Date of Report: July 1, 1997

LCMR Work Program - Final Report

I. **Project Title and Project Number:** STREAM FLOW PROTECTION

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A. **Legal Citation: ML 95, Chp. 220, Sec. 19, Subd. 9c.**

Total biennial LCMR budget: $215,000
Balance: $0

Appropriation Language: $550,000 of this appropriation is from the trust fund and $445,000 is from the future resources fund to the commissioner of natural resources to implement projects for the acquisition, restoration, improvement, and development of fisheries habitat and hatchery rehabilitation. Up to $215,000 of the trust fund appropriation is available to continue the stream flow protection program for the second 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. Data compatibility requirements in subdivision 14 apply to this appropriation.

B. **Status of Match Requirement:** N/A

II. **Project Summary:** The overall goal of the Stream Flow Protection Program is to develop the water management tools to help maintain Minnesota's stream communities. During the drought of 1976, protected flows were established on more than 30 streams in Minnesota based on hydrologic statistics. The more recent drought in 1987 has shown that these emergency measures are inadequate to protect aquatic life in our streams. The LCMR funding is being used to provide stream data that is integral to our overall stream protection efforts. This program will collect stream habitat data, and combine this with fish, macroinvertebrate and amphibian habitat requirements to develop protected flow recommendations that account for the biological values in our streams. Developing data on the habitat requirements of stream organisms, coordinating program activities and implementing protected flows are other components of the overall stream protection program that this project will serve. Eventually, habitat-based protected flows will be developed and monitored statewide.

III. **Six Month Work Program Update Summary:** We have completed flow recommendations and watershed reports for 5 of Minnesota's 39 major watersheds. The 5 are: the Yellow Medicine (as previously reported), Red Lake, Wild Rice, Buffalo, and Otter Tail River watersheds (reports included with this update). In the next six months we will prioritize establishing at least 3 new sites and collecting as much data as possible at those sites. The three new sites will be established on the Cottonwood, Rock, and Pomme de Terre rivers (Figure 1).

Deviations from our previous work program include: 1), establishing sites and collecting data on the Straight River as part of an effort to examine the sustainability of the trout stream resource under increasing groundwater use within the watershed, 2), increasing the number of sites on the Pomme de Terre River watershed to better characterize the high gradient portion of river, and 3), delaying completion of the St. Croix River report until December. As mentioned in the January 1997 program update, we have collected two sets of flow data from two sites on the Straight River near Park Rapids, MN. The Straight River is probably the most widely recognized trout stream in Minnesota (Waters 1977). Our involvement was requested by the Department's Division of Waters, as part of an effort to examine the sustainability of the trout stream resource under increasing groundwater use within the watershed. Our portion of the study is to quantify the impacts of groundwater withdrawal on the fisheries and invertebrate habitat of the Straight River and help to establish a sustainable water yield in the basin. By this time, we had hoped to collect a low flow data set at our two established study sites and have completed modeling and report writing - however, a suitable low flow never occurred. As a consequence, we were unable to proceed with the project. We hope to collect the needed flow information before October of this year, and then complete modeling and report writing by December.

We had previously reported that data collection was completed for the Pomme de Terre watershed, but after reassessing our sites for that watershed, we concluded that an additional study site was needed to characterize the lower, high gradient portion of that river. The lower St. Croix River watershed report is not complete at this time; the report should be completed by December 1997. Time constraints, and technical considerations related to the stream gage at Taylors Falls, prevented completion of the report at this time. As detailed below, we relate our streamflow recommendations to a calibrated stream gage in the watershed. Streamflow at the USGS gage in Taylors Falls is severely impacted by operation of the Northern States Power hydroelectric generating facility upstream of the gage. Operation of the facility induces severe fluctuations in streamflow which complicates application of our recommendations, by masking the true streamflow upstream of the hydroelectric facility. Operation of the facility and it's impact on the freshwater mussel assemblage of the St. Croix River were discussed in a report included with the July 1, 1995 LCMR Final Report for this program.

Our schedule has been further complicated by a recent request for our participation in a study being coordinated within the Ecological Services section to determine the current distribution, abundance, and habitat associations of the Topeka Shiner (*Notropis topeka*) in Minnesota, to define the flow regimes necessary to support the species. Topeka shiner was first considered for listing as an Endangered Species by the USFWS in 1991 and a preliminary evaluation of its status was prepared in 1993. In Minnesota, the Topeka shiner was designated as a Species of Special Concern in 1984 due to its restricted distribution in the state, its restriction to a landscape dominated by agriculture, and its vulnerability to the effects of flood control, siltation, and other types of water quality degradation associated with agriculture (Coffin and Pfannmuller 1988). In anticipation of the potential controversy related to establishing stream conditions which adequately protect Topeka shiner, will be establishing at least two study sites on the Rock River in southwest Minnesota.

In the next 6 months, we will focus on establishing 3 new sites in southern Minnesota, and completing the St. Croix River watershed report. We will establish 1), a new site in the high gradient lower reach of the Pomme de Terre watershed 2), at least two sites in the Rock River watershed in extreme southwestern Minnesota, and 3), a site on the Cottonwood River.

IV. **Statement of Objectives:**

Objective A. Target collecting stream habitat information on 4 of the 39 major watersheds. Data on stream habitat information (depth, velocity, substrate, width, water surface elevations, etc.,) will be collected during three flow ranges (low, medium, high), on representative streams in 4 of the 39 major watersheds, to enable hydraulic and habitat modeling and prediction of habitat conditions at all flows. At this time, our targeted watersheds are: the Pomme de Terre, Wild Rice, Pelican River Subbasin of the Otter Tail and the Cottonwood rivers.

Objective B. Develop community-based protected flows on 5 of the 39 watersheds, and bring total of completed watersheds to 8.
The emphasis for this biennium will be on completing the modeling and analysis of data collected during the first biennium using a habitat guild approach to the Instream Flow Incremental Methodology (IFIM). With the stream habitat information we have collected previously and that 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 5 additional watersheds, (total of 8 watersheds) by the end of FY97. The targeted watersheds will be: the Otter Tail, Buffalo, Wild Rice, Cottonwood and Pomme de Terre.

Timeline for Completion of Objectives:

	7/95	1/96	6/96	1/97	6/97
Objective A. Target collecting stream habitat information on 4 of the 39 major watersheds.	X	XX		X	
Objective B. Develop community-based protected flows on 5 of the 39 major watersheds bringing total of completed watersheds to 8.	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXX				

V. **Objectives/Outcome:**

A. Title of Objective/Outcome: Target collecting stream habitat information on 4 of the 39 major watersheds.

A.1. Activity: Select IFIM study sites on representative streams in selected watersheds and collect hydraulic and habitat data.

A.1.a. Context within the project: At this funding level, we cannot continue collecting stream habitat data at an adequate level to finish the 39 watersheds. Our emphasis for this biennium is on finishing data collection in 4 of the 39 major watersheds and developing protected flows and producing final reports for as many watersheds as possible.

As before, when we do collect field data, the Instream Flow Incremental Methodology (IFIM) will be used. The amount of data required to run the computer models is very large. Because the current funding level will only cover staff salaries and therefore support a minimum of field work, this portion of the project will continue to collect the necessary stream habitat data in selected watersheds, with the target of completing the data collection for 4 of the 39 major watersheds. As noted below in Objective B, the bulk of funding will go towards modeling and analysis of previously collected data, and write-up of our watershed `packages'.

Stream flow data will be collected following the Instream Flow Incremental Methodology (IFIM). Over the coarse of the 8 bienniums, and providing funding is increased to FY94-95 levels, 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 one). 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 (1992-1994). 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 5 study sites on 2 streams. The Red Lake River watershed has the Clearwater and the Red Lake River, both very important, from a water management perspective. The added sites 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 4 additional watersheds will have complete data sets by the end of the FY96-97 biennium.

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.

A.1.b. Methods: The 4 targeted watersheds for finishing data collection are: Pomme de Terre, Wild Rice, Cottonwood, and the Pelican River subbasin of the Otter Tail. Following methods described in Bovee (1982) and Trihey and Wegner (1981), we will collect stream hydraulic and channel structure data. Field data will be collected in the following sequence: 1) establish transects, benchmark and headstakes; 2) survey a closed level loop to establish the elevation of the headstakes; 3) survey water surface elevations at each transect; 4) measure velocity, depth and substrate along each transect; 5) survey stream bed elevations at each transect; 6) sketch study site and take measurements needed to prepare site map; and, 7) determine station index values, assign weighing factors and photograph each transect.

Transects will be located to characterize both the hydraulic and microhabitat conditions of the study sites. The downstream and upstream most transects should cross at well defined hydraulic controls to allow the greatest flexibility in selecting appropriate PHABSIM hydraulic models. Additional transects will be located across each major habitat type (e.g., pools, riffles, raceways, etc.) and at transitions between habitat types (e.g., riffle tailouts). At a minimum, five to seven transects will be established at each study site as recommended by Trihey and Wegner (1981) for a single riffle-pool sequence. Field measurements will be collected at three or more flows (low, medium, and high). We will record water surface elevations at each transect for each flow and measure a complete set of water velocities at the high flow. Water surface elevations will be surveyed to the nearest 0.001 ft using differential leveling techniques (Bouchard and Moffitt 1965; Brinker and Taylor 1963). To determine if water surface elevation measurements were taken during steady flow, a permanent staff gage will be established at each study site and will be monitored during all field work. All elevations will be "tied" together (i.e., referenced to a common benchmark) to allow the use of the WSP hydraulic model for determining stage-discharge relations. Permanent headstakes will be established at the ends of each transect above the high water mark to serve as points of known elevations for water surface elevation measurements. A closed level loop will be used to establish headstake elevations. Mean column velocity and depth will be measured and substrate described at verticals (measurement points) along each transect. The number and location of verticals will depend on hydraulic and channel structure characteristics. Twenty to thirty measurements are recommended for determining velocity distributions and calculating discharge (Trihey and Wegner 1981). In addition to the permanent staff gage, a temporary staff gage established at each transect will be read immediately prior to taking and upon completing measurements along each transect. Discharge will be calculated after each transect is completed. Mean column velocity will be measured at 0.6 of the depth in water less than 2.5 ft deep, at 0.2 and 0.8 of the depth in water 2.5 to 4.0 ft, and at 0.2, 0.6, and 0.8 of the depth in water deeper than 4.0 ft (Leopold et al. 1964). Velocities will be measured with Price AA and Pygmy current meters equipped with digitizers (digitizers automatically keep track of revolutions and time and converts these to velocity in ft/s). Water depth will be measured to the nearest 0.1 ft with a top setting wading rod. At each vertical, the percent area covered by each substrate type will be recorded to the nearest 10 percent. Substrate will be described according to the following size categories (diameter in inches): silt (<0.0024), sand (0.0024-0.125), gravel (0.125-2.5), cobble (2.5-5.0), rubble (5.0-10.0), small boulder (10.0-20.0), large boulder (20.0-40.0) and bedrock (>40.0).

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.

A.1.c. Materials: Field materials necessary to accomplish this objective are listed under Buchanan and Somers (1969) and include: vehicles, velocity meters with top setting rods, tape(s), surveying equipment, waders, staff gages, headstakes, and data forms. A boat and transect cable with reel may be required for some rivers.

A.1.d. Budget: $0

A.1.e. Timeline: This portion of the project is on-going until all 39 watersheds are studied. For this segment, it will be completed by June 30, 1997.

	7/95	**1/96**	**6/96**	**1/97**	**6/97**	
Site Scoping	X		X		X	Fieldwork
	X		X	X		

A. **Status:** Since the January 1997 update, no new data has been collected. To this point, we have completed data collection for 6 watersheds: the Yellow Medicine, Otter Tail, Red Lake, St. Croix, Wild Rice, and Buffalo River watersheds. We had previously reported that data collection was completed for the Pomme de Terre River watershed, however, we reassessed our sites in that watershed and decided that an additional site was needed to properly characterize the lower portion of the river. It is unlikely that data collection will be completed for that watershed before the next update in December. Of the remaining targeted watersheds listed in A.1.b above, the Cottonwood River Watershed is close to having complete data sets, but is not yet completed. We have completed data collection on the Little Cottonwood River, a subbasin, within the Cottonwood Watershed. A substantial effort will be required to complete data collection on the Cottonwood River because we will need two more sites with complete data sets to adequately cover this large, complex watershed.

We have deviated from our previous work plan priorities during the last year. In addition to the above activities, we have begun work on the Straight River near Park Rapids, and will establish at least one site on the Rock River. The Straight River is probably the most widely recognized trout stream in Minnesota (Waters 1977). This work was requested by the Division of Waters, as part of an effort to examine the sustainability of the trout stream resource under increasing groundwater use within the watershed. A recent United States Geological Survey (USGS) study established a tie between stream flows and groundwater withdrawals. Our part of the study is designed to quantify the impacts of groundwater withdrawal in the fishery of the Straight River and help to establish a sustainable water yield for the basin. Two sites were established on the Straight River and data has been collected at essentially 2 flow levels. We will need to measure one more flow at each site to complete data collection for that river and begin modeling. The Rock River site will be established as part of a study addressing the current distribution and abundance of the Topeka Shiner (*Notropis topeka*) in Minnesota, to determine flow regimes necessary to support the species. The Topeka Shiner was listed as a Species of Special Concern in Minnesota in 1984, and considered for listing by the U.S. Fish and Wildlife Service in 1991. A recent review of data on the species in the Natural Heritage Information System reveals that the Topeka Shiner has been collected from only five streams in the state within the past ten years. All collections were within the Rock River Watershed in southwestern Minnesota. The recent status report on the Topeka Shiner states that "Existing land-use practices, dewatering of streams with associated reductions in groundwater levels and the continuing development of watershed impoundments represent the greatest existing threats to the species (USDI 1993, p. 15). In light of this and other, similar sentiments from other sources, it appears that an analysis of required flow for the species would be important in stemming future declines of the species.

B. **Title of Objective/Outcome:** Develop community-based protected flows on 5 of the 39 watersheds, and bring total of completed watersheds to 8.

B.1. Activity: Model stream habitat data to predict changes in fish habitat with changes in flow.

B.1.a. Context within the project: Field data 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 computer based models developed by the USFWS, 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 streams in the watershed that were not modeled. Detailed descriptions of completed study streams and their watersheds, including hydrology, geology, biology, land use and current water use will be included in a final report (watershed package) for each watershed.

B.1.b. Methods: The targeted watersheds for completion of the modeling are: the Otter Tail, Buffalo, Wild Rice, Cottonwood and Pomme de Terre. 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.

The first step in hydraulic modeling is developing a relation between stage and discharge (i.e., predicting water surface elevations as a function of discharge). Since complete data sets will be collected at multiple flows, and transects will be tied together, stage-discharge relations can be developed using any of the available models (STGQS4, WSP and MANSQ), either separately or in combination. As stated above, all models will be executed to determine which is the most appropriate for each study site and transect. Typically, MANSQ is used to predict the starting water surface elevation at the first transect and WSP is then used to predict water surface elevations at upstream transects. Once water surface elevations are calibrated, velocity distributions will be simulated using the derived stage-discharge relations and the IFG4 model. IFG4 predicts velocities based on Manning's equation.

Once the hydraulic model is developed, criteria describing habitat types (riffles, pools raceways) as delineated by depth and velocity (Aadland 1993) will be input into the model to predict how habitat changes in relation to changes in discharge. In addition, suitability criteria for appropriate representatives (fish, invertebrate, and amphibian species which are found in the river system) of six habitat guilds and other important game and nongame species will be input into the model to determine relationships between habitat and discharge. Related research conducted by the Instream Flow Team, not tied to this proposal, is defining habitat requirements of mussels and other stream invertebrates. Eventually, reptilian, avian and mammalian species may also be included where flow affects important habitat. Community characteristics and species composition will be determined from DNR and other (such as university) stream surveys and our own sampling done concurrently with collection of hydraulic data.

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, termed the Optimum Community Habitat Flow (OCHF). 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.

B.1.c. Materials: Materials necessary to accomplish this objective consist of high capacity IBM compatible computers and the PHABSIM programs developed by the USFWS. The major equipment is in place and in use. Most of the staff has taken the training necessary to run the computer models competently and are experienced in analyzing the data.

B.1.d. Budget: $154,500

B.1.e. Timeline: This portion of the project will be completed by June 30, 1997.

	7/95	1/96	6/96	1/97	6/97
Data Analysis	XXXXXXXXXXXXXX				
Develop Flows	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX				
Interpretation and Report	XXXXXXXXXX		XXXXXXXXXXXX		

B. Status: The Yellow Medicine Watershed report has been completed and has been reviewed by Department staff and other professionals. In addition, we have completed reports for the Red Lake, the Buffalo, Otter Tail, and the Wild Rice River watersheds. The 4 recently completed reports are included, and should be considered "drafts" at this time. An additional review will be completed by Section of Ecological Services personnel, after which, comments will be reviewed and considered for inclusion. Once finalized, the reports, will be distributed to Department personnel, as well as user groups and environmental groups in each watershed, or upon request. The reports will be used by the Department of Natural Resources' Division of Fish and Wildlife, and Waters to guide rule revisions and establish biologically sound streamflow protection levels for their respective watersheds, as well as to help further the understanding of issues related to stream flow in each watershed.

The lower St. Croix River watershed report is not complete at this time. Time constraints, and unresolved issues related to the stream gage at Taylors Falls, prevented completion of the report at this time. However, the report should be completed by December 1997. As detailed below, we relate our streamflow recommendations to a calibrated stream gage in the watershed. Streamflow at the USGS gage in Taylors Falls is severely impacted by operation of the Northern States Power hydroelectric generating facility upstream of the gage. Operation of the facility induces severe fluctuations in streamflow which complicates application of our recommendations, by masking the true streamflow upstream of the hydroelectric facility. Operation of the facility and it's impact on the freshwater mussel assemblage of the St. Croix River were discussed in a report included with the July 1, 1995 LCMR Final Report for this program.

We have changed the terminology used to identify our community-based flow recommendations the Optimum Community Habitat Flow (OCHF) to "Community-based Flow" or CBF. The CBF is the flow that best meets the habitat needs of the diverse biotic communities found in Minnesota's rivers and streams and is based on results from IFIM habitat modeling. CBFs are developed on a seasonal basis to address the seasonally related habitat needs of riverine organisms. The seasonal CBFs serve as the basis for establishing protected flows.

Seasonal CBFs were developed at 12 study sites in four watersheds: Red Lake River, Otter Tail River, Buffalo River, and Wild Rice River watersheds. Because protected flows are going to be monitored and implemented at calibrated stream gages, these CBFs were related to stream gages within the watersheds. This was done by relating the drainage area at each study site to the drainage area of the gages within the watershed. To adjust the CBF discharge to the corresponding discharge at the gage, the CBF was multiplied by the ratio of the drainage area of the gage to the drainage area of each study site.

The following bracket approach for establishing and implementing protected flows at stream gages is being recommended by the Division of Fish and Wildlife to determine when surface water appropriations from rivers, streams, and ditches would be limited or suspended. When the discharge at the gage is greater than 150% of the CBF (the CBF adjusted to the gage), appropriators upstream from the gage would be allowed to withdraw their total permitted amount. When the discharge at the gage is between 50% and 150% of the CBF, total appropriations upstream from the gage would be limited to 20% of the CBF, or total permitted appropriations, whichever is less. When the discharge at the gage is below 50% of the CBF, all appropriations upstream from the gage would be suspended. The middle bracket, when the discharge is between 50% and 150% of the CBF and total appropriations are limited to 20% of the CBF, was chosen because it: 1) is sufficiently wide to be useful as a management tool, 2) encompasses flows that provide the most habitat for most species, and 3) simultaneously allows for some offstream appropriation while protecting instream resources. Abruptly suspending all appropriators within a watershed when the flow at the gage drops below the recommended flow would not be ideal for appropriators, the riverine ecosystem, or regulators. The three tier bracket allows both appropriators and regulators time to adjust operations accordingly as flows drop from one bracket to the next. The bracket approach was based on analyses of historic flow records and resulting effects of various appropriation scenarios on the flow regime.

Bracketed protected flow recommendations were established at two stream gages within the Buffalo and Red River watershed, three stream gages within the Wild Rice River watershed, and one stream gage within the Otter Tail River watershed. By way of example, when flows at the Hawley gage on the Buffalo River (Table 1) are above 183 cfs, appropriators upstream from the gage would be allowed to take their full permitted amount of water. When flows at the gage are between 61 and 183 cfs, total appropriations upstream from the gage would be limited to 24.4 cfs (or 20% of the CBF). Within this bracket, the 20% cap translates into allowing total appropriations that range from 13% to 40% of the available flow (24.4 cfs is 13% of 183 cfs and 40% of 61 cfs). When the flow at the gage drops below 61 cfs, all appropriations upstream from the gage would be suspended. This same approach was used for determining when appropriations would be limited or suspended upstream from the gages in all four watersheds. Detailed descriptions of this approach and the potential impacts to off-stream users is part of each of the 4 watershed packages we have prepared and are including with this report. As we develop the analysis of water use trends and further examine the amount of water available for both in-stream and off-stream uses, our watershed packages will incorporate this information and the potential impacts to users will be clarified.

Table 1. Recommended protected flows and allowable appropriations by season based on the flow at USGS gage no. 05061000 on the Buffalo River near Hawley, MN (see Buffalo River Watershed Report for more details).

Season:	CBF at Hawley gage:	If flow at Hawley gage is:	...then the action for appropriations upstream of Hawley gage:
		>183 cfs	Appropriators may take total permitted amount
April 16 - May 28	122 cfs	61-183 cfs	Appropriators may take a combined total of 24.4 cfs or total permitted amount, whichever is less
		<61 cfs	Suspend all appropriations
		>69 cfs	Appropriators may take total permitted amount
May 29 - April 15	46 cfs	23-69 cfs	Appropriators may take a combined total of 9.2 cfs or total permitted amount, whichever is less
		<23 cfs	Suspend all appropriations

VI. Evaluation: In the FY96-97 biennium the program can be evaluated by its ability to: 1) finish modeling, analysis and report writing on 5 watersheds. More importantly, the overall goal is to have completed 8 watersheds by the end of the second biennium. The emphasis of our work in this biennium will be on completing the modeling and report writing for data collected during the previous biennium. Funding at this level allows for little fieldwork. However, FY 96-97 will allow modeling, analysis, and write-up which is the most time-consuming portion of our program.

The fieldwork for this entails collecting data on at least one stream per watershed, at two sites and 3 flows (low, medium and high) per stream. There is an important caveat to our goal of 8 watersheds completed; because most streams worked on are unregulated, we are dependent on mother nature to provide us with the different low, medium and high flows, during the field season. The past two years (1993 & 1994) are a good example; because of the heavy rains and high stream flows all during the open water season, we have found it impossible to get the low flow data sets on all of our streams. This type of constraint may or may not be a factor in evaluating this project properly for the upcoming biennium. Much depends on the watersheds we are working on and the weather conditions. Additionally, this project can be evaluated by its ability to 2) assess flows in these selected watersheds in terms of habitat requirements for the aquatic community; and, 3) incorporate these habitat needs into an appropriate flow protection scenario.

In the long-term, the project should be evaluated on its ability to successfully use the information collected to implement an instream flow protection program that incorporates the biological values in our agency's water management decisions.

VII. Context within the field: 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). Bovee (1986) identified two classification systems for use in selecting target species for the IFIM, based on 1) fisheries management objectives, and, 2) adaptations of species to riverine environments. We have chosen the latter, as outlined by Leonard and Orth (1988) for warmwater stream systems and present the logic for this approach below (adopted from Leonard and Orth (1988)).

1) Selection of appropriate species and life stages on which to base analyses of instream flow needs is a critical step in determining flow regimes necessary to support fish populations (Orth (1987).
2) Species selection is extremely important because flow dependent habitat characteristics of a stream (e.g., depth velocity, substrate, cover) influence community structure and stability (Gorman and Karr 1978, Schlosser 1982b, Moyle and Vondracek 1985).
3) Changes in these habitat characteristics may cause shifts in species composition (Moyle and Baltz 1985, Bain et al. 1988).
4) Selected species should have, among them, a wide range of habitat needs (Leonard and Orth 1988).
5) Because warmwater streams are characterized by high species richness (Orth 1987), direct analysis of habitat requirements for all species is prohibitive. The guild approach was used to simplify the species selection process.
6) A guild is defined as "a group of species that exploit the same class of environmental resources in a similar way." (Root 1967).
7) Food and habitat are the most important resource axes identified in previous resource-partitioning studies of stream fishes (Ross 1986).
8) Species using similar resources should be affected similarly by the alteration of those resources (Roberts and O'Neil 1985).
9) Consequently, recommendations for instream flow must represent a compromise among the needs of all species (Leonard and Orth 1988).
10) The ultimate objective of instream flow recommendations should be to maintain the integrity of the aquatic biota (Moyle and Baltz 1985). Management objectives will continue to be an important component of selecting target species, but they should accommodate the needs of the entire aquatic fauna (Leonard and Orth 1988).

Several aspects and assumptions of the models are being validated under a separate phase of this project (not LCMR funded). These include transferability of habitat suitability criteria (Aadland and Chisholm, in review) and community response to flow regime. 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.

VIII. Budget context: As indicated above, the other half of this effort to set habitat-based protected flows involves the creation of habitat suitability criteria. Information on the habitat needs of species, during specific times, and for specific life-stages, is wed to the stream hydraulic information that this project collects, through the use of the PHABSIM models. Output of this process is the habitat-flow relationships that form the basis of our protected flows. The habitat suitability criteria portion of this overall effort are being collected through RIM general fund monies at $113,500/year for both the FY94-95 and FY96-97 bienniums.

IX. 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.

An important objective of this 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.

X. Time: Stewardship of our watersheds requires an extensive commitment. The intent of this project is to establish a data collection program that will be operable for a minimum of 16 years at this funding level. Funding beyond the FY96-97 biennium will continue to be requested from LCMR.

XI. Cooperation:
Dr. Luther Aadland
Instream Flow Team, 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.

XII. Reporting Requirements: Semi-annual reports will be submitted not later than January 1, 1996, July 1, 1996, January 1, 1997, and a final status report by June 30, 1997.

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