SUSITNA HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

EXAMINATION OF SUSITNA RIVER DISCHARGE AND TEMPERATURE CHANGES DUE TO THE PROPOSED SUSITNA HYDROELECTRIC PROJECT

UNIVERSITY OF ALASKA

ARCTIC ENVIRONMENTAL INFORMATION AND DATA CENTER

UNDER CONTRACT TO

HARZA-EBASCO
SUSITNA JOINT VENTURE

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Report by

Arctic Environmental Information
and Data Center

Under Contract to
Harza-Ebasco Susitna Joint Venture

Prepared for
Alaska Power Authority

Final Report
February 1984

NOTICE

ANY QUESTIONS OR COMMENTS CONCERNING
THIS REPORT SHOULD BE DIRECTED TO
THE ALASKA POWER AUTHORITY

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INTRODUCTION

PROJECT BACKGROUND

The Alaska Power Authority is proposing to construct a 1620 megawatt hydroelectric project on the Susitna River, approximately 120 miles northeast of Anchorage, Alaska. Licensing of this project by the Federal Energy Regulatory Commission (FERC) requires, in part, that the Power Authority provide an analysis of the environmental effects of the project including a description of the present conditions, an evaluation of expected impacts, and proposals to mitigate those impacts.

The Susitna project aquatic resources impacts are expected to result primarily from changes in Susitna River discharge and temperature patterns. In general, these effects are expected to be reduced summer streamflow and increased winter streamflow relative to preproject conditions. Summer stream temperatures downstream from the project are expected to be cooler and winter temperatures warmer than those currently recorded (APA 1983).

The aquatic impact assessment program is designed primarily to predict aquatic impacts at study sites selected to represent similar areas which cannot be intensively studied because of cost or time constraints. Central to this type of assessment is the delineation of pre- and postproject discharge and temperature effects in terms of their expected magnitude and significance to aquatic organisms.

It is therefore necessary, when proposed project configuration is finalized, to determine the magnitude of expected project changes (in this case discharge and temperature) from the project location to the downstream point at which effects may no longer be considered significant. In so doing, two things are accomplished: first, the stream reaches or segments within which discharge and temperature are homogeneous are determined and serve to stratify the river prior to assigning study site impacts to larger unstudied areas; second, physical bounds are put on the reach of river where discharge and temperature changes are significant, and thus within which impact studies should be concentrated.

APPROACH OF THE STUDY

In this paper proposed mainstem Susitna flows resulting from project operation are examined in relation to natural flows. Attempts are made to identify reaches of the river where postproject flows are statistically indistinguishable from natural flows. We believe that flow-related aquatic impact issues cannot be addressed in areas of the river where natural and operational flow regimes are statistically the same.

Temperature variations are addressed by comparing natural stream temperatures with downstream temperatures resulting from project operation. We feel it desirable to show natural and postproject temperatures expected during normal and extreme meteorologic/hydrologic conditions. To do this, those summer periods which resulted in the normal, maximum and minimum stream temperatures under predevelopment conditions were selected from stream temperature simulations which used historical meteorology and hydrology data. The data from these three selected summer periods (1970 for the minimum, 1980 for the normal and 1977 for the maximum) were combined with postproject modifications to compare the difference between predevelopment and postproject stream temperatures. The postproject simulations will, therefore, represent the range of temperatures expected under natural variations in hydrology and meteorology.

The sparcity of daily discharge and water temperature data in the Susitna basin dictates the use of monthly timesteps for most simulation modeling. Data for large time steps are expected to mask some short-period variations, thus conclusions drawn from these monthly simulations must be made with caution. Simulations are presently underway using weekly time periods in which greater short-term variations are expected to appear. This second round of simulations is also being done on a yearly basis, whereas only summer periods (June through September) have been addressed in this report.

Thoughout this report the terms "natural flow" and "preproject flow" are used synonomously in reference to the estimated flow regime of the Susitna River which occurred since record-keeping began with water year 1950. These estimated flows are a composite of the flows recorded at USGS gage stations in the basin and the statistically-generated flows developed by APA (1983) to fill gaps in the record.

METHODS

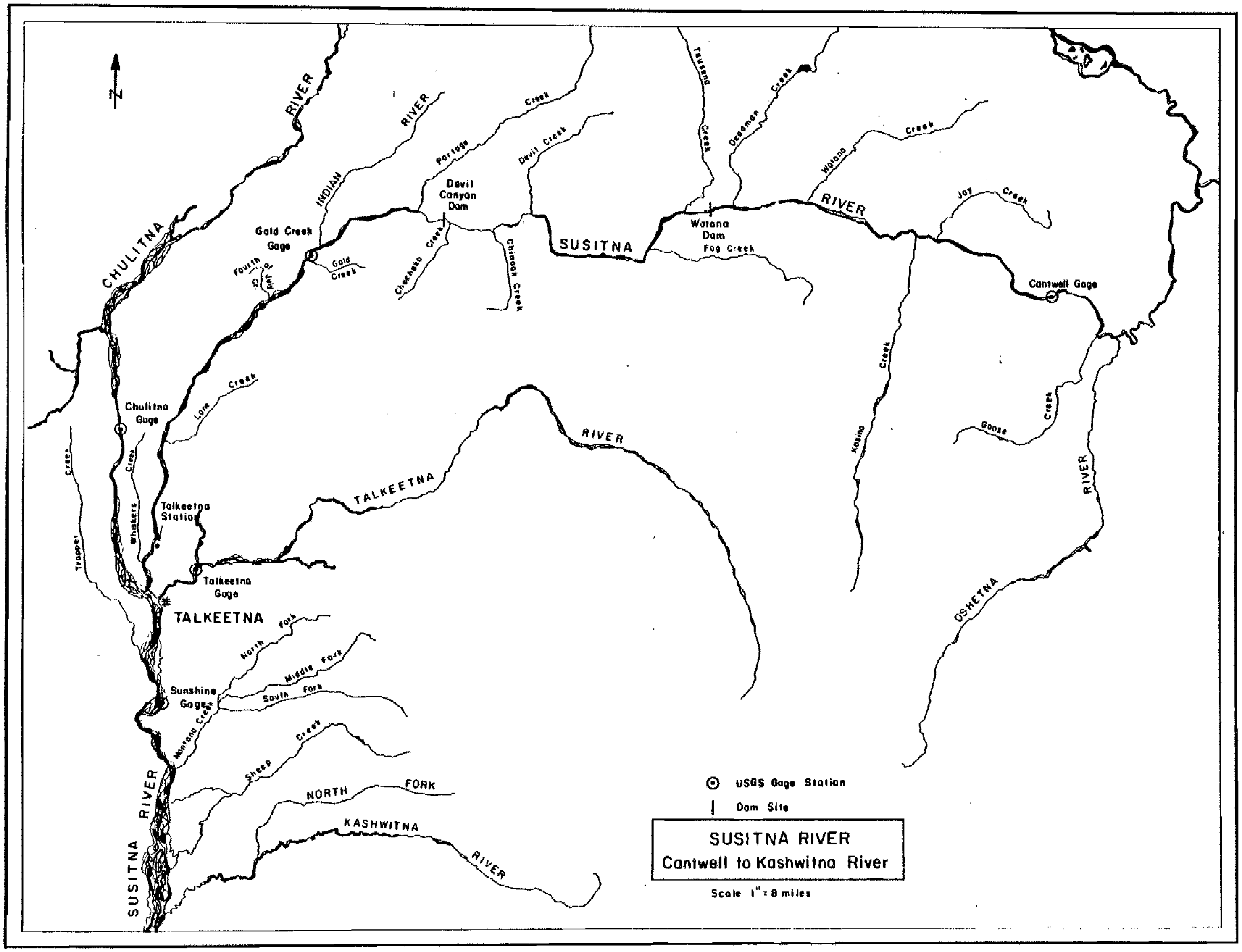
DISCHARGE

Pre- and Postproject Flows

Preproject mean monthly discharges for the Susitna River downstream from the Watana dam site (Figure 1) were estimated using the statistically-filled streamflow data[1] given in the FERC license application (APA 1983) and a water balance computer program (H2OBAL) developed by AEIDC. The H2OBAL program (AEIDC 1983) computes contributing tributary inflow to the Susitna River from small subbasins based either on watershed area or precipitation-weighted

1. A multisite regression technique was used to analyze existing monthly streamflow data and fill in periods of missing record for the USGS stations within the basin (APA 1983).

Figure 1. Region of present temperature study, Cantwell gage to Sunshine Station.



watershed area. From this, mainstem flows are determined for a number of locations. The watershed area weighting method was used for these simulations. This was done to maintain as much consistency as possible with the methods previously employed by Acres American, Inc. It should be emphasized that since the H2OBAL program only generates mainstem flow data for locations between gage stations, flows used in this report for gage locations (Gold Creek, Watana, Chulitna, Talkeetna and Susitna Station) are consistent with those appearing in the license application. The only exception is at Sunshine Station, where flows available in the license application sometimes result in negative inflows when water balancing. Flows at this station were determined by

$$Q_S = \frac{11000.}{10736.} \times (Q_{GC} + Q_T + Q_C)$$

where Q_S, Q_{GC}, Q_T, and Q_C refer to flow at Sunshine Station, Gold Creek, Talkeetna, and Chulitna, respectively,

11000. is the area (mi^2) of the watershed defined at Sunshine Station, and

10736. is the area (mi^2) of the summed watersheds defined at Gold Creek, Chulitna, and Talkeetna gages.

Employing H2OBAL results in the reconstruction of Susitna River mean monthly streamflows for the water years 1950 through 1981 at all gage stations and significant tributary confluences from the Watana dam site to Susitna Station, 26 miles from the river mouth at Cook Inlet. Postproject streamflows can be predicted at the same locations using the 32-year postproject flows at the Watana dam site (one-dam scenario) or the Devil Canyon dam site (two-dam scenario) as simulated by the ACRES reservoir operation models. These models provide release discharge estimates after simulating power production based on the dimensional properties of the dam(s). One model simulates Watana dam only, while another simulates conjunctive operation of both Watana and Devil Canyon dams.

The reservoir operation schedule presented in the Application for FERC License (APA 1983), the "C" scenario, was analyzed in this report. This scenario is indicated in the License Application (APA 1983) to balance the cost of impact mitigation measures and loss in net economic benefits. It reflects the minimum flow demand at Gold Creek for 6000, 6480, 12000 and 9300 cubic feet per second (cfs) respectively in June, July, August and September for fishery purposes.

Operational flows expected during the summer of the second year of filling the Watana reservoir were also simulated. This period is of special concern due to the cold (4 C) water that would be released from the lower level dam outlet during this season (APA 1983). Minimum releases measured at Gold Creek for the summer filling period are 6000, 6480, 12000 and 9100 cfs for June, July, August and September respectively (APA 1983). During some years, enough water is available from tributary inflow between Watana and Gold Creek to meet this requirement without releasing any water from the reservoir. For such cases, a minimum Watana release of 1,000 cfs has been specified (APA 1983).

Statistical Testing

The statistical analysis of the 32-year flow series is used to describe the flow regime for the natural and operational scenarios at a given mainstem location and, if possible, to determine the point downstream from the project where operational flows become indistinguishable from natural flows. All statistical methods used are described in this section although initial statistical results determine which, if any, additional testing is done on the data.

In testing for statistical significance, the pre- and postproject flow series at each mainstem node location are considered as samples of distinct flow populations. Moving downstream from the lower reservoir, inflowing tributaries will dampen the differences between natural and operational flows. During months where reservoir releases do not differ greatly from natural flows at the dam site, it is reasonable to expect that the 32-year sample of operational flows would become statistically indistinguishable from the sample of natural flows at some point downstream.

Ideally, if both natural and operational flow series approximate normal distributions at each node location for a given month, testing for significant differences at mainstem locations progressing downstream is relatively straightforward. The statistical test that can be used in this case is a comparison of population means with both population variances unknown and not assumed equal (Johnson and Leone 1964). The test statistic has a distribution approximating a Student's t distribution with 31 degrees of freedom.

Yevjevich (1972) suggests two criteria for determining whether or not a normal function should be applied to an empirical distribution. These requirements incorporate the skewness (a measure of symmetry) and kurtosis (a measure of peakedness) of a distribution through the skewness coefficient C_s, and the excess coefficient, C_e. For normally distributed populations, both parameters equal 0. The population a sample is drawn from can be considered normal if it meets the following requirements:

$$-0.2 \leq C_s \leq 0.2 \quad \text{and}$$

$$-0.5 \leq C_e \leq 0.5.$$

The skewness coefficient is approximated for a small sample (Chow 1964) by

$$C_s = \frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} (X_i - \overline{X})^3$$

where n = the sample size (= 32),

X_i = the mean monthly flow during the i^{th} year for a given site and month,

$\overline{X}$ = the mean of the n monthly flows at a given site.

The coefficient of excess (Yevjevich 1972) is determined by

$$C_e = \frac{n^2}{(n-1)(n-2)(n-3)} \sum_{i=1}^{n} (X_i - \overline{X})^4 - 3$$

where variables are as above.

When data fails to meet these requirements, Yevjevich gives two options: fit the data to another distribution or transform the variable values to fit a normal distribution. Frequently, discharge data series are positively skewed due to extreme high-flow events. In these cases, replacing flow values with the logarithm of flows may normalize the series and has a justifiable hydrologic basis (Chow 1964). This is only useful, however, if both pre- and postproject flow distributions are positively skewed. When this is not the case, no further statistical manipulation is attempted here. For flow series that fit the transformed lognormal distributions (using the C_s and C_e values of the transformed data), the test for significant differences can be performed.

An additional statistical parameter of a sample distribution which appears in the tabular output is the coefficient of variation, C_v. This is simply the standard deviation divided by the mean.

TEMPERATURE

Initial Temperatures at Cantwell, Chulitna and Talkeetna

To begin a natural condition temperature simulation, starting temperatures are required for the Susitna River at the Cantwell gage and the Chulitna and Talkeetna rivers at the USGS gages near the town of Talkeetna. When these data are not available, initial temperatures are synthesized by (1) using SNTEMP to compute an equilibrium temperature for the period of missing data, and (2) using this calculated equilibrium temperature to estimate an initial water temperature from a regression model developed from observed water temperatures and calculated equilibrium temperatures (AEIDC 1983). The reliability of these regression models restricts the accuracy of the physical process temperature simulations. For example, if the regression model for the Cantwell gage predicts an initial temperature of 8 C when the actual stream temperature was 7 C, this one degree overprediction would cause overprediction throughout the simulated length of river. The temperatures predicted with the regression models and the 95% confidence intervals for individual stream temperature values are presented in Figure 2. The

Figure 2. Regression model-predicted initial temperatures (C) with 95% confidence intervals.

	SUSITNA RIVER AT CANTWELL USGS GAGE		CHULITNA RIVER AT USGS GAGE		TALKEETNA RIVER AT USGS GAGE	
	$\hat{T}$	95% Confidence Interval	$\hat{T}$	95% Confidence Interval	$\hat{T}$	95% Confidence Interval
1970 (minimum)						
June	7.97	±1.38	6.48	±2.35	7.85	±5.79
July	8.90	±1.40	6.87	±2.38	5.17	±6.28
August	7.47	±1.39	6.27	±2.38	6.70	±5.89
September	3.81	±1.82	4.44	±3.62	1.37	±8.19
1977 (maximum)						
June	11.12	±1.61	7.39	±2.57	10.88	±6.36
July	10.60	±1.54	7.69	±2.74	11.71	±6.70
August	9.22	±1.41	7.21	±2.48	10.23	±6.14
September	5.35	±1.57	5.16	±2.98	3.69	±6.89
1980 (average)						
June	8.68	±1.39	6.54	±2.35	8.18	±5.79
July	10.20	±1.50	7.47	±2.61	10.88	±6.36
August	8.28	±1.38	6.53	±2.35	7.91	±5.79
September	5.22	±1.59	4.89	±3.20	3.19	±7.14

$\hat{T}$ = predicted temperature

difference in the level of confidence among the three regression models is a result of the number of data points available for computing mean monthly temperatures and the type of data collected. Continuous data was collected at Cantwell gage for June to September of 1980 and 1982, continuous data was collected at Chulitna gage in 1982 with grab samples in 1980, and only grab samples were available at Talkeetna gage for June to September of 1980 and 1981. Comparisons between the observed and regression model-predicted temperatures for 1980 (representing a normal year) are presented in Figure 3.

Reservoir Release Temperatures

Presently, reservoir release temperature estimates are very sparse. The reservoir thermal model, DYRESM, has been run for both reservoirs only for 1981 conditions (APA 1983). We have estimated mean monthly release temperatures (Figure 4) from the continuous thermograph output from these runs. Since reservoir outflow temperatures are expected to vary from year to year due to differences in meteorology, hydrology, available reservoir storage and power requirements, applying these temperatures to other years may not be representative. Consequently, downstream temperatures were simulated under operational conditions for only one year (1981).

Release temperature estimates for the second year of filling the Watana reservoir have been made without DYRESM simulations. Until the reservoir level rises to where the normal (upper) outlet facilities can be used (estimated as late summer or fall of the second year of filling), releases are restricted to the lowest outlet facilities (APA 1983). A water temperature of 4 C is expected at the level of this outlet and thus was used for simulating under cold, normal and warm temperature conditions. The selection of these representative conditions is discussed in the following section.

Figure 3. Regression model-predicted initial temperatures (C) for June to September 1980

	SUSITNA RIVER AT USGS CANTWELL GAGE			CHULITNA RIVER AT USGS GAGE			TALKEETNA RIVER AT USGS GAGE		
MONTH	$\hat{T}$	Tobs	n	$\hat{T}$	Tobs	n	$\hat{T}$	Tobs	n
June	8.68	8.5	31	6.54	6.8	1	8.18	-	0
July	10.20	10.0	30	7.47	7.1	1	10.88	8.3	1
August	8.28	9.0	30	6.53	-	0	7.91	8.8	1
September	5.22	4.5	31	4.89	-	0	3.19	-	0

$\hat{T}$ = predicted temperature
Tobs = observed temperature, computed as average of mean daily temperatures
n = number of days of observed temperature data

Figure 4. Estimated mean monthly summer reservoir release temperatures (C) (based on 1981 DYRESM results, ACRES 1983)

	June	July	August	September
Watana (1 dam)	7.7	9.5	8.7	8.3
Devil Canyon (2 dams)	6.0	7.2	6.7	7.5

Selection of Conditions Producing Normal and Extreme Temperatures

The Susitna study application of the stream temperature model, SNTEMP (AEIDC 1983), was used to estimate the range of natural temperature variations in the mainstem Susitna River from the USGS Cantwell gage station to Talkeetna Station just above the Chulitna confluence (river mile 103.0, site of the Talkeetna fishwheel). Mean monthly river temperatures were calculated for the summer months (June through September) for the fifteen-year period of readily available meteorology data, 1968 through 1982. Meteorology data from Talkeetna (U.S. National Climatic Center 1968-1982) and recorded and statistically-filled flow data (APA 1983; R&M 1982a, 1982b) were used.

Predicted mean monthly Susitna River temperatures at Talkeetna Station for the fifteen-year summer period are shown in Figure 5. The ranking (coldest to warmest) for each month as well as the overall seasonal ranking are also given in this figure. In the case of two years having the same monthly temperature (July 1972 and 1975), equal ranks (averaged) were assigned.

The three years chosen from these rankings to represent cold, normal and warm temperature conditions were 1970, 1980 and 1977 respectively. 1981 was eliminated from consideration as the normal year due to the variation in June and July temperatures (warm June followed by a cold July). These years represent the normal and extremes in seasonal water temperatures, a product of both meteorology and hydrology for that period.

Postproject Simulations

Projected reservoir release flows and temperatures were used as initial conditions for simulating the downstream temperature effects of filling and operation of the dams. For the second year of Watana filling and the Watana-only operational scenarios, the simulated river reach begins at the

Figure 5. SNTEMP-predicted temperatures (C) and rank of the mainstem Susitna at Talkeetna Station for June through September, 1968 through 1982.

YEAR	JUN	Rank	JUL	Rank	AUG	Rank	SEPT	Rank	Av. Temp	Av. Rank	Seasonal Rank
1968	10.52	13	12.58	13	11.46	13	6.44	7	10.25	11.5	13
1969	10.45	10	11.83	10	9.52	4	6.80	12	9.65	9.0	9
1970	8.75	4	10.27	1	9.06	2	5.10	2	8.30	2.25	1
1971	9.00	6	10.64	4	10.30	9	5.77	4	8.93	5.75	5
1972	7.75	1	11.64	8.5	10.05	7	4.87	1	8.57	4.38	3
1973	8.65	3	11.03	5	8.64	1	5.15	3	8.37	3.0	2
1974	9.79	8	10.60	3	10.02	6	6.41	6	9.20	5.75	6
1975	8.52	2	11.64	8.5	9.40	3	6.07	5	8.91	4.62	4
1976	10.73	14	12.78	14	11.20	10	6.55	9	10.32	11.75	14
1977	11.61	15	12.95	15	11.50	14	6.88	13	10.74	14.25	15
1978	10.50	12	11.84	11	11.29	11	7.13	14	10.19	12.0	11
1979	10.00	9	12.09	12	11.37	12	7.76	15	10.23	12.0	12
1980	8.97	5	11.57	7	10.27	8	6.61	10	9.36	7.5	8
1981	10.46	11	10.40	2	9.95	5	6.52	8	9.33	6.5	7
1982	9.77	7	11.38	6	11.53	15	6.71	11	9.85	9.75	10

Watana dam site. For the two-dam scheme, the simulated reach is shortened to begin at the Devil Canyon dam site.

The three years selected to represent normal and extreme summer water temperature conditions were used to define the range of expected effects. Basin flow and meteorology data for these three periods were used with the corresponding projected reservoir release flows and temperatures. Since river water temperatures are functions of both hydrology and meteorology, both these data sets were used together for a given year.

RESULTS AND DISCUSSION

DISCHARGE

Single-Dam Scenario (Watana Only)

Tabulated statistical results comparing natural mainstem Susitna flows with single-dam operational flows are given in Appendix A. Attempts to determine reaches where operational flows show statistically significant differences from natural flows were unsuccessful. This was due to the variations in the shape of the sample distributions with respect to natural versus operational flow samples, and in the consistency of flow distribution shapes at node locations progressing downriver.

As mentioned previously, sample distributions of operational flows must be similar in shape to those of natural flows for the proposed test of significance. Additionally, the distribution shape must remain consistent progressing from node to node downriver. Since the observed results did not meet these requirements, significance testing of the differences between flow distributions could not be done.

There is a trend of the natural flow distribution toward positive skewness. Nine months showed C_s values at most node locations greater than 0.2; one month showed a symmetric distribution (May), and only two months

(October and January) showed negative skewness. Dam operations tend to reduce the positive skewness during winter months and increase positive skewness during the summer. Five monthly flows, including December through March, reversed skewness coefficients to the negative ($C_s < -0.2$) under project operation. For the four summer months (June through September), operational flows remained positively skewed. Reservoir operations, while specifying minimum summer flow requirements to facilitate fish usage, also tend to capture higher flows for winter releases. The result is elimination of extreme flows in both directions (high and low), increasing kurtosis as reflected in the coefficient of excess values.

There is a tendency for variation in both skewness and kurtosis when moving downstream. This appears to be due in large part to the effects of the larger tributaries. These tributaries generally do not respond in concert with the upper Susitna River; hence, the shape of the mainstem flow distribution is often altered significantly at the confluence of these rivers. Additionally, there was a tendency for increased positive skewness in the lower river reach near and below the Yentna confluence. This effect is seen both in natural and postproject flows.

Since the four summer months showed the greatest consistency in the shape of natural and operational flow distributions, and as these months are of greatest concern, the same statistics were run on the flow data after a log transformation (results in Appendix B). Improvement in the C_s and C_e values was not sufficient to warrant significance testing of these transformed values.

Perhaps the most useful result presented in Appendix A appears under the "% CHANGE" column. This value is determined by

$$\frac{\text{postproject flow} - \text{preproject flow}}{\text{preproject flow}}$$

and is given for each node location.

Flow augmentation under project operation occurs during seven months, October through April. For the four midwinter months (December through March), this augmentation exceeds 100 percent as far downstream as Susitna Station. The remaining five months undergo flow deficits, the most substantial during June and July. The absolute flow increase for any location downstream from the Watana damsite and the relative change in flows at Gold Creek, Sunshine and Susitna Station are shown graphically in Figure 6. Profiles comparing natural and single-dam operational flows for each month are shown in Appendix C.

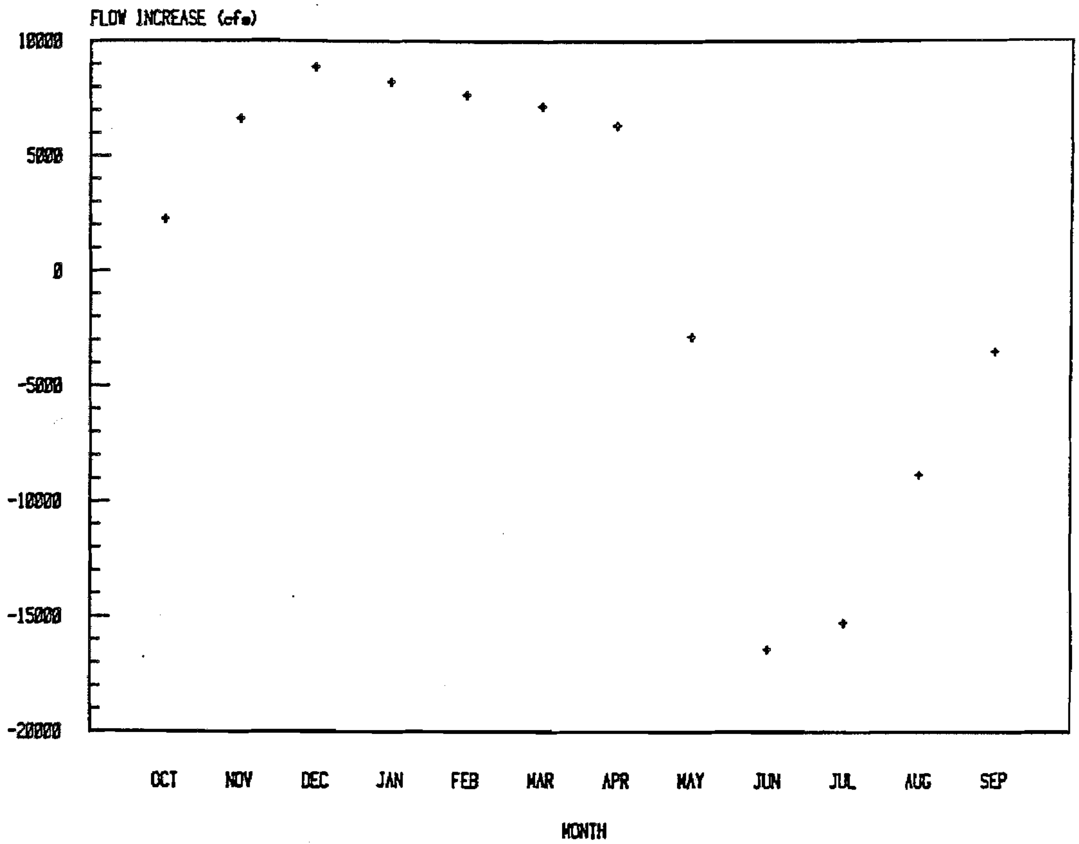
Two-Dam Scenario

Mainstem river flows resulting from operation of the two-dam system differ only slightly from that of single-dam operation (statistical results in Appendix D). In general, differences between natural and post-construction flows become more severe with addition of the Devil Canyon dam. When comparing results in the tabular output, the node at "CHINCHEE" for the single-dam case corresponds to the "D.C. DAM" node in the two-dam scenario.

For the six month winter period, November through April, the flow augmentation seen under the single-dam scheme is increased slightly. For the May through August period, there is slightly less mainstem flow than under single-dam operation and, consequently, greater flow deficits. The only diversion from this pattern of more severe flow differences occurs in September and October when flow regimes are slightly closer to natural conditions. There is less of a flow deficit in September and slightly less augmentation in October. Figure 7 shows a graphical representation of the absolute changes in flow at any location downstream from the Devil Canyon dam

Figure 6. Project-related flow changes, 1-dam scenario.

Absolute flow increases with dam operation, systemwide



Relative change in postproject over preproject flows at three sites

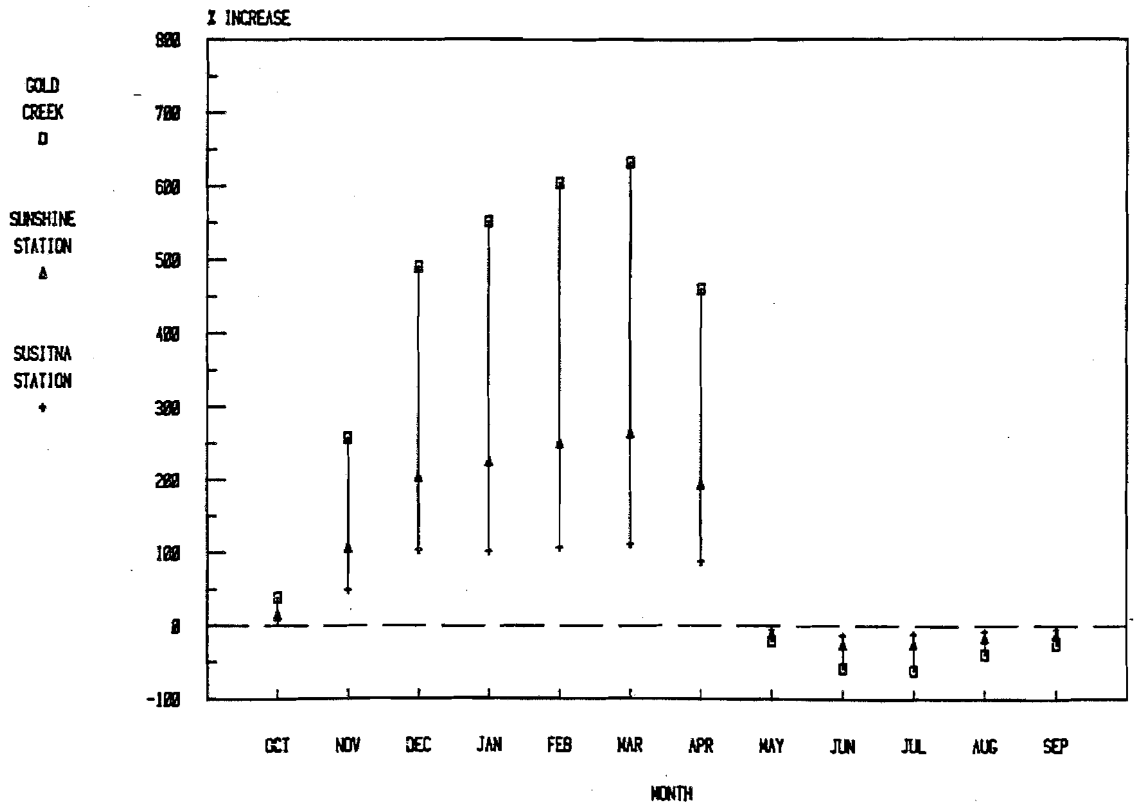
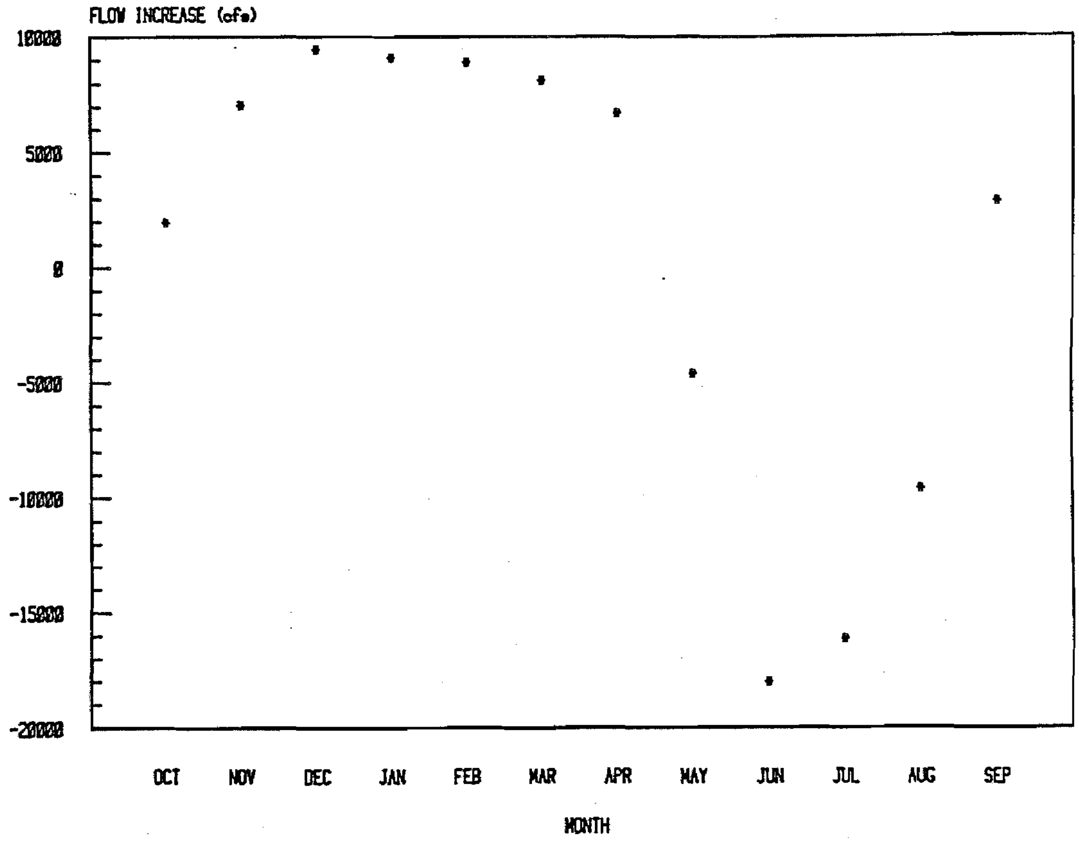
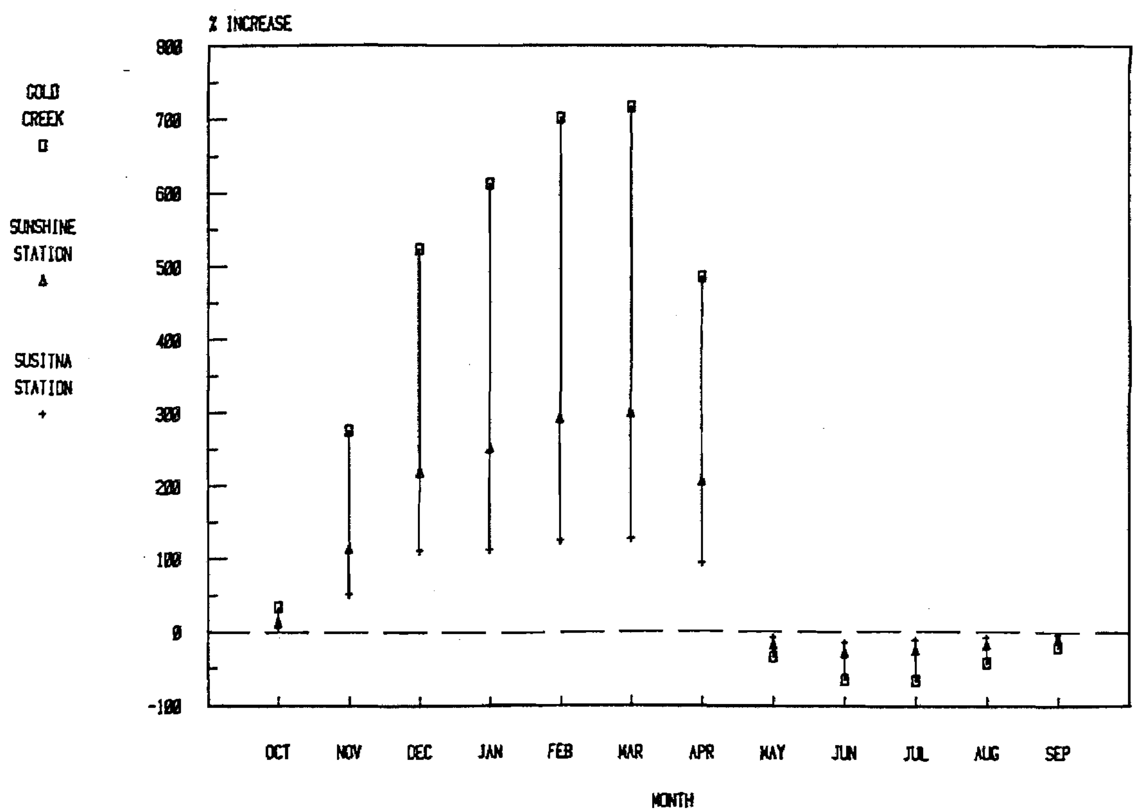


Figure 7. Project-related flow changes, 2-dam scenario.

Absolute flow increases with dam operation, systemwide



Relative change in postproject over preproject flows at three sites



site due to the paired dam operation (positive when postproject flows are greater than natural flows). The percent change in postproject flows over preproject flows for Gold Creek, Sunshine and Susitna Station mainstem locations are also shown on this figure. Patterns of skewness and kurtosis for natural and operational flows were similar in this case to those in the single-dam case. Consequently, testing for river reaches with significant flow differences was not pursued. Flow profiles of natural and two-dam operational conditions are shown in Appendix E.

TEMPERATURE

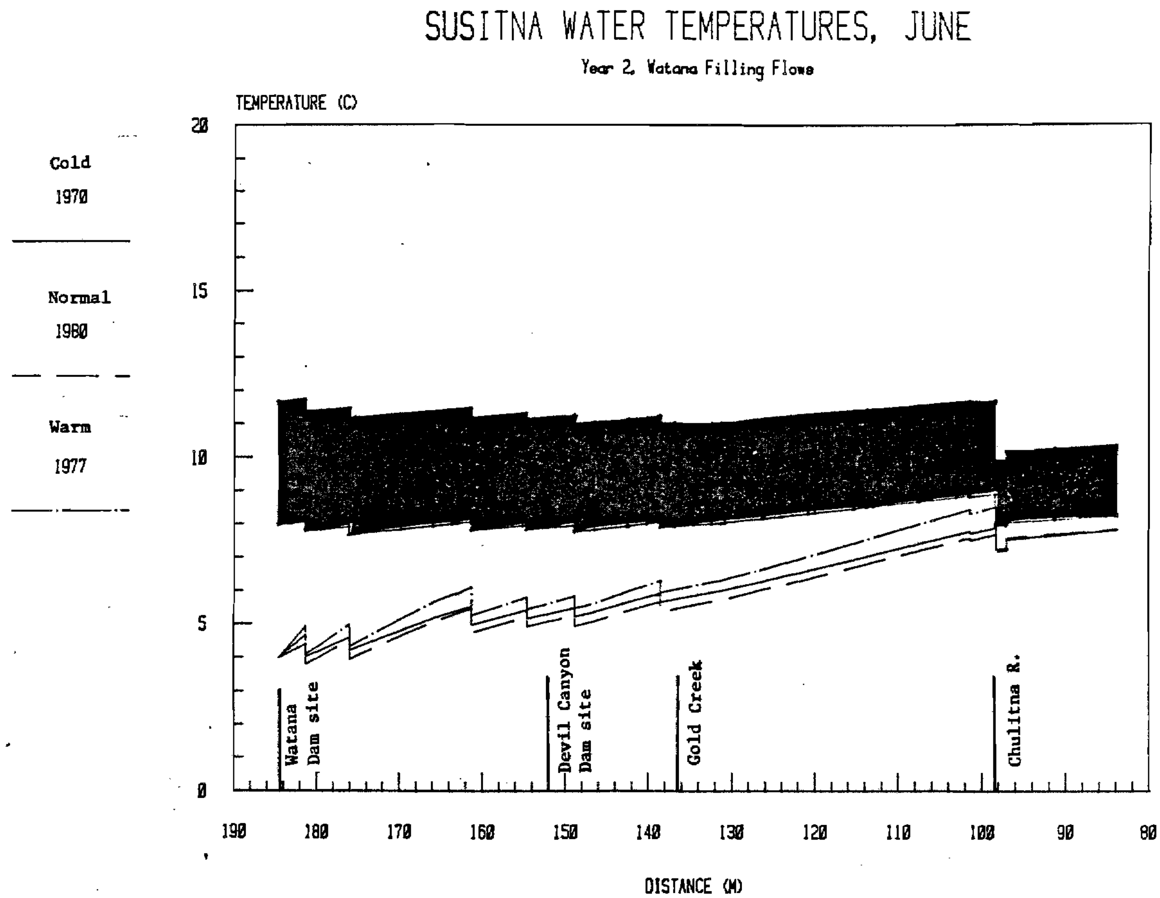
Postproject Simulations

Watana Filling. The downstream effects of the second year of filling Watana reservoir were simulated using the three selected years representing normal and extreme conditions. These simulations are of special concern due to the potential impact of 4 C release waters on the fishery resources. Four monthly temperature profiles (June through September) for the three years appear in Figure 8.

These profiles show conditions from the proposed Watana dam site to Sunshine Station below the confluences of the Chulitna and Talkeetna rivers. The projected filling flows and temperatures were used to initialize the temperature model. The expected normal, cold and warm temperature profiles are presented along with the minimum (1970) and maximum (1977) natural conditions (banded area) for comparison. The temperature discontinuity at river mile 98 represents the influence of the Chulitna River (instantaneous mixing is assumed). The smaller discontinuities throughout the simulated length are a result of the smaller tributaries mixing with the Susitna River.

Note that the cold natural hydrology/meteorology does not always result in the minimum temperature profiles for filling conditions; conditions

Figure 8. River temperature profiles for second year of filling Watana reservoir. Shaded band represents range of simulated natural temperature conditions.



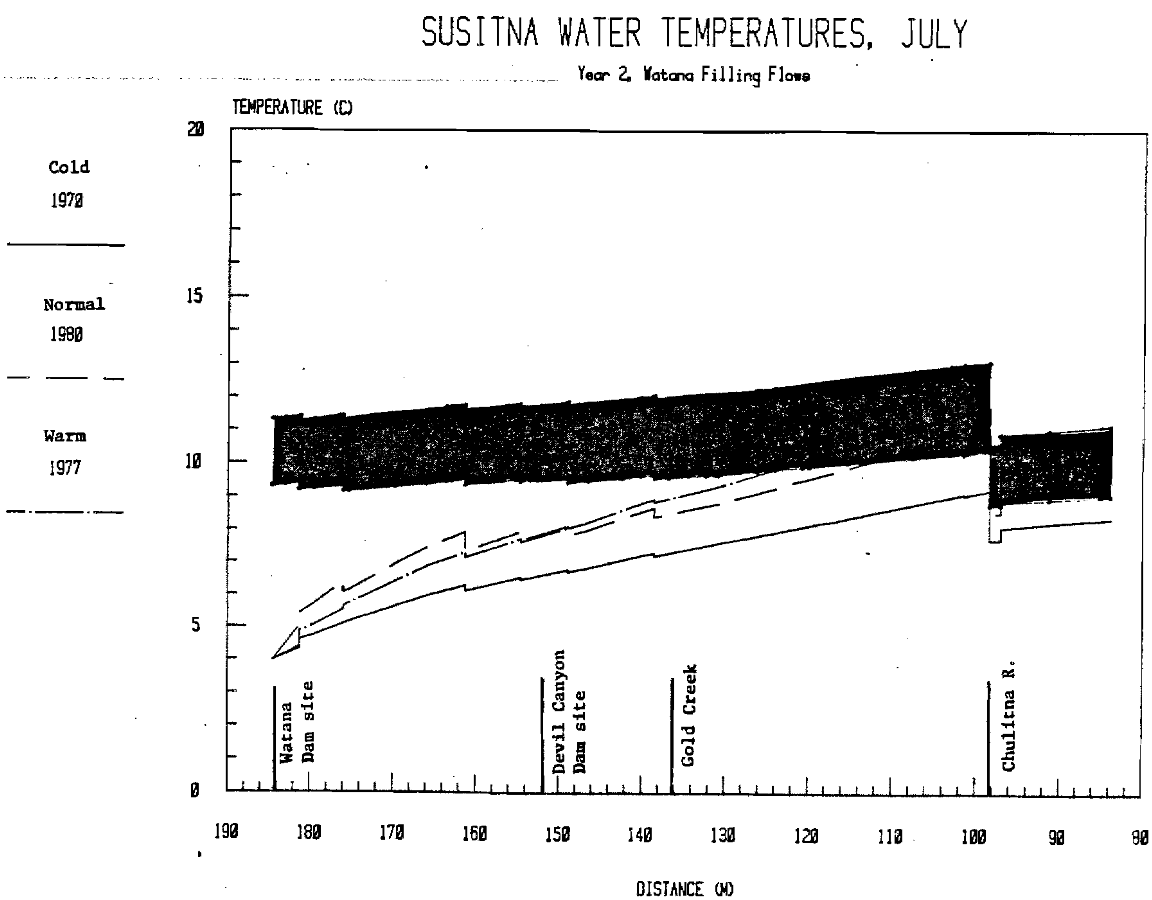
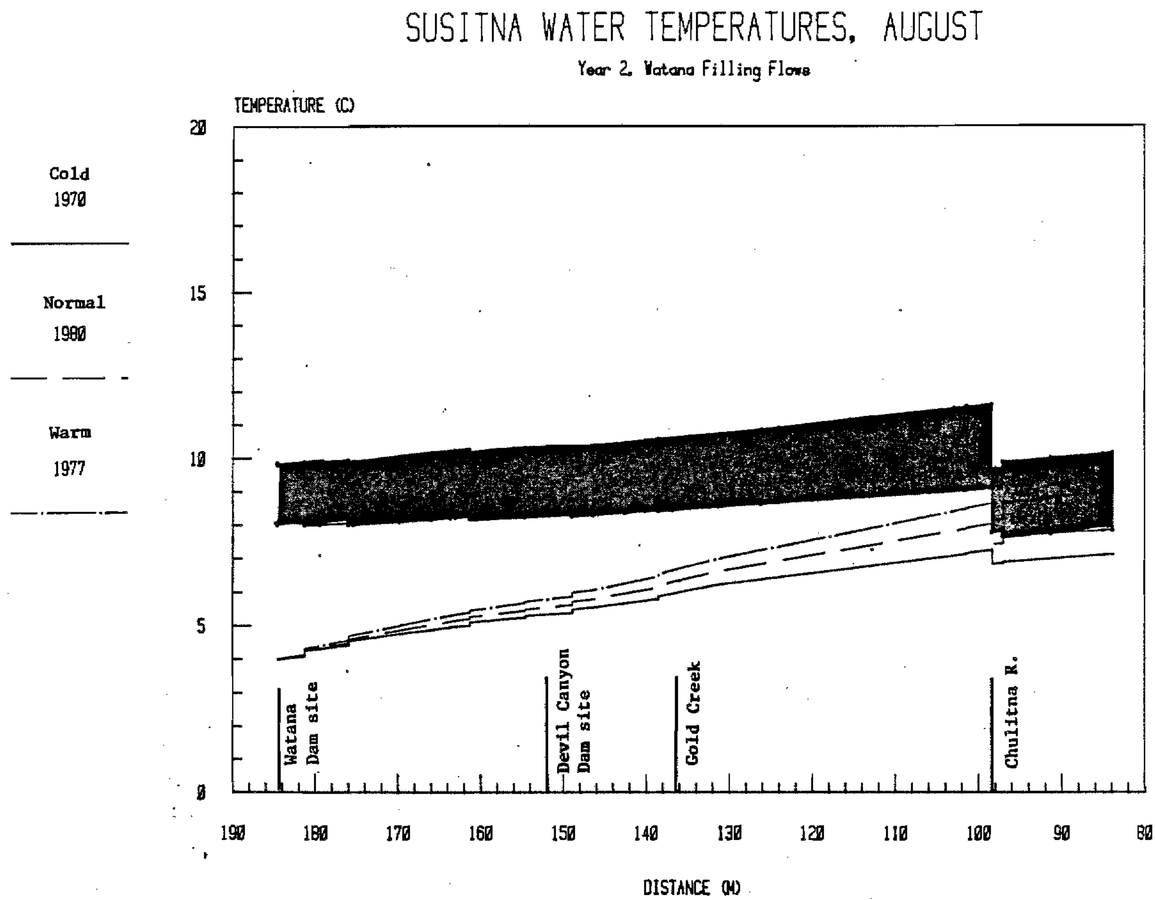
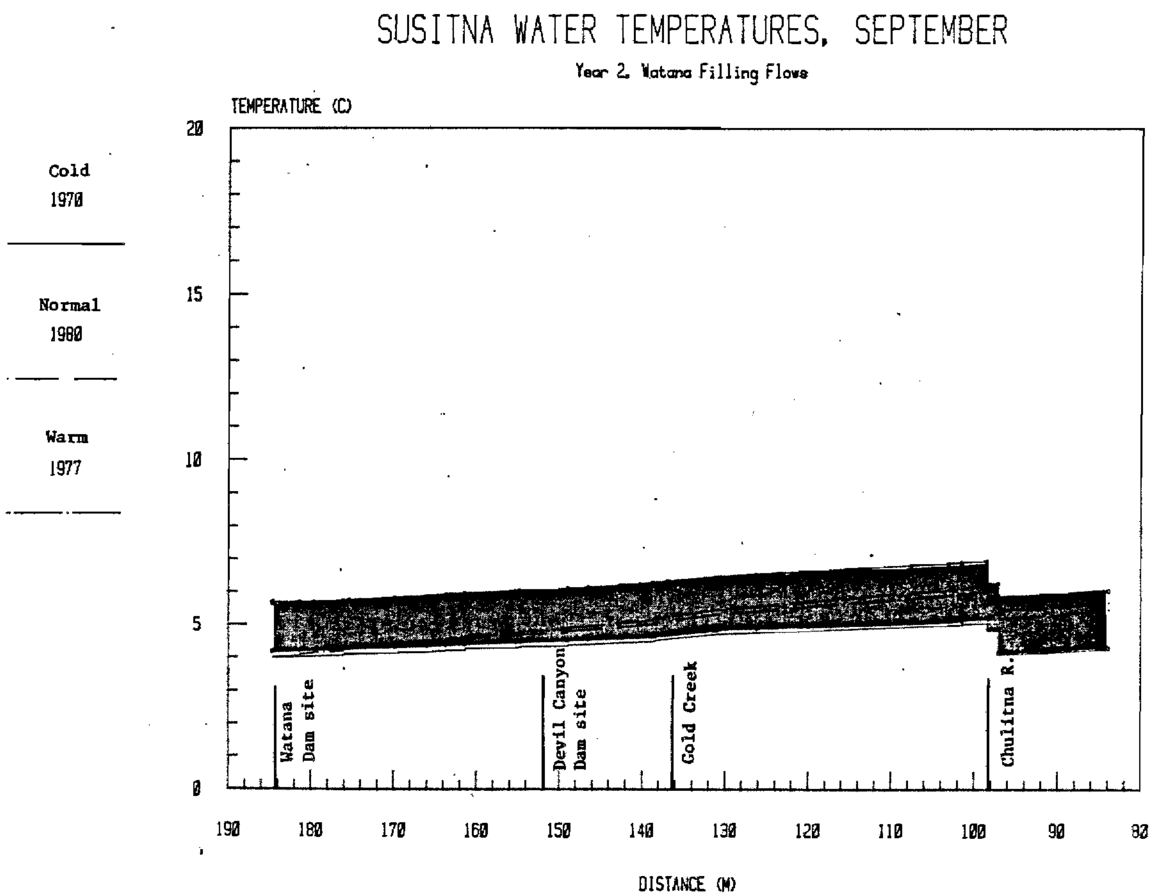


Figure 8 (Continued). River temperature profiles for second year of filling Watana reservoir. Shaded band represents range of simulated natural temperature conditions.





representing June 1970 resulted in a warmer temperature than those produced by the normal (June 1980) condition. This is a result of two factors. First, combinations of meteorology and hydrology were selected for seasonal (sequential June to September) normal, cold and warm temperatures. Thus, even though the natural temperatures expected for June 1970 were lower than the temperatures of June 1980 (refer to Figure 5 and the temperature profiles for natural conditions, Appendix F), June 1970 was not the minimum June and June 1980 was not the average June. We selected seasonal conditions as an initial approach to best represent natural events; we would not expect the coldest June to be followed by the coldest July, August and September.

Second, we have used combinations of existing hydrologic conditions with existing meteorologic conditions. Again, this approach was selected to be more representative of natural events, rather than mixing hydrologic and meteorologic conditions to form a synthetic data set. This appears to be responsible for a number of interesting results. Downstream temperatures simulated under the filling scenario for June 1970 were higher than those for June 1980. The larger tributary inflows during 1980 apparently keep mainstem temperatures low, even though the 4 C reservoir flow release was higher during June 1970 than during June 1980. A similar anomaly appears in July when the normal condition year (1980) produced the warmest temperatures.

Two additional points are brought out in the results of this scenario. The impact of the tributaries on the mainstem is significant, especially in June. The cooler waters of the tributaries and the lower flows in the mainstem combine in their effects to result in a slow recovery to natural conditions. Reduction in the range of temperatures expected downstream is also significant. The temperature profile produced during the second year of filling will fall within a narrow band relatively independently of the hydrology and meteorology occurring during that year.

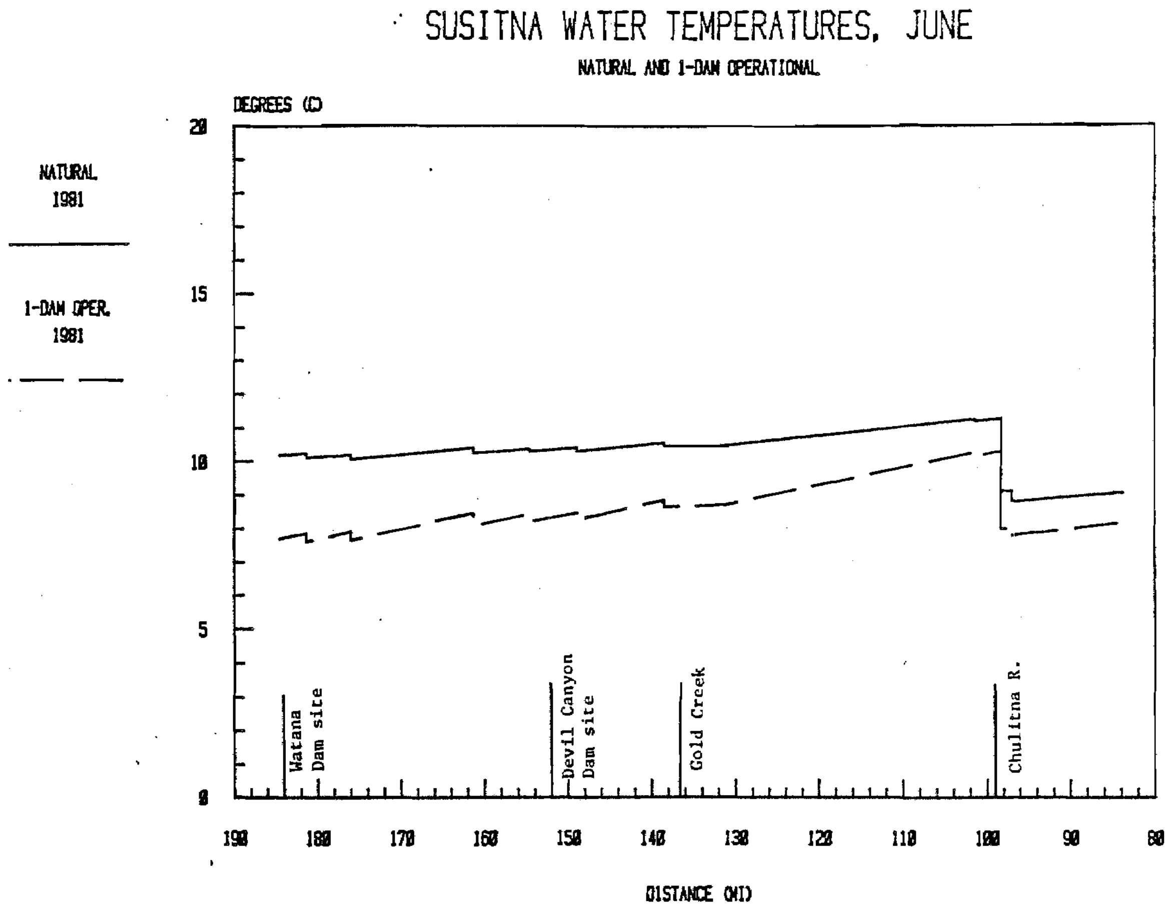
Operational Scenarios. Since reservoir release temperatures are available for only one year and as there is no appropriate technique for estimating release temperatures short of using a reservoir temperature model, we were limited to simulating one-dam and two-dam effects for the single year for which the simulated reservoir release temperatures were available. This has several shortcomings. With only one year of simulation, no estimate of the range of effects is available. Additionally, the year for which the reservoir release temperatures are available (1981) was a normal year based on the seasonal average (seasonal rank was 7 of 15, see Figure 5) but was composed of a warm June (rank = 11) and a cold July (rank = 2). Thus the downstream temperatures predicted using the 1981 meteorology and hydrology will not represent average conditions for June and July. The simulations for Watana-only summer season operation are presented in Figure 9 and the Watana plus Devil Canyon operation are presented in Figure 10.

These simulations imply that there will be observable temperature differences below the Chulitna and Talkeetna confluences. Interpretation of these results should be made with consideration to the low accuracy available from the Chulitna and Talkeetna initial temperature regression models (refer to Figure 2). Fortunately, the regression model for the Chulitna River, which has more influence due to greater flow, is more accurate than the Talkeetna model (AEIDC 1983). As previously stated, 1983 field season data will improve the accuracy of these regression models.

SUMMARY

An analysis was done comparing the natural flow regime of the Susitna River with those expected under operation of a single dam (Watana) and a two-dam project. This provides a direct comparison of operational flows with

Figure 9. River temperature profiles for natural and 1-dam operational conditions.



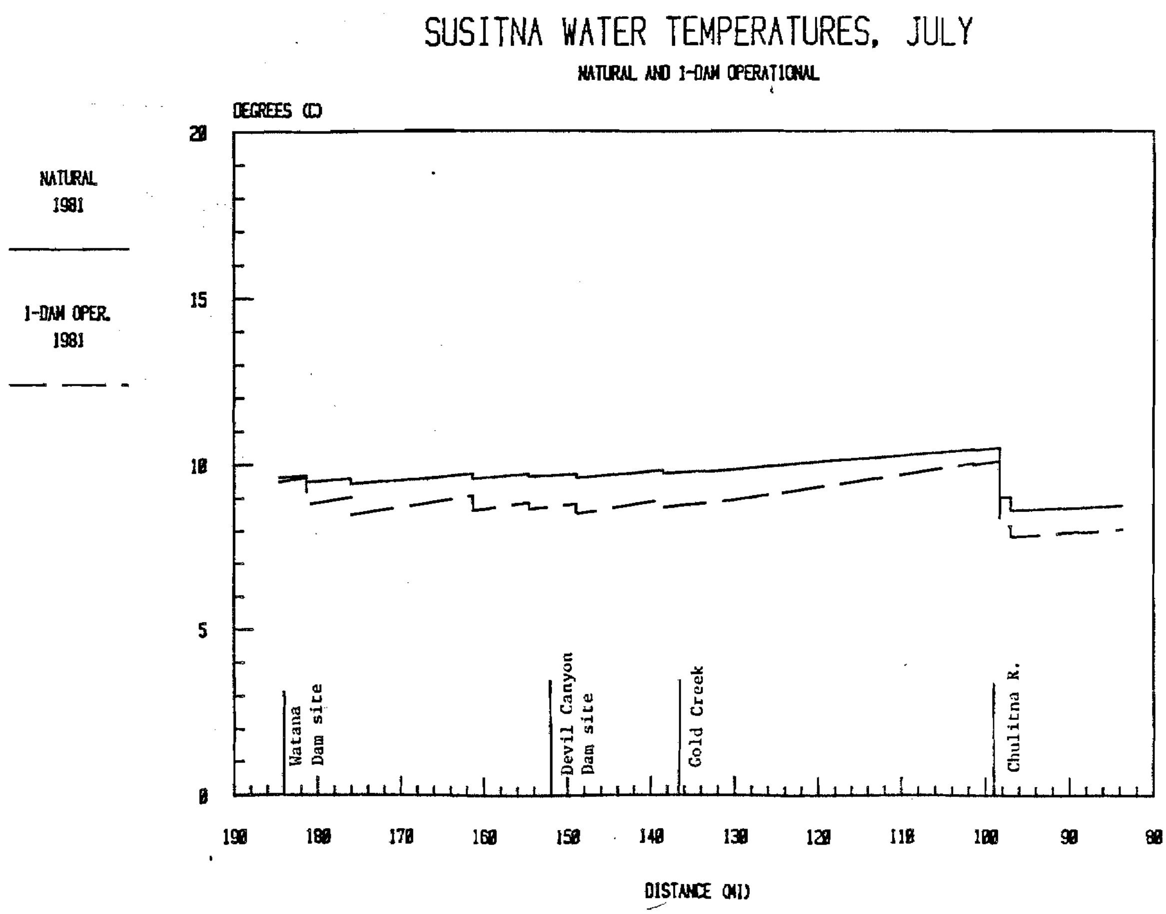
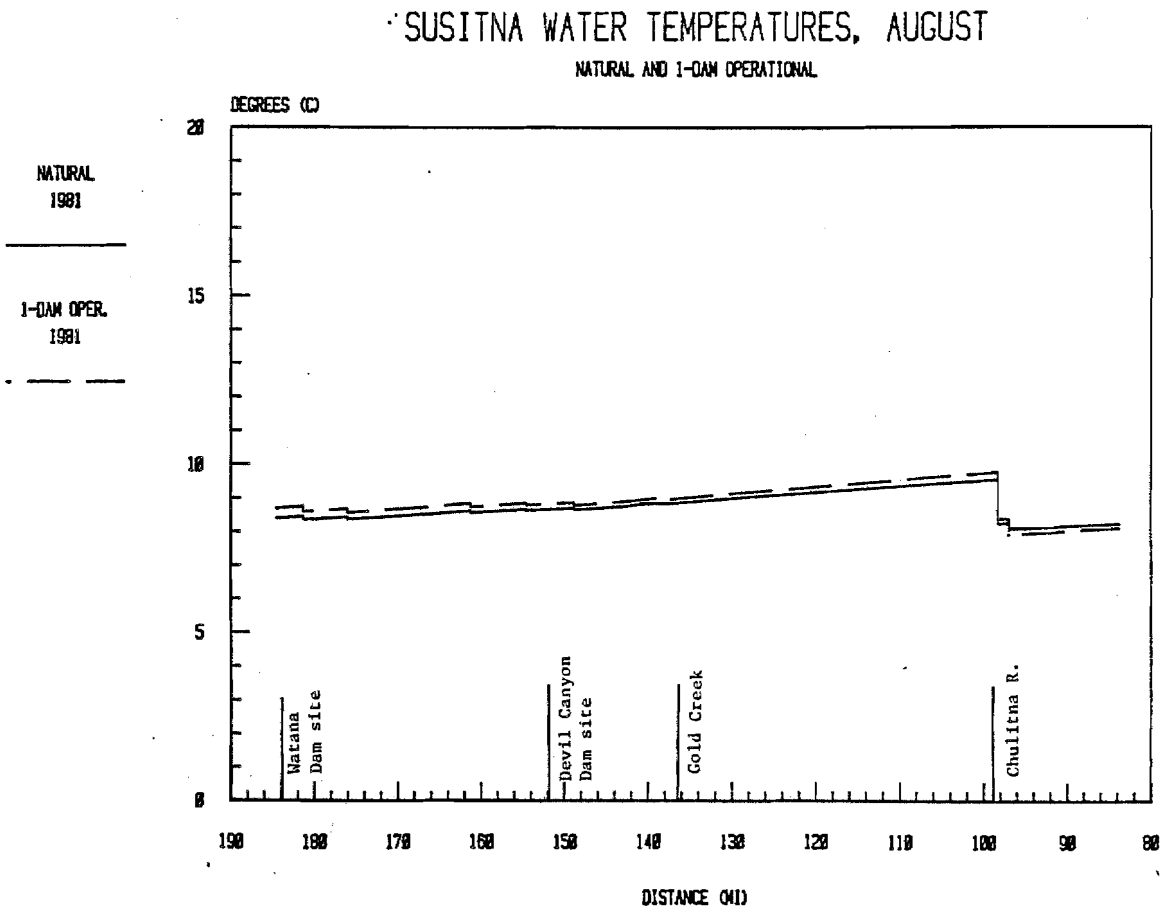


Figure 9 (Continued). River temperature profiles for natural and 1-dam operational conditions.



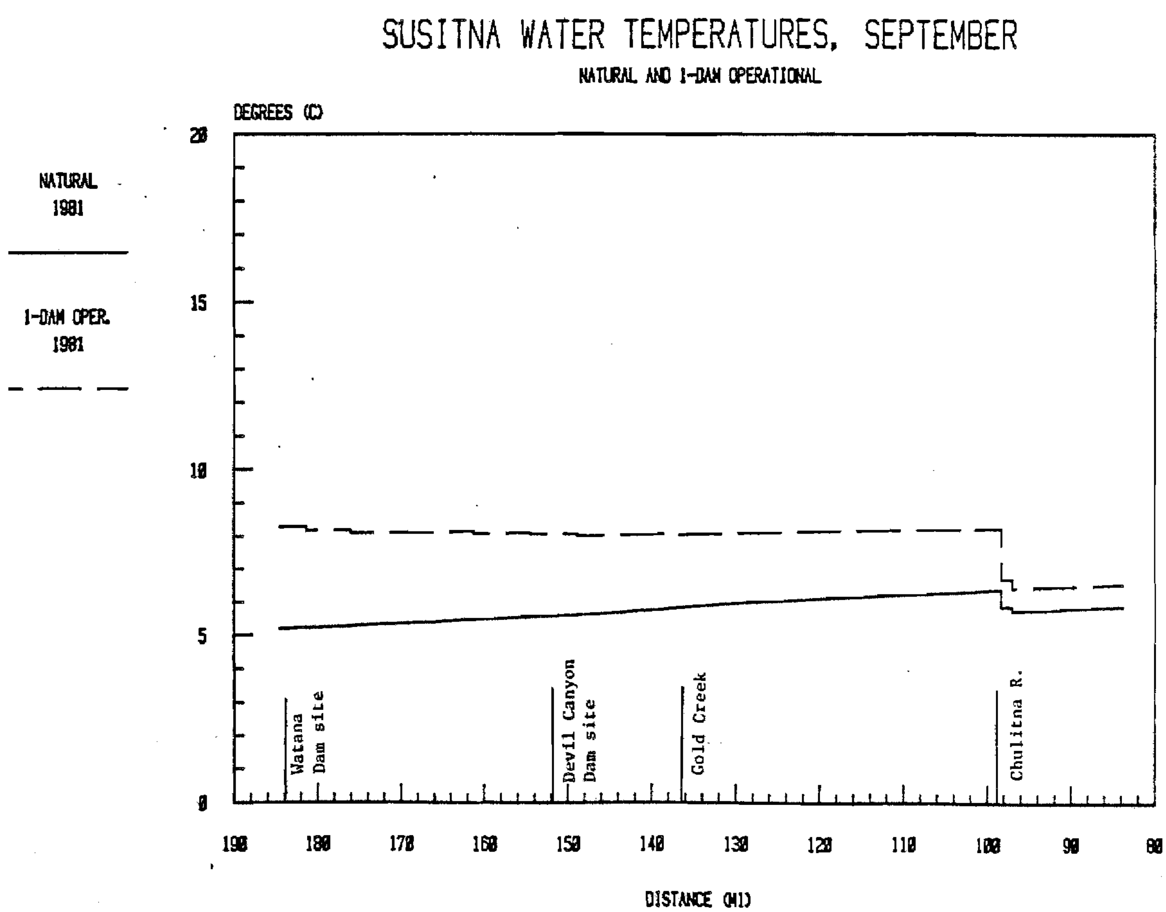
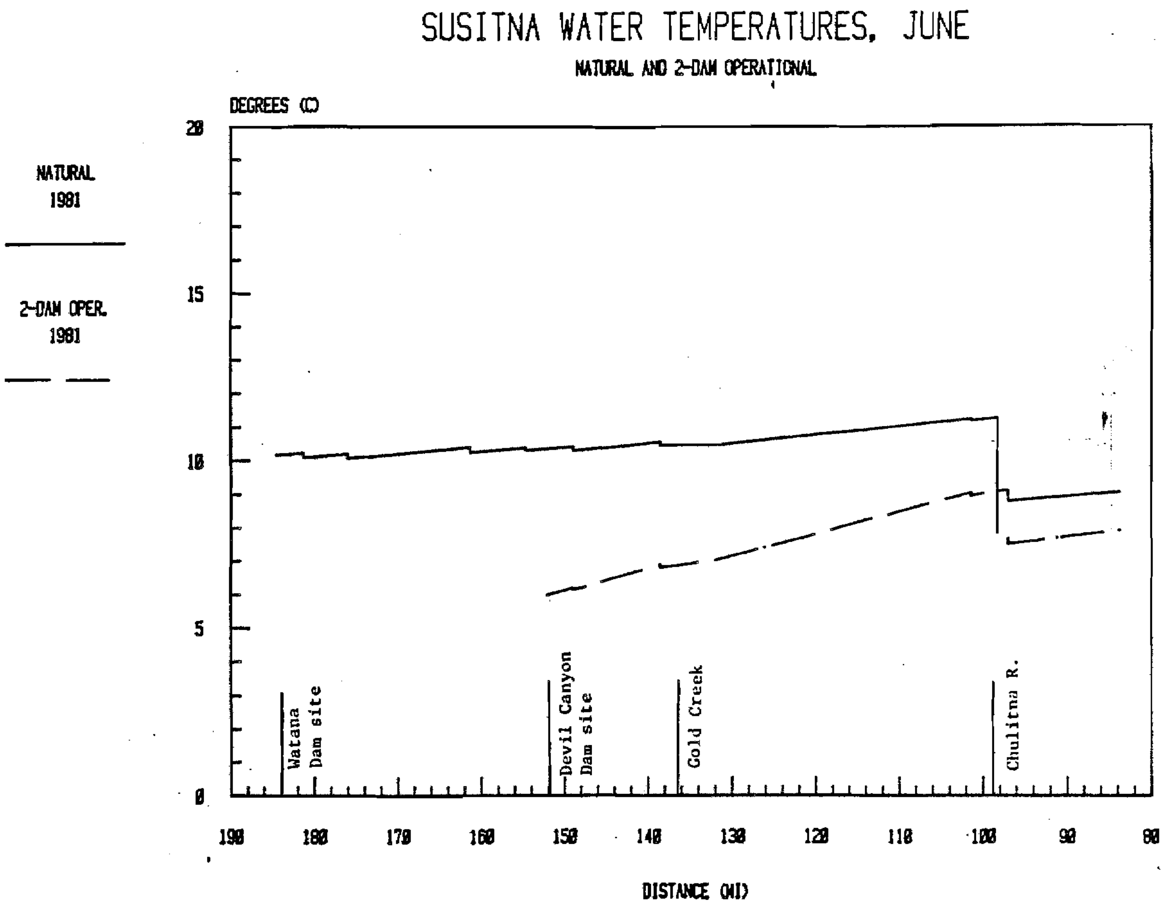


Figure 10. River temperature profiles for natural and 2-dam operational conditions.



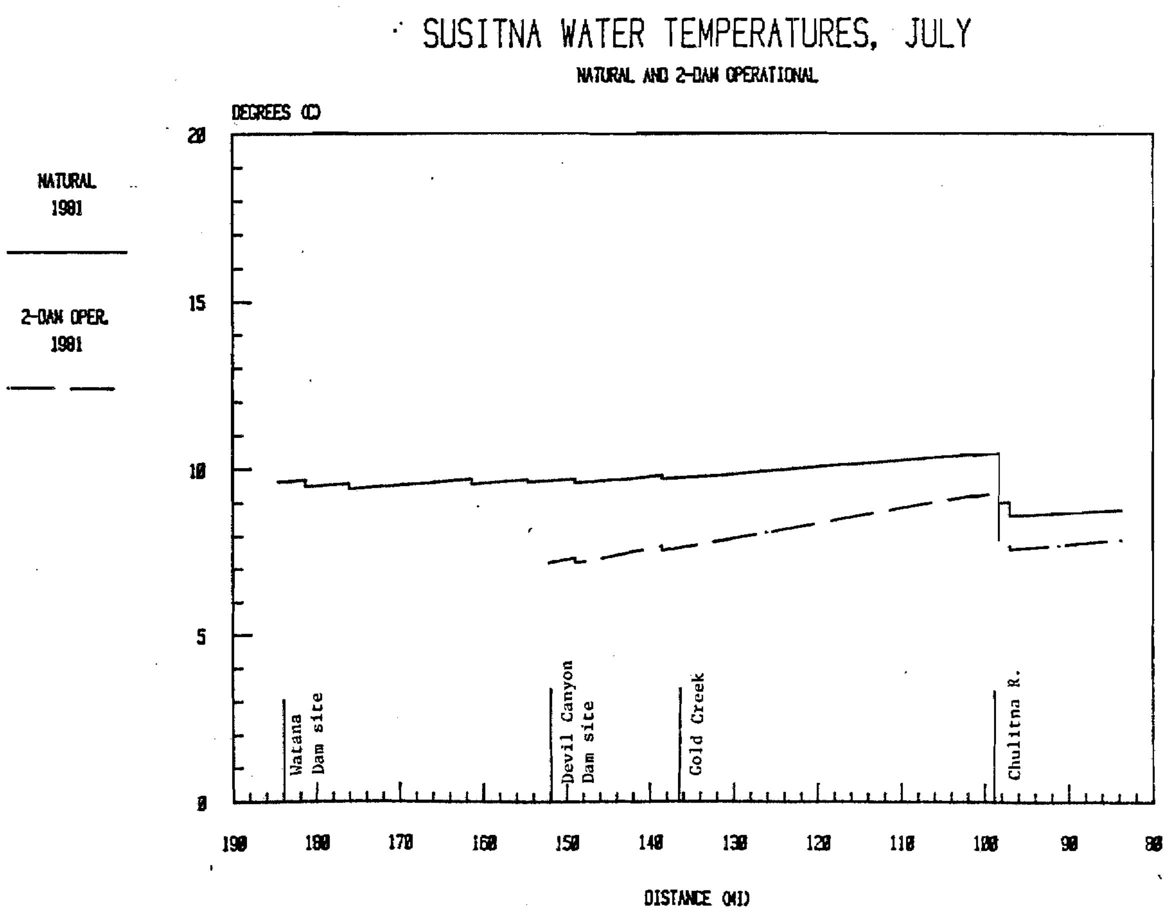
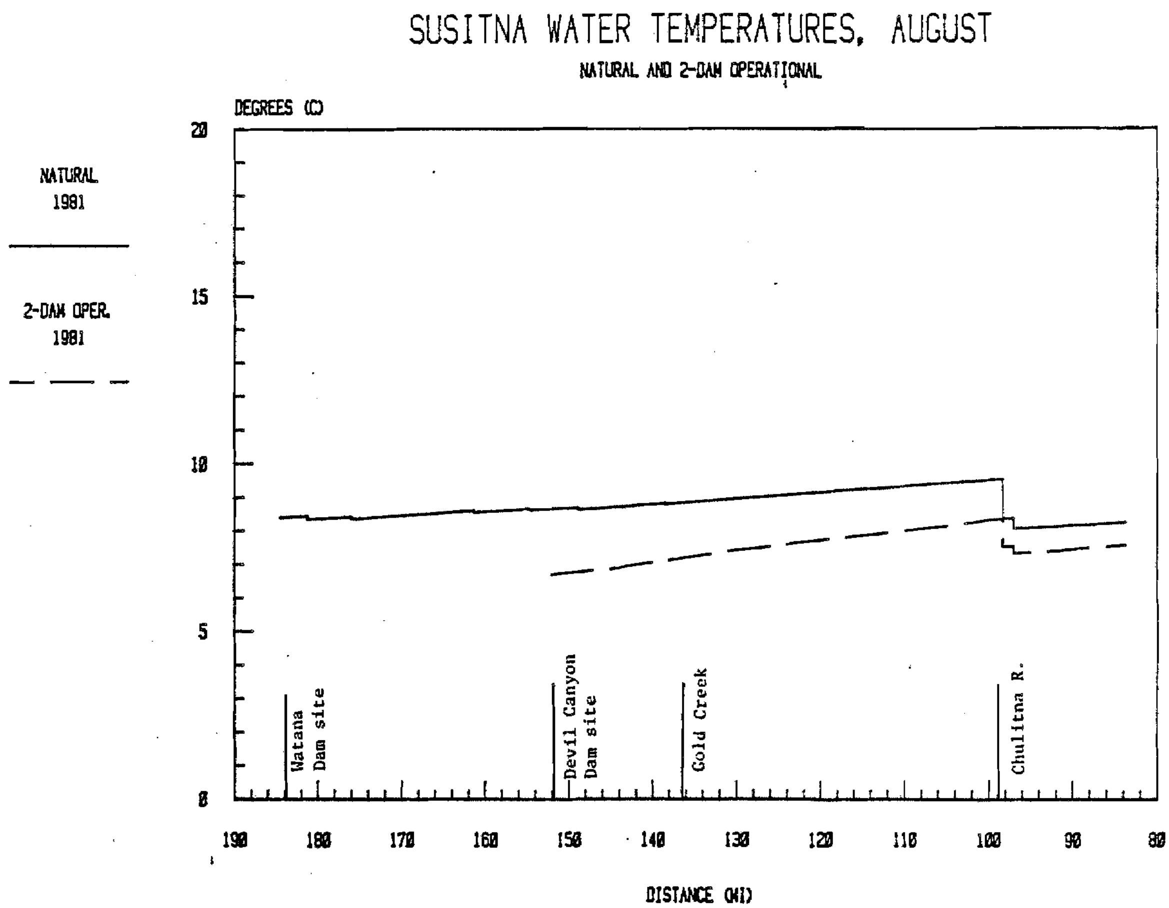
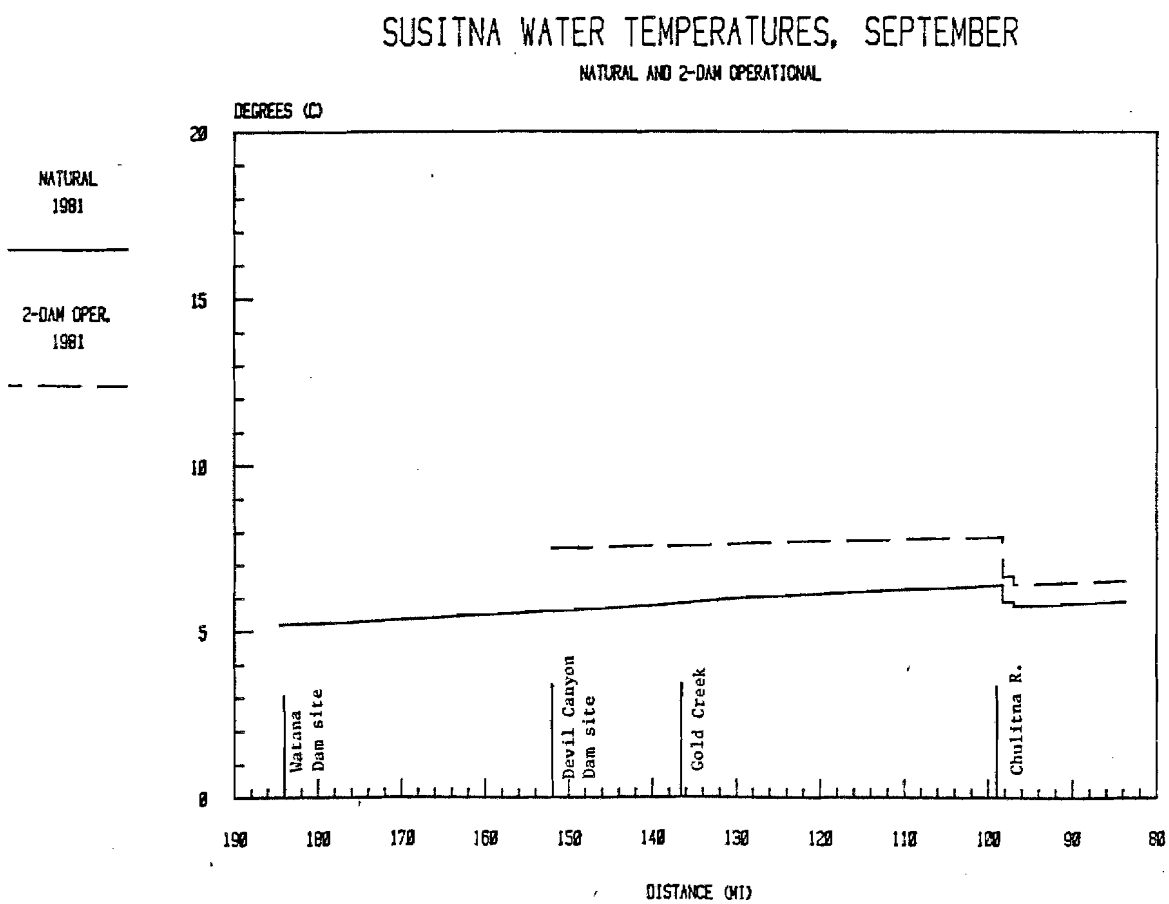


Figure 10 (Continued). River temperature profiles for natural and 2-dam operational conditions.





natural flows during any month at a number of mainstem locations. However, the effort to delineate river reaches where postproject flows differ significantly from natural flows has been unsuccessful. The purpose of this effort was to limit the area where flow-related impacts (other than water quality issues) need to be considered. Being unable to establish these limits, it appears necessary to include the entire length of river below the Watana dam site when considering aquatic habitat effects.

Simulations were done using the SNTEMP model to examine the effects of the project on the downstream temperature regime of the Susitna River. Two scenarios have been simulated thus far, that of the second year of filling the Watana reservoir, and the normal operation of both a single- and two-dam configuration under 1981 summer meteorologic and hydrologic conditions. The filling scenario was run under cold, normal and warm summer conditions in an effort to determine the extent of possible deviations from natural river temperatures.

During June and August of the second year of filling the Watana reservoir, 4 C release waters consistently result in lower-than-normal temperatures as far as the Chulitna River confluence. Beyond this point to Sunshine, the limit of current temperature predictive capabilities of SNTEMP, river temperatures remain approximately 1 C cooler than normal, and under cold meteorological conditions may fall below the temperature range normally encountered. The July temperature regime is similar, but may reach the normal river temperature range before the Chulitna confluence. During all three months, tributaries have greater influence on mainstem temperature than under natural conditions due to the smaller mainstem flows during the filling period. This results in a cooling effect on the mainstem during June and July, and in a warming effect during August. During September when the mainstem river normally has cooled considerably, temperature deviations are smaller and fall very close to the band of normal temperature conditions.

Simulations under 1981 operational conditions show cooler-than-normal river temperatures early in the summer period (June) switching to warmer-than-normal temperatures by September. Thus at some point in late August or early September, operational river temperatures will match those of the natural regime. Both the single- and two-dam schemes show this same pattern, with the two-dam configuration having the greater deviation from the natural temperature regime.

The most serious restriction in this study was the lack of estimates for reservoir release temperatures. We feel that the 1981 DYRESM results cannot be applied when simulating other years. Thus, at this time we are unable to establish a range of downstream temperatures resulting from project operations. There is clearly a need for additional DYRESM simulations for representative years.

Initial condition river temperature estimates based on regression models have been made with very limited data and thus have wide confidence intervals. Incorporating data collected during the 1983 field season will considerably enhance these models and thus the predictive ability of SNTEMP.

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APPENDIX A

FLOW STATISTICS FOR THE SINGLE-DAM SCENARIO

Location by River Mile of H2OBAL Flow Calculation Nodes

NODE	RIVER MILE
Watana	184.4
Tsusena	181.3
Fog	176.0
Devil	161.3
Chinchee	154.6
D.C. Dam	152.0
Portage	148.8
Indian	138.6
Curry	116.8
Whiskers	101.4
Chulitna	98.2
Talkeetna	97.2
Trapper	91.2
Sunshine	83.8
Montana	77.2
Sheep	70.0
Kashwitna	61.2
Little Willow	50.5
Willow	49.8
Deshka	40.6
Susitna Station	25.8

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY OCTOBER

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
WATANA	4522.8	6766.1	49.6	1108.7	1286.4
TSUSENA	4774.6	7017.9	47.0	1172.9	1327.5
FOG	4995.3	7238.6	44.9	1232.1	1367.5
DEVIL	5215.5	7458.9	43.0	1293.5	1411.1
CHINCHEE	5334.3	7577.7	42.1	1327.5	1435.9
PORTAGE	5569.5	7812.8	40.3	1396.4	1487.6
INDIAN	5770.8	8014.1	38.9	1456.8	1534.3
CURRY	5931.9	8175.3	37.8	1486.0	1553.3
WHISKERS	5985.8	8229.2	37.5	1495.8	1559.8
CHULITNA	11397.0	13640.3	19.7	2385.1	2224.7
TALKEET	14145.4	16388.7	15.9	2970.8	2772.5
TRAPPER	14189.9	16433.2	15.8	2980.1	2781.2
SUNSHINE	14286.8	16530.2	15.7	3000.5	2800.1
MONTANA	14835.3	17078.7	15.1	3088.2	2880.7
SHEEP	15298.1	17541.5	14.7	3176.0	2963.7
KASHWIT	16052.3	18295.6	14.0	3343.2	3125.5
LWILLOW	16480.8	18724.1	13.6	3450.2	3230.4
WILLOW	17012.1	19255.5	13.2	3593.5	3372.1
DESHKA	18349.0	20592.4	12.2	3997.7	3775.3
SU STA	31426.9	33670.3	7.1	9270.2	9076.5

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
WATANA	.245	.190	.085	.883	-.741	-.470
TSUSENA	.246	.189	.070	.898	-.768	-.407
FOG	.247	.189	.063	.904	-.780	-.344
DEVIL	.248	.189	.061	.904	-.785	-.279
CHINCHEE	.249	.189	.061	.903	-.785	-.243
PORTAGE	.251	.190	.064	.895	-.782	-.174
INDIAN	.252	.191	.068	.886	-.777	-.119
CURRY	.251	.190	.060	.878	-.787	-.118
WHISKERS	.250	.190	.057	.874	-.790	-.119
CHULITNA	.209	.163	-.003	.187	-.731	-.668
TALKEET	.210	.169	-.022	.179	-.762	-.521
TRAPPER	.210	.169	-.022	.178	-.762	-.522
SUNSHINE	.210	.169	-.022	.175	-.762	-.525
MONTANA	.208	.169	-.004	.190	-.830	-.479
SHEEP	.208	.169	.025	.212	-.832	-.420
KASHWIT	.208	.171	.095	.262	-.740	-.294
LWILLOW	.209	.173	.143	.298	-.648	-.213
WILLOW	.211	.175	.208	.345	-.508	-.108
DESHKA	.218	.183	.375	.471	-.095	.158
SU STA	.295	.270	1.057	1.015	1.697	1.333

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY NOVEMBER

	MAINSTEM FLOWS (CFS)			STANDARD DEVIATION	
LOCATION	PRE-	POST-	% CHANGE	PRE-	POST-
WATANA	2059.0	8667.7	321.0	600.2	1845.7
TSUSENA	2160.9	8769.6	305.8	626.3	1860.1
FOG	2250.2	8858.9	293.7	650.9	1873.5
DEVIL	2339.3	8948.0	282.5	676.9	1887.6
CHINCHEE	2387.4	8996.1	276.8	691.4	1895.5
PORTAGE	2482.6	9091.3	266.2	721.0	1911.7
INDIAN	2564.0	9172.7	257.7	747.3	1926.2
CURRY	2633.3	9242.0	251.0	762.8	1936.6
WHISKERS	2656.4	9265.1	248.8	767.9	1940.1
CHULITNA	4854.2	11462.9	136.1	1201.1	2226.2
TALKEET	6077.9	12686.5	108.7	1446.5	2429.0
TRAPPER	6097.0	12705.7	108.4	1451.1	2432.7
SUNSHINE	6138.6	12747.3	107.7	1461.0	2440.7
MONTANA	6374.2	12982.9	103.7	1532.1	2499.2
SHEEP	6573.0	13181.7	100.5	1596.9	2552.1
KASHWIT	6896.9	13505.6	95.8	1710.7	2644.7
LWILLOW	7081.0	13689.7	93.3	1779.3	2700.6
WILLOW	7309.2	13917.9	90.4	1867.6	2772.9
DESHKA	7883.5	14492.1	83.8	2103.1	2968.2
SU STA	13500.7	20109.4	49.0	4795.2	5403.5

ADDITIONAL STATISTICS

	COEF. OF VARIAT.		SKEW COEFFICIENTS		EXCESS COEFFICIENTS	
LOCATION	PRE-	POST-	PRE-	POST-	PRE-	POST-
WATANA	.291	.213	.462	-.093	.291	-1.575
TSUSENA	.290	.212	.377	-.094	.121	-1.569
FOG	.289	.211	.318	-.096	.012	-1.560
DEVIL	.289	.211	.273	-.097	-.069	-1.549
CHINCHEE	.290	.211	.253	-.098	-.102	-1.541
PORTAGE	.290	.210	.223	-.099	-.152	-1.524
INDIAN	.291	.210	.204	-.099	-.180	-1.507
CURRY	.290	.210	.203	-.095	-.179	-1.498
WHISKERS	.289	.209	.202	-.094	-.179	-1.495
CHULITNA	.247	.194	.271	.045	-.220	-1.120
TALKEET	.238	.191	.230	.062	-.284	-.997
TRAPPER	.238	.191	.230	.062	-.284	-.995
SUNSHINE	.238	.191	.230	.064	-.284	-.989
MONTANA	.240	.193	.343	.123	.048	-.862
SHEEP	.243	.194	.444	.176	.361	-.735
KASHWIT	.248	.196	.612	.268	.900	-.497
LWILLOW	.251	.197	.705	.323	1.209	-.346
WILLOW	.256	.199	.815	.391	1.583	-.148
DESHKA	.267	.205	1.059	.561	2.441	.387
SU STA	.355	.269	1.852	1.531	5.550	4.193

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY DECEMBER

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
WATANA	1414.8	10300.9	628.1	391.3	1930.6
TSUSENA	1494.8	10381.0	594.5	422.6	1944.4
FOG	1565.0	10451.2	567.8	451.0	1956.9
DEVIL	1635.0	10521.2	543.5	480.1	1970.0
CHINCHEE	1672.8	10559.0	531.2	496.0	1977.3
PORTAGE	1747.6	10633.7	508.5	528.0	1992.1
INDIAN	1811.6	10697.8	490.5	555.8	2005.1
CURRY	1860.3	10746.5	477.7	564.8	2010.2
WHISKERS	1876.6	10762.7	473.5	567.7	2011.9
CHULITNA	3418.1	12304.3	260.0	733.2	2087.5
TALKEET	4275.5	13161.6	207.8	879.8	2167.1
TRAPPER	4288.9	13175.1	207.2	882.5	2168.9
SUNSHINE	4318.2	13204.4	205.8	888.6	2172.8
MONTANA	4452.6	13338.8	199.6	923.8	2194.3
SHEEP	4566.0	13452.1	194.6	957.3	2214.4
KASHWIT	4750.8	13636.9	187.0	1018.5	2250.8
LWILLOW	4855.7	13741.9	183.0	1056.3	2273.3
WILLOW	4985.9	13872.1	178.2	1106.0	2303.2
DESHKA	5313.5	14199.6	167.2	1242.0	2386.9
SU STA	8517.5	17403.7	104.3	2891.7	3638.1

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
WATANA	.277	.187	.304	-.614	-.544	-1.345
TSUSENA	.283	.187	.338	-.603	-.397	-1.338
FOG	.288	.187	.373	-.593	-.259	-1.330
DEVIL	.294	.187	.410	-.583	-.121	-1.318
CHINCHEE	.297	.187	.430	-.577	-.048	-1.311
PORTAGE	.302	.187	.468	-.566	.091	-1.296
INDIAN	.307	.187	.500	-.555	.202	-1.280
CURRY	.304	.187	.492	-.552	.183	-1.277
WHISKERS	.303	.187	.489	-.551	.177	-1.276
CHULITNA	.214	.170	-.042	-.541	-.515	-1.207
TALKEET	.206	.165	-.155	-.539	-.435	-1.089
TRAPPER	.206	.165	-.155	-.539	-.435	-1.087
SUNSHINE	.206	.165	-.155	-.538	-.435	-1.084
MONTANA	.207	.165	-.108	-.524	-.436	-1.074
SHEEP	.210	.165	-.058	-.508	-.439	-1.062
KASHWIT	.214	.165	.036	-.476	-.439	-1.037
LWILLOW	.218	.165	.094	-.454	-.433	-1.019
WILLOW	.222	.166	.165	-.424	-.419	-.994
DESHKA	.234	.168	.337	-.337	-.355	-.915
SU STA	.339	.209	.994	.554	.416	.182

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY JANUARY

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
WATANA	1165.5	9399.2	706.4	312.0	1278.9
TSUSENA	1231.3	9465.0	668.7	334.4	1291.6
FOG	1289.0	9522.7	638.8	355.6	1303.4
DEVIL	1346.5	9580.2	611.5	377.8	1315.7
CHINCHEE	1377.6	9611.3	597.7	390.1	1322.5
PORTAGE	1439.0	9672.7	572.2	415.3	1336.5
INDIAN	1491.6	9725.3	552.0	437.4	1349.0
CURRY	1532.4	9766.1	537.3	444.1	1353.2
WHISKERS	1546.0	9779.7	532.6	446.3	1354.6
CHULITNA	2893.9	11127.6	284.5	542.7	1431.0
TALKEET	3579.0	11812.6	230.1	632.1	1487.5
TRAPPER	3590.2	11823.9	229.3	634.1	1488.8
SUNSHINE	3614.8	11848.4	227.8	638.4	1491.8
MONTANA	3756.0	11989.7	219.2	656.2	1497.4
SHEEP	3875.3	12108.9	212.5	672.6	1503.0
KASHWIT	4069.5	12303.2	202.3	701.9	1513.6
LWILLOW	4179.9	12413.6	197.0	719.8	1520.5
WILLOW	4316.8	12550.5	190.7	743.2	1529.8
DESHKA	4661.2	12894.9	176.6	807.3	1557.2
SU STA	8030.0	16263.7	102.5	1613.0	2056.9

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
WATANA	.268	.136	.209	-1.055	-.766	-.426
TSUSENA	.272	.136	.198	-1.036	-.729	-.442
FOG	.276	.137	.195	-1.017	-.707	-.455
DEVIL	.281	.137	.199	-.997	-.687	-.468
CHINCHEE	.283	.138	.204	-.986	-.677	-.474
PORTAGE	.289	.138	.220	-.963	-.652	-.485
INDIAN	.293	.139	.237	-.941	-.627	-.494
CURRY	.290	.139	.237	-.935	-.627	-.497
WHISKERS	.289	.139	.237	-.933	-.627	-.498
CHULITNA	.188	.129	.020	-.901	-.705	-.511
TALKEET	.177	.126	.036	-.832	-.389	-.506
TRAPPER	.177	.126	.036	-.830	-.389	-.506
SUNSHINE	.177	.126	.036	-.827	-.389	-.505
MONTANA	.175	.125	.098	-.802	-.293	-.501
SHEEP	.174	.124	.157	-.777	-.199	-.495
KASHWIT	.172	.123	.261	-.732	-.030	-.479
LWILLOW	.172	.122	.322	-.704	.069	-.467
WILLOW	.172	.122	.396	-.666	.192	-.449
DESHKA	.173	.121	.573	-.559	.481	-.387
SU STA	.201	.126	1.177	.554	1.380	.752

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY FEBRUARY

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
WATANA	983.3	8685.4	783.3	255.8	1260.7
TSUSENA	1041.6	8743.7	739.5	273.9	1268.5
FOG	1092.6	8794.8	704.9	292.1	1276.1
DEVIL	1143.6	8845.7	673.5	312.1	1284.4
CHINCHEE	1171.1	8873.3	657.7	323.4	1289.0
PORTAGE	1225.6	8927.7	628.5	347.0	1298.9
INDIAN	1272.2	8974.3	605.4	368.2	1307.8
CURRY	1306.5	9008.6	589.5	373.7	1310.8
WHISKERS	1318.0	9020.1	584.4	375.5	1311.8
CHULITNA	2443.5	10145.6	315.2	440.4	1373.8
TALKEET	3015.2	10717.3	255.4	519.1	1417.8
TRAPPER	3024.7	10726.8	254.6	520.7	1418.8
SUNSHINE	3045.4	10747.5	252.9	524.3	1420.9
MONTANA	3176.7	10878.8	242.5	541.3	1421.0
SHEEP	3287.5	10989.6	234.3	556.9	1421.9
KASHWIT	3468.0	11170.1	222.1	584.7	1424.6
LWILLOW	3570.6	11272.7	215.7	601.6	1426.8
WILLOW	3697.8	11399.9	208.3	623.7	1430.3
DESHKA	4017.8	11720.0	191.7	683.5	1442.6
SU STA	7148.7	14850.8	107.7	1415.3	1788.6

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
WATANA	.260	.145	.359	-1.314	-.366	.151
TSUSENA	.263	.145	.293	-1.299	-.474	.126
FOG	.267	.145	.259	-1.282	-.580	.104
DEVIL	.273	.145	.253	-1.262	-.652	.080
CHINCHEE	.276	.145	.261	-1.250	-.667	.067
PORTAGE	.283	.145	.297	-1.225	-.642	.042
INDIAN	.289	.146	.343	-1.200	-.561	.022
CURRY	.286	.146	.344	-1.195	-.565	.017
WHISKERS	.285	.145	.344	-1.193	-.567	.015
CHULITNA	.180	.135	.362	-1.141	-.276	-.020
TALKEET	.172	.132	.222	-1.065	-.625	-.088
TRAPPER	.172	.132	.222	-1.063	-.625	-.089
SUNSHINE	.172	.132	.222	-1.059	-.625	-.091
MONTANA	.170	.131	.287	-1.025	-.613	-.119
SHEEP	.169	.129	.342	-.993	-.567	-.140
KASHWIT	.169	.128	.432	-.936	-.439	-.170
LWILLOW	.168	.127	.482	-.902	-.343	-.183
WILLOW	.169	.125	.541	-.856	-.210	-.196
DESHKA	.170	.123	.673	-.731	.157	-.208
SU STA	.198	.120	1.113	.604	1.951	1.181

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY   MARCH

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
WATANA	898.3	8098.4	801.5	257.3	735.3
TSUSENA	946.7	8146.8	760.5	272.7	743.1
FOG	989.2	8189.3	727.9	287.6	750.6
DEVIL	1031.6	8231.7	698.0	303.6	758.8
CHINCHEE	1054.5	8254.5	682.8	312.6	763.5
PORTAGE	1099.7	8299.8	654.7	331.2	773.3
INDIAN	1138.4	8338.5	632.5	347.8	782.2
CURRY	1169.0	8369.1	615.9	353.2	785.0
WHISKERS	1179.2	8379.3	610.6	354.9	785.9
CHULITNA	2184.4	9384.5	329.6	432.7	830.8
TALKEET	2679.6	9879.7	268.7	500.9	874.0
TRAPPER	2688.0	9888.1	267.9	502.5	875.0
SUNSHINE	2706.4	9906.5	266.0	505.9	877.2
MONTANA	2824.9	10025.0	254.9	516.9	881.4
SHEEP	2924.8	10124.9	246.2	526.7	885.3
KASHWIT	3087.7	10287.8	233.2	543.7	892.4
LWILLOW	3180.2	10380.3	226.4	553.9	896.9
WILLOW	3295.0	10495.1	218.5	567.0	903.0
DESHKA	3583.7	10783.8	200.9	602.0	920.1
SU STA	6408.0	13608.1	112.4	1033.9	1207.8

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
WATANA	.286	.091	.762	-1.396	.152	1.123
TSUSENA	.288	.091	.738	-1.360	.078	1.090
FOG	.291	.092	.719	-1.324	-.003	1.056
DEVIL	.294	.092	.706	-1.284	-.086	1.020
CHINCHEE	.296	.092	.702	-1.261	-.127	.998
PORTAGE	.301	.093	.699	-1.213	-.198	.955
INDIAN	.306	.094	.701	-1.168	-.243	.918
CURRY	.302	.094	.700	-1.152	-.244	.899
WHISKERS	.301	.094	.700	-1.147	-.244	.893
CHULITNA	.198	.089	.489	-.926	-.490	.595
TALKEET	.187	.088	.574	-.724	-.112	.458
TRAPPER	.187	.088	.574	-.720	-.112	.455
SUNSHINE	.187	.089	.574	-.711	-.112	.448
MONTANA	.183	.088	.613	-.655	-.018	.406
SHEEP	.180	.087	.647	-.606	.068	.375
KASHWIT	.176	.087	.703	-.522	.219	.335
LWILLOW	.174	.086	.734	-.472	.308	.318
WILLOW	.172	.086	.772	-.410	.419	.302
DESHKA	.168	.085	.862	-.249	.692	.292
SU STA	.161	.089	1.248	1.011	1.860	1.367

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY APRIL

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
WATANA	1099.7	7478.1	580.0	301.0	810.6
TSUSENA	1156.8	7535.3	551.4	318.7	820.9
FOG	1206.8	7585.3	528.5	336.5	831.0
DEVIL	1256.8	7635.3	507.5	356.1	842.1
CHINCHEE	1283.8	7662.2	496.9	367.4	848.5
PORTAGE	1337.1	7715.6	477.0	390.8	862.1
INDIAN	1382.8	7761.2	461.3	411.9	874.5
CURRY	1419.7	7798.1	449.3	419.0	877.4
WHISKERS	1432.0	7810.5	445.4	421.3	878.5
CHULITNA	2660.7	9039.1	239.7	568.0	935.3
TALKEET	3238.8	9617.3	196.9	678.4	1001.5
TRAPPER	3249.0	9627.5	196.3	680.5	1002.9
SUNSHINE	3271.2	9649.7	195.0	685.2	1005.9
MONTANA	3398.0	9776.4	187.7	701.4	1020.2
SHEEP	3504.9	9883.4	182.0	715.9	1032.9
KASHWIT	3679.1	10057.6	173.4	741.2	1054.9
LWILLOW	3778.1	10156.6	168.8	756.3	1068.0
WILLOW	3900.9	10279.4	163.5	775.8	1084.8
DESHKA	4209.8	10588.2	151.5	828.2	1130.0
SU STA	7231.3	13609.8	88.2	1472.8	1707.9

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
WATANA	.274	.108	.669	-1.423	.766	1.275
TSUSENA	.275	.109	.704	-1.366	1.052	1.201
FOG	.279	.110	.732	-1.309	1.219	1.132
DEVIL	.283	.110	.763	-1.246	1.329	1.061
CHINCHEE	.286	.111	.781	-1.210	1.373	1.024
PORTAGE	.292	.112	.819	-1.134	1.444	.953
INDIAN	.298	.113	.855	-1.066	1.497	.896
CURRY	.295	.113	.855	-1.040	1.494	.868
WHISKERS	.294	.112	.854	-1.032	1.493	.859
CHULITNA	.213	.103	.792	-.490	1.453	.469
TALKEET	.209	.104	.801	-.143	.988	.234
TRAPPER	.209	.104	.801	-.137	.988	.233
SUNSHINE	.209	.104	.801	-.125	.988	.231
MONTANA	.206	.104	.841	-.085	1.016	.245
SHEEP	.204	.105	.875	-.051	1.048	.262
KASHWIT	.201	.105	.930	.007	1.114	.301
LWILLOW	.200	.105	.961	.040	1.159	.329
WILLOW	.199	.106	.998	.082	1.221	.369
DESHKA	.197	.107	1.086	.187	1.398	.491
SU STA	.204	.125	1.482	.929	2.823	1.958

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY MAY

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
WATANA	10354.6	7519.7	-27.4	3209.8	2088.0
TSUSENA	10957.3	8122.3	-25.9	3385.8	2242.5
FOG	11485.2	8650.3	-24.7	3555.5	2403.2
DEVIL	12012.3	9177.4	-23.6	3737.2	2582.7
CHINCHEE	12296.7	9461.7	-23.1	3839.7	2686.1
PORTAGE	12859.3	10024.4	-22.0	4050.8	2901.9
INDIAN	13341.0	10506.1	-21.2	4239.1	3096.6
CURRY	13657.1	10822.2	-20.8	4320.8	3173.5
WHISKERS	13762.8	10927.8	-20.6	4348.2	3199.4
CHULITNA	23570.9	20736.0	-12.0	7412.1	6441.1
TALKEET	27743.3	24908.4	-10.2	8372.3	7351.7
TRAPPER	27830.6	24995.7	-10.2	8398.6	7377.6
SUNSHINE	28020.9	25185.9	-10.1	8456.0	7434.1
MONTANA	29096.9	26261.9	-9.7	8521.1	7494.3
SHEEP	30004.7	27169.8	-9.4	8587.3	7558.0
KASHWIT	31484.2	28649.3	-9.0	8716.9	7686.5
LWILLOW	32324.9	29489.9	-8.8	8802.0	7772.6
WILLOW	33367.3	30532.3	-8.5	8918.8	7892.0
DESHKA	35990.0	33155.1	-7.9	9264.3	8250.1
SU STA	61646.0	58811.1	-4.6	15113.7	14344.0

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
WATANA	.310	.278	-.595	.637	.412	-.313
TSUSENA	.309	.276	-.597	.641	.507	-.171
FOG	.310	.278	-.585	.622	.539	-.114
DEVIL	.311	.281	-.564	.594	.535	-.102
CHINCHEE	.312	.284	-.549	.578	.523	-.108
PORTAGE	.315	.289	-.517	.546	.482	-.133
INDIAN	.318	.295	-.485	.522	.436	-.162
CURRY	.316	.293	-.493	.492	.423	-.210
WHISKERS	.316	.293	-.496	.482	.419	-.225
CHULITNA	.314	.311	-.270	.196	.132	-.269
TALKEET	.302	.295	-.321	.095	.142	-.243
TRAPPER	.302	.295	-.321	.094	.142	-.242
SUNSHINE	.302	.295	-.321	.092	.142	-.240
MONTANA	.293	.285	-.341	.071	.168	-.252
SHEEP	.286	.278	-.352	.059	.188	-.259
KASHWIT	.277	.268	-.360	.049	.217	-.264
LWILLOW	.272	.264	-.359	.048	.232	-.264
WILLOW	.267	.258	-.353	.052	.249	-.260
DESHKA	.257	.249	-.314	.081	.280	-.239
SU STA	.245	.244	.323	.525	.119	-.078

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY JUNE

	MAINSTEM FLOWS (CFS)			STANDARD DEVIATION	
LOCATION	PRE-	POST-	% CHANGE	PRE-	POST-
WATANA	23023.7	6628.4	-71.2	6208.7	3382.8
TSUSENA	23997.9	7602.6	-68.3	6468.5	3600.5
FOG	24851.3	8456.1	-66.0	6702.4	3806.6
DEVIL	25703.4	9308.1	-63.8	6941.1	4024.5
CHINCHEE	26162.9	9767.6	-62.7	7071.9	4146.3
PORTAGE	27072.4	10677.1	-60.6	7334.3	4395.1
INDIAN	27851.0	11455.8	-58.9	7562.7	4615.3
CURRY	28579.7	12184.5	-57.4	7725.2	4764.4
WHISKERS	28823.3	12428.1	-56.9	7779.6	4814.6
CHULITNA	52400.5	36005.2	-31.3	11963.1	9179.9
TALKEET	63957.6	47562.3	-25.6	15000.0	11987.4
TRAPPER	64158.9	47763.6	-25.6	15047.2	12034.0
SUNSHINE	64597.4	48202.1	-25.4	15150.1	12135.4
MONTANA	66517.9	50122.6	-24.6	15366.8	12326.1
SHEEP	68138.3	51743.0	-24.1	15569.4	12512.3
KASHWIT	70779.1	54383.8	-23.2	15936.9	12862.4
LWILLOW	72279.5	55884.2	-22.7	16164.2	13085.6
WILLOW	74140.0	57744.7	-22.1	16465.2	13385.3
DESHKA	78821.3	62426.0	-20.8	17305.6	14240.7
SU STA	124613.8	108218.5	-13.2	29227.0	26666.1

ADDITIONAL STATISTICS

	COEF. OF VARIAT.		SKEW COEFFICIENTS		EXCESS COEFFICIENTS	
LOCATION	PRE-	POST-	PRE-	POST-	PRE-	POST-
WATANA	.270	.510	1.101	2.522	2.489	6.122
TSUSENA	.270	.474	1.054	2.412	2.313	5.660
FOG	.270	.450	1.013	2.289	2.160	5.194
DEVIL	.270	.432	.972	2.155	2.010	4.716
CHINCHEE	.270	.424	.950	2.081	1.932	4.462
PORTAGE	.271	.412	.907	1.935	1.782	3.981
INDIAN	.272	.403	.871	1.814	1.659	3.597
CURRY	.270	.391	.872	1.793	1.666	3.544
WHISKERS	.270	.387	.873	1.786	1.669	3.527
CHULITNA	.228	.255	1.316	1.771	3.305	4.422
TALKEET	.235	.252	.964	1.321	1.949	2.655
TRAPPER	.235	.252	.964	1.320	1.949	2.653
SUNSHINE	.235	.252	.964	1.318	1.949	2.648
MONTANA	.231	.246	.872	1.208	1.626	2.227
SHEEP	.228	.242	.798	1.116	1.365	1.882
KASHWIT	.225	.237	.682	.970	.970	1.355
LWILLOW	.224	.234	.621	.891	.764	1.082
WILLOW	.222	.232	.550	.800	.530	.773
DESHKA	.220	.228	.397	.605	.046	.153
SU STA	.235	.246	.143	.283	-.522	-.377

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY JULY

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
WATANA	20810.0	5549.6	-73.3	3484.0	1473.1
TSUSENA	21555.8	6295.4	-70.8	3659.6	1611.9
FOG	22209.2	6948.8	-68.7	3817.9	1748.5
DEVIL	22861.5	7601.1	-66.8	3979.4	1895.6
CHINCHEE	23213.3	7952.9	-65.7	4067.8	1978.6
PORTAGE	23909.6	8649.2	-63.8	4245.3	2149.0
INDIAN	24505.7	9245.3	-62.3	4399.6	2300.3
CURRY	25238.4	9978.0	-60.5	4497.1	2392.5
WHISKERS	25483.4	10222.9	-59.9	4529.7	2423.5
CHULITNA	53167.0	37906.5	-28.7	7644.7	5808.8
TALKEET	64309.8	49049.3	-23.7	9266.1	7320.4
TRAPPER	64512.1	49251.7	-23.7	9295.2	7349.1
SUNSHINE	64953.0	49692.6	-23.5	9358.7	7411.7
MONTANA	67180.1	51919.7	-22.7	9458.2	7497.8
SHEEP	69059.2	53798.8	-22.1	9550.8	7581.8
KASHWIT	72121.5	56861.0	-21.2	9718.4	7739.9
LWILLOW	73861.4	58600.9	-20.7	9822.4	7840.9
WILLOW	76018.9	60758.4	-20.1	9959.8	7976.9
DESHKA	81447.4	66187.0	-18.7	10344.9	8367.7
SU STA	134549.6	119289.1	-11.3	16035.1	14357.6

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
WATANA	.167	.265	.587	1.693	-.042	1.857
TSUSENA	.170	.256	.610	1.653	.012	1.951
FOG	.172	.252	.627	1.586	.052	1.917
DEVIL	.174	.249	.641	1.508	.088	1.817
CHINCHEE	.175	.249	.647	1.465	.104	1.748
PORTAGE	.178	.248	.657	1.382	.133	1.596
INDIAN	.180	.249	.664	1.315	.153	1.463
CURRY	.178	.240	.655	1.276	.138	1.349
WHISKERS	.178	.237	.652	1.263	.133	1.312
CHULITNA	.144	.153	.458	.721	-.455	-.144
TALKEET	.144	.149	.354	.501	-.370	-.273
TRAPPER	.144	.149	.354	.501	-.370	-.274
SUNSHINE	.144	.149	.354	.499	-.370	-.276
MONTANA	.141	.144	.368	.532	-.322	-.159
SHEEP	.138	.141	.381	.562	-.274	-.048
KASHWIT	.135	.136	.404	.610	-.184	.152
LWILLOW	.133	.134	.417	.638	-.127	.274
WILLOW	.131	.131	.434	.673	-.051	.430
DESHKA	.127	.126	.478	.754	.158	.830
SU STA	.119	.120	.731	.991	1.666	2.478

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY AUGUST

	MAINSTEM FLOWS (CFS)			STANDARD DEVIATION	
LOCATION	PRE-	POST-	% CHANGE	PRE-	POST-
WATANA	18628.1	9778.8	-47.5	4102.8	2562.8
TSUSENA	19350.4	10501.1	-45.7	4284.1	2638.9
FOG	19983.2	11133.9	-44.3	4451.6	2728.0
DEVIL	20614.9	11765.6	-42.9	4626.1	2835.8
CHINCHEE	20955.6	12106.4	-42.2	4722.8	2901.0
PORTAGE	21629.9	12780.7	-40.9	4919.3	3043.1
INDIAN	22207.3	13358.0	-39.8	5092.4	3177.1
CURRY	22853.1	14003.8	-38.7	5214.6	3276.7
WHISKERS	23069.0	14219.7	-38.4	5255.6	3310.6
CHULITNA	46115.6	37266.4	-19.2	9078.7	7353.7
TALKEET	56684.8	47835.6	-15.6	11761.1	9691.7
TRAPPER	56863.2	48013.9	-15.6	11798.1	9727.9
SUNSHINE	57251.8	48402.6	-15.5	11878.8	9806.6
MONTANA	59065.7	50216.4	-15.0	11921.9	9826.9
SHEEP	60596.2	51746.9	-14.6	11966.8	9854.4
KASHWIT	63090.2	54241.0	-14.0	12055.9	9919.0
LWILLOW	64507.3	55658.1	-13.7	12115.4	9966.6
WILLOW	66264.5	57415.3	-13.4	12197.8	10036.3
DESHKA	70685.8	61836.6	-12.5	12446.3	10262.4
SU STA	113935.4	105086.2	-7.8	17221.9	15231.8

ADDITIONAL STATISTICS

	COEF. OF VARIAT.		SKEW COEFFICIENTS		EXCESS COEFFICIENTS	
LOCATION	PRE-	POST-	PRE-	POST-	PRE-	POST-
WATANA	.220	.262	1.414	2.380	2.421	6.542
TSUSENA	.221	.251	1.428	2.646	2.426	7.673
FOG	.223	.245	1.439	2.810	2.412	8.395
DEVIL	.224	.241	1.447	2.913	2.387	8.842
CHINCHEE	.225	.240	1.450	2.946	2.369	8.976
PORTAGE	.227	.238	1.455	2.972	2.329	9.047
INDIAN	.229	.238	1.458	2.961	2.290	8.943
CURRY	.228	.234	1.449	2.944	2.269	8.844
WHISKERS	.228	.233	1.446	2.937	2.262	8.805
CHULITNA	.197	.197	1.112	1.731	2.296	4.318
TALKEET	.207	.203	.801	1.145	1.210	2.434
TRAPPER	.207	.203	.801	1.143	1.210	2.430
SUNSHINE	.207	.203	.801	1.140	1.210	2.420
MONTANA	.202	.196	.820	1.173	1.216	2.465
SHEEP	.197	.190	.834	1.196	1.216	2.493
KASHWIT	.191	.183	.849	1.222	1.209	2.514
LWILLOW	.188	.179	.854	1.232	1.201	2.513
WILLOW	.184	.175	.858	1.238	1.188	2.501
DESHKA	.176	.166	.851	1.227	1.139	2.416
SU STA	.151	.145	.317	.434	.447	.746

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY SEPTEMB

	MAINSTEM FLOWS (CFS)			STANDARD DEVIATION	
LOCATION	PRE-	POST-	% CHANGE	PRE-	POST-
WATANA	10791.9	7310.8	-32.3	3044.8	1165.8
TSUSENA	11306.2	7825.1	-30.8	3211.7	1091.9
FOG	11756.7	8275.6	-29.6	3365.5	1069.5
DEVIL	12206.5	8725.4	-28.5	3525.4	1089.2
CHINCHEE	12449.1	8968.0	-28.0	3613.9	1116.7
PORTAGE	12929.2	9448.1	-26.9	3793.2	1202.1
INDIAN	13340.2	9859.1	-26.1	3950.6	1302.7
CURRY	13702.4	10221.3	-25.4	4043.0	1374.2
WHISKERS	13823.4	10342.3	-25.2	4074.0	1398.9
CHULITNA	25768.0	22286.9	-13.5	7098.0	4809.1
TALKEET	31786.3	28305.2	-11.0	8835.8	6416.9
TRAPPER	31886.3	28405.2	-10.9	8863.6	6443.4
SUNSHINE	32104.2	28623.1	-10.8	8924.2	6501.3
MONTANA	33241.7	29760.6	-10.5	9021.0	6608.4
SHEEP	34201.5	30720.4	-10.2	9114.8	6715.1
KASHWIT	35765.6	32284.5	-9.7	9290.7	6919.0
LWILLOW	36654.3	33173.2	-9.5	9402.9	7050.5
WILLOW	37756.3	34275.1	-9.2	9553.6	7228.0
DESHKA	40529.0	37047.8	-8.6	9986.2	7738.7
SU STA	67651.7	64170.6	-5.1	16667.4	15167.0

ADDITIONAL STATISTICS

	COEF. OF VARIAT.		SKEW COEFFICIENTS		EXCESS COEFFICIENTS	
LOCATION	PRE-	POST-	PRE-	POST-	PRE-	POST-
WATANA	.282	.159	.257	.131	-.382	.948
TSUSENA	.284	.140	.260	.587	-.401	1.504
FOG	.286	.129	.267	1.058	-.420	1.987
DEVIL	.289	.125	.276	1.466	-.438	2.368
CHINCHEE	.290	.125	.282	1.623	-.448	2.499
PORTAGE	.293	.127	.295	1.782	-.467	2.583
INDIAN	.296	.132	.307	1.790	-.482	2.498
CURRY	.295	.134	.307	1.800	-.489	2.627
WHISKERS	.295	.135	.307	1.799	-.491	2.657
CHULITNA	.275	.216	.654	1.856	.577	4.702
TALKEET	.278	.227	.613	1.403	.357	2.966
TRAPPER	.278	.227	.613	1.399	.357	2.953
SUNSHINE	.278	.227	.613	1.391	.357	2.927
MONTANA	.271	.222	.598	1.366	.375	2.878
SHEEP	.267	.219	.582	1.334	.383	2.804
KASHWIT	.260	.214	.551	1.266	.381	2.626
LWILLOW	.257	.213	.532	1.221	.372	2.502
WILLOW	.253	.211	.507	1.160	.354	2.333
DESHKA	.246	.209	.441	1.002	.278	1.869
SU STA	.246	.236	.119	.291	-.528	-.211

APPENDIX B

FLOW STATISTICS FOR THE LOG-TRANSFORMED DATA, SINGLE-DAM SCENARIO

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY JUNE

LOCATION	MAINSTEM FLOWS (LN CFS) PRE-	POST-	STANDARD DEVIATION PRE-	POST-
WATANA	10.011	8.718	.259	.368
TSUSENA	10.053	8.863	.260	.353
FOG	10.087	8.974	.261	.347
DEVIL	10.121	9.073	.262	.343
CHINCHEE	10.138	9.122	.263	.343
PORTAGE	10.172	9.213	.265	.342
INDIAN	10.200	9.284	.266	.343
CURRY	10.226	9.349	.265	.334
WHISKERS	10.235	9.369	.264	.332
CHULITNA	10.844	10.465	.214	.227
TALKEET	11.041	10.742	.227	.234
TRAPPER	11.044	10.746	.227	.234
SUNSHINE	11.051	10.756	.227	.234
MONTANA	11.081	10.796	.225	.231
SHEEP	11.105	10.828	.223	.229
KASHWIT	11.143	10.878	.222	.226
LWILLOW	11.165	10.906	.221	.225
WILLOW	11.190	10.939	.221	.225
DESHKA	11.252	11.017	.221	.224
SU STA	11.705	11.562	.243	.253

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
WATANA	.026	.042	.174	1.881	.557	2.989
TSUSENA	.026	.040	.151	1.737	.479	2.606
FOG	.026	.039	.128	1.552	.411	2.169
DEVIL	.026	.038	.105	1.354	.344	1.742
CHINCHEE	.026	.038	.093	1.248	.310	1.530
PORTAGE	.026	.037	.068	1.052	.243	1.163
INDIAN	.026	.037	.046	.899	.190	.902
CURRY	.026	.036	.050	.893	.195	.901
WHISKERS	.026	.035	.052	.891	.196	.899
CHULITNA	.020	.022	.466	.921	1.050	1.654
TALKEET	.021	.022	.199	.527	.488	.827
TRAPPER	.021	.022	.199	.526	.488	.825
SUNSHINE	.021	.022	.199	.524	.488	.822
MONTANA	.020	.021	.155	.467	.344	.628
SHEEP	.020	.021	.119	.418	.227	.464
KASHWIT	.020	.021	.063	.339	.051	.212
LWILLOW	.020	.021	.034	.297	-.040	.083
WILLOW	.020	.021	-.001	.246	-.142	-.061
DESHKA	.020	.020	-.077	.134	-.342	-.335
SU STA	.021	.022	-.340	-.260	-.127	-.033

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY JULY

	MAINSTEM FLOWS (LN CFS)		STANDARD DEVIATION	
LOCATION	PRE-	POST-	PRE-	POST-
WATANA	9.930	8.594	.164	.228
TSUSENA	9.965	8.721	.166	.223
FOG	9.994	8.821	.168	.221
DEVIL	10.023	8.910	.170	.222
CHINCHEE	10.038	8.956	.171	.223
PORTAGE	10.067	9.039	.173	.225
INDIAN	10.092	9.105	.175	.227
CURRY	10.121	9.183	.174	.220
WHISKERS	10.131	9.208	.173	.218
CHULITNA	10.871	10.532	.142	.148
TALKEET	11.062	10.790	.143	.147
TRAPPER	11.065	10.794	.143	.147
SUNSHINE	11.071	10.803	.143	.147
MONTANA	11.106	10.848	.140	.142
SHEEP	11.134	10.884	.137	.138
KASHWIT	11.177	10.940	.134	.133
LWILLOW	11.202	10.970	.132	.131
WILLOW	11.231	11.007	.130	.128
DESHKA	11.300	11.093	.125	.123
SU STA	11.803	11.683	.117	.116

ADDITIONAL STATISTICS

	COEF. OF VARIAT.		SKEW COEFFICIENTS		EXCESS COEFFICIENTS	
LOCATION	PRE-	POST-	PRE-	POST-	PRE-	POST-
WATANA	.017	.027	.269	1.479	-.369	1.059
TSUSENA	.017	.026	.282	1.372	-.337	.985
FOG	.017	.025	.290	1.247	-.310	.853
DEVIL	.017	.025	.295	1.121	-.285	.708
CHINCHEE	.017	.025	.297	1.056	-.272	.632
PORTAGE	.017	.025	.298	.939	-.250	.495
INDIAN	.017	.025	.298	.850	-.232	.392
CURRY	.017	.024	.292	.828	-.236	.349
WHISKERS	.017	.024	.290	.821	-.237	.334
CHULITNA	.013	.014	.215	.477	-.488	-.374
TALKEET	.013	.014	.072	.220	-.328	-.315
TRAPPER	.013	.014	.072	.219	-.328	-.315
SUNSHINE	.013	.014	.072	.218	-.328	-.316
MONTANA	.013	.013	.090	.252	-.327	-.278
SHEEP	.012	.013	.105	.279	-.320	-.237
KASHWIT	.012	.012	.127	.321	-.296	-.152
LWILLOW	.012	.012	.139	.344	-.277	-.096
WILLOW	.012	.012	.154	.370	-.246	-.019
DESHKA	.011	.011	.186	.427	-.146	.200
SU STA	.010	.010	.280	.485	.999	1.520

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY AUGUST

	MAINSTEM FLOWS (LN CFS)		STANDARD DEVIATION	
LOCATION	PRE-	POST-	PRE-	POST-
WATANA	9.812	9.162	.202	.219
TSUSENA	9.849	9.236	.203	.205
FOG	9.881	9.296	.204	.197
DEVIL	9.912	9.352	.205	.192
CHINCHEE	9.929	9.381	.205	.190
PORTAGE	9.960	9.436	.207	.189
INDIAN	9.986	9.480	.208	.188
CURRY	10.015	9.528	.208	.186
WHISKERS	10.024	9.543	.207	.185
CHULITNA	10.721	10.509	.188	.180
TALKEET	10.925	10.757	.203	.194
TRAPPER	10.928	10.761	.203	.194
SUNSHINE	10.935	10.769	.203	.194
MONTANA	10.967	10.807	.197	.186
SHEEP	10.994	10.838	.192	.181
KASHWIT	11.035	10.886	.186	.173
LWILLOW	11.058	10.913	.182	.169
WILLOW	11.086	10.944	.178	.165
DESHKA	11.152	11.020	.170	.157
SU STA	11.632	11.552	.152	.144

ADDITIONAL STATISTICS

	COEF. OF VARIAT.		SKEW COEFFICIENTS		EXCESS COEFFICIENTS	
LOCATION	PRE-	POST-	PRE-	POST-	PRE-	POST-
WATANA	.021	.024	.824	1.581	.978	3.636
TSUSENA	.021	.022	.845	1.989	.989	4.720
FOG	.021	.021	.863	2.251	.990	5.521
DEVIL	.021	.021	.879	2.423	.982	6.080
CHINCHEE	.021	.020	.887	2.481	.976	6.272
PORTAGE	.021	.020	.902	2.539	.959	6.438
INDIAN	.021	.020	.912	2.538	.942	6.392
CURRY	.021	.020	.905	2.523	.932	6.328
WHISKERS	.021	.019	.902	2.516	.928	6.298
CHULITNA	.018	.017	.313	.875	1.621	2.793
TALKEET	.019	.018	.029	.259	1.318	1.987
TRAPPER	.019	.018	.029	.258	1.318	1.985
SUNSHINE	.019	.018	.029	.256	1.318	1.980
MONTANA	.018	.017	.094	.344	1.197	1.901
SHEEP	.017	.017	.143	.410	1.099	1.831
KASHWIT	.017	.016	.210	.501	.949	1.712
LWILLOW	.016	.016	.241	.544	.869	1.641
WILLOW	.016	.015	.274	.587	.774	1.549
DESHKA	.015	.014	.328	.652	.563	1.309
SU STA	.013	.012	-.103	.005	.118	.212

STATISTICAL RECORD OF 32-YEAR SUMMARY, WATANA ONLY SEPTEMB

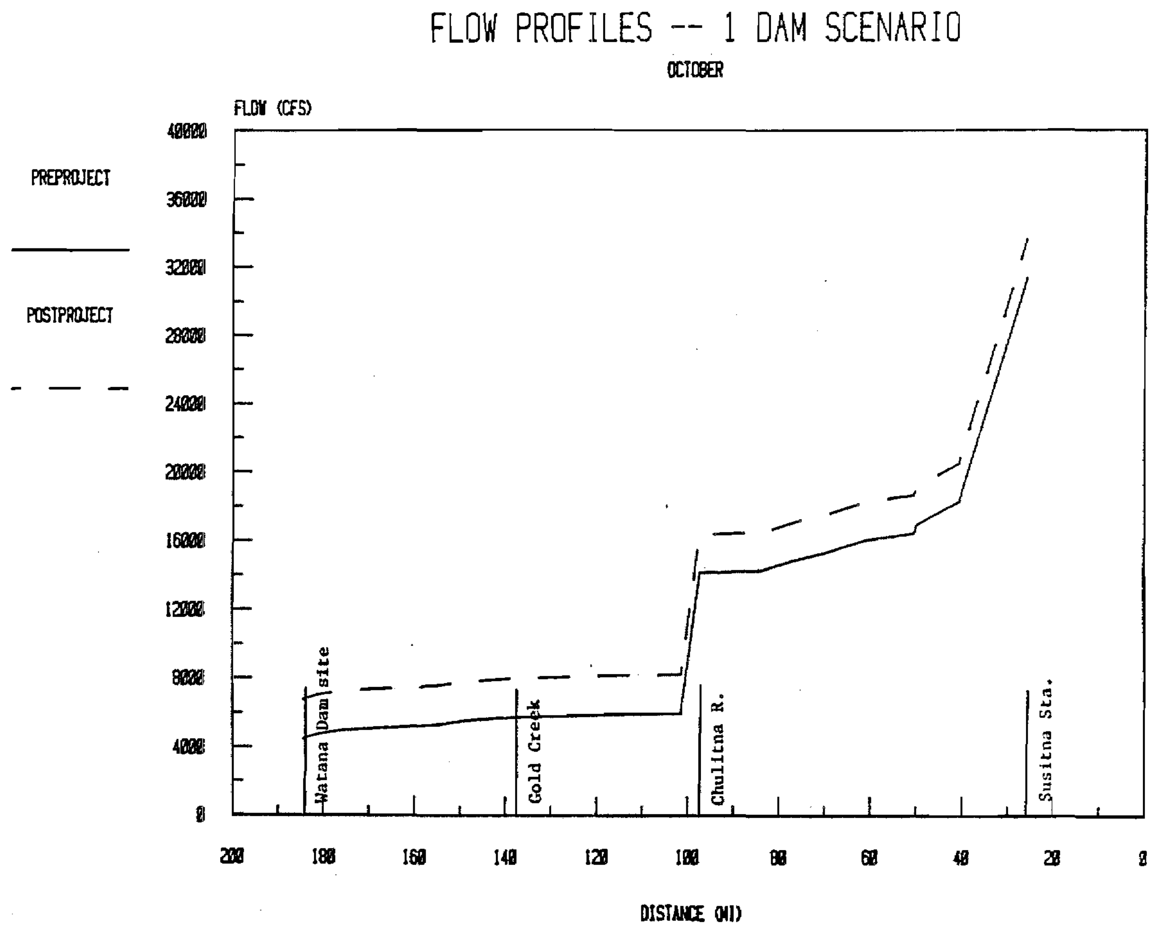
	MAINSTEM FLOWS (LN CFS)		STANDARD DEVIATION	
LOCATION	PRE-	POST-	PRE-	POST-
WATANA	9.246	8.884	.292	.164
TSUSENA	9.292	8.956	.294	.138
FOG	9.331	9.013	.296	.124
DEVIL	9.368	9.067	.299	.117
CHINCHEE	9.387	9.095	.300	.115
PORTAGE	9.424	9.147	.303	.117
INDIAN	9.455	9.189	.305	.121
CURRY	9.482	9.224	.304	.123
WHISKERS	9.491	9.236	.304	.123
CHULITNA	10.121	9.992	.274	.193
TALKEET	10.330	10.229	.276	.210
TRAPPER	10.333	10.232	.276	.210
SUNSHINE	10.340	10.240	.276	.210
MONTANA	10.376	10.279	.270	.206
SHEEP	10.406	10.312	.266	.204
KASHWIT	10.452	10.362	.260	.201
LWILLOW	10.478	10.389	.257	.200
WILLOW	10.508	10.422	.254	.200
DESHKA	10.580	10.500	.249	.200
SU STA	11.091	11.042	.256	.241

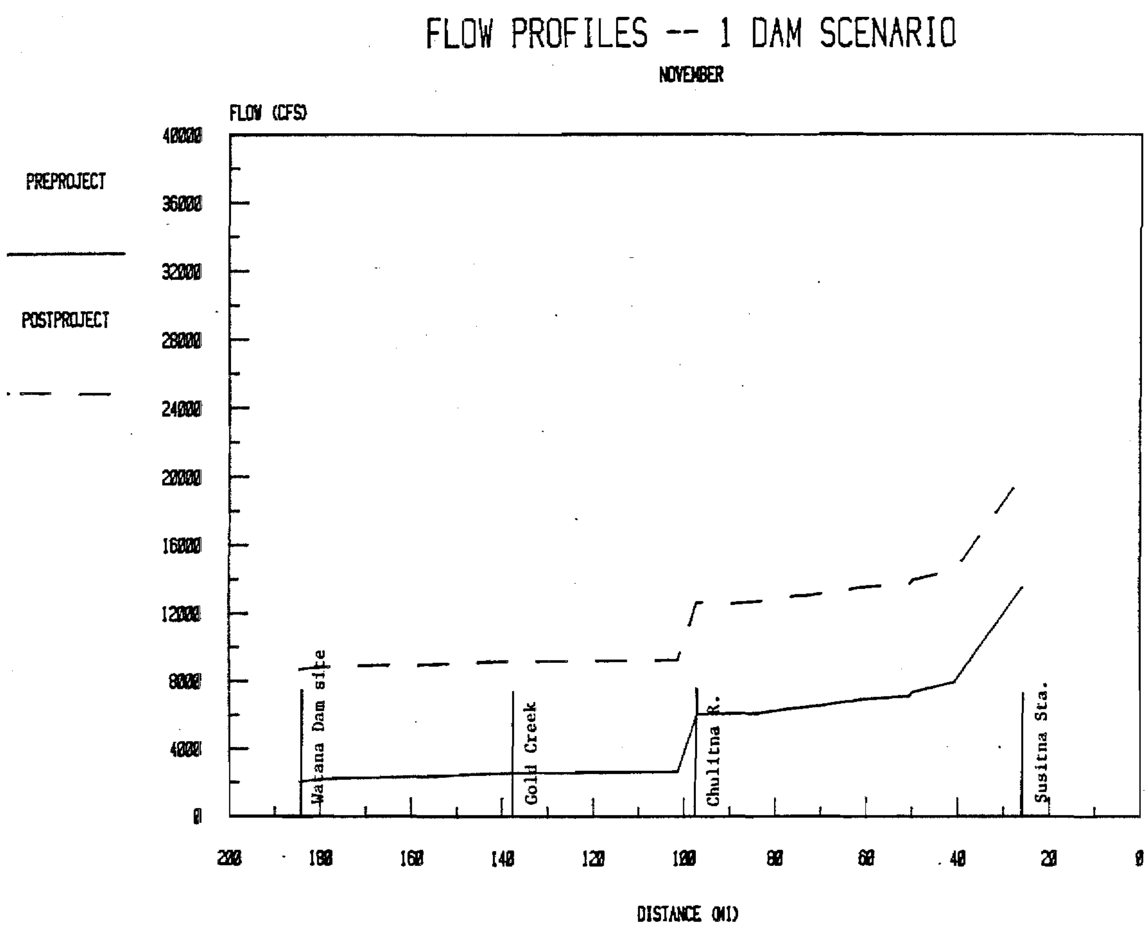
ADDITIONAL STATISTICS

	COEF. OF VARIAT.		SKEW COEFFICIENTS		EXCESS COEFFICIENTS	
LOCATION	PRE-	POST-	PRE-	POST-	PRE-	POST-
WATANA	.032	.018	-.271	-.434	-.467	.734
TSUSENA	.032	.015	-.266	.066	-.481	.790
FOG	.032	.014	-.258	.625	-.496	1.038
DEVIL	.032	.013	-.247	1.154	-.511	1.463
CHINCHEE	.032	.013	-.240	1.370	-.520	1.696
PORTAGE	.032	.013	-.226	1.595	-.538	1.991
INDIAN	.032	.013	-.213	1.607	-.553	2.001
CURRY	.032	.013	-.207	1.598	-.565	2.078
WHISKERS	.032	.013	-.205	1.590	-.568	2.091
CHULITNA	.027	.019	-.011	1.052	-.195	2.367
TALKEET	.027	.021	.004	.636	-.364	1.177
TRAPPER	.027	.021	.004	.633	-.364	1.168
SUNSHINE	.027	.021	.004	.626	-.364	1.149
MONTANA	.026	.020	-.012	.613	-.332	1.124
SHEEP	.026	.020	-.027	.591	-.310	1.078
KASHWIT	.025	.019	-.054	.540	-.284	.965
LWILLOW	.025	.019	-.070	.505	-.274	.886
WILLOW	.024	.019	-.090	.459	-.267	.779
DESHKA	.024	.019	-.138	.341	-.273	.502
SU STA	.023	.022	-.305	-.200	-.572	-.325

APPENDIX C

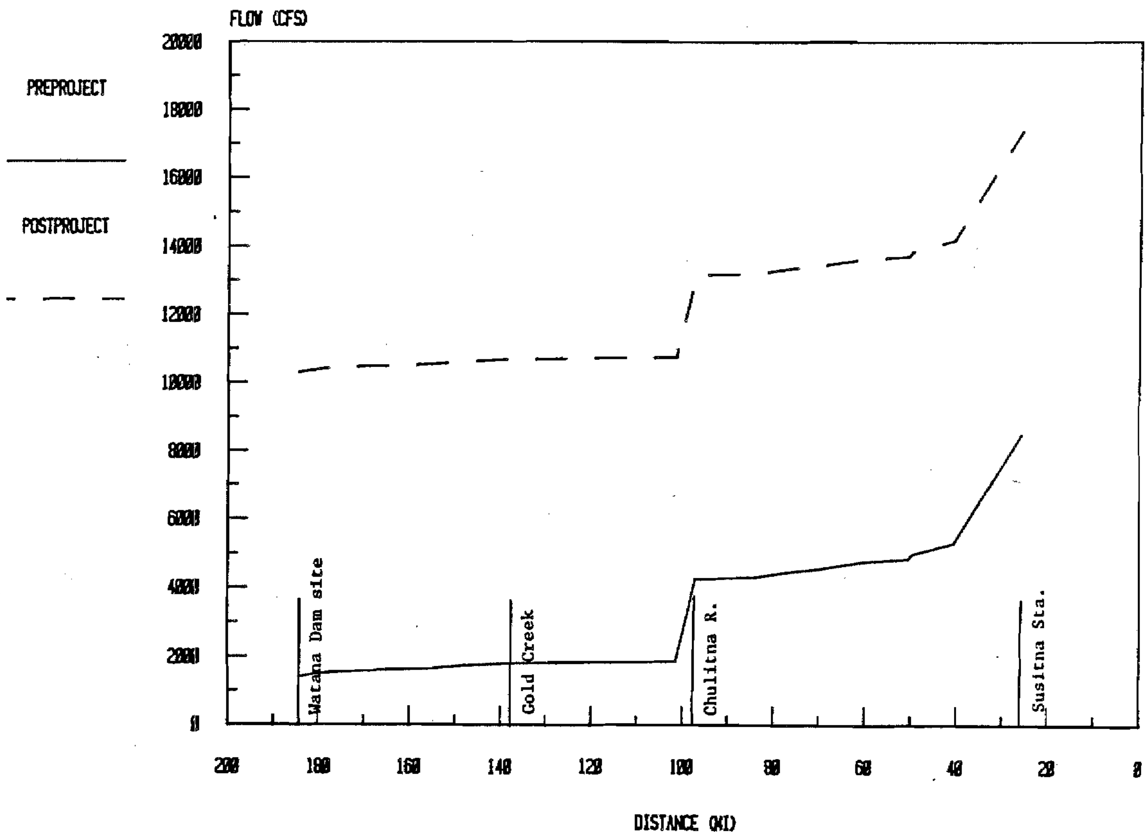
MONTHLY FLOW PROFILES FOR NATURAL AND SINGLE-DAM OPERATIONAL CONDITIONS


FLOW PROFILES -- 1 DAM SCENARIO
OCTOBER
FLOW (CFS)
PREPROJECT
POSTPROJECT
40000
36000
32000
28000
24000
20000
16000
12000
8000
4000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)


FLOW PROFILES -- 1 DAM SCENARIO
NOVEMBER
FLOW (CFS)
PREPROJECT
POSTPROJECT
40000
36000
32000
28000
24000
20000
16000
12000
8000
4000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)

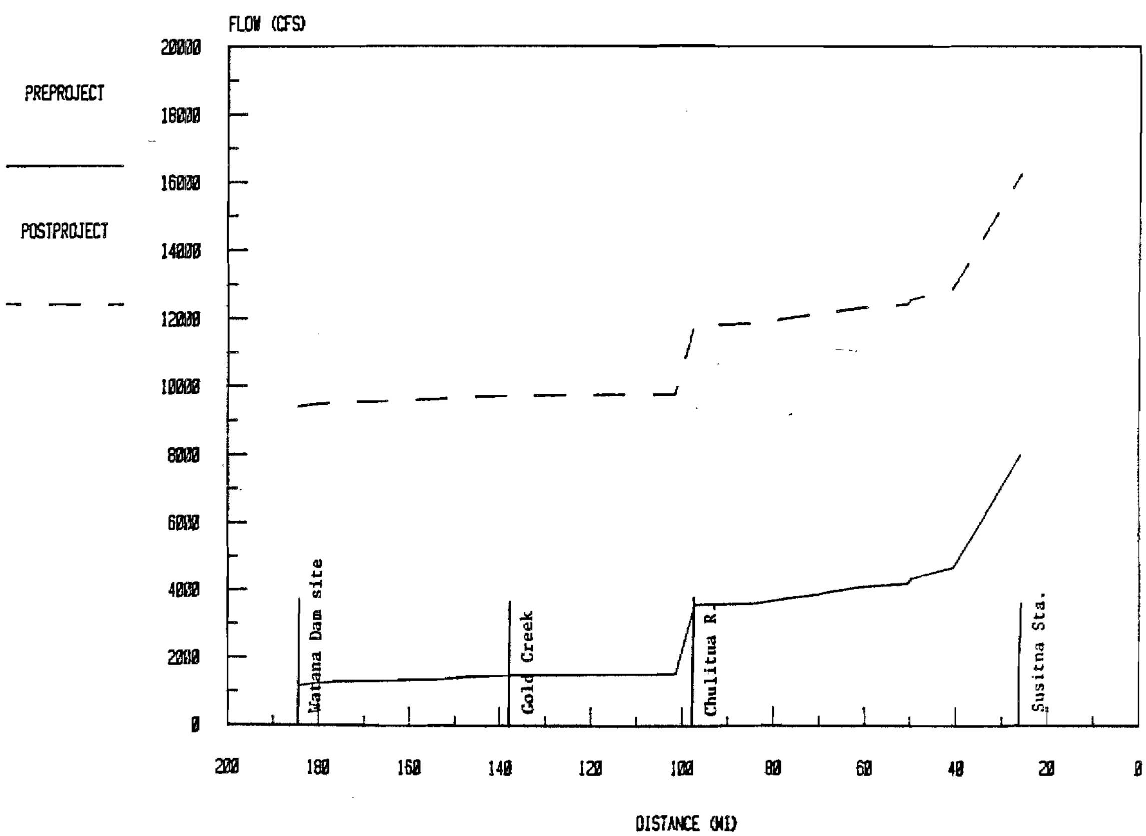
FLOW PROFILES -- 1 DAM SCENARIO

DECEMBER



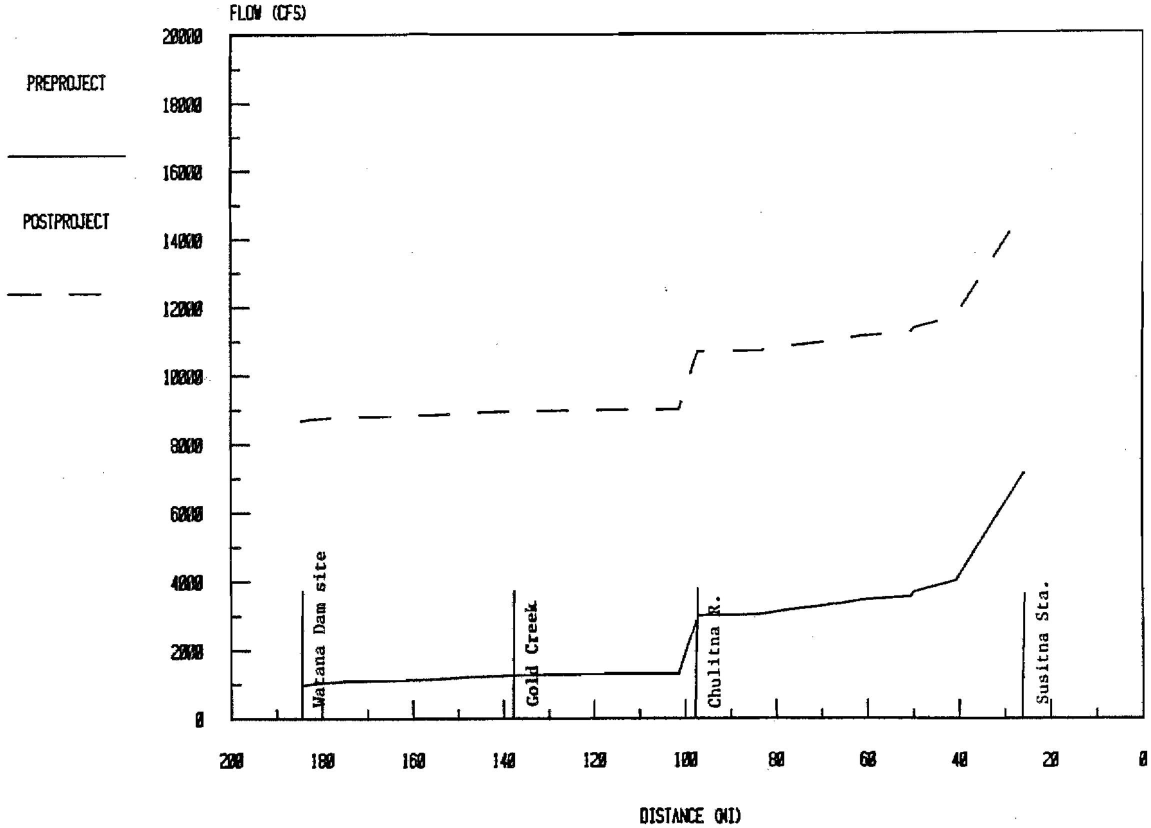
FLOW PROFILES -- 1 DAM SCENARIO

JANUARY



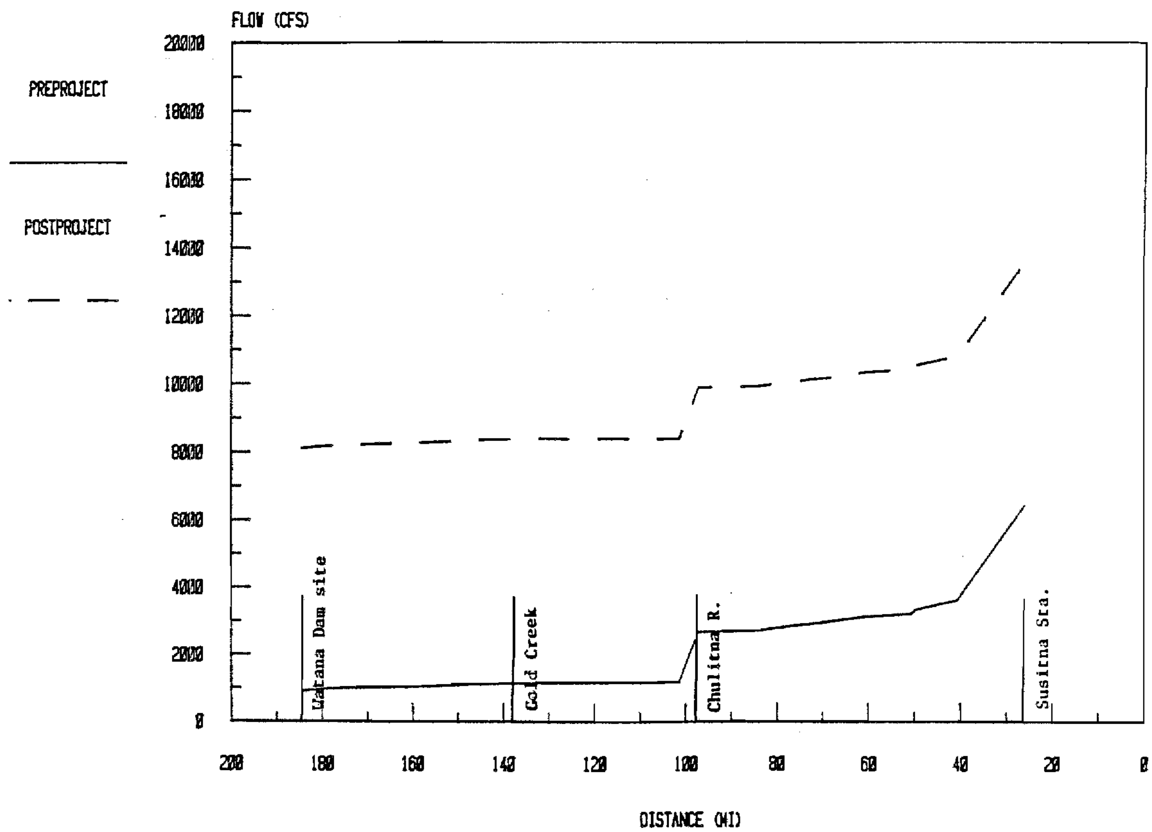
FLOW PROFILES -- 1 DAM SCENARIO

FEBRUARY



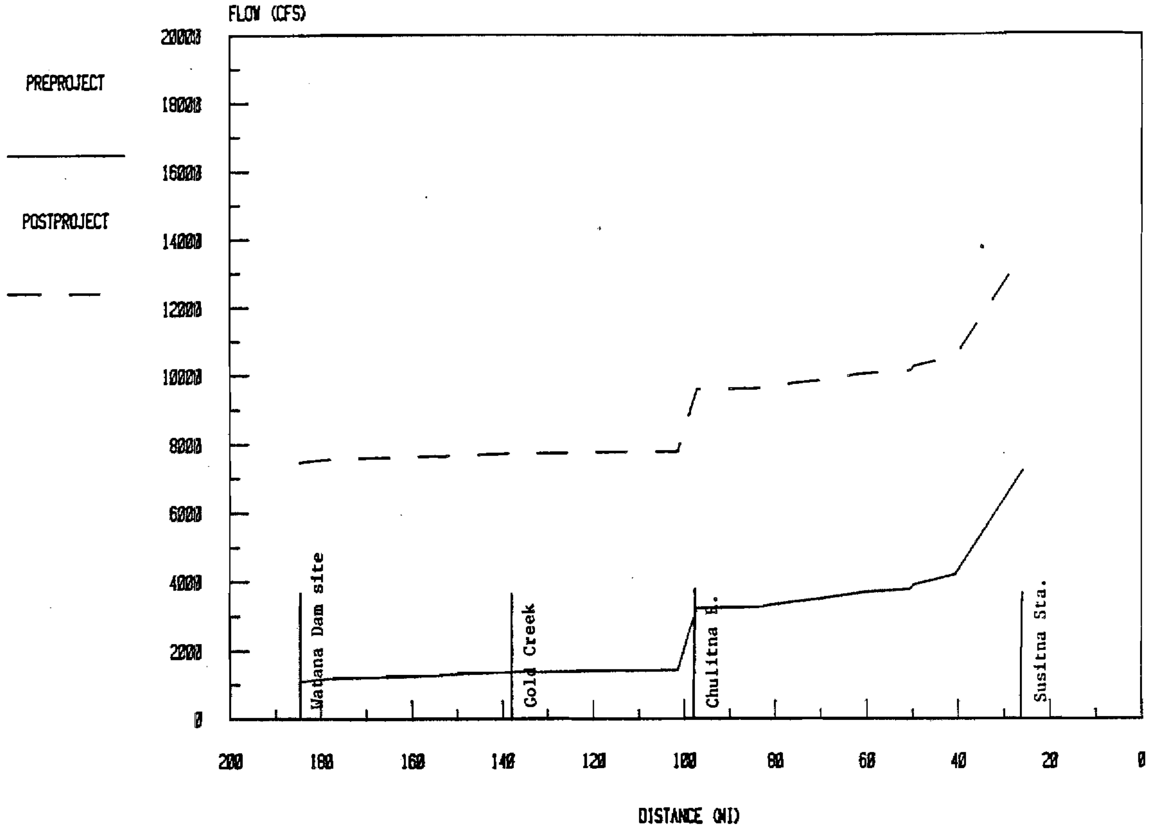
FLOW PROFILES -- 1 DAM SCENARIO

MARCH



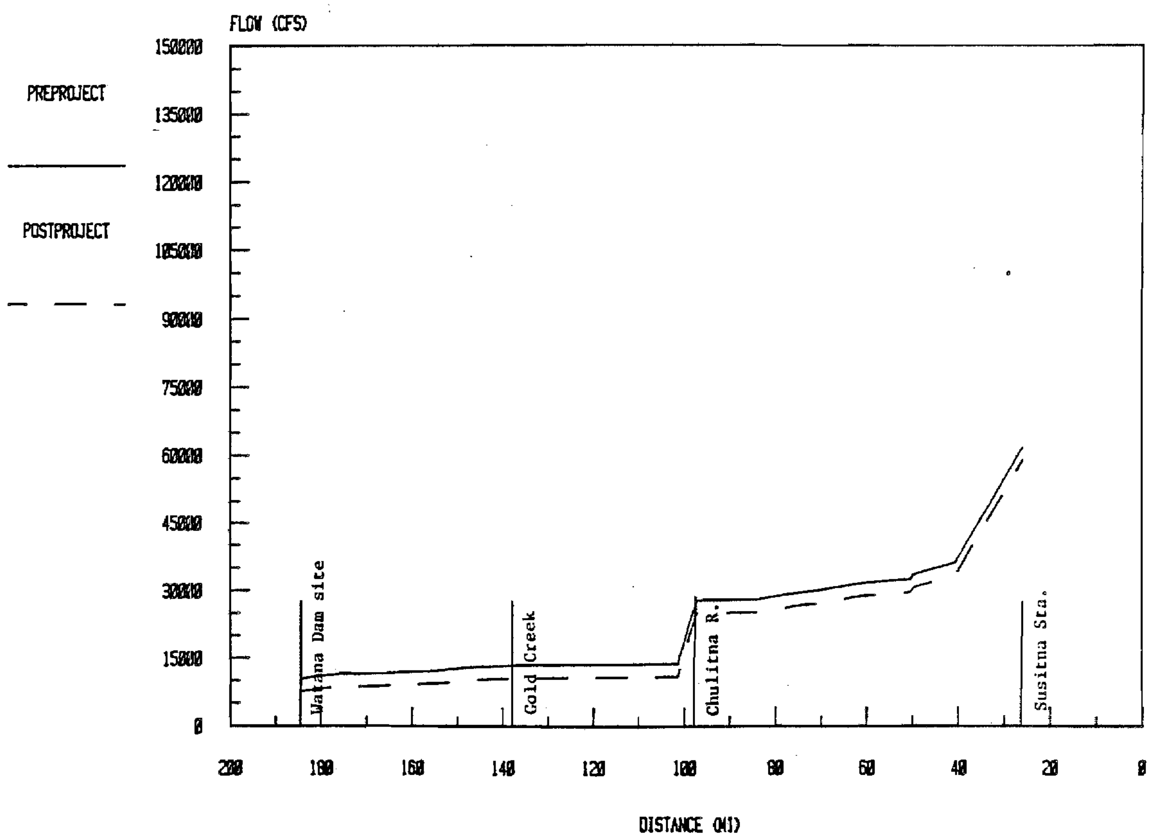
FLOW PROFILES -- 1 DAM SCENARIO

APRIL



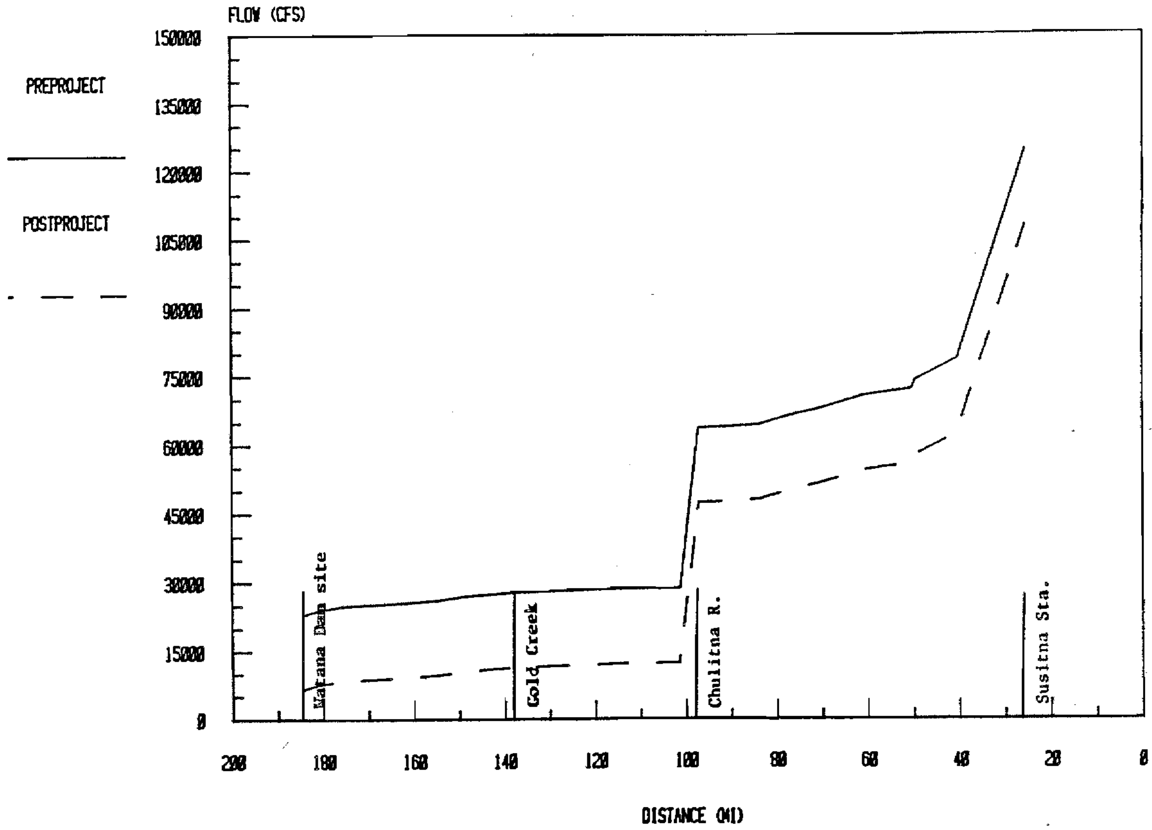
FLOW PROFILES -- 1 DAM SCENARIO

MAY



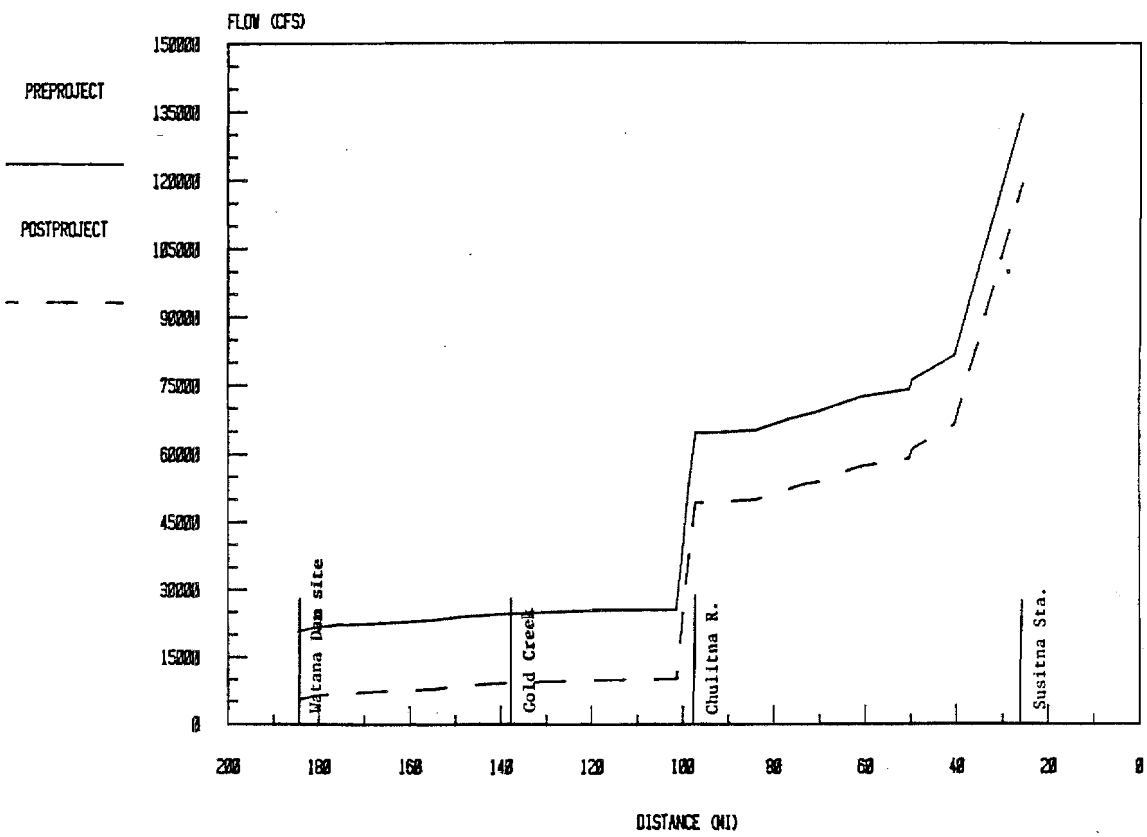
FLOW PROFILES -- 1 DAM SCENARIO

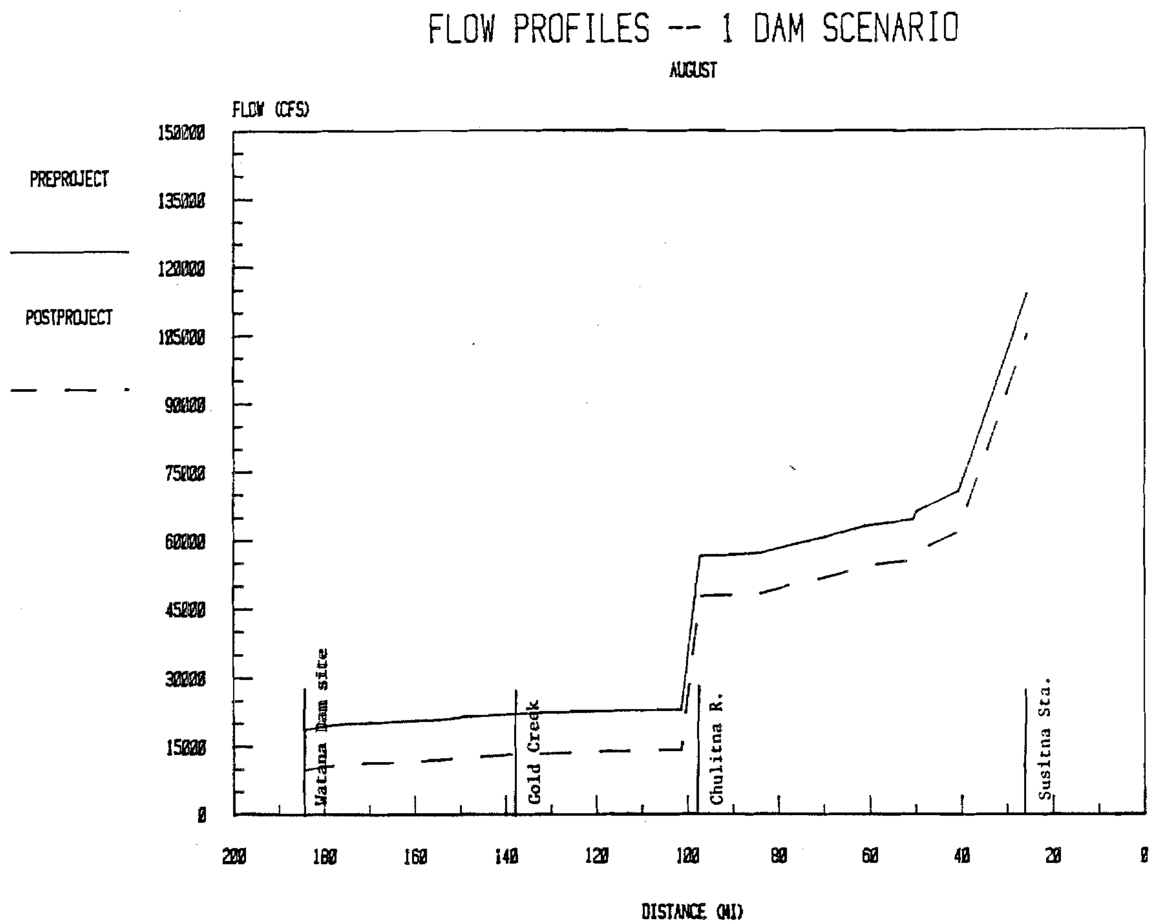
JUNE

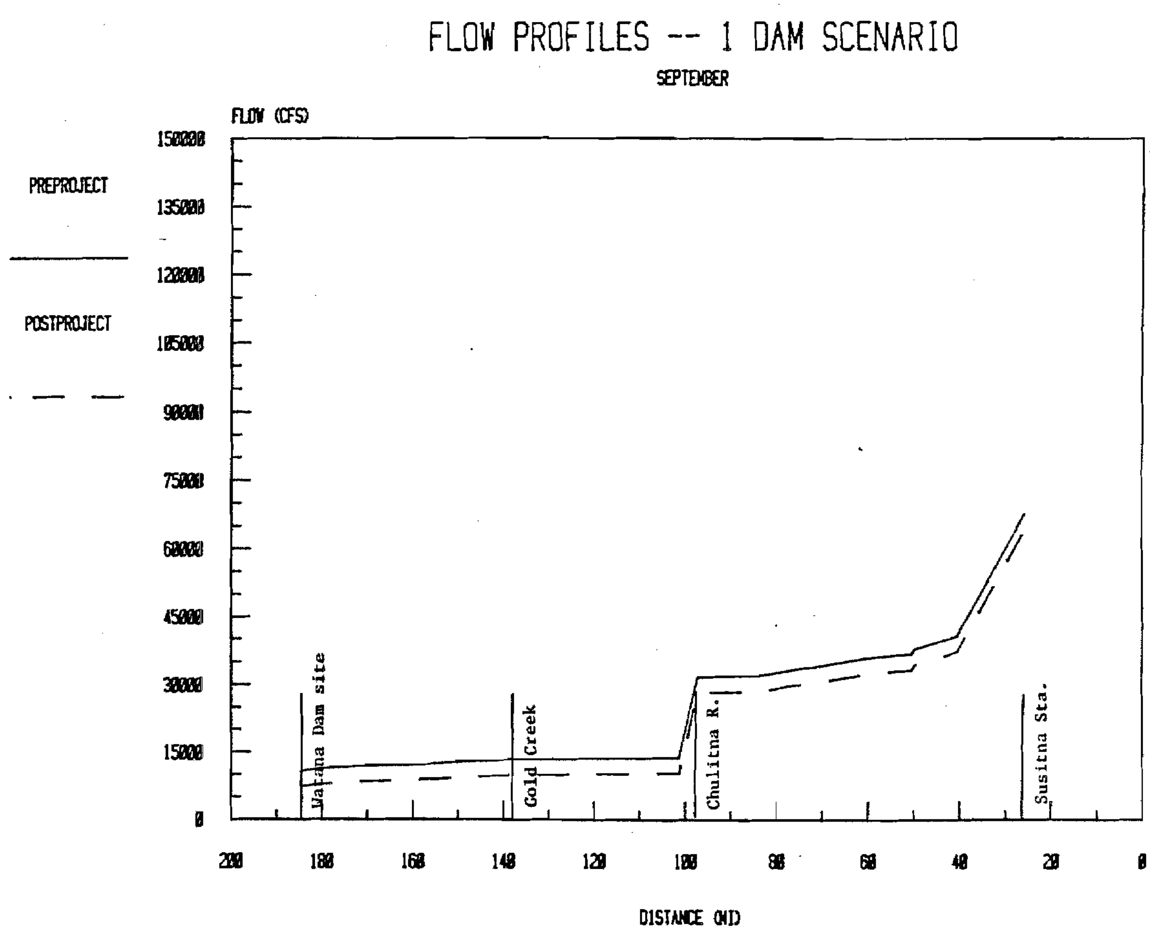


FLOW PROFILES -- 1 DAM SCENARIO

JULY




FLOW PROFILES -- 1 DAM SCENARIO
AUGUST
FLOW (CFS)
PREPROJECT
POSTPROJECT
150000
135000
120000
105000
90000
75000
60000
45000
30000
15000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)


FLOW PROFILES -- 1 DAM SCENARIO
SEPTEMBER
FLOW (CFS)
PREPROJECT
POSTPROJECT
150000
135000
120000
105000
90000
75000
60000
45000
30000
15000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)

APPENDIX D

FLOW STATISTICS FOR THE TWO-DAM SCENARIO

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO OCTOBER

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	5334.3	7318.5	37.2	1327.5	1067.7
PORTAGE	5569.5	7553.6	35.6	1396.4	1105.7
INDIAN	5770.8	7754.9	34.4	1456.8	1142.3
CURRY	5931.9	7916.1	33.4	1486.0	1158.2
WHISKERS	5985.8	7970.0	33.1	1495.8	1163.7
CHULITNA	11397.0	13381.1	17.4	2385.1	1928.5
TALKEET	14145.4	16129.5	14.0	2970.8	2471.5
TRAPPER	14189.9	16174.0	14.0	2980.1	2480.0
SUNSHINE	14286.8	16271.0	13.9	3000.5	2498.5
MONTANA	14835.3	16819.5	13.4	3088.2	2572.7
SHEEP	15298.1	17282.3	13.0	3176.0	2652.4
KASHWIT	16052.3	18036.4	12.4	3343.2	2812.2
LWILLOW	16480.8	18464.9	12.0	3450.2	2917.5
WILLOW	17012.1	18996.3	11.7	3593.5	3060.8
DESHKA	18349.0	20333.2	10.8	3997.7	3471.6
SU STA	31426.9	33411.1	6.3	9270.2	8845.4

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.249	.146	.061	1.334	-.785	.828
PORTAGE	.251	.146	.064	1.343	-.782	.995
INDIAN	.252	.147	.068	1.335	-.777	1.113
CURRY	.251	.146	.060	1.328	-.787	1.110
WHISKERS	.250	.146	.057	1.325	-.790	1.108
CHULITNA	.209	.144	-.003	.576	-.731	.254
TALKEET	.210	.153	-.022	.443	-.762	-.016
TRAPPER	.210	.153	-.022	.441	-.762	-.019
SUNSHINE	.210	.154	-.022	.435	-.762	-.026
MONTANA	.208	.153	-.004	.432	-.830	-.068
SHEEP	.208	.153	.025	.440	-.832	-.066
KASHWIT	.208	.156	.095	.474	-.740	.003
LWILLOW	.209	.158	.143	.501	-.648	.071
WILLOW	.211	.161	.208	.542	-.508	.174
DESHKA	.218	.171	.375	.654	-.095	.467
SU STA	.295	.265	1.057	1.097	1.697	1.638

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO NOVEMBER

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	2387.4	9444.6	295.6	691.4	1909.4
PORTAGE	2482.6	9539.8	284.3	721.0	1919.2
INDIAN	2564.0	9621.2	275.2	747.3	1928.3
CURRY	2633.3	9690.5	268.0	762.8	1936.2
WHISKERS	2656.4	9713.6	265.7	767.9	1938.8
CHULITNA	4854.2	11911.4	145.4	1201.1	2170.4
TALKEET	6077.9	13135.1	116.1	1446.5	2362.8
TRAPPER	6097.0	13154.2	115.7	1451.1	2366.1
SUNSHINE	6138.6	13195.9	115.0	1461.0	2373.1
MONTANA	6374.2	13431.4	110.7	1532.1	2410.1
SHEEP	6573.0	13630.2	107.4	1596.9	2445.7
KASHWIT	6896.9	13954.1	102.3	1710.7	2511.8
LWILLOW	7081.0	14138.2	99.7	1779.3	2553.5
WILLOW	7309.2	14366.4	96.6	1867.6	2609.2
DESHKA	7883.5	14940.7	89.5	2103.1	2767.1
SU STA	13500.7	20557.9	52.3	4795.2	5037.8

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.290	.202	.253	-.308	-.102	-1.581
PORTAGE	.290	.201	.223	-.309	-.152	-1.571
INDIAN	.291	.200	.204	-.310	-.180	-1.559
CURRY	.290	.200	.203	-.314	-.179	-1.552
WHISKERS	.289	.200	.202	-.315	-.179	-1.549
CHULITNA	.247	.182	.271	-.345	-.220	-1.258
TALKEET	.238	.180	.230	-.364	-.284	-1.148
TRAPPER	.238	.180	.230	-.364	-.284	-1.146
SUNSHINE	.238	.180	.230	-.363	-.284	-1.142
MONTANA	.240	.179	.343	-.358	.048	-1.103
SHEEP	.243	.179	.444	-.348	.361	-1.069
KASHWIT	.248	.180	.612	-.318	.900	-1.005
LWILLOW	.251	.181	.705	-.295	1.209	-.963
WILLOW	.256	.182	.815	-.260	1.583	-.903
DESHKA	.267	.185	1.059	-.148	2.441	-.711
SU STA	.355	.245	1.852	1.012	5.550	2.286

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO   DECEMBER

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	1672.8	11128.3	565.2	496.0	2073.4
PORTAGE	1747.6	11203.0	541.1	528.0	2081.1
INDIAN	1811.6	11267.1	521.9	555.8	2088.2
CURRY	1860.3	11315.8	508.3	564.8	2092.6
WHISKERS	1876.6	11332.1	503.9	567.7	2094.1
CHULITNA	3418.1	12873.6	276.6	733.2	2202.0
TALKEET	4275.5	13730.9	221.2	879.8	2288.2
TRAPPER	4288.9	13744.4	220.5	882.5	2289.7
SUNSHINE	4318.2	13773.7	219.0	888.6	2293.2
MONTANA	4452.6	13908.1	212.4	923.8	2306.3
SHEEP	4566.0	14021.5	207.1	957.3	2319.4
KASHWIT	4750.8	14206.2	199.0	1018.5	2344.3
LWILLOW	4855.7	14311.2	194.7	1056.3	2360.4
WILLOW	4985.9	14441.4	189.6	1106.0	2382.4
DESHKA	5313.5	14768.9	178.0	1242.0	2446.8
SU STA	8517.5	17973.0	111.0	2891.7	3567.5

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.297	.186	.430	-.836	-.048	-1.113
PORTAGE	.302	.186	.468	-.834	.091	-1.109
INDIAN	.307	.185	.500	-.831	.202	-1.104
CURRY	.304	.185	.492	-.831	.183	-1.102
WHISKERS	.303	.185	.489	-.830	.177	-1.101
CHULITNA	.214	.171	-.042	-.820	-.515	-1.017
TALKEET	.206	.167	-.155	-.816	-.435	-.928
TRAPPER	.206	.167	-.155	-.816	-.435	-.927
SUNSHINE	.206	.166	-.155	-.816	-.435	-.924
MONTANA	.207	.166	-.108	-.812	-.436	-.911
SHEEP	.210	.165	-.058	-.805	-.439	-.898
KASHWIT	.214	.165	.036	-.785	-.439	-.874
LWILLOW	.218	.165	.094	-.769	-.433	-.858
WILLOW	.222	.165	.165	-.745	-.419	-.837
DESHKA	.234	.166	.337	-.666	-.355	-.771
SU STA	.339	.198	.994	.405	.416	.275

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO JANUARY

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	1377.6	10484.8	661.1	390.1	1738.6
PORTAGE	1439.0	10546.2	632.9	415.3	1746.9
INDIAN	1491.6	10598.8	610.6	437.4	1754.4
CURRY	1532.4	10639.6	594.3	444.1	1757.5
WHISKERS	1546.0	10653.2	589.1	446.3	1758.5
CHULITNA	2893.9	12001.1	314.7	542.7	1831.9
TALKEET	3579.0	12686.1	254.5	632.1	1876.7
TRAPPER	3590.2	12697.4	253.7	634.1	1877.8
SUNSHINE	3614.8	12721.9	251.9	638.4	1880.1
MONTANA	3756.0	12863.2	242.5	656.2	1881.6
SHEEP	3875.3	12982.4	235.0	672.6	1883.6
KASHWIT	4069.5	13176.7	223.8	701.9	1888.0
LWILLOW	4179.9	13287.1	217.9	719.8	1891.2
WILLOW	4316.8	13424.0	211.0	743.2	1895.9
DESHKA	4661.2	13768.3	195.4	807.3	1911.1
SU STA	8030.0	17137.2	113.4	1613.0	2279.3

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.283	.166	.204	-1.066	-.677	-.501
PORTAGE	.289	.166	.220	-1.064	-.652	-.498
INDIAN	.293	.166	.237	-1.061	-.627	-.496
CURRY	.290	.165	.237	-1.060	-.627	-.498
WHISKERS	.289	.165	.237	-1.059	-.627	-.498
CHULITNA	.188	.153	.020	-1.009	-.705	-.547
TALKEET	.177	.148	.036	-.975	-.389	-.576
TRAPPER	.177	.148	.036	-.974	-.389	-.576
SUNSHINE	.177	.148	.036	-.973	-.389	-.576
MONTANA	.175	.146	.098	-.965	-.293	-.570
SHEEP	.174	.145	.157	-.956	-.199	-.565
KASHWIT	.172	.143	.261	-.938	-.030	-.554
LWILLOW	.172	.142	.322	-.925	.069	-.547
WILLOW	.172	.141	.396	-.908	.192	-.537
DESHKA	.173	.139	.573	-.853	.481	-.504
SU STA	.201	.133	1.177	.058	1.380	.274

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO FEBRUARY

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	1171.1	10094.4	761.9	323.4	1926.6
PORTAGE	1225.6	10148.8	728.1	347.0	1933.0
INDIAN	1272.2	10195.4	701.4	368.2	1938.8
CURRY	1306.5	10229.8	683.0	373.7	1940.9
WHISKERS	1318.0	10241.3	677.0	375.5	1941.7
CHULITNA	2443.5	11366.8	365.2	440.4	1996.8
TALKEET	3015.2	11938.5	295.9	519.1	2028.1
TRAPPER	3024.7	11948.0	295.0	520.7	2028.8
SUNSHINE	3045.4	11968.6	293.0	524.3	2030.3
MONTANA	3176.7	12100.0	280.9	541.3	2027.0
SHEEP	3287.5	12210.7	271.4	556.9	2024.7
KASHWIT	3468.0	12391.3	257.3	584.7	2021.8
LWILLOW	3570.6	12493.9	249.9	601.6	2020.7
WILLOW	3697.8	12621.1	241.3	623.7	2019.8
DESHKA	4017.8	12941.1	222.1	683.5	2020.2
SU STA	7148.7	16071.9	124.8	1415.3	2205.9

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.276	.191	.261	-1.414	-.667	.235
PORTAGE	.283	.190	.297	-1.410	-.642	.231
INDIAN	.289	.190	.343	-1.406	-.561	.228
CURRY	.286	.190	.344	-1.405	-.565	.227
WHISKERS	.285	.190	.344	-1.404	-.567	.227
CHULITNA	.180	.176	.362	-1.387	-.276	.216
TALKEET	.172	.170	.222	-1.362	-.625	.195
TRAPPER	.172	.170	.222	-1.362	-.625	.195
SUNSHINE	.172	.170	.222	-1.360	-.625	.194
MONTANA	.170	.168	.287	-1.349	-.613	.181
SHEEP	.169	.166	.342	-1.338	-.567	.170
KASHWIT	.169	.163	.432	-1.317	-.439	.152
LWILLOW	.168	.162	.482	-1.303	-.343	.141
WILLOW	.169	.160	.541	-1.285	-.210	.128
DESHKA	.170	.156	.673	-1.232	.157	.095
SU STA	.198	.137	1.113	-.313	1.951	.297

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO MARCH

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	1054.5	9204.0	772.9	312.6	1301.2
PORTAGE	1099.7	9249.2	741.1	331.2	1310.2
INDIAN	1138.4	9288.0	715.9	347.8	1318.2
CURRY	1169.0	9318.5	697.2	353.2	1320.9
WHISKERS	1179.2	9328.7	691.1	354.9	1321.8
CHULITNA	2184.4	10334.0	373.1	432.7	1359.8
TALKEET	2679.6	10829.1	304.1	500.9	1397.4
TRAPPER	2688.0	10837.5	303.2	502.5	1398.3
SUNSHINE	2706.4	10855.9	301.1	505.9	1400.2
MONTANA	2824.9	10974.4	288.5	516.9	1402.7
SHEEP	2924.8	11074.3	278.6	526.7	1405.1
KASHWIT	3087.7	11237.2	263.9	543.7	1409.5
LWILLOW	3180.2	11329.7	256.3	553.9	1412.3
WILLOW	3295.0	11444.5	247.3	567.0	1416.0
DESHKA	3583.7	11733.2	227.4	602.0	1426.7
SU STA	6408.0	14557.5	127.2	1033.9	1625.0

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.296	.141	.702	-1.018	-.127	.165
PORTAGE	.301	.142	.699	-1.003	-.198	.140
INDIAN	.306	.142	.701	-.988	-.243	.119
CURRY	.302	.142	.700	-.982	-.244	.109
WHISKERS	.301	.142	.700	-.980	-.244	.105
CHULITNA	.198	.132	.489	-.893	-.490	-.032
TALKEET	.187	.129	.574	-.812	-.112	-.118
TRAPPER	.187	.129	.574	-.811	-.112	-.121
SUNSHINE	.187	.129	.574	-.807	-.112	-.125
MONTANA	.183	.128	.613	-.784	-.018	-.151
SHEEP	.180	.127	.647	-.764	.068	-.170
KASHWIT	.176	.125	.703	-.729	.219	-.200
LWILLOW	.174	.125	.734	-.708	.308	-.215
WILLOW	.172	.124	.772	-.681	.419	-.232
DESHKA	.168	.122	.862	-.608	.692	-.266
SU STA	.161	.112	1.248	.238	1.860	.106

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO APRIL

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	1283.8	8005.8	523.6	367.4	984.3
PORTAGE	1337.1	8059.1	502.7	390.8	996.4
INDIAN	1382.8	8104.7	486.1	411.9	1007.4
CURRY	1419.7	8141.6	473.5	419.0	1011.5
WHISKERS	1432.0	8154.0	469.4	421.3	1012.9
CHULITNA	2660.7	9382.7	252.6	568.0	1071.4
TALKEET	3238.8	9960.8	207.5	678.4	1164.8
TRAPPER	3249.0	9971.0	206.9	680.5	1166.3
SUNSHINE	3271.2	9993.2	205.5	685.2	1169.6
MONTANA	3398.0	10120.0	197.8	701.4	1186.1
SHEEP	3504.9	10226.9	191.8	715.9	1200.5
KASHWIT	3679.1	10401.1	182.7	741.2	1224.9
LWILLOW	3778.1	10500.1	177.9	756.3	1239.3
WILLOW	3900.9	10622.9	172.3	775.8	1257.6
DESHKA	4209.8	10931.8	159.7	828.2	1303.9
SU STA	7231.3	13953.3	93.0	1472.8	1891.6

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.286	.123	.781	-.237	1.373	.012
PORTAGE	.292	.124	.819	-.201	1.444	-.064
INDIAN	.298	.124	.855	-.169	1.497	-.123
CURRY	.295	.124	.855	-.157	1.494	-.134
WHISKERS	.294	.124	.854	-.153	1.493	-.138
CHULITNA	.213	.114	.792	.060	1.453	-.050
TALKEET	.209	.117	.801	.272	.988	.002
TRAPPER	.209	.117	.801	.275	.988	.002
SUNSHINE	.209	.117	.801	.281	.988	.003
MONTANA	.206	.117	.841	.303	1.016	.053
SHEEP	.204	.117	.875	.323	1.048	.099
KASHWIT	.201	.118	.930	.357	1.114	.177
LWILLOW	.200	.118	.961	.376	1.159	.224
WILLOW	.199	.118	.998	.401	1.221	.284
DESHKA	.197	.119	1.086	.465	1.398	.442
SU STA	.204	.136	1.482	.982	2.823	1.894

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO MAY

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	12296.7	7656.8	-37.7	3839.7	1529.4
PORTAGE	12859.3	8219.4	-36.1	4050.8	1725.2
INDIAN	13341.0	8701.1	-34.8	4239.1	1912.5
CURRY	13657.1	9017.2	-34.0	4320.8	1991.4
WHISKERS	13762.8	9122.9	-33.7	4348.2	2018.1
CHULITNA	23570.9	18931.0	-19.7	7412.1	5605.2
TALKEET	27743.3	23103.4	-16.7	8372.3	6540.5
TRAPPER	27830.6	23190.7	-16.7	8398.6	6566.0
SUNSHINE	28020.9	23380.9	-16.6	8456.0	6621.5
MONTANA	29096.9	24457.0	-15.9	8521.1	6666.5
SHEEP	30004.7	25364.8	-15.5	8587.3	6719.1
KASHWIT	31484.2	26844.3	-14.7	8716.9	6833.1
LWILLOW	32324.9	27685.0	-14.4	8802.0	6912.7
WILLOW	33367.3	28727.4	-13.9	8918.8	7025.9
DESHKA	35990.0	31350.1	-12.9	9264.3	7376.3
SU STA	61646.0	57006.1	-7.5	15113.7	13598.1

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.312	.200	-.549	.320	.523	-1.237
PORTAGE	.315	.210	-.517	.311	.482	-1.086
INDIAN	.318	.220	-.485	.293	.436	-.980
CURRY	.316	.221	-.493	.274	.423	-.972
WHISKERS	.316	.221	-.496	.267	.419	-.969
CHULITNA	.314	.296	-.270	.412	.132	.217
TALKEET	.302	.283	-.321	.276	.142	.120
TRAPPER	.302	.283	-.321	.274	.142	.119
SUNSHINE	.302	.283	-.321	.269	.142	.117
MONTANA	.293	.273	-.341	.240	.168	.108
SHEEP	.286	.265	-.352	.220	.188	.099
KASHWIT	.277	.255	-.360	.198	.217	.085
LWILLOW	.272	.250	-.359	.190	.232	.077
WILLOW	.267	.245	-.353	.187	.249	.068
DESHKA	.257	.235	-.314	.200	.280	.050
SU STA	.245	.239	.323	.561	.119	-.059

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO JUNE

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	26162.9	8146.2	-68.9	7071.9	1833.3
PORTAGE	27072.4	9055.7	-66.6	7334.3	2103.0
INDIAN	27851.0	9834.3	-64.7	7562.7	2344.3
CURRY	28579.7	10563.0	-63.0	7725.2	2476.5
WHISKERS	28823.3	10806.6	-62.5	7779.6	2521.8
CHULITNA	52400.5	34383.8	-34.4	11963.1	6962.7
TALKEET	63957.6	45940.9	-28.2	15000.0	9806.2
TRAPPER	64158.9	46142.1	-28.1	15047.2	9852.4
SUNSHINE	64597.4	46580.6	-27.9	15150.1	9953.1
MONTANA	66517.9	48501.2	-27.1	15366.8	10167.8
SHEEP	68138.3	50121.6	-26.4	15569.4	10378.8
KASHWIT	70779.1	52762.3	-25.5	15936.4	10776.4
LWILLOW	72279.5	54262.7	-24.9	16164.2	11029.7
WILLOW	74140.0	56123.2	-24.3	16465.2	11369.0
DESHKA	78821.3	60804.5	-22.9	17305.6	12330.8
SU STA	124613.8	106597.1	-14.5	29227.0	25537.0

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.270	.225	.950	-.029	1.932	-1.467
PORTAGE	.271	.232	.907	-.046	1.782	-1.345
INDIAN	.272	.238	.871	-.063	1.659	-1.261
CURRY	.270	.234	.872	-.057	1.666	-1.198
WHISKERS	.270	.233	.873	-.053	1.669	-1.174
CHULITNA	.228	.202	1.316	1.160	3.305	2.171
TALKEET	.235	.213	.964	.765	1.949	1.213
TRAPPER	.235	.214	.964	.766	1.949	1.216
SUNSHINE	.235	.214	.964	.767	1.949	1.223
MONTANA	.231	.210	.872	.663	1.626	.898
SHEEP	.228	.207	.798	.579	1.365	.638
KASHWIT	.225	.204	.682	.455	.970	.260
LWILLOW	.224	.203	.621	.394	.764	.074
WILLOW	.222	.203	.550	.327	.530	-.124
DESHKA	.220	.203	.397	.207	.046	-.474
SU STA	.235	.240	.143	.284	-.522	-.227

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO JULY

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	23213.3	7094.5	-69.4	4067.8	1340.5
PORTAGE	23909.6	7790.8	-67.4	4245.3	1479.2
INDIAN	24505.7	8386.9	-65.8	4399.6	1610.4
CURRY	25238.4	9119.6	-63.9	4497.1	1696.9
WHISKERS	25483.4	9364.6	-63.3	4529.7	1726.3
CHULITNA	53167.0	37048.2	-30.3	7644.7	5185.1
TALKEET	64309.8	48191.0	-25.1	9266.1	6682.8
TRAPPER	64512.1	48393.3	-25.0	9295.2	6711.2
SUNSHINE	64953.0	48834.2	-24.8	9358.7	6773.2
MONTANA	67180.1	51061.3	-24.0	9458.2	6850.5
SHEEP	69059.2	52940.4	-23.3	9550.8	6928.2
KASHWIT	72121.5	56002.7	-22.3	9718.4	7078.4
LWILLOW	73861.4	57742.6	-21.8	9822.4	7176.2
WILLOW	76018.9	59900.1	-21.2	9959.8	7309.2
DESHKA	81447.4	65328.6	-19.8	10344.9	7697.3
SU STA	134549.6	118430.8	-12.0	16035.1	13778.8

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.175	.189	.647	.392	.104	-1.313
PORTAGE	.178	.190	.657	.387	.133	-1.152
INDIAN	.180	.192	.664	.394	.153	-1.010
CURRY	.178	.186	.655	.402	.138	-.966
WHISKERS	.178	.184	.652	.405	.133	-.951
CHULITNA	.144	.140	.458	.577	-.455	-.336
TALKEET	.144	.139	.354	.356	-.370	-.418
TRAPPER	.144	.139	.354	.355	-.370	-.419
SUNSHINE	.144	.139	.354	.355	-.370	-.419
MONTANA	.141	.134	.368	.370	-.322	-.364
SHEEP	.138	.131	.381	.386	-.274	-.301
KASHWIT	.135	.126	.404	.418	-.184	-.166
LWILLOW	.133	.124	.417	.439	-.127	-.075
WILLOW	.131	.122	.434	.466	-.051	.049
DESHKA	.127	.118	.478	.538	.158	.395
SU STA	.119	.116	.731	.848	1.666	2.110

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO AUGUST

LOCATION	MAINSTEM FLOWS (CFS) PRE-	POST-	% CHANGE	STANDARD DEVIATION PRE-	POST-
D.C. DAM	20955.6	11333.7	-45.9	4722.8	1596.3
PORTAGE	21629.9	12008.0	-44.5	4919.3	1681.3
INDIAN	22207.3	12585.3	-43.3	5092.4	1782.0
CURRY	22853.1	13231.2	-42.1	5214.6	1856.9
WHISKERS	23069.0	13447.1	-41.7	5255.6	1883.4
CHULITNA	46115.6	36493.7	-20.9	9078.7	5959.9
TALKEET	56684.8	47062.9	-17.0	11761.1	8327.4
TRAPPER	56863.2	47241.3	-16.9	11798.1	8363.3
SUNSHINE	57251.8	47629.9	-16.8	11878.8	8441.6
MONTANA	59065.7	49443.8	-16.3	11921.9	8459.6
SHEEP	60596.2	50974.3	-15.9	11966.8	8486.8
KASHWIT	63090.2	53468.3	-15.3	12055.9	8554.2
LWILLOW	64507.3	54885.4	-14.9	12115.4	8605.1
WILLOW	66264.5	56642.6	-14.5	12197.8	8680.4
DESHKA	70685.8	61063.9	-13.6	12446.3	8928.2
SU STA	113935.4	104313.5	-8.4	17221.9	14288.5

ADDITIONAL STATISTICS

LOCATION	COEF. OF VARIAT. PRE-	POST-	SKEW COEFFICIENTS PRE-	POST-	EXCESS COEFFICIENTS PRE-	POST-
D.C. DAM	.225	.141	1.450	3.318	2.369	11.149
PORTAGE	.227	.140	1.455	3.457	2.329	11.819
INDIAN	.229	.142	1.458	3.407	2.290	11.578
CURRY	.228	.140	1.449	3.376	2.269	11.514
WHISKERS	.228	.140	1.446	3.360	2.262	11.462
CHULITNA	.197	.163	1.112	1.123	2.296	3.016
TALKEET	.207	.177	.801	.676	1.210	1.715
TRAPPER	.207	.177	.801	.677	1.210	1.714
SUNSHINE	.207	.177	.801	.679	1.210	1.712
MONTANA	.202	.171	.820	.723	1.216	1.752
SHEEP	.197	.166	.834	.755	1.216	1.774
KASHWIT	.191	.160	.849	.797	1.209	1.786
LWILLOW	.188	.157	.854	.815	1.201	1.780
WILLOW	.184	.153	.858	.832	1.188	1.761
DESHKA	.176	.146	.851	.844	1.139	1.662
SU STA	.151	.137	.317	.229	.447	.319

STATISTICAL RECORD OF 32-YEAR SUMMARY, 2 DAM SCENARIO SEPTEMB

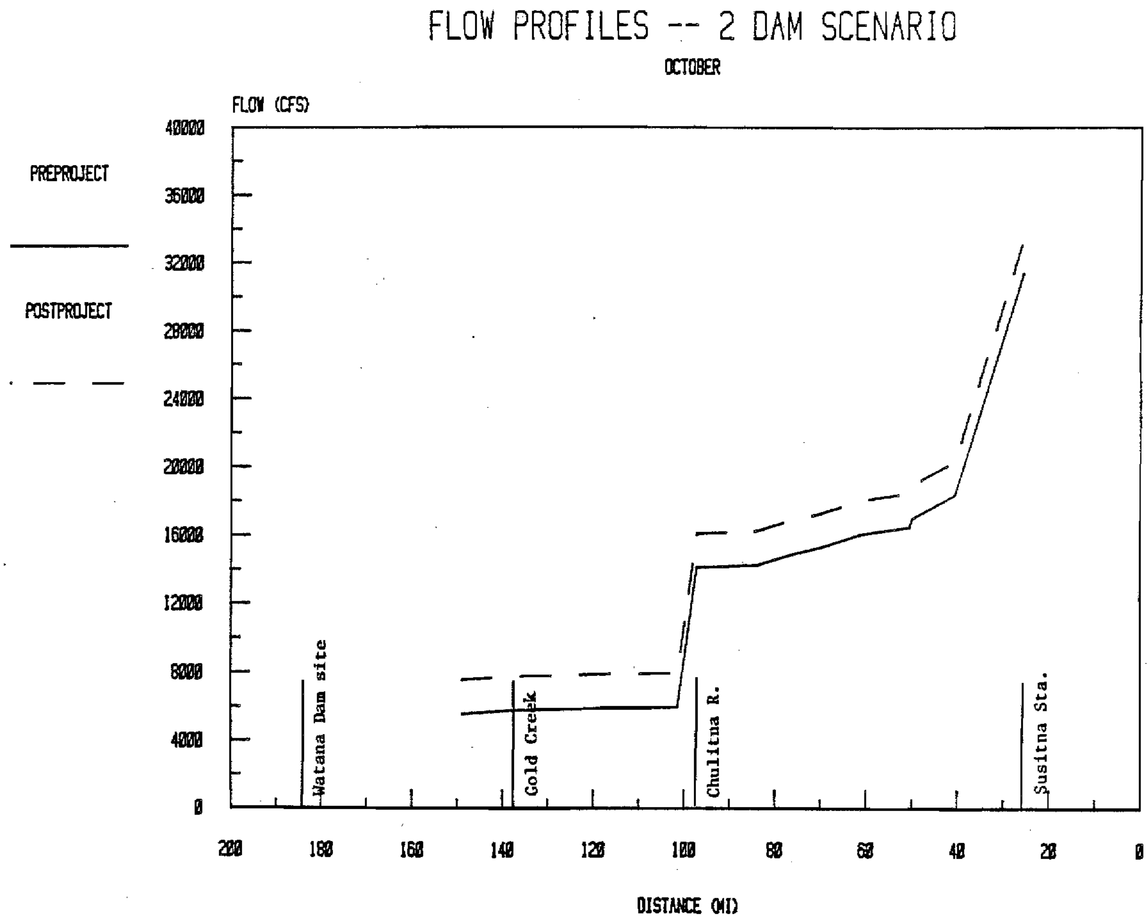
	MAINSTEM FLOWS (CFS)			STANDARD DEVIATION	
LOCATION	PRE-	POST-	% CHANGE	PRE-	POST-
D.C. DAM	12449.1	9603.0	-22.9	3613.9	2331.7
PORTAGE	12929.2	10083.1	-22.0	3793.2	2397.6
INDIAN	13340.2	10494.2	-21.3	3950.6	2469.3
CURRY	13702.4	10856.3	-20.8	4043.0	2513.5
WHISKERS	13823.4	10977.4	-20.6	4074.0	2529.0
CHULITNA	25768.0	22921.9	-11.0	7098.0	5416.6
TALKEET	31786.3	28940.2	-9.0	8835.8	6815.0
TRAPPER	31886.3	29040.2	-8.9	8863.6	6840.6
SUNSHINE	32104.2	29258.2	-8.9	8924.2	6896.3
MONTANA	33241.7	30395.7	-8.6	9021.0	7018.5
SHEEP	34201.5	31355.5	-8.3	9114.8	7136.5
KASHWIT	35765.6	32919.6	-8.0	9290.7	7356.4
LWILLOW	36654.3	33808.2	-7.8	9402.9	7495.5
WILLOW	37756.3	34910.2	-7.5	9553.6	7681.4
DESHKA	40529.0	37682.9	-7.0	9986.2	8207.7
SU STA	67651.7	64805.6	-4.2	16667.4	15638.2

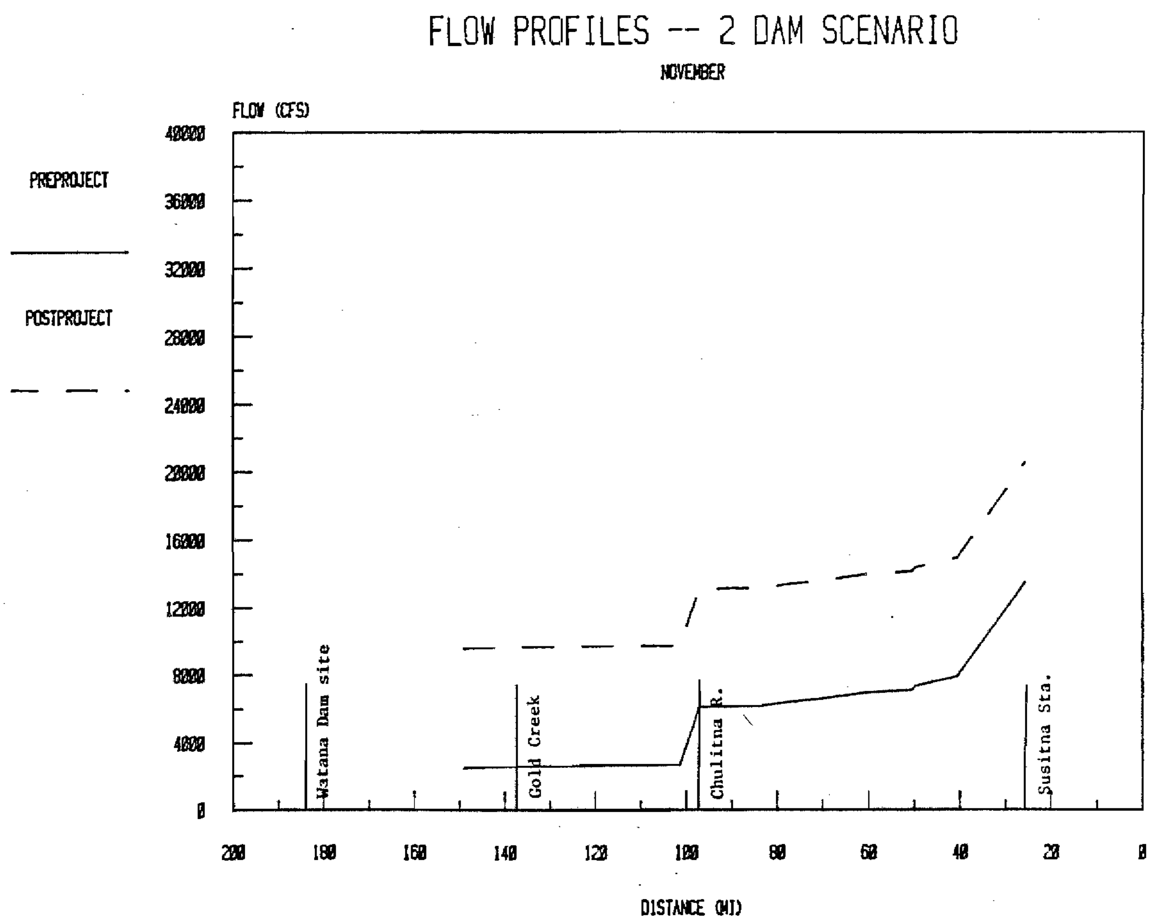
ADDITIONAL STATISTICS

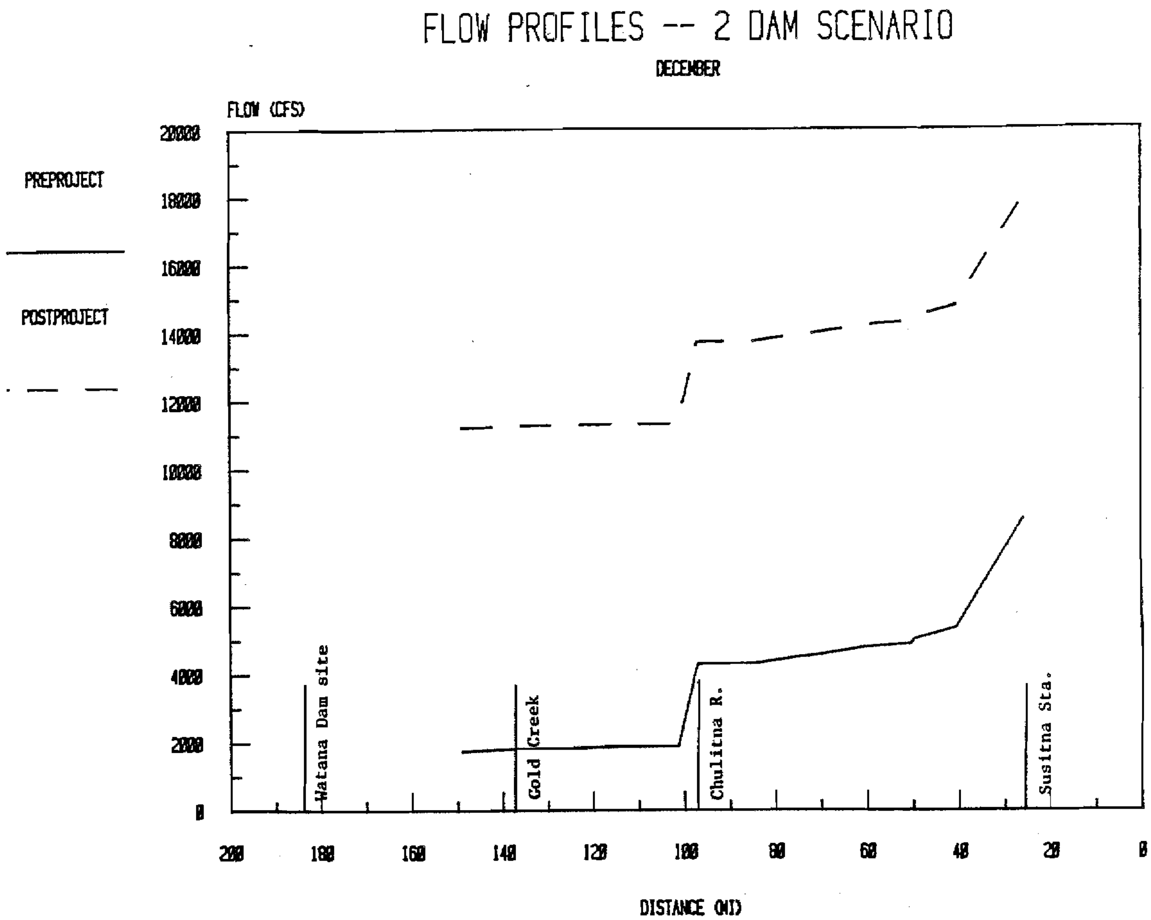
	COEF. OF VARIAT.		SKEW COEFFICIENTS		EXCESS COEFFICIENTS	
LOCATION	PRE-	POST-	PRE-	POST-	PRE-	POST-
D.C. DAM	.290	.243	.282	1.967	-.448	3.010
PORTAGE	.293	.238	.295	2.088	-.467	3.435
INDIAN	.296	.235	.307	2.145	-.482	3.692
CURRY	.295	.232	.307	2.142	-.489	3.747
WHISKERS	.295	.230	.307	2.139	-.491	3.760
CHULITNA	.275	.236	.654	1.820	.577	4.905
TALKEET	.278	.235	.613	1.325	.357	2.868
TRAPPER	.278	.236	.613	1.322	.357	2.855
SUNSHINE	.278	.236	.613	1.314	.357	2.827
MONTANA	.271	.231	.598	1.313	.375	2.891
SHEEP	.267	.228	.582	1.302	.383	2.909
KASHWIT	.260	.223	.551	1.266	.381	2.873
LWILLOW	.257	.222	.532	1.238	.372	2.822
WILLOW	.253	.220	.507	1.197	.354	2.733
DESHKA	.246	.218	.441	1.079	.278	2.421
SU STA	.246	.241	.119	.375	-.528	.126

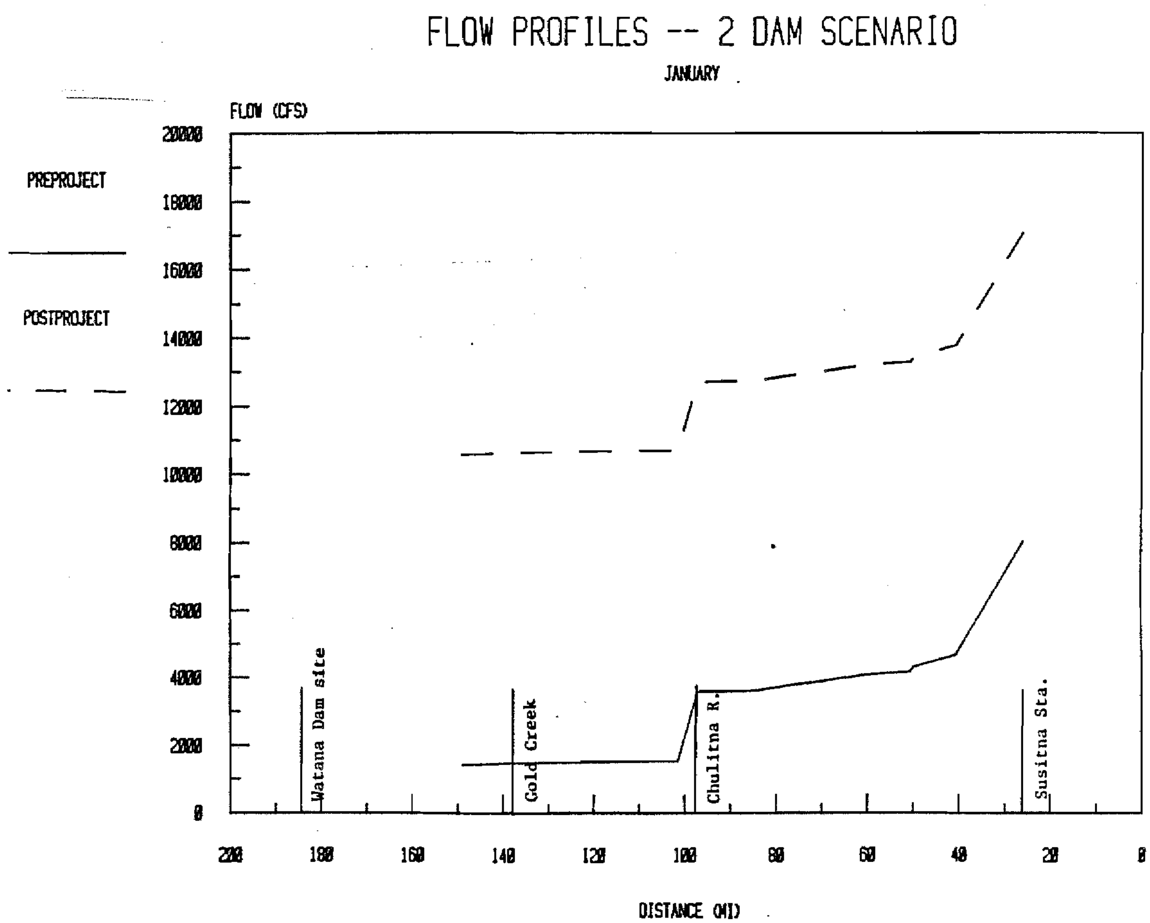
APPENDIX E

MONTHLY FLOW PROFILES FOR NATURAL AND TWO-DAM OPERATIONAL CONDITIONS


FLOW PROFILES -- 2 DAM SCENARIO
OCTOBER
FLOW (CFS)
PREPROJECT
POSTPROJECT
40000
36000
32000
28000
24000
20000
16000
12000
8000
4000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)

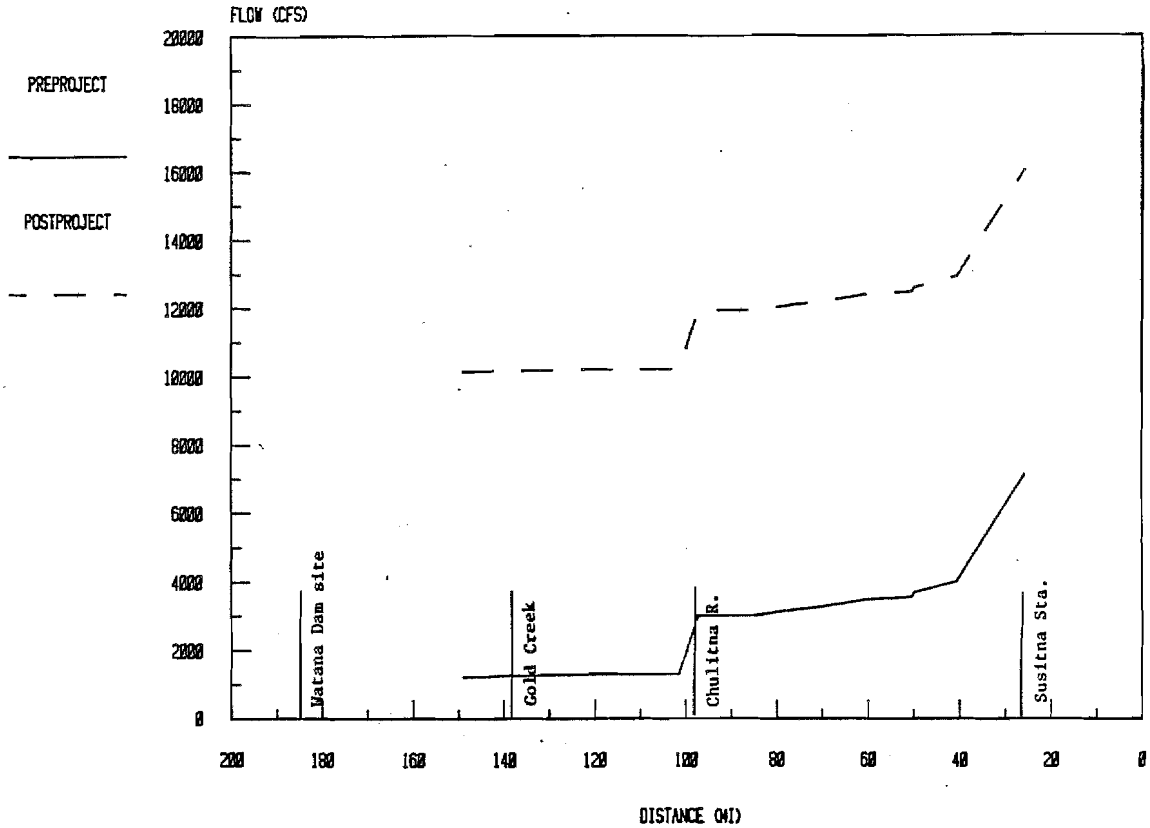

FLOW PROFILES -- 2 DAM SCENARIO
NOVEMBER
FLOW (CFS)
PREPROJECT
POSTPROJECT
40000
36000
32000
28000
24000
20000
16000
12000
8000
4000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)


FLOW PROFILES -- 2 DAM SCENARIO
DECEMBER
FLOW (CFS)
PREPROJECT
POSTPROJECT
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)


FLOW PROFILES -- 2 DAM SCENARIO
JANUARY
FLOW (CFS)
PREPROJECT
POSTPROJECT
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)

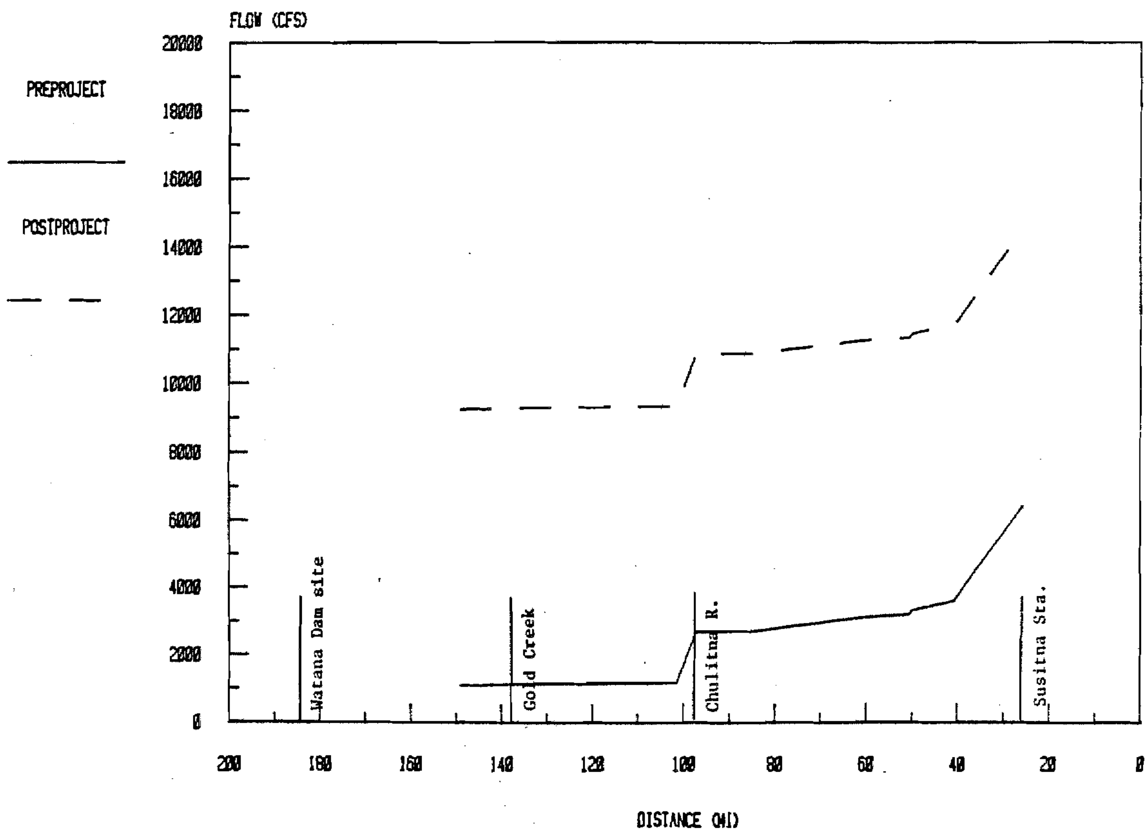
FLOW PROFILES -- 2 DAM SCENARIO

FEBRUARY



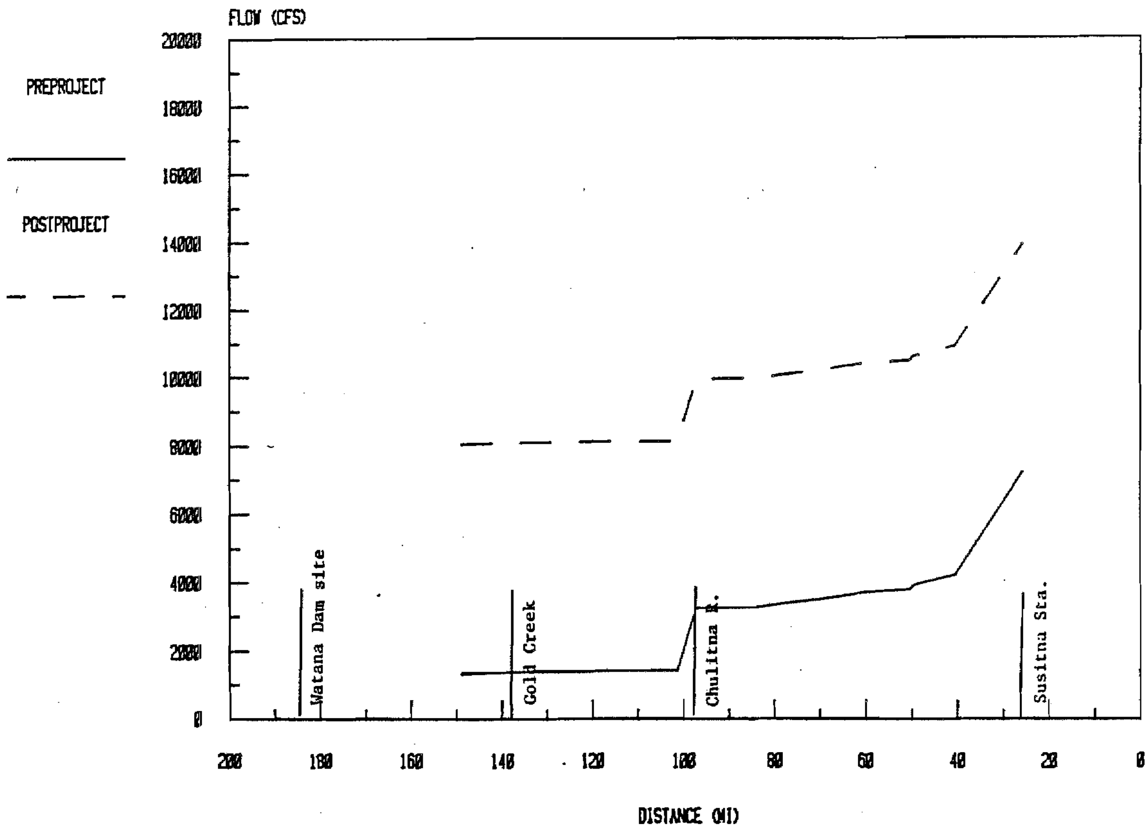
FLOW PROFILES -- 2 DAM SCENARIO

MARCH



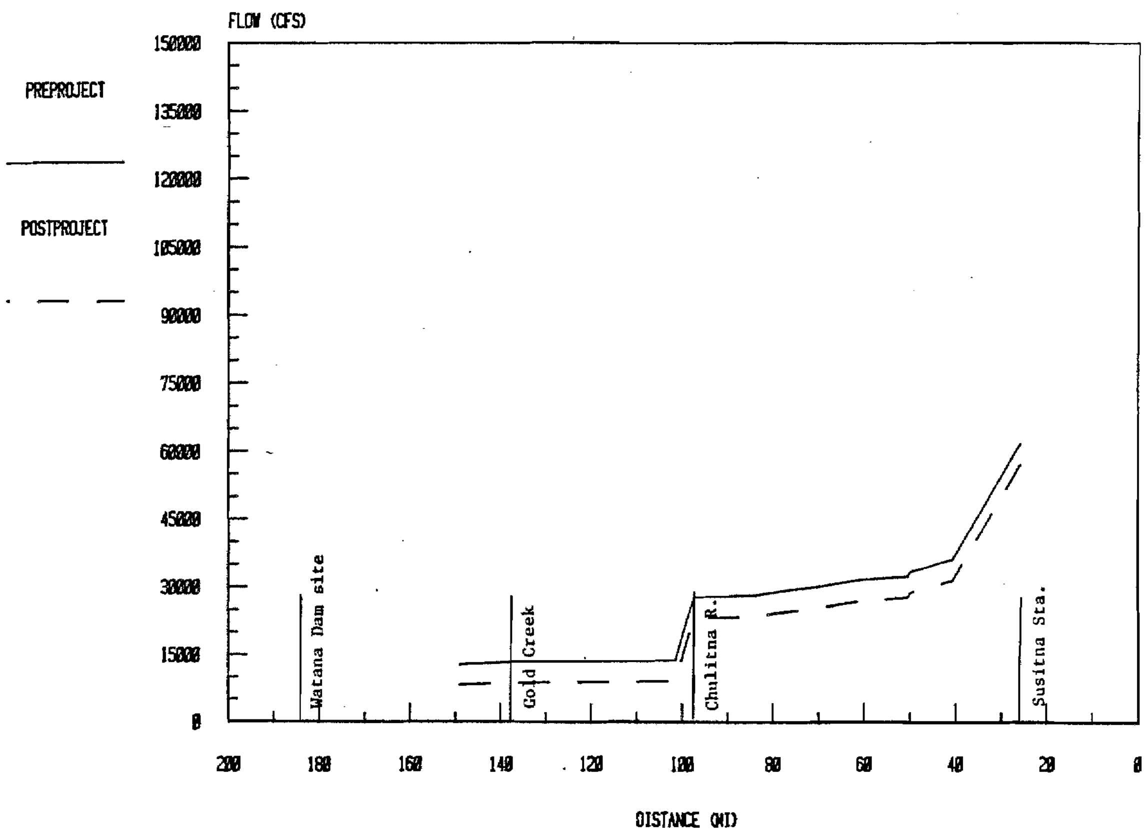
FLOW PROFILES -- 2 DAM SCENARIO

APRIL



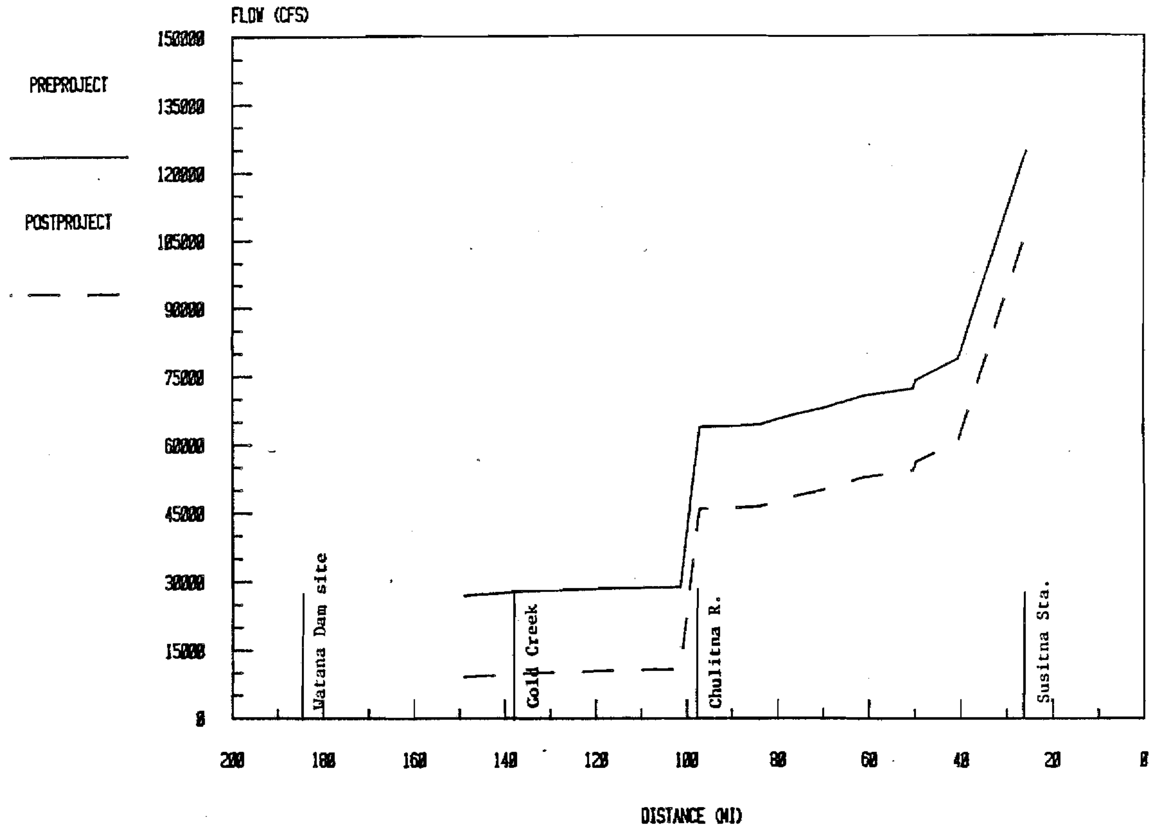
FLOW PROFILES -- 2 DAM SCENARIO

MAY



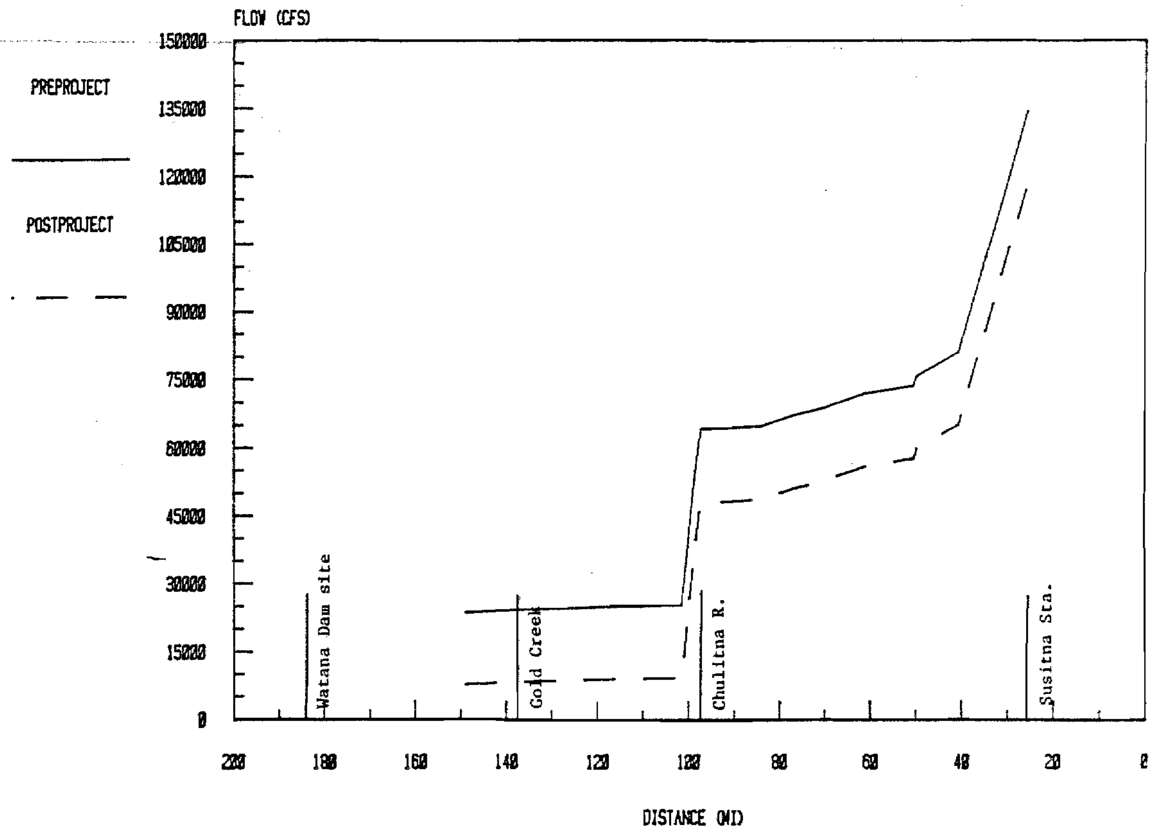
FLOW PROFILES -- 2 DAM SCENARIO

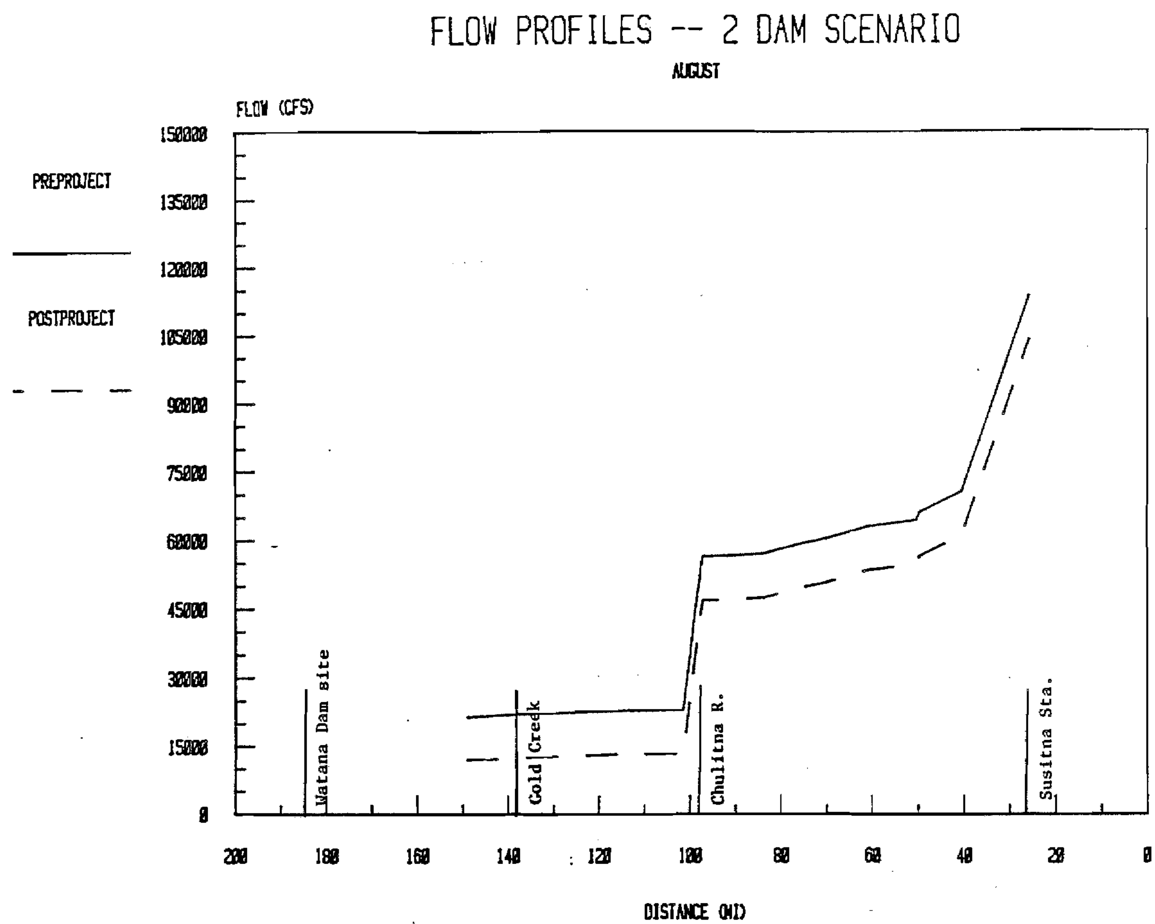
JUNE

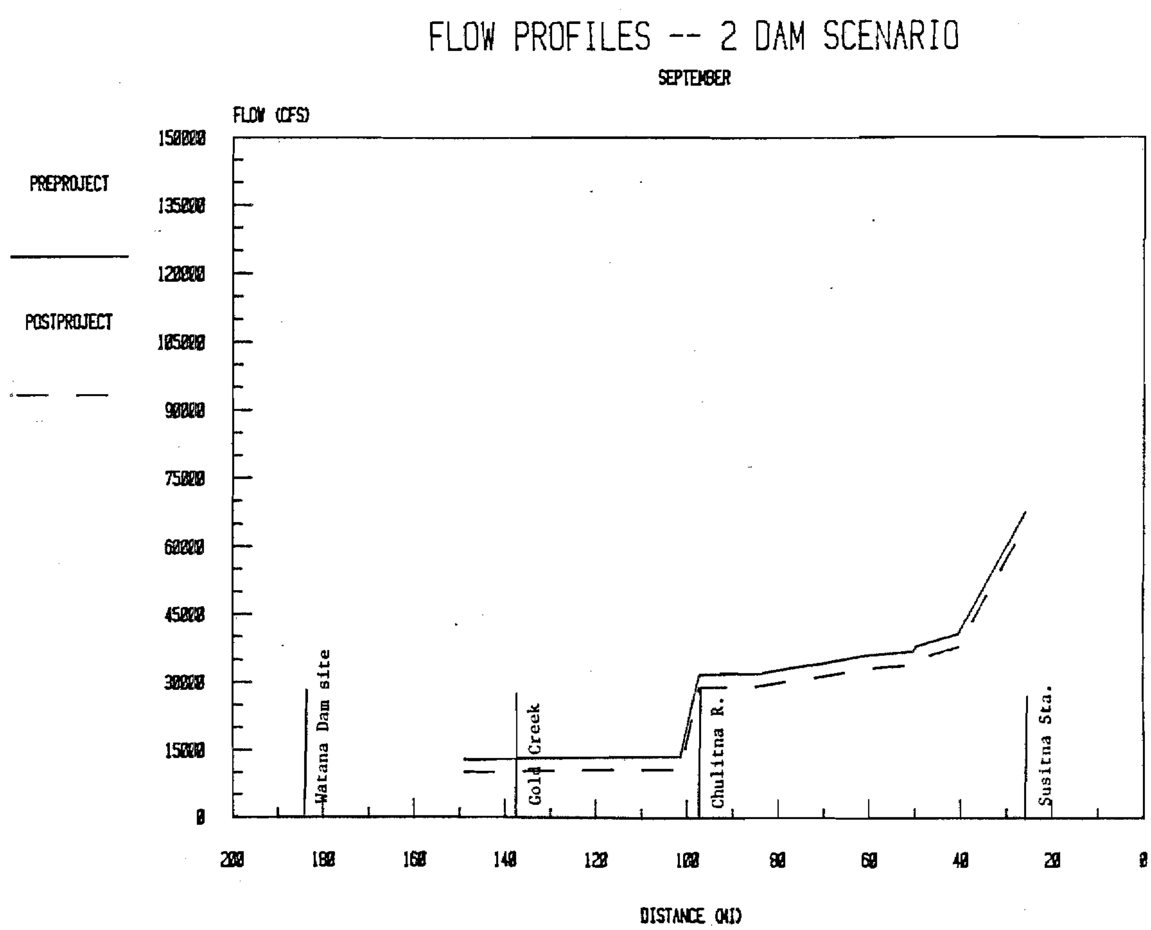


FLOW PROFILES -- 2 DAM SCENARIO

JULY

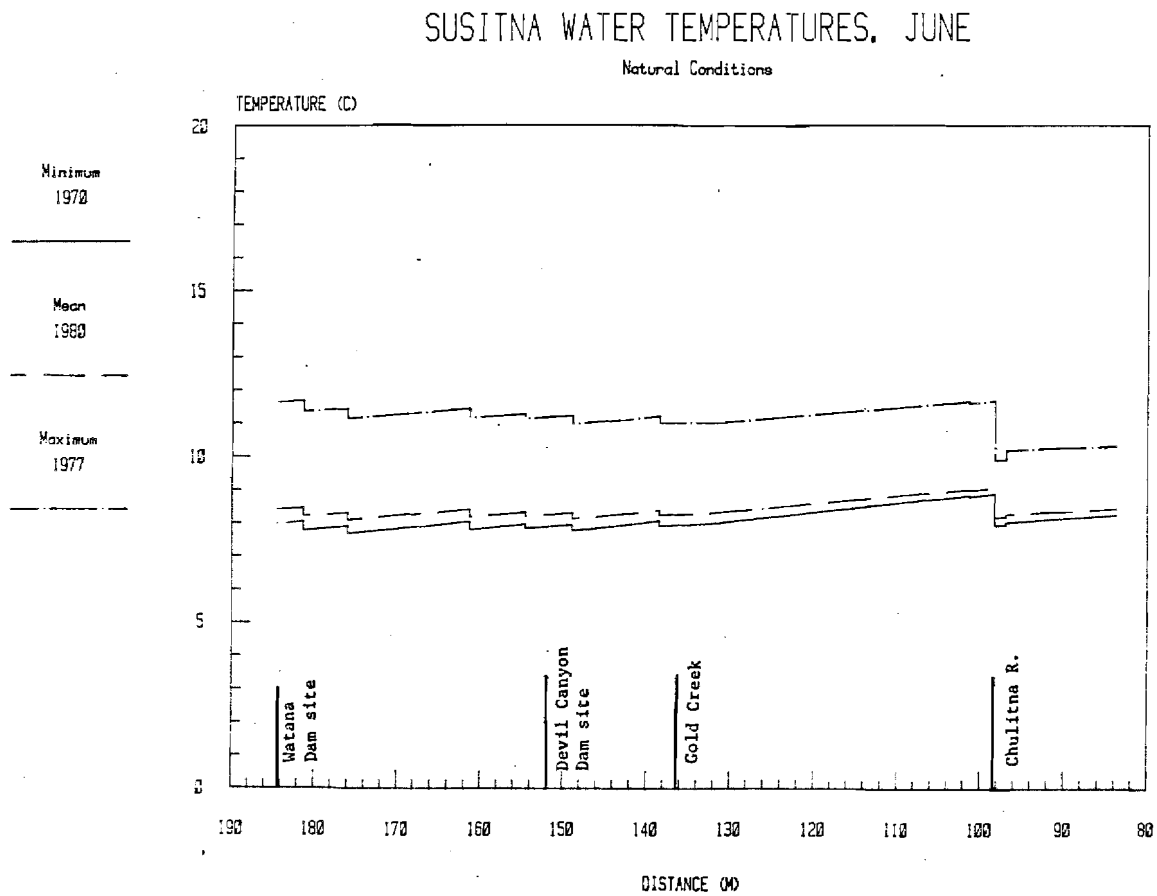


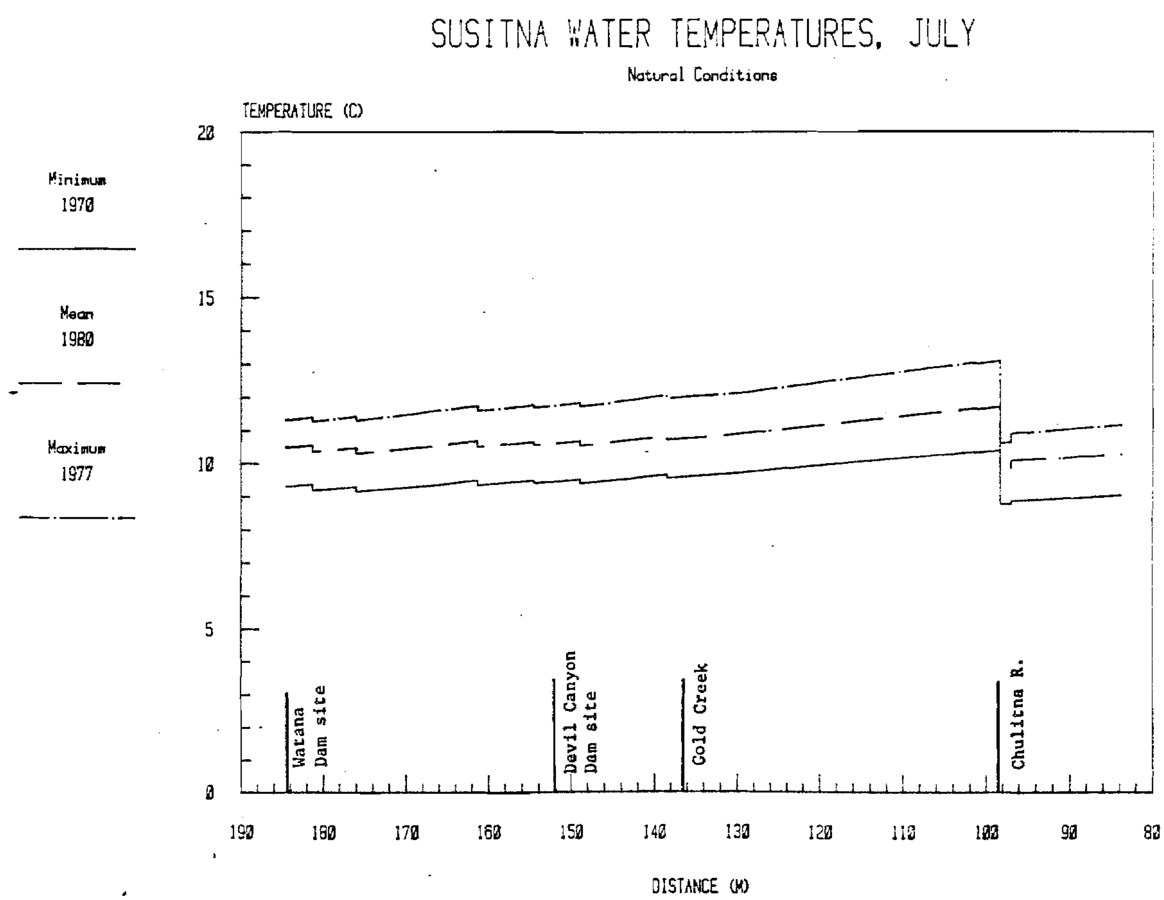

FLOW PROFILES -- 2 DAM SCENARIO
AUGUST
FLOW (CFS)
PREPROJECT
POSTPROJECT
150000
135000
120000
105000
90000
75000
60000
45000
30000
15000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)

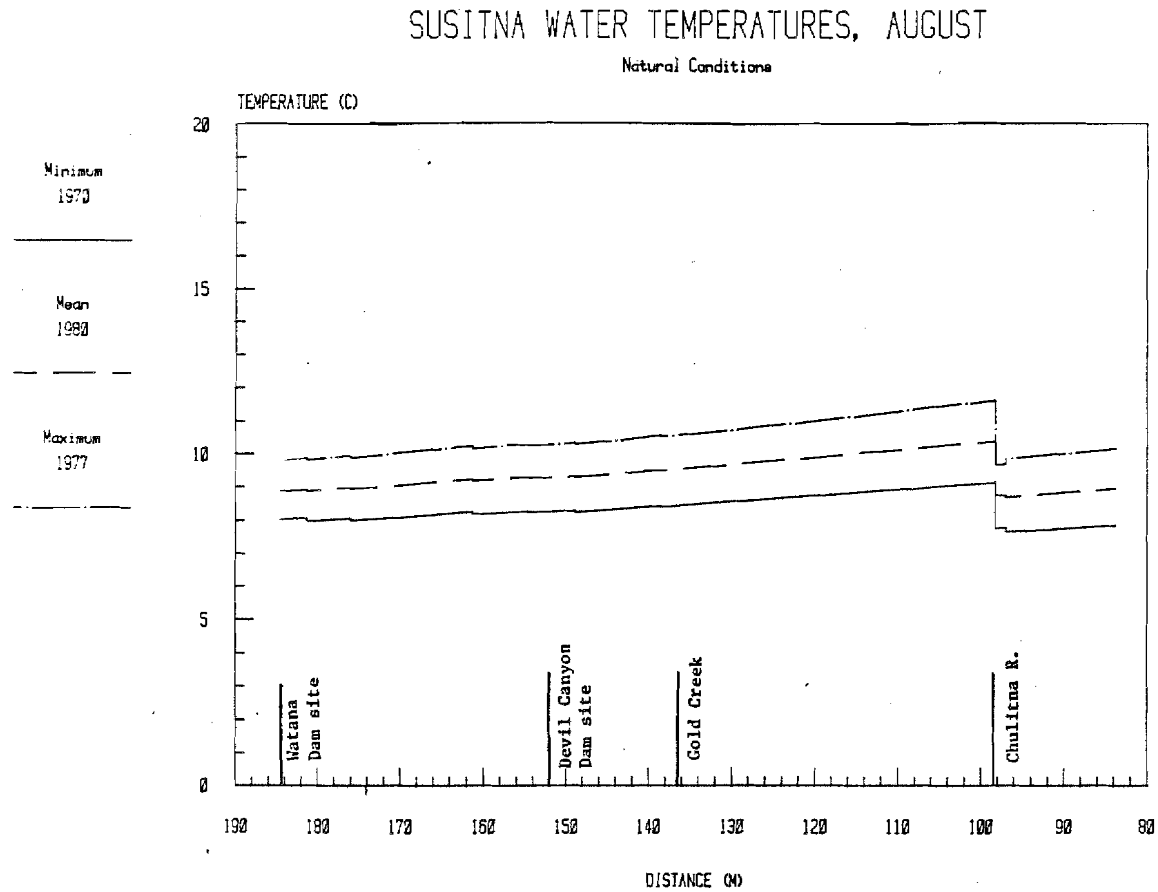

FLOW PROFILES -- 2 DAM SCENARIO
SEPTEMBER
FLOW (CFS)
PREPROJECT
POSTPROJECT
150000
135000
120000
105000
90000
75000
60000
45000
30000
15000
0
Watana Dam site
Gold Creek
Chulitna R.
Susitna Sta.
200
180
160
140
120
100
80
60
40
20
0
DISTANCE (MI)

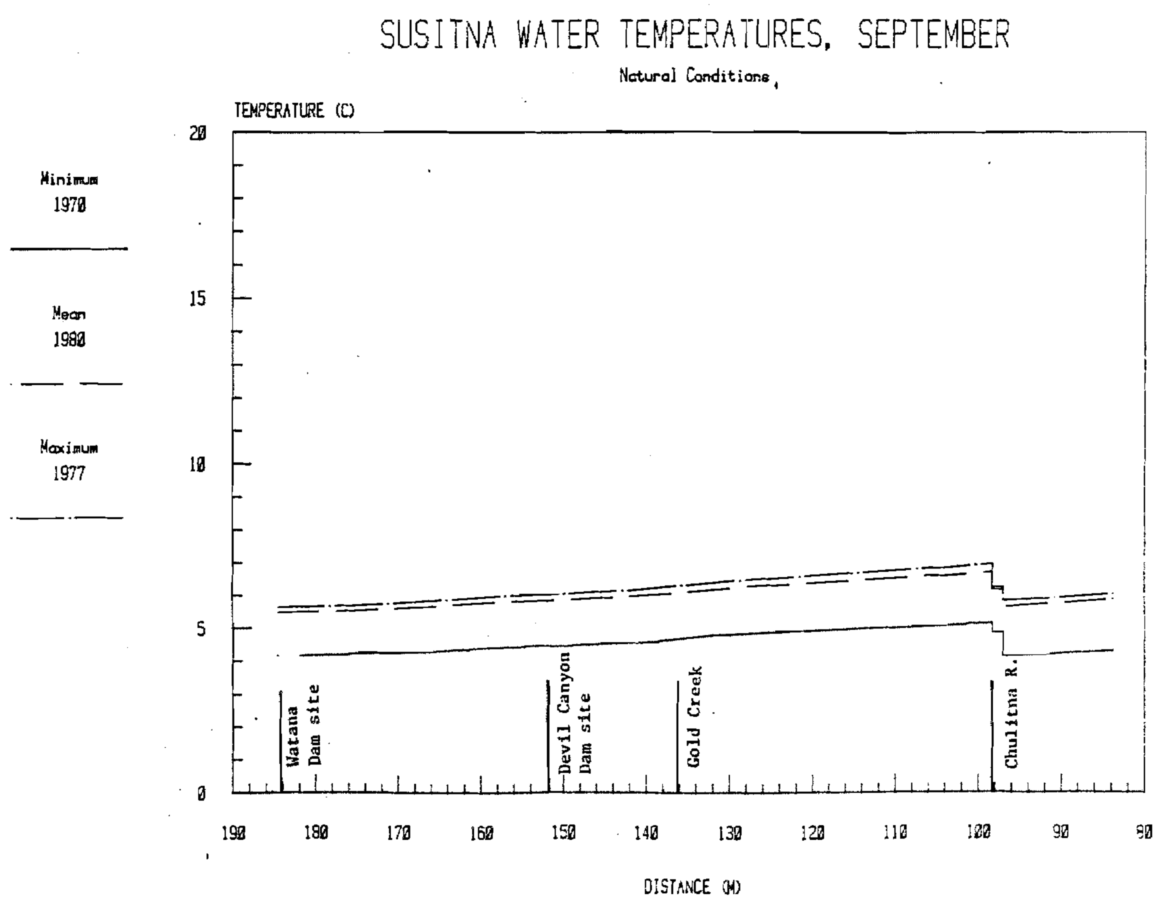
APPENDIX F

NATURAL RIVER TEMPERATURE PROFILES FOR NORMAL AND EXTREME CONDITIONS


SUSITNA WATER TEMPERATURES, JUNE
Natural Conditions
TEMPERATURE (C)
Minimum
1970
Mean
1980
Maximum
1977
Watana
Dam site
Devil Canyon
Dam site
Gold Creek
Chulitna R.
DISTANCE (M)


SUSITNA WATER TEMPERATURES, JULY
Natural Conditions
TEMPERATURE (C)
Minimum
1970
Mean
1980
Maximum
1977
Watana
Dam site
Devil Canyon
Dam site
Gold Creek
Chulitna R.
DISTANCE (M)


SUSITNA WATER TEMPERATURES, AUGUST
Natural Conditions
TEMPERATURE (C)
Minimum
1970
Mean
1980
Maximum
1977
20
15
10
5
0
Watana
Dam site
Devil Canyon
Dam site
Gold Creek
Chulitna R.
190
180
170
160
150
140
130
120
110
100
90
80
DISTANCE (M)


SUSITNA WATER TEMPERATURES, SEPTEMBER
Natural Conditions
TEMPERATURE (C)
Minimum
1970
Mean
1980
Maximum
1977
20
15
10
5
0
Watana
Dam site
Devil Canyon
Dam site
Gold Creek
Chulitna R.
190
180
170
160
150
140
130
120
110
100
90
80
DISTANCE (M)