Integrating Recreational Instream Flow Requirements into Management of Multiple Use Rivers

by

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ABSTRACT

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This document was prepared in partial fulfillment of the requirements of the MEDes Degree in the Faculty of Environmental Design, The University of Calgary

Recreation instream flow needs (IFN) were determined for the Bow River from the Ghost Dam to the Highway-22 bridge at Cochrane, AB in the summer of 1997. Expert judgement, user surveys, and a controlled flow experiment were used in conjunction to develop flow preference curves for angling, canoeing, kayaking, and rafting.

The minimum acceptable flow and the preferred flow conditions for recreation were identified from the preference curves. The minimum acceptable flow for all forms of recreation in this reach was 59cms. The preferred flow, defined as the lower limit in the range of optimum flows, was 113cms for all forms of recreation. Efforts should be made to provide a variety of flows to satisfy all recreation users.

The Ghost Dam is a hydropeaking facility operated by TransAlta Utilities Limited. Two major impacts of hydropeaking on recreation were found for this site. There is a loss of recreation potential for all activities in the mornings when the minimum flow of 8.5cms is released from the dam, and a loss of angling potential in the late summer months when the maximum flow of 221cms is released in August and September.

Managing rivers for multiple use is only successful in Alberta to the point where the terms of any existing licenses are not threatened. A mechanism is needed to either force negotiations with all users to be conducted in good faith, or to revisit and change old water licenses to include instream flow values into the management policies for Alberta's rivers.

Keywords: Recreation, Instream Flow Needs, Hydropeaking, Bow River, Flow Preference Curves, Multiple Use

EXECUTIVE SUMMARY

The Bow River is a major resource in Southern Alberta used for recreation, irrigation, power generation, municipal water supply, industrial water supply, and waste assimilation. Recreation instream flow needs (IFN) were determined for the Bow River from Ghost Dam to Cochrane, Alberta during the summer of 1997 using three methods. The first method was to interview experienced users of the Bow River to collect background information and to corroborate the data collected by the other two methods. The second method involved a user survey, implemented at a major access site on the river, to provide flow evaluations from the general recreation public. The final method used was a controlled flow experiment where three different flows were evaluated on a single day using timed flow releases from Ghost Dam.

Recreation on the Ghost Dam reach of the Bow River consists of four major activities: canoeing, rafting, kayaking, and angling. Powerboats do use this reach, but were only observed occasionally. Canoeing was the most common boating activity, accounting for over 40% of the user surveys collected. Rafting was the second most common boating activity followed by kayaking.

Angling is also an important recreation activity on this section of the Bow River. Due to the multiple access points used by anglers throughout this section of the Bow River, conducting surveys at the major boating access point did not provide a good estimate of angling use on the river. An alternate survey approach involving the distribution of self-administered survey packages through local fishing groups and fishing stores was implemented. This approach did not allow for an estimate of the abundance of anglers relative to the boating groups. Previous studies have indicated that fishing is the dominant recreation activity on all reaches of the Bow River.

In defining recreation IFN, two critical flows were identified. The first flow is the lowest flow needed to sustain an acceptable recreation experience, and the second flow is the lower limit of the optimal range for recreation, or the preferred flow.

Ghost Dam generally releases five distinct flows into the Bow River, which can all be experienced for recreation. Each flow released from Ghost Dam provides very different conditions for recreation. Some recreation activities can have competing flow preferences, particularly between angling and the boating activities. The recreation conditions at each operating flow from Ghost Dam are:

- 8.5cms – minimum-operating flow from Ghost Dam, unacceptable conditions for all recreation activities.
- 59cms – the lowest flow that sustains an acceptable recreation experience for all recreation activities.
- 113cms – optimal flow conditions for angling and kayaking, and good conditions for canoeing and kayaking.
- 164cms – acceptable, but not preferred, conditions for all recreation activities.
- 221cms – optimal flow conditions for canoeing and rafting, good conditions for kayaking, but unacceptable for angling.

From this summary, 59cms is the lowest flow to sustain recreation for all recreation activities and 110 is the lower limit of the optimum range for all recreation activities. A flow of 221cms is within the optimum range for boating activities, but it is unacceptable for angling. Although 59cms is identified as the lowest flow to sustain recreation, supplying a range of optimum flows, from 113 to 221cms, is required to maintain suitable recreation conditions within a single season.

Two types of potential impacts on recreation from TransAlta's hydropeaking operation schedule were identified. The first is the daily impact of releasing the minimum-operating flow too late into the morning, resulting in unacceptable conditions for all recreation activities. The second impact is a seasonal issue related to the peak operating flow being released during the late summer and early fall. This is primarily only a concern for anglers, since the high flows benefit boaters by extending the potential recreation season when optimum flows can be experienced.

Daily impacts of flow on recreation can be managed by making an effort to limit the number of days that unacceptable low flows are released during daylight hours. This is primarily concerning the release of the minimum flow late into the morning and periodically at other times of the day. The minimum flow was found totally unacceptable for all recreation activities.

The peak flow provides optimum conditions for boaters, but is unacceptable for anglers. Anglers expect lower flows during August and September. To manage the impact of the peak flow on recreation, a trade-off could be made to avoid the peak flow during the late summer during naturally low flow conditions. This would provide an improvement to angling on this reach, and can still produce good late season conditions for boating.

An increase in the minimum flow release and a narrower range of flow variation is likely required to improve fish habitat in this section of the Bow River. If this strategy is adopted, then there will also be benefits for recreation. Boating will still benefit from an extended recreation season due to the continued hydropeaking operation. Anglers will also benefit from a more stable flow, lower late season flows, and the predicted increase in fish productivity.

Currently, in Alberta the new Water Act requires instream flow data to be collected. The recognition of recreation as a legitimate use of water resources is a step in the right direction. However, instream flow recommendations are passed through a multi-step planning process. During this process, there are multiple opportunities for the recreation IFN recommendations to be watered down, or ignored all together. Unless recreation interests are strongly represented at every step of the process, the collection of recreation IFN data is a futile exercise that gets lost in the planning process. A mechanism is needed either to force negotiations with all users to be conducted in good faith, or to revisit and change old water licenses to include instream flow values into the management policies for Alberta's rivers.

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1 INTRODUCTION

With the growth of the population and the economy of a region, there is an increased demand for the consumptive use of rivers and for river-based recreation (Brown et al., 1992). Managing for different objectives such as irrigation, power generation, recreation, or ecological integrity, will all result in different instream flow requirements (Shelby et al., 1992). In many cases, recreation is given a low priority when determining management strategies for river resources and the resulting management plan does not successfully integrate all of the resource values. To adequately assess management trade-offs between the competing uses of the river resource, there must be an understanding of the relationship between flow and recreation quality and value (Brown et al., 1992).

The Bow River is a major resource in southern Alberta for recreation, irrigation, power generation, municipal water supply, industrial water supply, and waste assimilation. Recreation users can have conflicting needs amongst themselves, and with the consumptive users of the Bow River.

The flow of the Bow River is controlled in many sections of the river via dams and diversion weirs. As the population of Calgary grows, the demands on the Bow River will increase. Past studies have shown the importance of the Bow River for recreation (Thompson et al., 1987), but there is no information relating the direct effects of flow on recreation quality. To manage a multiple-use river for different flow regimes, the impacts of flow regulation to all of the affected resource values should be considered.

1.1 DRIVING FORCES

In Alberta, there are a few key driving forces that can be used to justify conducting an instream flow needs (IFN) study for river based recreation. First, the number of recreation users and the increased organisation of recreation users have provided a louder voice for protecting recreation resources in the province. This is reflected in representation of recreation organisations, such as the Calgary Area Outdoor Council, in provincial planning processes and the establishment of projects such as the Fisheries and Recreation Enhancement Working Group on the Kananaskis River in Alberta.

Driving forces from a policy standpoint include the Water Management Principles for Alberta, which states that multi-purpose use of water is the underlying principle in all water resource planning and development in the province (Alberta Environmental Protection, 1997). There is also recognition that water resource management in Alberta should include maintaining flows for beneficial instream uses (Alberta Environmental Protection, 1997). However, the Alberta Government has a water management policy that recognises the importance of water use for human consumption, for food production, for industrial use, and for other uses, in that order (Alberta Environmental Protection, 1997). This hierarchy leaves water-based recreation as a low priority of use for Alberta's rivers.

In addition to Alberta's water management policy, there is also a water management policy for the South Saskatchewan River Basin. The basic principles of this policy are for multi-purpose use and the need to define instream flows to protect minimum and preferred flow conditions (Alberta Environmental Protection, 1997). However, despite this policy, all existing water licenses will be respected by the Government of Alberta according to the priority date of issue of each license (Alberta Environmental Protection, 1997). This means that licenses with the earliest dates of issue will have the right to their full license before any water can be reserved for instream uses.

Although there is a policy for managing rivers in Alberta for multi-purpose use, Makuk (1988) found that very few management projects have succeeded in this approach. Makuk also reports that in locations where multi-purpose use is attempted in Alberta, it is applied in a very arbitrary manner. Since the time of Makuk's report, Alberta has progressed, but still lacks a method for adequately applying multi-purpose principles in the management of rivers.

Information has been collected across Alberta for AEP over the past 15 years to define instream flow requirements for other instream uses, including a fish habitat IFN study conducted on the same reach of the Bow River as the current study (EMA 1994). The soon to be proclaimed Water Act in Alberta is a final major driving force that is behind many of the new IFN studies across Alberta. The Act has initiated the need to collect IFN data, but it is yet to be determined how any new IFN data will be incorporated into the management of Alberta's rivers. More IFN projects are currently being planned by AEP for completion in the immediate future.

1.1.1 Alberta's Water Act

The Government of Alberta's Water Act (R.S.A. 1996, c. W-3.5), which is scheduled for proclamation in the fall of 1998, is the most important driving force for water management in the province at this time. The purpose of the new Act, as stated in Section 2 of the Act, is to "support and promote the conservation and management of water, including the wise allocation and use of water...."

The new Water Act also contains several statements that provide direction for determining and protecting instream flows for the purpose of recreation, and other instream uses. In particular, the following sections of the Act outline specific responsibilities that are relevant for defining instream flow needs for recreation in Alberta.

> ***7(1) The Minister must establish a framework for water management planning for the Province within 3 years after the coming into force of this Act (pg. 18).***
>
> ***8(2) The Minister must establish a strategy for the protection of the aquatic environment as part of the framework for water management planning in the province (pg. 19).***
>
> ***8(3) The strategy referred to in subsection (2) may include***
>
> > ***a) identification of criteria to determine the order in which water bodies are to be dealt with,***
> >
> > ***b) guidelines for establishing water conservation objectives,***
> >
> > ***c) matters relating to the protection of biological diversity, and***
> >
> > ***d) guidelines and mechanisms for implementing the strategy (pg. 19).***

Of particular note in the above statements is the need to establish water conservation objectives as a component of the strategy for the protection of the aquatic environment. Within the Act, a water conservation objective is defined as:

> *1(1)(iii) ... the amount and quality of water established by the Director under Part 2, based on information available to the Director, to be necessary for the*
>
> *i) protection of a natural water body or its aquatic environment, or any part of them,*
>
> *ii) protection of tourism, recreational, transportation or waste assimilation uses of water, or*
>
> *iii) management of fish or wildlife,*
>
> *and may include water necessary for the rate of flow of water or water level requirements (pg. 15).*

From these sections within the Water Act, there is a clear reference for providing information on the flow requirements to protect recreation. Determining instream flows for recreation does not guarantee that those flows will be protected explicitly for that purpose. Clearly, if no information is available to the Minister, then the flow needs for recreation will not be considered in the development of water conservation objectives.

1.2 INITIATION OF THE STUDY

Alberta Environmental Protection (AEP) initiated the current study through the recreation sub-committee of the Bow Basin Plan to investigate the instream needs for recreation within the Bow Basin. The results from the study will also be used in the review of water management in the South Saskatchewan River Basin to be conducted in 2000.

One of the goals of the Bow Basin Plan is to develop conservation objectives, which will result in a water management plan to be approved under the new Water Act (Bow River Water Quality Council, 1996). In the initial phase of the Bow Basin Plan, several public meetings were held to discuss water management concerns with the public. The summary of the public's comments is:

> *The Bow River should remain a resource in the public domain to allow it to be used for recreation of all types. Although it is unreasonable to expect unrestricted access, a balance is needed to ensure overuse does not ruin the recreational experience. This plan should identify and promote a wide range of river-oriented activities for both personal enjoyment and recognize the financial benefits of the recreational (including fishing) industry to Alberta (Bow River Water Quality Council 1996, pg. 9).*

In addition to this statement, there was specific concern raised by the public on the effects of hydro peaking on recreation on the Bow River below the Ghost Dam (Bow River Water Quality Council, 1996).

1.2.1 Funding

Student Temporary Employment Program (STEP) funding was secured for the summer of 1997 to conduct surveys on the Bow River and interview experienced Bow River recreation users. The survey design was approved by AEP, and the project was conducted as an AEP study. Permission to use the information collected while under the employment of AEP was granted for the purpose of this Masters Degree Project. An initial draft summary report of the results was produced for AEP and distributed to the committee members on the Bow Basin Plan and to TransAlta Utilities.

AEP provided the resources necessary to print the survey forms and to distribute a mail-out survey package. AEP also provided access to a vehicle for travel to and from the survey location each weekend from June through August 1997. Initially, the objective of this project was to examine the entire Bow River. However, due to timing and resource constraints, the focus of the project shifted to a single section of the Bow River and concentrated on the impacts of hydropeaking on recreation.

1.3 STUDY OBJECTIVES

The goal of this study is to determine a relationship between the flow in the Bow River and water-based recreation quality. Using the established relationship between recreation and flow, determine how different management alternatives will affect recreation. The specific objectives of the study are to:

- Define the existing uses of the Bow River at the study site and evaluate any potential instream flow conflicts.
- Determine the minimum acceptable flow and optimum flow conditions for the major recreation activities at the study site on the Bow River and determine if these conditions can be better met under different management scenarios.
- Describe alternate river conditions based on different management scenarios for hydropower, protecting fish habitat, and mimicking natural conditions.
- Assess how the recreation preferences developed in the study can be incorporated with the other uses of the Bow River at the study site.
- Review the different management scenarios with respect to meeting the optimum conditions for recreation.
- Make recommendations for incorporating instream flow requirements into a management plan for multiple use rivers.

2 METHODOLOGY

The purpose of this project was to define the instream flow needs (IFN) for water-based recreation on the Bow River. Whittaker et al. (1993) outlined an eight-step process for developing an IFN study for recreation, illustrated in Figure 2.1. The procedure outlined in Figure 2.1 provided the foundation for the design of the recreation IFN study for the Bow River.

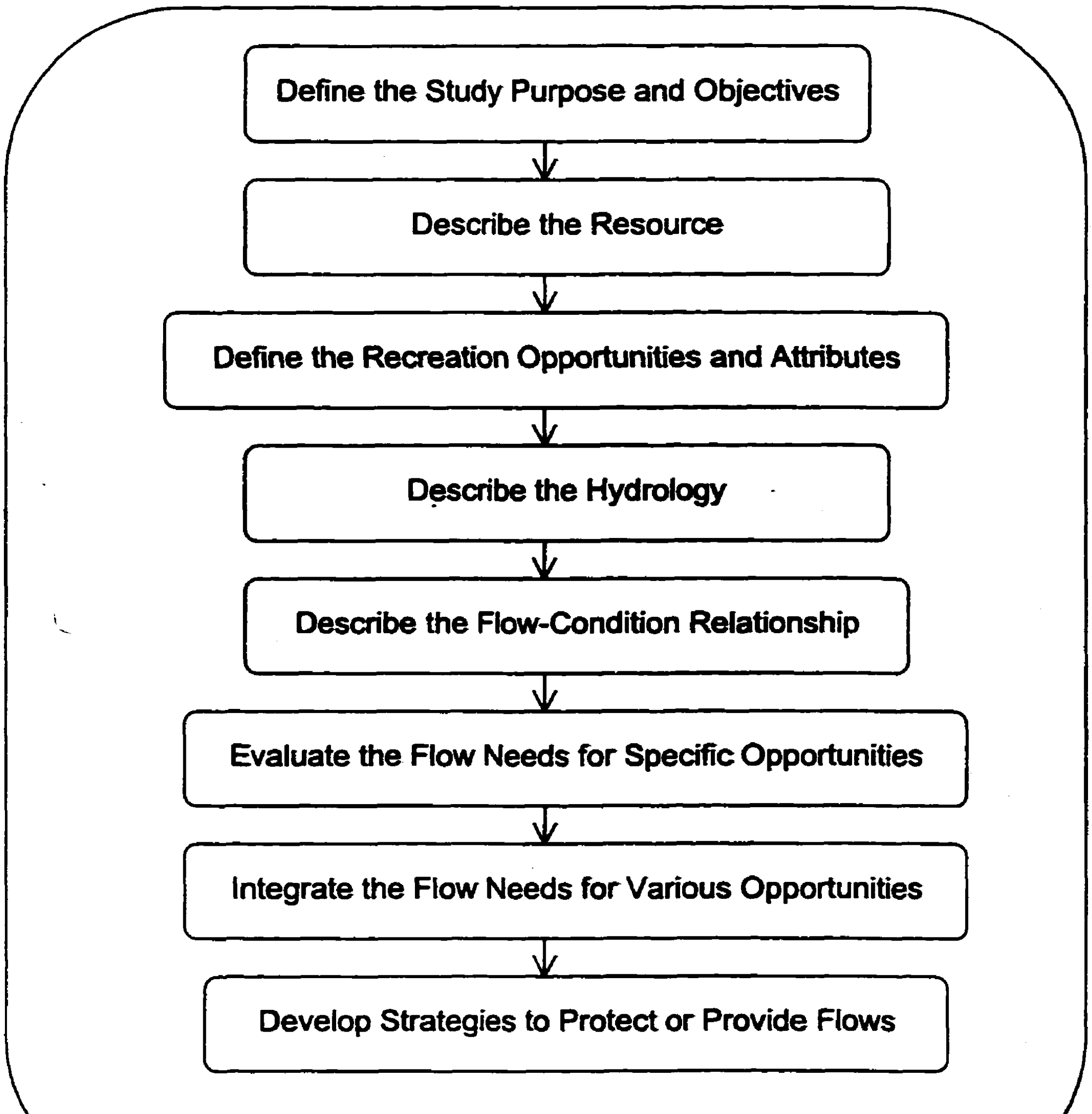


Figure 2.1: Recommended steps to follow for developing an IFN study for recreation (after Whittaker et al. 1993).

The methodologies used for this study consisted of an initial literature review, the designing of a user-survey, survey implementation, expert judgement, a controlled flow experiment, and data analysis.

2.1 LITERATURE REVIEW

A literature search was conducted to obtain information for the purposes of:

- determining the approaches used for conducting a recreation IFN study,
- determining the desired results from a recreation IFN study,
- describing the resources, hydrology, recreation opportunities and attributes for the Bow River, and
- defining the major existing uses of the Bow River.

The majority of the background information regarding the available recreation resources and the distribution of recreation use on the Bow River was obtained from previous recreation studies conducted for AEP. AEP provided information on the existing licenses for irrigation, hydropower, and industrial withdrawals for the Bow River. Hydrology data for the Bow River was obtained from the Operational Support Branch of AEP, Environment Canada's historical streamflow summaries, and TransAlta Utilities. The former Corporate Management Services division of AEP in Calgary provided access to all of the above documents pertaining to the Bow River.

Initial key word searches using the CARL UnCover database and Biological Abstracts CD-Rom produced only four relevant matches to "streamflow recreation," "instream flow recreation," and "flow recreation." A table-of-contents search in CARL UnCover for past issues of the journal "Rivers" revealed several useful articles that were not revealed by the keyword search. The reference lists from the initial articles highlighted further documents to be obtained from published journals. Several studies were obtained by contacting Professor Bo Shelby from Oregon State University (shelbyb@ccmail.orst.edu), a major author within the field of recreation streamflow. The Bureau of Land Management in Colorado was also contacted to obtain several major instream flow studies that were conducted through their department. A final keyword search conducted by an on-staff librarian at the AEP Library in Edmonton was completed using the Library's CD-Rom databases.

From the literature review, it was found that expert judgement, formal user-surveys, and systematic assessments of alternative flows were the most common methods for determining the flow requirements for recreation (Brown et al. 1992). All of these methods were determined to be suitable for application to the Bow River.

2.2 EXPERT JUDGEMENT

Experienced Bow River recreation users were interviewed individually and in focus group meetings prior to the design of the surveys to collect background information and during the study to supplement the survey data. Experienced water-based recreational users were identified and contacted through recreation clubs and through personal references from other recreational users. The author conducted all of the interviews. The information collected was used to determine the types of water-based recreation activities engaged in on the Bow River and the flow concerns for recreation on different reaches of the Bow River.

The interviews and focus groups were conducted on an open discussion platform to allow for any type of input regarding how flow has affected users' recreational activities. The interviewer directed the discussions to uncover attitudes about trends in the flow that produce good and poor recreation conditions on the Bow River. Discussions about angling were held with members of the Hook and Hackle Club on three separate occasions during club meetings and with Trout Unlimited (Jumpingpound Chapter) members at two different club meetings. Interviews were also conducted with seven Bow River angling guides and outfitters. Discussions about boating were held with members of the Bow Waters Canoe Club on three occasions, the Rocky Mountain Paddling Centre on three occasions, and the University of Calgary Outdoor Programs Centre on five occasions. Boating guides from Canadian Heritage Tours and Heritage Canoe Adventures were interviewed on several occasions over the course of the summer to compare how the different flows they experienced altered the recreation conditions. See Appendix I for a complete list of contacts.

Historical flow data for many reaches of the Bow River, and particularly for the reach below the Ghost Dam, typically has not been easily available to the public. Due to the lack of historical flow information, expert users could not be asked to relate their recreation preferences to specific flow ranges they have experienced in the past.

information collected from expert users was used to help identify trends and concerns with the existing management of the flow on the Bow River and to supplement data collected by other methods.

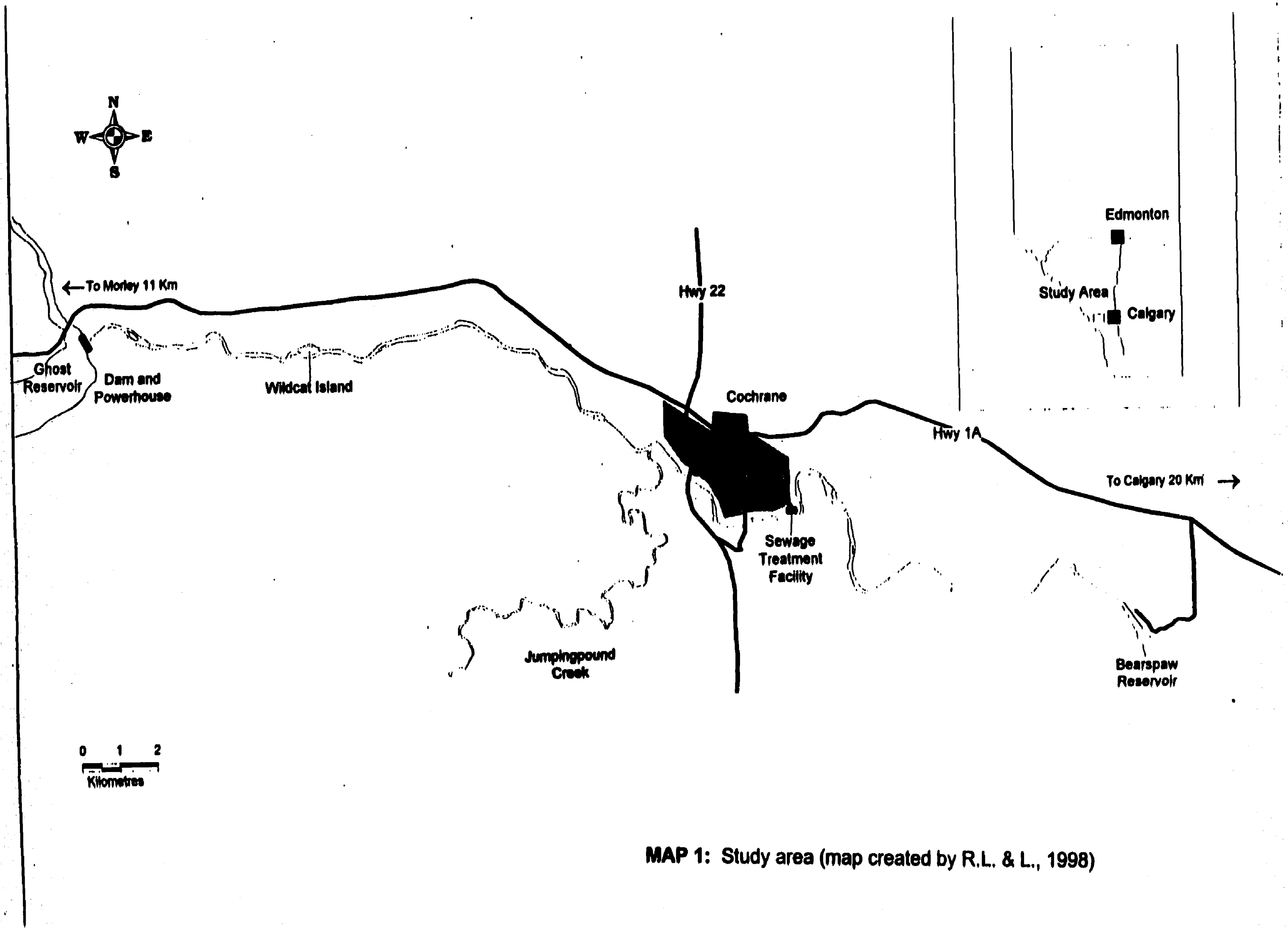
2.3 *ON-SITE SURVEYS*

A user survey was developed for the purpose of determining the optimal instream flow conditions for different recreation activities on the Bow River. An on-site survey allowed the collection of information from the general recreation population, reduced the potential for sampling bias, and allowed for an immediate evaluation of a specific flow without having to rely on the recall of expert users.

2.3.1 Survey Design

Berdie et al. (1986), and Wildt and Mazis (1978) were initially utilized as references for developing the basic survey design criteria. Other recreation surveys and instream flow studies from the United States were then researched and used as models for developing the survey. The style of the survey and the general wording of the questions were modified from Alberta Environmental Protection 1995, Duffield et al. 1994, Whittaker et al. 1993, Vandas et al. 1990, and Thompson et al. 1987b.

Members of AEP reviewed a preliminary survey for length and clarity of wording. A revised survey was then tested in the field on the weekend of May 30 through June 1 on the Bow River at the Highway 22-access point in Cochrane, AB (see Map 1 for survey location). Eight surveys were administered to river users participating in canoeing, kayaking, rafting, and fishing. Modifications were made to the survey based on the reactions and comments of the sample group. Several questions that were proving difficult to answer were removed to clarify and shorten the survey so it could be administered in less than ten minutes. The sample groups responded with extreme suspicion about the motive of a willingness-to-pay question that was to be used for determining the economic value of flow to recreation. It was decided by AEP that economic information for recreation was not required at this time, and the question was eliminated. The survey was administered once again on the weekend of June 7 and June 8. This version of the survey was determined to be acceptable as the final draft of the survey (see Appendix II for the boater survey).



MAP 1: Study area (map created by R.L. & L., 1998)

After preliminary surveys of anglers, it was decided that many novice anglers were unaware of the impact of flow on their fishing success. In most cases, they rated the flow based on their fishing success. The poor success may have been a factor of skill and not flow. Inexperienced anglers may not be able to differentiate between the two factors. The section for anglers in the original survey was removed and a separate survey was created to distribute to experienced Bow River anglers. After speaking with several anglers, and by modifying survey questions from Whittaker et al. (1993), an angler survey was developed to be distributed to experienced Bow River anglers (see Appendix III for the angler survey).

Since many anglers gain access to the river at isolated locations, conducting surveys at a single access point was not a practical approach. Many of the anglers who were interested in participating in the study were willing to complete multiple self-administered surveys over the course of the summer as the flow naturally changed. This technique allowed for a comparison of different flows by a single angler over the course of a fishing season. Surveys were mailed out to members of the Hook and Hackle Club of Calgary with their newsletter and to members of the Jumpingpound Chapter of Trout Unlimited. The survey package included instructions to complete six survey forms, one double-sided page each in length, along with a postage paid pre-addressed return envelope. Surveys were also distributed through fly-fishing shops in Calgary and Cochrane, as well as to several guiding companies. Reminders were included in later newsletters and the author gave verbal reminders at club meetings.

Ethics committee approval from the Faculty of Environmental Design was deemed not necessary by the EVDS Ethics Committee Chairperson since the project was approved and being administered as an AEP project.

2.3.2 On-Site Survey Implementation

Surveys of recreation users were done throughout the summer and early fall of 1997. The author administered all of the surveys at a major access point on the Bow River (Map 1). AEP provided a vehicle on the weekends during the summer to drive to the survey location. Due to the limited personnel available for this study and the weekend time restrictions for vehicle use, it was decided that a single reach of the Bow River should be the focus for the on-site survey portion of the study.

The Bow River was divided into eleven reaches based on park boundaries, dam locations, major access points, and reaches identified in previous studies (Thompson et al. 1987a, Bow River Water Quality Council 1994, EMA, 1994). The criteria used to select the location of the survey reach included:

- proximity to Calgary,
- a high level of recreation use,
- a wide range of recreation activities and skill levels utilizing the site,
- limited access along the reach to concentrate users at a major downstream take-out point,
- the presence of an upstream dam capable of controlling the flow to deliver a wide range of flows over a short period of time, and
- the availability of good flow data for the reach.

The Bow River within Calgary's city limits receives the largest volume of recreation use of the reaches defined (SSRBPP 1984, Thompson et al. 1987a). However, it lacked several of the essential criteria described above. It was determined that the reach upstream of Calgary starting at the Ghost Dam best fit the criteria. The parking lot at the Highway-22 bridge at Cochrane is the only easily accessible take-out point between the Ghost Dam and the Bearspaw Dam. The author and AEP staff decided that this would be the best location on the Bow River to conduct the surveys.

Thompson et al. (1987b) found that the level of weekend recreation use on the Bow River was approximately 1.5-times that of weekday recreation use. Due to the limited availability of a vehicle for this study, surveys were conducted on weekends to make the most efficient use of survey time. The surveys began June 1 and ended September 28, 1997. Thompson et al. (1987b) also found that the majority of weekend recreation was concentrated in the early afternoon hours. After trying several different starting times, it was determined the busiest time to conduct the surveys was between 11:00am and 7:00pm on the weekends.

One member from each boat or group leaving the Bow River at the Highway 22-access point was approached and asked if they or any member of the group would participate in a recreation survey. The purpose of the study and the duration of the interview were stated when each group was approached. Each participant was asked to evaluate the flow they had just experienced. The flow experienced and evaluated by each group was determined later from hourly flow data provided by TransAlta Utilities (TAU).

2.4 CONTROLLED FLOW EXPERIMENT

Controlled flow experiments are considered to be a relatively powerful tool for determining the impacts of streamflow on recreation (Brown et al. 1992). An upstream dam that is capable of releasing a wide range of flows over a short period of time is a requirement for a controlled flow experiment. Each flow is tested by a sample group of recreation users. The different flows can be evaluated individually after each run or compared at the end of the test. The advantage of this approach is that it allows for easy comparison of different flow levels without having to rely on long-term recall, while at the same time, keeping the influence of other environmental factors relatively constant (i.e. weather, season). TAU fluctuates the flow of the Bow River below Ghost Dam on a daily basis to meet their system's peak power demand (Komex 1994). On Tuesday September 30 1997, it was arranged with Dan Smith, the hydro-scheduler of TAU, to time the release of water below the Ghost Dam to allow for three different flow levels. Due to the shorter days and cooler temperatures, only three runs could be comfortably fit into a single day. Arrangements were also made with the Petro Canada Wildcat Hills Gas Plant to gain access to the river using their private road. The reach from the Ghost Dam to the gas plant is approximately a 5.5km in length and could be boated in approximately 60 minutes allowing for sufficient time to return to the Ghost Dam starting point for the next run. A driver was used to meet the group at the gas plant with a van and boat trailer to take the group back to the start for the next run.

A group of seven volunteers, including two kayakers and five canoeists (two tandem boats and one solo boat) floated the section from the Ghost Dam to the gas plant at three different flow rates. A minimum of a one-hour delay was needed after each flow increase to allow the flow in the river channel to even out (Dan Smith, TAU hydro-scheduler, pers. comm.). Time was allowed for comment sheets to be filled out after each run. After the final run, the volunteers were also asked to rate which of the three flows they preferred, or if they preferred a flow higher or lower than those tested based on their own experience. Table 2.1 outlines the timing of the controlled flow experiment.

Table 2.1: The timing and flow release schedule for the controlled flow experiment conducted on the Bow River below the Ghost Dam on September 30, 1997.

Flow (cms)	Time of Flow Increase at the Ghost Dam	Start Time of Test Run	Finish Time of Test Run
59	07:00	10:00	11:15
112	11:00	12:30	13:30
163	14:00	15:00	15:45

2.5 *DATA ANALYSIS*

The date and both the starting and finishing times of each group was recorded at the start of the interview. Hourly data of the flow releases at the Ghost Dam for the entire summer were provided by TAU. The flow being evaluated for each survey was determined based on the time the group was on the river and relating it to the hourly flow data from the Ghost Dam. The five distinct flows for which user-surveys were conducted below the Ghost Dam are 59cms, 112cms, 165cms, 215cms, and spring run-off. Eventually, each flow became visually recognizable to the interviewer, and the flow at the time of the interview was recorded and later confirmed with the hourly data. The run-off flows ranged from 235cms to 295cms in 1997. Data from these flows was pooled since the dam is not capable of controlling these flows and the characteristics of the river are similar at these high flows.

It takes approximately five minutes to change the flow being released from the Ghost Dam, and in most cases, changes in flow are made at the top of the hour (Dan Smith, pers. comm.). As a result of a flow change, the hourly flow data recorded will indicate a flow somewhere between the initial and final flow. In cases where a group reported starting their trip at an hour that corresponds to a change in flow, the resulting flow after the change was used for analysis, not the average flow reported in the data. The water level at the time of the survey was also recorded by a visual inspection to assist in determining the appropriate flow to be used in the analysis.

The on-site surveys were separated into the three major forms of boating recreation identified on this reach of the Bow River; canoeing, kayaking, and rafting. The data from the survey forms was entered into a Microsoft Excel spreadsheet for analysis. Variables from the survey, such as flow preference and rating of recreation quality, for each flow were averaged for each recreational activity. An analysis of variance (ANOVA) test, conducted with Excel's data analysis function, determines if there is a significant difference in response between boat types for each flow (Zar, 1984). If a significant difference is found, a Tukey test is conducted to determine which of the groups are statistically different (Zar, 1984). The average responses for each activity can then be plotted against the flow being evaluated to create flow evaluation curves. These plots indicate a range of preferred flows for each activity and a threshold where the flow is unacceptable for recreation. A 95% confidence interval is also included in each evaluation curve. The survey packages collected from the anglers were analyzed with the same techniques as described above.

The flow preferences developed from the surveys were compared to the expert judgements and the comments made during the controlled flow experiment to refine the results. Information about skill level, experience on the Bow River below the Ghost Dam, and weather conditions were used to assist in understanding any discrepancies found between the results obtained from the different methods.

Once a relationship between flow and recreation use was made, the results were compared with information about other potential management scenarios. Historical hourly flow data from the past 12 years was used to develop a baseline case of how the current hydropeaking operations have affected recreation below the Ghost Dam. The recreation season was defined from May 15 through September 30 for this study. Flow data between 05:00 and 21:00 hours for the past 12 years was analysed to determine the frequency of low flow events for every day during the recreation season, and the frequency of high flow events during August and September. Daytime low flow events will negatively impact all recreation activities, while the high flow events during August and September impact anglers.

Natural flows, fish habitat flows, irrigation flows, and hydropeaking flow scenarios were all compared with the recreation IFN recommendations. Negative impacts on recreation were described in terms of the duration when suitable conditions are not available for each recreation activity for each scenario. In instances where impact duration could not be determined, then the scenario was evaluated as an improvement, no change, or a decline in the recreation potential compared with the current conditions.

The potential conflicts of integrating recreation instream values with other uses were compared for each management scenario. Opportunities to enhance instream recreation conditions with minor adjustments in dam releases were investigated. Recommendations for an instream flow management plan were developed for the study reach.

A review of the existing methods for incorporating recreation into river management was conducted using personal communications with AEP staff responsible for such initiatives. The evaluation on the effectiveness of current methods for incorporating recreation into multiple use river management in Alberta was derived from the author's professional judgement.

3 Literature Review of Recreation IFN Studies

The field of instream flow needs (IFN) studies for recreation is still relatively new. The majority of the studies have emerged from the United States in the last 20 years. Prior to 1976, virtually no method existed for quantifying IFN for recreation (Jackson et al. 1989). The Cooperative Instream Flow Service Group of the U.S. Fish and Wildlife Service developed a modeling procedure for identifying minimum and optimum flow ranges for recreation (Hyra 1978). The method was adapted from the Instream Flow Incremental Methodology (IFIM) used for modeling fish habitat developed by the U.S. Fish and Wildlife Service. Hyra's procedure uses depth and velocity measurements to create a calculation of a river's weighted-usable area for recreation. The weighted usable area equates an area of low desirability to an equivalent area of optimal desirability (Hyra 1978). The depth and velocity criteria developed by Hyra are summarized in Table 3.1.

Table 3.1: Criteria for minimum, maximum, and optimum depths and velocities for several recreation activities (converted from Hyra 1978).

Activity	Depth (m)			Velocity (m/s)		
	Minimum	Maximum	Optimum	Minimum	Maximum	Optimum
Fishing - Wading	0.23	1.22	0.30-0.76	0.0	0.76	0.08-0.61
Fishing – Powerboat	0.91	NA	>1.07	0.0	1.52	0.15-0.61
Fishing - Drift Boat	0.30	NA	>0.61	0.0	1.22	0.15-0.46
Wading	0.15	1.22	0.23-0.76	0.0	0.91	0.08-0.61
Swimming	0.91	NA	>1.22	0.0	0.91	0.08-0.23
Boat - Low Power	0.91	NA	>1.07	0.0	2.13	0.15-0.91
Boat - High Power	1.07	NA	>1.22	0.0	3.66	0.15-2.44
Canoe/Kayak	0.30	NA	>0.76	0.0	3.05	0.15-2.13
Rafting	0.61	NA	>0.91	0.0	4.27	0.30-3.05
Tubing/Floating	0.46	NA	>0.61	0.0	2.44	0.30-1.52

Brown et al. (1992) suggest that using a weighted usable area is an unnecessarily complex way to express recreation potential and can obscure the dependent variable of recreation quality. Brown et al. (1992) state that a hydraulic modeling technique may not adequately represent complex water features important for boating and fishing. They suggest that translating flow into depth and velocity may be unnecessary, confusing and can prove difficult to calibrate in the model.

In addition, the original criteria for recreation activities shown in Table 3.1 lumped canoeing and kayaking together in the same category. Kayaks can tolerate more extreme conditions and kayakers will utilize different features of a river compared to a canoeist. The method developed by Hyra is still used in some studies (Nestler et al. 1986, Milhous 1990), but most recreation IFN studies rely on alternate methods that have been developed more recently.

3.1 COMMON METHODS FOR RECREATION INSTREAM FLOW STUDIES

Recently, a major driving force for many of the recreation IFN studies conducted in the United States has been the Federal Power Act. Under the Act, the Federal Energy Regulatory Commission (FERC) must consider conditions which provide adequate flow protection for instream resources, including recreation, when they are evaluating hydropower licenses (Shelby et al. 1992a). In response to the requirements of FERC, and to other federal and state laws in the United States, recreation IFN studies are becoming fairly common and standard methodologies are being developed.

Brown et al. (1992) and Shelby et al. (1992a) give comprehensive reviews of the common research methods that are used to conduct a recreation IFN study. Brown et al. (1992) distinguish between studies that measure the direct effects of streamflow on recreation versus studies that concentrate on the indirect effects of streamflow on recreation. Direct or short-term effects can include the quality of rapids, fishing success, or travel time. Indirect or long-term effects can include the maintenance of gravel bars, channel form, and fish habitat over time. This study focuses on the direct effects of streamflow on recreation quality for the Bow River.

Brown et al. (1992) and Shelby et al. (1992a) categorized recreation IFN studies into four groups based on methodologies. The methodology categories are: expert judgement, user surveys, systematic experience of alternate flows, and mechanical measurements. Mechanical measurement studies used sound as a variable for evaluating the aesthetic quality of a river at different flows using a decibel meter. This descriptive technique was not considered to be applicable for this study and is not discussed. The other three methods are explained below.

3.1.1 Expert Judgement

The most common method for developing recreation IFN recommendations is with the use of expert judgement to determine the direct effects of streamflow on recreation, although most of these studies seldom get published (Brown et al. 1992). Expert judgement studies are mainly descriptive and usually involve only a single site visit (Whittaker et al. 1993). Collecting expert judgement data can be quick and inexpensive, but this method is limited as a stand-alone approach (Whittaker et al. 1993). Professional judgement can be used for indirect effect studies, and is often used to supplement alternate approaches for direct effect studies (Whittaker et al. 1993). In some situations, such as extremely remote rivers, professional judgement techniques may be the only logistical option for a recreation IFN study (e.g. Van Haveren et al. 1987).

3.1.2 User Surveys

A user survey, either by an on-site interview or as a mail-out questionnaire, is another very common approach for a recreation IFN study. The majority of published studies rely on some type of user survey to collect their data (Shelby et al. 1992a). Surveys can provide good quantitative data for developing a statistical relationship between recreation quality and flow to generate a flow evaluation curve. User surveys with a large sample size can avoid the problem of bias that may be present in expert judgement or small sample size methods (Whittaker et al. 1993). The disadvantages of this approach are the need for competent survey design and implementation, and the increased time, personnel, and funding required to conduct a large survey program (Whittaker et al. 1993).

A common survey approach is to conduct on-site interviews of recreation users and have them evaluate the quality of the flow that they just experienced (Whittaker et al. 1993). Flow evaluation curves are created by statistically relating the responses from the survey population to the different flows that were evaluated. Some survey studies have used photographs or verbal descriptions of different flows to allow the survey respondents to evaluate multiple flows at the same time (Whittaker et al. 1993). In some situations (e.g. Vandas et al. 1990, Shelby et al. 1992b), mail-out surveys were distributed to river guides and experts for evaluating multiple flows relying on their experience and memory to recall the conditions at each different flow. This approach is only possible if there is a large population of river guides. The guides must also have had access to and checked flow data before their trips to be able to accurately describe the river conditions without the guides requiring additional site visits.

3.1.3 Systematic Assessment of Alternate Flows

A systematic assessment of flows requires that each participant experience the desired range of flows in a short time period so their frame of reference and judging criteria remains relatively constant (Shelby et al. 1992a). The full range of flows to be assessed can either be depicted photographically or actually experienced by the judges. The use of photographs or videos to depict a range of different flows is often necessary where it is not possible for the participants to experience the full range of flows in a short time period (Brown et al. 1992). Carefully taken photos or videos can adequately represent river conditions to assess the scenic quality of a river (Brown et al. 1992).

In situations where an upstream dam is capable of controlling the flow, a systematic assessment can be done where all of the participants can experience each flow in a short period. Experiencing each flow level in a short period may also bring to light changes in the water conditions that may be missed using photographs or expert judgement (Brown et al. 1992). Experiencing each flow is also better than photographs for activities such as boating and fishing, where the complexities of water features may not be fully represented in a picture (Brown et al. 1992). Information can be gathered by either using individual surveys or having a group discussion after all of the flows have been tested. The survey approach is preferred to allow quantitative data to be collected and to avoid individual participants from dominating a group discussion (Brown et al. 1992).

3.1.4 Comparison of Methods

Whittaker et al. (1993) outline the advantages and disadvantages of each method described above. Expert users may provide biased information, but they are also more likely to describe in detail how changes in flow can change the recreation conditions. Formal surveys of the user population are time consuming and expensive, but they can provide unbiased data. The average respondent in a survey may also have limited knowledge of how a change in flow might affect their recreation experience, which might limit their ability to evaluate the flow. A systematic assessment of flows is an excellent method, but most rivers do not have the physical requirements to conduct a controlled flow experiment. Even if the conditions are present, organizing a test group large enough to statistically evaluate the responses is difficult. Photographs can be used for the assessment, but a series of pictures similar in quality and composition, which can represent the entire range of flows for a particular reach, can take several seasons to compile. Many previous studies have employed a combination of techniques for collecting recreation IFN data. Using multiple methods allows for a comparison of results between methods and takes advantage of the different benefits of each technique. The different methods are summarized below in Table 3.2.

Table 3.2: Summary of advantages and disadvantages described by Whittaker et al. (1993) between the different methods commonly used in recreation IFN studies.

	Study Bias	Cost	Logistics
Expert Judgement	Potentially High	Low	Quick and easy to implement
User Surveys	Low	High	Time consuming to plan and implement
Systematic Assessment	Moderate	Moderate	Quick, but limited by potential application sites

3.2 EXPECTED RESULTS

The most important result that a study should highlight are the flow evaluation curves for each recreation opportunity on the study reach (Whittaker et al. 1993). An inverted-U flow evaluation curve was consistently found in the recreation IFN studies

(Brown et al. 1992). An inverted-U flow evaluation indicates that recreation quality is poor at low flows and high flows, and recreation quality is optimized at a range of intermediate flows. Each river will have different flow evaluation curves depending on the physical attributes of the river, and the type of recreation experience that is expected. An evaluation of a white-water river will focus on the flow that produces the best rapids. Upper or lower flow thresholds may exist where the rapids are no longer challenging or they become unsafe. If a river is primarily used as a scenic boat trip or overnight trips, then flow factors such as travel time and exposed camping sites might be the most important variables. A low flow can make the trip too long and a high flow may cover gravel bars needed for camping. A hypothetical flow evaluation curve is illustrated in Figure 3.1, indicating the acceptable range of flows for recreation and the optimum flows for recreation.

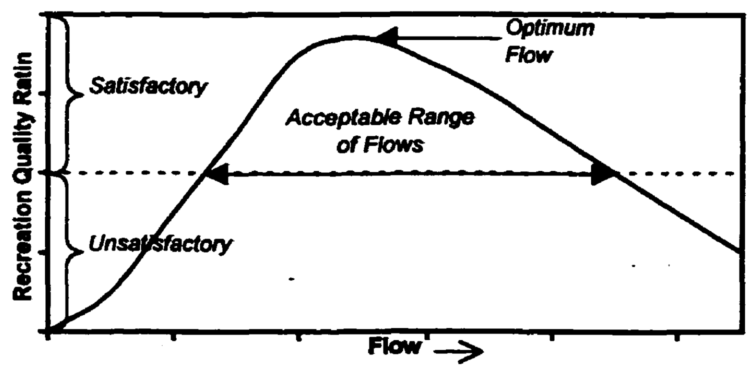


Figure 3.1: Hypothetical flow evaluation curve indicating an acceptable range of flows and unsatisfactory recreation conditions at low and high flows.

In some instances, the flow evaluation curve levels off at higher flows and does not drop below the satisfactory threshold as indicated in Figure 3.1. Vandas et al. (1990) found that the open-canoe evaluation curve exhibited the typical inverted-U pattern that dropped-off at higher flows for the Dolores River in Colorado. However, the evaluation curves for white-water boats maintained a satisfactory rating across a wide range of higher flows in the same study.

A flow evaluation curve can identify the unacceptable, minimum, and optimum flow ranges for each recreation activity on a river (Brown et al. 1992). Unacceptable recreation flows are defined in Figure 3.1 as the range of flows below the dashed-satisfactory rating line. These unacceptable flows are not the physical minimum flows at which a boat cannot travel down the river rather, they represent the evaluation of recreation quality where most users define the recreation experience as poor. The minimum flow can then be defined as the lowest flow where the evaluation curve crosses the satisfactiry rating threshold (dashed line) shown in Figure 3.1. The optimum flow is the range of flows where the flow evaluation curve peaks. The rating of recreation quality can change with experience and skill level. If necessary, skill and experience can be incorporated into the analysis if there is a difference in responses between skill levels.

3.3 *Integrating Recreation IFN with other River Uses*

The most difficult component in completing a recreation IFN study is determining methods for incorporating the information gathered into a management strategy for the river being studied. In some areas, such as remote rivers, recreation or scenic quality of the river might be the most important attributes to consider. However, in most rivers, water is also needed for providing fish habitat, maintaining the riparian ecosystem, irrigation, hydroelectricity, municipal water supply, industrial use, and waste assimilation. Each use can be seen as having a unique flow request or withdrawal request that must be integrated to develop different flow scenarios (Shelby et al. 1992a).

To aid in management decisions, a threshold flow for each river use should be defined for the season it is required (Whittaker et al. 1993). Once this step is completed, the flow requirements for each use can be compared to determine which uses are compatible and which uses are conflicting (Whittaker et al. 1993). In many cases, river managers often request a single minimum flow for recreation. However, it is also important to define and consider a full range of flows that can provide different recreation experiences for each recreation activity (Brown et al. 1992). It is then critical to express a recreation flow request in terms of the level of recreation quality desired for each recreation activity (Brown et al. 1992).

3.4 *Flow Protection Strategies*

A flow protection strategy must evaluate and blend legal, administrative, and technical alternatives in an effort to maintain instream flow-dependent values (Jackson et al. 1989). Any flow protection strategy must recognize all existing uses of the river, and must be realistic and flexible to accommodate the many competing interests in water supply (Jackson et al. 1989). In some instances, protecting the value with the highest instream flow requirement will also protect all other values (Jackson et al. 1989). Conflicts between instream users may still occur, such as the minimum for whitewater may be too high for fishing, but allocating flows across different seasons can often balance the needs of conflicting users (Jackson et al. 1989).

In a negotiation process for determining water use, trade-offs between competing uses obviously have to be made to balance the benefits to the different users. It is inevitable that some water users will believe their use of water is more valuable to society than other competing uses. Several studies determine the economic value of instream flow for recreation in an attempt to create a common unit for comparing the relative value of the different uses of water (e.g. Loomis and Creel 1992, Duffield et al. 1992). Developing a common unit of comparison between river users that can allow for equal consideration of each use is a possibility for evaluating how to balance trade-offs between users. The value gained for maintaining a recreation flow could be compared with the lost value from other uses in providing the instream flow for recreation in a benefit-cost analysis (Loomis and Feldman 1995). Loomis and Creel (1992) found that the recreation benefits of increased flow were competitive with the agricultural value of flow in July and August for the San Joaquin Valley in California. Duffield et al. (1992) also found that at low flows, maintaining instream flows for recreation provided a more valuable use of water than diverting the water for irrigation on Montana's Big Hole and Bitterroot Rivers.

Representing the value of recreation to society, and indeed the value of all of the other uses, in economic terms alone may not adequately portray the true benefits of each use to society. Choosing a final flow regime requires evaluative information about management objectives for the different uses of the river, and the standards for the conditions required for each use (Shelby et al. 1992a). Economic information may provide a common unit to attempt to balance the costs and benefits of each use. However, in the end, the final decision is often judgement-based and politically-driven (Shelby et al. 1992a). The best method to ensure consideration of recreation in management decisions is to start with a clear understanding of the flow-recreation relationship (Shelby et al. 1992a).

4 BACKGROUND RESEARCH

4.1 DESCRIPTION OF THE STUDY AREA

The Bow River has its headwaters in the Rocky Mountains of Alberta at Bow Lake and flows to the southeast through Calgary until it joins the Oldman River and becomes the South Saskatchewan River at the Grand Forks east of Lethbridge. TransAlta Utilities Limited (TAU) operates a system of hydroelectric facilities on the Bow River and several of its major tributaries. The river profile of TAU's Bow River operation is shown in Figure 4.1 (TAU, from Komex 1994).

The section of the Bow River used for the study site is west of Calgary beginning at the Ghost Dam and ending at the Highway-22 bridge at Cochrane (Map 2, created by AEP, 1997). This reach of the Bow River has the following characteristics:

- 18.2 km in length and approximately 100m wide (measured Map 2)
- a gradient of 2.3m/km
- minimal meandering
- permanent vegetated islands (EMA 1994)

The land to the north of the river in the study site is bordered mainly by private ranching property. The Canadian Pacific Railway parallels the river to the south for most of the reach until it crosses the river at a bridge located 14.3 kilometers downstream of the Ghost Dam. The railway-bridge is the only human-built obstruction along this reach until the Highway 22-bridge at the take-out point. Two gas pipelines are suspended above the river, but do not obstruct any instream activities. The Stoney Indian Reserve also borders the river to the south from the dam to the town of Cochrane.

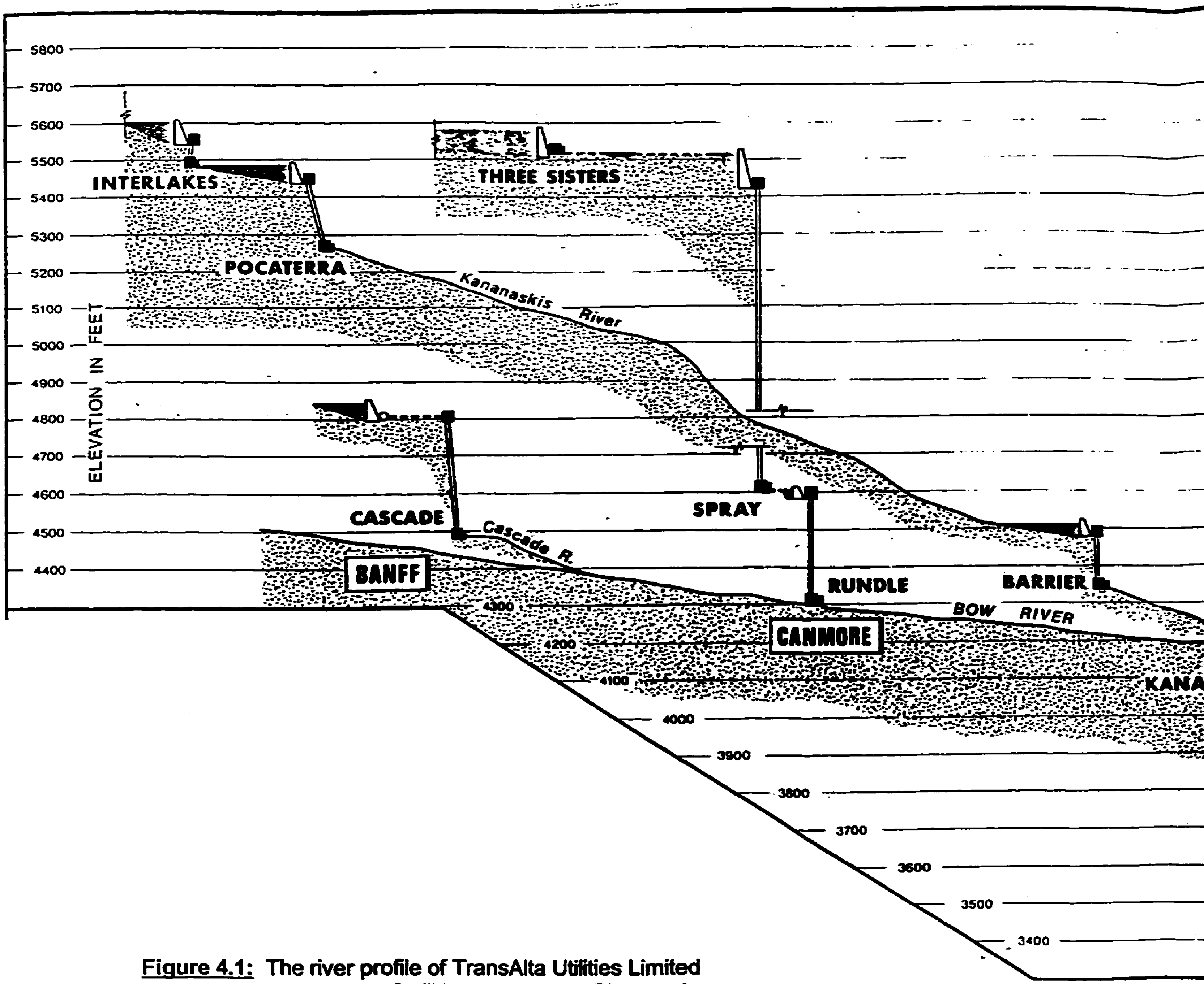
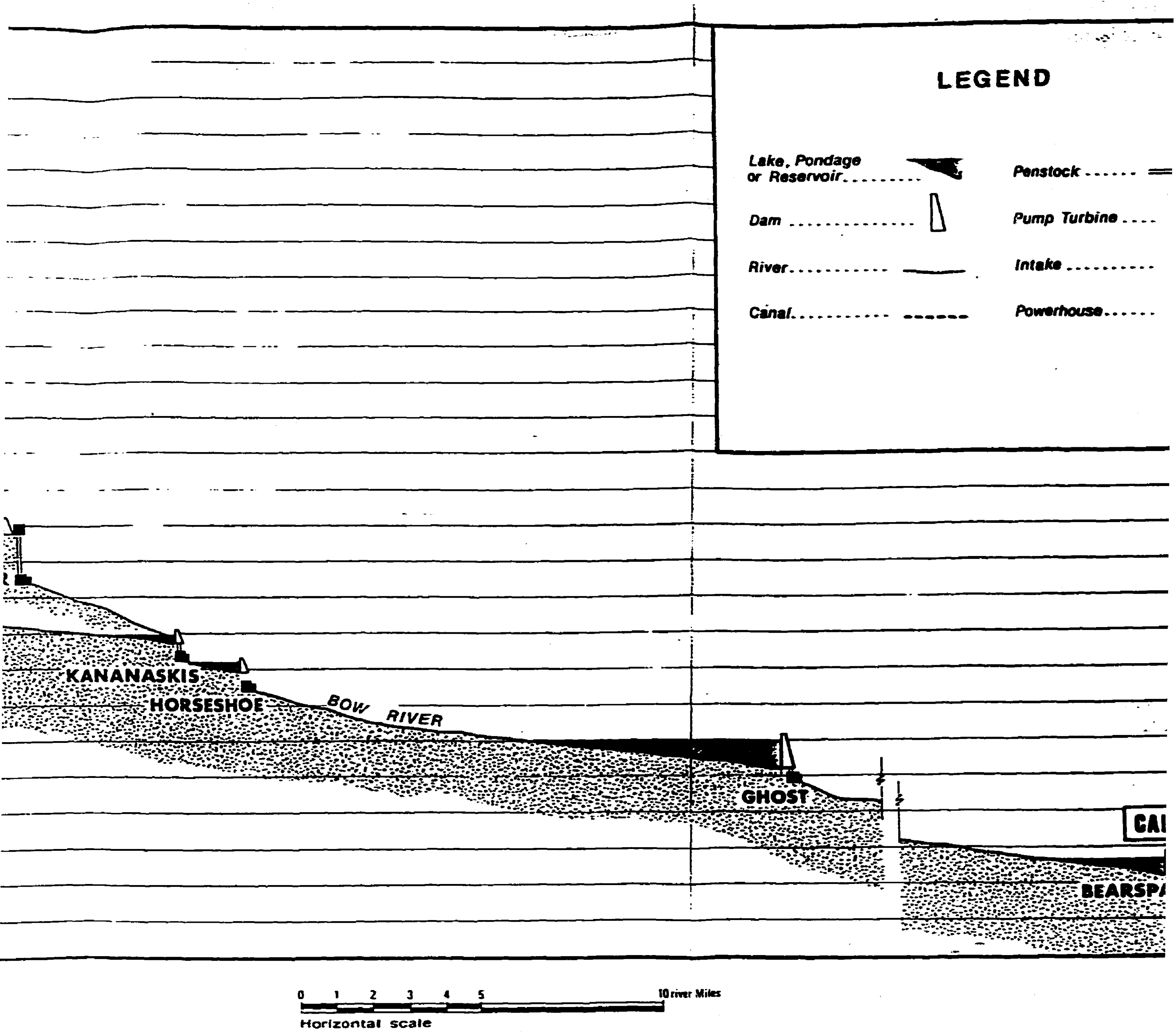


Figure 4.1: The river profile of TransAlta Utilities Limited hydropower facilities on the Bow River and its tributaries (from Komex 1994).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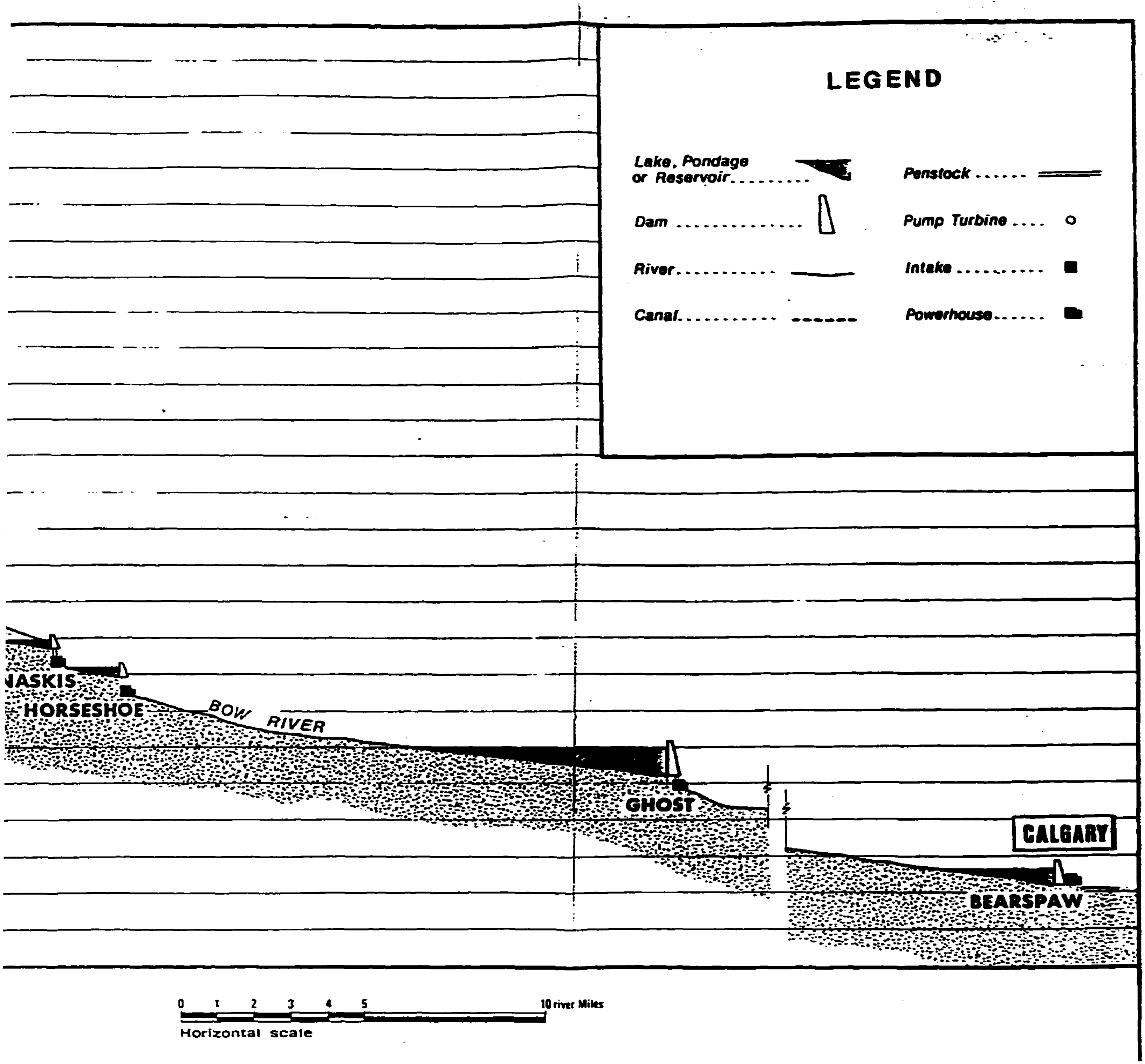
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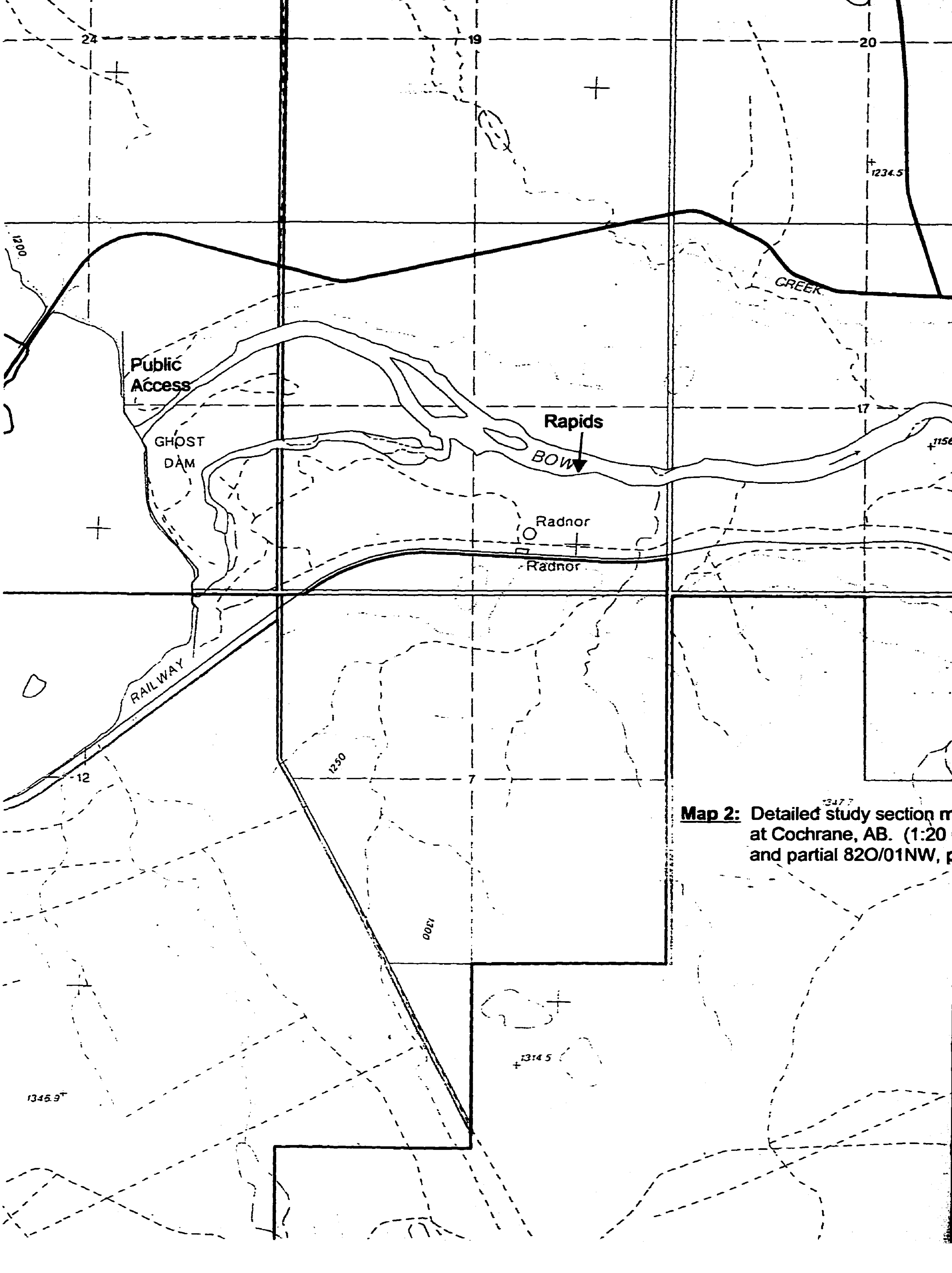

Map 2: Detailed study section m
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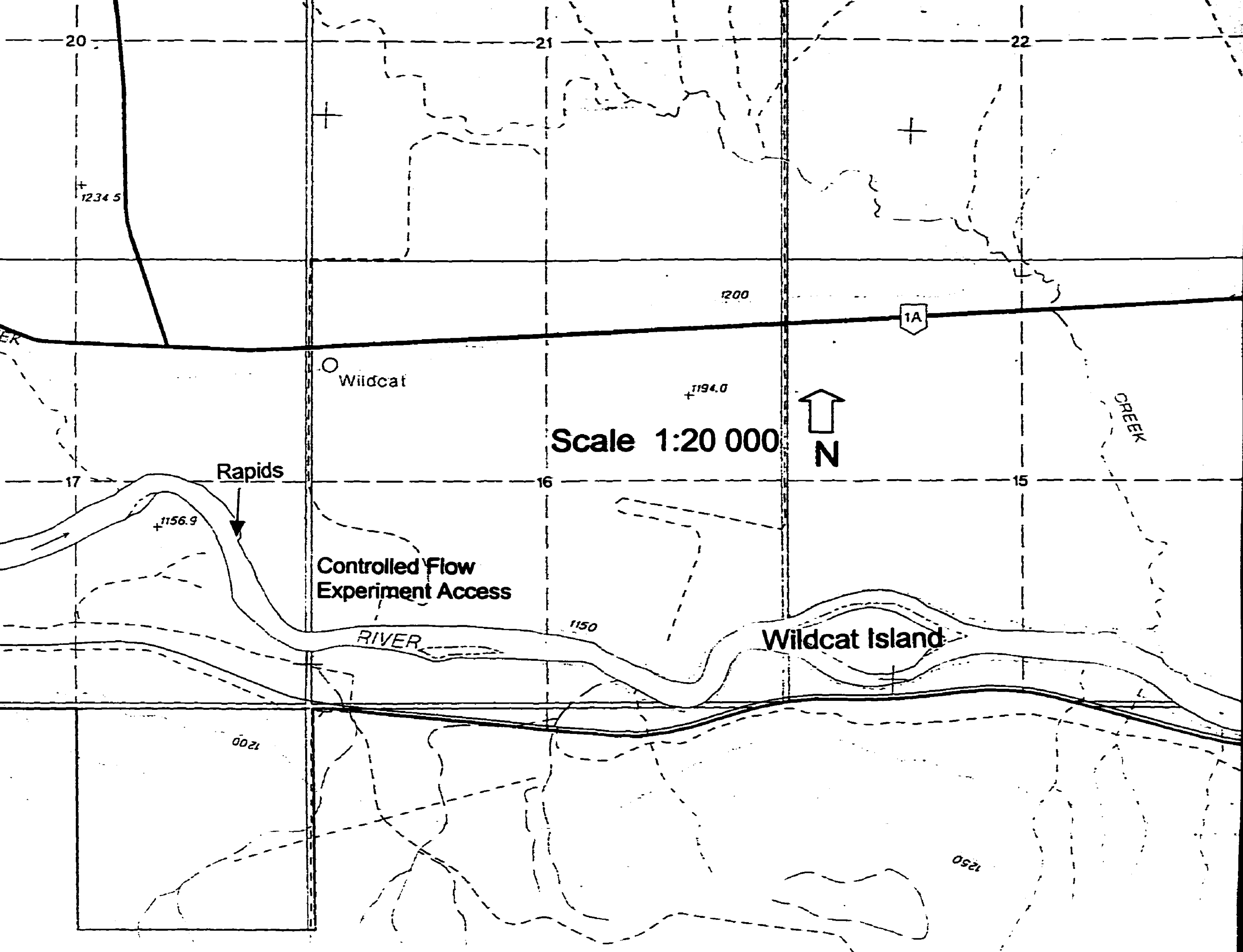

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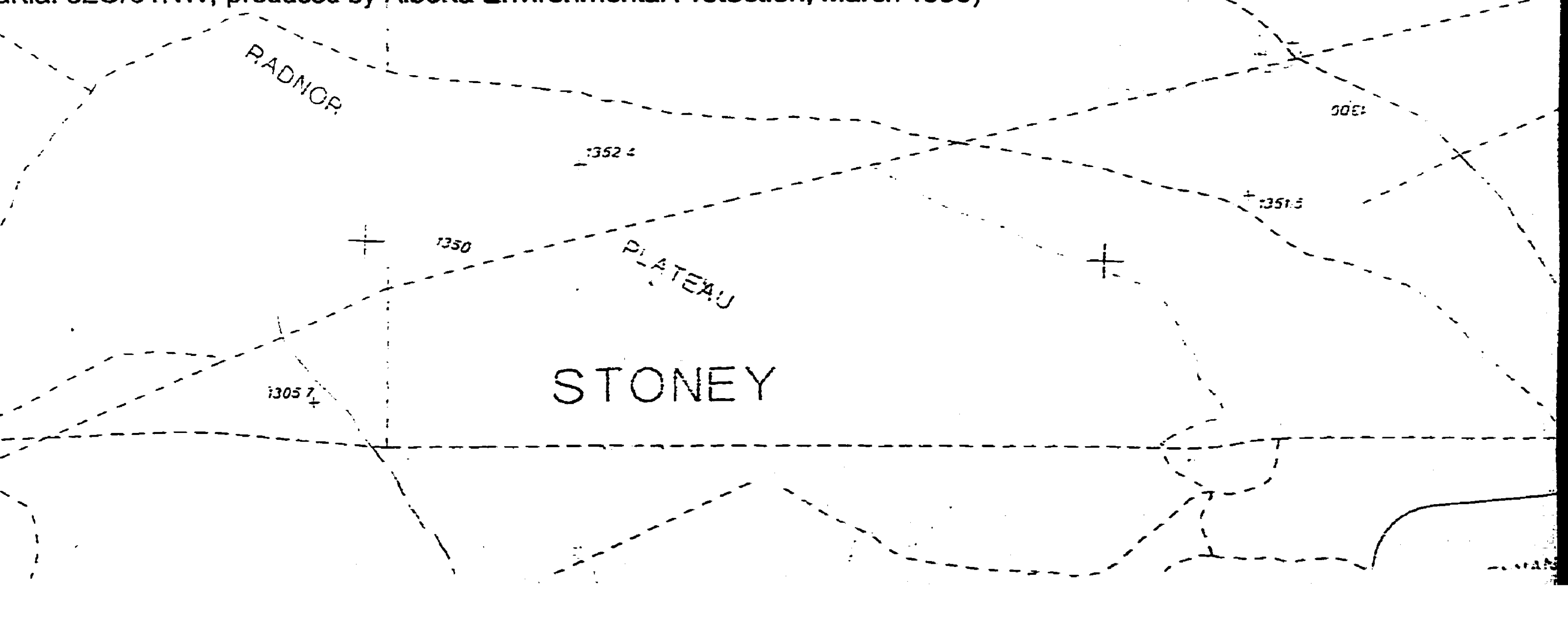

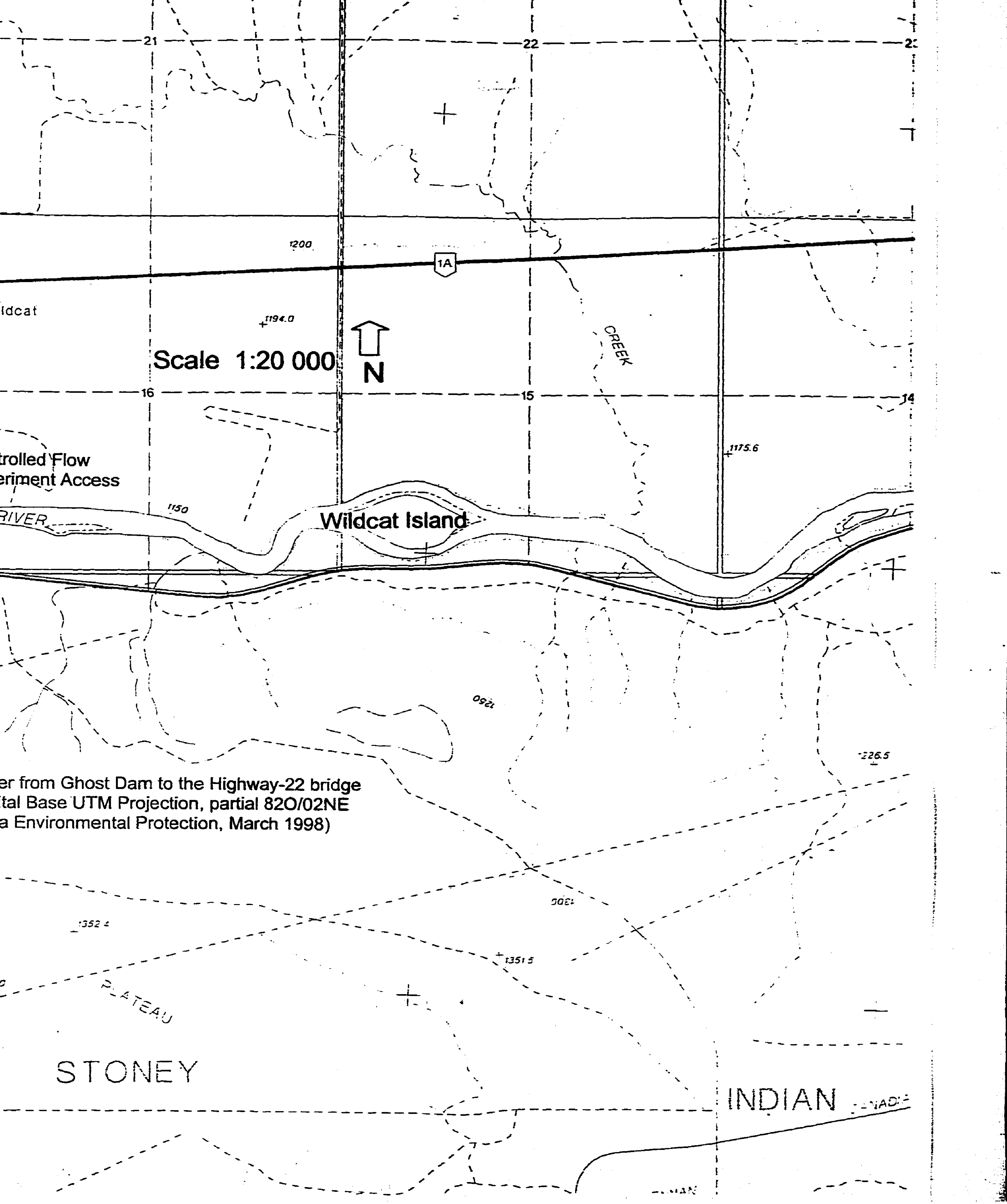

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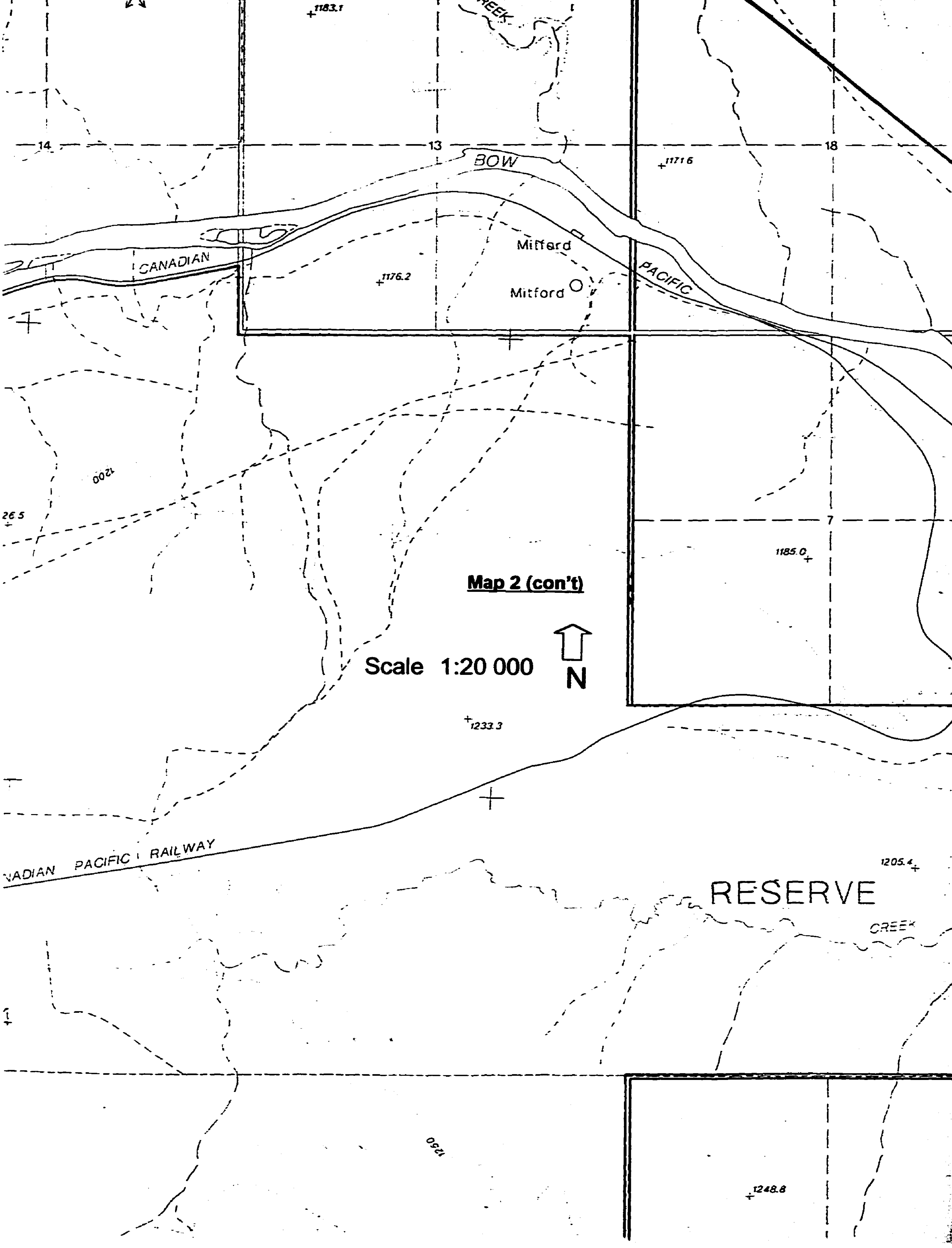
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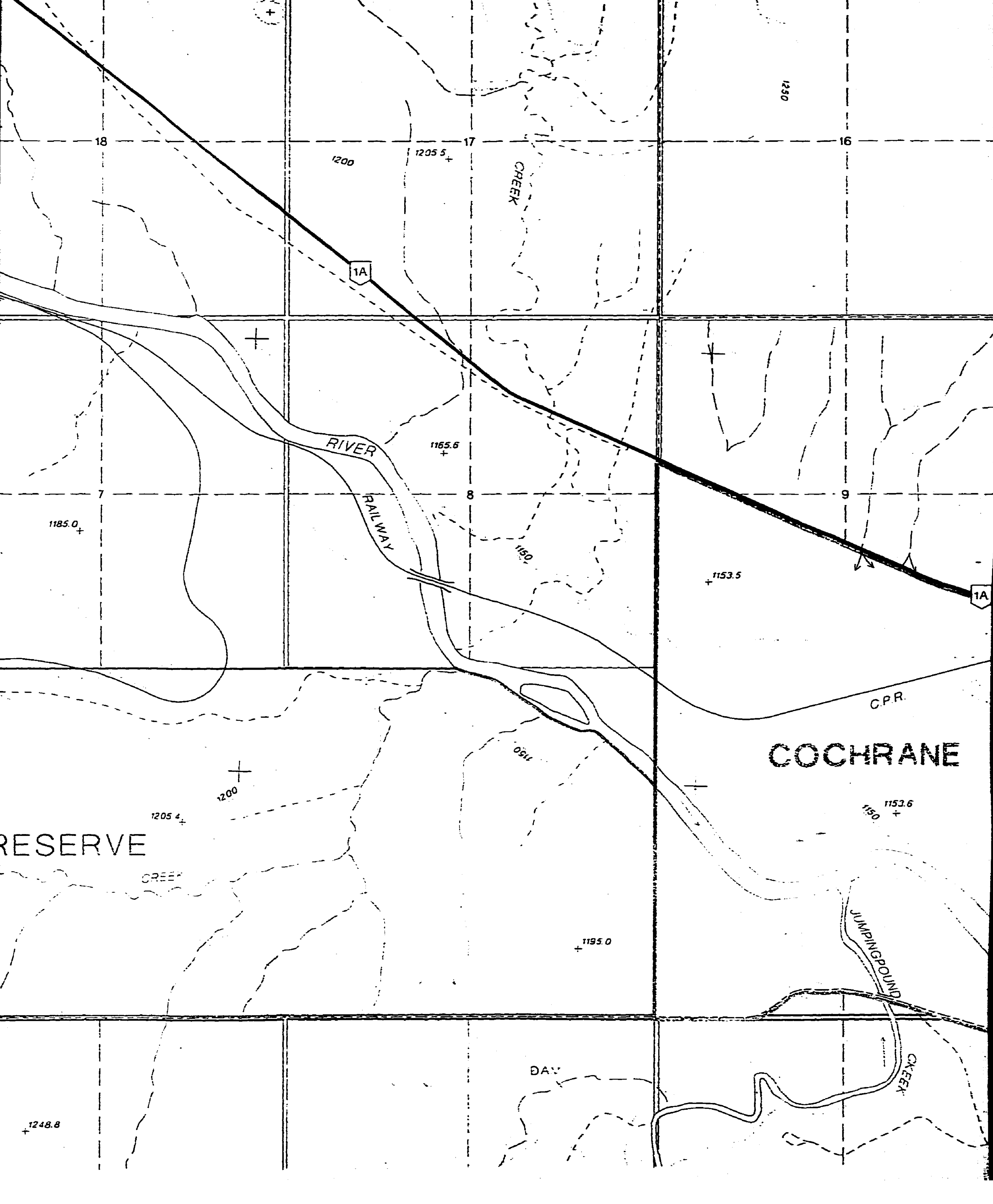

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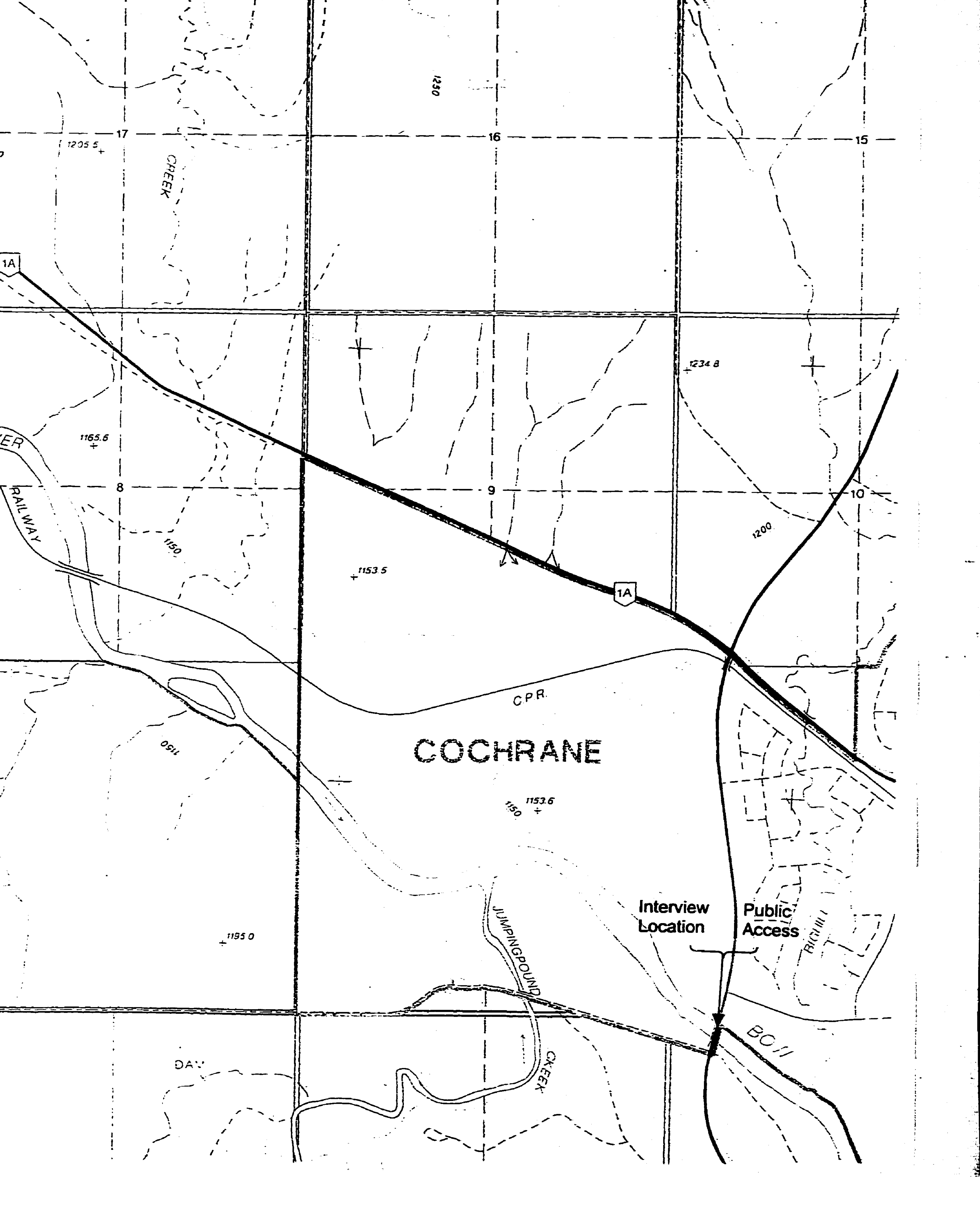

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4.2 STUDY SITE DETERMINATION

In all past recreation studies conducted on the Bow River, the river was divided into discrete reaches for the purposes of implementation and analysis. The scope of the project dictates the level of detail required in defining the river reaches. For this study, the Bow River has been divided into different reaches based on: the location of dams, jurisdictional boundaries, landscape features, inputs and withdrawals of water, and common access points along the length of the river. Whenever possible, reach boundaries defined from other studies were used. In general, a single reach should contain similar recreation features and landscape form, and should have a similar flow from top to bottom. Some of the downstream reaches for the Bow River are longer due to limited access, common landscape features, and lower recreational use within the reach. The reaches of the Bow River defined for this study are listed below.

Reach 1: Bow Lake (source) to Lake Louise

Reach 2: Lake Louise to Banff National Park Boundary

Reach 3: Banff National Park Boundary to Kananaskis River

Reach 4: Kananaskis River to Ghost Dam

Reach 5: Ghost Dam to Bearspaw Dam

Reach 6: Bearspaw Dam to the WID Weir (Calgary)

Reach 7: WID Weir to Highway 22X (Calgary)

Reach 8: Highway 22X to Highwood Confluence

Reach 9: Highwood Confluence to the Siksika Reserve

Reach 10: Siksika Reserve to Bassano Dam

Reach 11: Bassano Dam to the Mouth

4.2.1 Study Site Selection Criteria

Due to the time and resource constraints of the AEP study, a single reach was examined in detail during the summer of 1997. Criteria were developed to determine the most appropriate reach to be studied that would meet the project objectives for defining recreation IFN.

The criteria used to select the location of the survey reach included:

- proximity to Calgary,
- a high level of recreation use,
- a wide range of recreation activities and skill levels utilizing the site,
- limited access along the reach to concentrate users at a major downstream take-out point,
- the presence of an upstream dam capable of controlling the flow to deliver a wide range of flows over a short period of time, and
- the availability of good flow data for the reach.

With consideration for travel time and cost, only reaches five through nine were considered to be potential sites for the 1997 field survey. The reaches downstream of Calgary are primarily used for fishing. On-site surveys would be more time consuming for this reach since there are multiple common access points to the river. Although the Bow River is significantly controlled upstream of these reaches, there is no immediate upstream control to allow for a controlled flow experiment. As an alternative to the on-site surveys, the Hook and Hackle Club in Calgary agreed to distribute surveys to its members through their newsletter as part of the AEP project. The Bow River in Calgary receives a substantial volume of use, but the multiple access points to the river and the limited range of skill types using this reach did not make it preferable for the survey program. In addition, the Bearspaw Dam does not have the capability to control the flow for a controlled flow experiment.

The reach of the Bow River from the Ghost Dam to the Bearspaw Dam best fit the criteria and was chosen as the study site for this project. There is a wide range of recreation use on this reach covering a wide range of skill levels. The river is suitable for novice white-water boating, intermediate canoeing, and beginner rafting. Drive-in access is limited to a single upstream and single downstream point. The hydropeaking at Ghost Dam makes it an ideal site for a controlled flow experiment.

4.3 HYDROLOGY AT THE STUDY SITE

Average flows on a monthly, weekly, or even daily time-step do not properly illustrate the hourly variation of flow at a hydropeaking facility. However, the average monthly flows give an indication of what could be expected without hydropeaking. The average monthly-recorded flows for the Bow River below Ghost Dam from 1933 through 1988 are (Environment Canada 1989):

- May – 96.1cms
- June – 190cms
- July – 163cms
- August – 112cms
- September – 85.6cms
- October – 59.5cms

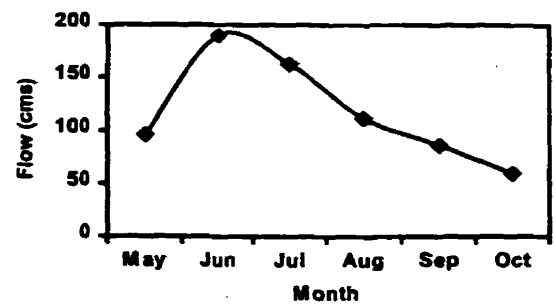


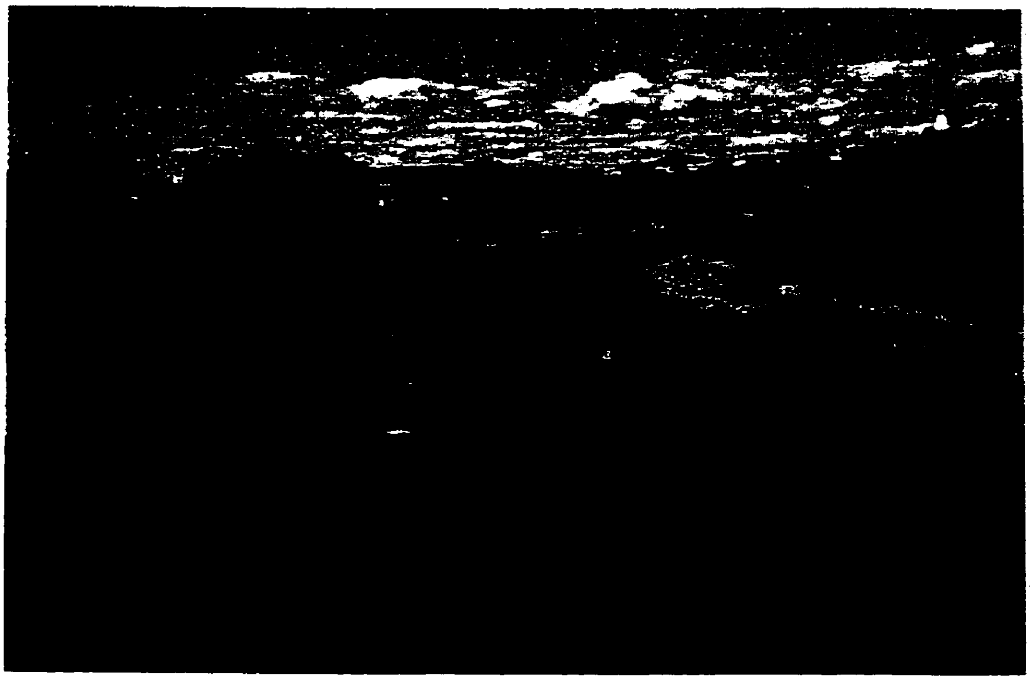
Figure 4.2: Average monthly flows below Ghost Dam.

The Ghost Dam is operated under a license issued to TransAlta Utilities Limited (TAU) by the Province of Alberta in 1947, dating back to an interim federal license issued in 1929 (AEP 1997). The license allows TAU to utilize and store the entire flow of the Bow River at the Ghost site for the purpose of power generation (AEP, 1997). TAU's general pattern of operation is to store water during the off-peak hours and incrementally increase the flow to the maximum operating level to meet the peak energy demand in the afternoon (Dan Smith, pers. comm.). The resulting daily hydrograph from Ghost Dam to Bearspaw Reservoir has dramatic flow fluctuations on a 24-hour cycle. Photo 1 and Photo 2 illustrate the extreme flow difference between the minimum flow of 8.5cms and the peak flow of 221cms.

The operating flows of Ghost Dam are quite specific and are determined by the turbine configuration of the dam. Intermediate flows are rarely released to avoid operating a turbine at less than peak performance. TransAlta records flows in cubic feet per second (cfs). All flows were converted to cubic meters per second (cms) using the multiplication factor of 0.028317.

Photo 1 (top): View of the Bow River looking upstream from the Highway 22 bridge at the peak operating flow of 221cms from the Ghost Dam, August 1997.

Photo 2 (bottom): View of the Bow River looking upstream from the Highway 22 bridge at the minimum operating flow of 8.5cms from the Ghost Dam, August 1997.



The Ghost Dam operates at five distinct flows during the summer, which are defined by the size of the turbines in the dam. The Ghost Dam summer operating flows are:

- 300cfs (8.5cms) – minimum operating flow to store water
- 2100cfs (59cms) – transition flow
- 4000cfs (113cms) – transition flow
- 5800cfs (164cms) – maximum operating flow at lower daily average flows
- 7800cfs (221cms) – peak operating flow at higher daily average flows

The timing of the flow release can vary for any number of reasons, but typically the flow released from the dam must roughly match the incoming flow into the Ghost Reservoir. A general guideline to the timing of flow release during the summer months is outlined in Table 4.1. Each different input flow, shown in bold along the top row of the table corresponds with a different hourly pattern of flow releases.

Table 4.1: General guide for the hourly timing of flow discharge (cms) during summer months from the Ghost Dam based on different daily average input flows (data provided by Dan Smith, TransAlta, 1997) (N.B. TAU is not bound by this schedule and deviations can result at any time without warning).

	Hourly flow outputs for average daily flow inputs at Ghost Dam (cms)							
Hour	**59**	**68**	**76**	**85**	**93**	**102**	**113**	**127**
1	8.5	8.5	8.5	8.5	8.5	8.5	59	59
2	8.5	8.5	8.5	8.5	8.5	8.5	59	59
3	8.5	8.5	8.5	8.5	8.5	8.5	8.5	59
4	8.5	8.5	8.5	8.5	8.5	8.5	8.5	59
5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
6	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
7	8.5	8.5	8.5	8.5	8.5	59	59	59
8	8.5	8.5	59	59	59	59	59	59
9	59	59	59	59	59	59	59	164
10	59	59	59	59	164	164	164	164
11	59	59	59	164	164	164	164	221
12	113	164	164	164	164	221	221	221
13	113	164	164	164	164	221	221	221
14	113	164	164	164	221	221	221	221
15	113	164	164	164	221	221	221	221
16	113	164	164	164	221	221	221	221
17	59	59	164	164	113	113	221	221
18	59	59	59	164	113	113	113	221
19	59	59	59	59	113	113	113	113
20	164	113	113	113	113	113	113	113
21	164	113	113	113	113	113	113	113
22	59	59	113	113	59	113	113	113
23	59	59	59	59	59	59	113	113
24	8.5	8.5	8.5	8.5	59	59	59	59

At a high input flow of 127cms in Table 4.1, there are long blocks of time when the peak generating flow of 221cms is released. At a low input flow of 59cms, there are long blocks of time when the minimum flow 8.5cms is released. The hour indicated in the left column represent the flow released during the previous hour of the day. As an example, hour 1 represents the flow from midnight, or 00:01 hours, until 01:00 hours. The flow reported for hour 12 represents the average flow from 11:01 until 12:00.

A typical 48-hour hydrograph for the Bow River below Ghost Dam during the summer of 1997 is illustrated in Figure 4.3. The flow downstream of the Bearspaw Dam is also included in Figure 4.3 to illustrate how the flow from the Ghost Dam is stabilized through Calgary and to show the approximate daily average flow released from the Ghost Dam.

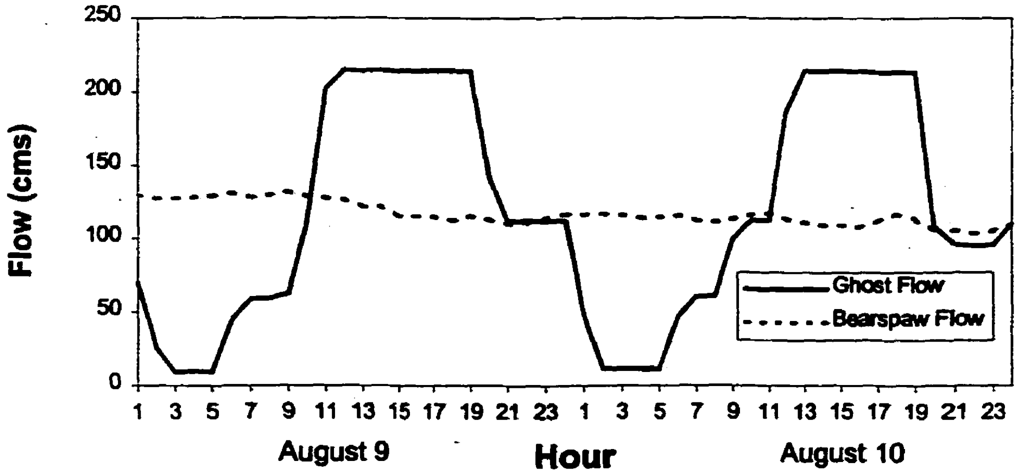


Figure 4.3: Hourly flows released below Ghost Dam and Bearspaw Dam on the Bow River for the weekend of August 9 and 10, 1997 (Data provided by Trans Alta Utilities).

The Ghost Dam operates as a run-of-the-river system, meaning the reservoir is not capable of storing water on a long-term basis and the daily average flow released from the dam is roughly the same as the daily average flow entering the reservoir (Komex 1994). The Bearspaw Dam then evens out the fluctuating flow from the Ghost Dam and the resulting flow through Calgary is stable. The Ghost Reservoir is also not capable of major attenuation of flood peaks, and flood flows are typically passed directly through the dam without any daily fluctuations. Once the floodwaters recede, TAU begins operation of their daily store-and-release cycle.

4.4 *Existing Licenses and Water Uses at the Study Site*

As discussed above, the major license for this reach of the Bow River is TransAlta's license to use and store the entire flow of the river for the purpose of generating electricity. Water from the Bow River is diverted for municipal water supply and treated wastewater effluent is returned to the Bow River at the town of Cochrane (BRWQC 1994). Water is also used for agricultural and domestic purposes on this reach, however the volume of water diverted is relatively minor.

Irrigation is the major consumptive use of water in the Bow River basin, accounting for about 75% of all possible licensed diversions (BRWQC 1994). The other major licenses for diverting water are for municipal withdrawals, which have a flow return rate of about 94% (BRWQC 1994). About 98% of the irrigation withdrawals are downstream of the Bearspaw Dam by the three irrigation districts on the Bow River (BRWQC 1994):

- the Western Irrigation District – diversion occurs within the Calgary city limits,
- the Bow River Irrigation District – diversion occurs near Carseland, and
- the Eastern Irrigation District – diversion occurs near Bassano.

All of the irrigation district withdrawal licenses have priority dates preceding the Ghost Dam license and can call for the entire natural flow in low flow years (AEP 1997). Under these conditions, TransAlta can not store as much water in its entire system and the daily average flow releases from their dams is higher than normal (Dan Smith, pers. comm.). This alters the normal hydropeaking schedule and also results in a lack of storage capabilities in the reservoirs for the winter.

4.5 Recreation Activities on the Bow River

4.5.1 Existing Recreation Studies

There are three existing recreation studies that identify the types and intensity of recreation on the Bow River. All of the studies were completed for the Government of Alberta.

4.5.1.1 Bow River Recreation Study

The Bow River Recreation Study (Thompson et al. 1987) used river surveys of recreation users, guided angler surveys, and household phone surveys to collect information about recreation use on the Bow River. The study found that recreational activities on the Bow River could be divided into four main categories: fishing, boating, swimming, and land-based activities alongside the river. The study determined that approximately 70% of Calgary residents used the Bow River Valley for some type of recreation, with the majority participating in land-based activities alongside the river. Most of the land-based activities occurred within the Calgary city limits and involve walking, jogging, cycling and picnicking along the bicycle/walking paths and in the many parks along the river.

Of the recreational activities that involve direct use of the Bow River, fishing was by far the dominant activity. Recreational fishing was particularly important downstream of Calgary from Fish Creek to the Siksika Reserve, where much of the local and commercial guided angling efforts for trophy rainbow and brown trout occurred. The Bow River Recreation Study completed on-site surveys of recreation users on the Bow River and reported that 85% of the user-days were spent fishing. Boating was the second most popular activity with 19% of the user-days. This study covered an area from downstream of the Bearspaw Dam to the Siksika Reserve.

4.5.1.2 South Saskatchewan River Basin Planning Program (SSRBPP)

The South Saskatchewan River Basin Planning Program (SSRBPP 1984) estimated that upstream of the Bearspaw Dam, 79% of the user-days were spent fishing, although both boating and swimming were more prominent on this reach compared to downstream reaches. The estimates of recreation use for each activity from the SSRBPP are comparable to the Bow River Recreation Study results where the two studies overlap in location. Below the Bassano Dam, overall use drops dramatically compared to the upper reaches with relatively low levels of activity in fishing, swimming, and boating.

4.5.1.3 Little Bow Project

Another study completed as part of the environmental impact assessment of the Little Bow Project also supports the findings of the aforementioned studies (AEP 1994). A household phone survey indicated that a majority of water recreation was land-based. Of the water-based activities, fishing was the dominant activity attracting 76% of the visits (not user-days) on the Bow upstream of Highway 22X, and 84% of the visits downstream. The study estimated residents from Calgary and its surrounding communities make 189,000 recreation visits to the Bow River and its major tributaries each year.

These three studies indicate that water-based recreation is an important activity for the regional populations along the Bow River. The Bow River is also an important international fishing destination, and is one of the best trout rivers in Canada. All of the studies indicate that fishing is the single most dominant instream activity throughout the entire length of the Bow River. Due to the varying degrees of detail, and the age of two of the studies, it is difficult to predict the current level of use along the Bow River. Many of the patterns, however, are likely to be consistent.

4.5.2 Existing Recreational Resources

It takes approximately three hours to float from Ghost Dam to the Highway 22-bridge at the peak operating flow released by TransAlta. Head winds are commonly experienced and can cause difficult paddling in this reach of the Bow River, particularly at downstream locations where the river becomes wider and flatter, slowing travel velocities.

The Bow River from the Ghost Dam to the Bearspaw Dam is considered a Grade II section of river with a number of Class II rapids for boating at average summer flows

(Alberta Government Travel Bureau 1978). A Grade II rating is defined as a river with most of the passages clear, fairly frequent rapids with medium-sized waves, low ledges, and with possible sweepers and logjams (Alberta Government Travel Bureau 1978). The minimum skill level suggested to safely negotiate a Grade II river is an intermediate Open Canadian paddler (i.e. open canoe) or a novice White-water paddler (i.e. decked canoe, kayak, or raft) (Alberta Government Travel Bureau 1978). The American Whitewater Affiliation suggests that if the water temperature is below 10°C, the river should be considered one grade more difficult (Alberta Government Travel Bureau 1978). This last point is particularly relevant during spring run-off on the Bow River when the water is very high and cold, and a spill from a boat could result in a prolonged swim down the river and the potential for hypothermia.

At medium flows, the width of the river allows for all of the rapids and any sweepers along the bank to be easily avoided. At low flows, a Class II ledge becomes exposed, which creates an obstacle across the entire width of the river. There is also less room to avoid the other rapids on this reach at low flows, but the river is not as powerful and the waves are smaller, creating less of a safety concern.

Wildcat Island is located approximately 6.2km downstream of the dam (see Map 2). The facilities on the island are very basic with a few benches set up for picnicking, and several small clearings for campsites. Many paddlers will pull out at Wildcat Island as a planned stop for a picnic.

The only public drive-up access points to the river in this reach are directly below the Ghost Dam and at the parking lot adjacent to the Highway 22-bridge at Cochrane. There are no facilities at the Ghost Dam except for the road access to the river. Parking is not permitted next to the river at the dam, but is allowed at the top of the valley alongside the access road. The facilities at the Highway 22-bridge include a parking lot, walking trails along the river, and several sitting benches. There are no washroom facilities at any point along the river, although there are many restaurants and gas stations just a few kilometers down the road in Cochrane.

Walk-in access is possible at several locations along the reach. Petro Canada's Wildcat Hills Gas Plant has a private road that is probably the most common walk-in access point and is used mostly by anglers. The walk from the access road to the river is approximately one kilometre in length.

There are several companies that offer guided group trips down this section of the river. However, private users are by far the dominant category of users. Heritage Canoe Adventures and Canadian Heritage Tours were the most frequent commercial users observed on this reach of the Bow River during 1997. Heritage Canoe Adventures, based in Cochrane, offer trips for large groups in voyageur canoes while Canadian Heritage Tours offers group trips in tandem open canoes. Several organizations, including the Rocky Mountain Paddling Centre and the University of Calgary, also use this reach as a component of an instructional course for kayaking and canoeing. Guided fishing trips are also available through Robert's Fly Shop and Fishing Co. in Cochrane and through several local fishermen.

4.5.3 Fishery Resources

The following information about the fishery resources was obtained a sportfish population study conducted by R.L. & L. (1998). The sport fish species found in the Bow River between Ghost Dam and Bearspaw Dam are:

- Mountain Whitefish (*Prosopium williamsoni*),
- Rainbow Trout (*Oncorhynchus mykiss*),
- Brown Trout (*Salmo trutta*),
- Burbot (*Lota lota*),
- Bull Trout (*Salvelinus confluentus*), and
- Brook Trout (*Salvelinus fontinalus*).

The dominant sport fish species in this reach are, by far, Mountain Whitefish followed by Rainbow Trout. There is estimated to be small populations of Brown Trout and Burbot and remnant populations of Bull Trout and Brook Trout located within this reach of the Bow River. The population estimate of sport-fish below

Ghost Dam, using biomass per unit area as an indicator, is considerably lower than population estimates conducted throughout the Bow corridor (R.L.&L., 1998).

Both the Bearspaw Dam and the Ghost Dam block fish movement at either end of this reach. All of the fish species must feed, spawn, and over-winter within the confines of this 41km reach of the Bow River. Jumpingpound Creek, located just upstream of the Highway 22-bridge, is the only significant tributary for sport fish on this section of the Bow River (Rees, 1988). The Jumpingpound Creek is also provides critical spawning habitat for rainbow trout that reside in the Bow River (D.A. Westworth, 1994). Brown Trout spawn in the mainstem of the Bow River, and spawning sites on this section of the Bow River are limited due to a lack of suitable gravel substrate (R.L.&L. 1998). Mountain Whitefish spawning habitat is more widely distributed throughout the mainstem of this section of the Bow River, which is one reason for the larger mountain whitefish population (R.L.&L. 1998). The over-wintering habitat for most of the fish in this reach is in the Bearspaw Reservoir and in several deep pools along the length of the river.

Angling on this reach is relatively unproductive due to the daily fluctuations of flow caused by the Ghost Dam (McLennan 1996). Trout Unlimited and TransAlta have completed several habitat improvement projects along the reach by placing large boulders at several locations in the Bow River around Cochrane. These boulders are intended to provide habitat for fish at both high and low flows to improve angling conditions on this section of the Bow River.

An IFN study was conducted on the Bow River, which included the reach from Jumpingpound Creek to Bearspaw Dam (EMA 1994). This reach is at the bottom end of the study sections used in this study, but the results can be considered applicable upstream to Ghost Dam for the purpose of this report. The IFN recommendations for fish habitat protection from this report are:

- 40cms during low flow years
- 50cms during average flow years
- 75cms during high flow years

These recommendations apply to steady flow conditions and do not consider the impact of hydropeaking on the availability of fish habitat.

4.6 EXISTING BOW RIVER RECREATIONAL IFN CRITERIA

4.6.1 South Saskatchewan River Basin Planning Project (SSRBPP)

The SSRBPP (1984) used depth criteria of 0.6m to develop minimum flow requirements for canoeing on the Bow River. The depths were translated into flows using a hydraulic model created by Alberta Environment. Brown et al. (1991) suggest that hydraulic modeling of flows based on depth criteria at selected transects may not adequately describe the complex nature of water movement in rapids or the formation of riffle-pool complexes for fishing. The SSRBPP reported the minimum flows for recreation on the Bow River to be:

- Banff - Calgary: 30cms
- Calgary - Highwood: 35cms
- Highwood - Carseland: 40cms
- Carseland - Bassano: 40cms
- Bassano - Mouth: 40cms

The SSRBPP study, however, only looked at canoeing needs and did not explore the instream flow needs of other recreation users. Fishing from a boat, rafting, and power-boating generally all have higher depth requirements than the 0.6m used to create the above flows. A similar study conducted on the Red Deer River identified the minimum flows to be 10cms for wading, 10-40cms for canoeing, 28-75cms for rafting, and 85-100cms for power boating (Wood Bay 1994). The Red Deer River study illustrates the variable flow requirements for each major form of river recreation. Another drawback to the SSRBPP study's recommended flow is the poor separation of unique river reaches. Of particular note, the reach of the Bow River from Banff to Calgary has many different characteristics from start to finish. The Bow River in Banff is a relatively confined and narrow mountain river. It then flows through the foothills and becomes a much wider prairie river with roughly double the flow by the time it reaches Calgary. The types of recreation experiences and the physical characteristics of the Bow River are very different within the Banff to Calgary reach used by the SSRBPP, and they should not be lumped together when defining recreation instream flow needs.

4.6.2 River Trip Report Cards (1985-1996)

The River Trip Report Card project created by Alberta Environmental Protection has collected evaluations of recreation boaters from rivers throughout Alberta since 1985, but a formal report of the results has never been published. The report cards were distributed throughout the recreation community and completed report cards were returned to Alberta Environmental Protection by mail. The river trip report cards asked for an evaluation of the general flow level at the time of the trip using a seven-point rating scale. The exact wording and layout for the flow evaluation section on the river trip report cards as follows:

Water level general: 1) impossibly low, 2) much too low, 3) low, 4) just right,
5) little high, 6) much too high, 7) dangerously high

The flow evaluation question used on the report cards was vague, the presentation was difficult to read, and the rating categories should have been revised. The results from this program are limited due to small sample sizes for many reaches and the poor format and wording of the flow evaluation question.

The report cards collected for the Bow River below the Ghost Dam were pooled together with reaches of the Bow River through Calgary. The problem with this approach is that hourly flow data is required for the Ghost Dam reach for analysis. The Ghost Dam reach also has two sets of Class II rapids and passes mainly through undeveloped ranch lands. These factors result in a different river experience compared to the Calgary reach, which has no rapids and passes through an urban setting.

Surveys from the river trip report card program that evaluated the Ghost Dam reach were re-examined using hourly flow data provided by TransAlta Utilities. There were only 39 useable surveys for the Ghost Dam reach of the Bow River from the 12 years for which surveys were collected. The survey respondents for the Ghost Dam reach encompassed a full range of skill levels and included both canoe and kayak groups.

Regardless of the faults in the program, survey responses were averaged to identify the range of flows indicated as "just right" on the river trip report cards. The following list is the average flow ratings, where a rating of "4" corresponds to a survey response of "just right." A higher rating means the flow was too high and a lower rating means the flow was too low.

- 93cms-123cms – average rating of 3.6 based on 10 responses
- 150cms-175cms – average rating of 4.25 based on 12 responses
- 195cms-227cms – average rating of 4.33 based on 12 responses

One response for a flow of 4cms was rated as "impossibly low", three responses for flows ranging from 248cms to 288cms were rated as a "little high", and one response for a flow of 452cms gave a rating of "much too high."

From the river trip report card data, an acceptable flow range for recreational paddling is defined as 93cms-227cms. This data only represents canoeing and kayaking interests and should be considered preliminary.

5 RESULTS

5.1 KEY INFORMANT INTERVIEWS

The purpose of the key informant interviews for this project was to identify issues of concern about the effects of flow in the Bow River on recreation and to provide feedback on the survey design. Experienced water-based recreational users were identified and contacted through recreation clubs and through personal references from other recreational users. The interviews were informal and were conducted with individuals over the phone and in a group discussion setting. General comments were recorded during the on-site interviews to allow for input by recreation users that were not involved in a club or organization.

5.1.1 Experienced Boaters

Experienced Bow River paddlers were contacted through the Bow Waters Canoe Club, Canadian Heritage Tours, Heritage Canoe Adventures, Rocky Mountain Paddling Centre, and the University of Calgary Outdoor Programs office (Appendix I). All of the people contacted indicated that the Bow River below the Ghost Dam is a Class II section that provides good rapids, standing waves, and eddies for beginner to intermediate paddlers. Several paddling instructors indicated that this reach is good for teaching and practicing basic river paddling techniques and it is used frequently for instructional purposes.

Most of the rapids and surfing waves are located on the upper section of this reach from the Ghost Dam to Wildcat Island. The major recreational river feature located on this reach is a ledge that becomes exposed at lower flows. The ledge spans most of the river width and requires an intermediate skill level to navigate safely. There is also a Class II rapid approximately two kilometres downstream from the Ghost Dam that creates two-foot standing waves. There are also a number of other smaller rapids, standing waves, and strong eddy lines throughout the reach that make this reach more challenging than the reach through Calgary. According to the respondents, the eddies on this reach become larger and more powerful with higher flows, while the rapids and surfing waves are best at an intermediate flow before they become washed out at higher flows.

According to several of the boaters that were interviewed, the use of the Bow River below the Ghost Dam for recreational boating is often dependent on the flow of other rivers around Calgary. The University of Calgary kayak club organizes trips on a drop-in basis, mainly for people who have just completed their introductory kayak course. On most occasions, the club will go to the Kananaskis River below the Barrier Dam for better white-water conditions compared to the Bow River below the Ghost Dam. However, when the Barrier Dam shuts off, the alternate site is typically the Bow River below the Ghost Dam.

Many of the boaters interviewed also indicated that the Bow River below the Ghost Dam was a good paddling reach in the late summer and fall. Many of the smaller rivers, such as the Highwood River or the Elbow River above the Glenmore Dam, become too low to paddle and the Bow River below the Ghost Dam is a good alternative close to Calgary.

5.1.2 Experienced Anglers

Anglers familiar with the Ghost Dam reach of the Bow River were contacted through:

- the Jumpingpound Creek Chapter of Trout Unlimited Canada in Cochrane,
- the Hook and Hackle Club based in Calgary, and
- fly-fishing outfitters and guides in both Cochrane and Calgary.

A major theme that was stated repeatedly from experienced anglers is that the flow of the river is not as critical as the stability of the river. Many of the anglers that were interviewed had over 20-years experience fishing the Bow River, they have observed the following trends:

- stable water levels produce the best fishing conditions,
- falling water levels produce adequate fishing conditions, and
- rising water levels produce poor fishing conditions.

All of the anglers interviewed believed the daily fluctuations in flow created by the Ghost Dam are damaging the sport fishery on this reach of the Bow River. Because of the relatively poor fishing conditions on this reach, many of the people interviewed felt that anglers are concentrated at alternate sites on the Bow River, resulting in higher congestion and a lower quality recreational experience.

Another concern was voiced about the high flows experienced late into August and September on this reach of the Bow River. TAU released a flow of 221cms for at least a couple of hours almost every day of the summer until the end of September in 1997. At this flow in the late summer, several respondents indicated that the water level is above the vegetation line, which caused erosion and turbidity resulting in poor fishing conditions along the river. The high water elevation and water velocity at 221cms also made it near impossible and dangerous to wade in the river. At this high flow, fishing from shore or even from a boat is also difficult.

5.1.3 Comments from Survey Participants

Survey participants were asked to comment on any issues they felt were important with respect to this reach of the Bow River. The majority of the respondents simply stated that it was an excellent trip and made no other comments. It was expressed many times that it is very desirable to have a nice stretch of river so close to Calgary that can provide good recreation opportunities. Several respondents were concerned about maintaining the water quality and naturalness of the river, which add to the enjoyment of the reach.

Many groups made use of Wildcat Island, located approximately half way down the trip near the Petro Canada Gas Plant, to stop for lunch or even camp. A concern was given that an increasing level of use on the island may result in increased garbage and human waste on the island. There was also a concern for a need to protect wildlife habitat on the island and all along the river.

Many people who use this reach of the river for recreation are not aware of the daily flow fluctuations caused by the Ghost Dam and visually check the flow of the Bow River in Calgary expecting a similar flow upstream. People who are aware that the river level fluctuates are frustrated that there is no commonly known method for obtaining the timing of flow releases for this reach. One power-boater became stranded on a sand bar near Cochrane on October 19, 1997 when the flow suddenly dropped to 41cms at 17:00 hours, and was frustrated with the inconsistency in the timing of the flow changes. Many people expressed an interest in having the time of flow releases made publicly available. As mentioned earlier, the dam fluctuations and minimum operating flow are major concerns of anglers, and several boaters also expressed that this concern. There was a general concern of the perceived impact of the fluctuations on the aquatic ecosystem.

One of the most frequent comments was a request for banning jet boats from this reach. These comments were usually made on days when a jet boat was also on the river. Jet boats were seen by some as a potential danger to boaters and wading anglers, disruptive to fishing, and generally loud and unpleasant. Supporters of jet boating say that a few bad drivers are the problem, and that proper boating etiquette can solve many of the conflicts.

Other comments by river users included: improved parking at Ghost Dam, installing washroom facilities at the Highway 22 Bridge parking lot, poor access at the gas plant, declining water quality, litter along the shore line, increased congestion, and too much development close to the river in Cochrane.

5.2 Survey Results

Over the course of the 1997 field season from June through to September, 279 groups were observed totaling 1353 recreation users. An average of ten groups was counted per day with an average group size of about five people. The busiest days were July 20 with 29 groups and 135 people, August 10 with 28 groups and 121 people, and September 7 with 22 groups and 197 people.

Out of the 279 groups observed, 54 groups were not approached for an interview for the following reasons:

- 23 groups passed by the take-out site and continued downstream.
- 16 groups were just starting their activity and did not return to the take-out site.
- 7 groups were missed because the interviewer ran out of forms.
- 5 groups launched at the interview site to head downstream.
- 3 groups were not interviewed for other reasons.

In total, **225 groups** were approached for an interview of which,

- 3 groups refused to participate in the survey, and
- 222 groups participated representing a **response rate of 98.7%**.

An additional 19 kayak survey forms received from the University of Calgary Kayak Club are not included in the survey totals listed above.

The three groups that refused to participate were jet skiers, and all claimed that a lack of time was the reason for not participating. Jet boaters and power boaters completed a total of six forms, but were not included in the statistical analysis as a major recreation group for this reach of the Bow River.

During the early stages of the on-site surveys, six anglers were interviewed before it was decided a different approach should be taken. Novice anglers were having difficulty determining how the flow may have affected their fishing trip. Of the forms completed, five of the forms were at 221cms and the other form was at 164cms. All of the respondents indicated that their fishing success was poor and that they would

An alternate approach was developed for anglers that involved distributing survey packages to experienced anglers that contained multiple survey forms to be completed over the course of the summer. The packages were distributed through the local chapter of Trout Unlimited Canada and through Robert's Fly Shop and Fishing Co. in Cochrane. A total of 20 survey packages were distributed and 12 survey packages were returned with a total of 39 survey forms completed for four different flows.

A total of 257 forms were suitable for analysis for the four major recreation types observed on the Bow River: canoes, kayaks, rafts, and angling. Table 5.1 highlights the distribution of forms collected by boating type and by flow.

Table 5.1: Distribution of forms completed for each major boating type for each flow level experienced from June through September 1997.

	Number of Forms for Each Flow						
	59cms	**113cms**	**164cms**	**221cms**	**240cms**	**294cms**	**Totals**
Canoe	5	13	12	51	6	10	97
Kayak	1	15	3	26	1	1	47
Raft	5	15	10	44	0	0	74
Angling	6	10	10	13	0	0	39
Totals	**17**	**53**	**35**	**134**	**7**	**11**	**257**

The number of responses in Table 5.1 may not adequately represent the relative level of participation for each activity on this reach of the Bow River. An additional 19 kayak forms were obtained from Wednesday-evening kayak club trips and therefore only 61% of the kayak forms were collected during the normal weekend survey period. As well, the number of anglers on the river relative to the other activities can not be inferred from this data since angler forms were distributed to a group of experienced anglers to be completed on their own time. Counting the number of anglers on the river at the time of the interviews was not possible without a boat. Although fishing on this reach may not be as intensive compared with the downstream reaches, the proportion of anglers to other recreation users is expected to be higher than suggested in Table 5.1.

High flow warnings were issued on local television and radio broadcasts for the weekends of June 7-8 and June 14-15 during the spring run-off in 1997. On these weekends, only canoeists and kayakers with intermediate skill level, or higher, were observed during the survey hours.

The majority of the interviews were conducted at a flow of 221cms, since this was the most common operating flow during peak hours for the entire survey season in 1997. Boaters rarely experienced a low flow of 59cms during the time when the weekend interviews were conducted. The flow increased above 59cms in the early morning on most of the weekends, and boaters were usually entering the river in the late morning at higher flows. Boaters also rarely experienced a flow of 164cms since the flow increased directly from 113cms to 221cms for most of the summer in 1997.

5.3 FLOW EVALUATION CURVES

The survey forms were separated into the major types of recreation and were analyzed individually. A flow evaluation curve was plotted by averaging each respondent's evaluation for each different flow tested.

Two different questions on the survey form provide information for flow evaluation curves. The first question had the respondent rate the quality of their recreation experience with respect to the flow conditions experienced on their trip. The following question was asked:

> *"How would you rate today's flow condition for your activity:*
> *5) Extremely good,*
> *4) Good,*
> *3) Acceptable,*
> *2) Poor,*
> *1) Extremely poor."*

The results from this question should hypothetically form the inverted-U curve that is common in other recreation IFN studies. The lowest acceptable flow is then defined as the point on the curve where the average response crosses the threshold rating of "acceptable." All points on the curve above the "acceptable" line are considered to correspond with the range of acceptable flows, with the optimum flow defined as the peak in the curve. All points on the curve below the "acceptable" rating correspond to flows that are considered unacceptable for recreation. An example of this type of flow evaluation curve is shown in Chapter 3 (Figure 3.1).

The second question used to produce a flow evaluation curve is to ask the respondent if they would prefer a different flow from what they had just experienced for their activity.

"In your experience, would you prefer a flow for your activity that was:

-2) Much lower than today,

-1) Slightly lower than today,

0) Same as today,

1) Slightly higher than today,

2) Much higher than today?"

In a similar study in Maine, this was found to be the essential question in determining the flow preferences for recreation (Giffen and Parkin 1992).

The optimum flow is defined as the flow where an average response of "prefer the same flow" is found. A response of "prefer the same flow" is given a rating of zero, a preference for a higher flow is given a positive rating and a preference for a lower flow is given a negative rating. The range of acceptable flows is defined as the average responses that fall within the preference ratings of "prefer slightly higher flow" and prefer slightly lower flow." The range of unacceptable flows can then be defined as all points that lie outside of the range of acceptable flows.

Figure 5.1 illustrates a hypothetical flow evaluation curve derived from the question for flow preference relative to the flow just experienced by the respondent.

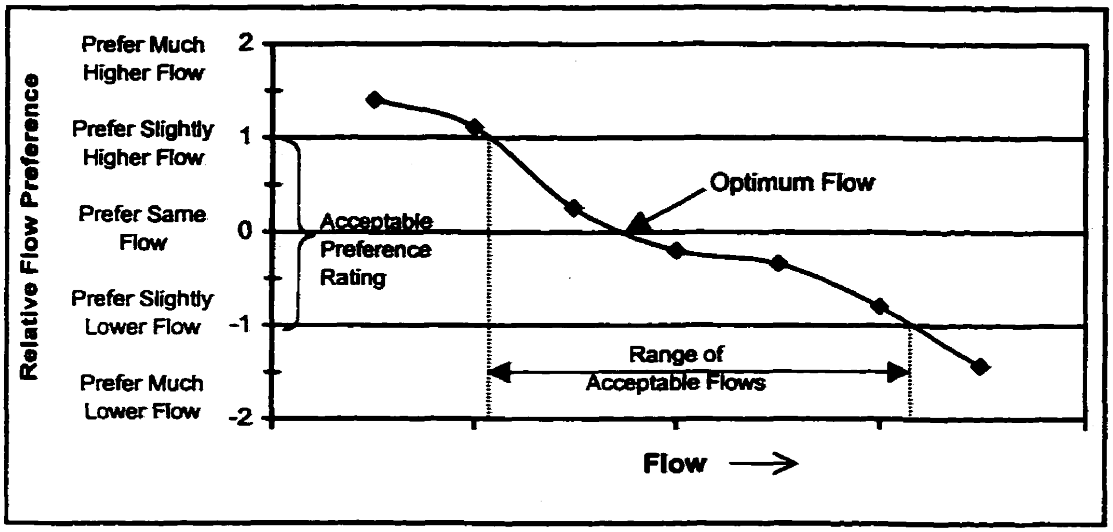


Figure 5.1: Hypothetical flow evaluation curve stating the preference for a similar, higher, or lower flow relative to the flow experienced by the survey respondent.

5.3.1 Canoe Flow Evaluations

Canoeing was the most common boating activity observed accounting for 44% of the boating groups surveyed. Canoeists interviewed for the survey ranged in skill levels from beginner to expert. Canoeists on average had the highest skill level and experience of the boating groups. The following summarizes the characteristics of the canoeists interviewed.

- The skill levels of the canoe respondents (self defined) were – 15% beginner and novice, 45% intermediate, and 40% advanced and expert.
  - 59% of respondents had taken more than five previous trips on this reach of the Bow River.
- The average canoe group size observed during the surveys was four people using two canoes.

5.3.1.1 Canoe Recreation Quality

The rating of recreation quality at each flow by canoeists is summarized below in Table 5.2 and Figure 5.2.

Table 5.2: Distribution of canoeist's recreation quality rating responses with the mean and standard deviation for each flow level using the numerical equivalent assigned to each response (e.g. 4 for good and 2 for poor).

	Distribution of Responses at Each Flow						
Flow	Extremely Good (5)	Good (4)	Acceptable (3)	Poor (2)	Extremely Poor (1)	**Mean**	**Standard Deviation**
59cms	0	1	3	1	0	3.0	0.71
113cms	3	5	5	0	0	3.8	0.80
164cms	3	8	1	0	0	4.2	0.58
221cms	23	26	2	0	0	4.4	0.58
240cms	3	3	0	0	0	4.5	0.55
294cms	4	6	0	0	0	4.4	0.52

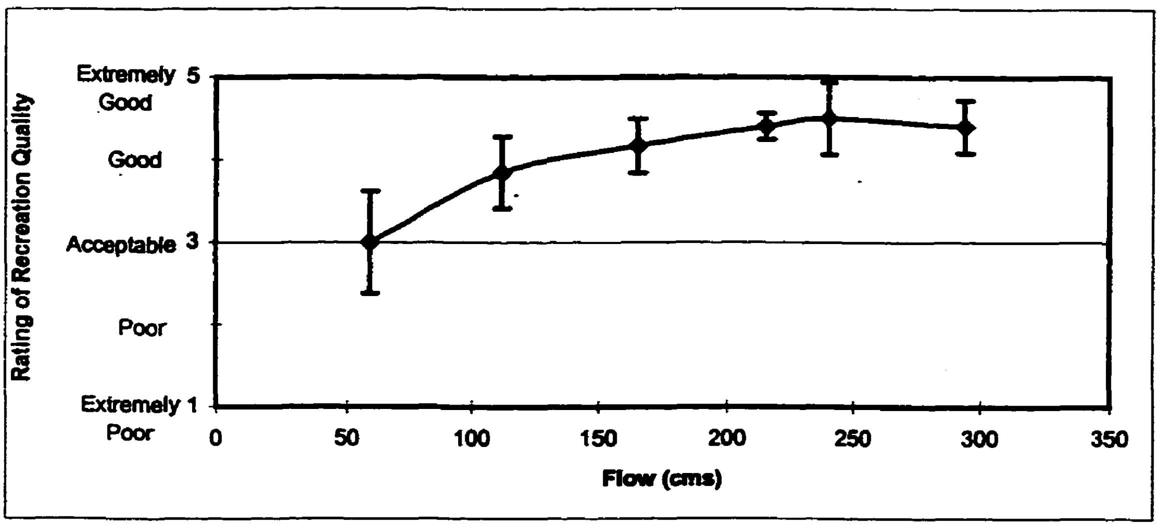


Figure 5.2: Canoe flow evaluation curve created from the mean response for recreation quality with a 95% confidence interval.

Both Table 5.2 and Figure 5.2 indicate that the average rating of recreation quality is acceptable for all of the flows experienced with increasing recreation quality at the higher flows. From Table 5.2, it can be seen that only a single canoe respondent gave a "poor" rating of recreation quality, and that was for a flow of 59cms. The agreement of responses between respondents was good for all of the flows as indicated by the standard deviations.

The flow evaluation curve levels off at the high flows experienced in the 1997 field season, but higher flows are possible on this reach of the Bow River. All of the flows higher than 164cms received an average rating above "good" for recreation quality, with the optimum range of flows from 221cms to 294cms. Of particular note in interpreting the optimum range of flows is that the canoeists paddling during the spring run-off flows above 240cms were all of an intermediate or higher skill level. The rating at 221cms is representative of a full range of skill levels, and is the optimum flow for all canoeists.

5.3.1.2 Canoe Flow Preference

The second critical question to be answered in this study is in regards to flow preference. The results for canoeists are summarized below in Table 5.3 and Figure 5.3. The results from this question generally agree with the results from the recreation quality question above except at 59cms. The average flow preference value for 59cms is 1.4, which falls between a response of "prefer slightly higher" and "prefer much higher" flow than was experienced at 59cms. This response is defined as being outside of the range for acceptable flows. This difference in results may be due to other factors, such as nice weather or an enjoyable experience, which might positively influence the evaluation of recreation quality but not influence the evaluation of flow preference.

Table 5.3: Summary of canoeist's relative flow preference responses with the mean and standard deviation for each flow level.

	Distribution of Responses at Each Flow						
Flow	Prefer Much Higher (+2)	Prefer Slightly Higher (+1)	Prefer Same Flow (0)	Prefer Slightly Lower (-1)	Prefer Much Lower (-2)	Mean	Standard Deviation
59cms	2	3	0	0	0	1.4	0.55
113cms	3	6	5	0	0	0.88	0.77
164cms	2	3	8	0	0	0.54	0.78
221cms	2	11	32	13	0	0.01	0.72
240cms	0	1	2	4	0	-0.5	0.63
294cms	0	2	4	3	0	-0.15	0.75

The acceptable range of flows defined by the flow preference question for canoeing is 113cms and higher. Although the flow evaluation curve in Figure 5.3 crosses the acceptable range at about 100cms, TAU does not operate at this flow, so the next highest flow of 113cms is used in defining the lower acceptable flow limit for recreation. In agreement with the recreation quality results, the optimum flow from Figure 5.3 is at 221cms where it crosses the "prefer same flow" rating. The level of agreement between respondents was generally poorer than that for the recreation quality results as indicated by the higher standard deviation values.

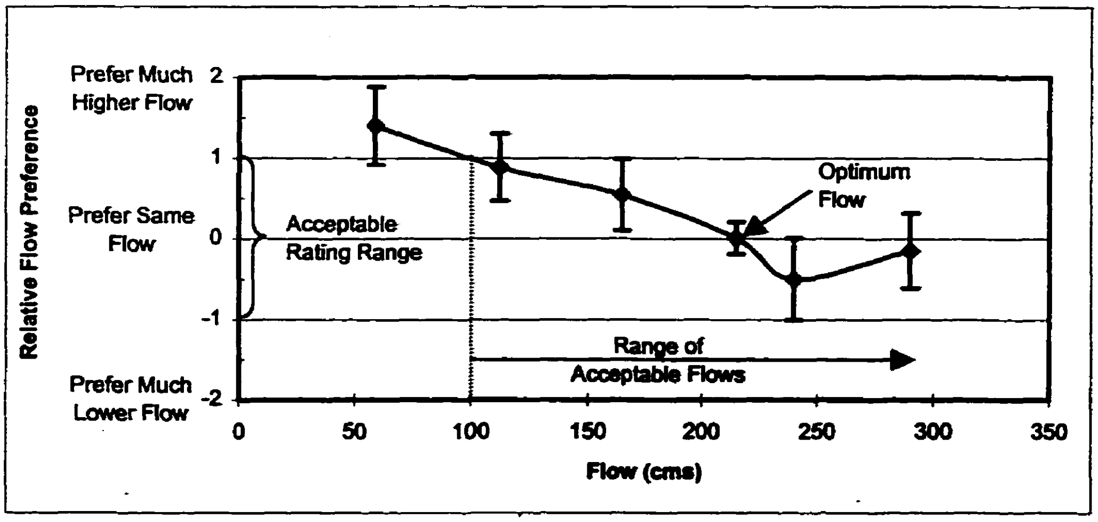


Figure 5.3: Canoe flow evaluation curve created from the mean response for the flow preference of respondents relative to the flow they experienced with 95% confidence intervals.

Table 5.4 outlines some of the specific recreation attributes that were evaluated in the survey that can help to explain the differences between recreation quality and flow preferences. Safety was generally not a concern at any of the flows for the canoe respondents, with good ratings given for each flow. Travel time, the quality of the rapids, and the quality of the eddies were all given their lowest ratings at a flow of 59cms. All of these attributes likely contributed to 59cms getting the worst quality and preference ratings of the flows that were evaluated. The only attribute that appeared to decline at the higher flows was the quality of the eddies. Discussions with the canoeists at the time of the interview indicated that the eddy lines become washed-out at these higher flows. Although the major rapids also become washed out at the higher flows, larger rolling waves still make the trip challenging.

Table 5.4: Average rating by canoe respondents for the quality of specific trip attributes that can affect recreation quality. Based on a five-point scale with a rating of 5 for "totally acceptable" and a rating of 1 for "totally unacceptable."

Flow	Safety	Travel Time	Quality of Rapids	Quality of Eddies
59cms	4.2	3.2	3.3	3.2
113cms	4.5	4.0	3.8	4.2
164cms	4.8	4.6	4.5	4.0
221cms	4.5	4.4	4.1	4.3
240cms	4.3	4.7	4.2	3.8
294cms	4.5	4.6	4.2	3.4

In summary for canoeing:

- The lowest acceptable flow for canoeing can be defined at 59cms. Although the flow preference data have this flow outside of the acceptable range, the recreation quality and trip attribute ratings show that this flow provides a marginal recreation experience.
- The range of preferred flows can be defined as 113cms and higher, with the optimum flow for canoeing at 221cms.

5.3.2 Kayak Flow Evaluations

Kayaking was the least common paddling activity on this reach of the Bow River. Only 28 kayak groups were observed during the survey hours. Additional kayak surveys were conducting during Wednesday evening kayak trips organized through the University of Calgary. Most kayakers surveyed on this reach were inexperienced in comparison with the canoe groups. The following summarizes the characteristics of the kayakers using the Bow River below the Ghost Dam:

- The skill levels of kayak respondents were – 40% beginner and novice, 43% intermediate, and 17% advanced and expert.
- Only 23% of the respondents had taken more than five previous trips on this reach of the Bow River.
- The average kayak group size observed during the surveys was 3.5 people.

5.3.2.1 Kayak Recreation Quality

Table 5.5 and Figure 5.4 summarize the kayak results for rating of recreation quality. Only one form was collected from kayakers at 59cms, 240cms, and 294cms, and could not be included in the flow evaluation curve. Only three forms were collected at 164cms, and therefore there is reduced confidence in the results reported.

Table 5.5: Summary of kayaker's recreation quality rating responses with the mean and standard deviation for each flow level.

	Distribution of Responses at Each Flow						
Flow	Extremely Good (5)	Good (4)	Acceptable (3)	Poor (2)	Extremely Poor (1)	**Mean**	**Standard Deviation**
59cms	0	1	0	0	0	N/A	N/A
113cms	4	8	3	0	0	4.1	0.70
164cms	1	1	1	0	0	4.0	1.0
221cms	6	16	4	0	0	4.1	0.63
240cms	1	0	0	0	0	N/A	N/A
294cms	0	1	0	0	0	N/A	N/A

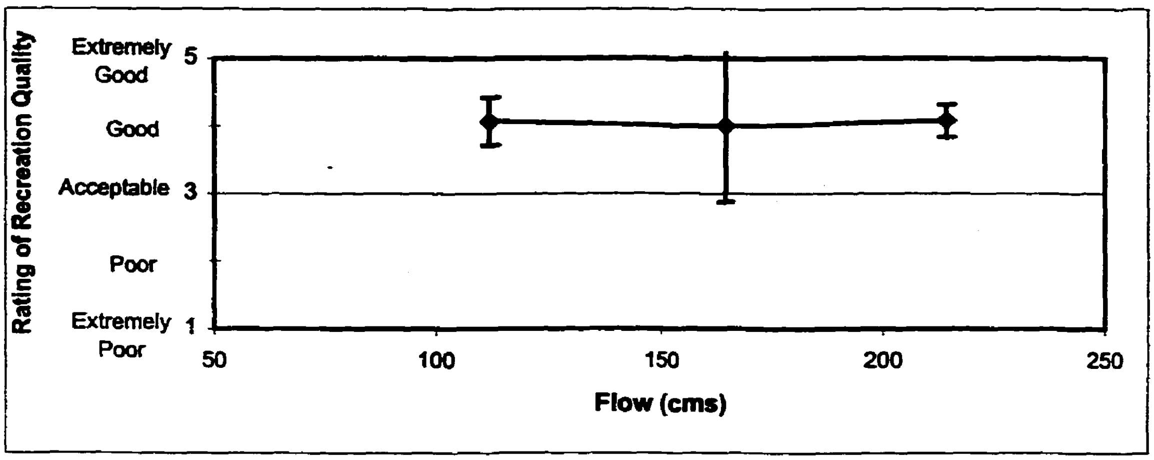


Figure 5.4 Kayak flow evaluation curve created from the mean response for recreation quality with a 95% confidence interval.

The flow evaluation curve for kayaking is limited to data for only three flows, and only two of the flows have adequate sample sizes. Surveys at lower flows are required to determine where the range of acceptable flows begins for kayaks. Both 113cms and 221cms were given "good" recreation quality ratings with reasonable sample sizes and standard deviations of 0.70 and 0.63 respectively. Both of these flows are rated equally and both can be considered the optimum flows based on the information available from the survey data. The flow quality rating at 164cms is based on only three forms in which each respondent gave a different quality rating.

5.3.2.2 Kayak Flow Preference

The flow preference results for kayaking are summarized in Table 5.6 and Figure 5.5. The flow preference evaluations illustrated in Figure 5.5 do not provide much more insight into kayaking preferences for this reach of the Bow River. The flow preference data indicate that all three flows analyzed are within the acceptable range of flows, however, there is a more distinct indication that 221cms is preferred over the other flows. The agreement between respondents was low for 113cms, with four different evaluations and a standard deviation of 0.83. There was more agreement at 221cms with evaluations in three categories and a standard deviation of 0.71.

Table 5.6: Summary of kayaker's relative flow preference responses with the mean and standard deviation for each flow level.

Flow	Distribution of Responses at Each Flow					Mean	Standard Deviation
	Prefer Much Higher (+2)	Prefer Slightly Higher (+1)	Prefer Same Flow (0)	Prefer Slightly Lower (-1)	Prefer Much Lower (-2)		
59cms	0	1	0	0	0	N/A	N/A
113cms	2	4	8	1	0	0.47	0.83
164cms	0	2	1	0	0	0.67	0.58
221cms	0	8	14	7	0	0.02	0.71
240cms	0	0	0	1	0	N/A	N/A
294cms	0	0	0	1	0	N/A	N/A

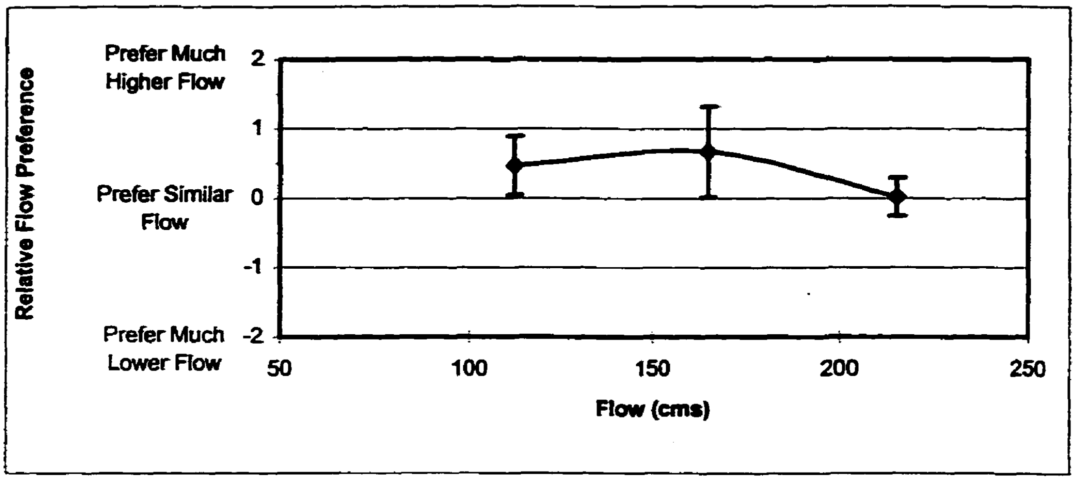


Figure 5.5: Kayak flow evaluation curve created from the mean response for the flow preference of respondents relative to the flow they experienced with 95% confidence intervals.

Table 5.7 summarizes the average rating for several recreational trip attributes for this reach of the Bow River. All of the attributes were rated as being "good" or better. The quality of rapids at 221cms was slightly below a "good" rating, as was the rating for the quality of eddies at 113cms. Both of these responses are expected since many of the surfing waves that kayakers seek become washed out at higher flows, and the eddy lines and the size of the eddies are weaker and smaller at lower flows. The ratings at 164cms were again based on only three forms, and the accuracy of the results for this flow are uncertain.

Table 5.7: Average rating by kayak respondents for the quality of specific trip attributes that can affect recreation quality. Based on a five-point scale with a rating of 5 for "totally acceptable" and a rating of 1 for "totally unacceptable."

Flow	Safety	Travel Time	Quality of Rapids	Quality of Eddies
113cms	4.4	4	4	3.9
164cms	5	4.7	4.7	4.7
221cms	4.5	4.3	3.7	4.1

In summary for kayaking:

- The lowest acceptable flow for kayaking can not be defined from the survey data. The preferred range of flows for kayaking, of the flows evaluated, is from 113cms to 221cms, with 221cms rated as the optimum flow.

5.3.3 Raft Flow Evaluations

Rafting was the second most common boating activity observed on the Bow River during 1997. The group sizes for rafting were generally large and many family groups with children were observed during the surveys. Rafters also had lower skill levels and previous experience than the canoe groups. The following summarizes the characteristics of rafters interviewed in this study:

- The skill levels of rafting respondents were – 51% beginner and novice, 34% intermediate, and 15% advanced and expert.
- 50% of the respondents had taken more than five previous trips on this reach of the Bow River.
- The average raft group size observed during the surveys was 7 people.

5.3.3.1 Raft Recreation Quality

Table 5.8 and Figure 5.6 summarize rafter's rating of recreation quality. The level of agreement in the evaluation recreation quality was very good at the higher flows. There was much more discrepancy between respondent's evaluations at 59cms and 113cms resulting in large standard deviations, as shown in Table 5.8. A single respondent gave a rating of "poor" for both 59cms and 113cms, which contributed to the wider range of responses at these flows.

Table 5.8: Summary of rafter's recreation quality rating responses with the mean and standard deviation for each flow level.

	Distribution of Responses at Each Flow						
Flow	Extremely Good (5)	Good (4)	Acceptable (3)	Poor (2)	Extremely Poor (1)	**Mean**	**Standard Deviation**
59cms	1	1	2	1	0	3.4	1.1
113cms	4	6	4	1	0	3.9	0.92
164cms	1	7	2	0	0	3.9	0.57
221cms	20	22	2	0	0	4.4	0.58
240cms	N/A	N/A	N/A	N/A	N/A	N/A	N/A
294cms	N/A	N/A	N/A	N/A	N/A	N/A	N/A

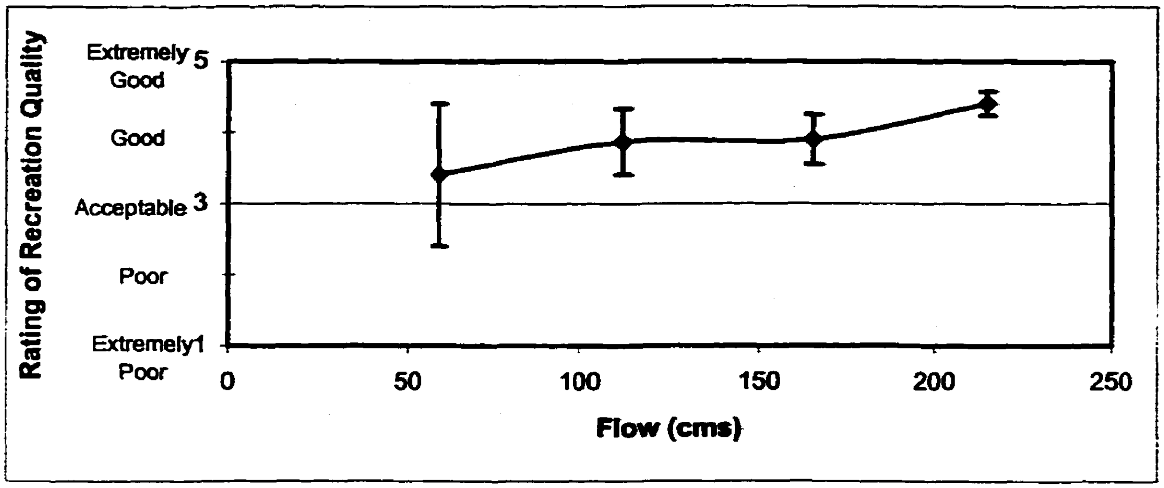


Figure 5.6: Raft flow evaluation curve created from the mean response for recreation quality with a 95% confidence interval.

The recreation quality for rafting is rated lowest at 59cms and highest at 221cms as shown in Figure 5.6. The optimum flow for recreation quality was found to be at 221cms with an average recreation quality rating of 4.4. The average evaluations for 113cms and 164cms are the same at 3.9, but the level of agreement between respondents was much better at 164cms with a standard deviation of 0.57.

5.3.3.2 Raft Flow Preference

The flow preference data for rafters is shown in Table 5.9 and Figure 5.7 below. All flows that were evaluated received an average preference for a higher flow. The preference at 221cms has the closest evaluation to "prefer the same flow" and can clearly be seen as the optimum flow for rafting. Similar to the canoeing evaluation, the average preference at 59cms for rafting is between "prefer slightly higher" and "prefer much higher." This rating lies outside of what is defined as an acceptable flow, and therefore the range of acceptable flows for rafting based on the flow preference data, begins at 113cms.

Table 5.9: Summary of rafter's relative flow preference responses with the mean and standard deviation for each flow level.

Flow	Distribution of Responses at Each Flow					Mean	Standard Deviation
	Prefer Much Higher (+2)	Prefer Slightly Higher (+1)	Prefer Same Flow (0)	Prefer Slightly Lower (-1)	Prefer Much Lower (-2)		
59cms	2	3	1	0	0	1.3	0.67
113cms	3	6	6	0	0	0.80	0.77
164cms	1	6	2	1	0	0.70	0.82
221cms	3	14	25	7	0	0.28	0.77
240cms	N/A	N/A	N/A	N/A	N/A	N/A	N/A
294cms	N/A	N/A	N/A	N/A	N/A	N/A	N/A

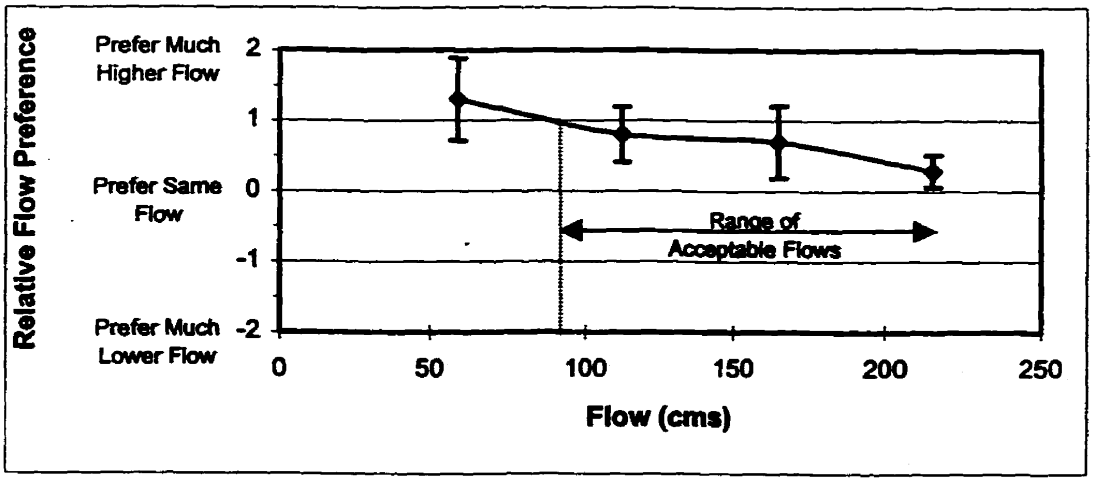


Figure 5.7: Raft flow evaluation curve created from the mean response for the flow preference of respondents relative to the flow they experienced with 95% confidence intervals.

Table 5.10 summarizes the average ratings by rafters of specific trip attributes that can affect overall recreation quality and flow preference results. As with all of the other boating activities, safety was not a concern at any of the flows evaluated. Both travel time and the quality of the rapids received marginal evaluations at the lower flows. At 221cms, travel time in particular had a large jump in the rating, and may be the most important trip attribute for rafting groups on this reach of the Bow River.

Table 5.10: Average rating by raft respondents for the quality of specific trip attributes that can affect recreation quality. Based on a five-point scale with a rating of 5 for "totally acceptable" and a rating of 1 for "totally unacceptable."

Flow	Safety	Travel Time	Quality of Rapids
59cms	4.4	3.4	3.2
113cms	4.8	3.9	3.8
164cms	4.8	3.8	3.7
221cms	4.6	4.6	4.0

In summary for rafting:

- The lowest acceptable flow for rafting is 59cms. As with the canoe evaluation, the flow preference rating at 59cms was outside of the acceptable range. However, the recreation quality and trip attribute ratings show that 59cms provides a marginal rafting experience on this reach of the Bow River.
- The preferred range of flows for rafting is 113cms and higher, again with 221cms defined as the optimum flow.

5.3.4 Angling Flow Evaluations

Angler flow evaluations were created using mail-out surveys completed by anglers familiar with this reach of the Bow River. Again, the number of forms for anglers does not adequately represent the relative proportion of angling use versus boating use on this reach. A boat would be required to travel up and down the reach to count the number of anglers on the river. Unlike boaters, anglers will commonly gain access to the river at several different walk-in locations and do not have to exit the river at the survey location. Anglers are also more likely to fish in the early morning and evening, not during the afternoon survey period designed to interview boating groups.

5.3.4.1 Angling Recreation Quality

Table 5.11 and Figure 5.8 summarize the recreation quality evaluations of anglers for the Bow River downstream of Ghost Dam. Evaluations during the spring run-off were not collected. However, the water turbidity during run-off naturally produces poor fishing conditions and anglers commonly avoid the river during the weeks of spring run-off.

Table 5.11: Summary of angler's recreation quality rating responses with the mean and standard deviation for each flow level.

	Distribution of Responses at Each Flow						
Flow	Extremely Good (5)	Good (4)	Acceptable (3)	Poor (2)	Extremely Poor (1)	**Mean**	**Standard Deviation**
59cms	0	3	3	0	0	3.5	0.55
113cms	2	5	3	0	0	3.9	0.74
164cms	0	5	4	1	0	3.4	0.70
221cms	0	1	2	6	4	2.0	0.91
240cms	N/A	N/A	N/A	N/A	N/A	N/A	N/A
294cms	N/A	N/A	N/A	N/A	N/A	N/A	N/A

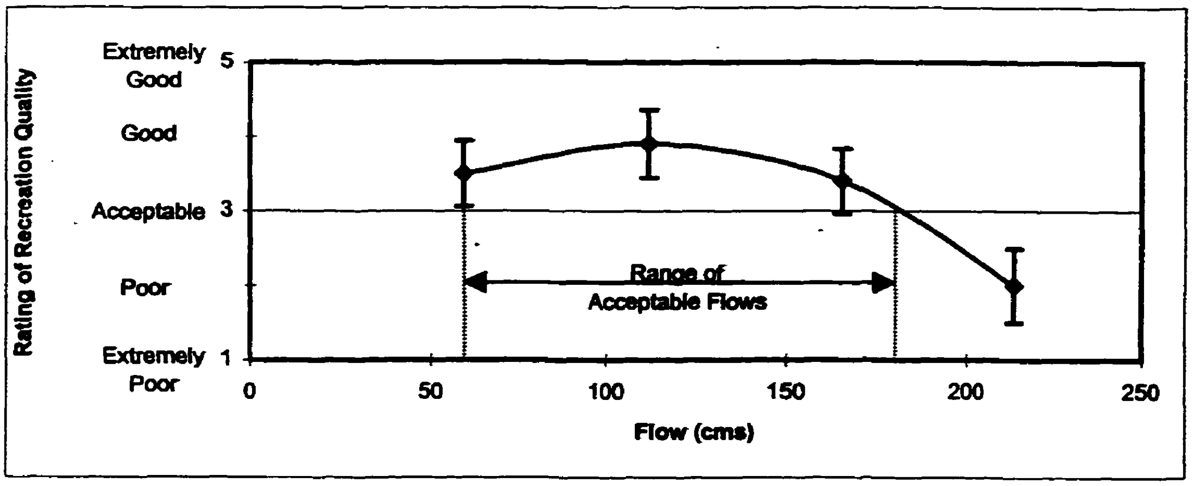


Figure 5.8: Angling flow evaluation curve created from the mean response for recreation quality with a 95% confidence interval.

The range of acceptable flows for angling is defined as 59cms to 164cms, with the peak rating at 113cms. The optimum flow is defined as 113cms but it still only received a "good" rating, suggesting that fishing on this reach is never excellent. The angling quality at 221cms was clearly defined as "poor" and is the only time that recreation quality is below the acceptable level for any of the recreation activities. The single rating of "good" at 221cms was given at the end of June, shortly after spring run-off.

5.3.4.2 Angling Flow Preference

Evaluations of angling flow preferences are summarized in Table 5.12 and Figure 5.9. The flow preference data support the recreation quality evaluations. The acceptable range of flows is defined as 59cms to 164cms. 221cms is beyond the limits of an acceptable evaluation.

Table 5.12: Summary of angler's relative flow preference responses with the mean and standard deviation for each flow level.

	Distribution of Responses at Each Flow						
Flow	Prefer Much Higher (+2)	Prefer Slightly Higher (+1)	Prefer Same Flow (0)	Prefer Slightly Lower (-1)	Prefer Much Lower (-2)	Mean	Standard Deviation
59cms	0	4	3	0	0	0.58	0.49
113cms	0	2	9	0	0	0.15	0.34
164cms	0	0	1	9	0	-0.90	0.32
221cms	0	0	1	6	6	-1.4	0.65
240cms	N/A	N/A	N/A	N/A	N/A	N/A	N/A
294cms	N/A	N/A	N/A	N/A	N/A	N/A	N/A

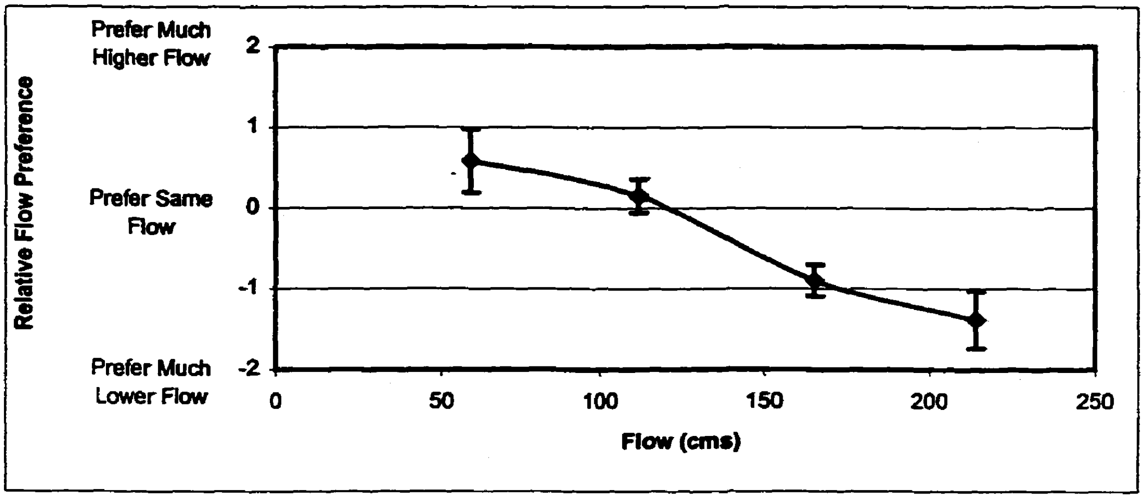


Figure 5.9: Raft flow evaluation curve created from the mean response for the flow preference of respondents relative to the flow they experienced with 95% confidence intervals.

The specific attributes of the effect of flow on fishing can be subtle and difficult to detect or understand without considerable angling experience. For instance, the activity of the fish (in making strikes at a lure) can be a result of the flow, and it can also be a result of poor fishing techniques. Two of the easier flow dependent attributes to evaluate are summarized in Table 5.13.

Table 5.13: Average rating by angling respondents for the quality of specific trip attributes that can affect recreation quality. Based on a five-point scale with a rating of 5 for "totally acceptable" and a rating of 1 for "totally unacceptable."

	Ability to Wade Safety	Activity of the Fish
59cms	4.5	3.3
113cms	3.7	3.7
164cms	2.7	3.0
221cms	1.8	2.1

Although some anglers will fish from a boat, most will fish from shore and wade into the river to cast. Wading becomes virtually impossible at the higher flows, and even walking along the shore is difficult at 221cms. The activity of the fish was not rated very high for any flow, but it is most highly rated at 113cms.

In summary for angling:

- The lowest acceptable flow for angling is 59cms.
- The preferred range of flows is from 59cms to 164cms, with 113cms defined as the optimum flow for angling.

5.3.5 Power Boating

Although not as common as the other recreation activities, powerboats are permitted on this reach of the Bow River. Many powerboats are used strictly for transportation on this reach by anglers. Other powerboat types, mainly jet-skis, were also observed on this reach during 1997. Jet boating is the main powerboating activity on this reach. Complaints about jet skis were common by other recreation users on the river, particularly on days when jet skiers were on the river.

Only six survey forms were completed for powerboats, which included both jet boats and propeller boats. The greatest numbers of powerboats were observed during the run-off in June. Powerboats were observed using the river at 164cms and 221cms without any problems with navigation or hitting bottom.

A complaint was issued to AEP on October 20 1997 after a boater hit bottom when the flow of the river dropped from 113cms to 41cms at approximately 5:00pm on October 19, 1997. The complainant is a frequent boater on the river and is aware of the potential for rapid flow changes. His major complaint is regarding the inconsistent timing of the flow changes. From this anecdotal information, it is likely that the operating flow of 59cms is close to the minimum flow required for safely navigating the river by powerboat.

5.4 SURVEY SUMMARY

Figures 5.10 and 5.11 demonstrate that the recreation quality and flow preference rating curves overlap for boating activities but do not completely overlap with the angling curve. The angling evaluations appear to be very different from the boating flows, particularly at the higher flows. ANOVA and Tukey Tests (Zar, 1984) were conducted to determine if there were statistical differences in the responses between activities for each flow that had evaluations from more than one activity.

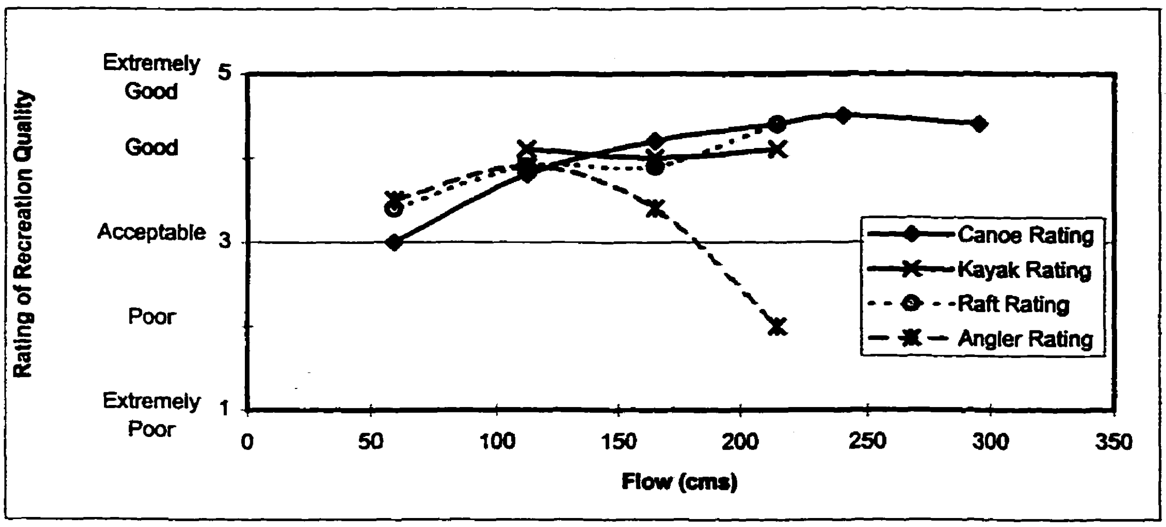


Figure 5.10: Evaluation curves of recreation quality for the major types of recreation on the Bow River below the Ghost Dam.

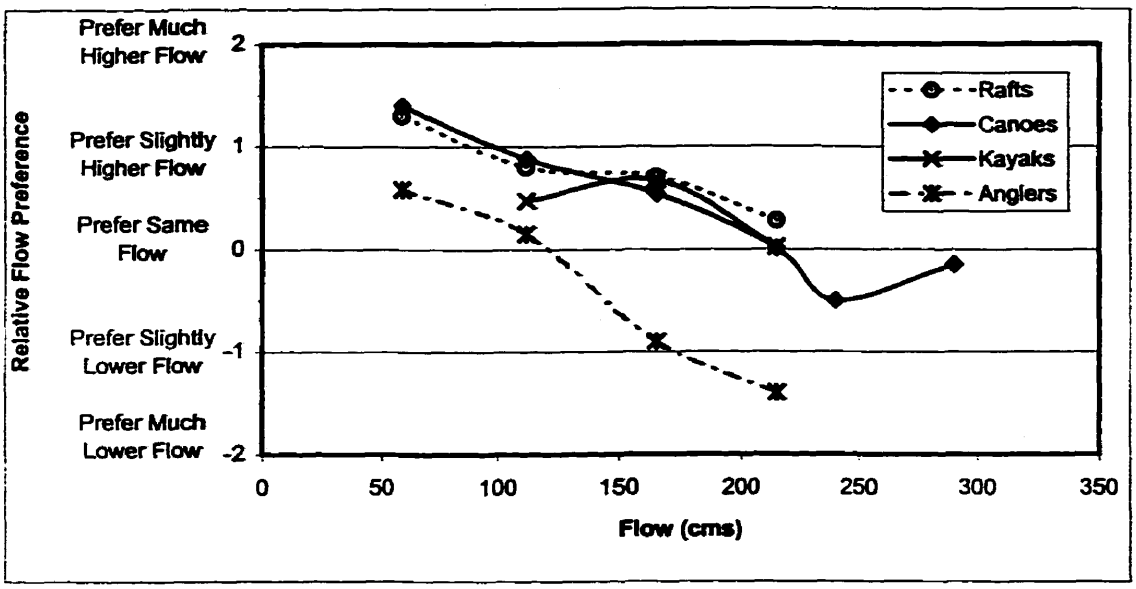


Figure 5.11: Evaluation curves of flow preferences for the major types of recreation on the Bow River below the Ghost Dam.

The ANOVA will test the null hypothesis that the responses by each recreation type for each different flow are equal (using $\alpha=0.05$). If the hypothesis is rejected (if $p<0.05$), then at least one of the group's response is different from the other groups. The Tukey test is then used to determine which responses are significantly different.

- **59cms** – the null hypothesis could not be rejected for recreation quality ($p=0.59$) or flow preference ($p=0.06$), and therefore the responses from all of the recreation types are statistically the same.
- **113cms** – the null hypothesis could not be rejected for recreation quality ($p=0.88$) or flow preference ($p=0.07$), and therefore the responses from all of the recreation types are statistically the same.
- **164cms** – the null hypothesis could not be rejected for recreation quality ($p=0.07$), but was rejected for flow preference ($p=2.3*10^{-5}$). The Tukey test conducted for flow preference found no significant differences between the boating activity responses, but the angling response was significantly different from all of the boating responses.
- **221cms** – the null hypothesis was rejected for recreation quality ($p=3.2*10^{-23}$) and for flow preference ($p=1.0*10^{-9}$). The Tukey test found that only the angling responses were significantly different from the other responses for both recreation quality and flow preference.

5.5 Controlled Flow Experiment

5.5.1 Description of the Flow

In cooperation with TransAlta Utilities (TAU), a controlled flow experiment (CFE) was arranged for September 30 1997. The three flows planned for release were 59cms, 113cms, and 164cms (Dan Smith, pers. comm.). See photographs 3 through 5 for an illustration of the different features present at the three test flows of the controlled flow experiment.

Several of the participants had been on this reach three days earlier at 221cms. Participants in the experiment were volunteers familiar with this reach of the Bow River. The group included two kayakers and five canoeists (two tandem canoes and one solo canoe). Each trial started at the Ghost Dam and finished at the Wildcat Hills Gas Plant approximately 5.5kms downstream (see Map 2).

5.5.2 59cms Test Run

The river was generally shallow and slow and the duration of the trip was approximately 75 minutes to for the 5.5km section. The river was navigable but some rock dodging was required. A few shallow areas resulted in minor scraping in a tandem canoe. Larger rafts would likely scrape bottom in several spots and some skill would be required to stay in the main channel. The ledge near the gas plant was semi-exposed, posing a potential hazard to beginner and novice boaters. Several rocks were exposed at the ledge rapid location, and there was little room to avoid this section of rapids, for novice paddlers unfamiliar with this section of the river (Plate 4). The calm areas of the river were very slow. The portion of the reach to Cochrane, which is slower and shallower than the upper reach, would be slower than expected by most paddlers. All participants in the CFE would prefer a higher flow than 59cms, although the semi-exposed ledge at this flow provided a unique experience relative to that at higher flows.

5.5.3 113cms Test Run

At 113cms, the rapids were more exciting than at the lower flow and the eddy lines became more defined. The travel time at this flow was approximately 60 minutes, and would be considered slow for rafting. Surfing waves for kayaks were best at this

flow. Navigation was easy and there was room to avoid every rapid if desired. Rocks were generally covered and rock dodging was less of a concern. There was plenty of room to walk along the shore of the river for fishing. The kayak participants in the CFE both identified 113cms as the best flow for their activity. Their reasoning was that the surfing waves at this flow were ideal for kayaking, the eddies became stronger, and there were generally more features for a kayaker to take advantage of at this flow.

5.5.4 164cms Test Run

At 164cms, the river was stronger and faster with a travel time of approximately 45 minutes. Many of the rapids and surfing waves were washed out. The eddies became larger are more defined. Navigation was easy for all types of boats and the trip was relatively safe and quick. The water level was up to the vegetation line and it became more difficult to walk along the shore. The rapids were beginning to wash out and the waves were no longer suited to kayak surfing.

The canoeists in the CFE indicated that 113cms was the best flow of the three tested, however, a flow greater than 165cms would be preferred. Several of the canoe participants had experienced a flow of 221cms two days prior to the CFE and they rated this as their preferred flow. Their reasoning for this choice was based on the stronger eddies and larger rolling waves along the shores of the river that are present at 221cms. Although the rapids are washed out for surfing by kayaks, the wave trains at the rapids become larger at the higher flow of 221cms. The intermediate flow of 165 seems to wash out the features seen at 113cms, yet the features that appear at 221cms have not yet developed.

In summary from the CFE:

- **59cms** – generally too low for all activities. The ledge rapid is exposed.
- **113cms** – optimum flow for kayaking. Best conditions of the flows tested.
- **164cms** – acceptable conditions. Canoeists prefer a higher flow (221cms) to all of the flows tested.

5.6 SUMMARY OF RESULTS

Instream recreation on the Bow River below the Ghost Dam consists mainly of angling, canoeing, kayaking, and rafting. During the summer, TAU generally operates using five different flows: 8.5cms, 59cms, 113cms, 164cms, and 221cms. The lowest flow of 8.5cms is typically released at night, but several people that were interviewed had experienced this flow at some point during 1997 and in previous years. Boats cannot navigate the river at 8.5cms, and this flow is completely unacceptable for recreation. The remaining four flows were experienced by survey respondents from all of the major recreation types. Three of the flows were also tested in a controlled flow experiment.

For the most part, the controlled flow experiment results corroborated the survey results, and the major conclusions developed from the survey were upheld. The controlled flow experiment did provide further insight into the kayak survey data and produced key information for determining the optimum flow for kayaking. The survey data could not provide a clear indication for the optimum kayak flow with virtually equal recreation quality ratings for 113cms and 221cms. A flow preference of 221cms was indicated from the survey data, but the controlled flow experiment revealed that 113cms provides the best conditions for kayaking. Table 5.14 and Figure 5.12 summarize the critical recreation flows developed from the survey, controlled flow experiment, and key informant interviews.

Table 5.14: Summary of recreation flow requirements for the Bow River below Ghost Dam for each major recreation type, developed from the survey and controlled flow experiment results.

	8.5cms	59cms	113cms	164cms	221cms
Angling	Too Low	Minimum	**Preferred**	Acceptable	**Unacceptable**
Canoe	Too Low	Minimum	Acceptable	Acceptable	**Preferred**
Kayak	Too Low	Minimum	**Preferred**	Acceptable	Acceptable
Raft	Too Low	Minimum	Acceptable	Acceptable	**Preferred**

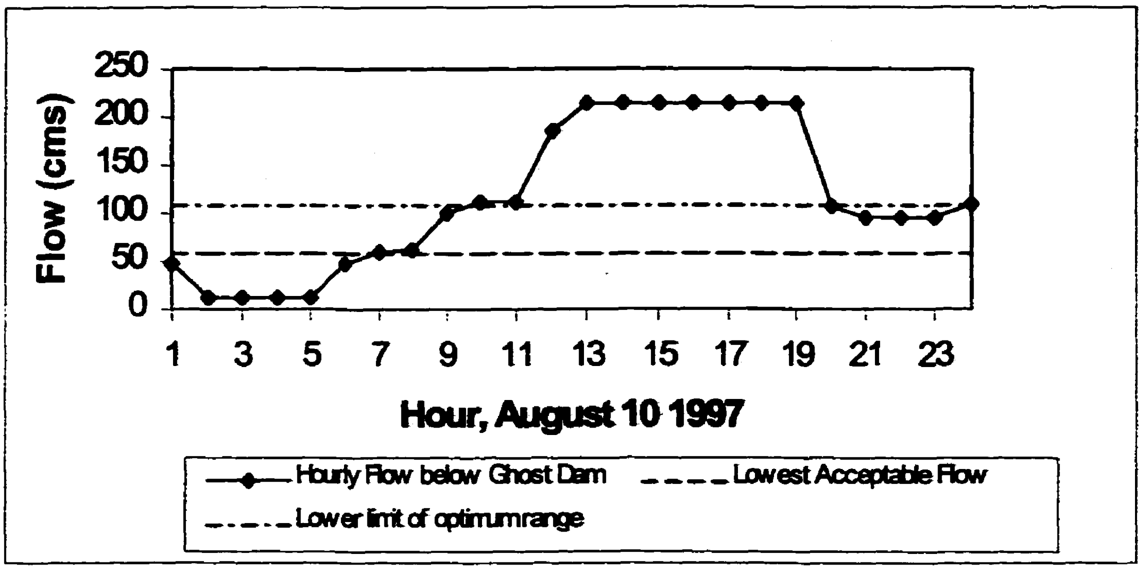


Figure 5.12: Summary of the threshold recreation instream flow needs for the Bow River below Ghost Dam for all recreation activities.

Figure 5.12 illustrates the two basic flow requirements for recreation on the Bow River. The lower flow limit at 59cms provides marginal recreation opportunities on this reach of the Bow River and should not be considered a flow that will provide sustainable recreation conditions. The threshold at 113cms is the lower limit of the optimum range for all recreation opportunities. There are two distinct preferred flows for this reach of the Bow River, the first is at 113cms for kayaking and angling, and the second is at 221cms for canoeing and rafting. Consideration of recreation in the management of the Bow River requires provision of the full range of flows within the range of 113cms to 221cms. Managing flows for recreation should not focus on a single threshold flow.

6 ANALYSIS OF FLOW TIMING

Thompson et al. (1987) determined that most of the recreation on the Bow River occurs from the May long weekend through to the Labour Day long weekend in September. They also found that most of the recreation activity occurs during the middle of the day. However, good weather conditions during 1997 resulted in a high level of recreation use until the end of September. For the purpose of this report, the potential recreation season will be defined from May 15 through September 30. Flow data was analysed from 05:00 hours to 21:00 hours to represent the potential hours in the day that can be used for recreation. The reason for using such an early starting time is to account for the 3.5-hour time lag for the flow to reach Cochrane from the Ghost Dam. Hourly flow data recorded below the Ghost Dam from 1986 to 1997 was analysed for these time intervals to determine the potential impacts of the operations of TransAlta Utilities (TAU) on recreation.

All hourly flow data was provided by TAU, and was not extensively checked for errors. TAU records flows in cubic feet per second. All of the data was converted in Microsoft Excel spreadsheets using a multiplication factor of 0.028317. The hourly data represents the average of the flow for the preceding hour. As an example, the flow indicated for hour 12 of any day is the average flow from 11:01 until 12:00. As such, if a group starts a trip at 12:00, they will typically be experiencing the flow that is indicated by hour 12. Most boats can also travel faster than the flow, therefore the flow from the preceding hour will be an accurate representation of the flow conditions that were experienced. For the purpose of this report, the clock value of 12:00 will correspond to hour 12 flow data. It must be noted that the flow given for 12:00 will not reflect a change in flow that might occur at 12:01.

The flow values for hours when the flow is being changed is averaged and the recorded flow will fall in between the operating flows. To deal with this information in the analysis, cut-off values were created to determine at what point most of the flow during the hour recorded was at one flow versus the other flow. The average between the starting flow and the resulting flow was used to indicate the point where each flow contributed half of the average hourly flow. As an example, the cut-off flow used for the increase from 8.5cms up to 59cms is 34cms. All flows recorded to be less than 34cms were included as operating at 8.5cms for that hour.

6.1 IMPACTS OF FLOW

The flow data provided by TAU can be analysed to determine the historical impacts of TAU's operations on recreation over the last 12 years using the flow preference criteria for recreation developed from this study. The simplest, and probably most realistic, method for determining the impact of flow on recreation is to determine the number of times that recreation would have been rendered unacceptable based on the preference criteria.

There are two key flow conditions that can be seen as having a potential impact on recreation. The first scenario considers low flow impacts on boaters, and the second scenario considers high flow impacts on anglers. It must be acknowledged that these two scenarios represent competing interests and flow preferences, where boaters prefer high flows and anglers prefer moderate to low flows. However, there is a temporal difference between the two issues. The minimum boating flow can be seen as an issue of the time of day when the flow is increased to an acceptable level for boating. The acceptable flow for anglers is more of a seasonal issue of how late in the year and how frequently the maximum operating flow is released from the Ghost Dam.

6.1.1 TransAlta's Daily and Seasonal Operations

TAU operates under a general guideline for the timing of flow releases from Ghost Dam based on the daily average flow from the Bow and Ghost Rivers entering the Ghost Reservoir. The flow at the Ghost Reservoir is controlled by the releases from TAU's upstream dams. As default of using the average inflow to determine the hourly timing of flow releases, TAU's operations will change seasonally as the natural flow decreases in the late summer and fall.

A minimum flow is released at night to store water during off-peak energy hours, and is incrementally increased during the day until the peak flow is achieved by mid-afternoon. Into September, the peak energy demand begins to shift to the early evening, and the peak flow is adjusted to match that trend. The general summer operating schedule for TAU at the Ghost Dam is summarized in Table 4.1. It must be clear that this is just a guideline, and TAU is not bound by conditions in their license to operate according to this schedule. Deviations from this schedule can occur without warning for any number of reasons such as mechanical difficulties at the dam or difficulties or failures with other TAU power plants.

Determining the water-based recreation quality for the Bow River over the full range of TAU's operating flows below Ghost Dam allows for a complete evaluation of how the timing of flow releases will affect recreation. Five main flows are released below Ghost Dam during the summer months after the spring run-off has receded. Within each operational flow level, the flow recorded can vary by several cubic meters per second. For the purpose of this study, the flow variations are considered to have a minor and unnoticeable affect on recreation, and only five flow ranges were considered.

Each flow range provides a different level of recreation quality for each different recreation activity.

- **8.5cms** – unacceptable flow for all recreation activities.
- **59cms** – lowest acceptable flow for all of the recreation activities producing marginal recreation conditions, particularly for boating.
- **113cms** – optimum flow for angling and kayaking and an acceptable flow, but not preferred, for canoeing and rafting.
- **164cms** – acceptable flow for all activities, upper limit for angling, not preferred by any of the activities.
- **221cms** – optimum flow for canoeing and rafting and acceptable conditions for kayaking. This is an unacceptable flow for angling, particularly in the later part of the summer and early fall.

6.2 TIMING OF FLOW RELEASES

In accordance with their license, TAU could match the peak energy demand by storing water throughout the morning and evening and increasing the flow in a single step to produce power at peak times. TAU does not operate in this manner, but rather increases the flow in incremental steps until the peak operating flow is achieved in the afternoon to match the peak energy demand. There are several reasons why TAU increases the flow incrementally (Dan Smith, pers. comm.).

- Incremental increases in flow provide better aesthetics for most of the day for the residents of Cochrane and other land-owners along the river.

- The flow from the Ghost Dam must be evened out over the course of the day to allow the Bearspaw Dam to stabilize the flow through Calgary without the Bearspaw Reservoir getting too low or too high. This is critical since the Bearspaw Reservoir supplies North Calgary with drinking water.

- The daily average flow from the Ghost Dam must be at least 34cms to allow the Bearspaw Dam to maintain a minimum flow of 34cms through Calgary (this minimum through Calgary is an "unwritten rule" that TAU operates under).

- A rapid increase in flow from 8.5cms to 221cms would produce dangerous conditions for people on the river, with the potential for swamping boaters and anglers.

TAU's current operations provide good flows during the middle of the day for boating activities and extend the recreation season when preferred boating flows can be experienced. However, several guidelines could help to better manage the flow on a daily and seasonal basis for the benefit of all recreation activities without significantly disrupting the operation of the Ghost Dam. Two main practices that could improve operations for the benefits of recreation are to:

- Reduce the number of days that the minimum flow of 8.5cms is used during daylight hours, taking into consideration the time lag for an increase in flow to reach Cochrane. This will benefit all recreation users on the Bow River below the Ghost Dam.

- Reduce the number of days in late August and September that a peak flow of 221cms is used and operate under a schedule to use 165cms as the peak flow. This change will benefit anglers and at the same time still provide good conditions for late season boating around Calgary.

6.2.1 *Daily Flow Impacts*

To evaluate the historical effect of daily flow releases on recreation, 12 years of hourly flow data below Ghost Dam were analysed to determine the frequency of low flow events at specific times of the day. Flows for the period of May 15 through September 30 during potential recreation hours from 05:00 to 21:00 hours for each day were examined. The flow starting at 05:00 hours is used to allow for the lag time of over three hours for the flow to reach Cochrane. The flow at 21:00 hours is used since it actually represents the average flow from 20:01 to 21:00 hours, which still allows plenty of daylight in the summer for angling or boating below Ghost Dam.

The first step in the analysis was to look at the number of days for each year that a flow of 8.5cms was released during the potential recreation hours. The second step was to determine how late into the day this low flow was released. This process allows for an evaluation of how the timing of flow releases can negatively affect the morning recreation quality below the Ghost Dam. The flow should normally be increased no later than 06:00 hours at the higher input flows into the Ghost Reservoir and no later than 08:00 hours at the lower input flows.

Table 6.1 summarizes the number of days when a flow of 8.5cms was released from the Ghost Dam during the morning recreation hours for the years 1992 through 1997. Operating at 8.5cms until 05:00 hours will have the least impact on recreation. Under the theoretical flow release guide provided by TAU (see Table 4.1), the minimum flow of 8.5cms should be increased no later than 08:00 and should never extend until 09:00 or 10:00 hours under normal circumstances.

Table 6.1: Number of days during the period from May 15 through September 30 (139 days) where the minimum operating flow of 8.5cms* was released during morning hours on the Bow River below Ghost Dam. Data provided by TAU. (*Prior to 1997, a minimum flow of 3.7cms was used).

Year	Peak Daily Flow released from Ghost Dam (cms)	Days with low flow at 05:00	Days with low flow at 08:00	Days with low flow at 09:00	Days with low flow at 10:00
1997	296	90	18	5	3
1996	310	75	32	14	1
1995	449	44	20	6	0
1994	210	118	56	28	3
1993	218	98	10	1	0
1992	228	105	38	16	0
1991	380	33	18	2	1
1990	533	46	17	0	1
1989	261	83	40	3	1
1988	236	96	15	6	0
1987	212	104	21	5	1
1986	338	11	0	0	0
	Totals	908 days	228 days	95 days	11 days
	Percent of Total Days (1668)	54.4%	13.7%	5.7%	0.7%

The number of days when the minimum flow is used until 08:00 should be restricted to low flow periods. For most of the years analysed in Table 6.1, the number of days that were actually operated at the minimum flow until 08:00 was higher than would have been expected using the daily average flow as a guide.

Operating the Ghost Dam during the morning hours can be seen as having an impact on the recreation potential of this section. Although some people with experience on this section of the Bow River knew to wait until the afternoon, several less-experienced people arrived at the river to find that they could not start their trip.

For the most part, TAU does limit their low flow during daylight hours. On only 14% of the total days during the last 12 years was the dam operated at the minimum flow until 08:00 during the recreation season. The number of mornings operated at 8.5cms dropped off to only 6% at 09:00 hours. However, for a dry year such as 1994, the minimum flow extended until 09:00 on 20% of the days over the recreation season. Again, a low flow at 09:00 will have some impact on people starting a recreation trip from Ghost Dam, but will have a much greater impact on people accessing the river around Cochrane. In 1994, one out of every five days at Cochrane resulted in a flow of 8.5cms being present until the early afternoon. This would have provided both a significant aesthetic and recreational impact at Cochrane for that year.

Although TAU cannot control the number of days in each recreation season with a low average flow, how they manage the hourly releases on those days to limit their impact on recreation is within their power. In the years analyzed, TAU has been relatively successful at limiting the number of days that the minimum flow has extended into hour 10. During 1997, one of the three days with a late morning low flow was on a survey day. It was observed that two groups were forced to alter their trip plans and wait for the flow to increase.

In most cases, the minimum operating flow only affects morning recreation by delaying potential starting times. In several years, the minimum flow was released at different times in the afternoon or early evening. Although these events are not very common, a sudden reduction in the midday flow can cause a significant disruption and potential stranding of recreation users.

6.2.2 *Seasonal Flow Impacts*

Using the theoretical flow schedule provided by TAU, the peak flow of 221cms should only be used when the daily average incoming flow into the Ghost Reservoir is at or above 93cms. The average flow at Ghost Dam for the period from 1933 through to 1988 was 112cms in August and 82.6cms in September (Environment Canada, 1989). From the average monthly flows, both August and September would normally provide excellent angling and boating conditions in the absence of the hydropeaking at Ghost Dam. In particular, August should provide optimum flows for both angling and kayaking based on a flow preference of 113cms determined for this section of the river. Releasing the peak flow from the Ghost Dam reduces the number of days that optimum conditions can be expected in August and September (Table 6.2).

Table 6.2: The number of days in August and September that TAU has released the peak flow from the Ghost Dam for at least one-hour.

Year	Peak Daily Flow released from Ghost Dam (cms)	Days Operated at Peak Discharge for the months of August and September
1997	296	61
1996	310	48
1995*	449	2
1994	210	21
1993	218	60
1992	228	15
1991	380	45
1990	533	44
1989	261	54
1988	236	50
1987	212	34
1986	338	18
	*Totals	450
Percent of total days (671)		67%

(*1995 data was not included in the analysis since the Ghost Dam was undergoing maintenance and a problem with a turbine did not allow for the peak flow to be released.)

Anglers generally expect low flows during August and September since this is the natural pattern observed elsewhere on the Bow River. High flows create difficult fishing conditions, poor fishing success, and increased water turbidity. A peak in the flow can reduce the quality of the fishing experience, even if it happens for only one hour. The more stable the flow, the better the fishing conditions. It can be seen that any day that receives the peak flow, even if only for an hour, will result in a reduction of fishing quality. Table 6.2 shows that, on average, 67% of the days will have a peak flow release from the dam. In years like 1997, the peak flow was released every day during August and September resulting in poor fishing conditions for the entire recreation season.

6.3 MANAGING THE TIMING OF FLOW IMPACTS ON RECREATION

It should be stated that it is unreasonable for TAU to drastically change their current operating practices strictly to provide better recreation conditions. However, some simple guidelines may be useful in limiting the number of times at which poor recreation conditions are experienced. This can be accomplished on a daily and within a seasonal time frame.

6.3.1 Providing Optimum Flow Conditions

Unfortunately, no single flow produces the best recreation conditions for all activities below Ghost Dam. The major discrepancy between flow demands for activities is between angling and boating activities. Although the preferred flow for kayaking is the same as that for angling, kayaking conditions are still acceptable at 221cms while angling is unacceptable at this high flow. While all of the boating activities can have a high quality recreation experience at 221cms, angling is negatively affected if this flow is operated for the entire summer. If 113cms is released more often, then angling and kayaking groups will benefit, while canoeing and rafting are left with less than optimum conditions.

A logical solution might be to release the intermediate flow. However, the controlled flow experiment indicated that 164cms was not preferred by any activity and everyone would experience less than optimum conditions. Opportunities for daily and seasonal trade-off in the timing of flow releases are a possible solution for providing optimum recreation conditions for all activities during some point in the summer.

Under the existing operations, the hydropeaking provides an increase in boating recreation opportunities by extending high flows late into the recreation season when most other rivers around Calgary are too low or too slow to boat. If the daily timing concerns addressed above can be managed more effectively, than the hydropeaking can be seen as a benefit to boating activities. Although the hydropeaking may benefit boaters, about 25% of the survey respondents who commented about the management of the river indicated a concern for the effects of large flow variations on the aquatic ecosystem. Although the hydropeaking may benefit boating activities, boaters would likely be satisfied with lower flows late in the season if the practice would help to improve the ecosystem.

To balance the benefits between boaters and anglers, late season flows should be managed to reduce the number of days the peak generation flow is used. The moderate flows benefit anglers, and can still provide good conditions for boating.

6.3.2 *Avoiding Unacceptable Conditions*

It was determined that a flow of 8.5cms is unacceptable for all types of recreation on the Bow River below Ghost Dam. The obvious strategy for managing the daily timing of flow release to improve recreation below Ghost Dam is to limit the flow of 8.5cms to non-daylight hours. The difficulty in achieving this goal is that there is approximately a 3.5-hour time delay from when the flow is increased at the dam until it reaches Cochrane at the take-out site. Although this may be an insignificant point for boaters starting their trip at Ghost Dam, many anglers fish on the river around Cochrane, and the delay can result in poor conditions well into the afternoon.

As an example, on August 30, 1997, the flow at the interview site in Cochrane was observed at 8.5cms until 14:00 hours. From the flow data provided by TAU, it was confirmed that the flow was not increased until sometime between 10:30 and 11:00 hours at Ghost Dam. On this day, two boating groups leaving from Ghost Dam as well as a group that camped at Wildcat Island were forced to wait until the water level rose before starting their trip.

It seems obvious that situations like the one on August 30, 1997 should be avoided if possible. Not only can it disrupt the recreation activities of groups on that day, it may also influence decisions of whether or not to return to the site in the future. If situations like this become more common, water-based recreation at this site could suffer. Many of the groups leaving the river stop off in Cochrane for food or gasoline, and a reduction in recreation, because of poor conditions, could have an impact on local businesses. Such situations should also be avoided since they can reflect poorly on TAU's public image. Public image for TAU may become even more significant as Alberta heads into a deregulated electricity market.

Peak flows can also be managed on a daily basis to improve conditions for angling. Most anglers tend to fish in the early morning or in the evening to catch fish when they are most active. Managing high flows to avoid these times and providing a steady lower flow of either 165cms or 113cms would benefit anglers without causing a significant loss to boaters. This task becomes more difficult in the late summer and fall when the peak energy demand starts to shift later into the evening and overlaps with the best times of the day and the year for angling.

6.3.3 Seasonal Differences in Flow Preference

Seasonal differences in flow can also be applied to boaters. Most people with any experience on rivers expect the flow to decrease during the summer. This may influence what people define as an acceptable flow as the season changes. A flow that is acceptable or preferred during a low flow period may not be the same as the flow that is preferred during a high flow period. A group of surveys completed by a single canoe guide with Canadian Heritage Canoe illustrating this point.

The canoe guide completed six surveys over the summer at a wide range of flows. The first surveys were completed during a high flow period in July and ended in a low flow period in September. Most of the trips run by this guide started early in the morning, so there was the potential to experience the minimum operating flow. Table 6.3 illustrates how the guide's flow preference shifted from 221cms in July to a preference for 113cms later in the summer.

Table 6.3: Flow preferences and ratings from a single canoe guide on the Bow River below Ghost Dam at different dates during the summer of 1997.

Date	Flow (cms)	Preference	Overall Rating
July 18	**221**	**Prefer same as today**	**Extremely good**
July 23	164	Prefer slightly higher	Good
July 30	**113**	***Prefer much higher***	**Good**
August 13	8.5	Prefer much higher	Very poor
August 14	59	Prefer slightly higher	Acceptable
September 7	**113**	**Prefer same as today**	**Good**

Several important pieces of information can be gained from this evaluation.

- The flow preference shifted from a high flow to a lower flow as the season progressed.

- The flow of 113cms was given a preference for a much higher flow when only high flows had been experience. The same flow of 110cms was preferred in the late summer after several low flows had been experienced.

- The flow rating remained constant throughout the summer, with the highest flow receiving the only extremely good rating, and 113cms was given a good rating both times it was evaluated. This indicates that although the preference for flows may change with the season, the quality of the recreation experience remained constant.

As a confirmation for the unacceptable conditions of the minimum operating flow, the guide reported that his clients were forced to drag their boats for much of the trip. As a result of this experience, future trips were rescheduled to begin later in the day. Any exposure to such poor conditions will likely result in a loss of clients by guiding companies, as well as individuals being discouraged to return to this site on their own time. If poor conditions become common, then individuals and guiding companies will start to look for other areas to conduct their activities, resulting in increased pressures at other sites and a loss of recreation revenue for the town of Cochrane.

6.4 SUMMARY OF FLOW TIMING ISSUES

- The five distinct flows released below the Ghost Dam 8.5cms, 59cms, 113cms, 164cms, and 221cms) are determined by equipment specifications. Each flow corresponds to a turbine within the dam, and as a result, intermediate flows are not efficient to release. The turbines and their resulting flows, were not designed with recreation flow preferences in mind.

- Using the flow preference curves developed in this study, 8.5cms and 221cms were identified as causing negative impacts to water-based recreation. The minimum operating flow of 8.5 cms provides unacceptable conditions for all recreation activities, and the peak operating flow of 221cms provides unacceptable conditions for angling.

- The minimum operating flow should be managed on a daily time step to reduce the number of days that 8.5cms can be expected during daylight hours. Although most of the groups started their trips after 10:00am, some groups avoided starting earlier because of past experiences. The minimum flow is more of an impact to river users at Cochrane due to the three hour time lag for the flow to reach Cochrane from the Ghost Dam.

- The peak operating flow of 221cms provides excellent boating conditions, but unacceptable fishing conditions. To manage the conflict between the groups, two different approaches can be used. The first approach involves making a trade-off on a seasonal basis to reduce the number of days that the peak flow is used in the late summer as the flow naturally recedes. The second approach involves making a daily trade-off to reflect the different times of day each activity uses the river. Most anglers use the river in the morning and evenings, while boaters, on weekends at least, use the river during midday. Avoiding releasing the peak flow in the evenings can resolve some of the conflicts between users.

- The peak flow issue can not be entirely resolved on a daily basis since releasing 221cms at any time of day can result in decreased fishing success at any point after the increase. The preferred strategy during the late summer would be to avoid the peak flow all together, and use the next lowest flow and maintain a steady flow for as long as possible. Flows of 113cms, if released for longer periods of time in the morning and evenings, would provide optimum conditions for anglers and kayakers while maintaining good conditions for the other boaters.

- Changing the flow timing and peak flow release at the Ghost Dam will have an effect on TAU's entire system. If peak power production is lost at the Ghost Dam site as a result of modifications in the flow release schedule, then that loss must be made up elsewhere in the system. Since this reach of the Bow River is important for recreation, attempts could be made to investigate other upstream sites that are less critical for recreation and other instream values to play a larger role in TAU's hydropeaking system.

7 DISCUSSION

The Bow River is a critical resource in southern Alberta. It provides multiple benefits to society in the form of wildlife habitat, recreation opportunities, power production, municipal water supply, irrigation and agricultural uses, and waste assimilation. Managing a river to ensure that all of the different uses are addressed is a difficult task, and quite often, some uses will place conflicting demands on the resource.

7.1 RECREATION INSTREAM FLOW NEEDS

There are two key unacceptable flows that were defined for this section of the Bow River. The first unacceptable flow is the minimum operating flow of 8.5cms, which applies to all of the recreation activities. The second unacceptable flow is the peak operating flow of 221cms, which only applies to angling. Developing a strategy to manage the instream flow for recreation will require a trade-off between activities.

AEP identified two flows that should be identified when protecting instream flows. The first is the minimum flow required to maintain the basic instream flow need, and the second is the preferred flow to protect desirable instream flow conditions (AEP 1997).

From the flow preference curves created, 59cms is the minimum flow that provides an acceptable recreation experience for all activities. This may not be the true lower limit of acceptable flows, but it is the lowest acceptable operating flow released from the Ghost Dam. If at any time in the future, TAU plans to change their minimum operating flow, then another controlled flow experiment should be run to determine if a different flow in between 8.5cms and 59cms might provide acceptable recreation conditions. Using the recommendations provided by the SSRBPP (1984), the minimum flow was identified at 30cms. Based on the controlled flow experiment, which was run at 59cms, it was estimated that any further flow reduction below 59cms would create difficulties for boats in passing through shallow areas and would result in a very slow boat trip. However, a flow lower than 59cms, but higher than 8.5cms, might provide good angling conditions.

The preferred flow for water-based recreation was identified to be 113cms. A flow of 113cms provides the best all around recreation conditions for all of the activities. At this flow, conditions for angling and kayaking were rated their best. This flow also provides good conditions, although not optimal, for canoeing and rafting. However, a single flow cannot be used to describe the best recreation conditions for this site. The peak flow of 221cms is also important for all of the boating activities. The key to managing flows for recreation is to recognize the need for flow variation, and make trade-offs on either a daily or a seasonal basis.

7.2 *FISH HABITAT FLOW REQUIREMENTS*

Cushman (1985) found that rapidly varying flows from hydropeaking results in a reduction of the biotic productivity. Most species exposed to hydropeaking are not adapted to rapidly changing flows on a daily basis, and as a result, there is generally a reduction in the abundance, diversity, and productivity of riverine organisms.

The flow requirements for fish habitat on the Bow River are available from a study completed for Alberta Environment by Environmental Management Associates (EMA 1994). The EMA study was conducted for the Bow River around Calgary, and included as its upstream boundary a reach extending from Jumpingpound Creek to the Bearspaw Dam. The EMA study separated the Bow River from the Ghost Dam to the Bearspaw Dam into two reaches, with the confluence of Jumpingpound Creek as the separator between the reaches. For the purpose of this report, the information reported for the reach beginning at Jumpingpound Creek and extending downstream is extrapolated to the upstream reach. EMA (1994) used the instream flow incremental methodology to conduct the IFN study for fish habitat requirements.

The final output from the analysis is a Fish Rule Curve, which was developed by Locke (1988). The basic concept behind a Fish Rule Curve is that a multiple flow recommendation can be made for any specified time step. The multiple flow recommendation attempts to recognize yearly variations in flow by providing a flow recommendation to be used in dry, average, and wet years. The Fish Rule Curve recommendation for the Bow River from Jumpingpound Creek to the Bearspaw Reservoir reported by EMA (1994) was:

- 40cms for low flow years
- 50cms for average flow years
- 75cms for high flow years
- 75cms was identified as the optimum flow for providing the most fish habitat for the Bow River from Jumpingpound Creek to the Bearspaw Reservoir.

The results of the EMA study are constant flow recommendations, and do not consider the effects of hydropeaking. Although no specific recommendations have been developed regarding hydropeaking, it is likely that a scenario with a higher minimum flow release and a narrower range of flow fluctuation is required to achieve habitat improvement below Ghost Dam (Allan Locke, pers. comm.). If the flow fluctuation range were reduced below the Ghost Dam at some point in the future, angling would benefit from the potential increase in the fish population. The population estimate for the Bow River below the Ghost dam is considerably lower than population estimates for the Bow Corridor (R.L.&L. 1998). Since Jumpingpound Creek does provide spawning habitat for this reach of the Bow River, it might be assumed that the low population of sportfish is a result of a lack of habitat, particularly for young fish, due to hydropeaking. The limiting factor on the fish population may be due to the daily flow fluctuations and the lack of suitable bank mesohabitats for providing shelter from the changing flow (R.L.&L. 1998).

In the above scenarios, either the constant flow scenario using the fish rule curve recommendations, or the increased minimum flow scenario, appear to correspond with the recreation flow requirements.

- The minimum acceptable flow for recreation was defined as 59cms. A flow that is lower than 59cms but higher than 8.5cms might be acceptable for recreation, but such an intermediate flow was not tested for this study. The fish rule curve recommendations of 40cms in low flow years, 50cms in average years, and 75cms in high flow years are compatible with the minimum acceptable flow of 59cms for recreation. The only significant difference is that the preferred conditions for recreation are higher than the fish rule curve flows for dry and average years. The constant flow scenario would reduce the period when preferred flows for boating would be experienced, but would provide better conditions for angling in the late summer and fall. The constant flow scenario is unlikely for this section since some level of hydropeaking will continue.

- The second scenario of an increased minimum flow and a reduced range of flow fluctuation would likely complement the recreation IFN recommendations. If this operating plan was used, then it may accomplish many of the seasonal trade-offs required, balancing the benefits between boaters and anglers. An increased minimum flow would mean that the peak operating flow would likely be available less frequently during the late summer when the incoming flows into the Ghost Reservoir are dropping. This flow strategy would benefit anglers by providing more low flow days, along with the expected benefit of increased fish productivity. This hydropeaking regime would also extend the frequency of optimum flows for boating versus natural conditions, and would continue to provide good late season boating conditions for the Calgary area.

The second scenario assumes that TAU would still incrementally increase the flow through the day. An increase in the minimum flow could result in TAU releasing the minimum flow for longer periods in the day to make up for the lost storage opportunity. If this were the case, there would be a negative impact to all recreation users by reducing the number of hours each day that an acceptable recreation flow is available. Any change in the hydropeaking schedule should attempt to provide preferred recreation flows on the weekends and evenings.

7.3 NATURAL FLOW CONDITIONS

Comparing the existing flow conditions to the simulated natural flow conditions can give an indication to the level of change the system is exposed. The extreme hydropeaking below Ghost Dam is significantly different from the natural conditions. That aside, the frequency for which the peak operating flow and the minimum operating flow could be expected to occur under natural conditions can be compared to the current operations.

Duration curves provide information on the frequency that flow events can be expected based on a series of historical flow data. Duration curves can be used to plot a variety of hydrological statistics, such as the average monthly flow or the annual maximum flow. Maximum flow duration curves can be used for planning purposes to indicate the probability of flood events. For example, the 1-in-20 flood event is the flow on a flow duration curve that has only been exceeded 5% of the time over the period of record. Developments adjacent to rivers will generally use the 1-in-100 year flood as a planning guideline.

Duration curves are developed by sorting a series of flow data (using any time step) in descending order, ranking the data, and then calculating the percent exceedence value for each data point. The natural duration curves were developed from weekly flow data developed by AEP for the period of record from 1912 through 1988. Weekly data for calendar weeks 19 through 39 (which roughly correlates to May 15 to September 30) was used to represent the recreation season.

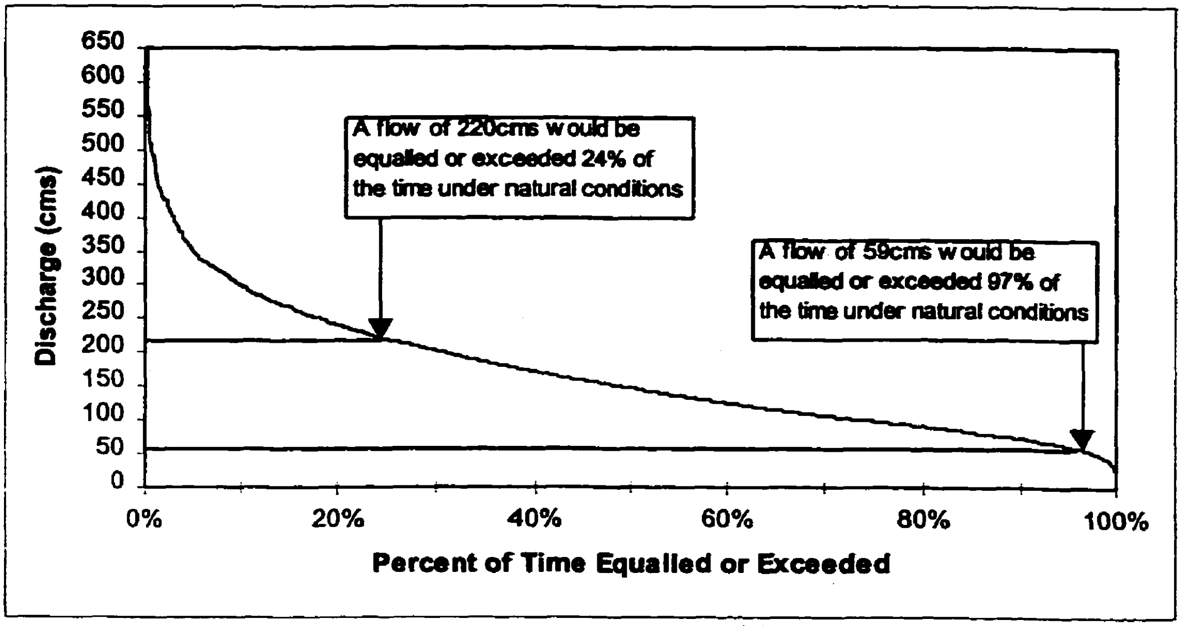


Figure 7.1: The natural flow duration curve at Ghost Dam using a weekly time step from flow data for calendar weeks 19 through 39 for the years 1912 through 1988 (data from AEP).

The duration curves used to represent the existing condition use daily time steps at a specified hour of the day taken from hourly data provided by TAU. These duration curves used data from May 15 through September 30 to represent the recreation season on the Bow River below the Ghost Dam.

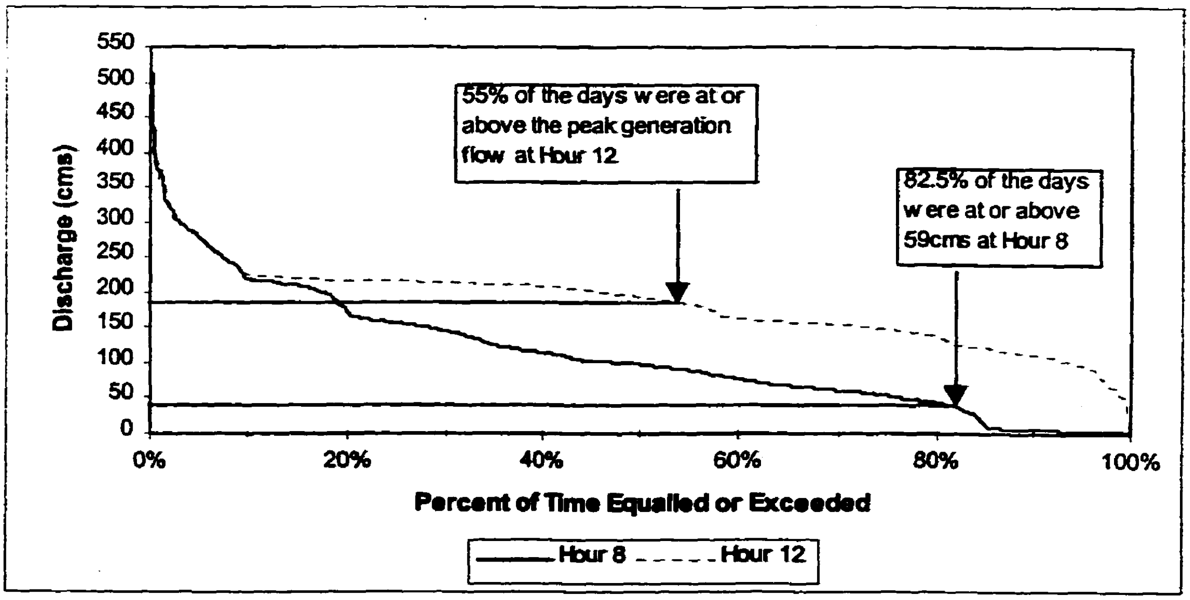


Figure 7.2: Flow duration curves representing the existing conditions below Ghost Dam using a daily time step at hour 8 and hour 12 for the days from May 15 through September 30 for the years 1986 through 1997 (data from TAU).

Figures 7.1 and 7.2 illustrate that the flow equivalent to TAU's peak generation flow of 221cms would only be expected approximately 24% of the time under natural conditions. Using the flow recorded at 12:00 below the Ghost Dam, which is generally when the peak flow is operated, Figure 7.2 shows a flow of 221cms or greater can be expected on approximately 55% of the days during the recreation season. Under the existing conditions, the peak generation flow of 221cms occurs more than twice as often than would be expected under natural conditions. The true exceedence value for the peak generation flow will actually be even higher than what is indicated in Figure 7.2 since the peak generation flow is not entirely represented by the flow data at 12:00. In fact, from Table 6.2, 67% of the days in August and September from 1986 through 1997 used the peak operating flow at some point during the day. Under natural conditions, only about 38% of the days during the recreation season should be unsuitable for angling, a difference of almost 30%.

The flow duration curves illustrate that hydropeaking provides a benefit to boaters by extending the recreation season. Under natural conditions, the equivalent to the peak flow from the dam would only occur about 24% of the during the recreation season. In contrast, the peak flow can be expected about 55% of the time under the hydropeaking schedule, an increase in 30% of optimum boating conditions. However, what is beneficial to boating at the peak flow is detrimental to angling. It can be seen that the conditions that provide good angling are reduced by 30%.

The downside of the extended boating season is that an unacceptable flow in the morning can be expected about 17.5% of time. If there were only boating activities on the river, then this would be a good trade-off of losing morning recreation opportunities to gain optimum conditions for a longer season. However, to accommodate all recreation users, the optimum conditions for each activity should be balanced out through the recreation season.

7.4 DOWNSTREAM IRRIGATION

Irrigation is not a significant factor on this section of the Bow River in most years. However, in extremely low flow years, the downstream irrigators can use their priority licenses to call for the full natural flow to be delivered downstream in order to meet their licenses. This occurred in 1995, and TAU could not operate under their normal hydropeaking schedule (Dan Smith, pers. comm.).

Under these conditions, anglers would have benefited from the relatively stable and lower flows while boaters would not have experienced the normal high flows late into the recreation season. Any further expansion of irrigation in the Bow River Basin will not have a similar impact since all new licenses will have later priority dates than the license for Ghost Dam. In low flow years, irrigators will still only be able to ask for the amount of water that was issued prior to the Ghost Dam license, which has a priority date of 1927 (AEP 1997). Irrigation expansion will be under review in the year 2000, and any new changes to irrigation licenses will include instream objective guidelines.

7.5 INCLUDING IFN IN DECISION MAKING IN ALBERTA

Makuk (1988) reported that, although the Government of Alberta had a policy to manage water resources using multi-purpose use (MPU) principles, very few water management projects succeeded in this approach. Makuk found that a MPU approach was used somewhat arbitrarily in Alberta, and quite often, recreation was not included as one of the primary uses. Makuk also states that the operative management approaches that were being used to resolve conflicts would often result in trade-offs between each user's resource requirements to the point where few users ever get ideal conditions.

Currently, under the guidance of the Water Act, and more specifically, the Bow Basin Plan, instream uses of rivers and multiple-use management are receiving increased attention (AEP, 1997). However, existing water licenses will maintain their priority dates, and instream uses receives the lowest priority in terms of important uses for water resources in Alberta (AEP, 1997).

The current process for incorporating recreation and other instream flow needs to create an instream flow objective is somewhat informal. The basic process for developing instream objectives within the Bow Basin Plan is illustrated in Figure 7.3. No single recommendation, whether it is the request for a recreation or fishery flow, has an absolute value that will be held up through the process. All recommendations are subject to compromise when the final trade-off between users is made. There must be support at each step of the way for any one recommendation to be fully considered during the negotiation and trade-off process. Currently in Alberta, it is my opinion that recreation is not yet considered as a valid use of river resources when compared with irrigation or hydroelectric operations.

Similar to what Makuk (1988) found, there is still no method for incorporating recreation, or other instream uses, into the decision making process. Although the information is being collected to define IFN values, there is no guarantee the recommendations will be adequately incorporated into the final management decision. In my experience, holders of licenses are very willing to cooperate with incorporating IFN recommendations as long as they don't interfere with their license.

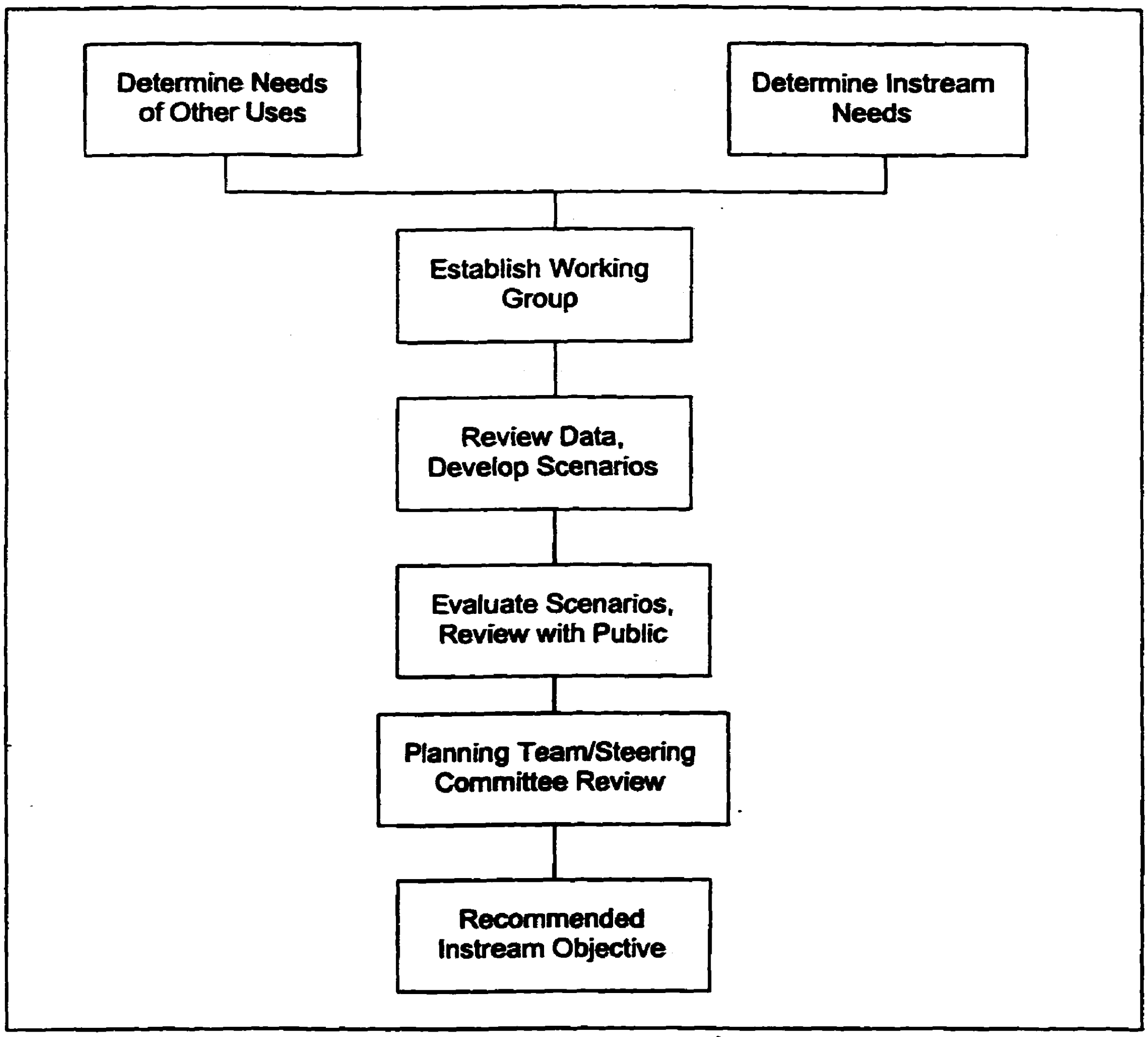


Figure 7.3: The general process for developing instream objectives within the Bow Basin Plan framework (Bob Morrison, AEP, pers. comm.).

In my experience, holders of licenses are willing to consider IFN recommendations until their license becomes threatened. There must be a method to bring water users to the table to negotiate possible trade-off scenarios in good faith. If existing license holders continue refuse to negotiate when difficult trade-off issues must be dealt with, then a mechanism for changing existing licenses may be required. TAU is involved in some programs, such as the Recreation Enhancement Working Group on the Kananaskis River, where different instream flow alternatives are being investigated.

One advantage the United States has over Canada with changing outdated licenses is the Federal Energy Regulation Commission (FERC). Under the Federal Power Act, hydropower companies must include instream flow considerations each time they renew their license for their facilities (Shelby et al. 1992). There is no such regular review process for hydropower or diversion facilities in Alberta where licenses can be modified to include an instream flow requirement. The Wild and Scenic River Act and the Endangered Species Act are two other common tools for protecting instream flow values (Shelby et al. 1992).

Without any legal backing to protect instream flows, the recommendations made by IFN studies in Alberta can be easily watered down in negotiation. Alberta's Water Act gives guidance to collect IFN information. However, there is no method for including instream values, particularly recreation, equally with out-of-stream values in the management of multiple use rivers.

7.6 SUMMARY

In summary:

- The current hydropeaking practices are beneficial to boating activities by extending the recreation season, but are worse than the natural condition for angling and for fish habitat.
- A single flow can not be prescribed for recreation to provide the best flow conditions for all activities. The flow of 113cms (4000cfs) is the best all around flow in providing optimum conditions for angling and kayaking, and good, but less than optimum, conditions for canoeing and rafting.
- Modifications in the flow to meet the needs of fish habitat can be a constant flow recommendation defined by the fish rule curve or by increasing the minimum operating flow and reducing the flow variability. Either of these strategies should also be beneficial in making the necessary compromises in the seasonal timing of flow requirements between angling and boating
- Downstream irrigation requirements do not affect this section of the Bow River, except in very low flow years. When downstream irrigators request the full natural flow to meet their licenses, the Ghost Dam basically operates as a run-of-the-river facility and reduces TAU's overall storage capabilities.
- Currently, AEP has placed a need to collect IFN data for all instream uses. However, there appears to be no concrete method for incorporating these flow recommendations into the existing management of regulated rivers.

8 RECOMMENDATIONS

The first step for incorporating recreation into the management of the Bow River is to develop good information on the flow requirements for each recreation activity. The instream flow needs (IFN) recommendations for recreation for the Bow River from the Ghost Dam to the Highway-22 bridge at Cochrane, AB, are:

- 59cms (2100cfs) to maintain minimally acceptable recreation conditions,
- 113cms (4000cfs) as the lower limit to the optimum range of flows to provide the best combination of recreation quality for all of the water-based activities, and
- 221cms (7800cfs) provide optimum conditions for canoeing and rafting, but is unacceptable for angling.

The optimum flow for the major boating activities is higher than the optimum flow for angling. A single flow recommendation is ineffective at providing optimum conditions for all of the recreation activities. Efforts should be made to provide a wide range of flows during the recreation season to satisfy all of the recreation users, and to create some variety in the recreation experience.

The flow recommendations listed above can be used to assess any flow scenario that is created in terms of the number of hours, days, or weeks when flows are unacceptable for recreation. For this case, recommendations are based on hourly, daily, and seasonal impacts to recreation.

8.1 RECOMMENDATIONS FOR TRANSALTA UTILITIES (TAU)

There are some relatively simple recommendations that can be made for TAU to better manage for, or consider, recreation in their daily operations of the Ghost Dam.

1. Avoid the release of the minimum operating flow during potential recreation hours. A cut-off time of 08:00 can be used, past which minimum flows should not be released.

2. To further benefit recreation and river aesthetics at Cochrane, the minimum flow of 8.5cms should be shifted, as far back into the night as is logistically possible, to increase the potential for morning recreation.

3. Maintain flows of 113cms for as long as possible in the mornings and evenings during the recreation season. This will provide optimum conditions for anglers and kayakers while still providing good conditions for other boaters. This flow is probably the best all around flow for recreation on this section of the Bow River and should be maximized during late summer.

4. Manage for the peak flow of 221cms to be released during midday on the weekends for boaters and a flow of 113cms to be released in the evenings for anglers during periods of high flow.

5. During periods of lower flow, attempt to avoid using the peak flow of 221cms and maximize the hours spent at 113cms.

6. There is a need for better communication between TAU and the public regarding the timing of flow changes, and the large range of flow changes, that are planned on a daily basis below the Ghost Dam. Posting of the dam operating schedule on TAU's web-site, similar to that done for the Barrier Dam on the Kananaskis River for kayakers and canoeists, is one option to communicate the flow schedule to the public. Providing information to post at boat rental stores, such as the University of Calgary Outdoors Program, Mountain Equipment Coop and the Rocky Mountain Paddling Centre, could be another method for getting information to the public.

7. TAU should also take a proactive role in informing Albertans about the environmental costs of providing peaking power and encourage energy conservation during the peak energy hours.

8. An increase in the minimum flow and narrowing the range of flow variation released at the Ghost Dam would be beneficial to all recreation activities and would likely increase fish habitat. If such an approach is ever considered, a controlled flow experiment should be run to determine the recreation quality at the new minimum flow. Any efforts to improve the river ecosystem and at the

same time benefit recreation users can be used to promote TAU's corporate image.

9. Investigations should be done to determine if habitat modifications could improve the availability of habitat for fish in this reach of the Bow River. Steps should be taken to protect spawning habitat in the tributaries along with efforts to improve the fish populations in the mainstem of the Bow River.

The first seven recommendations can be considered in the immediate future, and simple tasks such as improving the accessibility to flow data for the public, could be completed with very little effort. With a few minor changes in the daily timing of flow releases from the Ghost Dam, TAU can increase the recreation potential on this section of the Bow River.

As Calgary and Cochrane continue to grow, the pressure on this section of river as a recreational resource will also increase. Extending the potential recreation hours in the day by a couple of hours can provide new opportunities for people to enjoy a relaxing and uncongested recreation experience. Without the increase, more and more people will be forced to use the river during the middle of the day, causing potential crowding problems. Crowding was already becoming an issue by the end of the 1997 recreation season, and will only get worse in time. By knowing the flow requirements for recreation and by considering recreation needs in managing flow schedules, then there is the potential to have very few conflicts on this section of the Bow River.

Changing the hydropeaking schedule at the Ghost Dam is a longer-term goal, and should involve all of the affected river users. In the wake of deregulation, it is difficult to know how changing the timing of hydropeaking operations might affect TAU's overall network. Upstream hydropower facilities on reaches that are less important for recreation might be able to take over some of the loss in energy production if the hydropeaking schedule at the Ghost Dam is altered to enhance recreation.

TAU should take a leading role in the protection of Jumpingpound Creek's spawning habitat to improve the chance for an increase in the fish population on this section of the Bow River. TAU could improve its corporate image by taking a proactive role in enhancing or protecting important fisheries habitats throughout its jurisdiction, not just on reaches where they operate. By being proactive, and working in areas that are not directly affected by their operations, TAU could create a working relationship with anglers and conservation groups. By focussing efforts on projects outside of operating areas to compensate the public for lost fisheries potential on the reaches where TAU do operate, then both anglers and TAU could benefit.

8.2 *Integrating Recreation into Alberta's River Management*

Water-based recreation has been slow to gain acceptance as a legitimate use of water resources in Alberta. Many steps must be taken to fully integrate recreation into the management of multiple use rivers.

10. There is a need to define recreation IFN across the province. To date, very few studies have been conducted in Alberta, and recreation IFN work is lagging behind fish habitat and riparian vegetation IFN studies. Data collection is an essential first step before proceeding with any negotiations for defining IFN recommendations.

11. There is a need in Alberta to coordinate IFN projects between all of the IFN disciplines. Currently, fish habitat, riparian vegetation, and recreation studies are all conducted separately. If coordination occurred in the planning stage, then instream values as a whole could be better represented in the process of negotiation. With the hiring of a new IFN biologist in the summer of 1998, Alberta Environmental Protection is now in a position to allocate more resources towards coordinating all of the IFN disciplines for future projects.

12. There is a need to better represent instream flow values in the decision making process in Alberta. Managing rivers for multiple use is still done in an informal way and largely unchanged since Makuk (1988) reported on this issue. Instream objectives are developed using the IFN information provided by different instream users in a consultation process with government agencies, water users, interest groups, and the public. There is not a recognized procedure for how to proceed with the consultation process, or how the IFN information should be evaluated before a final decision about instream flow objectives is made. This can result in a lack of consistency of how instream flow recommendations are made within the

different regions of Alberta and can allow for regional decisions to be influenced by local interest groups.

13. There must be strong recreational representation by organized recreation groups during the consultation process used for determining instream flow objectives. Recreation support should also come from within Alberta Environmental Protection as directed by the Water Act. Currently, the Calgary Area Outdoor Council sits on several committees that are responsible for defining instream flow objectives. However, there must be recognition that industry stakeholders have more resources, in terms of money, expertise, and personnel, which will give them an unfair advantage over non-profit recreation groups in the negotiation process. A sharing of resources by industry, such as covering expenses to attend meetings and for data collection on behalf of the non-profit groups should be considered. Similar cost sharing approaches are currently used in the environmental assessment process in Canada where the proponent is responsible for the costs incurred by the members of the review panel (see www.ceaa.gc.ca/costrecovery/order_e.htm). Another example of this type of cost sharing system is used by the Canadian Chemical Producers Association, which covers the cost for public members on its National Advisory Panel created as one component within the Responsible Care voluntary initiative (see www.ccpa.ca/english/RespCare/NAPterms.html).

14. Increased organization and public involvement of recreation groups is needed to challenge the corporate image of consumptive users in the public domain. This pressure may influence license holders to negotiate instream flow issues in good faith. The Government of Alberta must also be challenged to make changes in the existing management of water resources. Much of the public is unaware of who is using the water and how much water is allocated. Some groups, such as Trout Unlimited, are already very successful at raising money and public awareness about fish population and habitat issues. Other recreation groups could follow the model set out by Trout Unlimited for raising money to create more public awareness.

15. A mechanism is required to bring all water users together to negotiate in good faith in order to resolve difficult trade-off issues. Existing license holders are

usually willing to consider incorporating multiple use into their management practices until the terms of their license becomes threatened. If negotiations threaten the terms of a license, the license holder can simply walk away from the table without any penalty. If multiple use practices are only successful when no compromises are required, then multiple use isn't really working. The purpose of trying to define a mechanism to resolve difficult trade-off issues is to be able to apply multiple use principles in regions where there are conflicts amongst users. Without a mechanism to ensure that all parties are willing to negotiate openly, no trade-offs can be accomplished. In the United States, when difficult trade-off issues about instream flow can't be resolved, the end result is almost always litigation, which is both costly and time consuming (Bovee et al. 1998).

16. Potential mechanisms for resolving difficult trade-off issues should be investigated. Pressure could be put on existing license holders in the future if there is a change in voting pattern as a result of increased urbanization. The urban population is likely to put a higher value on instream flow values of water over consumptive uses of water. Increased public pressure to protect instream values may force corporations to voluntarily change their existing practices to maintain or improve their corporate image. A water pricing system can be an effective tool for resource management to improve the equity of the distribution of costs and benefits between users (Thompson, 1993) and should be considered for application in Alberta. A per unit pricing system can reduce overall water consumption, and a peak demand surcharge to be applied during low flow conditions can reduce the demand when the resource is under stress (Thompson et al., 1993). Currently in Alberta, irrigators do not pay for the water they use, hydropower operators pay a small fee for passing water through their turbines, recreation users do not pay for use of the rivers, and fish and the aquatic ecosystem can not pay to protect their flow requirements.

17. There is currently no process to reevaluate existing water licenses in Alberta. Many of the major water licenses on the Bow River were issued in the early 1900s during an era where instream values were not a priority. All license holders with early priority dates continue to operate under the original terms of their licenses. The terms of the licenses do not necessarily reflect the values of present day Albertans on how best to use Alberta's water resources. In the

United States, the Federal Power Act provides a legal mechanism that forces all hydropower licenses to be reevaluated on regular intervals, and all evaluations must now consider instream values (Shelby et. Al. 1992a). If negotiations on multiple use fail because license holders balk at any changes to their current operations, a mechanism will then be needed for reevaluating or changing licenses.

18. On rivers that are not fully allocated, the Water Act should be used as a tool for protecting instream flows before major conflicts arise. Under the current system in Alberta, reserving water for instream purposes on a fully allocated river is futile. At low flows, when instream reservations are most needed, any license with a priority date preceding the water reservation has first rights to the water. This situation can be avoided in the future by taking a proactive stance to protect instream flows before conflicts arise. It is likely easier to protect instream flows now rather than trying to restore flows in an over allocated system later. There is a strong push within Alberta Environmental Protection to conduct IFN studies across the province. However, it remains unclear how the senior managers and directors within Alberta Environmental Protection will use the information to meet the requirements set out by the Water Act.

It is apparent that conflicts amongst water users will only get worse. If global climate change is a reality, then there is likely to be an increase in demand for irrigation water and for sources of non-CO_2 generating power such as hydroelectricity. As Calgary continues to grow at a rapid pace, the demand for water-based recreation will also increase. The problems to be dealt with in water management in the future for Alberta are only going to get more difficult. Mechanisms are needed now in order to resolve the existing conflicts between water users before the affected parties become hostile with each other and any hope for resolution vanishes.

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APPENDIX I – CONTACT LIST

TransAlta Utilities – Box 1900 Station M, 110-12th Ave S.W., Calgary, AB T2P 2M1

- Dan Smith. – Hydroscheduler
- Roger Drury

Alberta Environmental Protection – Deerfoot Square, 2938 – 11th St. NE., Calgary, AB, T2E 7L7

- Russ Lewis – Senior Environmental Planner
- Allan Locke – Head, Instream Flow Needs Programs (932-2388)
- Bob Morrison – Senior Environmental Planner

Bow Waters Canoe Club – P.O. Box 697, Station J, Calgary AB, T2A 4X8, (403) 235-2922

Hook and Hackle Club – P.O. Box 6949, Station D, Calgary AB, T2P 2G2

Canadian Heritage Tours – (403) 241-5275

University of Calgary Outdoor Program – (403) 220-5038

- J.C. Losier

Trout Unlimited Canada, Jumpingpound Chapter

- Daryl Vincent – President, (403) 932-6117

Roberts Fly Shop and Fishing Co. – 104 – 2nd Ave, Cochrane, AB, T0L 0W0 (403) 932-5855

Heritage Canoe Adventures – 103-127 1st Ave W. Cochrane, AB, T0L 0W0, (403) 932-3442

Bow River Angling Outfitters Association

- Michael Guinn - 612 Queensland Dr. S.E., Calgary, AB, T2J 4G7, (403) 271-0799

Appendix II – Boater Survey

Alberta
ENVIRONMENTAL PROTECTION

Bow River Recreation Flow Survey (Boaters)

This survey is part of an instream flow study for the Bow River being run by Alberta Environmental Protection. Thank-you for volunteering to participate in this project. The information you provide will help to represent the needs of your recreation activity in future decisions for the Bow River.

We would like you to answer some questions about recreation. It will only take about 10 minutes to complete. Your answers will be kept confidential. Give only one response to each question unless instructed otherwise. It is **very important** that you include an accurate **date and time** of when you participated in the study. Please complete the survey **immediately after** leaving the river. Surveys can be returned in the postage-paid envelope provide with the survey.

Weather: ☐ sunny ☐ partly sunny ☐ cloudy ☐ rain

Did you perceive the air temperature to be:

☐ cold ☐ cool ☐ warm ☐ hot

Was the wind: ☐ strong ☐ gusty ☐ moderate ☐ calm

Home Postal Code: ______________

Where did you start your trip on the Bow River today:______________________

Where did you end your trip on the Bow River today:______________________

Date: __________ (month/day) **Time out of the river:**__________ **AM / PM**

Age:__________ ☐Male ☐Female

How many hours were you on the river today:____________

How many were in your group:_____: how many male____ how many female____

1. What was your primary boating activity on the Bow River today?

- ❑ Canoeing
- ❑ Rafting
- ❑ Tubing/Floating
- ❑ Kayaking
- ❑ Jet Boat (less than 14' boat)
- ❑ Jet Boat (larger than 14' boat)

2. What were the main reasons for choosing this site over other sites today?

- ❑ Close to home
- ❑ Easy access
- ❑ Recommended by others
- ❑ Good rapids
- ❑ Part of an organized trip
- ❑ Good site for my skill level
- ❑ Better than other sites
- ❑ Trying a new site
- ❑ Other____________________

3. What would you consider your skill level to be in this activity?

- ❑ Beginner (just learning)
- ❑ Novice (know the basic skills)
- ❑ Intermediate
- ❑ Advanced
- ❑ Expert

The FLOW of a river is a *combination* of the speed of the water, the depth of the water, and the width of the river. Consider how the FLOW CONDITIONS TODAY influenced your recreation activity when answering the following questions.

4. Do you check what the flow of the Bow River is before participating by:

- ❑ A visual inspection of the river
- ❑ Obtaining actual flow data (where)______________________
- ❑ Talk to others
- ❑ Past experience
- ❑ You don't check

5. Does knowledge of the flow for the Bow River influence your choice of trip (e.g. if you come or not, site selection, when you go, type of equipment used)?

- ❑ NO
- ❑ YES, please explain____

6. How would you rate **today's flow** conditions for your activity?

- ❑ Extremely good
- ❑ Good
- ❑ Acceptable
- ❑ Poor
- ❑ Extremely poor

7. In your experience, would you **prefer** a flow for your activity that was:

- ❑ Much lower than today
- ❑ Slightly lower than today
- ❑ Same as today
- ❑ Slightly higher than today
- ❑ Much higher than today
- ❑ Don't know

8. Navigation refers to your ability to travel the river unobstructed. Did any of the following cause **problems** with navigation today (***check all that apply***)?

YES	NO	
❑	❑	Rough water, rapids, waves
❑	❑	Narrow channel width
❑	❑	Exposed boulders or bedrock
❑	❑	Rocks just beneath water surface
❑	❑	Exposed or shallow riffle areas
❑	❑	Submerged or partly submerged vegetation
❑	❑	Overhanging shoreline vegetation
❑	❑	Bridges
❑	❑	Other man-made obstructions
❑	❑	Other______________________________

9. Based on **your** experience, how would you rate the difficulty of manoeuvring your water-craft in the river today (i.e. avoiding obstacles, steering the boat)?

- ❑ easy
- ❑ moderately difficult
- ❑ difficult
- ❑ very difficult

10. The flow of the river can influence a number of factors that can change the quality of your trip. Rate how the ***FLOW*** influenced your trip by circling a single number for each factor that best represents your opinion. If conditions were unacceptable, please indicate whether the flow was too low or too high.

	The flow was....					If unacceptable, was the flow:	
	Totally Unacceptable	Unacceptable	Neutral	Acceptable	Totally Acceptable	Too Low	Too High
Safety	1	2	3	4	5	❑	❑
Water clarity	1	2	3	4	5	❑	❑
Water odour	1	2	3	4	5	❑	❑
Speed of travel	1	2	3	4	5	❑	❑
Quality of rapids	1	2	3	4	5	❑	❑
Quality of eddies	1	2	3	4	5	❑	❑
Navigation ability	1	2	3	4	5	❑	❑
Manoeuvrability	1	2	3	4	5	❑	❑
Overall evaluation	1	2	3	4	5	❑	❑

11. What would you consider to be the minimum skill level required to successfully travel down the river today using the same type of water-craft as you did?

- ❑ Beginner (just learning)
- ❑ Novice (know the basic skills)
- ❑ Intermediate
- ❑ Advanced
- ❑ Expert
- ❑ Don't know

12. Have you **ever** experienced problems with low flow on **this part** of the river?

- ❑ NO
- ❑ YES (explain)____

13. Have you **ever** experienced problems with high flows on **this part** of the river?

- ❑ NO
- ❑ YES (explain)____

Consider the following boating problems.

Hits: Any contact with the bottom or rocks without slowing down.

Stops: Contact with the bottom or rocks that stops the boat, but which is corrected easily without getting out of the boat.

Boat Drags: A grounding that requires boaters to get out of their boat and pull it off of the obstacle.

Portages: When boaters have to carry or pull their boat around an obstacle or rapid.

14. How many times did you have the following encounters today, **and** do you think that number of incidents was acceptable *without decreasing your trip satisfaction*?

I **hit** bottom _____ times today.	Was this acceptable?	❑ yes	❑ no
I was **stopped** _____ times today.	Was this acceptable?	❑ yes	❑ no
I had to **boat drag** _____ times today.	Was this acceptable?	❑ yes	❑ no
I had to **portage** _____ times today.	Was this acceptable?	❑ yes	❑ no

15. How many years have you participated in your activity on **this part** of the river?

__________ years.

16. How many times have you participated in your activity at this site?

- ❑ First time
- ❑ 2-5
- ❑ 6-10
- ❑ 11-25
- ❑ 26-50
- ❑ more than 50

17. Over the time you have been coming to this site, has the quality of recreation:

- ❑ stayed about the same
- ❑ improved
- ❑ declined
- ❑ don't know

Please feel free to make any comments about the flow of the Bow River.

YOU ARE NOW FINISHED THE SURVEY. THANK-YOU FOR YOUR PARTICIPATION.

APPENDIX III – ANGLER SURVEY

Alberta
ENVIRONMENTAL PROTECTION

BOW RIVER RECREATION FLOW SURVEY (ANGLER)

Thank-you for participating in the following recreation survey for Alberta Environmental Protection. As an experienced user of the Bow River, your knowledge is extremely valuable in determining the best flows for recreation. The information you provide will help in representing some of the needs of anglers in future decisions for the Bow River.

The flow is a *combination* of the speed of the water, the depth of the river, and the width of the river. Consider all of the following questions as they relate to the flow of the Bow River and how they affected your ability to fish the river.

Please complete your first survey as soon as possible, and then complete the following surveys every two to three weeks. If you are unable to complete all of the surveys, please fill in as many as possible and mail in the survey using the postage paid envelope provided. If you have any questions, or would like more surveys sent to you, please contact Kasey Clipperton at 297-6250 or at home at 228-2716.

What is your home postal code?_______________

Age____________ ☐ Male ☐ Female

What would you consider your skill level to be for this activity?

☐ Novice ☐ Intermediate
☐ Advanced ☐ Expert

Years of experience fishing the Bow River:_____________

How many times do you normally fish on the Bow River during a *single season*?

☐ 1 - 5 times ☐ 26 - 50 times
☐ 6 - 10 times ☐ more than 50 times
☐ 11 - 25 times

Are you a guide, outfitter, or a private user on the Bow River?

☐ Guide
☐ Outfitter
☐ Private User

Bow River Recreation Study – 1st Survey

(Complete as soon as possible)

Date:_____________ (month/day) Time off the river:____________(AM/PM)

Starting Location:________________ Finishing Location:__________________

Hours on the River:__________________

Water Temperature (if measured):____________

Visibility Depth (if measured):_______________

What equipment and methods did you use to fish the bow river today (check all that apply)?

Did you use:
- ☐ Dry flies
- ☐ Nymphs
- ☐ Streamers
- ☐ Spincasting w/ lures
- ☐ Baitfishing

Did you fish by:
- ☐ Drift boat
- ☐ Boat, power
- ☐ Floating
- ☐ Wading
- ☐ Shore

Number of Fish Landed: Rainbow Trout________

Brown Trout__________

Mountain Whitefish________

Other (name)________________________ (number landed)__________

Other (name)________________________ (number landed)__________

In your experience, do you think the BEST flow conditions for angling at this site are:

- ☐ Much lower than today
- ☐ Slightly lower than today
- ☐ Same as today
- ☐ Slightly higher than today
- ☐ Much higher than today

Please continue on the back of this page.

OVERALL, how would you rate today's FLOW conditions for fishing?

- ☐ Extremely good
- ☐ Good
- ☐ Acceptable
- ☐ Poor
- ☐ Very poor

Please consider your past experience on the Bow River and how the following might change with flow. RATE **how the flow** influenced the following attributes of today's fishing trip, considering how they compare to your past experience at different flows.

Was the flow:

	Totally Unacceptable	Unacceptable	Neutral	Acceptable	Totally Acceptable
Ability to wade safely	1	2	3	4	5
Ability to locate fish	1	2	3	4	5
Distribution of fish	1	2	3	4	5
Activity of fish	1	2	3	4	5
Fishing success	1	2	3	4	5
Water temperature	1	2	3	4	5
Water clarity	1	2	3	4	5
Water odour	1	2	3	4	5
If you used a boat:					
Ability to navigate your boat (i.e. travel the river unobstructed)	1	2	3	4	5
Ability to maneuvre your boat (i.e.get to shore, go back upstream)	1	2	3	4	5
Travel time down the river	1	2	3	4	5

Do you have any comments of how the flow affected this trip?

You are now finished survey #1.