A REVIEW OF

INSTREAM FLOW NEEDS

METHODOLOGIES

Prepared by:
Instream Flow Needs Committee

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PPWB Report No. 145

PRAIRIE PROVINCES WATER BOARD

TABLE OF CONTENTS

Report # 145

Page Number

PRAIRIE PROVINCES WATER BOARD

LIST OF TABLES FIGURES AND APPENDICES

PRAIRIE PROVINCES WATER BOARD

CHAPTER 1

INTRODUCTION

An instream flow need is often defined as the amount of water required in a stream to sustain aquatic organisms and processes. The objective of an instream flow recommendation is to provide flows that mimic the natural hydrograph recognizing stream flow variability during and across years. Methods to determine instream flow needs (IFN) first appeared in the published literature in the 1960s. However, as the demand for water increased all over the world, so too did the need to estimate the flows needed to sustain the streams' ecosystems. Instream flow models were developed for various uses (e.g. fish, mussels, wildlife, riparian areas, recreation), stream types (i.e. bedrock or alluvial) and geographic regions (e.g. New England, Oregon, or USFS Region 4 methods).

The Prairie Provinces Water Board (PPWB) oversees and reports on the Master Agreement on Apportionment for eastern flowing streams in the Prairie Provinces (Figure 1). As part of the 1982 PPWB Historical and Current Water Uses in the Sask.-Nelson Basin, the Environmental Considerations Sector looked at instream flow needs. This sector focused on corridors along lakes and rivers in the basin. The fish habitat assessment was based on the "Montana Method", which is more correctly called the Tennant Method. Additional data were obtained from biological surveys and commercial and sport fisheries catch data supplemented by information from local field personnel. The sector report provided maps which identified known critical areas for fish, especially spawning areas, migration channels, wintering areas and areas of large concentrations. Some of these studies are listed in the Appendix.

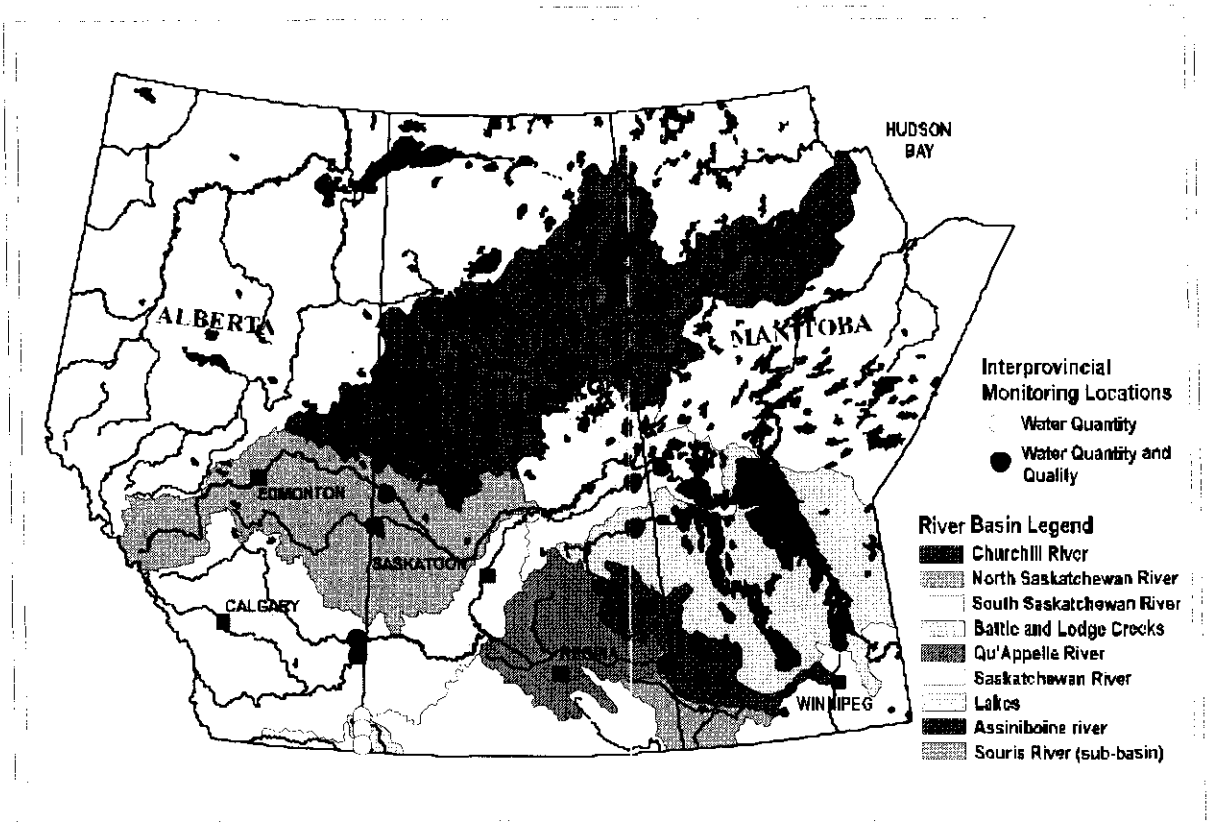


Figure 1: PPWB Mandate Area with Monitoring Locations

More recently, the PPWB determined that an inventory and evaluation of techniques used in estimating instream flow methodologies were needed due to the increasing attention governments are giving to instream flow needs in water rights allocation and in the management of river systems. Therefore, at its March 13, 1997 meeting, the Board agreed to establish an Instream Flow Needs Committee (IFNC) to review and evaluate the different methodologies currently used in the region to estimate instream flow needs. The PPWB Instream Flow Needs Committee first met in July 1997 with membership from PPWB agencies and other agencies having an interest in this topic. A list of the committee members is given in Appendix A . The Committee developed Terms of Reference, as shown in Appendix B.

PRAIRIE PROVINCES WATER BOARD

CHAPTER 2

METHODS

Instream flow methods for fisheries are often categorized as either discharge (simplest), hydraulic rating, or habitat preference (most complex) models. Instream flow issues fall along a continuum of complexity and contentiousness (Stalnaker 1995). Moreover, different technical solutions are appropriate for each of the continuum poles. Simple, low controversy issues can usually be addressed quickly and inexpensively using discharge models that provide a seasonal or monthly recommended flow rate from streamflow records. However, more complex and controversial scenarios are best resolved with an approach capable of synthesizing in-depth flow requirements for all vested interest groups (e.g. habitat preference model), including but not limited to agriculture, domestic and municipal water supplies, fish, flood management, recreation, riparian areas, sewage dilution, water quality, and wildlife.

The following briefly describes the concept underlying each of the instream flow categories, strengths and weaknesses of each category, and an example. Table 1 summarizes the methods and gives examples of models for each method.

2.1. Discharge Methods

Discharge methods assess historical streamflow records and often express the instream flow requirement as a fixed percent of mean or median, annual or monthly flow. Discharge methods are the simplest, least expensive, and least time consuming of the IFN methods to conduct. However, they do not include physical habitat or biological information nor do they provide for the development of a habitat-discharge relationship for assessing flow-habitat tradeoffs (Table 1).

Tennant's method (1976), sometimes called the Montana method, and Tessman's modification of Tennant's method (1980) are two commonly used discharge methods. Tennant used stream gauging records to calculate mean annual flow (MAF), and established range of base flow conditions and an associated level of habitat protection on the basis of his qualitative assessment of habitat conditions generated by various flow regimes (e.g. from April-September, 60% MAF would result in an outstanding level of habitat protection). Tennant's method reserves an amount of water for each of the seasonal periods of April-September and October-March (Table 2).

Table 1. Summary of instream flow model categories.

STRENGTHS	WEAKNESSES	MODELS
Discharge Methods		
Quick Inexpensive No field work Applicable to many stream types	No impact prediction capability Can't assess habitat-flow tradeoffs Biological data not considered	Tennant Tessman Bayha UWRM NEFRX4 NGPRPX1 HOPPE 1 FLOW
Hydraulic Rating Methods		
Intermediate in complexity Intermediate in cost Habitat-Discharge curve developed	Site specific, usually biologically critical areas Most applicable to small streams	Wetted Perimeter Critical Area
Habitat Preference Methods		
Habitats aerially quantified Specific to life stage and species Impact prediction and tradeoff assessment capabilities	Field requirement's high Requires expert assistance Expensive	WRRI HQI IFIM WASH
Multiple habitat variables considered		CALIF PHABSIM

Table 2. Criteria of the Tennant Method (Tennant, 1975)

Flow Rating	Recommended Base Flow Regime (Percentage of Average Annual Flow) October - March	April - September
Flushing or Maximum	200	200
Optimal Range	60 - 100	60 - 100
Outstanding	40	60
Excellent	30	50
Good	20	40
Fair or Degrading	10	30
Poor or Minimum	10	10
Severe Degradation	less than 10	less than 10

The Tennant method fails to address seasonal variations in flow and has potential to reserve more water than may normally flow in a river. Tessman's modification was

developed to better mimic annual stream periodicity and avoids over appropriation of flow resulting from a strict application of Tennant's method. IFN recommendations are made on a monthly basis and incorporate mean monthly flow (MMF) as well as MAF (Table 3). Tessman also recommends a two-week period of 200% MAF during the month of highest runoff for flushing flows.

Table 3. Tessman's criteria for determining IFN

Situation	Minimum Monthly Flow
1. MMF < 40% MAF	MMF
2. MMF > 40% MAF and 40% MMF < 40% MAF	40% MAF
3. 40% MMF > 40% MAF	40% MMF
Where MAF is mean annual flow and MMF is mean monthly flow. Tessman specified a 14-day period of 200% MAF during the month of highest runoff for flushing purposes.	

2.2. Hydraulic Rating Method

Hydraulic rating methods employ data from single or multiple transects to develop hydraulic rating or habitat-discharge curves that describe the variation of a physical habitat parameter with discharge at a specific location. These methods are intermediate in cost and complexity, but are limited in application by being site specific (Table 1). However, because hydraulic rating methods are site specific, they are well suited to studying biologically critical areas (e.g. riffles).

The wetted perimeter inflection point method is an example of a hydraulic rating method. The wetted perimeter is the distance along the bottom and sides of a channel cross section which are in contact with water. As discharge increases, the wetted perimeter also increases. However, the rate of increase in the size of the wetted perimeter is not constant and depends on channel geometry. The wetted perimeter increases rapidly from zero at no discharge up to the point where the water fills the stream bed which is the stream's approximate maximum width. Beyond the point of maximum width, increases in discharge contribute mainly to increases in stream depth with little increase in stream width, consequently the rate at which wetted perimeter increases with discharge decreases. This change in the rate of increasing wetted perimeter marks the inflection point and defines the instream flow recommendation. Measurements are usually taken at riffles because they tend to have more rectangular cross-sectional profiles than other stream habitat types, and tend to be shallower and therefore proportionately more sensitive to disturbance than other habitat types. Riffles are of biological importance in streams for food (benthic) production. The wetted perimeter method is less useful for determining flows need for spawning and egg incubation, especially in prairie streams.

2.3. Habitat Preference Methods

The Instream Flow Incremental Methodology (IFIM) is a widely used approach to determining flows for habitat preference. By developing a relationship between weighted usable area (an index of habitat suitability) and discharge, the IFIM allows the quantification of suitable habitats in a stream reach over a range of discharges on a species-specific and life stage-specific basis. Data on stream width, water velocity, substrate type or cover are collected at multiple transects. The suitability of these variables for specific life stages of target species is also determined through field measurements. Cross-sectional profiles are measured at three or four flows and habitat usability curves are constructed, plotting usable area against discharge.

IFIM treats habitat suitability criteria as either macro or micro habitat. Macro-habitat suitability refers to variables that vary longitudinally downstream (e.g., water quality, channel morphology, discharge, and temperature). Micro habitat suitability incorporates variables that are site specific and can vary horizontally as well as longitudinally. (i.e., depth, velocity, substrate material, and cover). IFIM integrates these two measures of habitat into habitat units that are then related to flow over time, resulting in a habitat time series. The habitat time series displays the availability of suitable habitats over a given period of record (e.g. 10 years). The analyst can then answer questions such as; how much habitat is available 90% of the time, or what happens to available habitats if the flow is reduced 20% in high flow months? This information makes it possible to analyze the effects of changes in flow on each life stage of every species for which habitat suitability data are available. This technique can result in a set of monthly or weekly flow windows, within which flow might vary depending on water supply. The result is the ability to predict changes in the habitat over time, to make recommendations for wet and dry periods, and to quantify habitat duration similar to the firm flow concept in hydrology (Trihey 1981).

Habitat preference methods tend to be the most complex and expensive instream flow assessment methods (Table 1), however, the strength of these methods is in the prediction of impacts and the assessment of tradeoffs. The IFIM does not provide minimum or optimum flow guidelines but serves as a basis for negotiations with other water users.

A number of computer models have been developed using the IFIM methodology. The Physical Habitat Simulation System (PHABSIM) (Stalnaker 1995) is a set of linked computer models used to describe the spatial and temporal habitat features of a river and is a widely used habitat preference model.

PRAIRIE PROVINCES WATER BOARD

CHAPTER 3

METHODS USED IN THE PRAIRIE PROVINCES

The three prairie provinces share several trans-boundary streams, many of which ultimately flow through Manitoba and into Hudson Bay. While a widely accepted standard method or methodology for determining instream flow requirements does not exist between the provinces, the Master Agreement on Apportionment generally ensures half the natural flow in trans-boundary streams originating in Alberta flows into Saskatchewan, and likewise from Saskatchewan to Manitoba. Of the three prairie provinces, only Alberta has selected a discharge (Tessman's modification of Tennant's method) and habitat preference model (IFIM) to determine provincial instream flow requirements for fish.

A survey of individuals responsible for instream flow programs in nearby American states indicated they have adopted at least one discharge method and a habitat preference method to determine IFN (Table 4). Most states surveyed used Tennant's method as their discharge model and all were using the IFIM as the habitat preference model. The agencies responsible for setting instream flows in Montana select from a variety of discharge models depending on the stream type being assessed.

Table 4. Instream flow models adopted by nearby jurisdictions

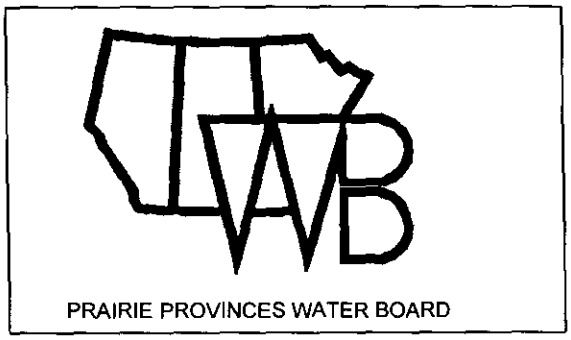
Location	Instream Flow Category	
	Discharge	Habitat Preference
Minnesota	Tennant	IFIM
N. Dakota	Tennant	IFIM
S. Dakota	Tennant	IFIM
Montana	Various	IFIM

The IFNC selected Allan Locke, Joel Hunt and Richard Orr from Alberta, Manitoba and Saskatchewan, respectively, to document the application or assessment of instream flow methods/methodologies in their provinces. Information was collected from respective agency records and reports, and consultants.

This information included general location, length of the river and study area, stream order and mean annual discharge (to indicate river size), instream flow method used and the target species and/or life stages, reason for the study and critical factors, cost (consultants provided best estimates when exact cost was not readily available), date, comments and references. Some of the related information was not applicable depending on the instream flow method under discussion. For example, the number of study reaches is basic information for an IFIM study but not always applicable when using a discharge model.

The IFNC recognized the value of including information on hydrological monitoring (i.e. follow-up assessment of whether instream flow recommendations were being provided by the water management agency) and biological monitoring (investigating how aquatic organisms respond to the specified flows) for each of the cases reported in this document. Only Alberta has conducted any follow-up biological monitoring, in the Oldman Basin, and monitors hydrological information to verify compliance with instream flow recommendations. In Alberta, the Instream Objective Flow (IO), natural flow and actual flow are posted on the Internet every morning. Water license administrators check these flow numbers every day. When the actual flow approaches the IO flow, the most junior licensees are notified and are shut down if actual flows drop below the IO flows. Only those licenses that are subject to IO flows are affected. Senior licenses are not affected by the "new" IO flow restrictions. Many reaches on the Oldman, Bow and Highwood Rivers have IO flow requirements.

The Instream Objective is a composite of the 80% fish rule curve, water quality, recreation, and vegetation instream needs numbers. The fish rule curve value is a weekly flow determined from a composite weighted usable area curve resulting in a 20% reduction in habitat from the optimal peak (Locke 1994).



CHAPTER 4

RESULTS

Summaries of instream flow methods applied/assessed in each of the provinces are listed in the Appendices (Alberta, D; Manitoba, E; Saskatchewan, F).

4.1 Alberta

Numerous streams in Alberta have had instream flow needs estimated using Tessman's modification that are not included in the Appendix. Sixteen IFIM studies and one application of Tessman's modification of Tennant's method, which had been subsequently compared with a remote sensing technique, are reported in the Appendix. IFIM studies were conducted on seven streams in the Bow River sub-basin (Bow, Elbow, Highwood, Kananaskis and Sheep Rivers and Pekisko Creek, (Appendix D1-5), five streams in the Oldman River sub-basin (Belly, Oldman, St. Mary, Waterton Rivers and Willow Creek) (Appendix D8-12), and one in each of the Red Deer, Battle, Sturgeon, Vermillion, and Peace Rivers (Appendix D13-17 respectively). Biological information needed for an IFIM study was collected for Smith-Dorrien Creek but the IFIM study was not done.

In most cases, the Fisheries Management Division of Alberta Environmental Protection was responsible for the studies although most of the work was conducted by various consultants. Trout Unlimited Canada was the lead group for the IFIM study on the Elbow River (Appendix D2), and the Northern River Basins Study group was responsible for comparing the instream flow recommendation set using Tessman's modification and remote sensing technology (Appendix D17).

Most of the IFIM studies collected data on all life stages of various trout species and mountain whitefish. About half of these studies also included walleye as a target species. The four remaining studies (Battle, Sturgeon, Vermillion and Peace rivers) collected data on warm-water species like northern pike, walleye, suckers, goldeye and long-nosed dace (Appendix D14-17).

Reasons for conducting the respective IFIM studies were varied. The reasons for the studies were identified in fourteen (14) studies and were: five precipitated from dams, four were related to irrigation, two were to develop databases for warm-water streams,

and one each due to water sharing, water licensing allocations, and to gain field experience.

The IFIM studies were conducted between 1982 and 1997. Estimated contract costs were from $19,000 for the Pekisko Creek study, where IFIM data was compared with the Thompson methodology (Oregon method), (1986)(Appendix D5) to $470,000 for the Oldman River Dam project (1988-1990)(Appendix D9).

In 1991, Tessman's modification was used to establish an instream flow recommendation for the Peace River (Appendix D17). Since the work was conducted by government employees, the studies had no contract costs. In 1994, the Northern River Basins Study (Courtney et al, 1996) contracted $180,000 to test a remote sensing technique for determining instream flow needs on the Peace River. The conclusion was that the technique offered promise but was problematic and expensive.

4.2 Manitoba

Manitoba's experiences with IFN can be divided into pre and post specific development proposals (primarily irrigation). In total, seven different methods were used to assign instream flow recommendations in the nine cases reported. In 1982-83, and 1985 Fisheries Branch biologists conducted IFIM studies on the Valley (4.29 m^3/s), Whiteshell (3.4 m^3/s) and Rennie (0.55 m^3/s) rivers, respectively (Appendix E1-2). In 1990, an IFIM study was conducted on the Souris River (19.3 m^3/s) by an independent consultant (Appendix E3) as part of the Environmental Impact Assessment for the Rafferty-Alameda Dams project. The Water Resources Branch of Manitoba Natural Resources established an instream flow recommendation for the summer on the Seine River (1.49 m^3/s) using the minimum mean monthly flow during June-September over the period of record (Appendix E4).

Instream flow studies, that resulted from development proposals, were conducted as part of the Provincial Environment Act licensing process. Instream flow recommendations for Environment Act licenses have received consultative input from a variety of agencies including, but not limited to, the Manitoba Provincial Fisheries and Water Resources branches, the Department of Environment, the Federal Department of Fisheries and Oceans, and the Prairie Farm Rehabilitation Administration (PFRA).

During the study of the Plum River tributaries, the Agassiz Irrigation Association (AIA) and the PFRA proposed using 50% of the 80% exceedence volume (e.g. Buffalo Creek, 0.487 m^3/s) and converted this to a flow over 25 days (Appendix E5). This method was subsequently modified to 50% of the median spring volume which was converted to a daily flow over 90 days (Appendix E6). In 1995, the Fisheries Branch and the Department of Fisheries and Oceans used 50% of the median spring flow for Cypress River (0.699 m^3/s) (Appendix E7). Central Manitoba Irrigators and PFRA proposed using Tennant's method (40% mean annual flow) to set instream flow requirements for Whitemud River tributaries (e.g. Rat Creek, 0.327 m^3/s) in 1996 (Appendix E8). AIA

and PFRA proposed using 35% of the median spring volume converted to a daily flow over 90 days in the most recent proposal for tributaries of the Plum and Morris rivers (e.g. Boyne River, 1.32 m^3/s)(Appendix E9).

Streams where the irrigation associations and PFRA have proposed instream flow recommendations are used primarily for spawning and egg incubation of northern pike, suckers and minnow species, although walleye and freshwater drum are of concern in some streams. Walleye spawning and egg incubation were the focus for the IFIM studies on the Whiteshell, Rennie and Valley rivers. Spawning and egg incubation of northern pike, walleye and yellow perch were of interest during the IFIM study on the Souris River. Sustaining all aquatic organisms was the objective of the instream flow study for the Seine River.

Irrigation water storage was the reason necessitating instream flow requirements in five of the nine cases. Establishing instream flow requirements is part of the Environment Act licensing process. The purpose of the Souris River study was to assess the potential to support future water developments and to build an inventory of fish and fish habitat. Water management and operations were of interest in the studies of the Whiteshell, Rennie and Valley Rivers.

Few dollars were spent on contracts as most of the instream flow methods studies relied on provincial and federal employees reviewing historical and synthesized flow records. However, the contract for the IFIM study on the Souris River in 1990 was for $150,000 (E3).

4.3 Saskatchewan

Saskatchewan reported four instream flow studies using four different methods, and a study comparing existing and natural flows in twelve streams to instream flow values derived using Tennant's method (Appendix F1-16). Three instream flow recommendations were for the South Saskatchewan and/or the Saskatchewan Rivers (Appendix F1-3; mean annual discharge 260 and 500 m^3/s, respectively) and one for the Qu'Appelle River (Appendix F11). One additional study is in progress. The Tessman modification of the Tennant method is being applied to streams of the Assiniboine River basin as part of the Saskatchewan-Manitoba Upper Assiniboine River Basin Study (per. com - R. Orr).

In 1963, when the development of instream flow methods was very much in its infancy, the South Saskatchewan River Development Commission led an effort to establish an instream flow recommendation based on an amount of water that would provide suitable oxygen levels for fish survival (Appendix F1). The Wildlife Branch of Saskatchewan Tourism and Renewable Resources conducted a study to determine optimum and minimum instream flows for fish and for the operation of the Katepwa fishway in 1981 (Appendix F16). In 1987, Sask Water and Environment Canada led a multi-disciplinary study where one component was to use Tennant's method to make

instream flow recommendations for a total of seven reaches of the South Saskatchewan River from the Alberta border downstream to the confluence with the Saskatchewan River (Appendix F2). Saskatchewan Environment and Resource Management used a two-dimensional hydraulic model (CDG2D) and fish habitat preference curves to simulate lake sturgeon spawning habitat and make appropriate instream flow recommendations in a dewatered five-km reach of the Saskatchewan River from E. B. Campbell hydroelectric dam to the power station in 1997 (Appendix F3).

Saskatchewan Environment and the PPWB were responsible for a study to compare existing and natural flows with instream flow values derived using Tennant's method for the South (mean annual discharge, 260 m^3/s) and North Saskatchewan (220 m^3/s), Battle (16 m^3/s), Saskatchewan (500 m^3/s), Carrot (20 m^3/s), Torch (9 m^3/s), Sturgeon-Weir (50 m^3/s), Qu'Appelle (7.7 m^3/s), Assiniboine (5.3 m^3/s), Souris (3.7 m^3/s), Red Deer (7.3 m^3/s), and Swan (3.9 m^3/s) Rivers (Appendix F2-15).

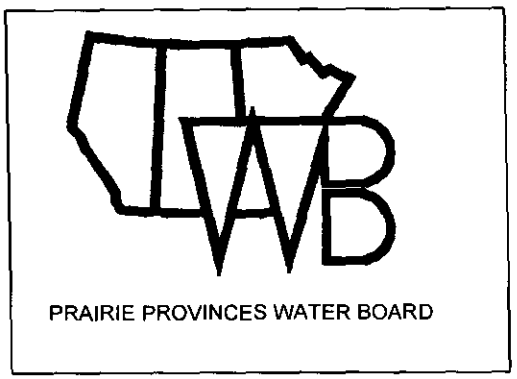
None of the studies were targeted at a specific species or life stage with the exception of the two-dimensional hydraulic modeling of lake sturgeon spawning habitat in the Saskatchewan River (Appendix F3) and on the Qu'Appelle River where habitat and flows were observed in relation to acceptable conditions for spawning and juvenile rearing of walleye and northern pike (Appendix F16).

Instream flow needs were assessed on the South Saskatchewan and main stem Saskatchewan Rivers in 1963 because of Gardiner Dam construction and anticipated reduced flows and dissolved oxygen levels (Appendix F1). The instream flow issue was revisited in 1987 on the South Saskatchewan River as part of a multi-disciplinary study focusing on maintaining habitat for fish populations (Appendix F2). The reason for the study to simulate lake sturgeon spawning habitat was that construction and operation of the E. B. Campbell hydroelectric dam had dewatered a reach of the Saskatchewan River that previously functioned as spawning habitat for these fish (Appendix F3).

The 1980 study comparing existing flows with instream flow recommendations derived using Tennant's method was one component of the PPWB Historical and Current Water Uses Study in the Saskatchewan-Nelson Basin and focused on characterizing the suitability of existing instream flows for fish (Appendix F2-15). Instream flows were rated as good to excellent in the North, South, and main stem Saskatchewan, Torch, Sturgeon-Weir and Swan rivers. Poor to optimum flows existed in the Qu'Appelle River but tended to be rated higher in spring. Flows in Battle River were rated as fair to severely degraded in winter. The Assiniboine, Souris and Red Deer rivers were rated as having severely degraded flows in winter, marginal during summer and optimal in spring. The authors added the existing instream flow recommendation of 0.1 m^3/s for the Souris River was inadequate to maintain year-round habitats.

The contracted cost ranged from $10,000 (1997; mostly salary) for the two-dimensional hydraulic simulation of lake sturgeon spawning habitat on the Saskatchewan River

(Appendix F3) up to $27,000 (1987) to apply Tennant's method to maintain fish habitats in the South Saskatchewan River (Appendix F2). Saskatchewan Environment and PPWB paid $17,500 (1980) to have the existing flow of the twelve streams compared to instream flow recommendations using Tennant's method (Appendix F2-15).



CHAPTER 5

DISCUSSION

Not only has Alberta conducted the most instream flow studies of the three provinces but virtually all of the studies conducted in Alberta were IFIM studies. Considering the cost and type of output from an IFIM study, this possibly indicates that the demands for water accelerated earlier and are more advanced in Alberta than in Saskatchewan or Manitoba. Alberta has identified Tessman's modification and IFIM as their discharge and habitat preference models for determining instream flows requirements when water allocation applications are received. While Manitoba has started the process, neither Manitoba nor Saskatchewan has identified instream flow models for use in their provinces. Minnesota, North and South Dakota, and Montana use IFIM and Tennant's method as their habitat preference and discharge methods, respectively. Montana also makes extensive use of the wetted perimeter method.

Although awareness has been heightened for the need for ecosystem-based management, only the IFIM study on Battle River, Alberta (D14) considered a forage, nongame fish (longnose dace) as a target species. The general assumption for instream flow recommendations seems to be that, by providing adequate flows and spawning conditions for higher profile game fish, conditions will be adequate for all aquatic organisms. This assumption may not be true. Conditions for successful spawning and egg incubation of emerald shiners may not be the same as for, or accommodated by, those conditions needed for walleye. Flow conditions for mussels and/or aquatic insects may also not coincide with the conditions desired for game fish. Often study objectives dictate only one target species (e.g. A10, A32) but the resource managers must be aware of biological assumptions being made or, potentially, conditions optimized for the few top predators may be detrimental to the many prey species on which the predators depend. This lack of knowledge may be compounded since resources are inadequate for further studies and to conduct post instream flow recommendation monitoring. Monitoring could indicate how fish populations and aquatic communities are responding to the flows being set.

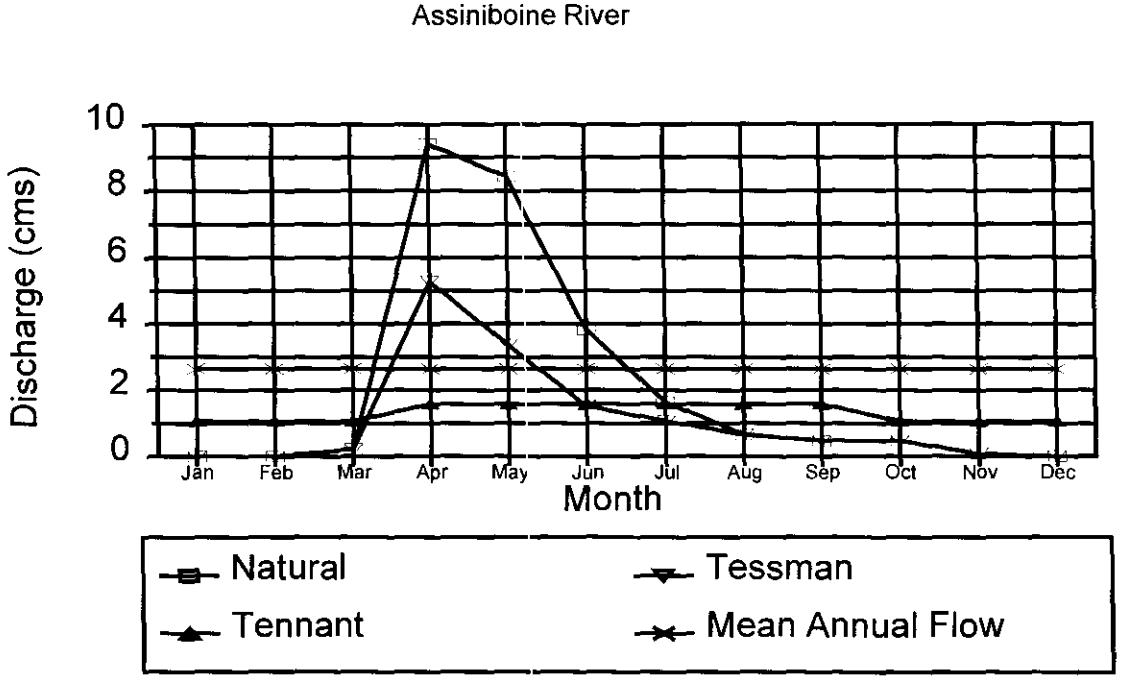
Irrigation withdrawals and the effect of dams on rivers were the primary reasons the instream flow studies reported in this paper were conducted in the three prairie provinces. In Alberta, the headwork structures and the main irrigation canals are constantly undergoing "rehabilitation". This generally means lining them but also

making them deeper and wider so they are more efficient. This is a regular maintenance procedure which goes on from time to time. As well, the irrigation expansion guidelines have been set, so any "maintenance" takes into account this expansion, even though the laterals and pivots are not in place yet. In Manitoba, irrigators indicate there is potential for an additional 30,000 acres of potatoes to be in production in the near future. No dams are currently under construction in any of the three provinces, nor are any plans for future dams firmly in place. Of course, many other consumptive and non-consumptive users of water exist. As the human population continues to grow, so too will be the demand for adequate quantities of good quality water.

Clearly, if aquatic ecosystems are to be protected, the estimation of Instream Flow Needs is going to be more common in the near future. Tennant's method and Tessman's modification of Tennant's method are two widely used discharge methods. Instream flow recommendations can be made with either of these models by quickly reviewing flow records and at low cost. The estimates also tend to be conservative and do not provide tradeoff assessment capabilities.

Of these two methods, the Tessman modification is more appropriate for use in the prairie provinces. The Tennant method prescribes only two levels of flow through the course of a year: a higher level to be applied during the spring and the summer period and a lower level to be applied during the fall and winter. This neither reflects the natural hydrograph or the actual availability of water during low flow periods of the year. However, the Tessman modification closely resembles the natural hydrograph, but with damped peaks. This allows for water withdrawals for offstream uses while still providing peak flows for instream needs at those times of the year when they naturally occur. Designation of flows on a monthly basis by the Tessman method provides a more natural hydrograph compared to the Tennant method. Instream flow recommendations resulting from application of the Tennant and Tessman methods to a natural flow regime are illustrated in Figure 2. Note that the Tennant recommendation illustrated corresponds to the "outstanding " designation described in the Tennant method.

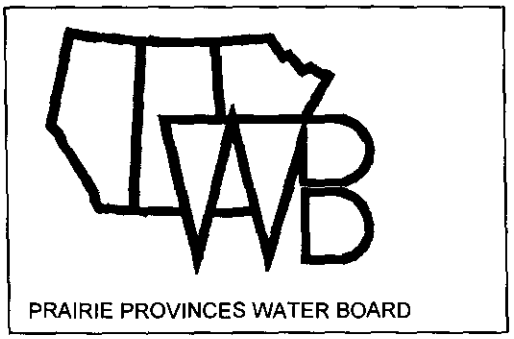
Figure 2. Comparison of Tennant and Tessman Recommendations



By comparison, IFIM is much more complex; requiring training and extensive field work with expensive equipment to conduct a proper assessment (roughly $2,000,000 has been spent on IFIM studies in Alberta). The results from the IFIM model can provide the ability to predict changes in habitat quality with changes in flows and therefore assess the associated tradeoffs. While IFIM produces most useful results, natural resource agencies will be challenged to provide the required funding.

All the methodologies discussed in this report will, if done correctly, yield a recommended instream flow. However, one methodology cannot be selected over another based on biological suitability and correctness. The assumptions made are that the more streamflow data available, the more site specific the species habitat criteria, the more hydraulic measurements at "critical areas", and the more baseline information on the stream, then the better the instream flow recommendation.

This assumption may be correct, but the methods may or may not accurately predict the effects of flow changes on fish and the habitat. The instream flow needs methodologies assume that if habitat is maintained at a given level, the fish population will also be maintained. These methods assume a direct relationship between habitat and fish population.



CHAPTER 6

RECOMMENDATIONS

After review of the methods used within the region to estimate instream flow need the Instream Flows Needs Committee recommends:

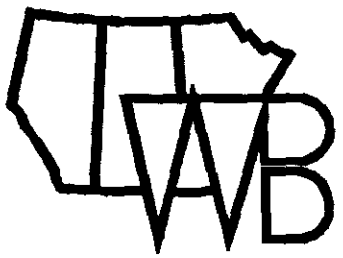
1. The Tessman modification of Tennant's method be used for scoping and planning studies for instream flow needs.

2. Where the fishery is critical or the proponent wishes to use a major portion of the available flow, the instream flow incremental methodology (IFIM) should be used.

3. The impacts on aquatic life should be monitored following the implementation of instream flow recommendations.

4. The flow recommendations derived from the Tessman method and from IFIM studies should be compared.

5. Other methods should continue to be considered, such as the wetted perimeter method. The wetted perimeter method may provide, at a modest cost, recommendations for specific, critical habitat features, however the method needs to be validated through monitoring.



CHAPTER 7

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APPENDICES

APPENDIX A:

PRAIRIE PROVINCES WATER BOARD
INSTREAM FLOW NEEDS COMMITTEE
MEMBERS AND ALTERNATES

Dave Donald, Head
Ecosystems Health Assessment
Ecological Research Division
Prairie and Northern Region
Environment Canada
Room 300, 2365 Albert Street
Regina, SK S4P 4K1
Tel: 306-780-6723
Fax: 306-780-7614
E-Mail: david.donald@ec.gc.ca

David Green, Environment Officer
Water Quality Specialist
Water Quality Management
Manitoba Environment
123 Main Street, Suite 160
Winnipeg, MB R3C 1A5
Tel: 204-945-0585
Fax: 204-948-2357
E-Mail: dgreen@gov.mb.ca

Allan Locke
Aquatic Habitat Protection Biologist
Instream Flow Needs Program
Fisheries Management Division
Environment Protection
Alberta Environmental Protection
Box 1420, Provincial Building
228 - 213 - 1st Street
Cochrane, AB TOL OWO
Tel: 403-932-2388
Fax: 403-932-2158
E-Mail: alocke@telusplanet.net

Joel Hunt, Biologist
Habitat Management, Fisheries Branch
Department of Natural Resources
Box 20, 200 Saulteaux Crescent
Winnipeg, MB R3J 3W3
Tel: 204-945-7794
Fax: 204-948-2308
E-Mail: jhunt@nr.gov.mb.ca

Neil Harden, P. Eng.
Hydrologist, Water Resources Branch
Manitoba Natural Resources
1577 Dublin Avenue
Winnipeg, MB R3E 3J5
Tel: 204-945-6118
Fax: 204-945-7419
E-Mail: nharden@nr.gov.mb.ca

Allen Pietroniro, Research Scientist
National Hydrology Research Institute
Environment Canada
11 Innovation Blvd.
Saskatoon, SK S7N 3H5
Tel: 306-975-4394
Fax: 306-975-5143
E-Mail: Al.Pietroniro@ec.gc.ca

Garnet Gobert
Senior Resource Planner
Watershed Strategies Branch
Sask Water
3rd Fl., 111 Fairford Street East
Moose Jaw, SK S6H 7X9
Tel: 306-694-3953
Fax: 306-694-3944
E-Mail: ggobert@saskwater.com

Pat McGarry, Manitoba Regional
Environmental Officer
Prairie Farm Rehabilitation Administration
200 - 303 Main Street
Winnipeg, MB R3C 3G7
Tel: 204-983-4832
Fax: 204-983-2178
E-Mail: pf21318@em.agr.ca

Rick Orr, Aquatic Habitat Protection Specialist,
Fish and Wildlife Branch
Saskatchewan Environment and
Resource Management
Room 436 - 3211 Albert St.
Regina, SK S4S 5W6
Tel: 306-787-8200
Fax: 306-787-9544
E-Mail: orr.rick.erm@govmail.gov.sk.ca

Karen Broughton
Impact Assessment Biologist
Fish and Habitat Management
Central and Arctic Region
Fisheries and Oceans
Freshwater Institute
501 University Crescent
Winnipeg, MB R3T 2N6
Tel: 204-983-5250
Fax: 204-984-2402
E-Mail: broughtonk@wpgdfo.dfo.ca

R.L. Kellow, (Chair)
Executive Director
Prairie Provinces Water Board
Environment Canada
Room 300, 2365 Albert Street
Regina, Saskatchewan
Tel: 306-780-7004
Fax: 306-780-6810
E-Mail: Richard.Kellow@ec.gc.ca

J.D. Rogers (Secretary)
Resource Conservation Officer
Transboundary Waters Unit
Environment Canada
Room 300, 2365 Albert Street
Regina, Saskatchewan
Tel: 306-780-6584
Fax; 306-780-6810
E-Mail: Jim.Rogers@ec.gc.ca

APPENDIX B:

TERMS OF REFERENCE

PRAIRIE PROVINCES WATER BOARD
COMMITTEE ON INSTREAM FLOW NEEDS

BACKGROUND:

Estimated instream flow needs for streams are used as a tool to help protect aquatic ecosystems. Because jurisdictions use different methodologies to estimate instream flow requirements, the Prairie Provinces Water Board recognized the need to collaborate on evaluating the different methods for use by the three provinces. The Board, therefore, agreed at its March 13, 1997 meeting, that an ad hoc technical committee should be struck to make recommendations on Instream Flow Needs in the prairies.

OBJECTIVES:

1. Provide a forum to exchange information on instream flow needs.

2. Catalogue and review the methodologies used by Alberta, Saskatchewan, Manitoba, and neighbouring jurisdictions, to determine "instream flow needs", The experience of each jurisdiction, especially the provinces, in using each methodology should be included.

3. Establish a list of suitable methodologies which should be used to determine and assess the instream flow needs, with specific reference to ensuring the protection of fish. The list should include the advantages, disadvantages and stream suitability of each methodology.

4. Assist the Board, as requested, in determining appropriate methods for determining instream flow needs at interprovincial reaches. If suitable methods are unavailable, make appropriate recommendations for developing new, revised or adapted methods and protocols.

MEMBERSHIP:

The membership of the Instream Flow Needs Committee will include representatives from each of the PPWB member agencies as appointed by the board members. In addition, board members may appoint members from other agencies that are involved in the issue of determining instream flow needs. The

chairmen of the Instream Flow Needs Committee shall be the Executive Director of the Transboundary Waters Unit of Environment Canada.

MEETING AND MINUTES:

The Committee shall meet at intervals, as necessary, to complete its mandate in a timely manner.

Minutes of each meeting will be taken by the Transboundary Waters Unit of Environment Canada. Draft minutes will be circulated to members for comment within three weeks.

REPORTING SCHEDULE:

The committee will provide a progress report to the Board at its semi-annual meetings.

APPENDIX C

DEFINITIONS OF TERMS

1 FLOW - One Flow Method - Sams, R.E. & Pearson, L.S., 1963. A study to develop methods for delivering spawning flows for anadramous salmonids, Oregon

HOPPE - named for Hoppe, R.A. 1975, Minimum streamflows for fish, Montana

HQI - Habitat Quality Index, Burns, N.A. 1982, Habitat, Quality Index Procedures Manual, Wyoming Game and Fish, Cheyenne, Wyoming

HSC - habitat suitability criteria

IFIM - instream flow incremental methodology

IFN - instream flow needs

LIAM - Legal Institutional Analysis Model

NGPRPX1 - Northern Great Plains Resource Program

PHABSIM - Physical Habitat Simulation System computer models

PHABSIM- physical habitat simulation models

PPWB Prairie Provinces Water Board

SNTEMP - stream temperature computer model

WASH - Washington Method, Collings, M.R. 1974, Generalization of spawning and rearing discharges for several Pacific salmon spears in Western Washington USGS

WRRI - Water Resources Research Institute, Wyoming

WUA - weighted usable area index

APPENDIX D

SUMMARY OF INSTREAM FLOW STUDIES IN ALBERTA

Bow River

Basin: South Saskatchewan River Basin
Sub-basin: Bow River Basin
Study Area: Confluence of Jumpingpound Creek to 11 km downstream of Highway 547 bridge
Length of River: 500 km (not including the portion in Banff National Park)
Stream Order:
Mean Annual Discharge:
Length of Study Area: 116 km
Number of Study Reaches: 5
Instream Use Studied: Fisheries, riparian vegetation, recreation, water quality
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Rainbow trout, brown trout, and mountain whitefish, all life stages
Agency Responsible for Study: Fisheries Management Division
Reason for Study: W.I.D. / B.R.I.D. / E.I.D. Headworks license renewal
Study Focus / Critical Factor: Maintain habitat for the world class trout fishery.
Date of Study: 1990 - 1994
Study Cost (contract dollars): $ 309,000
Status of Study: IFN report completed. IFN recommendations will be written into new licenses for the W.I.D. and B.R.I.D. headworks. IFN recommendations will be used in the Year 2000 Review of Irrigation Expansion Guidelines.
Comments: Habitat use data were collected to develop site-specific SI curves.
References:

Golder Associates Ltd. 1994. Instream Flow Needs Investigation of the Bow River. Prepared by Environmental Management Associates and W.E.R. Engineering for the Fish and Wildlife Division, Edmonton. 267 pp.

Fernet, D.A. and J.J. Helwig. 1992. Development of Mountain Whitefish Habitat Preference Criteria for the Bow River. Prepared by Environmental Management Associates for the Fish and Wildlife Division, Edmonton. 27 pp.

Elbow River

Basin: South Saskatchewan River Basin
Sub-basin: Bow River Basin
Study Area: Glenmore Reservoir downstream to the mouth
Length of River: 108 km
Stream Order:
Mean Annual Discharge:
Length of Study Area: 11.2 km
Number of Study Reaches: 1
Instream Use Studied: Fisheries
Fisheries Component / Method Used: IFIM
Target Species/Life Stages: Rainbow trout, brown trout, and mountain whitefish
Agency Responsible for Study: Trout Unlimited Canada
Reason for Study:
Study Focus / Critical Factor: Protect brown trout spawning habitat
Date of Study: April 1994 – June 1995
Study Cost: $42,000
Status of Study: Completed.
Comments:
References:

Golder Associates Ltd. 1997. A fisheries investigation of the Lower Elbow River. Submitted to Trout Unlimited Canada, Calgary, AB., and the Fisheries Habitat Development Program, Edmonton, AB. April 1997. Report 942-2257, 28pp. + App.

Highwood River

Basin: South Saskatchewan River Basin
Sub-basin: Bow River Basin
Study Area: Confluence of Pekisko Creek downstream to the Bow River
Length of River: 175 km
Length of Study Area:
Number of Study Reaches: 5
Instream Use Studied: Fisheries, riparian vegetation, recreation, aesthetics, water quality
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Rainbow trout and mountain whitefish, all life stages.
Agency Responsible for Study: Fisheries Management Division
Reason for Study: Little Bow Reservoir Project / Moratorium imposed on the Highwood River
Study Focus / Critical Factor: Prevent fish kills in late summer
Date of Study: 1984 - 1990
Study Cost (contract dollars): $ 80,000
Status of Study: Under review by NRCB
Comments: Habitat use observations were collected to develop site-specific SI curves.
References:

Fernet, D.A. and R.F. Courtney. 1991. Fisheries Procedures for Analyzing Water Management Alternatives, Highwood River. Prepared for Fish and Wildlife Div., Edmonton. Prepared by EMA, Calgary. 23 pp.

Walder, G.L. 1991. Flushing Flow Requirements for the Highwood River. Prepared for Planning Div., Edmonton. 17 pp.

Locke, A.G.H. 1994. The Highwood River: Instream Flow Needs for Fish and Flow Scenario Evaluations. Prepared for Fish and Wildlife Services, Edmonton. 108 pp.

Kananaskis River

Basin: South Saskatchewan River Basin
Sub-basin: Bow River Basin
Study Area: Lower Kananaskis Lake downstream to Barrier Reservoir
Length of River:
Stream Order:
Mean Annual Discharge:
Length of Study Area:
Number of Study Reaches: 2
Instream Use Studied: Fisheries, recreation, water temperature
Fisheries Component / Method Used: Instream Flow Incremental Methodology / cdg2d model
Target Species/Life Stages: Brown trout and mountain whitefish, all life stages
Agency Responsible for Study: Fisheries Management Division / TransAlta Utilities
Reason for Study: Part of the overall initiative to mitigate impacts of hydropower in the basin
Study Focus / Critical Factor: Recommend stable flows
Date of Study: 1996 - 1997
Study Cost (contract dollars): $95,000
Status of Study: Final report received February 1998.
Comments: Habitat use data were collected to develop site-specific SI curves.
References:

Courtney, R.F., Walder, G.L. and R.L. Vadas. 1998. Instream Flow Requirements for Fish in The Kananaskis River. Prepared for the Fisheries and Recreation Enhancement Working Group, Clagary. Prepared by EnviResourece Consulting Ltd, Calgary and Sirius Aquatic Sciences. Turner Valley. February 25, 1998, 73pp. + App.

Pekisko Creek

Basin: South Saskatchewan River Basin
Sub-basin: Bow River Basin
Study Area:
Length of River:
Stream Order:
Mean Annual Discharge:
Length of Study Area:
Number of Study Reaches: 5
Instream Use Studied: Fisheries, stockwatering, and aesthetics
Fisheries Component / Method Used: Thompson Method / IFIM
Target Species/Life Stages: Rainbow trout / spawning and fry.
Agency Responsible for Study: Planning Division, Fisheries Management Division
Reason for Study: Provide sharing of water amongst all users
Study Focus / Critical Factor: Protect the spawning and incubation life stages of rainbow trout
Date of Study: 1986
Study Cost (contract dollars): $19,000
Status of Study: Complete
Comments: Attempted to compare two methods. Used the IFIM data.
References:

Fernet, D.A. and S.M. Matkowski. 1986. Instream Flow Needs of Fishes in Pekisko and Stimson Creeks. Prepared for Planning Division, Edmonton. Prepared by EMA, Calgary. 26 pp.

Fernet, D.A. and R.F. Courtney. 1990. Instream Flow Requirements for Fish in Pekisko Creek. Prepared for Habitat Branch, Edmonton. Prepared by EMA, Calgary. 25 pp.

Sheep River

Basin: South Saskatchewan River Basin
Sub-basin: Bow River Basin
Study Area: 1 km upstream of the Highway 2 bridge downstream to mouth
Length of River: 101 km
Stream Order:
Mean Annual Discharge:
Length of Study Area: 3 km
Number of Study Reaches: 1
Instream Use Studied: Fisheries
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Rainbow trout and mountain whitefish / fry, juvenile and adult
Agency Responsible for Study: Fisheries Management Division
Reason for Study: Gain field experience in using the IFIM. First application in Alberta
Study Focus / Critical Factor:
Date of Study: 1982-1983
Study Cost (Contract dollars): All components done in-house.
Status of Study: Complete.
Comments:
References:

Locke, A.G.H. 1987. Microhabitat Utilization and Preference Curve Development for Rainbow Trout Fry in Four Creeks in Southwestern Alberta. Pub. No.T/143. ISBN: 0-86499-450-8. 53 pp.

Locke, A.G.H. 1988. Sheep River instream flow needs study. Alberta Forestry, Lands and Wildlife. Edmonton, AB. Pub. No. T/162, 105pp. + App.

Smith-Dorrien Creek

Basin: South Saskatchewan River Basin
Sub-basin: Bow River Basin
Study Area: Headwaters to Lower Kananaskis Lake
Length of River: 15.4 km
Stream Order:
Mean Annual Discharge:
Length of Study Area: 13.9 km
Number of Study Reaches: 1
Instream Use Studied: Fisheries
Fisheries Component / Method Used: Habitat suitability curves and fisheries data
Target Species/Life Stages: Bull trout / spawning and juvenile
Agency Responsible for Study: Fisheries Management Division
Reason for Study:
Study Focus / Critical Factor:
Date of Study: 1991-1992
Study Cost (Contract dollars): $22,000
Status of Study: Complete.
Comments: Site specific SI curves developed.
References:

Environmental Management Associates. 1994. Bull Trout Juvenile and Spawning Habitat Preference Criteria, Smith-Dorrien Creek, Alberta. Prepared for Fish and Wildlife Division, Edmonton. Prepared by EMA, Calgary. 18 pp.

Belly River

Basin: South Saskatchewan River Basin
Sub-basin: Oldman River Basin
Study Area: Paine Lake downstream to the mouth
Length of River: 172 km
Stream Order:
Mean Annual Discharge:
Length of Study Area: 160 km
Number of Study Reaches: 5
Instream Use Studied: Fisheries, water quality
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Brown trout, rainbow trout, cutthroat trout, walleye and mountain whitefish / all life stages
Agency Responsible for Study: Fisheries Management Division
Reason for Study: South Saskatchewan River Basin Planning Program
Study Focus / Critical Factor:
Date of Study: 1987 - 1994
Study Cost (contract dollars): $75,000
Status of Study: Completed
Comments: Habitat suitability curves used from the Oldman and Crowsnest Rivers.
References:

Bjornson, C.P. and D.A. Fernet. 1989. Instream flow needs investigations of the St. Mary, Belly and Waterton Rivers, 1988. Prepared for Habitat Branch, Fish and Wildlife Division, Edmonton, AB. Prepared by EMA, Calgary. 102pp. + App.

Environmental Management Associates. 1994. Instream Flow Requirements for Fishes of the St. Mary, Belly and Waterton Rivers. Prepared for Fish and Wildlife Services, Edmonton. Prepared by EMA, Calgary. 87 pp.

Oldman River

Basin: South Saskatchewan River Basin
Sub-basin: Oldman River Basin
Study Area: Paine Lake downstream to the mouth
Length of River: 450 km
Stream Order:
Mean Annual Discharge:
Length of Study Area: 310 km
Number of Study Reaches: 6
Instream Use Studied: Fisheries, riparian vegetation, recreation, water quality
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Brown trout, rainbow trout, walleye, sauger and mountain whitefish / all life stages
Agency Responsible for Study: Fisheries Management Division
Reason for Study: Oldman River Dam Project
Study Focus / Critical Factor:
Date of Study: 1988 - 1990
Study Cost (contract dollars): $470,000
Status of Study: Completed
Comments: Habitat use data were collected from the Oldman and Crowsnest Rivers to develop site-specific SI curves.
References:

Fernet, D.A. and S.M. Matkowski. 1986. Oldman River Dam environmental mitigation/ opportunities plan. Phase II: Fish fistribution, abundance, critical habitats and relationships with streamflow downstream of the Oldman River damsite. Prepared for Planning Division, Alberta Environment, Edmonton. Prepared by EMA, Calgary, 137pp. + App.

Fernet, D.A., R.F. Courtney and C.P. Bjornson. 1990. Instream Flow Requirements for Fishes in the Oldman River Dam. Prepared for Public Works Supply and Services, Edmonton. Prepared by EMA, Calgary. 137 pp.

St. Mary River

Basin: South Saskatchewan River Basin
Sub-basin: Oldman River Basin
Study Area: St. Mary Reservoir downstream to the mouth
Length of River: 163 km (not including the portion in the U.S.)
Length of Study Area:
Stream Order:
Mean Annual Discharge:
Number of Study Reaches: 4
Instream Use Studied: Fisheries, water quality
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Rainbow trout, brown trout, cutthroat trout, walleye and mountain whitefish / all life stages
Agency Responsible for Study: Fisheries Management Division
Reason for Study: South Saskatchewan River Basin Planning Program
Study Focus / Critical Factor:
Date of Study: 1987 - 1994
Study Cost (contract dollars): $ 75,000
Status of Study: Complete
Comments: Habitat suitability curves used from the Oldman and Crowsnest Rivers.
References:

Bjornson, C.P. and D.A. Fernet. 1989. Instream flow needs investigations of the St. Mary, Belly and Waterton Rivers, 1988. Prepared for Habitat Branch, Fish and Wildlife Division, Edmonton, AB. Prepared by EMA, Calgary. 102pp. + App.

Environmental Management Associates. 1994. Instream Flow Requirements for Fishes of the St. Mary, Belly and Waterton Rivers. Prepared for Fish and Wildlife Services, Edmonton. Prepared by EMA, Calgary. 87 pp.

Waterton River

Basin: South Saskatchewan River Basin
Sub-basin: Oldman River Basin
Study Area: Waterton Reservoir to mouth
Length of River: 97 km (not including portion in the U.S. or Waterton national Park)
Stream Order:
Mean Annual Discharge:
Length of Study Area:
Number of Study Reaches: 2
Instream Use Studied: Fisheries, water quality
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Brown trout, rainbow trout, cutthroat trout, walleye and mountain whitefish / all life stages
Agency Responsible for Study: Fisheries Management Division
Reason for Study: South Saskatchewan River Basin Planning Program
Study Focus / Critical Factor:
Date of Study: 1987 - 1994
Study Cost (contract dollars): $75,000
Status of Study: Completed
Comments: Habitat suitability curves used from the Oldman and Crowsnest Rivers.
References:

Bjornson, C.P. and D.A. Fernet. 1989. Instream flow needs investigations of the St. Mary, Belly and Waterton Rivers, 1988. Prepared for Habitat Branch, Fish and Wildlife Division, Edmonton, AB. Prepared by EMA, Calgary. 102pp. + App.

Golder Associates. 1994. Instream Flow Requirements for Fishes of the St. Mary, Belly and Waterton Rivers. Prepared for Fish and Wildlife Services, Edmonton. Prepared by EMA, Calgary. 87 pp.

Willow Creek

Basin: South Saskatchewan River Basin
Sub-basin: Oldman River Basin
Study Area: Chain Lakes downstream to the mouth
Length of River: 177 km
Stream Order:
Mean Annual Discharge:
Length of Study Area: 150 km
Number of Study Reaches: 5
Instream Use Studied: Fisheries, riparian vegetation, water quality
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Brown trout, rainbow trout, and bull trout / all life stages
Agency Responsible for Study: Fisheries Management Division
Reason for Study: Pine Coulee Project
Study Focus / Critical Factor:
Date of Study: 1991 - 1992
Study Cost (contract dollars): $126,000
Status of Study: Completed
Comments: Habitat use observations were collected to develop site-specific SI curves.
References:

Fernet, D.A., Bjornson, C.P. and J.J. Helwig. 1992. Willow Creek Instream Flow Needs Investigations. IFIM Data Decks. Prepared for Fish and Wildlife Div., Planning Div., and Alberta Water Resources Commission. Prepared by EMA, Calgary.

Fernet, D.A., Bjornson, C.P. and J.J. Helwig. 1992. Willow Creek Instream Flow Needs Investigations. Fisheries Component. Prepared for Fish and Wildlife Div., Planning Div., and Alberta Water Resources Commission. Prepared by EMA, Calgary. 111 pp.

Red Deer River

Basin: South Saskatchewan River Basin
Sub-basin: Red Deer River Basin
Study Area: Dickson Dam downstream to the Alberta / Saskatchewan border
Length of River: 708 km (not including the portion in Banff National park)
Stream Order:
Mean Annual Discharge:
Length of Study Area: 538 km
Number of Study Reaches: 4
Instream Use Studied: Fisheries, riparian vegetation, recreation, water quality
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Brown trout, walleye, goldeye and mountain whitefish / all life stages
Agency Responsible for Study: Fisheries Management Division
Reason for Study: South Saskatchewan River Basin Planning Program / Year 2000 Review
Study Focus / Critical Factor:
Date of Study: 1991 - 1998
Study Cost (contract dollars): $413,000
Status of Study: Final report received July 1998.
Comments: Used expert judgment to modify and create final suitability criteria.
References:

Fernet, D.A. 1983. The Fishery Resource and Habitat Characteristics of the Red Deer River between Dickson Damsite and Drumheller Prior to Reservoir operation. Prepared for Planning Div., Edmonton. Prepared by EMA, Calgary. 142 pp.

Environmental Management Associates. 1994. Mountain Whitefish Spawning Habitat Preference Criteria, Red Deer River. Prepared for Fish and Wildlife Services, Edmonton. 10 pp.

Golder Associates Ltd. 1998. Red Deer River Instream Flow Needs Study. Prepared for Fisheries Management Division, Edmonton. 45pp. + App.

Battle River

Basin: North Saskatchewan River Basin
Sub-basin: Battle River Basin
Study Area: Outlet of the Forestburg Reservoir downstream to east of Hwy 41
Length of River:
Stream Order:
Mean Annual Discharge:
Length of Study Area:
Number of Study Reaches:
Instream Use Studied: Fisheries
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species/Life Stages: Northern pike / juvenile and adult; walleye / adult, white sucker / fry, juvenile, adult; longnose dace / juvenile and adult.
Agency Responsible for Study: Fisheries Management Division
Study Objective: To derive habitat suitability curves for warmwater species of fish in the Battle River. Habitat use and habitat availability data for mean column velocity, depth, and substrate and cover were collected. Habitat preference curves were developed for northern pike, white sucker and adult longnose dace and walleye.
Study Focus / Critical Factor:
Date of Study: 1995
Study Cost (contract dollars): $40,000
Status of Study: Completed
Comments:
References:

Courtney, R.F. and G.L. Walder. 1996. Habitat Preference Curves for Fish in the Battle River, 1995. Prepared by EnviResource Consulting Ltd. and Sirius Aquatic Sciences for the Fisheries Management Division, Edmonton. 9 pp.

Sturgeon River

Basin: North Saskatchewan River Basin
Sub-basin: Sturgeon River Basin
Study Area:
Length of River:
Stream Order:
Mean Annual Discharge:
Length of Study Area:
Number of Study Reaches: 2
Instream Use Studied: Fisheries
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species: Northern pike
Agency Responsible for Study: Fisheries Management Division
Reason for Study: Develop a database for warmwater streams
Study Focus / Critical Factor:
Date of Study: 1992
Study Cost: All components done in-house
Status of Study: Completed
Comments: Compared IFIM data with Tessman recommendations.
References:

Olson, T. 1995. DRAFT. Evaluation of flow percentages as instream flow recommendations for Alberta streams. Alberta Environmental Protection, Fish and Wildlife Service.

Vermilion River

Basin: North Saskatchewan River Basin
Sub-basin: Vermilion River Basin
Study Area:
Length of River:
Stream Order:
Mean Annual Discharge:
Length of Study Area:
Number of Study Reaches: 1
Instream Use Studied: Fisheries
Fisheries Component / Method Used: Instream Flow Incremental Methodology
Target Species: Northern pike
Agency Responsible for Study: Fisheries Management Division
Reason for Study: Develop a database for warmwater streams
Study Focus / Critical Factor:
Date of Study: 1993
Study Cost: All components done in-house
Status of Study: Completed
Comments: Compared IFIM data with Tessman recommendations
References:

Olson, T. 1995. DRAFT. Evaluation of flow percentages as instream flow recommendations for Alberta streams. Alberta Environmental Protection, Fish and Wildlife Service.

Peace River

Basin: Peace River Basin
Sub-basin: Peace River Basin
Study Area:
Length of River:
Stream Order:
Mean Annual Discharge:
Length of Study Area:
Number of Study Reaches:
Instream Use Studied: 1991 – Fisheries wildlife, and recreation; 1995 – fisheries
Fisheries Component / Method Used: 1991 – Tennant; 1995 - Multispectral Videography / CASI System
Target Species/Life Stages: All indigenous species and life stages
Agency Responsible for Study: 1991 - Fisheries Management Division; 1995 - Northern River Basins Study
Reason for Study: In 1991, negotiations were initiated between Alberta and British Columbia regarding flows in the Peace River. In 1995, the NRBS decided to test a remote sensing technique for determining IFN on the Peace River.
Study Focus / Critical Factor:
Date of Study: 1991 and 1995
Study Cost (contract dollars): 1991 – In house; 1995 - $180,000
Status of Study: Completed
Comments:
References:

Locke, A.G.H. 1991. Minimum Instream Flow Values for Fish and Proposed Water Balance Modeling Evaluation Criteria for the Peace River in Alberta. Prepared for Fish and Wildlife Division, Edmonton. 27 pp.

Alberta/British Columbia Instream Flow Needs Sub-committee. 1991. Peace River Instream Flow Needs. Alberta/British Columbia Transboundary Water Issues. Prepared for the Peace River Technical Advisory Committee. 58 pp.

Courtney, R.F., C. Wrightson and G. Farrington. 1995. A Pilot Study of the Use of Remote Sensing to Analyze Fish Habitat on the Peace River in Alberta. Prepared for the Northern River Basins Study under Project 4131-D1. Prepared by EnviResource Consulting Ltd. and Integrated Terrestrial Systems. pp. 69.

APPENDIX E

SUMMARY OF INSTREAM FLOW STUDIES IN MANITOBA

Valley River

Basin: Dauphin Lake.
Sub-basin: Valley River.
Study Area: Valley River, from the mouth upstream to the intersection of Highway 10.
Length of River: Unknown, drainage area 2,880 km^2 at Dauphin, MB.
Stream Order: 5th order.
Mean Annual Discharge: 4.29 m^3/s.
Length of Study Area: Unknown.
Number of Study Reaches: 16.
Instream Use Studied: Fisheries.
Fisheries Component/Method Used: Instream Flow Incremental Methodology.
Target Species/Life Stages: Walleye/spawning, incubation.
Agency Responsible for Study: Manitoba Fisheries Branch.
Reason for Study: Commercial walleye production had decreased dramatically from 1940-50's to the 1980's in Dauphin Lake.
Study Focus/Critical Factor: To determine 1) extent of utilization of the Valley River by fish for spawning and feeding, 2) present environmental conditions under which walleye were spawning, 3) factor(s) limiting walleye reproductive success, 4) impact of land use changes and activities on the fishery resource.
Date of Study: 1982-83.
Study Cost (contract dollars): $0.00; in-kind provincial government contribution.
Status of Study: Complete.
Comments: Recommended 2 m^3/s for the first 50 days following the peak of the runoff as an absolute minimum flow recommendation but preferred 5-10 m^3/s.

References: Gaboury, M.N. 1985. A fisheries survey of the Valley River, Manitoba, with particular reference to walleye reproductive success. MS Report #85-02. Fisheries Branch, Manitoba Natural Resources.

Whiteshell and Rennie Rivers

Basin: Winnipeg River.
Sub-basin: Whiteshell River.
Study Area: Whiteshell and Rennie rivers.
Length of River: Whiteshell River drainage area, 884 km^2; Rennie River 159 km^2.
Stream Order: Whiteshell River to follow; Rennie River 2nd order.
Mean Annual Discharge: Whiteshell River, 3.4 m^3/s; Rennie River 0.55 m^3/s.
Length of Study Area: Unknown.
Number of Study Reaches: Two on Whiteshell River; one on Rennie River.
Instream Use Studied: Fisheries, particularly spawning habitat.
Fisheries Component/Method Used: Instream Flow Incremental Methodology.
Target Species/Life Stages: Walleye/fry and adults.
Agency Responsible for Study: Manitoba Fisheries Branch.
Reason for Study: Develop a comprehensive water management and regulation plan to accommodate the various users.
Study Focus/Critical Factor: For both rivers, determine flow requirements to optimize suitable spawning/incubation habitat for walleye and determine the impacts of current water regulation on spawning walleye.
Date of Study: 1985.
Study Cost (contract dollars): $0.00; in-kind provincial government contribution.
Status of Study: Complete.
Comments: Whiteshell and Rennie rivers originate in the boreal forest/precambrian shield. This report does not specify an instream flow recommendation but rather water management options. It seems like the data is available to make instream flow recommendations for walleye spawning habitat and egg incubation.

References: McGarry, P.T. 1985. Water requirements for walleye on the Whiteshell and Rennie rivers. Fisheries Branch. Manitoba Natural Resources.

Souris River

Basin: Assiniboine River.
Sub-basin: Souris River.
Study Area: Souris River in Manitoba from the U.S. border to it's confluence with the Assiniboine River.
Length of River: 273 km long from US border to confluence with Assiniboine River, drainage area 48,100 km^2 at Melita, MB.
Stream Order: 7 th order stream at the confluence with Assiniboine River.
Mean Annual Discharge: 19.3 m^3/s.
Length of Study Area: 273 km.
Number of Study Reaches: Five.
Instream Use Studied: Fisheries.
Fisheries Component/Method Used: Habitat Evaluation Procedures and Instream Flow Incremental Methodology.
Target Species/Life Stages: Northern pike, walleye and yellow perch/fry, juvenile, adult and spawning.
Agency Responsible for Study: Souris Basin Development Authority, Estevan, Saskatchewan and The Souris River Water Commission, Melita, Manitoba.
Reason for Study: Provide a detailed fisheries inventory of the Souris River in Manitoba and a database that could be used to conduct a habitat-based assessment of the effects of water management of the fish fauna. This study was also part of the Environmental Impact Assessment for the Rafferty-Alameda dams project.
Study Focus/Critical Factor: Inventory.
Date of Study: 1990.
Study Cost (contract dollars): $150,000.00
Status of Study: Complete.
Comments: Instream flow recommendations were not made in the report, however, the authors suggest the data is available to complete the task.

References: Bjornson, C.P., D.A. Fernet and R.F. Courtney. 1990. Fisheries studies of the Souris River basin in Manitoba draft report. Environmental Management Associates. Prepared for Souris Basin Development Authority, Estevan, Saskatchewan and The Souris River Water Commission, Melita, Manitoba.

Seine River

Basin: Red River.
Sub-basin: Seine River.
Study Area: Seine River.
Length of River: Unknown, drainage area 1,470 km^2.
Stream Order: 4th order at St. Anne, MB.
Mean Annual Discharge: 1.49 m^3/s.
Length of Study Area: To follow.
Number of Study Reaches: Not applicable.
Instream Use Studied: Survival of all aquatic organisms was considered.
Fisheries Component/Method Used: Minimum mean monthly flow (using natural flow records 1942-1961) between June and September.
Target Species/Life Stages: All aquatic organisms considered.
Agency Responsible for Study: Manitoba Water Resources.
Reason for Study: To assess instream flow requirements and the demand for water withdrawals. This information was compared with the supply capabilities of the river to determine whether the Seine River was capable of meeting the proposed demands.
Study Focus/Critical Factor: Provide a threshold condition which would allow continued survival of aquatic organisms.
Date of Study: 1992.
Study Cost (contract dollars):
Status of Study: Complete.
Comments: To follow.

References: Smith, M.J. 1992. Water Management Strategies for the Lower Seine River. Master's Practicum. Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba.

Plum River tributaries

Basin: Red River.
Sub-basin: Plum River.
Study Area: Buffalo Creek (dugouts S7, S12, S11A,B,C); Hespeler Drain, dugout S5a.
Length of River: Unknown, drainage area, Buffalo Creek, 453 km^2 at Altona. N/A for Hespeler Drain.
Stream Order: Buffalo Creek-3rd order at Altona; Hespeler - 2nd order at dugout S5a.
Mean Annual Discharge: Buffalo Creek, 0.487 m^3/s. N/A for Hespeler Drain.
Length of Study Area: Not applicable.
Number of Study Reaches: Applied at each of six dugouts although S11a-c are very close together.
Instream Use Studied: Fish and fish habitat.
Fisheries Component/Method Used: For sites on Buffalo Creek, 50% of the 80% exceedence volume at the Altona gauge station was converted to a flow rate over 25 days. The downstream domestic use allowance was added. The instream flow recommendation for a given site was calculated by multiplying the instream flow recommendation at the Altona gauge station by the site proportion of the drainage area. These flow rates ranged between 60-80% MAF which falls into the optimum range as classified by Tennant. However, it was 30% MAF (fair or degrading) when compared to Tessman's method. For Hespeler Creek, daily mean flows were estimated by transposing the recorded daily mean flows at the Buffalo Creek at Altona gauging station by the ratio of the annual runoff volumes estimated for Hespeler Creek and the recorded annual runoff volumes at the gauging station.
Target Species/Life Stages: Northern pike, suckers, minnows/adults, egg incubation.
Agency Responsible for Study: PFRA/AIA.
Reason for Study: AIA proposes irrigation water storage dugouts in upstream reaches.
Study Focus/Critical Factor: These streams range from intermittent to occasionally continuously flowing. The objective of the instream flow requirement is to provide adequate flow and water quality for spawning and egg incubation. Water withdrawals are generally intended to capture and store spring runoff.
Date of Study: 1994-95.
Study Cost (contract dollars): $0.00; in-kind federal and provincial government contributions.
Status of Study: Complete.
Comments: Instream flow requirements were set for site specific locations and incorporated into licenses. MAF; mean annual flow, PFRA; Prairie Farm Rehabilitation Administration, AIA; Agassiz Irrigation Association.

References: Agassiz Irrigation Association, Irrigation Reservoir Projects, Plum River System, Phase I and II, Box 750, Winkler Manitoba, R2W 4A8. Also see Environment Act Proposal File #3636.00, Environment Act License #1771 for Phase I; Environment Act Proposal File #3636.10, Environment Act License #1917 for Phase II

Plum River tributaries .

Basin: Red River.
Sub-basin: Plum River.
Study Area: Buffalo Creek S11f; Buffalo Drain S14, Rosenheim Drain S16, Hespeler Drain S15.
Length of River: Unknown, drainage area, Buffalo Creek, 453 km^2 at Altona. N/A for Hespeler or Rosenheim drains.
Stream Order: Buffalo Creek as above; Buffalo Drain, 3rd order; Rosenheim Drain, 4th order; Hespeler Drain, 4th order.
Mean Annual Discharge: Buffalo Creek, 0.487 m^3/s. N/A for Hespeler or Rosenheim drains.
Length of Study Area: Not applicable.
Number of Study Reaches: Applied at each of four dugouts.
Instream Use Studied: Fish and fish habitat.
Fisheries Component/Method Used: 50% of median spring volume (March-May 50% exceedence volume) converted to a daily flow over 90 days. Median spring volume calculated from gauging station flow records on respective streams where available, synthesized as above for Hespeler Drain where not available. Downstream domestic uses added. Site specific recommendations calculated as a proportion of drainage area and the area of escarpmental drainage.
Target Species/Life Stages: Northern pike, suckers, minnows/adults and egg incubation.
Agency Responsible for Study: PFRA/AIA.
Reason for Study: AIA proposes irrigation water storage dugouts in upstream reaches.
Study Focus/Critical Factor: These streams range from intermittent to occasionally continuously flowing. The objective of the instream flow requirement is to provide adequate flow and water quality for spawning and egg incubation. Water withdrawals are generally intended to capture and store spring runoff.
Date of Study: 1994-95.
Study Cost (contract dollars): $0.00, in-kind federal and provincial government contributions.
Status of Study: Complete.
Comments: Instream flow requirements were set for four and incorporated into licenses.
References: Agassiz Irrigation Association, Irrigation Reservoirs - 1995 Projects, Plum River System, Phases III and IV, Box 750, Winkler Manitoba, R2W 4A8. Also see Environmental Act Proposal File #3636.20 and Environmental Act License #2093.

Cypress River

Basin: Assiniboine River
Sub-basin: Cypress River
Study Area: Swansfleet Farms
Length of River: Unknown, drainage area 277 km^2.
Stream Order: 3rd order at Swansfleet farms.
Mean Annual Discharge: 0.669 m^3/s.
Length of Study Area: Not applicable.
Number of Study Reaches: Applied at each of two dugouts.
Instream Use Studied: Fish; (spring spawning and egg incubation).
Fisheries Component/Method Used: 50% of mean March-May flow.
Target Species/Life Stages: Northern pike, suckers and minnows/adults and eggs.
Agency Responsible for Study: Manitoba Environment, Fisheries and DFO.
Reason for Study: Two proposed irrigation dugouts.
Study Focus/Critical Factor: Provide sufficient flow and water quality for spawning and egg incubation.
Date of Study: 1995
Study Cost (contract dollars): $0.00; in-kind federal and provincial government contributions.
Status of Study: Complete.
Comments: Instream flow recommendation incorporated into license. Most flow occurs during the spring runoff period (March to May), with many months from April to October having a mean monthly flow of zero (28 year period of record). No instream flow recommendation was made for June to February because there were no proposed water withdrawals for this period. The instream flow recommendation was site specific to the irrigation dugouts. DFO; Department of Fisheries and Oceans.

References: Environment Act Proposal File #3923.00, Swansfleet Farms Ltd. - Irrigation Projects. Environment Act License #2125.

Whitemud River tributaries .

Basin: Lake Manitoba.
Sub-basin: Whitemud River.
Study Area: Bagot, Beaver, Image, Rat, and Squirrel creeks.
Length of River: Unknown, drainage areas, Beaver Creek, 289 km^2; Rat Creek, 300 km^2
Stream Order: Bagot Creek, 3rd order; Beaver Creek, 4th order; Image Creek, 3rd order; Rat Creek, 5th order; Squirrel Creek, 4th order.
Mean Annual Discharge: Beaver Creek, 0.295 m^3/s; Rat Creek, 0.327 m^3/s. Remainder not available.
Length of Study Area: Not applicable.
Number of Study Reaches: Applied at each of nine dugouts.
Instream Use Studied: Fish and fish habitat.
Fisheries Component/Method Used: Tennant; proponent recommended 40% MAF. Tennant classifies 40% MAF as good for April-September period. MAF calculated from gauging station flow records on respective streams where available, synthesized as above for Plum River tributaries (A-23, A-24) where not available. Site specific recommendations calculated as a proportion of drainage area.
Target Species/Life Stages: Northern pike, walleye, freshwater drum, suckers, minnows/adults, egg incubation.
Agency Responsible for Study: PFRA/CMIA.
Reason for Study: CMIA proposes irrigation water storage dugouts in upstream reaches.
Study Focus/Critical Factor: These streams range from intermittent to occasionally continuously flowing. The objective of the instream flow requirement is to provide adequate flow and water quality for spawning and egg incubation. Water withdrawals are generally intended to capture and store spring runoff.
Date of Study: 1996.
Study Cost (contract dollars): $0.00, in-kind federal and provincial government contributions.
Status of Study: Ongoing.
Comments: Instream flow recommendations are under review. License has been issued. CMIA; Central Manitoba Irrigation Association.

References: Environmental Act Proposal, Central Manitoba Irrigation Association Inc., Irrigation Reservoirs, Whitemud Watershed Phase I, May 1996. Also see Environmental Act Proposal File # 4170.00 and Environmental Act License # 2219.

Morris River/Plum River tributaries .

Basin: Red River.
Sub-basin: Morris River/Plum River.
Study Area: Morris River; Boyne River, Tobacco Creek. Plum River; Hespeler Drain, Rosenheim Drain, Buffalo Creek, Buffalo Drain.
Length of River: Unknown, Boyne River drainage area, 958 km^2; Buffalo Creek as above; remainder not available.
Stream Order: Boyne River, 5th order; Tobacco Creek, 3rd order. Plum River as above.
Mean Annual Discharge: Boyne River, 1.32 m^3/s; Buffalo Creek as above; remainder not available.
Length of Study Area: Not applicable.
Number of Study Reaches: May be applied at up to 15 dugouts.
Instream Use Studied: Fish and fish habitat.
Fisheries Component/Method Used: 35% of median spring volume (March-May 50% exceedence volume) converted to a daily flow over 90 days. Median spring volume calculated from gauging station flow records on respective streams where available, synthesized where not available.
Target Species/Life Stages: Northern pike, suckers, minnows/adults, egg incubation.
Agency Responsible for Study: PFRA/AIA.
Reason for Study: AIA proposes irrigation water storage dugouts in upstream reaches.
Study Focus/Critical Factor: These streams range from intermittent to continuously flowing. The objective of the instream flow requirement is to provide adequate flow and water quality for spawning and egg incubation. Water withdrawals are generally intended to capture and store spring runoff.
Date of Study: 1996.
Study Cost (contract dollars): $0.00, in-kind federal and provincial government contributions.
Status of Study: Ongoing.
Comments: Instream flow recommendations are under review.

References: Agassiz Irrigation Association, Irrigation Reservoirs - 1996 Projects, Plum River Phase V and Morris River Phase II, June 1996, Box 750, Winkler Manitoba, R2W 4A8. Also see Environmental Act Proposal File # 3636.40 and Environmental Act License # 2224.

APPENDIX F

SUMMARY OF INSTREAM FLOW STUDIES IN SASKATCHEWAN

South Saskatchewan River

Basin: Saskatchewan-Nelson
Sub-Basin: South Saskatchewan
Study Area: South Saskatchewan River from Gardiner Dam downstream to the Forks and the main Saskatchewan River from the Forks downstream to The Pas, MB
Length of River: 1000 km from the confluence of the Bow and Old Man Rivers to the Forks
Stream Order:
Mean Annual Discharge: 260 m^3/s
Length of Study Area: 750 km (Gardiner Dam to The Pas, MB)
Number of Study Reaches: Not applicable
Instream Use Studied: Water quality, fish, water intakes, ferry operation, navigation
Fisheries Component/Method Used: Oxygen conditions suitable for fish were estimated from observations of conditions at existing flows.
Target Species/Life Stages: No fish species or life stages specified.
Agency Responsible for Study: South Saskatchewan River Development Commission
Reason for Study: Construction of Gardiner Dam
Study Focus/Critical Factors: Fisheries component intended to determine flows sufficient to maintain suitable oxygen levels for survival of fish.
Date of Study: 1963
Study Cost:
Status of Study: Completed. Recommended minimum flow written into license.
Comments: Study consisted of gathering input from potentially affected users and agencies. Their experience with impacts of past low water levels were considered in determining acceptable low flows. Impacts of low water flows to fish were considered in relation to expected dissolved oxygen levels. Physical habitat availability was not considered.

References: S.R. Blackwell. 1963. Minimum streamflow requirements downstream from the South Saskatchewan Dam. South Saskatchewan River Development Commission.

South Saskatchewan River

Basin: Saskatchewan-Nelson
Sub-Basin: South Saskatchewan
Study Area: South Saskatchewan River from Alberta border downstream to the Forks of the Saskatchewan River.
Length of River: 1000 km from the confluence of the Bow and Oldman Rivers to the Forks.
Stream Order:
Mean Annual Discharge: 260 m^3/s
Length of Study Area: 750 km (Alberta border to the Forks)
Number of Study Reaches: Seven reaches including Swift Current Creek and Saskatoon South-East Water Supply. Five reaches on the South Saskatchewan River proper.
Instream Use Studied: Recreation, fish, wildlife, ferry operation, waste assimilation
Fisheries Component/Method Used: Tennant method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Canada - Saskatchewan South Saskatchewan River Basin Study Board
Reason for Study: One component of a multi-disciplinary study by SaskWater and Environment Canada on the Saskatchewan portion of the South Saskatchewan River Basin.
Study Focus/Critical Factors: Maintain habitat for fish populations in the river and associated water bodies.
Date of Study: 1987
Study Cost: $27,000
Status of Study: Completed. Recommended minimum instream flows for fish habitat are less than required by the PPWB Master Agreement on Apportionment and the license requirements for the Gardiner Dam.
Comments: No field observations conducted. Study also made recommendations for water levels in lakes within the study area.

References: Beak Associates Consulting Ltd. 1987. Instream Water Use South Saskatchewan River Basin. Technical Report E.7. Prepared for Canada - Saskatchewan South Saskatchewan River Basin Study.

Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Saskatchewan River

Basin: Saskatchewan-Nelson
Sub-basin: Saskatchewan River
Length of River: 1000+ km
Stream Order: ?
Mean Annual Discharge: 500 m^3/s (zero in study area since 1960)
Study Area: Former rapids (Tobin and Squaw Rapids) in a dry river bed, extending from E.B. Campbell hydro-electric dam to power-station.
Length of Study Area: 5 km
Number of Study Reaches: 3
Instream Use Studied: Fish habitat.
Fisheries Component / Method Used: Simulation of spawning habitat, based on predictions from two-dimensional hydraulic model (CDG2D) and fish preference curves. Different potential discharges through the former rapids were simulated. These ranged from the pre-dam average of 1,200 m^3/s during June spawning to an arbitrarily low 200 m^3/s. Both the natural river bed and a virtually channelized version were used.
Target Species/Life Stages: Lake sturgeon (Acipenser fulvescens). Spawning only.
Agency Responsible for Study: Saskatchewan Environment and Resource Management, Fish & Wildlife Branch
Reason for Study: Complete loss of spawning habitat from construction and operation of E.B. Campbell hydro-electric dam.
Study Focus / Critical Factor: Determine minimum flows required to provide adequate sturgeon spawning habitat.
Date of Study: 1997
Study Cost (contract dollars): $10,000
Status of Study: Report in progress. Recommendations will be discussed with hydro-electric utility.
Comments: This simulation could not have been done with standard IFIM methods. Preference curves were based on literature references, physiological considerations, and effects of bottom-roughness.

References: Ghanem, A., P. Steffler, F. Hicks, and C. Katopodis. 1996. Two-dimensional hydraulic simulation of physical habitat conditions in flowing habitats. Regulated Rivers: Research and Management 12:185-200.

Ghanem, A., P. Steffler, F. Hicks, and C. Katopodis. 1995. Two-dimensional finite element modeling of flow in aquatic habitats. University of Alberta, Dep. Civil Engineering, Water Resources Engineering Report No. 95-S1, xiii and 122 p.

Wallace, R. G. 1991. Species recovery plan for lake sturgeon in the lower Saskatchewan River (Cumberland Lake area). Saskatchewan Parks and Renewable Resources, Fisheries Technical Report 91-3, viii and 51 p.

The following water courses are part of an overview study for Saskatchewan Environment and PPWB by Prier (1980). In this review, existing and natural flows were compared to values derived from the Tennant Method to characterize effect of the flow regime on fish. No field observations were conducted in this study.

South Saskatchewan River

Basin: Saskatchewan-Nelson
Sub-Basin: South Saskatchewan
Study Area: South Saskatchewan River from Alberta border downstream to the Forks of the Saskatchewan River.
Length of River: 1000 km from the confluence of the Bow and Oldman Rivers to the Forks.
Stream Order:
Mean Annual Discharge: 260 m^3/s
Length of Study Area: 750 km (Alberta border to the Forks)
Number of Study Reaches: Not applicable.
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/Prairie Provinces Water Board
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin).
Status of Study: Completed.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. The existing flow regime was rated as excellent. No recommendations were made for management of flows.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

North Saskatchewan River

Basin: Saskatchewan-Nelson
Sub-Basin: North Saskatchewan
Study Area: North Saskatchewan River from Alberta border to the Forks
Length of River: approx. 1300 km
Stream Order:
Mean Annual Discharge: 220 m^3/s (at Deer Creek)
Length of Study Area: 500 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows are highly rated. No recommendations for management of flows.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Battle River

Basin: Saskatchewan-Nelson
Sub-Basin: North Saskatchewan
Study Area: Battle River at its confluence with the North Saskatchewan River
Length of River: 900 km
Stream Order:
Mean Annual Discharge: 16 m^3/s (at Battleford)
Length of Study Area: Not applicable
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows in winter are fair to severely degraded. No recommendations are made for management of flows.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Saskatchewan River

Basin: Saskatchewan-Nelson
Sub-Basin: Saskatchewan
Study Area: Saskatchewan River from the Forks to the Manitoba border
Length of River: 450 km
Stream Order:
Mean Annual Discharge: 500 m^3/s
Length of Study Area: 500 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows are rated as good to excellent. No recommendations are made for management of flows.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Carrot River

Basin: Saskatchewan-Nelson
Sub-Basin: Saskatchewan
Study Area: Wakaw Lake to confluence with Saskatchewan River
Length of River: 630 km
Stream Order:
Mean Annual Discharge: 20 m^3/s(near Turnberry)
Length of Study Area: 600 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows are rated as severely degraded from January to March. No recommendations are made for management of flows.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Torch River

Basin: Saskatchewan-Nelson
Sub-Basin: Saskatchewan
Study Area: Candle Lake to confluence with Saskatchewan River
Length of River: 300 km
Stream Order:
Mean Annual Discharge: 9 m^3/s(near Love)
Length of Study Area: 300 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows are rated as good to excellent. No recommendations are made for management of flows.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Sturgeon-Weir River

Basin: Saskatchewan-Nelson
Sub-Basin: Saskatchewan
Study Area: Deschambeault Lake area to confluence with Saskatchewan River
Length of River: approx. 500 km
Stream Order:
Mean Annual Discharge: 50 m^3/s(outlet of Amisk Lake)
Length of Study Area: Not applicable
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows are rated as good to excellent. No recommendations are made for management of flows.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Qu'Appelle River

Basin: Saskatchewan-Nelson
Sub-Basin: Qu'Appelle
Study Area: Lake Diefenbaker to the Manitoba border
Length of River: 770 km
Stream Order:
Mean Annual Discharge: 7.7 m^3/s (at Welby)
Length of Study Area: 750 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows vary considerably, from poor to optimum depending on the year. Conditions are rated slightly higher in spring and summer. No recommendations are made for management of flows.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Assiniboine River

Basin: Saskatchewan-Nelson
Sub-Basin: Assiniboine
Study Area: Preceville area to Lake of the Prairies
Length of River: 1290 km
Stream Order:
Mean Annual Discharge: 5.3 m^3/s (at Kamsack)
Length of Study Area: 350 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows are characterized as severely degraded from December through March and marginal from August to November. Optimum conditions are present in April through June. No recommendations are made for management of flows.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Souris River

Basin: Saskatchewan-Nelson
Sub-Basin: Souris
Study Area: Headwaters to U.S. border
Length of River: 1300 km
Stream Order:
Mean Annual Discharge: 3.7 m^3/s (at U.S. border)
Length of Study Area: 450 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows are characterized as severely degraded during the winter and poor in August and September. The existing minimum flow objective of 0.1 m^3/s was considered inadequate to maintain year-round aquatic habitat. No recommendations for flow management were made.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Red Deer River

Basin: Saskatchewan-Nelson
Sub-Basin: Lakes
Study Area: Headwaters to Manitoba border
Length of River: 400 km
Stream Order:
Mean Annual Discharge: 7.3 m^3/s (near Erwood)
Length of Study Area: 375 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows are characterized as severely degraded from December to March. No recommendations for flow management were made.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Swan River

Basin: Saskatchewan-Nelson
Sub-Basin: Lakes
Study Area: Headwaters to Manitoba border
Length of River: 400 km
Stream Order:
Mean Annual Discharge: 3.9 m^3/s (near Norquay)
Length of Study Area: 200 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife, water quality
Fisheries Component/Method Used: Tennant Method
Target Species/Life Stages: No species or life stages specified.
Agency Responsible for Study: Saskatchewan Environment/PPWB
Reason for Study: One component of PPWB Water Demand Study of the Saskatchewan Nelson Basin.
Study Focus/Critical Factors: Characterize suitability of existing instream flow for fish.
Date of Study: 1980
Study Cost: $17,500 (includes several rivers in the Saskatchewan-Nelson Basin)
Status of Study: Study complete.
Comments: Study characterized existing flow regimes according to the ratings provided by the Tennant Method. Existing flows range from fair to good in winter to optimum in spring and summer. No recommendations for flow management were made.

References: Prier, M.H. 1980. Environmental considerations in the major tributaries of the Saskatchewan-Nelson Basin (Saskatchewan Sector) In Water Demand Study: Historical and Current Water Uses in the Saskatchewan-Nelson Basin. Appendix 6, Environmental Considerations 1982. Prairie Provinces Water Board.

Qu'Appelle River

Basin: Saskatchewan-Nelson
Sub-Basin: Qu'Appelle
Study Area: Lake Diefenbaker to the Manitoba border
Length of River: 770 km
Stream Order:
Mean Annual Discharge: 7.7 m^3/s (at Welby)
Length of Study Area: 750 km
Number of Study Reaches: Not applicable
Instream Use Studied: Fish, wildlife
Fisheries Component/Method Used: No formal method. Water levels in relation to habitat were observed for various flows.
Target Species/Life Stages: Walleye and northern pike.
Agency Responsible for Study: Saskatchewan Tourism and Renewable Resources
Reason for Study: To determine water flows needed for maintenance of fish and wildlife populations.
Study Focus/Critical Factors: Determine optimum and minimum instream flows for spawning and rearing habitat for walleye and pike.
Date of Study: 1981
Study Cost: Internal study.
Status of Study: Study complete.
Comments: Optimum and minimum flow recommendations were made for the river channel. Minimum flow also corresponds to the minimum discharge required for proper operation of the Katepwa fishway. Optimum, minimum and maximum water level recommendations were made for lakes in the system. Recommendations have not been adopted.

References: Dunn, C.L. and D. Hjertaas. 1981. Water management for fish and wildlife for the Qu'Appelle River system. Wildlife Branch, Department of Tourism and Renewable Resources, Saskatchewan.