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Date of Report: July 1, 2000

Project Completion Date: ~~December 31, 1999~~ July 1, 2000

LCMR Work Program Final Report

I. PROJECT TITLE: **STREAM HABITAT PROTECTION: CONTINUATION**

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Total Biennial Project Budget:

LCMR:	$225,000
-LCMR Amount Spent:	$225,000
=LCMR Balance:	$0

A. Legal Citation: ML 1997, [Chap.216], Sec.[15], Subd.14(d).

STREAM HABITAT PROTECTION: CONTINUATION $225,000.

Appropriation Language: This appropriation is from the trust fund to the commissioner of natural resources to accelerate the stream flow protection program. This is the third biennium of a proposed eight-biennium effort to establish a watershed level stream habitat database and develop the tools to set protected flows for ecosystem diversity. This appropriation is available until June 30, 2000, at which time the project must be completed and final products delivered, unless an earlier date is specified in the work program.

B. Status of Match Requirement: Not Applicable

II. PROJECT SUMMARY AND RESULTS

This program is designed to help protect stream resources by: 1) establishing a watershed-level stream habitat database and, 2) developing the tools to set protected flows based on habitat diversity and ecosystem integrity. The most widely recognized method for developing stream flow recommendations is the Instream Flow Incremental Methodology (IFIM). There are two primary data elements necessary for establishing IFIM-based protected flows: 1) collection of stream data to enable modeling of stream conditions, and 2) collection of habitat requirements for targeted stream fish and invertebrates. Under this funding we will collect stream habitat data (item 1), use it to model the stream, and combine this stream habitat data with information on the habitat requirements of the aquatic community which is collected by our program under a different funding source. Ultimately, we will determine how much water needs to remain in a stream to protect aquatic communities.

The first four years of funding (1994-1997) will have allowed us to: 1) collect hydraulic information on 8 watersheds, at three flow levels each, to develop models of the streams; 2) match this information with habitat suitability models to determine the change in biological habitat with change in flow, for 8 watersheds; 3) develop protected flow recommendations and draft a report summarizing all pertinent information in watershed packages, including sections on hydrology, current use and implications of the protected flows to users. As of this writing we have 7 completed watershed reports.

III. PROGRESS SUMMARY:

Result 1. Collecting Stream Habitat Information.

We are actively pursuing a major development in stream data collection techniques and modeling that has important ramifications for this project. Two-dimensional hydraulic models have been around for at least a decade but until recently have not been applied to research on habitat requirements and instream flow needs. This modeling technique, combined with total station survey equipment and methods for smaller streams and hydroacoustics and GPS survey equipment and methods for larger streams, should enable us to complete work on more watersheds faster and more accurately. We have begun training Program staff in the modeling and field data collection techniques associated with the two-dimensional models.

Generally, we collect data at two separate locations on a study river. We are currently working on 6 river systems: Rainy River, Rock River, Zumbro River, Rum River, Kettle River, and the Snake River (in east central Minnesota). Since our previous report to the LCMR, we have established 2 new sites on the Rainy River and have begun collecting data for use with the new two-dimensional hydraulic models mentioned above. We will also be collecting data for use with the new models, from rivers where we have already collected data for and developed one-dimensional models. This exercise will help familiarize our staff with the new data collection techniques and help us to understand the results produced by the new models.

We had anticipated that we would have completed data collection and would have developed protected flows for the Rock, Cottonwood, Cannon, Zumbro, and Crow Wing watersheds, however, further sites and data collection will be needed in each of those watersheds.

Result 2. Develop Community-based Protected Flows.

As detailed in previous reports, we use the data collected at two (2) sites on each river, and over three (3) flow ranges (low, medium and high) to build and calibrate a hydraulic model of the stream. The created model defines the habitat available at all flow ranges. Over the course of this project, often we have been limited by mother nature (e.g., the past 5 years have been `wet', and collecting data at lower flows has been a limiting factor).

We currently have 7 reports completed. These reports represent a significant body of work, given the complexity of streamflow issues. Each report, while having similar formatting and organization and using techniques outlined in this update, represents a unique solution to stream flow protection for each of the watersheds.

Another key use of the IFIM modeling that we employ is to ascertain the effects of flow regulation at dams. Although we anticipated having one additional watershed report at this time, we have completed a report detailing our recommendations for streamflow protection below a proposed hydroelectric facility on the Minnesota River near Granite Falls. The report was completed as part of the Federal Energy Regulatory Commission's (FERC) licensing process and will be used to assess the impact of the hydroelectric facilities operation on the Minnesota River. This report (available upon request) has been sent to the City of Granite Falls and their consultants Barr Engineering, as well as Department personnel. The data for this study was collected by the US Corp of Engineers and their consultants in exchange for our modeling the sites and using the information to help them examine operation of the Lac qui Parle reservoir. We will coordinate our efforts with the Army Corps of Engineers in the examination of flow regimes from Lac Qui Parle Reservoir over the next year. Time series analysis of the habitat available over time, including comparisons of various dam operation scenarios will be part of the rule curve update for the Lac Qui Parle Reservoir and serve as a basis for our recommendations.

The report used detailing our recommendation for protecting streamflow near Granite Falls is summarized below. The rapids below the Minnesota Falls Dam is a rare habitat along the mainstem of the Minnesota River. The rapids is rare because it consists of large, diverse substrates including those favored by spawning lake sturgeon (*Acipenser fulvescens*) and spawning shovelnose sturgeon (*Scaphirhynchus platorynchus*), and because there is little high gradient habitat along the Minnesota River. Rapids are an important habitat to many species in addition to sturgeon, including paddlefish (*Polyodon spathula)*, walleye (*Stizostedion vitreum vitreum*), sauger (*Stizostedion canadense)*, and redhorse species (*Moxostoma sp.)*. An existing hydroelectric facility on the Minnesota River, owned by the City of Granite Falls, upstream from the proposed Minnesota Falls facility is currently licensed to operate as a peaking facility. The natural flow regime below the Granite Falls facility has been altered by the peaking operation. Proposals for the Minnesota Falls facility state that operations will mitigate the effect of peaking from the Granite Falls Hydro. The river downstream of the proposed facility will benefit from the mitigation, and our recommendations will take advantage of that benefit. Our goal is to protect and restore the riverine and rapids community by maintaining their habitat through flow protection. These recommendations represent operation of the proposed facility that would benefit the river, and at this time do not consider the economics or feasibility of the proposed facility.

The interim values (Table 1) are inadequate based on our IFIM analysis (Table 2). The approach we are recommending to implement our protected flows will allow power production at the proposed hydroelectric facility over a range of flows based on inflows to the Granite Falls facility (in the City of Granite Falls) and "ranges" of habitat protection that take into account the year to year variations of natural flow regimes. The method used to deliver flow to the rapids should also minimize the effect of peaking in the rapids, and distribute flows as evenly as possible across the rapids. Moderating the effect of the peaking operation induced by Minnesota Falls Hydro would be beneficial to the river downstream of the proposed facility, and our recommendations reflect that benefit by allowing operation over a wide range of flows.

Table 1. Interim Flows for the Minnesota Falls Hydroelectric Project.

Season	Interim Minimum Flow
April 1 to May 31	780
June 1 to October 31	300
November 1 to April 1	150

Table 2. Flow protection recommendations for the rapids below Minnesota Falls Dam.

Season	...if inflow to the Granite Falls Facility is....	....then proposed Minnesota Falls Facility would...

April 1 to May 15	> 1400 cfs	maintain 1400 cfs in rapids
	> 850 and < 1400 cfs	maintain 850 cfs in rapids
	< 850 cfs	not operate
May 16 to July 31	> 800 cfs	maintain 800 cfs in rapids
	> 500 and < 800 cfs	maintain 500 cfs in rapids
	< 500 cfs	not operate
August 1 to November 4	> 500 cfs	maintain 500 cfs in rapids
	< 500 cfs	not operate

Result 3. Promote Stream Habitat Protection

Understanding the nature and extent of the threat posed by stream withdrawals is a fundamental step towards promoting protection of stream resources. During the past two fiscal years, we have devoted considerable effort to examine water appropriation levels as a function of available stream water in each watershed. The following are excerpts from our report (***Use and Availability of Surface Water in Minnesota***, included) that details this effort.

In Minnesota, total water withdrawal increased nearly 40% between 1985 and 1995 (Division of Waters 1997). During 1995, surface water accounted for 83% of the total water withdrawals, but only about half when not including power generation use (Division of Waters 1997). However, because Minnesota's per capita water use was one of the lowest of the 50 states, it is easy to conclude that use is at a low enough level to not have an impact. Without study, we simply do not know. Despite the rapid increase in water use in Minnesota and an extensive permit based water management system, water use and availability have not been formally summarized in a temporal or geomorphic scale that will aid in the assessment of habitat impacts due to water withdraws.

This study was designed as an initial reconnaissance survey of readily available data. As such, the estimates of water availability and the percentages of the available water permitted and used are best suited for comparison as relative values among watersheds in this study, for examining trends over time, for identifying watersheds that require a more detailed examination, and for identifying areas of potential controversy. In addition, permitted and reported water use data for individual watersheds will be used along with weighted usable area discharge relationships developed for streams in each watershed to assess biological impacts resulting from potential water use. If the goal of sustainable water management is to maintain stream resources and while allowing some development of the water resources, then information on water availability and use is a fundamental need.

Protecting natural aquatic ecosystems is not only vital for maintaining environmental health, but there are important feedbacks between these systems and both water quality and availability as well (Gleick 1998). Water withdrawals, whether from surface or ground water sources, impact the hydrology and subsequently the river system - both offstream and instream resources. Part of an effective and proactive water management program is to periodically and systematically assess what the impacts of management practices are, in this case, the level of actual and permitted water use. Jermar (1987) describes two general categories of information needed for water management: how much water there is, and the data to protect instream resources and stream function. The first category involves identification and monitoring of the water resource and its use, evaluation of future water needs, and compilation of balances of the resources and needs. The second category involves identifying flows for protecting or sustaining instream resources and stream function, identifying watersheds where the available water resources and offstream use may be in conflict, and include a definition of balance between resource protections and resource use.

Management agencies should be concerned about actively managing all parts of the stream hydrograph not just the low flows Hill et al. (1991). An incremental assessment of impacts related to water withdraws can be accomplished using PHABSIM models and a time series analysis of stream flows and withdraws. However, the first step is to quantify water withdraws in a manner which is temporally and spatially significant to the resource being analyzed. As such, information on water use by month and watershed will be used to assess impacts to stream function and aquatic habitat.

Current water management typically does not review water use in the context of what is available. The state maintains a database on the volume of water permitted and used and is typically summarized annually by a political boundary (county). Describing water resources and water use in a scale that incorporates the variability in time and space would be most useful for assessing environmental impacts. For example when describing water use annually the seasonality of water use and availability is not accounted for. Additionally, water withdrawal is distributed unevenly over geographic regions and does not correspond with the amount of water resources available (Shiklomanov 1997). The results of this analysis represent a new view of the data in which the two forms of information (water availability and water use) were combined in a watershed framework. Our goal was to describe water availability and use in a way that can be used in planning for future water development, provide an assessment of relative impacts resulting from water use and management, and to raise awareness in watersheds of high water use. The specific objectives were to estimate the percent of available river water that was both reportedly used and permitted to be used for each year and each month from 1988 to 1995 for each of the 81 watersheds in Minnesota.

The diversity of the stream's resources are intimately tied to stream flows. In addition to flows that will provide habitat for fish to survive, instream resources require periodic flows that will move sediment and clean gravel for spawning and food production, to maintain the channel shape and characteristics, and to maintain the riparian conditions (Hill et al. 1991). Currently, these flows are typically available, since these higher flows typically occur when demand for water is low with the exception in the Red Lake River basin. However, this does not mean these various higher flows do not require protection and should be monitored, because the future water needs of Minnesota and the possibility of water transfer out of Minnesota cannot be accurately predicted. Maintaining instream resources require long-term planning which involves, in part, developing protection standards that will work under unanticipated water use conditions.

To monitor water use and anticipate water use conflicts, the cumulative volumes of water permitted and used should be documented and compared to a measure of water availability on a watershed scale. Such data will allow one to efficiently document the current level of water appropriations relative to water availability and to estimate the reliability of flows to absorb additional withdraws. Use of an annual probability hydrograph would provide a means of monitoring and presenting the information and would account for seasonal variability in both water availability and use (Dunne and Leopold 1978). By comparing the monthly flow probability with monthly permitted use and reported use one can identify watersheds and time periods where water use conflicts are most likely to occur. Multiple examples of this technique were found and are presented in our report. The graphs reveal both the seasonal availability and variability of water and the probability that the mean discharge will be less than the values indicated. For example in the Pomme de Terre Watershed, it is most likely that a water conflict will occur during the month of August when the mean monthly permitted discharge was roughly equal to the 95% exceedence value. The graph also shows that the mean monthly permitted discharge is higher in the month of July, but it is more likely to have higher amounts of water during this time.

Legally, the Minnesota Department of Natural Resources must establish protected flow levels, which maintain stream resources, including fish and wildlife recreation and navigation. Given that the permit process is a way of allocating water resources among instream resources and users and offstream users, then seasonality of flow and water use should be considered. Two goals must be achieved: one, to allow the flows to occur that maintain stream function and two, to partition some water among offstream users. Under the current practice a permit holder is permitted an annual volume of water and must report the monthly volumes of water actually pumped. If water were appropriated monthly, then seasonality of flows and use could be accounted for.

In addition to permitted monthly volumes, a monthly cap of the cumulative volume permitted within a watershed would provide for long-term resource protection. A cap in the permit level for rivers could work similarly to the limit in the cumulative volume of water withdrawn from lakes, set at one-half acre-foot per acre of surface water (Minnesota Statutes, section 105.417, subdivision 3, clause a). Protected flows are not monitored at all times and cannot be accurately monitored in real time during the winter months, and high levels of use occurred in seven of the twelve months. Consequently, the cap can be considered a regulatory backup in the event a protected flow is not or can not be monitored. The cap would also help protect the higher levels of discharge required to maintain stream function. In addition, the cap provides an area hydrologist with an easily derived limit for each watershed, and would allow quick assessment of demand and water use trends. A stream permit level could be set at some exceedence probability quantile, such as the discharge exceeded 90% of the time. The Q_{90} converted to a monthly volume would then be the cumulative volume that could be permitted. The actual value would be the value that would maintain the relative frequency and magnitude of flows required for channel, riparian, and valley maintenance. An annual probability hydrograph with the cap in permitted volume identified would assist water users that require information on the probability of a particular flow. As noted earlier water permit levels do not appear excessive for the state as a whole, but demand for water is likely to increase, and by setting permit levels and biologically based protected flows now, future conflicts can be limited.

Based on the criteria of having at least two months during the 96 months analyzed in which at least 50% of the available water was permitted, there were fourteen watersheds that were more likely than others to have conflicts between instream resources and offstream users and among the offstream users. The watersheds were concentrated in the western part of the state, particularly the Red River Basin. An annual probability hydrograph was used to examine water use and supply more closely in each watershed. By plotting monthly permitted and reported water use on the annual probability hydrograph one can identify how often a given volume will be available and in turn determine relatively how likely water use conflicts may occur. Of the fourteen watersheds examined, six had at least one month in which the permitted volume was greater than the 90% exceedence value (on average, the monthly total permitted volume was not available 10% of the time).

The highest level of reported water use relative to water availability in the northwest part of the state during the spring. By monitoring permit and reported use levels in a watershed framework and developing monthly permit levels, current areas and months with possible conflicts can be identified. Moreover, impacts to the surface water supply due to additional permits can be identified.

Even in a state such as Minnesota, our water resources are limited. Future management emphasis should be placed on establishing sustainable water levels for each watershed and beginning democratic processes to regulate users, accounting for river ecology, economics, social values and future generations. Water supply is an important constraint in local, regional, and national planning. To insure a proper and consistent supply of water for both offstream and instream resources, the seasonal timing of water must be incorporated in the management practices and the volume of water permitted by watershed must be monitored. In conclusion, there are several points that can be drawn from this project:

1. With the exception of a few isolated watersheds, permit and use levels are at acceptable levels.
2. Based on the permit and use levels and monthly exceedence values, more attention should be concentrated on the following watersheds: Lac Qui Parle, Mustinka, Buffalo, Red Lake River, Upper and Lower Red Lake, and Clearwater.
3. To account for seasonal variation in water availability, a more hydrologically and biologically sound management practice and more administratively intensive would be to appropriate water monthly instead of annually.
4. Water resources should be managed within a watershed framework. This would involve changing the focus from county to watersheds for summaries of use and availability.
5. An annual probability hydrograph should be developed for each watershed, and any month in which the permitted or used volumes exceeded some set level (monthly Q_{90}) more detailed examination of the permits should be performed.
6. The cumulative volume of water permitted should be limited or capped. This will assist with protecting higher stream flows required for the long-term maintenance of instream and near-stream resource diversity and stream function.
7. An important aspect of stream resource protection is to establish protected flow levels, i.e. those flows set aside to protect stream resources, including fisheries and wildlife, recreation and navigation. A cap in the permit level should not be considered a replacement for a protected stream flow level.
8. The permitted volume should be monitored and limited, although the reported use was typically less. The proportion of the permitted volume that was reportedly used was variable and in the case of irrigation, actually increased as available water decreased, resulting in unreliable predictions of actual water use.
9. Estimates of the percent of the available water permitted and used could be improved by addressing the assumptions. If more detailed information for a watershed is required, then readily accessible and usable information on the location of pumping units and

percent permitted could be used to refine the estimate of the available water at the pumping site. Future research on consumptive use and return flow and ground water withdrawals and stream flow interactions would provide valuable information.

IV. OUTLINE OF PROJECT RESULTS

This is a continuation of a long-term project begun in FY94-95. The results listed below represent a continuation of the fundamental components of the program (data collection, modeling and development of flow recommendations and education) as well as a focus into critical water management issues revealed by project findings. Streams and the fish and wildlife habitat in them, are a product of stream flows, as are the resultant fishing, hunting and trapping. When we preserve stream flows, we contribute to the protection of aquatic communities within streams and the aesthetic and recreational opportunities they provide. This project is aimed at changing the way we directly manage water appropriations from our river systems, providing a fundamental step toward biologically based decision-making. The information collected and developed by the project will serve as a basis, within the Department, to begin the rulemaking process for establishing protected flows on Minnesota streams. This initiative is the first statewide program in the U.S. designed to use a fish community approach with the Instream Flow Incremental Methodology (IFIM) to develop protected flows for warmwater and coolwater streams.

- **Result 1: Continue collecting stream habitat information on the 39 major watersheds.**
  Background: The first six years of funding (1994-1999) have allowed us to: 1) collect hydraulic information on 10 watersheds, at three flow levels each, to develop models of the streams; 2) match this information with habitat suitability models to determine the change in biological habitat with change in flow, for 7 watersheds; 3) develop protected flow recommendations and draft a report summarizing all pertinent information in watershed packages, including sections on hydrology, current use and implications of the protected flows to users. Stream flow data will continue to be collected following the Instream Flow Incremental Methodology (IFIM). Representative streams and appropriate sites will be selected from each of the 39 major watersheds. Streams in agricultural watersheds with significant present appropriations or which are prone to increasing future appropriations will be assessed first (Figure 1). Hydrologists from the Department's Division of Waters will be coordinated with for study river selection and water appropriation summaries at appropriate intervals.

  Within a general targeted area, study sites are selected and data collection is begun for a relatively large number of streams. However, because our fieldwork is flow dependent, that is, we collect data when stream flow is near three general levels, (low, medium, high), we are susceptible to the whims of nature. For example, flows may not reach a `low' level in our target streams, as has been the case for the past three years (1993-1995). Also, this work is data intensive - we collect a lot of data on a stream to run the hydraulic models. As is detailed below in Methods, a study site typically consists of up to twenty transects, and velocity, substrate, and depth, as well as water surface measurements are collected at 20 to 50 cells per transect and at the three flow levels mentioned above. Another aspect of Minnesota rivers and watersheds, is that we often have to add study sites on streams in subbasins of the larger watersheds. An example is the Red Lake River watershed, where we have actually established 6 study sites on 3 streams. The Red Lake River watershed has the Clearwater, the Red Lake River, and the Sand Hill; all very important, from a water management perspective. All of the added streams are necessary accessions, because of the level of appropriations and potential controversy. The result of all this is that estimating how many single watersheds you will have complete data sets on by the end of a two year period, starting two years from now, is guesswork. Given the above caveats, we estimate that 6 additional watersheds will have complete data sets by the end of the FY98-99 biennium.

Methods: Sites will be chosen based on channel stability, presence of critical or representative fish and wildlife habitat, availability of hydraulic controls needed for modeling, and accessibility. Within each site, transects will be established across the stream to collect habitat information.

Calibration and quality assurance are key steps in the performance of any IFIM study (Stalnaker 1994). Since all habitat-based stream models rely on empirical measurements of the stream channel structure as inputs, it is imperative that users have an adequate understanding of the basic sampling protocols and knowledge of sediment transport and channel dynamics. All professional staff working on this project have taken a minimum of two IFIM training courses offered by the US Fish and Wildlife Service, including field techniques and PHABSIM modeling. In addition, all staff have taken advanced training in applied fluvial geomorphology.

Product: We will continue to target data collection among the following watersheds: Rainy, Cottonwood, Crow Wing, Lac Qui Parle, Red Wood, Hawk Creek, Mississippi Sauk, Crow, Snake, Rum, Little Fork, Cannon, Zumbro, and Chippewa. Because of the need for sampling each river at three flow levels (low, medium, and high), and the variable nature of precipitation and stream flow over time and space, we cannot make hard and fast declarations as to the identity or exact number of watersheds that will have complete data sets by the end of FY99. Nevertheless, our goal is to collect complete data necessary for modeling 6 watersheds per biennium. For that reason, we have expanded the scope of our targeted area to facilitate data collection under this level of uncertainty to the ~~13~~ 14 major watersheds listed above.

Budget: $56,250 Balance: $0

Completion Date: ~~October 31, 1999~~ June 30, 2000

- **Result 2: Develop community-based protected flows on the 39 major**

watersheds .

Background: Field data collected during this and previous bienniums will be analyzed from representative streams to develop protected flows for aquatic communities on a watershed basis. The Physical Habitat Simulation System (PHABSIM), a collection of models developed by the USFWS, and suitability curves, which present information on the habitat needs of aquatic organisms, will be used to predict changes in stream habitat with changes in flow. Results will be related to watershed variables (e.g., drainage area, soil type, runoff) for application to other un-studied streams in the watershed, and presented in `watershed packages', which represent a compilation of water management information and recommendations for each basin studied. Time series analysis using the habitat/discharge relationships we develop will allow assessment of the impacts of water withdrawals on river resources. We have begun this analysis as a way to research the utility of the recommended flows and predict the effects of water management (see Result 3).

Methods: Hydraulic and habitat modeling can be executed using any number of models (and model options) available within PHABSIM. Each model has advantages and disadvantages as well as specific data requirements. Field data will be collected such that any model or combination of models can be used as needed. Our general strategy will be to run various models and model combinations and compare their outputs to determine which is most appropriate for specific locations. The nature of the field data for each study site and transect will determine which model or combination of models is most appropriate.

Protected flow recommendations will be based on the following criteria: 1) protection of habitat and biodiversity of the aquatic community, 2) protection of habitat for rare and endangered species and, 3) protection of habitat for important game species. Prioritization of these criteria will be specific for each watershed. Community-based recommendations will be developed according to procedures described by Leonard and Orth (1988). Essentially, the approach involves examining the habitat-discharge relationships for appropriate habitat guild representatives and identifying a flow that yields an optimum mix of habitat. The same procedure will be used to examine relationships of flow to the area of six habitat types delineated by Aadland (1993); shallow pool, slow riffle, fast riffle, raceway, medium pool and deep pool. This will assist in the interpretation of habitat-discharge curves and facilitate final recommendations.

Product: With the stream habitat information we will collect this biennium, along with habitat suitability information also collected by the Division, we will model habitat relationships to flow. Our goal is to have final reports, with flow recommendations and supporting information, for 6 additional watersheds, (total of 14 watersheds) by the end of FY99. Modeling and analysis is obviously data dependent, and so the results from Objective A above will determine which watersheds are actually worked on during the biennium. As noted above, the targeted watersheds will be among: the Rainy, Cottonwood, Crow Wing, Lac Qui Parle, Red Wood, Hawk Creek, Mississippi Sauk, Crow, Snake, Rum, Little Fork, Cannon, Zumbro, and Chippewa.

Budget: $156, 000 Balance: $0

Completion Date: ~~December 31, 1999~~ July 1, 2000

- **Result 3: Promote stream habitat protection and system-based water management..**

  Background: To further integrate biologically-based protected flow recommendations into current water management decisions, project results need to be properly disseminated. To have this information incorporated, it first must be made available to the hydrologists writing the appropriation permits and to those who may be impacted by the recommendations. To that end, educational materials and management prescriptions will be developed and then disseminated through established delivery mechanisms. One of the main vehicles for delivery of this information that we will be using is slide presentations, at formal and informal venues. Project staff have used the current study findings to develop numerous presentations on river ecology that have been delivered to over 50 audiences. Current recommendations about various aspects of water flow management, restoration of river channels and river ecology have been delivered to audiences of state hydrologists, state and federal biologists, watershed district engineers, forest service staff, and conservation groups. In addition, 3 peer-reviewed publications are now complete or in preparation.

  Product: Presentations, educational materials and management prescriptions for biologically-based protected flows will be developed. Several projects are underway that will span the FY96-97 and FY98-99 bienniums, including the development of 1-2 information pamphlets that will introduce the issue and our approach to target audiences. During this biennium an emphasis will also be placed on the development of flow management guidelines for maintaining natural river channels. Further information is provided in the attached research addendum.

  Budget: $12,000 Balance: $0

  Completion Date: ~~December 31, 1999~~ July 1, 2000

V. **DISSEMINATION**: Results from this project will be presented at national, regional and state scientific meetings to peers in the fisheries and water management fields. Following presentations, the results will be published, in various forms, in peer-reviewed scientific journals. In some instances, our reports are developed in cooperation with other agencies. The data for the Minnesota Falls Report was gathered in a cooperative effort with the US Corp of Engineers to address several streamflow related issues on the Minnesota River. The reports based on that data will be distributed to Federal Agencies, State Agencies, City Government, and private industry.

An important objective of the Stream Habitat Protection project is to enhance water management and policy activities, particularly in decisions involving protected flow levels for our streams. The groundwork for this has already begun through the Department task force dealing with instream flow issues. Project staff will work with

DNR staff who are responsible for the state's water management, particularly the water allocation permits. Recommendations from this work will be coordinated with Area and Regional Fisheries Managers and Hydrologists. As part of our overall stream protection program, we will be engaging in a formal implementation process. Although the implementation process is not directly related to this LCMR proposal, in terms of specific objectives, it is the ultimate measure of the utility of this work.

Elements of our implementation process will include: watershed-level rulemaking for protected flows, user impact summaries, and an 'objectives-driven' citizen participation program. Staff from the Division of Waters is collaborating with us on the overall program effort and provides input on site selection, appropriation summaries and review of program direction. Continual evaluation and updating is an integral part of our implementation program; as a DNR initiative we will refine our areas of effort to reflect the needs of the program.

VI. CONTEXT

A. **Significance**: Fresh water is the earth's most precious natural resource. Animals and plants living in and around our streams are directly dependent on water, and we are dependent on it for drinking, cooking, bathing and recreation. Water is also vital for agriculture, waste disposal, transportation and industry. Off-stream demand for water is often linked to population growth and can be expected to increase as our population increases. Yet between 1985 and 1993, water use increased by 31% while the state's population grew only 8%.

Even in a `water-rich' state like Minnesota, water shortage is a reality and severe droughts have occurred in the very recent past (e.g., 1930-1934, 1977, 1988). To preserve our water and associated resources for present and future generations, we must protect in-stream values such as fish, wildlife, mussels, recreation, aesthetics and navigation. Fish and other aquatic life are often the primary reason for controversy over in-stream flows. In the past, protected flows were set using hydrologic statistics (protected flows are those flows left in the stream for in-stream uses). We know now that these methods are inadequate and essentially unrelated to the values that need to be protected. Our goal is to develop protected flow recommendations that are biologically valid and can be related to trade-off analysis between in-stream and off-stream uses.

The Instream Flow Incremental Methodology (IFIM) used by this project is the most commonly used instream flow method in North America (Reiser et al. 1989); it is the legally accepted instream flow method in several western states (e.g., California, Washington, Idaho), is well documented in agency manuals and handbooks, and is frequently discussed in published conference proceedings (e.g., Stalnaker 1979, 1981; Milhous 1984; Trihey and Stalnaker 1985). Still, biological expertise is needed in the analysis and interpretation of results produced by the IFIM (Gordon et al. 1992).

The fundamental assumption that population size is a function of habitat area and quality is a basic ecological concept (Odum 1954). However, stream reaches are segments of much larger river systems. Immigration and emigration are key compounding factors limiting the scientific validity of any validation of habitat/ population models. Just as we would not expect an immediate, measurable response in waterfowl populations with drainage or restoration of a wetland, we should not expect the fish population responses to be any less complex. Our work is not intended to supplant protection of our wetlands or restoration of watersheds through integrated resource management. Streams reflect the condition of their basins. This project is aimed at changing the way we directly manage water appropriation from our river systems; providing a fundamental step towards biologically based decision-making. The information collected and developed by the project will serve as a basis, within the Department, to begin the rulemaking process for these protected flows. Additional benefits in defining the relationships between various vertebrate and invertebrate species, stream habitat characteristics and flow may result when the data are integrated with a state GIS, but are considered secondary to the primary study objective of developing community-based protected flows on a statewide basis.

B. **Time**: Stewardship of our watersheds requires an extensive commitment to gathering the basic data that underpins sound management. The intent of this project is to establish a data collection program that will be operable for a minimum of 16 years. At this rate, the monitoring and research program established by this project will be operable for four additional bienniums beyond FY98-99, for a total of eight bienniums. We will continue to seek funding from the LCMR to pursue this work.

C. **Budget Context**: Information to describe the project context and budget history is presented as follows: 1) Funding History which summarizes expenditures for the previous three bienniums; 2) Proposed and Anticipated Expenditures for the FY98-99 and FY00-01 bienniums; and a 3) Detailed Budget for FY98-99.

1. Funding History

	July 91-June 93 Prior Expenditures	July 93-June 95 Prior Expenditures	July 95-June 97 Prior Expenditures
LCMR	-	$ 280,000	$ 215,000
Other State	$ 292,500	$ 227,000	$ 363,000
Non State Match			
In-Kind			$ 15,000
Total	**$ 292,500**	**$ 506,000**	**$ 593,000**

2. **Proposed and Anticipated Expenditures**

	July 97-June 99 Project Period	July 99-June 01 Future Expenditures
LCMR	$ 225,000	$ 225,000
Other State	$ 363,000	$ 363,000
Non State Match	-	-
In-Kind	$ 15,000	$ 15,000
Total	**$ 593,000**	**$ 593,000**

3. **Detailed Budget for FY98-99**:

Proposed Expenditures for the 1997-1999 LCMR Funding Period

Personnel		$ ~~215,000~~	$ 186,629
Equipment			$ 28,371
Acquisition			$ -
Development			$ -
Other			$ 10,000
• Travel	$ 10,000		
	$		
Total			**$ 225,000**

VII. COOPERATION:

This budget will provide funding for ~~3.5~~ 1.3 FTE's in unclassified positions to accomplish the tasks outlined in our work program.

Dr. Luther Aadland
Stream Habitat Program, Fergus Falls
Minnesota Department of Natural Resources

A fisheries research biologist with extensive instream flow experience, Dr. Aadland's primary role will be to coordinate all field activities of the project and direct the data analysis. Dr. Aadland will be donating approximately 30% of his time, at no cost to the project, as part of his overall duties with the Stream Habitat Program.

VIII. LOCATION: A map of the state is attached showing the watersheds where this program is working.

IX. Reporting Requirements: Periodic work program progress reports will be submitted not later than April 15, 1998, November 15, 1998, and ~~April 15, 1999~~ August 15 1999. A final work program report and associated products will be submitted by ~~December 31, 1999~~ July 1, 2000.

X. Research Projects: Refer to Research Addendum

XI. Literature Cited

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