RED RIVER BASIN FLOOD DAMAGE REDUCTION PROJECT MONITORING PROGRAM

RED RIVER BASIN FLOOD DAMAGE REDUCTION WORK GROUP
TECHNICAL AND SCIENTIFIC ADVISORY COMMITTEE
TECHNICAL PAPER NO. 9
APRIL 2003

INTRODUCTION AND PURPOSE

The Mediation Agreement (dated December 9, 1998) identified monitoring and evaluation as essential components of the flood damage reduction project process, which includes permitting, implementation and operation. The agreement addressed monitoring and evaluation during and after construction for the purposes of ensuring compliance with design parameters and measuring the effectiveness of projects at meeting flood damage reduction and natural resource objectives.

The Flood Damage Reduction Work Group identified a need for a guidance document on monitoring Flood Damage Reduction Projects. The Work Group assigned the preparation of this document to the Technical and Scientific Advisory Committee (TSAC). This document incorporates comments received by Project Teams, Watershed Districts and agencies.

The purpose of a project monitoring program is to:

- measure and document the effects of a specific flood damage reduction project toward achieving the flood damage reduction and natural resource objectives defined by the Project Team and in the Red River Basin Flood Damage Reduction Work Group Mediation Agreement dated December 9, 1998.

The purpose of this document is to:

Define different types of monitoring and how they relate to an overall monitoring program.

Define general roles and responsibilities for project monitoring.

Provide guidance for development of project monitoring plans, including:
- Selection of monitoring plan elements (i.e. variables to be monitored);
- Definition of monitoring methods for different variables and types of projects;
- Monitoring locations and durations for each monitoring element, and
- Considerations regarding who will perform monitoring and evaluation.

Monitoring can occur on four different levels: project evaluation, research and strategy evaluation, basin wide condition, or diagnostic. The four types of monitoring are defined as:

Project Evaluation Level – Monitoring performed at the project evaluation level quantifies the effectiveness of a project in meeting its design objectives and will be project specific. The

funding for this monitoring will be provided as part of the overall project budget. The project monitoring plan will be developed, and the results evaluated, by the Project Team.

Research and Strategy Evaluation Level – Monitoring performed at the research and strategy evaluation level evaluates more general issues. Monitoring programs developed for research and strategy evaluation will not be funded by projects.

Basin Wide Condition Level – Monitoring performed to determine basin wide conditions is useful for evaluation of project results on a basin-wide basis. This monitoring is generally funded and performed by state and federal agencies, which may work with Project Teams to identify basin wide goals, or to develop partnerships to accomplish this monitoring.

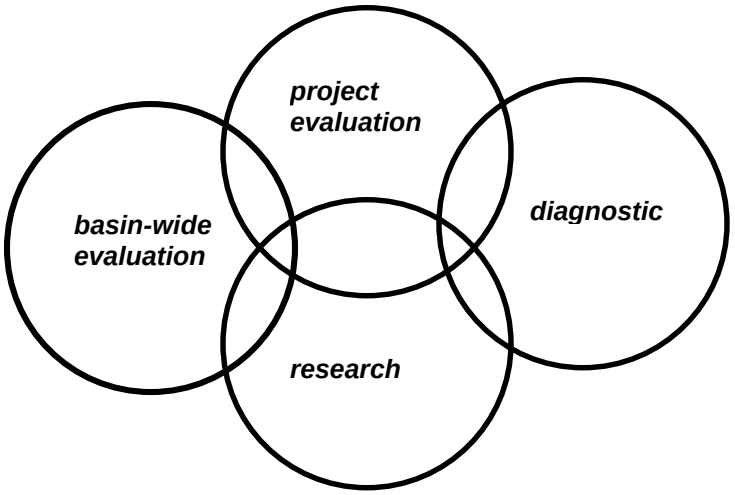
Diagnostic Monitoring – Diagnostic monitoring evaluates unanticipated specific situations associated with the project after construction. Diagnostic monitoring is initiated by recommendation of the Project Team to the Watershed District. That recommendation should include funding options. Diagnostic monitoring is performed for a limited time due to special situations associated with the project. It is not routinely performed.

The monitoring information collected in each of the four levels is inter-related (Figure 1) and potentially useful to Project Teams. Project Teams should identify other monitoring efforts in the area of the project, since other monitoring may provide useful information. Likewise, state or federal agencies may use results of project monitoring for other purposes, including research and strategy evaluation, condition analysis or diagnostic work.

The program for project evaluation monitoring is a function of:

- scope and scale of the project
- adequacy of data already, or being, collected for similar project types
- location of project with respect to basin wide and research level monitoring stations
- project complexity.

FIGURE 1
MONITORING LEVELS RELATION



The tasks included in the project monitoring plan should be tied to the measurement of specific project performance criteria and should not be done for the sake of monitoring.

PROCESS

The Project Team will design the project monitoring plan specific to the project's flood damage reduction and natural resource goals and objectives using this document as a guide. The results of the monitoring program will be included in a monitoring database for the Flood Damage Reduction projects. Therefore, results need to be reported in a format consistent with the database. The general monitoring process flowchart for project evaluation monitoring (Figure 2) shows two stages: development and implementation.

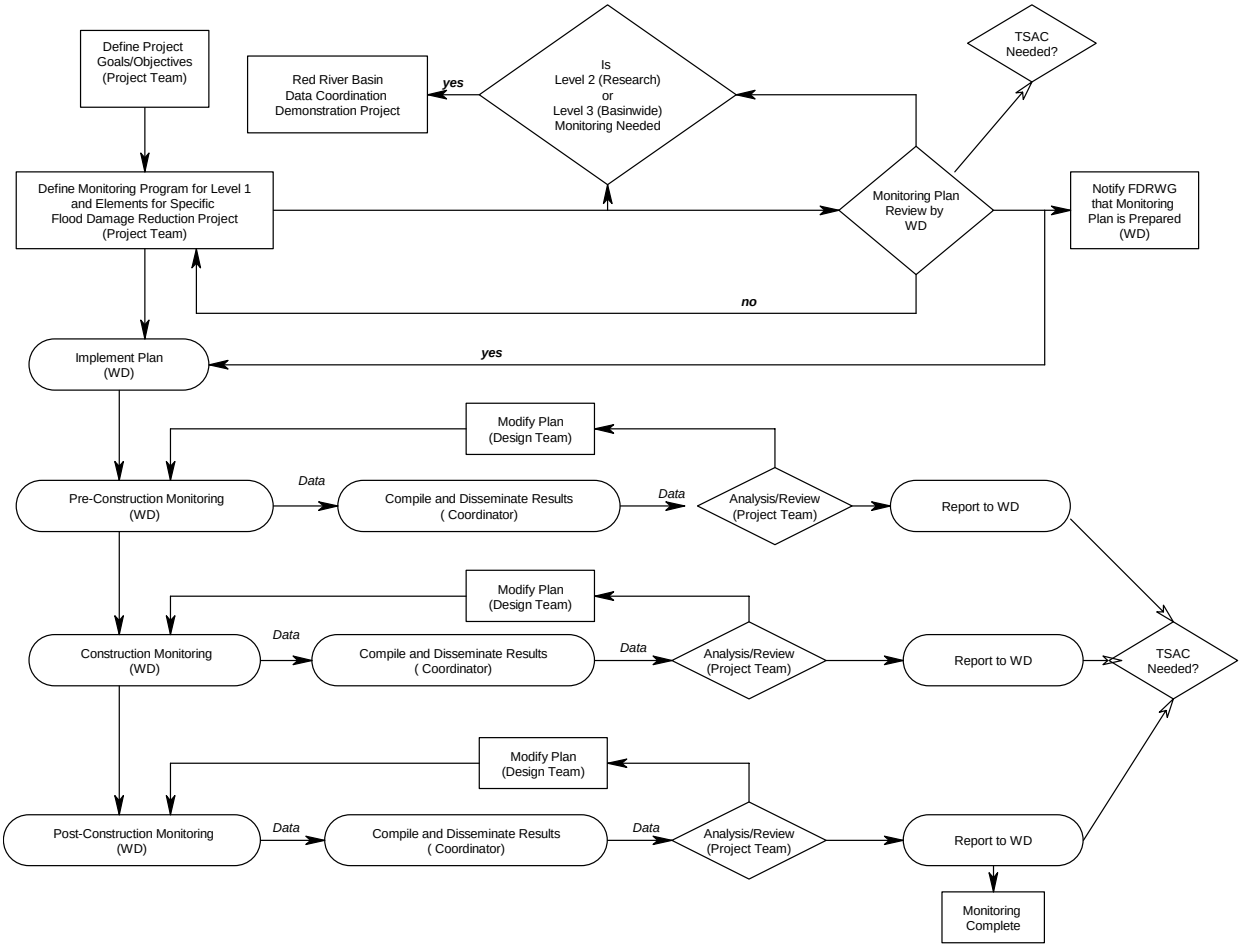
The first step in development of the monitoring plan is identification of the project's specific flood damage reduction and natural resource goals and objectives. The team then prepares a monitoring plan referencing the protocols and methods described in the companion document, *Red River Basin Flood Damage Reduction Project Monitoring Protocols*. The Project Team should also identify other types of monitoring that has occurred or is occurring in the vicinity of the project.

The Project Team then determines the temporal and spatial extent of the monitoring. The number of monitoring locations required to evaluate performance of the project varies according to the project's size and complexity.

The final monitoring plan lists goals of the project, parameters selected to evaluate achievement of the goals, other monitoring efforts in the past and present, location, frequency and duration of sampling, who will be performing the monitoring, equipment to be used for monitoring, and how the results will be evaluated. The Project Team may request assistance, if necessary, through the FDR Work Group for development of the monitoring plan.

Implementation of the project monitoring plan is the responsibility of the sponsoring Watershed District, although several parties may be responsible for execution of parts of the monitoring plan. The Project Team reviews and analyzes the results of the monitoring work throughout the monitoring period and reports these results to the Watershed District. The report documents the project's success in meeting the design objectives, recommends changes to the monitoring program or suggests changes to future project designs. TSAC could also review these reports if directed to do so by the Flood Damage Reduction Work Group.

FIGURE 2
PROJECT MONITORING PROCESS FLOWCHART



MONITORING RESPONSIBILITIES

Several entities will be involved in the monitoring process. These entities and their responsibilities include:

Project Team – The Project Team develops the monitoring plan, prepares a cost estimate, and identifies the funding mechanism for the monitoring plan. The Project Team will be responsible for analyzing and reporting the monitoring results.

Flood Damage Reduction Work Group – The FDR Work Group ensures that project monitoring plans are prepared, and evaluations conducted, consistent with the goals and objectives of the Mediation Agreement.

Watershed Districts – Watershed Districts implement monitoring activities, enter monitoring data into the accepted reporting format, and provide monitoring data to the Project Teams and database coordinator for evaluation and analysis as defined in the monitoring plan.

MPCA and Red River Basin Monitoring Project – The MPCA and this project assist Watershed Districts and Project Teams by conducting condition monitoring, linking condition monitoring to project monitoring, training Watershed District staff on monitoring techniques, protocols and equipment, providing assistance in the development and implementation of project monitoring plans, and advising the FDR Work Group and others on monitoring issues and needs.

Database Coordinator – The database coordinator position, if established, would oversee the collection of monitoring data and the monitoring databases, and ensure that data is disseminated to the Project Team and others for evaluation.

TSAC – TSAC assists the FDR Work Group when requested to do so. This assistance could include review of completed monitoring reports, study of particular problems associated with the monitoring process, assessment of research and basin wide monitoring plans, and review of monitoring methods for consistency, reliability and accuracy.

Others – Other agencies and stakeholders could be assigned responsibility for conducting specialized monitoring activities (e.g. DNR doing fish monitoring) and preparing recommendations for basin wide and research monitoring activities required as part of a project monitoring plan.

PROJECT MONITORING PLAN ELEMENTS

The monitoring plan for each of the flood damage reduction projects is based on the goals and objectives for each project. Once flood damage reduction and natural resources goals are defined, the next step would be to define each monitoring element (*what*) and the reason for each monitoring element to be included (*why*). The plan should also define the "*when*": timing, frequency and duration of monitoring; the "*where*" location of sampling sites, and the "*who*" of the monitoring plan: responsibility for the monitoring data collection, analysis and reporting.

What:

Monitored elements to be considered in the development of the monitoring plan include:

- *Hydrology*
- *Water Quality*
- *Biotic Elements (Plant and Animal)*
- *Channel Stability*
- *Eco-toxicological Elements*

Why:

The monitoring tasks included in the project monitoring plan should be tied to the measurement of specific project performance criteria and should not be done for the sake of monitoring. Some items, such as those covered by eco-toxicological monitoring, should only be monitored when identified as a specific project issue.

When:

Project evaluation monitoring should be conducted:

- *pre-construction*, ideally for two or three seasons before construction
- *during construction*, as necessary, to monitor compliance with design parameters
- *post-construction,* until project goals have been met, which may be five to 10 years.

Where:

Selection of sampling sites is a critical step in developing the monitoring plan. The monitoring plan for each project should include a description of the sampling site, its geographic coordinates, a statement of why the site was selected, and a description of any additional monitoring that has occurred at the site. A photograph and map of the site is also useful. Sampling sites are likely to be located:

- *within project*
- *upstream of project*
- *downstream of project*

Who:

Finally, the monitoring plan should define who will be responsible for the various elements of the monitoring activities. The elements include:

- *Equipment Acquisition and Maintenance*
- *Training of Personnel*
- *Quality Assurance and Quality Control*
- *Data Collection*
- *Chain of Custody for Lab Samples and Specimens*
- *Data Organization*
- *Data Analysis and Evaluation*
- *Reporting*
- *Information Dissemination*
- *Funding*
- *Review and Approval*

As indicated above, the first step in developing the project monitoring plan is to identify the goals of the project. This defines the purpose of the monitoring plan. Goals are broad statements. For example, the Agassiz Valley project has the following goals:

1. Flood Control designed to reduce flood damages downstream;
2. Wetland/Prairie Restoration to provide high quality habitat for flora and fauna;
3. Maintain Tax Base by managing the site to create income;
4. Research how wetlands are affected by bounces caused by flood control projects in northwestern Minnesota;
5. Education and Recreation to create natural trails, observation blinds, and kiosks; and
6. Low Flow Augmentation designed to augment low flows on the Snake River.

The next steps are to define the number and type of parameters to be measured, the frequency of measurement, the duration of monitoring, and quality assurance measures. Continuing the example, the Agassiz Valley Project Team identified stream flow, biological monitoring, channel stability, user satisfaction, tax records, and hydrograph, as the monitoring parameters needed to evaluate the project's success in meeting defined goals.

Each of the monitored elements considered in the monitoring plan development stage should be questioned, so that the completed monitoring plan will specify data collection for the parameters needed to evaluate the project and will not specify the collection of more data than necessary for parameter evaluation. Eco-toxicological elements should be monitored only when required for a specific project issue.

PROJECT TYPE CLASSIFICATIONS FOR MONITORING PURPOSES

Seventeen types of flood control projects were defined in the Red River Basin Flood Damage Reduction Mediation Agreement. For purposes of defining monitoring protocols and requirements, these project types are classified into five more general project types, or categories. Any flood damage reduction and natural resources project may combine features of several project types (e.g. wetland restoration within a large scale impoundment) and the monitoring requirements may also be combinations of approaches for individual project types.

Larger Scale Impoundment Projects:

Project types include:

- *Wet Dam*
- *Dry Dam*
- *On-Stream Storage Impoundment*
- *Off-Stream Storage Impoundment*

Smaller Scale Flow Control Projects:

Project types include:

- *Ditch Gating*
- *Culvert Sizing*

Watershed Land Use Modification Projects:

Project types include:

- *Land Use Changes*
- *Land Retirement*
- *Best Management Practice Incorporation*
- *River Corridor Restoration*
- *Riparian Buffer Strips*

Wetland Oriented Projects:

Project types include:

- *Flood Storage Wetlands*
- *Wetland Restorations*
- *Storage Easements*

Conveyance Improvement Projects:

Project types include:

- *Dredging and Channelization*
- *Setback Levees*
- *Conveyance Improvements*

MONITORING REQUIREMENTS

The Project Team will define specific project monitoring requirements in the monitoring plan. A tabulation of recommendations for monitored elements and their monitoring periods (Table 1) and the locations for this monitoring (Table 2) are provided for guidelines and to provide a basis for consistency among the monitored projects in the Flood Damage Reduction program's monitoring database. Unusual or specific project objectives may require additional, modified, or extended monitoring.

TABLE 1
MONITORING PERIOD GUIDELINES

	PROJECT TYPE				
Monitoring Program Elements	***Larger Scale Impoundment***	***Smaller Scale Flow Control***	***Watershed Land Use Modification***	***Wetland Oriented***	***Conveyance Improvement***
Hydrologic					
Continuous Stage					
Pre-Construction	-	-	-	-	-
Post-Construction	*Project Life*	-	*?*	*?*	*?*
Peak - Staff Gage					
Pre-Construction	-	-	-	-	-
Post-Construction	*Project Life*	*Project Life*	*Project Life*	*Project Life*	*?*
Periodic - Staff Gage					
Post-Construction	*Biotic Monitoring Period*	-	-	*Biotic Monitoring Period*	*Biotic Monitoring Period*
Water Quality					
General					
Pre-Construction	*1 yr.*	*?*	*?*	*?*	*1 yr.*
Post-Construction	*3-5 yrs.*	*?*	*?.*	*?*	*3-5 yrs.*
Specific Constituents					
Pre-Construction	*1 yr.*	-	*1 yr.*	*1 yr.*	*1 yr.*
Construction Period	*as req'd*	-	-	*as req'd*	*as req'd*
Post-Construction	*3-5 yrs.*	-	*3-5 yrs.*	*3-5 yrs.*	*3-5 yrs.*
Biotic					
Vegetation					
Pre-Construction	*1 yr.*	-	*1 yr.*	*1 yr.*	*1 yr.*
Post-Construction	*3-5 yrs., 10th yr.*	-	*3-5 yrs, 10th yr.*	*3-5 yrs, 10th yr.*	*3-5 yrs, 10th yr.*
Birds					
Pre-Construction	*1 yr.*	-	*1 yr.*	*1 yr.*	*1 yr.*
Post-Construction	*3-5 yrs., 10th yr.*	-	*3-5 yrs , 10th yr.*	*3-5 yrs, 10th yr.*	*3-5 yrs, 10th yr.*
Fish					
Pre-Construction	*1 yr.*	-	-	-	*1 yr.*
Post-Construction	*3-5 yrs., 10th yr.*	-	-	-	*3-5 yrs, 10th yr.*
Indicator Species					
Pre-Construction	*1 yr.*	-	-	*1 yr.*	*1 yr.*
Post-Construction	*3-5 yrs., 10th yr.*	-	-	*3-5 yrs, 10th yr.*	*3-5 yrs, 10th yr.*
Channel Stability					
Repeat Aerial Photography					
Pre-Construction	*1 yr.*	*?*	*?*	*?*	*1 yr.*
Post-Construction	*3-10 yrs.*	*?*	*?*	*?*	*3-10 yrs.*
Channel Section					
Pre-Construction	*1 yr.*	-	*?*	*?*	*1 yr.*
Post-Construction	*3-10 yrs.*	-	*?*	*?*	*3-10yrs.*
Channel Profile					
Pre-Construction	*1 yr.*	-	*?*	*?*	*1 yr.*
Post-Construction	*3-10 yrs.*	-	*?*	*?*	*3-10 yrs.*
Sideslope Vegetation					
Pre-Construction	*1 yr.*	-	-	-	*1 yr.*
Post-Construction	*3-10 yrs.*	-	-	-	*3-10 yrs.*

Legend:

x yr. -- *time period range for the monitoring activity (example: 3-5 yrs in the "Post-Construction" row would be monitored during the 3rd, 4th, and 5th years after completion of construction)*

xth yr. -- *defines a final monitoring activity for a specific year (example 10th yr. in the "Post-Construction" row defines monitoring during the 10th year after construction.*

? -- *optional monitoring requirement depending on project size and objectives*

- -- *no monitoring is recommended*

Project Life -- monitoring requirement for the life of the project

TABLE 2
MONITORING LOCATION GUIDELINES

	PROJECT TYPE				
Monitoring Program Elements	***Larger Scale Impoundment***	***Smaller Scale Flow Control***	***Watershed Land Use Modification***	***Wetland Oriented***	***Conveyance Improvement***
Hydrologic					
Continuous Stage					
Pre-Construction	-	-	-	-	-
Post-Construction	*1,2,3*	-	*?,2,3*	*?,2,3*	*2,3*
Peak - Staff Gage					
Pre-Construction	-	-	-	-	-
Post-Construction	*1*	*1*	*4*	*4*	*4*
Periodic - Staff Gage					
Post-Construction	*1*	*1*	*4*	*4*	*4*
Water Quality					
General					
Pre-Construction	*1,2,3,4,5*	1	*2,3*	*2,3*	*2,3,4,5,6*
Post-Construction	*1,2,3,4,5*	1	*2,3*	*2,3*	*2,3,4,5,6*
Specific Constituents					
Pre-Construction	*1,2,3,4,5*	-	*2,3*	*2,3*	*3,4*
Construction Period	*4*	-	-	*2,3*	*3,4*
Post-Construction	*1,2,3,4,5*	-	*2,3*	*2,3*	*3,4*
Biotic					
Vegetation					
Pre-Construction	*2,3,4,5,6*	-	*?*	*?*	*4,5,6*
Post-Construction	*2,3,4,5,6*	-	*?*	*?*	*4,5,6*
Birds					
Pre-Construction	*2,3,4,5,6*	-	*?*	*?*	*4*
Post-Construction	*2,3,4,5,6*	-	*?*	*?*	*4*
Fish					
Pre-Construction	*2,3,4,5,6*	-	-	-	*4,5,6*
Post-Construction	*2,3,4,5,6*	-	-	-	*4,5,6*
Indicator Species					
Pre-Construction	*2,3,4,5,6*	-	-	*?*	*4,5,6*
Post-Construction	*2,3,4,5,6*	-	-	*?*	*4,5,6*
Channel Stability					
Repeat Aerial Photography					
Pre-Construction	*2,3,4,5,6*	*4*	*4,5,6*	*4,5,6*	
Post-Construction	*2,3,4,5,6*	*4*	*4,5,6*	*4,5,6*	
Channel Section					
Pre-Construction	*2,3,4,6*	-	*?*	*?*	*4,5,6*
Post-Construction	*2,3,4,6*	-	*?*	*?*	*4,5,6*
Channel Profile					
Pre-Construction	*2,3,4,5,6*	-	*?*	*?*	*4,5,6*
Post-Construction	*2,3,4,5,6*	-	*?*	*?*	*4,5,6*
Sideslope Vegetation					
Pre-Construction	*4*	-	-	-	*4*
Post-Construction	*4*	-	-	-	*4*

Legend:

1. *Project Outlet*
2. *Permanent Watershed District monitoring station location upstream of project*
3. *Permanent Watershed District monitoring station location downstream of project*
4. *Representative location within improvement project limit*
5. *Immediately upstream of project*
6. *Immediately downstream of project*

? General locations to be established by Project Team based on project size and focus

MONITORING METHODS

This section introduces the concepts behind monitoring parameters related to project performance. Actual protocols are provided in a separate document, “Red River Basin Flood Damage Reduction Project Monitoring Protocols”.

HYDROLOGIC MONITORING

The amount of water influenced by a project is a critical measure of both flood damage reduction and natural resource enhancement objectives. The variability of steam flow has a primary influence on the biotic and abiotic processes that determine the structure and dynamics of stream ecosystems. Although high flows can cause flood damages, they also provide ecological functions of transporting sediment and connecting floodplains and wetlands to the channel.

Project Teams will have to decide whether to monitor for stage, flow or both. Stage is defined as the height of the water surface above a fixed elevation, generally applicable to measurement of flood damage reduction goals. Discharge is a measure of water flow and is used to measure natural resource enhancement goals. Hydrologic monitoring is required for assessment of both flood damage reduction and natural resource objectives. Although monitoring requirements for both are often similar, significant differences do exist.

When monitoring for flow, the plan will specify the method for obtaining flow values from measured stage data. It will be necessary to periodically calibrate the stage-discharge tables for the monitoring sites throughout the monitoring period.

Measurement of precipitation may be necessary, especially if changes in land use have occurred. The correlation between precipitation and stormwater runoff is an effective measure of effects of land uses on water resources.

Flood Damage Reduction Objectives -- Hydrologic monitoring assesses achievement of flood reduction objectives, and, provides information for calibrating the hydraulic models used to analyze the size, type and placement of future flood reduction projects in the Red River Basin.

Natural Resource Objectives -- Hydrologic monitoring requires the measurement of the flow regime in a stream over a range of conditions and flows. Natural resource objective hydrologic monitoring should show the frequency and duration of inundation of the floodplain. This information may be obtained from continuous hydrologic monitoring gage data or through the use of staff gage data read several times during the major storm events.

Protocols for hydrologic monitoring are included in the reference document “Red River Basin Flood Damage Reduction Project Monitoring Protocols”.

WATER QUALITY MONITORING

Water quality describes the suitability of water for a particular use based on selected physical, biological, and chemical characteristics. Therefore, water quality monitoring occurs when water quality is a stated goal of the project. For example, projects that have a goal of improving aquatic habitat may choose to monitor water quality to measure achievement of that goal.

Water quality monitoring should be limited to constituents identified in the project's goals and objectives. Measurement of pH, water temperature, dissolved oxygen and conductivity will answer water quality questions about the basic condition of the resource. These parameters can be measured in the field using meters or can be monitored continuously using a fixed recording station.

Additional questions about water quality conditions – such as the amount of sediment or nutrients – may require collection of water samples for analysis by a Minnesota Department of Health certified lab. These parameters could include total phosphorus, ammonia, nitrate-nitrite, total Kjeldahl nitrogen, total dissolved solids and total suspended solids. It requires training for staff who will collect samples, defined operating procedure for all the steps in the process from collecting samples, preparing samples for shipment, and quality assurance measures to assure confidence in results.

Protocols for water quality monitoring are included in the reference document "Red River Basin Flood Damage Reduction Project Monitoring Protocols".

ECO-TOXICOLOGICAL MONITORING

Specific condition monitoring is performed as a response to a specific project concern, or as a permitting issue. The Project Team should define probable situations that may require specific condition monitoring (e.g. avian botulism, methylated mercury presence, fish kills). The occurrence of this situation would trigger the implementation of specific condition monitoring as a diagnostic monitoring effort. If specific condition monitoring is expected to be required, the Project Team should describe the test and the monitoring protocol as part of the permitting process.

Protocols for water quality monitoring are included in the reference document "Red River Basin Flood Damage Reduction Project Monitoring Protocols".

BIOTIC MONITORING

Biological assessments are evaluations of the condition of waterbodies and upland resources, using surveys and other direct measurements of resident biological organisms (vegetation, birds, macroinvertebrates, and fish). Biological assessment results are used to answer the question of whether waterbodies support survival and reproduction of desirable fish, shellfish, and other aquatic species -- in other words, if the waterbodies meet their designated aquatic life uses.

Monitoring biological conditions demonstrates achievement of natural resource enhancement goals as defined by the Project Team. Pre-project monitoring should generally be done to establish base conditions for comparison. Hydrologic monitoring for evaluation of natural resource objectives should be done during the period of biotic monitoring.

Fish and invertebrate community data are paramount when determining the functionality of aquatic systems, which includes the watershed in which they lie. Aquatic biotic communities reflect watershed conditions because they are sensitive to changes in a wide array of environmental factors, which usually result from processes that occur in the upland, riparian, and floodplain areas. Therefore, if biotic communities change and/or deviate from what naturally would occur in the area, then stream or wetland functionality has likely changed.

Vegetation

Monitoring changes in plant communities will likely be an important component related to project objectives. Both upland and wetland plant communities may be involved. Wetland plant communities may be further subdivided into emergent zones and submergent/open water zones. Specific monitoring techniques will vary somewhat depending on the plant communities found in the project and the objectives of the project.

At the most basic level, monitoring should include the mapping of plant communities on air photos. Plant communities would be confirmed/identified by ground-truthing. A template for a list of plant communities is included in TSAC Technical Paper No. 12, "Wetland Hydrology and the Effect of Water Level Bounce on Wetland Diversity". Project Team members with basic botanical skills would be able to complete this level of monitoring.

Aerial mapping of plant communities can be supplemented, at the next level, with field measurements of vegetation coverage and plant species composition. The Minnesota Pollution Control Agency (MPCA) uses releves in the wetland emergent zone as the basis for using vegetation to assess wetland conditions and to develop an Index of Biological Integrity (IBI). In the wetland submergent/open water zone, plant species composition and abundance can be documented using techniques adopted by the MN DNR (MN DNR Shallow Lake Survey Manual – currently in draft form). Use of the timed meander search technique (Goff, et al, 1982) will provide a measure of vegetative diversity over a larger area in both upland and wetland habitats. Each of these techniques will require a higher degree of plant identification skills.

Specific protocols for vegetative monitoring are included in the reference document "Red River Basin Flood Damage Reduction Project Monitoring Protocols".

Birds

Birds can indicate the integrity (health or condition) of a landscape in addition to the integrity of individual wetlands (U. S. EPA, 2002). Monitoring changes in bird populations and use will help to evaluate the natural resource benefits of flood damage projects and will also help in the eventual development of wetland bird indices of biological integrity. When developing project goals and objectives related to avian populations, Project Teams may wish to consider key objectives of the *North American Waterfowl Management Plan*, the *Partners in Flight Conservation Plan*, and the *Northern Plains/Prairie Pothole Regional Shorebird Conservation Plan.* These plans each identify species of concern and habitat conservation objectives for both breeding and migrating birds.

Specific protocols for avian monitoring are included in the reference document "Red River Basin Flood Damage Reduction Project Monitoring Protocols".

Fish

Fish communities are excellent indicators of aquatic system "health" and functionality. Fish communities typically include species representing several trophic levels (e.g., omnivores, herbivores, insectivores, and psicivores). Meaningful water quality or instream habitat changes will alter trophic interactions and change the species composition of the fish community. By knowing the abundance (total number of fish), the diversity (number of different species), and trophic (food web) interactions, we get an idea of how "healthy" the fish community is in a given area, which gives an indication of how healthy the stream is and whether it is functioning

properly. This document assumes that the Minnesota DNR will provide the fish monitoring for Flood Damage Reduction Projects and, therefore, no specific methods are given.

Macroinvertebrates

Macroinvertebrates are organisms that are large (macro) enough to be seen with the naked eye and lack a backbone (invertebrate). They inhabit all types of running waters, from fast-flowing mountain streams to slow-moving muddy rivers. Examples of aquatic macroinvertebrates include insects in their larval or nymph form, crayfish, clams, snails, and worms. Most live part or most of their life cycle attached to submerged rocks, logs, and vegetation.

Aquatic macroinvertebrates are good indicators of stream quality because:

- They are affected by the physical, chemical, and biological conditions of the stream.
- They can't escape pollution and show the effects of short- and long-term pollution events.
- They may show the cumulative impacts of pollution.
- They may show the impacts from habitat loss not detected by traditional water quality assessments.
- They are a critical part of the stream's food web.
- Some are very intolerant of pollution.
- They are relatively easy to sample and identify.

The basic principle behind the study of macroinvertebrates is that some are more sensitive to pollution than others. Therefore, if a stream site is inhabited by organisms that can tolerate pollution, and the more pollution sensitive organisms are missing, a pollution problem is likely. For example, stonefly nymphs, aquatic insects that are very sensitive to most pollutants, cannot survive if a stream's dissolved oxygen falls below a certain level. If a biosurvey shows that no stoneflies are present in a stream that used to support them, a hypothesis might be that dissolved oxygen has fallen to a point that keeps stoneflies from reproducing or has killed them outright.

Sample collection and analysis methods for macroinvertebrates are specified in the reference document “Red River Basin Flood Damage Reduction Project Monitoring Protocols”.

Stream Corridor

The benefits of healthy, properly functioning riparian area to the physical and biological components of a stream system are widely recognized. These include, but are not limited to: filtering sediments and agricultural chemicals, stabilizing stream banks, reducing erosion, dissipating energy during high flow events, promoting water absorption and storage, and providing habitat for aquatic and terrestrial animals. Information gathered on riparian areas is designed to give us an indication whether physical processes in the riparian area are functioning properly, functioning properly but at risk of degradation, or not functioning.

Methods for assessing riparian zone function are included in the reference document “Red River Basin Flood Damage Reduction Project Monitoring Protocols”.

Channel Stability

Natural, properly functioning stream channels are stable when they maintain a consistent dimension, pattern and profile over time. Stream channel morphology is determined by stream

features and fluvial processes including: channel width, depth, slope, and roughness, water velocity, discharge, sediment load and sediment size. A change in one or more of these variables initiates a series of stream channel adjustments as the stream progresses toward a state of stability. Information on stream channel morphology provides insight into stream stability and function and can be used to predict channel behavior, guide management direction and design effective restoration projects.

Methods for assessing channel stability are included in the reference document "Red River Basin Flood Damage Reduction Project Monitoring Protocols".

MONITORING PROGRAM DATABASE

The rapid change of data storage and retrieval methods makes it difficult to recommend a specific data storage protocol. However, several issues are likely to be critical to successful data storage and retrieval. These issues result from the need for the data to be analyzed and used in a variety of applications by people with different backgrounds and experience.

Thus, considerations in developing the database storage system will include:

- Consistency of the data quality and format
- Similarity of monitored parameter data with respect to type, accuracy, and precision, so that past, present and future data can be compared
- Storage of the data for all projects within the Basin in a consistent format
- Storage of the data in a manner which will allow future retrieval with changing technological systems

The MCEA publication "Information Assessment for Creating a Web Site Serving Flood Damage Reduction and Natural Resource Projects in the Red River Basin of Minnesota" (Chapman, 2001) lists many present database repositories for Red River Basin monitoring data. Many of these repositories could be used to receive and maintain the project monitoring data. In addition, the document lists several organizations which will collect some part of each project's monitoring data and that will likely maintain collected data within their database systems.

Thus, the Project Team will need to recommend who will collect the monitoring data, who will receive, organize and maintain the databases for the collected data, and how the collected data will be provided for their analysis of project performance.

TSAC has developed a proposed monitoring data management concept as a start for the process. The concept recognizes that those with a use for data will be those most likely to maintain the database in a useful manner. This concept has not been tested against the financial considerations or political considerations which could be factors in the database management process. The concept includes the following components:

- *Data Collection and Quality Control*
- *Data Organization*
- *Data Analysis, Evaluation and Reporting*
- *Data Information Dissemination*

DATA COLLECTION AND QUALITY CONTROL

Responsibility for monitoring data collection and control of the data quality will be assigned by the Project Team.

The selection process evaluates capability of the proposed data collection group to perform the monitoring work over an extended time (see time periods for monitoring previously tabulated in Table 1); the capability to perform the monitoring work according to established protocols; and the capability to perform the monitoring work at the lowest costs.

As part of each monitoring plan, the Project Team should identify who will be performing monitoring and collecting data. The monitoring plan should define who will provide monitoring services, fees for those services, and conditions for the services. Whoever sets up the plan is responsible for setting up the monitoring. The actual monitoring should be done by the Project Team member or agency with expertise in that discipline.

Agencies or organizations that may be responsible for performing the project monitoring tasks in suggested order of priority include:

Hydrologic Monitoring

continuous stage data -- Watershed Districts, Watershed District consultants, USGS, DNR

staff gage data -- Watershed Districts, volunteers

Water Quality Monitoring

Field measurements -- MPCA, Red River Monitoring Project, Watershed Districts

Nutrients and sediments MPCA, Red River Monitoring Project, Watershed Districts

Eco-toxicological Monitoring

MPCA, Watershed Districts, universities

Biotic Monitoring

vegetation -- DNR, Watershed Districts, US Fish and Wildlife Service

birds -- DNR, Audubon chapter, US Fish and Wildlife Service, Watershed District consultants, universities

fish -- DNR

macroinvertebrates -- DNR, MPCA, Watershed Districts, consultants, universities

stream corridor -- DNR, MPCA, Watershed Districts, consultants, universities

Channel Stability

channel section and profile -- DNR, MPCA, Watershed Districts

DATA ORGANIZATION

Data organization includes the tasks of receiving the data from the data collectors, checking the data format and correcting the format to fit data into a data base (as necessary), and disseminating the monitored data to the project team for their analysis and evaluation. Since the flood damage reduction program will eventually consist of many projects, it is strongly recommended that a single organization (through the use of a database coordinator) be responsible for making sure the monitoring information is collected in a timely manner and that databases used as data repositories are being maintained in an useable manner. The database coordinator could also assist access to multiple databases used by Project Teams.

Watershed Districts will be responsible for organizing monitoring data and disseminating this data to the Project Teams. Participating state agencies are asked to store data they have collected in the agency databases. The project's monitoring plan should define how data will be organized, and who will be responsible for the data organization.

METHOD

Data storage should include:

- Project description data
- Sampling data
- Quality assurance measures

Project description data includes project name, location, type, descriptive characteristics and contacts. Project-level data would not change but would be used in annual reports or for future research.

Sampling data includes sample specific data and field sheets, identifying what type of data was collected, when, and where, laboratory analysis data and quality control/quality assurance records. Separate record layouts would be needed for the several types of monitoring data (hydrology, water quality, biotic elements, channel stability, and specific constituent elements).

Quality assurance measures indicate the credibility, reliability and accuracy of results. Measures used are specific to the types of monitoring. For example, field blanks and duplicate samples are typical quality assurance measures for water quality sampling.
Hard copies could be stored with the project proposer; electronic data could be entered into either relational databases (e.g. ACCESS™), spreadsheets (e.g. EXEL™) or GIS/CAD (e.g. ArcView™ , AUTOCAD™) that can be easily retrieved by the Project Team for analysis.

DATA ANALYSIS, EVALUATION AND REPORTING

DATA ANALYSIS AND EVALUATION

Data analysis and evaluation is proposed to be done primarily by the Project Team with assistance from others selected for analysis of specific data. The following flowchart (Figure 3) illustrates a process for analyzing monitored projects. This analysis would typically be done annually. Figure 3 is for the project level data analysis, evaluation and reporting. Others will analyze data for the basin-wide and research monitoring, and specialized analysis will be needed for any diagnostic monitoring.

Project Team -- The Project Team is charged with analysis of monitoring data to determine the success of the project in meeting the design objectives and with making recommendations for changes to both the project and to similar projects based on monitoring results. The project team provides important continuity between the design objectives and the actual results and should meet as a team at least annually during the monitoring period to interpret the monitoring results in terms of project objectives. This task can be assigned to specialized members of the Project Team, agencies or selected consultants with this expertise. The analysis should be in the form of an annual report that describes the results of the analysis for the preceding year and recommendations, conclusions, and a statement of the project's success in meeting the design objectives. If no monitoring was done during the year, the annual report would simply state that. Project Teams and Watershed Districts could use contracts to assure that monitoring and data reporting continue for the duration of the monitoring plan.

Consultants and Agency Staff -- Consultants and agency staff may be asked to analyze monitoring data due to time limitations of the Project Team and staff limitations of the Watershed Districts. The activities to be performed by these specialists should be identified and budgeted by the Project Team as part of the design documents preparation so that appropriate contracts can be established by the project sponsor.

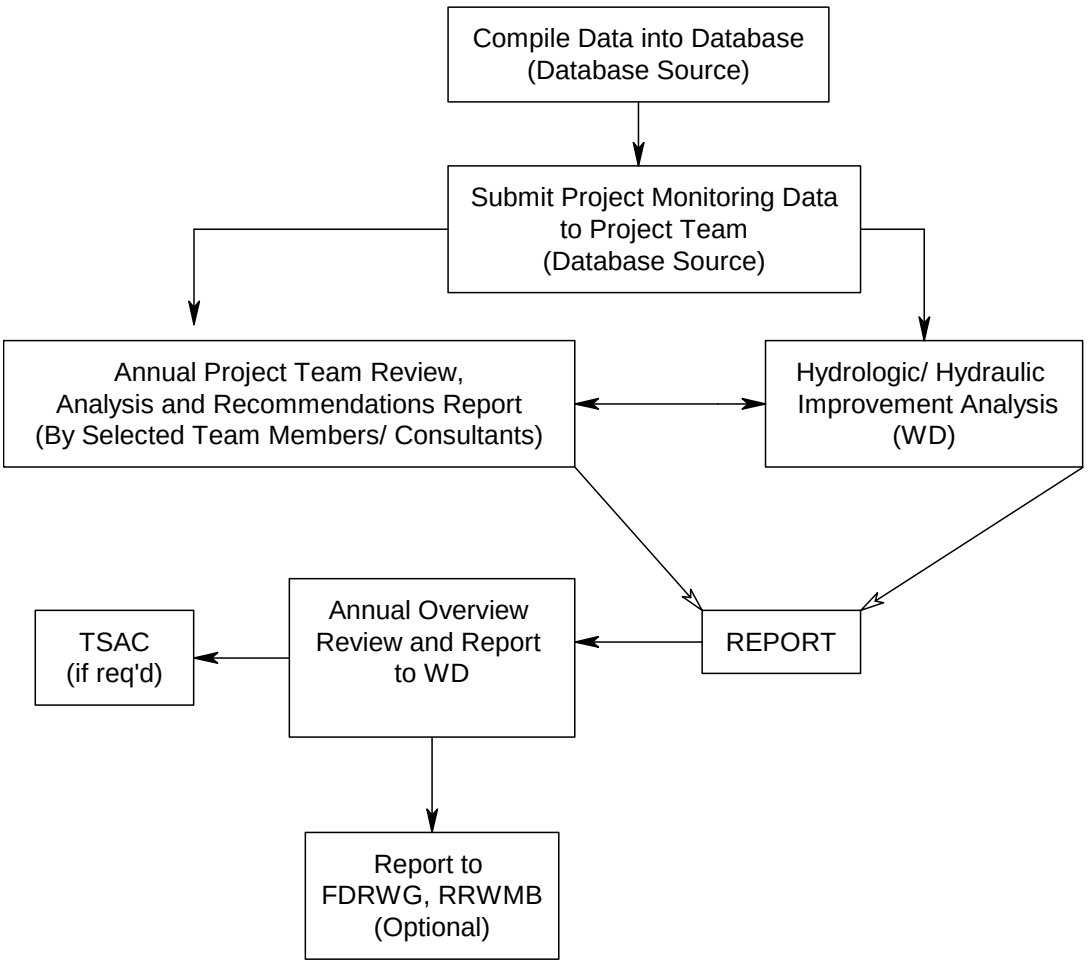
Data generated by project monitoring that can be stored in state and federal databases will be forwarded to those agencies for entry.

Watershed Districts -- The Watershed Districts would be the principle analysts of the hydrologic and hydraulic information collected in the monitoring program. Additionally, the Watershed Districts would compile the monitored data for which they are assigned responsibility and disseminate this data to the Project Teams. The Watershed Districts will also be responsible for annually incorporating monitored data into the Watershed District's hydrologic and hydraulic models, both as a measure of assessing project post-construction impact on watershed flooding and for making modifications to the watershed model.

Flood Damage Reduction Work Group -- The Work Group may act on funding requests for project modification based on monitoring results if requested to do so by the project sponsor.

TSAC -- TSAC may provide technical assistance for the different project types and provide guidance to the FDR Work Group, as requested.

FIGURE 3
MONITORING DATA ANALYSIS AND DISSEMINATION PROCESS



REPORTING

Project monitoring reporting should be done on an annual basis over the monitoring period. The intent of the annual monitoring report is to provide an ongoing record of the project's success in meeting design objectives and to provide a record of problems and recommendations resulting from the monitoring process.

Depending on the detail required in the monitoring plan, the report may include the following:

- monitoring data results

- monitoring data analysis results
- conclusions of the project's effectiveness in meeting design objectives based on the monitoring analysis
- any recommendations for project modification
- any recommendations for monitoring program modification
- statement of report approval by the Project Team members

It is recommended that the Project Team prepare the annual monitoring report for the Watershed District (Figure 3), distribute the report for review and comment, revise as necessary and then submit the completed annual report to the Watershed District.

DATA INFORMATION DISSEMINATION

The Red River Basin Decision Information Network is a Web-based virtual database developed as a result of planning by the International Red River Board in response to the Flood of 1997. The Red River Basin Commission has helped develop the Red River Basin Data Information Network (RRBDIN) to help local resource managers use available information, including monitoring data, in decision-making and to compare conditions across watersheds. It provides the means to enter, store and report data, and helps managers use data in project review and decision-making. Using this network could accomplish the following:

- Use the existing monitoring guidance to develop a common reporting format for water resource project monitoring in Red River Basin watersheds. This includes field sheets, data entry sheets, and project reporting forms. The reporting system will be based on MS Access, with the ability to provide paper reports.
- Establish a common data storage location.
- Establish a data-reporting feature that provides reports about monitoring by project, by parameter and by watershed.
- Provide necessary training and support to participating Watershed Districts for use of the data project.
- Incorporate review of relevant data into Watershed District activities.
- Report to Watershed Districts, state agencies, Red River Watershed Management Board and Flood Damage Reduction Work Group about projects and watershed conditions.

A critical goal is the use of data in management of projects and in decision-making to build new projects.

There are three distinct products proposed:

1. Products necessary for data entry;
2. Products necessary for preparation of reports, and
3. Products necessary for training.

Products and reports would be distributed through the FDR Work Group. Products and reports would also be distributed electronically on the Red River Basin Decision Information Network.