MEP FORECAST ISSUED AUG 18/89

APPENDIX E

Summer Water Temperature and Flow Management Project Reservoir Release Volume Calculations for July 10 to August 20,1989

Appendix E
Summer Water Temperature and Flow Management Project Reservoir Release Volume Calculations
for July 10 to August 20, 1989

Skins Lake Spillway base release for the period July 10 (191) to August 20 (232) = 47.7 m^3/s (1,685 cfs)
Therefore, Summer Water Temperature and Flow Management Project Base Volume = (232 - 190) * 47.7
= 2,003.4 m^3/s-days

Time period (Julian Day)	Time (hrs)	Flow Rate (m^3/s)	Volume (m^3/s-hrs)
July 10 (191) @ 0000 hrs to July 11 (192) @ 1600 hrs	40	47.7	1,908
July 11 (192) @ 1600 hrs to July 14 (195) @ 1600 hrs	72	227	16,344
July 14 (195) @ 1600 hrs to July 17 (198) @ 1300 hrs	69	453	31,257
July 17 (198) @ 1300 hrs to July 18 (199) @ 1600 hrs	27	14.2	383
July 18 (199) @ 1600 hrs to July 19 (200) @ 1500 hrs	23	453	10,419
July 19 (200) @ 1500 hrs to July 21 (202) @ 2145 hrs	54.75	14.2	777
July 21 (202) @ 2145 hrs to July 29 (210) @ 1600 hrs	186.25	170	31,663
July 29 (210) @ 1600 hrs to July 30 (211) @ 1600 hrs	24	453	10,872
July 30 (211) @ 1600 hrs to July 31 (212) @ 1600 hrs	24	14.2	341
July 31 (212) @ 1600 hrs to August 2 (214) @ 1600 hrs	48	453	21,744
August 2 (214) @ 1600 hrs to August 4 (216) @ 1545 hrs	47.75	14.2	678
August 4 (216) @ 1545 hrs to August 6 (218) @ 1600 hrs	48.25	453	21,857
August 6 (218) @ 1600 hrs to August 8 (220) @ 1600 hrs	48	283	13,584
August 8 (220) @ 1600 hrs to August 11 (223) @ 1600 hrs	72	14.2	1,022
August 11 (223) @ 1600 hrs to August 17 (229) @ 1600 hrs	144	170	24,480
August 17 (229) @ 1600 hrs to August 18 (230) @ 1420 hrs	22.3	453	10,117
August 18 (230) @ 1420 hrs to August 20 (232) @ 1400 hrs	47.7	14.2	677
August 20 (232) @ 1400 hrs to August 20 (232) @ 2400 hrs	10	0	0
Total	1008 (42 days)		198,124

Total Release Volume
= 198,124 m^3/s-hrs
= 8,255.2 m^3/s-days

Therefore, Volume Released for Cooling Purpc
= Total Volume - Base Volume
= 8,255.2 - 2,003.4
= 6,251.8 m^3/s-days

Average Flow over Summer Management Peri
(July 10 to August 20, 1989)
= 8,255.2 m^3/s-days / 42 days
= 196.6 m^3/s
= 6,943 cfs