Fargo-Moorhead Flood Risk Management Project

Minnesota Environmental Impact Statement: Draft Adaptive Management and Monitoring Plan

Appendix B
Vs. 2 – May 2016
Final EIS

This document was drafted for inclusion to the Minnesota state EIS and includes recommendations for the adaptive management and monitoring approach, specific protocol, and additional studies different to or above that which the USACE and Diversion Authority have proposed. This draft document was a collaborative effort between state and federal agencies, the Diversion Authority, and agency and organization representatives (consultants). The adaptive management discussions herein as well as the monitoring plans included will be revised with input from the Monitoring sub-teams and Adaptive Management and Monitoring Plan Team as new information becomes available pertaining to Project design and/or Project operation; plan details, participants, funding or schedule refinement; as field data is collected and analyzed; or as necessary for permits by regulatory authorities.

The FEIS Vs. 2 Draft AMMP includes only minor text edits over the DEIS version. Studies have not proceeded since the publication of the DEIS; however ongoing discussion revolving around mitigation have continued. The USACE has selected the Project as a demonstration project using a Split-Delivery Method. This is anticipated to shorten the Project construction timeframe from 8.5 years to 6.5 years. Those changes may impact the ability to perform the recommended amount of proposed pre-construction surveys; however, that would depend on when Project operation would be implemented. The adaptive management approach allows for these types of changes to the monitoring plans. It is for these reasons and others as discussed above, that this document remains in DRAFT format.

INTRODUCTION

The Fargo-Moorhead Flood Risk Management Project (Project) is located in the Fargo-Moorhead Metropolitan Area, within the area from approximately 12 miles west to 6 miles east of the Red River and from 20 miles north to 20 miles south of Interstate Highway 94. The Project consists of a diversion channel system including, but not limited to: excavated channels; control structures; tie-back embankments; an upstream staging area; levees; and environmental mitigation projects located inside and outside the project area. The purpose of the Project is to reduce flood risk, flood damages and flood protection costs related to flooding in the Fargo-Moorhead metropolitan area.

Investigations completed prior to and during the preparation of the Minnesota State Environmental Impact Statement (EIS) have determined that the Project has the potential to adversely affect natural resources. Specifically, the EIS has defined that the Project would result in impacts for aquatic habitat, riparian forest, and wetland resources. For these impacts, mitigation measures will be implemented to offset these adverse effects to the greatest extent practicable. For these impacts that have been defined to have a potential for adverse effects, monitoring plans have been prepared that will help to assess mitigation effectiveness and identify any appreciable changes to the environment outside that which was identified in the EIS.

The purpose of this Adaptive Management and Monitoring Plan (AMMP) is to provide a framework for evaluating accuracy of predicted environmental impacts, assessing the effectiveness of the mitigation features, and determining response actions or Project operation modification needs to ensure the levels of environmental effects observed post- Project operation are acceptable compared to predicted environmental impacts or mitigation performance criteria. This will be achieved by monitoring predicted Project impacts and planned mitigation projects. Monitoring results will then be evaluated against baseline conditions and performance criteria to determine the need for response actions (e.g., additional mitigation, Project changes, adjustments to operation, etc.). To the degree possible this plan also describes those response actions as well as how and when those response actions will be implemented. As part of this adaptive management approach, detailed pre-construction and post-construction surveys have and will continue to be performed. These surveys are discussed or summarized further in the document. The plan is specific to the Project and those purposes as defined in the EIS.

DEFINITION OF ADAPTIVE MANAGEMENT

Adaptive management is a process wherein management actions can be changed in response to a monitored response. It is a "learning by doing" management approach which promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood (National Academy of Sciences 2004). It is used to address the uncertainties often associated with complex, large scale projects. In adaptive management, a structured process is used so that the "learning by doing" is not simply a "trial and error" process (Walters, 1986).

COMPONENTS AND GOALS OF ADAPTIVE MANAGEMENT

Adaptive management for the purposes of this Project has three main components. There is a corresponding goal for the adaptive management program for each of those components.

The goal of the first component consists of evaluating the accuracy of the predicted environmental impacts, and has two parts:

1. Assess the accuracy of impact predictions by comparing impact predictions to observed physical parameters and
2. Improve the capability of the models used to identify and quantify Project-induced impacts.

The goal of the second component consists of assessing the effectiveness of the mitigation features at reducing impacts. To achieve this, mitigation projects will be monitored to 1. Determine if the mitigation projects are meeting pre-determined performance criteria; and 2. Determine the system's responses to specific criteria or parameters. The predictions will be compared to monitoring results to evaluate the overall effectiveness of the mitigation and ultimately the need for additional response actions.

The goal of the third component is to identify whether response actions or additional mitigation needs (e.g., Project operation adjustment, additional mitigation projects, etc.) are required. The purpose of this component is to identify response actions – that if implemented – will keep the levels of observed environmental effects of the Project within the predicted or acceptable limits of change. Response actions could be implemented any time during the post-construction monitoring phase. Monitoring will continue for a period necessary to evaluate the effectiveness of the mitigation feature that was changed or mitigation that was added. In the case of Project operation modifications, it may be necessary to reevaluate existing models and flood event response and planning.

ADAPTIVE MANAGEMENT AND MONITORING PLAN IMPLEMENTATION

Adaptive Management and Monitoring Plan Teams

An Adaptive Management and Monitoring Plan Team (AMMPT) has been assembled to provide essential support to the Project in meeting the goals in this adaptive management plan. The overall lead for this effort has been USACE and will continue to be USACE until the Project is turned over to the non-Federal sponsor; at that time the non-Federal sponsor would be responsible to lead the AMMPT. The team will apply the systemic approach to evaluating Project impacts, mitigation and mitigation effectiveness as described in this plan. The AMMPT consists of a multi-agency (State and federal) staff from the appropriate disciplines, including engineering, planning, environmental science and resource management. The members of the AMMPT include: the United State Army Corps of Engineers (USACE), non-Federal sponsors, the Corps Regulatory office in Omaha, U.S. Fish and Wildlife Service (FWS), Natural Resource Conservation Service (NRCS), North Dakota Game and Fish (NDGF), North Dakota Department of Health (NDDH), North Dakota State Water Commission (NDSWC), Minnesota Department of Natural Resources (MNDNR), Unites States Geological Survey (USGS), United States Forest Service (US Forest Service), and Minnesota Pollution Control Agency (MPCA). The AMMPT will assist the decision–making processes to evaluate adaptive management components described above.

Monitoring sub-teams have been established to provide resource-specific expertise on a particular resource or system monitoring components. The monitoring teams consist of multi-agency (State and federal) staff as well as other key organization experts and are further defined in their respective monitoring plans. Monitoring teams will work together to determine what surveys are needed, survey site locations, survey protocol, and survey schedules. Monitoring teams took into consideration

Project design, known impacts (and predicted impacts) as well as uncertainties. The monitoring team is responsible, as approved by the USACE and/or Diversion Authority, to oversee or to collect and analyze data and provide findings and recommendations to the AMMPT. One or more monitoring team participants will serve as a resource expert representative and participate in the AMMPT as well.

As the success of adaptive management depends on the reliability of the data collected, a team dedicated to quality assurance and quality control (QAQC) will be beneficial to this complex Project. This team will serve the larger AMMPT in report and data compilation. Likewise, a QAQC sub team with a representative from each of the monitoring plan teams and AMMPT, will be formed and included in report reviews to ensure that data is being collected as detailed in the plan(s) and is consistent with what was agreed upon and/or required for each mitigation and/or monitoring project. The QAQC teams may also function to ensure that data, both raw and analyzed, and reports are filed, recorded and stored appropriately and accessible.

Other sub teams may be formed through the AMMPT as needed. These may include those created to monitor mitigation measures that are not part of a larger monitoring plan, or those resources in which it is determined post-construction that conditions require a response action. The adaptive management plan will be modified by the AMMPT to reflect these changes. It will be expected that any additional sub teams will function similarly to those discussed above.

Monitoring Funding

Table 1 is included to provide an idea to what pre- and post- monitoring costs could be for the Project. The costs below were included as part of the overall Project costs during the feasibility study in the Final Feasibility Report and Environmental Impact Statement (USACE 2011). The estimated costs provided below in the table do not include costs associated with potential response actions as the need for some response actions have yet to be identified. Also since this estimate, initial geomorphic and aquatic biological assessments have been completed. Specific line-item costs have not been included for observations for fish stranding or floodplain forest success monitoring as these activities would be likely be a smaller effort and would be accomplished by the non-Federal sponsor as a part of Project operations and maintenance. The estimate below will be revised as Project costs are updated to reflect current dollars as well as design, mitigation, monitoring, and other changes as necessary.

Table 1: Overview of Estimated Costs for Monitoring for the Project

Project Phase	Studies	Cost
Pre-construction	Study Area Geomorphic Assessment: 1 event	$1,000,000
	Biotic Use: 3 events	$3,500,000
Total pre-construction		**$4,500,000**
Post-construction	Study Area Geomorphic Assessment: 2 events	$2,000,000
	Connectivity/Fish Passage Assessment	$7,500,000
	Biotic Use: 3 events	$3,500,000
Total post-construction		**$13,100,000**

Source: FFREIS, USACE 2011

Although cost is not the only factor to consider for monitor planning, cost does affect implementability or practicality of monitoring actions. The monitoring costs for mitigation will continue to be refined, and could increase or decrease depending on the number and location of mitigation and monitoring sites ultimately chosen. Information from these assessments and other existing information were used to develop more detailed monitoring plans which may change the overall costs of the monitoring efforts. These monitoring plans are discussed later in this document.

MONITORING

The purpose of monitoring is to better characterize pre-Project conditions for key resources, characterize these resources following Project implementation, verify resulting Project impacts to predicted impacts, and verify whether mitigation (if applicable) is offsetting the anticipated Project impacts. Monitoring provides feedback between decision making and system response relative to the established adaptive management and monitoring goals and baseline conditions. Monitoring goes towards meeting the first two components and respective goals of adaptive management.

The CEQ NEPA Task Force (CEQ 2003) suggests that the effectiveness of adaptive management hinges upon the development and execution of a scientifically rigorous monitoring and assessment program to analyze and understand system response to Project implementation. Several field assessments have been identified to aid in the monitoring of actual Project impacts, anticipated, or predicted impacts identified through environmental review; and of planned mitigation projects. The field assessments may be represented as standalone plans or be combined under a more specific resource monitoring plan as appropriate (e.g., water quality samples can be taken as part of other assessments).

The field assessments include:

- Geomorphic Assessments
- Water Quality Assessments
- Fisheries Assessments
- Fish Connectivity Assessments
- Macroinvertebrate Assessments
- Physical Habitat Assessments
- Floodplain Forest Assessments
- Wetland Assessments

The field assessments have been included within a combined resource monitoring plan if sampling methods and events were more efficient and because many of the resources are interconnected. Below provides an index to how these assessments have been organized within monitoring plans for the purposes of this AMMP.

- Geomorphology Monitoring Plan
  - Geomorphology Assessment
  - Water Quality Assessments
  - Hydrology Assessments
- Aquatic Biological Monitoring Plan
  - Fisheries Assessment
  - Macroinvertebrates Assessment

- Physical Habitat Assessments
- Fish Connectivity Assessments

- Wetland Monitoring Plan
- Floodplain Forest Monitoring Plan

<u>A note on groundwater monitoring</u>:

The Final Scoping Decision Document (FSDD) (MNDNR 2014) identified that the EIS will assess the need for groundwater monitoring (e.g., piezometers) as part of the AMMP. Potential Project effects on groundwater resources were discussed in the Final Feasibility Report/Environmental Impact Statement (FFREIS) (USACE 2011) under Significant Resources and within the Supplemental Environmental Assessment (Supplement EA) (USACE 2013) under Shallow Groundwater. The most used aquifer in the immediate vicinity of the proposed project is the West Fargo Aquifer. Long term data trends show that the aquifer level is declining over the historic period; however, the Project is not anticipated to intercept or cause impact this aquifer. All subsurface information gathered to date indicates that there would be, at a minimum, 30-60 feet of continuous glacial lake clay between the diversion channel invert and the top of the West Fargo Aquifer which will serve as effective seal or "aquiclude".

The USACE has constructed a system of direct burial piezometers installed along the proposed diversion alignment in North Dakota. The purpose of these is to determine the general ground-water conditions prior to construction and will be monitored for a time after construction in an effort to head off or mitigate any potential issues that may arise. Some additional ground water monitoring instrumentation is anticipated but has not been completely designed at present. It is anticipated that in any event that drawdown of the regional upper groundwater table will be significant.

The AMMP at this time does not include recommendations for groundwater monitoring in addition to what is currently being conducted by the USACE. In accordance with the concept of adaptive management, results from piezometer monitoring should be discussed with members of the AMMPT so that future monitoring efforts or potential response actions can be identified if necessary.

Monitoring Approach

The monitoring plan methods and schedules outlined within this document will remain flexible to adapt to the needs of the Project. As such, this AMMP, including the monitoring plans herein, are open to change. Modifications to the monitoring plan(s) could be needed due to altered conditions either pre- or post-construction or operation; alternative technologies or techniques that become available for monitoring; field conditions, and refinement of specific Project features, or mitigation and response actions. Mechanisms for modifications are addressed within each plan and within this AMMP.

Each monitoring plan includes a recommended schedule(s) based on the information available at the time the team drafted the plan and should be considered preliminary and open to revision based on data and resources available at subsequent planning steps. Monitoring schedules vary dependent on the resource under investigation and may further vary dependent on the resource variables included in the study or when Project operation occurs. In addition, many of the monitoring schedules may overlap with each other. Where this occurs, it is highly recommended that the AMMPT and monitoring teams attempt to coordinate field surveys concurrently so that data can be compared and utilized efficiently.

Monitoring activities are categorized as follows:

- Pre-Construction monitoring to establish a baseline prior to implementation of the Project. The field investigations performed for this would be conducted and be updated frequently to ensure information is available that reflects conditions just prior to the Project construction;
- Post-Construction monitoring of the impacts that occur, compare to those that were predicted, and evaluate the effectiveness of the mitigation features; and
- Post-Construction monitoring to document Project construction *and* operation effects on a specific resource.

Pre-construction monitoring efforts have and will continue to be led by the USACE and the Diversion Authority. Following construction, at a time yet to be determined coordination for monitoring would be the responsibility of the Diversion Authority or other non-Federal sponsors. All monitoring will be done collaboratively with the AMMPT and will be done in concert with the overall adaptive management approach outlined within this document.

<u>Pre-construction Monitoring</u>

Pre-construction monitoring includes studies that have already been completed, studies underway, and future planned and funded studies (including additional monitoring study needs identified through the EIS process). For the purposes of this AMMP, pre-construction is defined as the time period prior to construction and during construction activities. It is currently estimated that Project construction would take approximately 8.5 year.

Monitoring plans may include additional pre-construction assessments. Others may be introduced as additional information needs by the monitoring teams during the development of the draft monitoring plans. These may further be adjusted a Project designs are refined and as necessary by permitting authorities.

Monitoring and survey work that has been completed prior to and during the preparation of the EIS will be used as baseline data which may, resource dependent and as applicable to current Project design and operation, also serve as pre-construction data for use in monitoring plan development and/or modification. The USACE and Diversion Authority have provided this information for the preparation of the EIS, and will continue to provide as it is acquired and as needed to update this AMMP. Some of these reports may also be available through the USACE or Fargo-Moorhead Project (Flood Diversion Authority) website - www.fmdiversion.com. A chart of completed studies as they relate to the AMMP is included as Attachment 1.

<u>Post-construction Monitoring</u>

Post-construction is defined as the time period following construction completion of all the Project features. This includes monitoring that would occur following Project operation. There are many factors that contribute to this timeframe. Project designs and hydrology modeling must be finalized, many necessary permits or licenses would need to be acquired, much of the proposed mitigation would need to be completed or underway, and any additional studies or data needs would need to be met such as field verification of structure impacts for example.

As aforementioned, monitoring plans include anticipated schedules for post-construction and Project operation monitoring. However, depending on how long it takes for Project construction to take; those schedules may need to be adjusted or consider new methodologies or technologies, pre-construction data results, and unanticipated Project modifications.

<u>Pre- and Post-construction and Project Operation Monitoring Events Schedule</u>

INSERT Framework or Table of Summary of Major Monitoring Events Table [NOT AVAILABLE AT THIS TIME].

PROJECT UNCERTAINTIES – An Exercise in Monitoring Plan Development

Prior investigations, Project modeling, and baseline studies have led to predictions about future effects to biological resources, physical habitat, or geomorphic conditions. In turn, the USACE and Diversion Authority have planned mitigation projects to minimize resource impacts as discussed in the EIS. However, with predictions there is a degree of uncertainty about the type and severity of impacts the Project may actually have on resources. Those uncertainties include both the accuracy of the predictive impact tools, the changes to the environment, and the biological responses that will occur as a result of the changes in the environment.

Based on the Project features and Project operation information presented in the EIS, the MNDNR has compiled the following topics as those that are considered by MNDNR resource experts to be Project uncertainties including recommendations for monitoring and how they have been addressed within this AMMP through consultation with the USACE and Diversion Authority. These impact resources or resource concerns should not be interpreted to represent all possible Project uncertainties; however, this provides an idea of how impact concerns will be addressed through ongoing plan development and adaptive management.

Resource Impact or Resource Concern	AMMP and Recommendations - Response
Increased or new sedimentation within the inundation area and the effects on streams (e.g., stability, geomorphology changes, and stream type), wetlands, wildlife habitat, and mitigation sites as a result of Project operation.	o Pre- and post-construction sediment sampling has been added within the Geomorphology Monitoring Plan (GMP) to include surveying and measurements of overbank sedimentation in the natural levee and back channel or overbank areas including sediment coring to quantify the sedimentation due to Project overbank flow deposition. o Three additional pre-construction and several post-construction geomorphology (i.e. stream related surveys) are included in the GMP (data collection would include both field and desktop analysis). o The GMP includes additional cross section sites and the collection of longitudinal

	profiles in sampled stream reaches to assist in establishing baseline conditions and Project effects on stream stability/geomorphology. o Monitoring of the inundation areas is recommended to assess potential indirect impacts to wetlands due to Project operation. Considerations for the wetland mitigation and monitoring plan should include sedimentation monitoring and habitat function monitoring (i.e., wetland functional assessments). In the event that negative impacts are observed, additional replacement requirements that meet federal and state replacement requirements would also be necessary. o Addition of post-event assessments for mitigation sites; particularity if Project operation has occurred prior to good root establishment. Monitoring should include the evaluation of sedimentation impacts and habitat function.
Project operation effects on stream stability – stream banks, due to increased velocity, duration, extent, and depth of flooding within inundation area.	o Pre- and post-construction sampling has been added within the GMP that includes hydraulic and hydrology monitoring (including the addition of three new gages at select Project features). o Pre- and post-construction sampling has been included in the GMP for sedimentation that includes sampling for in-stream sedimentation, suspended sediment concentrations, bedload, and overbank sedimentation. o Three additional pre-construction and several post-construction geomorphology (i.e. stream related surveys) are included in the GMP (data collection would include both field and desktop analysis). o The GMP includes additional cross section sites and the collection of longitudinal profiles in sampled stream reaches to assist in establishing baseline conditions and Project effects on stream stability/geomorphology.
Aquatic invasive species migration by way of Project features.	o Project features aren't designed to impede invasive species migration; however, monitoring for biological connectivity has

	been included in the Aquatic Biological Monitoring Plan. Along with fish habitat and diversity assessments, this monitoring would help to identify if aquatic invasive species, such as invasive carp, are found within this area and utilizing waterways within the Project area.
Control structures, gates, or other Project feature failures.	o A Water Control Manual would be completed for the Project by the USACE prior to construction (as required by USACE regulation ER 1110-2-240) that would include provisions such as detailed operating instructions and assure Project safety. o An Operations, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) Manual would be completed for the Project at the end of construction. This document should include details on what would occur in the event of a feature malfunction or failure. o The MNDNR dam safety permit would require the OMRR&R as a condition of the permit. The permit may include additional provisions as necessary and dependent on final Project design.
Fish stranding and egg deposition within the diversion channel during Project operation.	o Observations would be made by the non-Federal sponsor following Project operation to determine if fish stranding is occurring and to what extent. The AMMPT in collaboration with resource experts would discuss observations to determine if response actions are necessary. Response actions could include Project operational changes such as reducing the rate that flows drop in the diversion channel by manipulating the diversion inlet gate operation when flood waters recede. This and other types of potential operational changes should be considered during the development of the final Operation Plan or OMRR&R Manual.
Aquatic connectivity – Project features becoming barriers for species resulting in less species diversity above and/or below structures.	o Monitoring for biological connectivity has been included in the Aquatic Biological Monitoring Plan.
Stream instability – head-cutting, to	o Ditch inlet structures would be designed

tributaries and ditches/waterways that are adjacent to those areas that would be inundated from Project operation (e.g., ditch inlets to diversion channel).	to minimize stage reductions within the ditches. Monitoring would occur upstream of these locations to make sure that head-cutting does not begin to occur.
Project operation changes – changes outside of agreed upon Operation Plan.	o Operations staff would not have the authority to operate the Project outside of the parameters of the Operation Plan, Water Control Plan, and OMRR&R Manual. Any necessary changes would need to be discussed thoroughly with the AMMPT and other resource and permitting agencies prior to implementation.
Project operation – actual flood frequency and/or events resulting in more (or less) Project operation.	o The AMMPT and necessary resource experts and participating agencies would meet to review Project operation frequency and possible causes and any necessary response actions needed assess or address potential impacts.

IMPACT PREDICTIONS AND MITIGATION EFFECTIVENESS – Specific and Performance Criteria

Assessing the accuracy of impact predictions and the effectiveness of mitigation are components one and two of the AMMP. The approach for monitoring would be the similar for both impact predictions and mitigation effectiveness. A monitoring plan is developed that includes both pre-and post-construction monitoring. Pre-construction to establish baseline conditions (may be based on studies completed during Project feasibility, environmental review documents, or to meet permit needs) and post-construction to measure changes during or following Project construction and operation. The difference between the two is the criteria used from which to measure the observed changes against.

Criteria developed to measure impact predictions (or unknown Project impacts to resources as these fall into the same scenario) are more difficult to develop as these may be based on modeled or hypothesized predicted outcomes. It may be assumed that changes are not likely to occur or that changes that occur are not likely to be significant but there isn't an established threshold for what constitutes a measureable change from a predicted impact or what would be considered a significant impact. Monitoring plan teams work to identify what could occur and what may be considered an "acceptable level of change" or a "significant" change. Pre-construction information collected plays a key role in defining baseline conditions, including existing conditions that may contribute to future changes observed.

Criteria that have been developed to measure the success of a specific mitigation action (such as floodplain forest mitigation) are considered performance criteria. There are typically several performance criteria developed for each mitigation action; each with its own goals that need to be met in order to meet mitigation requirements. Mitigation goals would be established by the USACE, Diversion Authority, Project agency participants through Project coordination actions, or those required by other regulating authorities). Performance criteria are usually defined within a mitigation plan and often follow existing guidelines (e.g., wetland mitigation ratio replacement and mitigation location requirements for the MN Wetland Conservation Act).

Included below is a summary of monitoring plan criteria that is currently being developed or that has been developed to date for the Project. Details are provided within each individual plan included with this AMMP. Note that the discussions below do not segregate between monitoring for impact predictions or for mitigation effectiveness.

Acceptable Level of Change Criteria – When no specific criteria has been developed

This document does not include specific performance criteria for all water quality or biologic parameters which would be monitored for the Project. Establishing criteria at this time for some resources has the potential to limit the ability of the AMMPT and partnering agencies to effectively implement adaptive management for the Project. The adaptive management and monitoring plan is based on a collaborative decision making process among experts in several natural resource organizations.

In some situations, external organizations are responsible for and may have already established acceptable thresholds such as water quality standards, for example. Many water quality standards have already been established in Minnesota by the Pollution Control Agency or in North Dakota by the North Dakota Department of Health. Water quality results from Project monitoring would adhere to those standards.

Yet in other situations, a particular resource may be dependent on several values or it may be necessary to consider several parameters when contemplating an acceptable level of change. For example, wetland performance standards will include hydrology and vegetation observations over a period of several years. The Project consists of several monitored wetland types, each have different performance ranges for hydrology and vegetation. For those resources, the range of performance measure standards or criteria are discussed in their respective mitigation and monitoring plans.

<u>Geomorphology Monitoring:</u>

The Red River and tributaries are dynamic river systems that naturally show movement of their mobile boundaries. A first step for evaluating the system and rates of change is to use existing data to start describing typical types of change and what types and scales of impacts will trigger a need for a response action. The draft monitoring plan included with this AMMP also identifies and recommends additional survey sites that would further help to establish baseline conditions. Sites that already show changes in response to existing processes will need to be monitored as well as sites that are expected to show change in response to the Project construction and operation. Test sites, i.e., control sites, outside of the Project impact area will also be monitored to help establish rates of change and natural variability in response to drivers other than the Project. Collecting reference and pre-construction data will help establish reference ranges of change rather than singular thresholds for delineating changes outside of the range of norms. Reference ranges of change or acceptable levels of change will be established for individual reaches or Stations as appropriate. This will ensure that ranges established consider local site conditions.

The specific criteria for defining impacts and response action levels will need to be further refined. The Geomorphology Monitoring Team (GMT) has started developing a list that includes:

- **Quantity/Nature of Change**
    - The fraction of total study area experiencing a given impact

- Human induced changes
    - Status of boundary conditions
    - Identified acceptable ranges of change for variables
    - Others
- **Hydrology & Hydraulics**
    - Driven by changes in land use, precipitation, others
    - Others
- **Water Quality/Biogeochemistry**
    - TMDL's
    - Others
- **Geomorphology**
    - Natural meander migration
    - Planform changes i.e.:
        - radius of curvature
        - sinuosity
    - Changes in Channel Migration and Rates
    - Incidence of slope failures: Existing, New, and Re-activated
    - Characteristics of bank and over bank areas/Riparian and other
    - Others
- **Biota**
- Vegetative characteristics
    - Bank
    - Overbank
    - Riparian
    - Others
- Ecosystem community characteristics
- Others

As stated above, vital data will need to continue to be collected and analyzed that will be used to help develop the significance criteria. This data would include key stability indices/ parameters of change such as:

- Cross sectional area
- Bed slope
- Width to Depth Ratio
- Thalweg elevation trends to indicate aggradation or degradation/incising
- Bank Height and slope

Explicit drivers that will be monitored and considered include but may not be limited to:

- Precipitation changes in duration, frequency, and volumes.
- Project operation variables
- Vegetation changes—Riparian Corridor, Trees, Power lines
- Overbank deposition
- Sediment
- Debris
    - Rotation into center of channel affects flows and can direct flow into banks.
    - Can also serve as bank protection

- Levees
  - Put weight on bank and increase potential for failure
- Hydraulic Drivers –Flow due to
  - Land use changes
  - Drainage

The significance of the changes will depend on the context of the change including: location, rates, and secondary impacts of the change on: channel stability, ecosystem functions and values, flood and infrastructure protection and others.

The GMT recognizes that there are several classes of criteria that can be used to set thresholds for defining impacts to the system. Those classes of criteria may be for example; impacts on structures, impacts on riparian habitat, impacts on meander migration rates, etc. and have different thresholds for triggering responses and need to be recognized and discussed explicitly in future.

Further discussion on criteria will need to occur prior to completion of and inclusion in the final monitoring plan. These discussions will continue through several sampling intervals as data both pre- and post-construction data collection help to inform what impacts are natural, as a result of some other action, or as a result of the Project.

<u>Aquatic Biological Monitoring:</u>

Aquatic fauna are important components of riverine systems and will be monitored to help assess the potential effects of the Project on key biological components of the Red River and tributaries. Because of the variability associated with biological monitoring, development of significance criteria is difficult and complex. Observations will be considered carefully and in concert with other monitoring activities such as geomorphology to evaluate whether the Project is having definite effects on the aquatic ecosystem.

However, there will be assessments completed which have more specific measures; such as Index of Biological Integrity scores or IBIs. IBI scores will be calculated to measure general habitat and river health within areas sampled for fish, macroinvertebrates, and physical habitat. This will be done for all study reaches to verify the level of impact, and whether mitigation is working effectively to alleviate significant impacts. Revised IBI scoring systems are currently being developed for the Red River Basin by both North Dakota (NDDH); and Minnesota (MN Pollution Control Agency). Once developed, the Aquatic Biological Monitoring Team (ABMT) will be able to further discussions on possible ranges for acceptable levels of change.

It can and should be noted that any significant observations such as those that may be labeled "significant" will require response actions and could be required as part of the MNDNR dam safety permit (application has not been received-permit requirements would be determined through a coordinated effort between MNDNR permitting staff and the applicant). An example of a "significant" observation would be a complete loss of biological connectivity as a result of Project features (i.e., constructed structures that may act as a barrier to certain species; therefore, resulting in significant species diversity differences upstream or downstream of the structure).

Wetland Monitoring

Adopted from the FFREIS – Attachment 6, Discussion of Habitat Loss, Mitigation Needs and Adaptive Management, USACE 2011

***Performance Standards*:**
Hydrology

1. Seasonally Flooded Basins. Hydrology shall consist of inundation by a few inches to 24 inches of water for a minimum of 14 consecutive days during the growing season under normal to wetter than normal conditions (70 percent of years based on most recent 30-year record of precipitation). Inundation shall be typically absent following the first 6 weeks of the growing season and soil saturation drops below 12 inches from the surface for the majority of the growing season in most years.
2. Fresh (Wet) Meadows, Sedge Meadows and Wet Prairies (Mineral Soils). Hydrology shall consist of saturation at or within 12 inches of the surface for a minimum of 30 consecutive days, or two periods of 15 consecutive days, during the growing season under normal to wetter than normal conditions (70 percent of years based on most recent 30-year record of precipitation). Inundation during the growing season shall not occur except following the 10-percent chance or larger event. The depth of inundation shall be 6 inches or less and the duration of any inundation event shall be less than 15 days. An exception can be made for sites with hummocky microtopography -- hollows between hummocks can have standing water depths of up to 6 inches for extended duration.
3. Shallow Marshes. Hydrology shall consist of saturation to the surface, to inundation by up to 6 inches of water, for a minimum of 60 consecutive days or two periods of 30 consecutive days or four periods of 15 consecutive days, during the growing season under normal to wetter than normal conditions (70 percent of years based on most recent 30-year record of precipitation). During the growing season, inundation by up to 18 inches of water following the 50-percent chance or larger event is permissible provided that the duration does not exceed 30 days (e.g., water depth drops from 18 inches to 6 inches within the 30 days).
4. Deep Marshes. Hydrology shall consist of inundation by 6 to 36 inches of water throughout the growing season, except in drought years (driest 10 percent of most recent 30-year period of precipitation record).

Vegetation

1. Herbaceous Species Composition:
   a) Fresh (wet) meadows, sedge meadows, wet prairies, and seasonally flooded plant communities (Type 1 and Type 2 wetlands) shall each achieve a species composition that includes 10 or more species of native/non-invasive grasses, sedges, ferns, rushes and/or forbs by year. Alternatively, a MnRAM vegetative diversity and integrity score of “high quality” by year 5 would also satisfy this performance standard.
   b) Shallow marsh and deep marsh plant communities shall be dominated by 3 or more native aquatic species, with at least 4 native plant species occurring within the shallow marsh communities on the site by year 5. A MnRAM vegetative diversity and integrity score of “high quality” for each these plant communities will also satisfy this performance standard.

c) Restored tallgrass prairie in the upland buffer and interior banks of the diversion channel shall be dominated by 3 or more species of native grasses, sedges, rushes, forbs and/or ferns, with approximately 80% or greater areal coverage of the total mitigation site, and at least 10 native species occurring within the area of the upland communities on the site by year 5.

2. Hydrophytes: More than 50% of all plant species within the wetland communities of the mitigation site shall be facultative (FAC) or wetter (FACW or OBL) excluding FAC-. 3.
3. Control of Invasive and/or Non-Native Species: Control of invasive and/or non-native plant species shall be carried out for five full growing seasons. Control shall consist of mowing, burning, disking, mulching, biocontrol and/or herbicide treatments. By the third growing season, any areas one-quarter acre in size or larger that have greater than 50 percent areal cover of invasive and/or non-native species shall be treated (e.g., herbicide) and/or cleared (e.g., disked) and then reseeded. Follow-up control of invasive and/or non-native species shall be implemented as stated above.

Floodplain Forest Monitoring

Adopted from the FFREIS – Attachment 6, Discussion of Habitat Loss, Mitigation Needs and Adaptive Management, USACE 2011

Performance Standards:

1. Restore native floodplain forest and herbaceous vegetation. The floodplain forest should include green ash, cottonwood, black willow, hackberry, silver maple, quaking aspen, American elm, American basswood, and bur oak.
2. Restore stand density with an average of 300 trees per acre over 80 percent of the mitigation site(s) with diameter at breast height (DBH) of 2 inches within 10 years. This tree density is typical for the Red River Basin floodplain forest in the Project vicinity.
3. Restore floodplain forest community with a target species composition of at least 10 percent by number of individual trees to be bur oak and hackberry, with the rest a mix of green ash, cottonwood, black willow, boxelder, American elm, silver maple and American basswood.
4. Allow some regeneration of native herbaceous plants, shrubs, and trees from locally produced propagules on 20 percent of the mitigation land area, to create diversity in forest and herbaceous vegetation in the mitigation area.
5. Protect and manage the site(s) in perpetuity by an agreement for management as a wildlife management area by the Minnesota Department of Natural Resources or North Dakota Game and Fish department.

Decision Criteria and Process – Acceptable Levels of Change/Response Actions /Additional Mitigation Needs

This subsection will define the criteria and process by which decisions are made concerning whether changes to or additional mitigation measures are needed or if Project modifications may be necessary. It will also describe the participants in the decision-making process, the timeline for making those decisions, required approvals from higher authorities, and necessary coordination with those not participating in making the decisions. This aligns with component three of the AMMP.

Decision Criteria

Specific criteria for acceptable levels of change have been or continue to be developed by the USACE, Diversion Authority and Monitoring Teams as appropriate. The AMMP currently includes specific criteria that have been developed to date as detailed above. The criteria are and will be based on prior investigations completed and pre-construction data collected that will serve as a baseline for current conditions. The specific or performance criteria will be compared to pre-construction data and post-construction assessments to determine if a response action is necessary. It should be noted that some standards may already exist and may be used if approved if they are found to meet the criteria required for this Project (e.g. wetland mitigation standards). Even though the USACE and Diversion Authority examined the performance of the Project under a range of flow conditions as well as identified impacts resulting from Project construction, the impacts that are experienced pre- and post-construction may be different from those that were examined and predicted during the feasibility phase and pre-construction phases.

Decision Process

The decision process associated with implementation of any adaptive management measures will be ongoing throughout the construction and post-construction (and Project operation) phases of the Project. The USACE and/or Diversion Authority will maintain communication with key regulatory agencies throughout the pre- and post-construction phases of the Project.

During the monitoring for pre- and post-construction phases, the monitoring teams (or Contractor) will gather and analyze data as prescribed in their respective monitoring plans. Findings and recommendations will be provided to the AMMPT in a report summary with necessary supporting information. Reports may be provided during several periods throughout any given year dependent on the monitoring schedules and Project operation. The AMMPT will be responsible for coordinating review of monitoring data and reports according to the monitoring plan schedules. The AMMPT will need to be cognizant of future field collection schedules or the severity of the issues presented when determining AMMPT review schedules as some reports may require more immediate attention than others.

The AMMPT will review report findings and recommendations and in cases where response action triggers are not pre-defined, will determine the next course of action. This may include further discussions with the monitoring team, requesting additional information, or accepting the monitoring teams proposed recommendations The AMMPT may also propose their own response action. The AMMPT will provide the respective monitoring team with their decision in a timely manner (e.g. to allow for schedule adjustments, monitoring plan modifications, and etc.). The final reviewed report will be shared with key organizations and will be made available to the public. As necessary, additional participation by other undefined organizations or professionals may be necessary and will be considered by the AMMPT when determining a course of action to take on recommendations.

Within the teams, the recommendations put forth may be determined by majority vote or some other agreed upon mechanism for decision making. The USACE and the Diversion Authority are responsible for making the final decision under most instances; however, the decision may be influenced by several factors. These include the implementability of the response action, success probability, and cost. In addition, individual agencies may act within their own authorities and may require response actions as part of permit conditions.

Every five years, or following Project operation (whichever occurs first), a cumulative report will be prepared by the Project Proposer with the AMMPT to include monitoring findings and recommendations, necessary modifications, Project operation, modeling or design updates, budget and other pertinent information. If applicable, the cumulative report schedule could be adjusted if Project operation occurs over consecutive years (or multiple times within a given year) so that information could be assessed together to better inform the need for response actions. The AMMPT will review the draft report and make any necessary changes within a timely manner. The draft cumulative report will be made available to the public. A public meeting may be requested or proposed by the AMMPT to discuss the draft report. The cumulative report may include recommendations or modifications to monitoring, mitigation and Project operation as well as propose additional mitigation. The final cumulative report would be made available to the public.

RESPONSE ACTION OR ADDITIONAL MITIGATION IMPLEMENTATION CONSIDERATIONS

Funding

Should the planned mitigation prove ineffective, or should impacts prove more significant than previously anticipated, then additional mitigation may be warranted. Additional mitigation needs, or contingency mitigation, may be determined and recommended or required by the respective resource monitoring team, the AMMPT or by other Project participating or key organizations. Decisions on the implementation of recommended additional mitigation needs would be tied to defined response trigger identified in the agreed upon plan.

Additional mitigation needs may require funding that has not yet been procured or appropriated. Federal Project funding will be provided through construction and until the Project is turned over to the non-Federal sponsors, a length of time that has not yet been determined. Thus, funding would be provided for construction of planned mitigation projects, and potentially some of the initial post-Project monitoring. It has yet to be determined whether the USACE or the non-Federal sponsor would be responsible for procuring funds for contingency mitigation.

A possible option for contingency mitigation funding could be through the Project Operations and Management fund. Funding for Project operation and maintenance is the responsibility of the non-Federal sponsors and would be determined by the non-Federal sponsors. Local tax revenue is the planned fund source for operation and maintenance expenditures. A fund could be established that would allow for unforeseeable expenses, such as the case of additional mitigation needs and response actions. This option has not been discussed by local sponsors at this time and would need to be thoroughly discussed to determine details and feasibility.

Local sponsors may also elect to collaborate with the AMMPT and other appropriate local, state and federal agency representatives to identify the appropriate funding source. This could include the use of local or State funds to address remaining mitigation needs. The local sponsors could also coordinate with USACE for possible funding under the USACE's Continuing Authorities Program (CAP) or coordinate with their congressional leaders for authorization and appropriation of additional funds to address contingency mitigation.

Regulatory Considerations

In accordance with Minnesota Rules Chapter 4410, any necessary environmental review must be completed prior to issuing Project approvals or permits. This includes any local and state permits. Projects occurring within the state of North Dakota must also comply with respective local, state, and federal rules for Project permitting and approval. If the mitigation is carried out by a federal agency, all applicable rules and procedures for Project review and approval will be complied with, including any environmental review requirements.

Some mitigation measures will have state environmental review requirements that must be fulfilled before local or state permits can be issued. With this in mind, The EIS includes the following known mitigation projects: wetland mitigation within the proposed diversion channel, fish passage at the Drayton Dam, and Wild Rice Dam removal. As a prerequisite for federal permitting, the USACE has already completed federal environmental assessments for both the Drayton Dam and Wild Rice Dam mitigation projects.

Mitigation projects identified or developed through final Project design and/or and response actions identified through adaptive management may require environmental review, and/or local, state or federal permits, depending on the nature of the action and the implementing agency. For mitigation and monitoring projects that have not been reviewed as discussed above, the Project Proposer and the cooperating agency partners will be responsible for complying with local, state, and federal environmental review and permitting and other regulatory requirements.

The Project Proposer and agency partners through the AMMPT will consider and coordinate the timing of potential mitigations and the corresponding approvals and permits needed for those actions. This may require additional planning to take into account the time needed for review, approvals, permits, funding allocation, and construction season. These considerations may influence the feasibility of mitigation and require consideration of alternative actions or timeframes.

Individual agencies may require response actions as part of permit conditions. For the MNDNR, as discussed in the EIS, the MNDNR requires a dam safety permit for the construction and operation of the embankment system and control features proposed for the Project. The AMMP at this time is being considered as a potential permit condition. In the case that the AMMP, or a future revised version of the AMMP, is a permit condition, the details set forth in the AMMP will be required to be adhered to and response actions may be identified and required separate or above that which is identified by the USACE and/or Diversion Authority of other non-Federal sponsor. More details on the MNDNR Dam Safety permit can be found within Section 3.15 of the EIS.

DATA STANDARDS AND STORAGE

As mentioned, data has already been collected prior to, and during, the completion of the EIS. Additional pre-construction data and post-construction data will be collected to meet permitting requirements and support the adaptive management process. The proposed monitoring plans will be refined to define implementable collection plans for needed data. The following addresses data standardizations and data storage needs for the Project.

Data Standards

The data has been, and will likely continue to be, collected by one or more contractors or agencies. As this data will be used to assess Project impacts and Project modeling predictions as well as mitigation effectiveness, it is vital that the data be collected and analyzed consistently. Protocols included within the monitoring plans have already been discussed by key organization participants. Any deviations to final protocols that are agreed upon by the monitoring teams, including those that may be identified during the environmental review process, will require monitoring team approval, updates to the monitoring plan document, and will need to be reported back to the AMMPT. In turn, any modifications made by the AMMPT will need to be agreed upon by the monitoring team, if applicable; and will need to be reflected in updates to the monitoring plan(s).

In addition to updating monitoring plans, any modifications to data collection, reporting or analyzing procedures will be documented in a master document. This document will track versions of the adaptive management and monitoring plans and will include descriptions or highlights of modifications. The local sponsor (or other agreed upon responsible party), will be responsible for the master document.

Data Storage

The data will need to be accessible and shared for redundancy and analysis purposes as well as stored as part of the monitoring record and for future data needs. The adaptive management and monitoring plan recommends that the local sponsors manage and host the official repository of data sets and completed analyses related to the Project.

To aid in data accessibility, the local sponsors (or other agreed upon responsible party) will establish a file and record naming system for all anticipated data file types. The file and record naming system will be applied to Project related documents.

ATTACHMENT 1 - Pre-construction Monitoring – Completed

The chart below includes a summary and/or reference to studies completed to date for the Project as they relate to the AMMP. This chart does not include references that were used or considered in the production of these studies. This information will be stored, along with future data and reports, in one location accessible to the AMMP teams and will be updated as new information becomes available.

Table 2. Data and Studies Completed to Date By Resource Type/Topic for Use in Adaptive Management and Monitoring.

Resource Type/Topic	Data collected	Results/Report	Author and Report Date(s)
Wetlands	Wetland Delineations for North Dakota Locally Preferred Plan (LPP) alignment, North Dakota 35K Corridor, and Minnesota Federal Comparable Plan (FCP) Alignment were completed in 2010	Feasibility Report and Environmental Impact Statement FFREIS). Fargo-Moorhead Metropolitan Area Flood Risk Reduction Project Wetland Determination Report Fargo, North Dakota/Moorhead, Minnesota	USACE, 2010
	Revised Reaches 1-4 (north alignment Shift) Supplemental Environmental Assessment	Supplemental Environmental Assessment, Design Modifications to the Fargo Moorhead Metropolitan Area Flood Risk Management Project (Supplemental EA)	USACE, 2011
	Oxbon-Hickson-Bakke	Supplemental EA	USACE, 2013
Fish Monitoring	Fish surveys completed on Rush River, Lower Rush River, Red River, Wild Rice River, Sheyenne River, Wolverton Creek, and Maple River.	Evaluation of Fish, Benthic Invertebrates and Physical Habitat	URS, 2013
Macro-invertabrates	Macroinvertebrate Assessment	Evaluation of Fish, Benthic Invertebrates and Physical Habitat	URS, 2013
Physical Habitat	Physical habitat Assessment, includes Substrate, Instream Cover, Channel Morphology, Riparian Zone, Pool/Riffle Quality, and Map Gradient	Evaluation of Fish, Benthic Invertebrates and Physical Habitat	URS, 2013
Floodplain Forest	Floodplain Forest surveys, tree identification, size, health, quantity, vegetation identification, secchi readings, shoreline observations, snag tree counts, cavity counts, etc.	FFREIS, Appendix F – Environmental	USACE, 2011

Mussels	Mussel surveys completed on Rush River, Lower Rush River, Maple River, Wild Rice River, Ditch 14, and Sheyenne River.	Mussel Survey at Fargo-Moorhead Diversion ditch Footprints, Biotic Sampled Sites, and Areas to be Abandoned by the Diversion Ditch	USACE, 2011
Water Quality		Nutrients, suspended sediment, and pesticides in water of the Red River of the North Basin, Minnesota and North Dakota, 1990-2004.	Christensen, V.G. (2007) U.S. Geological Survey, Minnesota Pollution Control Agency, Scientific Investigations Report 2007-5065, 36 pp. (publicly available)
		State of the Red River of the North – Assessment of the 2003 and 2004 water quality data for the Red River and its major Minnesota tributaries.	Paakh, B., Goeken, W., and Halvorsen, D. (2006). MPCA, Red River Water Management Board, 104 pp.
Geomorphology	Geomorphology surveys collected.	Geomorphology Study of the Fargo, ND & Moorhead, MN Flood Risk Management Project	West, 2012
	Sediment transport studies.	FFREIS, Attachment 5 Consultant's Report, Appendix F - Hydraulic Structures, Exhibit I Sediment Transport, USACE 2011	USACE, 2011

		Sediment concentrations, loads, and particle size distributions in the Red River of the North and selected tributaries near Fargo, North Dakota during the 2010 spring high-flow event.	Blanchard, R.A., Ellison, C.A., Galloway, J.M., and Evans, D.A., USGS, Scientific Investigations Report 2011-5064, 27 pp., 2010
		Sediment concentrations, loads, and particle-size distributions in the Red River of the North and selected tributaries near Fargo, North Dakota, during the 2011 spring high-flow event.	Galloway, J.M., Blanchard, R.A., and Ellison, C.A., USGS Scientific Investigations Report 2011-5134, 30 pp., 2011
		Sediment loads in the Red River of the North and selected tributaries near Fargo, North Dakota, 2010-2011.	Galloway, J.M., and Nustad, R.A., USGS Scientific Investigations Report 2012-5111, 46 pp., 2012
		Draft Sediment Transport Analysis for Diversion in the Red River Basin near Fargo-Moorhead.	USACE, 2012
		Continuous water-quality monitoring and regression analysis to estimate constituent concentrations and loads in the Red River of the North at Fargo and Grand Forks, North Dakota, 2003-12	Galloway, J.M., USGS Scientific Investigations Report 2014-5064, 37 pp., 2014
		FMM Geomorphology Baseline First-Draft Web Map; (*to be completed following sponsor review and notice to proceed on additional scope from Diversion Authority*.)	Barr Engineering, Web based application not yet public. February 18, 2015.

	Meander belt analyses.	First Draft Memo: Low Flow Channel Meander Belt Width.	Barr Engineering, January 16, 2012
		Second Memo: Low Flow Channel Meander Belt Width - FINAL.	Barr Engineering, February 21, 2012
		Draft Technical Memo: Meander Belt Width Analysis.	Barr Engineering, 2012

Source: Personal Communication, USACE 2014

ATTACHMENT 2 – Monitoring Plans

Aquatic Biological Monitoring Plan
Geomorphology Monitoring Plan
Wetland Monitoring Plan
Floodplain Forest Monitoring Plan

Fargo-Moorhead Flood Risk Management Project

Aquatic Biological Monitoring Plan

Fargo, North Dakota
Moorhead, Minnesota

Prepared for Minnesota Environmental Impact Statement
By Aquatic Biological Monitoring Team

DRAFT
Minnesota Final Environmental Impact Statement
Vs. 2 May 2016

U.S. ARMY CORPS OF ENGINEERS,
ST. PAUL DISTRICT, ST. PAUL, MINNESOTA

MONITORING COMPONENT

1.0 SITE-SPECIFIC FISH, MACROINVERTEBRATES, AND PHYSICAL HABITAT MONITORING

Aquatic fauna are important components of riverine systems and will be monitored to help assess the potential effects of the Project on key biological components of the Red River and tributaries. Because of the variability associated with biological monitoring, these observations should be considered carefully and in concert with other monitoring activities such as geomorphology to evaluate whether the Project is having definite effects on the aquatic ecosystem.

The Project could impact physical habitat in two primary ways. First, the footprint impacts for Project structures will result in direct loss or transition of aquatic areas. Second, altered hydrology could influence biota or physical habitat. Project mitigation is being developed to address footprint-related impacts. Mitigation has not been proposed for potential impacts to biota and physical habitat via altered hydraulics. However, such mitigation could be considered if monitoring verifies significant impacts are occurring.

Monitoring for fish, macroinvertebrates, and physical habitat will be performed for two primary reasons. First, to monitor the impact the Project is having on biota and overall physical habitat conditions (to include both areas with footprint impacts; and areas with altered hydraulics). Second, to evaluate the effectiveness of Project mitigation and determine if mitigation is adequately replacing aquatic habitat lost as a result of the Project.

Monitoring will employ a "Before-After-Control- Impact" design (BACI) to test for potential Project effects. This means that observations will be made both before and after Project construction. Monitoring sites will also be located both in areas where the Project has direct influence, as well as in areas that are outside of the influence of the Project. Waterbodies that will be evaluated for potential Project effects include: the Red River of the North; Wild Rice, Sheyenne, Maple and Rush rivers; and Wolverton Creek. Figure 1 depicts monitoring site locations.

Sampling methodologies for assessing fish, macroinvertebrates, and physical habitat will be based on standard methods employed by the States of North Dakota and Minnesota. For fish and macroinvertebrates, there are different sampling methodologies for wadeable verses non-wadable rivers and streams that will be employed. It should be noted that sampling conditions within these waterbodies can be extremely challenging, especially for fisheries sampling. This includes extremely high conductivities that can make fish collection via electroshocking more difficult, and variable water depths that can make sampling by either boat or wading difficult (wadeable vs. non-wadable). However, as feasible, sampling will occur when streams are at or near base flow conditions. This will help to reduce some of the potential issues above. Sampling methodologies are identified in Table 1.

1.1 METHODS

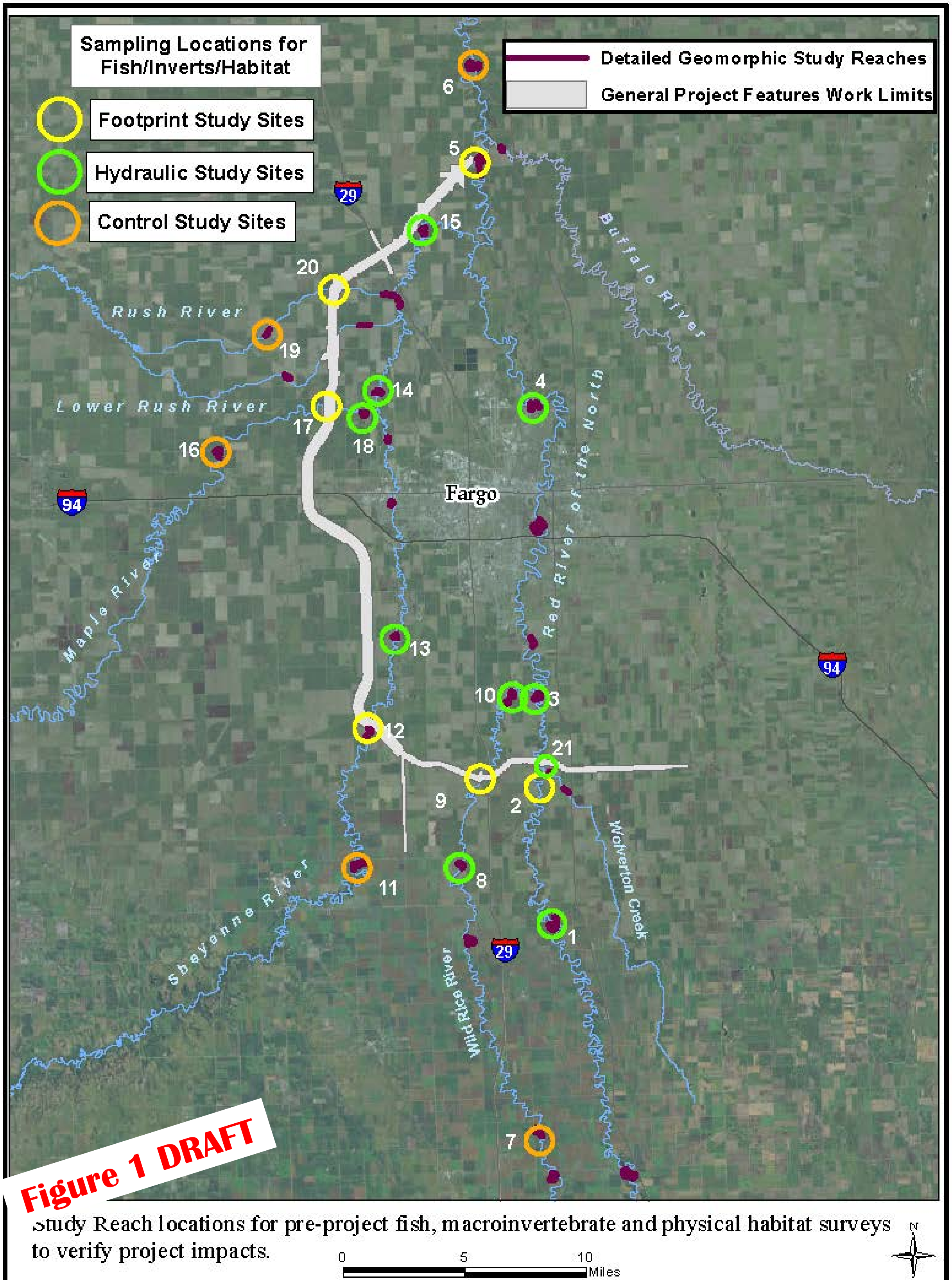
Metrics

Index of Biological Integrity (IBI) scores will be calculated to measure general habitat and river health within areas sampled for fish, macroinvertebrates, and physical habitat. This will be done for all study reaches to verify the level of impact, and whether mitigation is working effectively to alleviate significant impacts. Revised IBI scoring systems are currently being developed for the Red River Basin by both North Dakota (ND Dept. of Health); and Minnesota (MN Pollution Control Agency). These IBIs are both still in development, and will be based on prescribed sampling methodologies (note: IBI sampling methodologies will be included as an attachment once completed). These same sampling methodologies will be followed for this effort. Since the majority of study reaches are in North Dakota, the monitoring plan methods for IBI calculations will be based from those provided from North Dakota, unless otherwise noted. The use of these metrics is discussed further below.

Other metrics beyond IBI values could also be used to evaluate Project impacts and mitigation effectiveness. These will be considered by the Adaptive Management and Monitoring Plan Team (AMMPT), as appropriate, moving forward.

Study Reaches and Study Reach Lengths

<u>Study Reaches</u>: The study reaches that will be surveyed are identified in Figure 1 and Table 1. Study reaches include the likely footprint locations for concrete structures or channel diversions. They also include areas above and below structures where altered hydraulics could influence habitat and biota. Lastly, most rivers include one adjacent study reach to serve as a control site. The exception to this is Wolverton Creek, which may only be impacted through altered hydraulics (inundation) without any other project related direct alterations to habitat. The USACE will provide a GIS shapefile for the study reaches which will serve to further verify reach location. Survey site locations could be shifted based on site conditions, or in the case of footprint locations, if the locations of specific features shift based on advanced site design. Any modifications to survey site locations will be documented.



Study Reach locations for pre-project fish, macroinvertebrate and physical habitat surveys to verify project impacts.

Table 1. Locations for surveys of fish, macroinvetebrates, and physical habitat (as depicted in Figure 1).

Study Reach No.	River/Creek	Descriptor	Type	Study Reach Length (ft)	Method	Fisheries Gear Type
1	Red	Upstream	Test	4,000	Non-Wade	Boom-shocker
2	Red	Footprint	Test	4,500	Non-Wade	Boom-shocker
3	Red	Protected Area	Test	4,000	Non-Wade	Boom-shocker
4	Red	Protected Area	Test	4,000	Non-Wade	Boom-shocker
5	Red	Footprint	Test	2,500	Non-Wade	Boom-shocker
6	Red	Downstream	Control	4,000	Non-Wade	Boom-shocker
7	Wild Rice	Upstream	Control	3,000	Non-Wade	Mini-boom
8	Wild Rice	Upstream (Hyd)	Test	3,000	Non-Wade	Mini-boom
9	Wild Rice	Footprint Location	Test	4,500	Non-Wade	Mini-boom
10	Wild Rice	Protected Area	Test	3,000	Non-Wade	Mini-boom
11	Sheyenne	Upstream	Control	3,200	Non-Wade	Mini-boom
12	Sheyenne	Footprint	Test	4,300	Non-Wade	Mini-boom
13	Sheyenne	Protected Area	Test	3,200	Non-Wade	Mini-boom
14	Sheyenne	Protected Area	Test	3,200	Non-Wade	Mini-boom
15	Sheyenne	Protected Area	Test	3,700	Non-Wade	Mini-boom
16	Maple	Upstream	Control	2,500	Non-Wade	Mini-boom
17	Maple	Footprint	Test	5,600	Non-Wade	Mini-boom
18	Maple	Protected Area	Test	2,500	Non-Wade	Mini-boom
19	Rush	Upstream	Control	2,000	Wadeable	Stream shocker
20	Rush	Footprint	Test	2,000	Wadeable	Stream shocker
21	Wolverton	Upstream (Hyd)	Test	1,000	Wadeable	Stream shocker

The Lower Rush River was originally considered for biotic and habitat sampling. However, because this channelized drainage ditch is typically dry for long stretches of the summer, this intermittent tributary will be dropped from sampling for fish, macroinvertebrates, and physical habitat.

Study Reach Length: The distance of stream or river that should be sampled to adequately characterize diversity or biotic integrity varies. Lyons (1992) recommend sampling a stream segment at least 35 times the mean stream width for estimating species richness in midwestern U.S. streams with a DC stream shocker.

The distance of each survey reach is identified in Table 1. Footprint areas will be completely surveyed. All other survey reaches will sample an area at least 35 times the stream width. Field investigators must ensure that reach sample lengths are at least 35 times stream width, based on field conditions.

Monitoring Field Tasks

Monitoring Field Tasks conducted at each study reach include:

- Reach Reconnaissance Investigation
- Fisheries Assessment
- Physical Habitat Assessment

- Macroinvertebrate Assessment

These are discussed in more detail below.

Reach Reconnaissance Investigation: A Reach Reconnaissance Investigation of each study reach will be performed prior to every sampling event so that the field investigators will become familiar with each survey reach to the extent that will allow efficient sampling. The reconnaissance shall include a cursory view of survey sites, confirming the appropriate gear for sampling fish and macroinvertebrates based on sample reach characteristics as well as be used to confirm reach access and any other logistical issues for sampling. Whenever practical, the USACE and agency members will participate in the Reach Reconnaissance Investigation to observe and discuss conditions.

Study reaches may be accessed from public access (e.g., boat landings), public road crossings or private property. However, the USACE and/or the local sponsor will strive to provide rights-of-entry that would allow for access from adjacent property for all survey reaches. Site access on most tributary sites may be limited to portable equipment on private property.

Fisheries Assessment: Fisheries Assessments will be completed according to the appended sampling protocol for wadeable (Appendix A) and non-wadeable streams (Appendix B). For this plan the Rush River and Wolverton Creek would be considered wadable streams; and the Red, Wild Rice, Sheyenne and Maple rivers would be considered non-wadeable streams. However, conditions in these last three rivers can be extremely variable with conditions varying between wadeable and non-wadeable conditions. This largely includes conditions that range from shallow to deep depending on river discharge. Site conditions will be verified during the Reach Reconnaissance Investigation. Sampling methodology as presented in Table 1 may need to be adjusted based on site conditions. Shifts in sampling methodology can obviously impact the data collected and subsequent data comparison between and within sampling events. As such, data comparison by the resource agency team will need to be done carefully and with flexibility, to include an understanding that variability may occur due to adjustments in sampling methodology, and that such changes may be unavoidable due to field conditions, logistics or other reasons.

All fisheries assessments will be completed during daylight hours between 1 July and 30 September. Daylight hours are defined as starting sampling no earlier than 60 minutes after sunrise, and finishing no later than 60 minutes before sunset. Sampling shall occur when streams are at or near base flow conditions. Note that fisheries sampling will occur prior to macroinvertebrate and physical habitat assessments.

Electrical settings for electrofishing are described for boom-shocking in Appendix B. To the extent practicable these settings will be followed for boom-shocking, mini- boom-shocking and stream shocking. Power settings shall ultimately be selected on those needed for the optimum combination of voltage and amperage output to most effectively stun fish. This shall be determined on a trial and error basis at the beginning of each survey. Field staff shall try to avoid power settings so extreme that fish mortality becomes excessive. Because power output affects catch rates of fishes differently, it is critical that power settings and output from all electrofishing samples is recorded on field data sheets. Water quality observations (including temperature and conductivity) shall also be collected (outlined below).

The anticipated gear types for each reach are outlined in Table 1. This includes stipulations for sampling on the Red River with a boom-shocker versus use of a mini- boom for sampling. Any deviation in gear type, based on field conditions observed during reconnaissance, must be coordinated and approved through the Aquatic Biological Monitoring Team (ABMT) and the AMMPT.

Fisheries sampling gear types include the following (gear types are further discussed in the sampling methodologies attachments):

> *Stream-shocker*: Used in larger, wadeable streams and rivers. The stream-shocker is a towable unit that can effectively sample larger streams because it has additional power capabilities and employs two anodes, thus increasing the electrified zone. Three personnel are required for operation, one to control the electrofisher, one to control the anode, and one to transfer fish. A single electrofishing run is conducted in an upstream direction weaving between habitat types.
>
> *Mini-boom*: Used in non-wadeable streams and rivers that are either too small or that do not afford the access necessary to utilize a boom-shocker. The mini-boom electrofisher is a jon-boat that is light enough to be portaged, yet provides a stable work platform. Personnel consist of one person to operate the boat, monitor the control box, and ensure the safety of a single fish collector on the bow. A single electrofishing run is conducted in a downstream direction weaving between habitat types.
>
> *Boom-shocker*: Used in large, accessible rivers. The accepted sampling procedure is to slowly and methodically maneuver the electrofishing boat in a downstream direction maneuvering in and around submerged cover to advantageously position the netter(s) to pick up stunned and immobilized fish. Personnel consist of one person to operate the boat, monitor the control box, and ensure the safety of two fish collectors on the bow.

Field collection of fish *must* be conducted by qualified/trained technicians that are efficient with this type of sampling. During sampling, an effort shall be made to collect all fish observed. Fish < 20 mm in total length are not counted toward part of the catch.

Field identifications of fish *must* be conducted by qualified/trained fish taxonomists or fisheries biologist, familiar with local and regional ichthyofauna. Fish collected shall be identified in the field down to species using scientifically accepted taxonomic keys (e.g., Becker 2001, Pflieger 1997, Trautman 1981). Fish that cannot be identified will have a voucher specimen collected, preserved using accepted methods, and identified later in the lab. All fish will be measured to the nearest 10 mm and recorded.

At a minimum, the following information will be recorded for each survey:

- County
- Stream/river name, location description and reach number,

- o GPS coordinates for beginning and end of reach sampled
- o Date
- o Photograph of beginning and ending of each reach, looking upstream or downstream towards the area sampled
- o beginning and ending time of sample collection,
- o names of all sampling crew members
- o full description of gear type, basic unit design, number of anodes, power settings, etc.
- o All fish collected down to species, including length,
- o Conditions at the beginning of sampling, to include:
  - water temperature
  - conductivity
  - dissolved oxygen
  - Secchi disk depth
  - total suspended solids (as measured in Nephelometric Turbidity Units (NTUs)
  - Basic description of weather
- o Note any issues that may have influenced sampling effectiveness or efficiency
- o Depth range during sampling (minimum and maximum),
- o Approximate average depth,
- o General substrate types encountered, and qualitative abundance of each

Physical Habitat Assessment: Following completion of the Fisheries Assessment, field investigators will also perform an assessment of physical habitat and field water chemistry. Field investigators shall follow the protocol from Appendix B for non-wadeable streams. Physical Habitat Assessments for wadeable streams will follow the methodologies of the corresponding state (Appendix B and C for wadeable streams. Note that Lab water quality analyses shall not be performed as a part of this effort (Appendix C, E.3 Lab Water Chemistry)).

Macroinvertebrate Assessment: Macroinvertebrate Assessments shall be completed after Fisheries Assessments. Macroinvertebrate surveys will follow the methodology outlined in Appendix D for wadeable streams; and Appendix E for non-wadeable. Macroinvertebrate samples will be processed according to the methodology in Appendix F. Several acceptable laboratories are available for analysis. Before a laboratory is used, the USACE Project Biologist with input from the Aquatic Biological Monitoring Team (ABMT) must approve of the desired laboratory. State agency partners have used similar protocol and achieved satisfactory results through contracting with the following laboratories for macroinvertebrate analysis: Rithron Inc, (Missoula, MT); and Dr. Andre Delorme with Valley City State University.

1.2 SAMPLING FREQUENCY AND TIMING

Surveys for fish, macroinvertebrates, and physical habitat will be performed twice prior to construction. Additional sampling events will be considered based on results observed during the first two sampling efforts and funding availability. Post-construction monitoring will include at least two surveys performed within the first 20 years following Project completion. Additional assessments may be warranted if the Project operates frequently within the first 10 to 20 years, or studies during the geomorphic analysis indicate long-term changes occurring beyond this 20-

year timeline. Assessments will be performed in the same locations as those for the pre-construction surveys to identify any changes to habitat quality and the effects on biota.

Some of the impact concerns of the Project are associated with habitat change resulting from Project operations. Ideally, sampling events would then be done in response to flood events (17,000cfs or greater) triggering Project operations. Based on past hydrograph records there is a probability that a flow of 17,000 cfs or greater happens about every 10 years but it isn't possible to know exactly how many years will pass until the Project is operated. Also, many impact concerns are associated with habitat losses during construction, and the effectiveness of mitigation actions for those losses. These losses and gains would be more immediate. In addition, the USACE has a responsibility to report on mitigation effectiveness annually with agency partners and USACE Headquarters. To try and balance the need for mitigation reporting and the timeframes for impacts and mitigation effectiveness, the first post-construction assessment may not occur until the Project has operated at least one time. However, if the Project does not operate within the first 5 years that the entire Project is constructed, then the first round of post-construction monitoring will be performed to verify the status of habitat conditions at the time, and verify the impacts and mitigation associated with footprint impact sites. Note that monitoring may not occur the same year as Project operation given the logistics of sampling and even if the Red and Wild Rice River Control structures don't operate, the aqueducts result in a change of condition when they are put into operation.

The second round of post-Project assessments may not occur until Project operation has occurred at least once, and preferably multiple times. In this case, ABMT will recommend to AMMPT on when this second round of monitoring may best be done. However if Project operation has not occurred within the first 20 years, a second round of sampling will be performed at year 20. Also, this second round of sampling will be moved earlier if the first round of monitoring identified that Project mitigation was not offsetting project impacts. The second round of monitoring assessments may also be moved up if the Geomorphology Assessment identifies concerns. These and any changes in the timing, frequency or need for additional fish and macroinvertebrate assessment events will be discussed amongst the ABMT and ultimately decided by USACE and/or Diversion Authority as a part of the adaptive process.

1.3 FISH, MACROINVERTEBRATES, AND PHYSICAL HABITAT ASSESSMENT EVALUTION AND PROCESS

Assessment Responsibility: The USACE will perform all sampling pre- and post-construction prior to formal transmittal of the Project to the local sponsor. Once the Project Proposer assumes formal Project ownership, they will be responsible for post-construction monitoring of fish, macroinvertebrates, and physical habitat as outlined within this monitoring plan. Sampling results and subsequent discussion on adaptive management with USACE and partner agencies will be accomplished with the AMMPT as further discussed in this Adaptive Management and Monitoring Plan (AMMP).

Process for Evaluating Mitigation Effectiveness: Data collected above will be compared to verify habitat losses at identified Project impact sites have been offset by habitat gains at mitigation sites (the locations of these mitigation sites is yet to be determined). This will include identifying habitat quality in both impact sites and mitigation sites via IBI scores. These scores will be multiplied by the habitat areas to generate a "habitat unit." Mitigation gains in habitat units should offset habitat unit losses in impact areas. If mitigation gains remains below habitat losses, the ABMT will notify the AMMPT and discuss what additional actions may be needed to rectify the issue.

For footprint impact sites, the habitat conditions observed pre-construction (as measured by IBI scores) will be used to estimate the amount of habitat initially lost due to construction of the Project (habitat quality X habitat quantity). Then, the quality of aquatic habitat within new adjacent channels created as mitigation will be measured by fish and macroinvertebrate IBI scores. This will be multiplied by aquatic area to assess how much new aquatic habitat is actually created in these adjacent areas. The difference between the amount of aquatic habitat pre-construction and post-construction, as measured in habitat units, identifies the amount of mitigation need under the Project.

For mitigation sites, the habitat conditions observed pre-construction (or pre-mitigation action, as measured by IBI scores) will be used to estimate the amount of initial habitat (habitat quality X habitat quantity) available. Then, the quality of aquatic habitat in the same area following mitigation actions will be measured by fish and invertebrate IBI scores. This will be multiplied by aquatic area to assess how much aquatic habitat has improved in these areas, thus creating a new amount of habitat units. The difference between the amount of aquatic habitat pre-construction and post-construction, as measured in habitat units, identifies the amount of mitigation benefit created under the mitigation action. This amount of mitigation benefit (measured in habitat units) will need to meet the amount of habitat lost (measured in habitat units) through site-specific impacts.

The process for verifying impact levels and mitigation effectiveness is intended to be an adaptive process. The ABMT will meet to discuss all aspects of data available to ensure that mitigation is working to the level necessary to offset identified impacts. This will include consideration for how data was collected using the BACI approach, and whether changes may be due to the Project, or due to outside influences. It also will help verify that new, unexpected impacts haven't arisen and if they do, whether additional monitoring or study may be needed; and whether further recommendations are necessary for modifying Project operations, implementing additional mitigation, or other actions. The ABMT may also make recommendations for using alternative metrics or data, in addition to IBI scores, to create a more robust plan to ensure impacts have been adequately mitigated.

<u>Considerations for benthic fishes on the Red River</u>: The ABMT expressed concern that while the proposed methods may work well to assess general fish presence as an indicator of general habitat quality, it may not reflect well changes in some benthic fishes that are important within the Red River. Species such as channel catfish and lake sturgeon are very important to the Red River system but are not well collected by the field methods proposed above, especially within the Red River which is generally larger and deeper than the other tributaries. For these reasons, the natural resource agency group is considering incorporating gill netting into the sampling methodology for fish on the Red River only. The methodology still needs to be developed, but may generally follow procedures outlined in the Riverine Index Netting Manual of Instructions produced by the Ontario Ministry of Natural Resources (Version 2.0; March 2010). The ABMT will need to use the general

adaptive process outlined within this monitoring plan to collaboratively discuss the best approach to incorporating this gear type, including discussing the metrics to be generated and how these metrics may be used for comparison. It should be noted that data collected here would not be applicable to the generation of IBI scores, and thus would need to be considered separately. However, it would provide another reference point to verify if the Project is impacting benthic fishes. The data collection also should strive for consistency with other State protocols to ensure that netting data may be comparable with data collected outside this direct effort. Recommendations for potential gill netting will be developed prior to the next round of pre-construction monitoring.

2.0 MONITORING FOR IMPACTS TO CONNECTIVITY

Biological connectivity is an important functional value in river systems. Biological connectivity is the ability for aquatic organisms to move both laterally and longitudinally within aquatic systems to access habitat that optimizes the ability for fitness, survival and completing all life history requirements. The Project has the potential to affect how organisms move longitudinally through both the Red River mainstem and select tributaries. This could occur in three primary ways. First, while the control structures on the Red and Wild Rice rivers would be passable to fish when they are not in operation, they will likely be impassable when the Project is in operation due to high water velocities through the gate openings. Second, concerns have been expressed that the aqueducts crossing the Sheyenne and Maple rivers may limit connectivity due to shallow depths and uniform (and potentially elevated) flows through a long, straight concrete channel, with consistent velocities. Such artificial conditions may deter fish movement through the aqueducts. Lastly, because the diversion channel could draw fish up during periods of Project operation, impacting natural migrations that would have continued upstream within the Red River, the rock ramp is being designed to pass fish to and from the Rush River. Concerns about the magnitude of the draw at structures need to be discussed during the design phase. In addition to these concerns over Project features, the Project includes mitigation activities at two dams in an attempt to improve fish passage. These activities will also need monitoring to ensure effectiveness. Given these concerns, biological connectivity will be monitored to help assess the potential effects of the Project on this important function.

Impacts to lateral connectivity may also occur with operation of this project. Geomorphology assessments discussed in the Geomorphology Monitoring Plan could help confirm whether lateral connectivity, or fish access to the floodplain, is significantly impaired by the Project. It also could help confirm if there is significantly increased sedimentation in the floodplain of the staging area which could otherwise impact phytophilic fish species that commonly utilize these off-channel habitats.

Biological connectivity is a function that has been greatly impacted historically throughout the Project area. There are three existing lowhead dams on the Red River mainstem within the Project area in Fargo-Moorhead. These dams have recently been retrofitted with rock rapids fishways to promote fish movement past these obstacles. It is unknown how effectively these structures promote fish movement. Dams also exist on the lower extents of the Wild Rice, Sheyenne and Maple rivers within the Project area, limiting fish movement between the Red River and these tributaries. In the case of the Sheyenne River, the existing flood control project on the lower river likely is a significant barrier to fish movement under most conditions.

Ideally, monitoring for impacts to connectivity would include pre-construction monitoring to verify existing levels of connection. However, monitoring for connectivity can be labor intensive and costly. To simplify monitoring needs and previous impact discussions (e.g., state EIS), it is assumed that fish had the ability to freely move throughout the Red River. This assumption will likely be evaluated, particularly at the three fish passage structures in Fargo, when connectivity issues are considered through post-construction monitoring. The level of connectivity is much more limited on the Wild Rice, Sheyenne and Maple rivers where existing impediments in lower tributary reaches limit fish movement. This understanding of connectivity allows for the Project to move forward without performing extensive pre-construction monitoring across several rivers. The adaptive monitoring approach discussed below will focus on activities once the Project has been constructed.

2.1 METHODS

Metrics

Metrics will need to be developed during monitoring plan refinement. For monitoring of hydraulic conditions, metrics could include measurement of water velocity and comparison of these velocities with fish swim speed performance, including burst speed and/or prolonged swim speed. For monitoring of fish or other biota, it could include direct observation and quantification of fish performance moving around or through Project structures. This could include identifying some level of acceptable performance in terms of relative percentage or diversity of fish that are able to pass through Project structures.

Study Areas

Potential impacts to connectivity will be monitored at the following locations:

- Red River Control Structure
- Wild Rice River Control Structure
- Sheyenne River Aqueduct
- Maple River Aqueduct
- Lower End of Diversion Channel
- Drayton Dam Mitigation Fish Passage
- Three rock ramp structures in Fargo

A mitigation project also has been proposed at Wild Rice Dam. However, since this is strictly a dam removal project, the ABMT collectively agreed that monitoring connectivity at this location (i.e., mitigation success) isn't necessary. The Project would remove the dam (the barrier to connectivity) and return the area to conditions similar to pre-dam. Fish passage through this location would not differ appreciably than any other location upstream or downstream of the dam. It will be assumed that connectivity has been achieved with the dam removal.

2.2 SAMPLING FREQUNCY AND TIMING

Without pre-construction monitoring, field monitoring activities would not commence until Project features have been constructed and put into operation. Once constructed, Project feature questions that will require further evaluation include: 1) Do the Red and Wild Rice control structures limit fish movement during periods of Project operation?; 2) When are the aqueducts passable to fish, and under what conditions (e.g., do the aqueducts operate continuously)?; 3) To what extent does the diversion actively draw fish in during operation, and is this beneficial for getting fish to and from the Rush River?; and 4) How well does the Drayton mitigation project work to pass fish?

Monitoring for Project impacts would not be performed for some time. Although techniques for monitoring fish movement and biological connectivity are available, several tools are still relatively recently used and/or continue to be refined and improved. These include tools such as acoustic telemetry tagging, Passive Integrated Transponder (PIT) tagging, and sonar imaging (e.g., DIDSON sonars). All of these tools may be useful in characterizing fish movement and biological connectivity, and could see additional improvement in their respective technologies prior to any monitoring needs. As such, development of a detailed monitoring plan is premature at this time.

For the purpose of this monitoring plan, the general approach will be identified for evaluating potential impacts to connectivity. This approach will be refined as the time for monitoring is near.

2.3 CONNECTIVITY EVALUATION AND PROCESS

Evaluation of Hydraulic Conditions: Hydraulic conditions, including flow velocities and patterns, will be evaluated at Project structures under a range of flow conditions. For the Red and Wild Rice control structures, this may include measurement both during Project operation, as well as high flow conditions where the Project is not operating, but velocities are high enough where fish movement through the control structures could be in question. For the two aqueducts, this would likely include flows through the aqueduct from low summer-flow conditions, through flows where the aqueducts are actively spilling water. For the diversion channel this could include flow patterns and velocities for a couple different magnitude flood events. It could also include observations from a different diversion channel locations, such as the diversion outlet, and conditions adjacent to the Maple River aqueduct. Lastly, flow conditions may be evaluated at and around the Drayton Dam mitigation site at multiple river discharges.

Evaluation of Biological Connectivity: If questions still remain about impacts to biological connectivity following review of hydraulic conditions, additional biological sampling may be performed. The exact methodology and periodicity will be determined at that time, but may include:

a) Collection/observation of fish by nets or electrofishing;
b) Use of basic tags such as floy tags to observe fish movement;
c) Use of more advanced tagging such as acoustic tagging or PIT tagging; or use of DIDSON sonar to directly observe fish behavior.

The ABMT will be responsible for analyzing data. Findings may determine that modifications to mitigations or Project operation may be needed, or that additional mitigation may be warranted. These recommendations would be provided to the AMMPT for further consideration. The AMMPT will recommend actions in the broader context of the Project adaptive management plan; however, it is noted that the USACE and/or Project Proposer will be included in and may have ultimate decision authority or that regulatory agencies may require action as part of a permit condition.

Process for evaluating Mitigation Effectiveness: The process for comparison of metrics and verification of mitigation effectiveness still need to be developed by the ABMT. This will occur during the several years of project design and construction and prior to when impacts would be expected to occur. This will include involvement of Agency representatives during the design of project features, such as what has occurred for planning the Drayton Dam mitigation feature.

This process will need to carefully consider what data is needed to make these decisions, how that data could be collected, and how the comparisons can be made to verify impact levels and mitigation effectiveness. Metrics will need to be created to help measure connectivity impacts, and/or the effectiveness of mitigation, as appropriate. As with site-specific impacts discussed above, the ABMT will need to consider all aspects of data available to ensure that mitigation is working to the level necessary to offset identified impacts. It also will help verify that new, unexpected impacts haven't arisen and if they do, whether additional monitoring or study may be needed. The ABMT can also consider whether modifying project operations, implementing additional mitigation, or other actions, may be helpful to further minimize impacts to connectivity.

MONITORING RESPONSIBILITIES

Monitoring responsibilities would be with the USACE and the local sponsor prior to transferring project ownership. Once the local sponsor officially assumes responsibility of the project, monitoring becomes a local sponsor responsibility as a part of operation and maintenance of the overall project. As such, any pre-construction monitoring would be accomplished jointly between USACE and the local sponsor. Post-construction monitoring would initially be a joint venture, but fall to the sponsor sometime after.

Costs for monitoring were included as a part the estimated monitoring costs within the feasibility study. These will need to be further refined for monitoring of connectivity as these methods are still speculative at this time. Monitoring costs will be cost-shared until the time at which the Project Proposer takes over full ownership responsibilities of the Project. At that point, monitoring costs would be the responsibility of the local sponsor.

3.0 COLLABORATION AND COMMUNICATION PLAN

Collaboration and planning monitoring activities, results analysis and interpretation will occur jointly among USACE, project sponsorship and other key organizations as part of the AMMPT and ABMT teams adaptive management structure. The final decision on whether or not mitigation is meeting federal responsibilities lies with USACE. State and local permitting authorities will also have criteria and/or permit conditions associated with mitigation effectiveness and Project impacts that will need to be adhered to.

To successfully implement this Monitoring Plan will require coordinated communication between the agencies and stakeholders key to the planning, funding, and executing the plan components as discussed within the adaptive management plan framework. This section highlights the critical intersections of data needs and collaborations that would support effective and efficient data collection and analysis specific to the geomorphic facets of an adaptive management effort.

Identification of Key Organizations

1. United States Army Corps of Engineers, Local Sponsors, United States Fish and Wildlife Service, North Dakota Department of Game and Fish, Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, North Dakota State Water Commission, and North Dakota Department of Health.
2. If needed, participation with local watershed district or watershed organizations is anticipated to be coordinated by the Local Sponsors.

Agreement and Implementation of Protocols

A method for discussing protocols and keeping them up to date with changing contractors or field staff and agency personnel is critical for ensuring accuracy and comparability of data sets over time. A flow chart or decision matrix could be developed in the next stage of project planning as a communication guide for the following functions:

1. Coordination needs to happen in advance of field work, post-event situation, change in organizations/contractors, and change in protocol or technologies.
2. May require field visits to go over field methodologies, protocol.
3. Any changes or update to protocols agreed on by the key organizations technical experts will be shared with the larger AMMPT through the ABMT representative(s) to that group and the documentation will be updated and shared immediately for accountability.

Scheduling Data Collection Efforts

1. The fish/invertebrate monitoring schedule will set a lapsed time and event basis for monitoring different characteristics of the Project system. Coordination between the identified technical experts / organizations shall be done in advance of the actual field work so that concerns and potential changes can be addressed appropriately.
2. It is acknowledged that the AMMPT will be provided the recommended schedule and any deviations based on the needs of the Project. In turn, the AMMPT will communicate well in advance of the field season any suggested changes or necessary deviations based on other criteria like funding or changes in Project operation and other unanticipated changes.

Data Exchange

Data will and may be collected by more than one contractor or agency and that data needs to be shared for redundancy and analysis purposes.

1. Recommend that the local sponsors be the official repository/host of all of the data sets and completed analysis from the beginning of the monitoring program into perpetuity.
2. Raw data shall be shared with other requesting agencies after collection.
3. Post-Processed data can be shared with all of the agency participants on a regular basis.
4. Data from state resource agencies may be included in this data base.
5. Data needs to be shared within 2 months of the end of the data collection.
6. Results need to be shared with the AMMPT by the end of the calendar year or 3 months prior to the next anticipated field season.

Data Analysis

1. Meetings/discussions for analyzing and interpreting data with regards to fish/invertebrates will be open and scheduled for participation by all of the interested agencies.
2. The interpretation and any recommendations based on the results will be shared with the AMMPT.
3. The AMMPT will be responsible for determining appropriate responses based on the fish/invertebrate group recommendations.

Mitigation and Response Action Planning

1. The monitoring plan results will inform what future mitigation or response actions, if any, are necessary.
2. The Fish/Invertebrate Group provides to the AMPT any recommendations based on analyzed data that would be useful for the AMPT in collaboration with the Fish/Invertebrate Group to develop mitigation or response actions for unforeseen impacts to the habitat of the system.
3. It will be up to USACE and Project sponsorship to approve a recommended plan for implementation of any further action. Representatives will participate on the AMMPT. State and local permits may require actions through regulatory authorities on permits as permit conditions. Representatives for state and local authorities will also participate on the AMMPT.

Appendix A
Fisheries Sampling in Wadeable Streams

7.16

STANDARD OPERATING PROCEDURE FOR THE COLLECTION OF FISH IN WADEABLE RIVERS AND STREAMS

Summary

Fish are an important aquatic community, especially in perennial rivers and streams. Fish are not only highly visible to the public, but are also easily sampled by professional biologists. There are several attributes of fish communities that make them desirable for biological monitoring and assessment programs (Simon 1998). These attributes include: 1) fish populations and individuals generally remain in the same area during summer seasons; 2) fish communities are persistent and recover from natural disturbances rapidly; 3) most fish species have long life spans (3-10+ years) and can reflect both long-term and current water quality; 4) aquatic life uses described in most state's water quality standards are generally characterized in terms of fish; 5) the sampling frequency for trend assessment is less than the sampling frequency for short-lived organisms; and 6) the taxonomy, distribution, life histories, and tolerances to environmental stressors of most North American fishes is well documented.

Fish sampling follows a disciplined collection procedure to get a repeatable, representative, distance-specific, and quantitative estimate of taxa richness and biomass. Fish collection procedures must focus on a multi-habitat approach where all available habitats are sampled in proportion to their availability in the stream sample reach. Each sample reach should contain riffle, run, and pool habitat when available. In order to avoid their hydrological effects on habitat quality, the sample reach should be sufficiently upstream of any bridge or road crossing, whenever possible. In the end, however, wadeability and accessibility may ultimately determine the exact location of the sample reach. Sampling is conducted from mid to late summer to take advantage of stable, low flow conditions. The accurate identification of each fish collected is essential, and species-level identification is required (including hybrids). Field identification of fish is acceptable. However, voucher specimens must be preserved and retained for independent laboratory verification.

Regardless of the sampling method, all fish sampling gear types are considered selective to some degree. Electrofishing however, has proven to be the most comprehensive and effective single method for collecting stream fishes. Pulse DC (direct current) electrofishing is the method of choice to obtain a representative sample of fish at each sampling site.

The following methods have been developed, in part, based on the Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition (Barbour et al. 1999).

Equipment and Supplies

- North Dakota Game and Fish Department or other appropriate scientific collection permit(s)
- backpack, long-line, or tote barge-mounted electroshocker apparatus
- dip nets
- block nets (i.e., seines)
- polarized sunglasses
- life jacket
- electrician's high voltage rubber gloves
- chest waders
- ear protection (plugs or muffs)
- plastic buckets (20)
- small plastic perforated baskets (20)
- electronic scale
- spring scale
- measuring board
- ruler
- 1 liter and 500 ml jars for voucher/reference specimens
- 10 % buffered formalin (formaldehyde solution)
- fish collection field data sheets
- taxonomic key(s)
- pencils
- digital camera
- maps
- Global Positioning System (GPS)
- first aid kit

Procedures

1. Determine the sampling reach length and mark its upstream and downstream limits. When selecting the sample reach, consideration should be given to the influences of major tributaries and bridge/road crossings. Where feasible, the reach should be located a sufficient distance upstream from these influences so as to decrease their effect on overall habitat quality. The exact location (e.g., latitude and longitude) of the downstream limit of the reach should be determined with a Global Positioning System (GPS) and recorded on the Biological Monitoring Field Collection Data Form (Figure 7.16.1) along with the station ID, water body name, station description, major basin, level IV ecoregion, county, and township/range/section.

   Two methods may be employed to determine the sample reach. The first method is termed the "fixed-distance designation" and is considered the Department's default method for specifying the sampling reach. Using the fixed-distance method a standard 150 meter stream length is sampled. The sample reach should include a mixture of all available stream/river habitats (i.e., riffles, runs, pools, snags, overhanging banks). If all available habitats can not be sampled within the 150 meter designation, the sampling reach length should be extended either upstream or downstream by increments of 50 meters.

An alternative to the fixed-distance designation is the "proportional-distance designation." With this method, the sample reach is determined by taking the bank full width of the river or stream times a standard number (e.g., 40 times the stream width is used by EPA's Environmental Monitoring and Assessment Program (EMAP) for sampling). The method employed to determine the sample reach should be described in the project specific Quality Assurance Project Plan (QAPP).

2. Complete a habitat assessment of the sample reach. The Department's default habitat assessment methodology is the Rapid Bioassessment Habitat Assessment methodology described by Barbour et al. (1999). When other habitat assessment methods (e.g., EMAP) are used they should be described in the project specific QAPP.

3. Complete the remaining field information on the Biological Monitoring Field Collection Data Form (Figure 7.16.1) by recording information on ambient weather conditions, stream water quality (e.g., temperature, pH, specific conductance, dissolved oxygen), and physical condition (e.g., shoreline condition, bottom substrate, flow, average width and depth), the method of collection, start time, ending time and duration of sampling.

4. Begin sampling via long line electrofishing with a minimum of a three (3) person fisheries crew; one person to handle the wand, one person to pull the line and to carry buckets full of stream water to hold the stunned fish; and one person to attend the generator. The third person attending the generator should maintain visual contact with the electrofishing crew at all times and should be prepared to turn off the generator should there be an accident. The safety of all personnel and the quality of the data is assured through the adequate education, training, and experience of all members of the electrofishing team. At least one biologist with training and experience in electrofishing techniques and fish taxonomy **must** be involved in each sampling event. It is also required that at least 2 members of the fish collection team be certified in CPR (cardiopulmonary resuscitation) and have basic first aid training.

   Sampling begins at the bottom or furthest downstream end of the reach. Sampling is performed by shocking along both shorelines in streams 5 meters wide and wider, or following a serpentine pattern along both shores for streams less than 5 meters wide. All habitat and stream types are sampled thoroughly in an attempt to capture all fish encountered. Fish collected are held in buckets for later identification and enumeration.

   Note: When natural barriers to fish migration (e.g., riffle areas) are lacking in the sample reach, it is recommended that a blocking net be placed on either end of the reach to prevent fish from escaping.

5. Adult and juvenile specimens from each site are counted and identified to species utilizing taxonomic keys relative to the region. Smaller and more difficult to identify taxa can be preserved for later identification in the laboratory. Young of year fish less than 25 mm in length are not included in the analysis. As fish are sorted, record the number of individuals of each species collected, the composite weight of each species, and the minimum and maximum length of each species on the Fish Collection Field Form (Figure 7.16.2). All fish should be examined for the presence of gross external anomalies (e.g., deteriorated or eroded fins, lesions, or tumors) and their number recorded for each species. The presence of hybrid species encountered in the field should also be recorded, and when possible the potential parental combinations recorded.

6. A voucher sample with representation of each species sampled is jarred, preserved with 10% buffered formalin, and labeled for permanent record. A label, containing the site identification, river/stream name, site description, date of collection, and sampler(s), should be placed on the outside of the jar as well as inside the jar.

7. After data collection all fish not retained in the voucher sample are released back into the waters from which they came.

   Note: If any species of special concern (e.g., threatened or endangered) are encountered they should be noted and released *immediately* on site.

8. After the final site clean-up and prior to leaving, take a minimum of one upstream and one downstream photograph from the mid-point of the sample reach.

9. Quality and quantity assurance is verified by revisiting a minimum of 3 sites each sampling year. The re-sampling will identify the range of variance associated with the method of sampling and analysis employed. For future reference and verification a voucher collection of all species collected at each site will be preserved and archived by the NDDH.

References

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers: Periphyton, Benthic Macroinvertebrates and Fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.

Simon, T.P. 1998. Introduction: Biological Integrity and Use of Ecological Health Concepts for Application to Water Resource Characterization, in T.P. Simon Ed. *Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities*. CRC Press, Boca Raton, FL. 3-17.

North Dakota Department of Health
Division of Water Quality
Biological Monitoring Field Collection Data Form

Station ID: ____________________________________ Field Number: ___________________________________
Waterbody Name: ____
Station Description: ____
Latitude: _________________________________ Longitude: ____
County: ___________________________ Township: ________ Range: ________ Section: ___________________
River Basin: ____________________________________ Ecoregion: ____________________________________
Weather (air temp, wind, etc.): ____ Flow (cfs): _______________
Water Temp: __________ pH: ___________ Specific Cond.: _____________ Dissolved Oxygen: ______________
Reach Length (m): ___________ Average Reach Width (m): ___________ Average Reach Depth (m): __________
Stream Habitat Type (%): Riffle: ____ Pool: ____ Snag: ____ Aquatic Vegetation: ____ Undercut Bank: ____
Overhanging Vegetation: ____ Other: ____________________________________
Bottom SubstrateType(%): Boulder: ____ Cobble: ____ Gravel: ____ Sand: ____ Silt: ____ Clay: ____
Collection Method: ________________________Time Start: _________ Time Stop:_________ Total Time:______
Habitat Assesment: Yes or No Macroinvertebrate Sample: Yes or No Water Chemistry: Yes or No
Sampler(s): ____
Comments: ____
____

Figure 7.16.1. Biological Monitoring Field Collection Data Form.

North Dakota Department of Health
Division of Water Quality
Fish Collection Field Form

Station ID: ______________________________________ Field Number: ____________________________________
Waterbody Name: ____
Station Description: ____
Latitude: _____________________________________ Longitude: ____
County: ____________________________ Township: ________ Range: ________ Section: ____________________
River Basin: ______________________________________ Ecoregion: ______________________________________
Sampler(s): ____
Comments: ____

Species	Number of individuals	Length Range (mm)		Bulk Weight (g)	No. Anomalies	Voucher	
		Minimum	Maximum			Y	N

Figure 7.16.2 Fish Collection Field Form.

Appendix B
Fisheries Sampling in Non-Wadeable Streams

Quality Assurance Project Plan: Fish Assemblage Assessment Methods and Biological Criteria Development for the Red River of the North

Effective Date: August 15, 2010

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Group A: Project Management Elements

A.3: Distribution List

The Midwest Biodiversity Institute, Inc. proposes to develop a conceptual and technical basis for applying biocriteria and tiered uses in the Red River of the North mainstem along the North Dakota and Minnesota borders. This will be accomplished by collecting new data and analyzing existing data from the Red River mainstem. This project will be conducted in cooperation with the North Dakota Department of Health as a direct participant and Minnesota Pollution Control Agency (PCA) and the International Water institute as an interested observers. An initial list of interested entity contacts include:

North Dakota Dept. of Health, Mike Ell (mell@nd.gov)
Minnesota PCA, Scott Niemela (Scott.Niemela@state.mn.us)
Minnesota PCA, Dan Helwig (Helwig.Daniel@state.mn.us)
International Water Institute, Charles Fritz (Charles.Fritz@ndsu.nodak.edu)

We will add to the list as new participants are identified.

A.4: Project/Task Organization

The Great Lakes Environmental Center (GLEC) is the prime contractor and is responsible for all deliverables under the EPA work assignment. All phases of the proposed study will be coordinated and conducted by the Midwest Biodiversity Institute (MBI) as a subcontractor to GLEC. Chris Yoder, MBI, will serve as the principal investigator and project coordinator. In this capacity he will provide the primary oversight and management of all aspects of the project and ensuring that all methods and procedures are followed. He will also be directly responsible for maintenance and management of the Quality Assurance Project Plan (QAPP). MBI will assign qualified crew leaders who will be responsible for all data collection activities. Additional field personnel will be assigned to assist this person with field work under the direct supervision of the MBI project coordinator. A functional table of organization appears in Figure 1.

Advice and assistance with the design of the proposed study has been sought and will continue to be provided by the Region V state agencies, federal agencies, and nongovernmental organizations. Each agency and organization will benefit from the data and assessment produced by the proposed study. The states will benefit from the development of large river biological and habitat assessment tools and a standardized protocol. Users will benefit from the baseline assessment information and how it relates to the development of tiered aquatic life uses (TALUs) and biological criteria for non-wadeable rivers. This project is allied with other efforts to determine the feasibility and usefulness of developing tools like the Index of Biotic Integrity (IBI) and basic assemblage data for the development of numerical biological criteria nationwide.

Red River Quality Assurance Project Plan: Functional Table of Organization

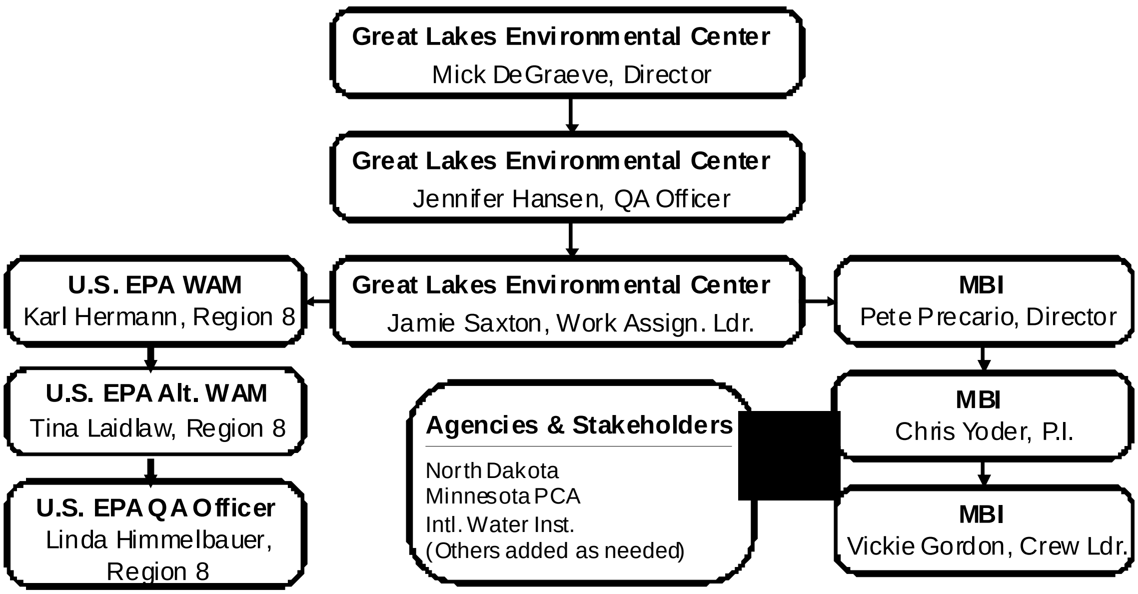

Figure 1. Functional table of organization for Red River bioassessment project implementation and management.

A.5: Problem Definition and Background

The proposed study will investigate the applicability of bioassessment methods for fish and macroinvertebrate assemblages in the development and management of TALUs in the Red River of the North. Fish will be the primary biological indicator sampled with a standardized, pulsed direct current (D.C.) boat electrofishing protocol developed in U.S. EPA, Region V as a means of assessing the structure, quality, attributes, and health of the fish assemblage in the Red River mainstem. Macroinvertebrates will be included as a supplemental indicator by the North Dakota Department of Health utilizing National River and Stream Assessment protocols (U.S. EPA 2008).

Methods and procedures for sampling fish assemblages that have proven effective in many areas of the U.S. will be used (Gammon 1973, 1976; Gammon et al. 1981; Hughes and Gammon 1987; Ohio EPA 1989; Lyons et al. 2001; Mebane et al. 2003; Emery et al. 2003). The principal focus of this study is on the fish assemblage and an accompanying qualitative habitat assessment following methods developed in Region V. A technical directive was issued on July 21, 2010 approving the use of these methods (Appendix 1). Macroinvertebrates and chemical/physical water quality will be added as supplemental indicators for the Red River mainstem in 2010 under the NRSA QAPP.

This project proposes to demonstrate the utility of a TALU based approach[1] to monitoring and assessment and water quality standards (WQS) in non-wadeable rivers. The principal objectives include the application of a standardized fish assemblage sampling protocol, an evaluation of the feasibility of developing regional biocriteria for large rivers, and TALUs as a result of the biocriteria development. While there are additional possible uses of the data and information that will be produced by this study, the principal focus is on the development and application of TALUs. This is a priority for the U.S. EPA National Biological Criteria Program.

Biological Assessment of Large, Non-Wadeable Rivers
While there is no single definition of a large, non-wadeable river it includes those lotic systems that cannot be ***adequately nor consistently*** sampled with wadeable sampling protocols. The operational extent of wadeable vs. non-wadeable may also vary between organism groups; for example a river may be wadeable for algal or macroinvertebrate sampling, but not for effective fish sampling. Others have used catchment area definitions; great rivers drain more than 10,000 mi^2 of land area (Simon and Sanders 1999) and large rivers more than 1000 mi^2 (Simon and Lyons 1995; Ohio EPA 1989; Table 1). What can be agreed upon by most is that the development of biological assessment tools, particularly those focused on assessments of condition and status, has lagged behind the development of wadeable stream methods. It is an objective of the proposed study to refine our understanding of where and when sampling and assessment methodologies for large, non-wadeable river fish assemblages should be applied.

Biological assessments have been conducted in large, non-wadeable rivers of the U.S. since the late 1940s. Most of the early efforts focused on the more easily measured biota of that time period (i.e., macroinvertebrates, periphyton, plankton), the inclusion of the fish assemblage being a rare and relatively recent addition. Single-gear assessments are even more recent and include the pioneering work by Gammon (1973, 1976, 1980) and Gammon et al. (1981) in Midwestern rivers, principally the Wabash River of Indiana. Other efforts followed and most were associated with studies of thermal effluents in response to Section 316[a] of the Clean Water Act (CWA) in the 1970s and early 1980s. A common frustration with these studies was the lack of a standardized approach to data collection and the absence of a conceptual framework for analyzing the data and producing meaningful and consistent assessments. The development of the IBI type approaches to analyzing and assessing fish and other assemblage data in the early 1980s (Karr 1981; Karr et al. 1986; Fausch et al. 1984) provided the missing conceptual framework. Ohio EPA (1987, 1989) developed fully standardized methods and an IBI for non-wadeable rivers and used it to support the long term assessment of rivers (Yoder et al. 2005). This was followed by the development of new approaches for non-wadeable rivers such as the Ohio River

[1] The "TALU based approach" includes tiered aquatic life uses (TALU) based on numeric biological criteria and implementation via an adequate monitoring and assessment program that includes biological, chemical, and physical measures, parameters, indicators and a process for stressor identification.

Table 1. Ohio EPA fish assemblage sampling methods for wadeable and non-wadeable sites (after Yoder and Smith 1999).

	Wading Methods		Boat Methods		
Category	Small Streams	Other Streams	Small Rivers	Large Rivers	Great Rivers[1] Lake Erie[2]
Waterbody Size Dimensions:[3]	<1.0-10 mi^2 <0.3-0.5m depth 1-2m width	10-500 mi^2 0.5-1.0m depth 2-20m width	150-1000 mi^2 >1.0m depth 10-100m width	1000-6000mi^2 >1.0m depth >50m width	>6000 mi2 >1.0 m depth (Ohio River)
Platform:	Backpack; Bank set	Tow boat; Bank set	12-14' boat	16' boat	18' boat 21' boat
Unit:	Battery/ Generator	Generator	Generator	Generator	Generator
Power Source:	12v battery/ 300-1750W alt.	1750-2500W alternator	2500-5000W alternator	5000W alternator	5000/7500W alternator
Amperage Output:	1.5-2A; 2-12A	2-12A	4-20A	15-20A	15-20A
Volts D.C. Output:	100-200; 150-300	150-300; 300-1000	500-1000	500-1000	500-1000
Anode Location:	Net ring	Net ring	Boom (Droppers)	Boom (Droppers)	Boom; Spheres[4]
Sampling Direction:	Upstream	Upstream	Downstream	Downstream	Downstream; Downcurrent
Distance Sampled:	0.15-0.20km	0.15-0.20km	0.5km	0.5km	0.5-1.0km
CPUE[5] Basis:	per 0.3km	per 0.3km	per 1.0km	per 1.0km	per 1.0km
Time Sampled (Typical):[6]	1800-3600 sec	1800-3600 sec	1800-3600 sec	2500-4500 sec	2000-3500
Time of Sampling:	Daylight	Daylight	Daylight	Daylight	Twilight/ Night

[1] Great Rivers generally exceed 6000 square miles drainage area at the sampling site.
[2] Lake Erie methods similar to great river methods (see Thoma 1999).
[3] Maximum pool depth in small streams; sampling depth along shoreline in larger rivers.
[4] Droppers are used in inland rivers and the Ohio R.; electrosphere design is used on Lake Erie only.
[5] CPUE: catch per unit of effort.
[6] Normal range - sampling time may vary upwards due to factors such as cover and instream obstructions.

(Simon and Emery 1999; Emery et al. 2003) and for Wisconsin rivers including the Mississippi, Wisconsin, St. Croix, and Chippewa Rivers (Lyons et al. 2001). The Wisconsin study showed the utility of the assessment end product, which is an improved understanding of the ecological consequences of multiple human impacts (point and nonpoint sources, hydromodifications, multiple stressors) in non-wadeable rivers and the sequence in which they occur. Only Ohio has applied true TALUs to non-wadeable rivers having adopted biocriteria in their WQS and routinely assessing via their monitoring and assessment program (Table 2).

Biological Criteria Development

An important objective of this proposal is to contribute to the continued development and use of biological criteria on a national and regional basis, specifically in non-wadeable streams and rivers. The proposed study will fulfill an important prerequisite to the development of TALUs by testing and developing existing and new multimetric indices. Biological criteria are numeric values or narrative expressions that describe the biological condition of an aquatic assemblage inhabiting the waters of a given designated use (U.S. EPA 1990). Benchmarks for TALUs are developed with respect to reference condition (least impacted), which is derived from assemblage data at least impacted reference sites and/or by an expert derivation process. More recently the EPA Biological Condition Gradient (BCG; Davies and Jackson 2006) has shown promise as a way to derive and calibrate expectations for riverine fish assemblages. While the restoration of most U.S. waters to a pristine state is not presently feasible, it is reasonable to base contemporary restoration goals on regional reference conditions that describe the best attainable biological condition and performance (Davis and Simon 1995). Principles for the successful development of numeric biological criteria include developing a reference condition, a regional framework, a characterization of the aquatic assemblage, and a habitat evaluation for specifically defined aquatic ecotypes (e.g., large rivers, wadeable streams, headwater streams, wetlands, lakes, etc.). Ohio EPA has been a national leader in the development and use of biological criteria and other Region V states are in the process of developing similar approaches.

A U.S. EPA working group established in 1999 developed a concept termed the Biological Condition Gradient, which is intended to foster the consistent development of biological assessment frameworks and biological criteria development across the U.S. This concept is also intended to enhance communication, understanding, and visualization of biological condition relative to the absolute gradient of possible biological quality from pristine to extremely degraded (Figure 3; Davies and Jackson 2006). A challenge for developing biological criteria for non-wadeable rivers is the apparent lack of reference analogs, at least compared to that which is more commonly available for wadeable streams. As an alternative, using direct sampling data combined with historical knowledge and reconstruction of historical assemblages by expert analysis may be used as a partial substitute for directly measured reference condition (Emery et al. 2003). The proposed study will contribute to this process on both a national and regional basis.

Table 2. Example of TALUs for non-wadeable rivers; numeric biological criteria for the Index of Biotic Integrity (IBI) that are applicable to boat electrofishing sites in Ohio (Ohio Administrative Code Chapter 3745-1).

Ecoregion	Modified Warmwater Habitat (MWH)[2]	Warmwater Habitat (WWH)	Exceptional Warmwater Habitat (EWH)
HELP – Huron/Erie Lake Plain	20/22	34	48
EOLP – Erie/Ontario Lake Plain	24/30	40	48
IP - Interior Plateau	24/30	38	48
ECBP – E. Corn Belt Plains	24/30	42	48
WAP – W. Allegheny Plateau	24/30	40	48

A.6: Project Description

The study will entail mostly boat electrofishing and qualitative habitat assessment at in the Red River of the North mainstem between Wahpeton, ND and the U.S.-Canada border. This will include using an intensive pollution survey sampling design for approximately 40-50 locations over a lineal distance of just under 400 miles (Appendix 2). Acceptable electrofishing data generated by state monitoring programs will also be considered in a supporting role.

Habitat characteristics will be recorded at all electrofishing sites using a modification of qualitative, observation based methods (QHEI; Rankin 1989, 1995) under seasonal low flow conditions. Attributes of habitat include substrate diversity and composition, degree of embeddedness, cover types and amounts, classes of flow velocity, channel morphology, riparian condition and composition, and pool and run-riffle depths. Gradient will be determined from USGS 7.5' topographic maps and water clarity will be measured with a secchi disk. Water quality includes field parameters such as temperature, dissolved oxygen (D.O.), and conductivity. This will determined at each sampling location with portable meters.

[2] MWH biocriteria for channelized/impounded sites.

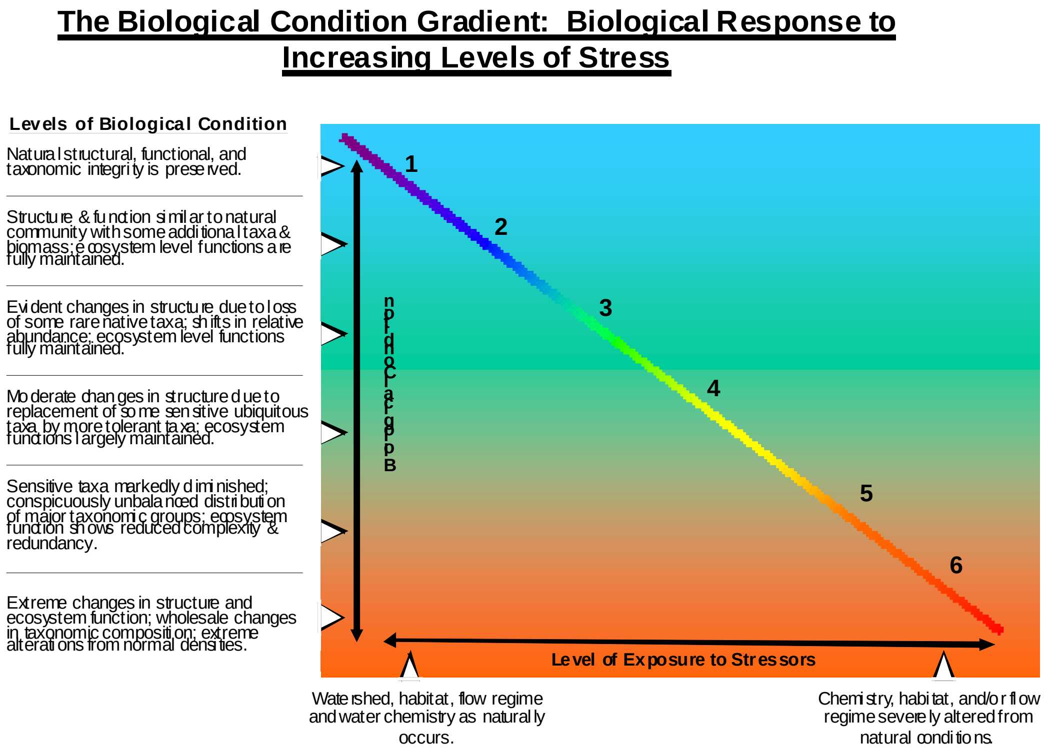

Figure 3. Tiered aquatic life use conceptual model showing a biological condition gradient and descriptive attributes of tiers along a gradient of quality and disturbance (updated July 2010).

Data Analyses

We expect to generate, at a minimum, baseline data on the relative abundance and distribution of fishes and qualitative habitat in the Red River of the North mainstem. This will include raw and summarized data comprised of species enumerations, catch per unit of sampling effort (CPUE by numbers and biomass), the incidence and severity of external anomalies on fish by species, basic field parameters such as temperature, conductivity, and D.O., and a qualitative habitat assessment (QHEI). All of this information will be entered and stored in a relational database managed by MBI and made available to project sponsors and participants. Specific data analyses that are planned include species relative abundance summaries by sampling location and river reach, spatial analyses of longitudinal patterns in fish assemblage attributes (species richness, CPUE, special interest species, structural and functional guilds, IBI scores) along mainstem reaches and with respect to major natural and human-influenced changes and gradients. We will also attempt to evaluate appropriate IBI metrics in keeping with the approaches employed by previous studies conducted under similar circumstances and following the original guidance of Karr et al. (1986). A summary of the newly derived Minnesota PCA IBI applicable to the Red River appears in Appendix 2 as an example of a regionally calibrated IBI. The Index of

Well-Being (Iwb) developed by Gammon (1976) and Gammon et al. (1981) and modified by Ohio EPA (1987; MIwb) will also be calculated and evaluated for its usefulness. The computational formula for the MIwb appears in Appendix 3. We will also examine other potentially applicable IBIs including the Fish Assemblage Community Index (FACI; Emery et al. 2007) and Long and Walker (2005) as they applied an IBI to the Winnipeg River.

A.7: Quality Objectives and Criteria

An important goal of a bioassessment program is to employ methods and equipment which are powerful enough to secure a sufficiently representative sample (accuracy), ensure reproducibility (precision), do so with a reasonable effort (cost-effective), and minimize potential bias induced by different operators thus making the results comparable. This has been accomplished within specific state programs (e.g., Ohio EPA), but it has only begun to be evaluated on a regional basis (Tewes et al. 2007). This study provides an opportunity to more precisely evaluate and define such objectives, which should lead to more consistency between states and programs. This is essential for the development of regionally applicable TALUs.

Data Attributes

The basic attributes of the data to be produced by the proposed study are counts and weights of fish delineated either individually or in the aggregate by species and by age classes. Species level taxonomy is the minimum data quality objective and identifications to subspecies will be determined when appropriate. Scientific nomenclature will follow that adopted by the American Fisheries Society (AFS; Nelson et al. 2004). Regionally applicable ichthyology texts with keys will be used. Information will also be recorded about the occurrence of anomalies, diseases, and parasites that are observed externally on each fish that is weighed and or counted following the methods used by Ohio EPA (1989) and further described by Sanders et al. (1999). Qualitative habitat data will also be produced using a method similar to that developed by Rankin (1989; Appendix 4) and as it has been modified for application to non-wadeable rivers.

Representativeness

Gammon (1973, 1976) assessed the representativeness of a standardized, pulsed D.C., large river boat electrofishing technique similar to that proposed for use in this study. Gammon determined that shoreline boat electrofishing over a distance of 0.5 km sampling along the shoreline with the greatest depth and most abundant cover, was the most effective *single* method for collecting a representative cross-section of the fish assemblage. Other studies have likewise shown boat electrofishing to be the single most effective gear for obtaining fish assemblage data in Midwestern streams (Funk 1958; Larimore 1961; Boccardy and Cooper 1963; Bayley et al. 1989), large rivers (Vincent 1971; Novotny and Priegel 1974; Hendricks et al. 1980; Ohio EPA 1987), the Ohio River (Sanders 1992; Simon and Emery 1995; Simon and Sanders 1999), and the Lake Erie shoreline (Thoma 1999). While boat electrofishing does not collect all of the species present, it can routinely collect more than 75-80% of the species that are present and approximate their relative abundances ***if it is executed***

correctly. This meets the purposes and requirements for biological assessments and biological criteria in that sufficiently representative data is produced to provide reliable signal about the health and well-being of the resource without the need to accomplish an exhaustive faunal inventory. The collection of relative abundance data includes the use of standardized sampling procedures designed to produce a sufficiently representative sample of the fish assemblage at a site with a reasonable expenditure of effort (i.e., 1-3 hours/site). As such this type of assessment is distinguished from the much more resource intensive efforts using multiple collection gear and those required to obtain estimates of population (standing crop) or a complete inventory of all species present. The numerous and previously referenced large river IBI development studies that followed Gammon's pioneering work have substantially confirmed the utility and representativeness of the approach. Lyons et al. (2001) correctly observed that single gear assessments might not be as useful for rare or single species issues or for detailed fisheries management needs such as stock assessments of commercially or recreationally important species. However, broad agreement between overall assemblage condition assessments and the correspondence of suitable conditions for rare species and fisheries goals has been demonstrated (Hughes and Gammon 1987; Yoder and Rankin 1995).

Precision and Accuracy
Ohio EPA (1987) extensively tested the reproducibility, accuracy, and precision of the same boat electrofishing sampling protocols that will be used in this project on their non-wadeable rivers. Based on a combination of data analyses from specially designed methods testing studies and the aggregate Ohio database, the reproducibility of an IBI score was determined to be 4 units out of a 12 to 60 scoring scale (Rankin and Yoder [1999] later revised the scoring range, 0-60). Rankin and Yoder (1990) showed coefficient of variations (CV) were on the order of 8-10% at least impacted and high quality sites. CVs increased at sites with lower IBI scores, presumably due to the effect of stressors at increasingly impacted sites. Fore et al. (1993) performed more extensive statistical analyses of the Ohio database and determined that IBI scores were reproducible to an error margin of 2-3 units. Their power analysis confirmed that the Ohio IBI was capable of distinguishing 6 discrete scoring ranges that approximate the delineations of the IBI scale into the qualitative descriptions of exceptional, good, fair, poor, and very poor. Angermier and Karr (1986) analyzed other statistical properties of the IBI focusing on the extent of redundancy among metrics. The results of their analysis showed that careful construction and derivation of an IBI following the original guidance of Karr et al. (1986) should produce a robust and non-redundant set of metrics.

Accuracy can also be examined in terms of the assessment produced by the subject method. Biological assessments are viewed as a direct measure of the aquatic life protection goals of the CWA and State water quality standards (as opposed to the surrogate assessment provided by chemical water quality criteria). This has given rise to the concept and interest in biological criteria and adoption by U.S. EPA of a national program (U.S. EPA 1990), methods (Barbour et al. 1997), and the development of formal implementation procedures

(U.S. EPA Aquatic Life Use Working Group). The issue at stake here is the accuracy of the delineation of waters as impaired or unimpaired for CWA purposes (e.g., Total Maximum Daily Loads). Historically, States and U.S. EPA based these decisions on chemical water quality data and comparison to State and national water quality criteria. However, studies that compared the relative performance of chemical and biological data and their respective abilities to detect impairment showed that biological data was far superior in its ability to detect impairment and minimize type II assessment error (Rankin and Yoder 1990b; Yoder and Rankin 1998). It is implicit in these studies that the better standardized and calibrated the biological assessment method and assessment criteria, the more able the method is to detect impairment and establish a relative degree of departure from a baseline criterion.

Measurement Range and Comparability
While there is no theoretical upper limit to many of the raw data parameters that comprise the baseline data that will be produced by the proposed study, most have practical limits. The practical range of these parameters is dependent on the natural attributes of the regional fish assemblage and the effectiveness of the sampling gear and procedure. For example, in a warmwater river in Ohio we can expect boat electrofishing to produce a sample of 20-30 species and several hundred fish among those species. In exceptional quality rivers, the number of species might increase to more than 35-40 among thousands of individuals. In the large cold water rivers of the western U.S., many fewer species and individuals are usually collected. However, in terms of regional reference condition and potential, the resulting biological assessment should rate the samples from Ohio and the Western U.S. the same with respect to its similarity to or departure from a regional reference condition. This is critical to establishing biological assessments that are comparable across the U.S. Thus the derivation of reference condition is a critical step in the bioassessment process and is one of the factors that can influence comparability.
The resulting assessments and biological indices have discrete scoring ranges, within which the raw data is stratified and compressed. For example, the original IBI and many of its contemporary applications used a scoring range of 12-60, i.e., metric scores of 5, 3, and 1 are assigned to each of 12 metrics. Newly developed IBIs have employed a scoring range of 0-100 (e.g., Lyons et al. 2001; Mebane et al. 2003), which is intuitively more meaningful as a theoretical scoring range and communication tool. The rigor, adequacy of the method, development, and calibration ultimately determines the accuracy, precision, and reproducibility of the index, its statistical rigor, and its resulting assessment.

Completeness
It is expected that all of the data collected by the proposed study will be used for one or more purposes. Some data may not prove to be useful for the more quantitative aspects of the planned analyses due to unforeseen or uncontrollable circumstances. However, the sampling protocols are designed to control the conditions under which sampling takes place so as to minimize these occurrences.

A.8: Training and Certification

The methods and protocols used in the proposed study require implementation by adequately trained and skilled biologists. The crew leader must be well trained and experienced in all aspects of conducting the sampling, making decisions that affect quality in the field, being familiar with the study area, and knowing how to identify all species of fish that might be encountered. This person must also be knowledgeable about safety procedures for boat electrofishing and boat and water safety. Presently, there are no formal certification requirements for such individuals except in a few instances. A biological assessment and biological criteria certification offered by the Ohio EPA under the Ohio Credible Data Law is one such example. The principal investigator designed and instructed in the Ohio EPA certification course since its inception in 1997. MBI field personnel assigned to this project will be directly supervised by the principal investigator and will have been trained in an apprenticeship format and taken the certification classes in pursuit of their own certification. Of particular importance will be training in the electrofishing procedure, use of the modified Qualitative Habitat Evaluation Index (QHEI), and the identification of external anomalies on fish. Each will follow the procedures outlined in Ohio EPA (1989) and Rankin (1989).

There are some key "symptoms" of incomplete sampling that would lead to an under-estimate of the fish assemblage. These are the time electrofished, the sampling results (i.e., are the expected results obtained?), water clarity, conductivity, temperature, sampling distance, time of day, and the electrofishing unit settings. All of this information is recorded for each sampling site and each may yield information about a problem that could result in the later disqualification of the data.

A.9: Documents and Records

The QAPP and all updates will be maintained by GLEC and MBI and provided to EPA and cooperating entities. A sampling plan will be developed with the sampling team and used to guide the selection of sampling sites in the field during reconnaissance and the initial sampling for each river survey. The core of this plan is the estimated sampling site in Appendix 1.

Field Data Recording

Field data and observations will be recorded on water resistant data sheets (Figures 4 and 5). Fish assemblage data including species, numbers and weights by species, lengths for selected species, external anomalies, chemical/physical data, site name and numeration, sampling crew membership, time of day, time sampled, distance sampled, and electrofishing unit settings and electrode configurations will be recorded on the fish sampling data sheet (Figure 4). Macroinvertebrates will be recorded on a standard bench sheet and include relative numbers by species. The QHEI, with appropriate modifications for non-wadeable rivers, will also be completed at each site on a habitat assessment data sheet (Figure 5). The crew leader will also maintain a field activities log noting daily circumstances related to field sampling and other information such as site access, weather,

Figure 4. Field data sheet for recording electrofishing collection data and for entry into the Ohio ECOS database.

Midwest Biodiversity Institute

Fish Data Sheet

Page ____ of ____

Crew Leader Boat Driver Netters

Project Code: ____

Field Crew: ____ Time of Day: ____ Site Code: ____

River/ Stream: ____ Location: ____

Date: ____ Distance: ____ Temp: ____ Seconds Fished: ____

River Code: ____ **Sampler Type:** ____ Conductivity: ____ Lat/Long (Beg): ____

RM: ____ Secchi Depth: ____ Diss. Oxy.: ____ Lat/Long (Mid): ____

Voltage: ____ Volt. Range: ____ D.O. %sat.: ____ Lat/Long (End): ____

% Range: ____ Amperage: ____ pH: ____ Lat/Long (X-Loc): ____

Anomalies: A- anchor worm; B- black spot; C- leeches; D- deformities; E- eroded fins; F- funguns; L- lesions; M- multiple DELT anomalies; N- blind
P- parasites; Y- popeye; S- emaciated; W- swirled scales; T- tumors; Z- other. [Heavy (H) or Light (L) code may be combined with above codes.]

Species	# Weighed	# Counted	Individual or Batch Weights or Length/ Weight	Anomalies	Lunke
V:	10x				☐
V:	10x				☐
V:	10x				☐
V:	10x				☐
V:	10x				☐
V:	10x				☐
V:	10x				☐
V:	10x				☐

Mass Weighing Convention: Total Weight → 536 (12) ← Number Weighed

Vouchers Collected: ☐

Figure 4. continued

Page ______ of ______

Species	# Weighed	# Counted	Individual or Batch Weights or Length/ Weight					Anomalies						Lunker
V:	10x													
V:	10x													
V:	10x													
V:	10x													
V:	10x													
V:	10x													
V:	10x													
V:	10x													
V:	10x													
V:	10x													
V:	10x													
V:	10x													
V:	10x													

Figure 5. Qualitative habitat evaluation index (QHEI) field sheet.

Midwest Biodiversity Institute

Qualitative Habitat Evaluation Index Field Sheet

QHEI Score: ____

River Code: ____ *RM:* ____ *Stream:* ____
Site Code: ____ *Project Code:* ____ *Location:* ____
Date: ____ *Scorer:* ____ *Latitude:* ____ *Longitude:* ____

1.) SUBSTRATE (Check ONLY Two Substrate TYPE BOXES; Estimate % percent

TYPE	POOL	RIFFLE		POOL	RIFFLE
☐ ☐ -BLDR/SLBS [10]	____	____	☐ ☐ -GRAVEL [7]	____	____
☐ ☐ -Lg BOULD [10]	____	____	☐ ☐ -SAND [6]	____	____
☐ ☐ -BOULDER [9]	____	____	☐ ☐ -BEDROCK [5]	____	____
☐ ☐ -COBBLE [8]	____	____	☐ ☐ -DETRITUS [3]	____	____
☐ ☐ -HARDPAN [4]	____	____	☐ ☐ -ARTIFICIAL [0]	____	____
☐ ☐ -MUCK [2]	____	____	☐ ☐ -SILT [2]	____	____

NUMBER OF SUBSTRATE TYPES: ☐ -4 or More [2]
(High Quality Only, Score 5 or >) ☐ -3 or Less [0]

SUBSTRATE ORIGIN
Check ONE (OR 2 & AVERAGE)
☐ -LIMESTONE [1]
☐ -TILLS [1]
☐ -WETLANDS [0]
☐ -HARDPAN [0]
☐ -SANDSTONE [0]
☐ -RIP / RAP [0]
☐ -LACUSTRINE [0]
☐ -SHALE [-1]
☐ -COAL FINES [-2]

SUBSTRATE QUALITY
Check ONE (OR 2 & AVERAGE)
SILT: ☐ -SILT HEAVY [-2]
☐ -SILT MODERATE [-1]
☐ -SILT NORMAL [0]
☐ -SILT FREE [1]
EMBEDDEDNESS: ☐ -EXTENSIVE [-2]
☐ -MODERATE [-1]
☐ -NORMAL [0]
☐ -NONE [1]

Substrate ☐ Max 20

COMMENTS: ____

2.) INSTREAM COVER (Give each cover type a score of 0 to 3; see back for instructions)

(Structure) TYPE: Score All That Occur
____ UNDERCUT BANKS [1] ____ POOLS > 70 cm [2] ____ OXBOWS, BACKWATERS [1]
____ OVERHANGING VEGETATION [1] ____ ROOTWADS [1] ____ AQUATIC MACROPHYTES [1]
____ SHALLOWS (IN SLOW WATER) [1] ____ BOULDERS [1] ____ LOGS OR WOODY DEBRIS [1]
____ ROOTMATS [1]

AMOUNT: (Check ONLY one or check 2 and AVERAGE)
☐ -EXTENSIVE > 75% [11]
☐ -MODERATE 25 - 75% [7]
☐ -SPARSE 5 - 25% [3]
☐ -NEARLY ABSENT < 5% [1]

Cover ☐ Max 20

COMMENTS: ____

3.) CHANNEL MORPHOLOGY: (Check ONLY one PER Category OR check 2 and AVERAGE)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILTIY	MODIFICATIONS / OTHER	
☐ -HIGH [4]	☐ -EXCELLENT [7]	☐ -NONE [6]	☐ -HIGH [3]	☐ -SNAGGING	☐ -IMPOUNDMENT
☐ -MODERATE [3]	☐ -GOOD [5]	☐ -RECOVERED [4]	☐ -MODERATE [2]	☐ -RELOCATION	☐ -ISLAND
☐ -LOW [2]	☐ -FAIR [3]	☐ -RECOVERING [3]	☐ -LOW [1]	☐ -CANOPY REMOVAL	☐ -LEVEED
☐ -NONE [1]	☐ -POOR [1]	☐ -RECENT OR NO RECOVERY [1]		☐ -DREDGING	☐ -BANK SHAPING
		☐ -IMPOUNDED [-1]		☐ -ONE SIDE CHANNEL MODIFICATIONS	

Channel ☐ Max 20

COMMENTS: ____

4.) RIPARIAN ZONE AND BANK EROSION (check ONE box PER bank or check 2 and AVERAGE per bank) River Right Looking Downstream

RIPARIAN WIDTH
L R (Per Bank)
☐ ☐ -VERY WIDE > 100m [5]
☐ ☐ -WIDE > 50m [4]
☐ ☐ -MODERATE 10 - 50m [3]
☐ ☐ -NARROW 5 - 10m [2]
☐ ☐ -VERY NARROW < 5m [1]
☐ ☐ -NONE [0]

FLOOD PLAIN QUALITY (*PAST 100 Meter RIPARIAN*)
L R (Most Predominant Per Bank)
☐ ☐ -FOREST, SWAMP [3]
☐ ☐ -SHRUB OR OLD FIELD [2]
☐ ☐ -RESIDENTIAL, PARK, NEW FIELD [1]
☐ ☐ -FENCED PASTURE [1]
L R
☐ ☐ -CONSERVATION TILLAGE [1]
☐ ☐ -URBAN OR INDUSTRIAL [0]
☐ ☐ -OPEN PASTURE, ROWCROP [0]
☐ ☐ -MINING / CONSTRUCTION [0]

BANK EROSION
L R (Per Bank)
☐ ☐ -NONE / LITTLE [3]
☐ ☐ -MODERATE [2]
☐ ☐ -HEAVY / SEVERE [1]

Riparian ☐ Max 10

COMMENTS: ____

5.) POOL / GLIDE AND RIFFLE / RUN QUALITY

MAX. DEPTH
(Check 1 ONLY!)
☐ - 1m [6]
☐ - 0.7m [4]
☐ - 0.4 to 0.7m [2]
☐ - 0.2 to 0.4m [1]
☐ - < 0.2m [POOL = 0}

MORPHOLOGY
(Check 1 or 2 & AVERAGE)
☐ -POOL WIDTH > RIFFLE WIDTH [2]
☐ -POOL WIDTH = RIFFLE WIDTH [1]
☐ -POOL WIDTH < RIFFLE WIDTH [0]
☐ -IMPOUNDED [-1]

CURRENT VELOCITY (POOLS & RIFFLES!)
(Check All That Apply)
☐ -EDDIES [1] ☐ -TORRENTIAL [-1]
☐ -FAST [1] ☐ -INTERSTITIAL [-1]
☐ -MODERATE [1] ☐ -INTERMITTENT [-2]
☐ -SLOW [1] ☐ -VERY FAST [1]
☐ -NONE [-1]

Pool / Current ☐ Max 12

COMMENTS: ____

CHECK ONE OR CHECK 2 AND ADVERAGE

RIFFLE DEPTH
☐ -*Best Areas > 10cm [2]
☐ -Best Areas 5 - 10cm [1]
☐ -Best Areas < 5cm [0]
☐ -NO RIFFLE but RUNS present [0]
☐ -NO RIFFLE / NO RUN [Metric = 0]

RUN DEPTH
☐ - MAX > 50 cm [2]
☐ - MAX < 50 cm [1]

RIFFLE / RUN SUBSTRATE
☐ -STABLE (e.g., Cobble, Boulder) [2]
☐ -MOD. STABLE (e.g., Large Gravel) [1]
☐ -UNSTABLE (Fine Gravel, Sand) [0]

RIFFLE / RUN EMBEDDEDNESS
☐ -NONE [2]
☐ -LOW [1]
☐ -MODERATE [0]
☐ -EXTENSIVE [-1]

Riffle / Run ☐ Max 8

COMMENTS: ____

6.) GRADIENT (ft / mi): ____ DRAINAGE AREA (sq.mi.): ____ % POOL: ☐ % GLIDE: ☐ % RIFFLE: ☐ % RUN: ☐

Gradient Score from Table 2 of Users Manual based on gradient and drainage area.

Gradient ☐ Max 10

**Best areas must be large enough to support a population of riffle-obligate species* and other relevant observations. Original data sheets will be retained by MBI. Voucher specimens collected during the proposed study will be deposited at an appropriate regional institution where curation of museum specimens is performed. As such they will provide a permanent record. These vouchers serve to validate new species distribution records and for verification of questionable field identifications. Each set of vouchers are labeled with the same location and date data recorded on the field sheet and they are also denoted on the field sheet. We are presently using The Ohio State University Museum of Biodiversity for depositing specimens and voucher identifications. OSUMB will provide to MBI a report on the accuracy of vouchered fish identifications and this will be made available to any interested party.

All data will be entered into an electronic data format maintained and supported by MBI. At this time we are using the Ohio ECOS data storage routine developed by Ohio EPA. This system is presently supported in a FoxPro format, which is translatable to other spreadsheet formats such as Access and Excel. The data analysis routines in Ohio ECOS for calculation of summarized fish assemblage information and aggregate indices such as the IBI and MIwb will be modified appropriately in concert with the data analysis and index development outputs of the proposed study.

Reporting
Progress reports will be made on a monthly basis and in accordance with the contract that is supporting the proposed study. A final report will be produced in accordance with the requirements of the work assignment tasks as detailed in the work plan. This report will include a basic reporting of the data, including the distribution and relative abundance of the fish species collected, any significant environmental assessment issues, an assessment of the feasibility of developing TALUs for the Red River, and recommendations for further monitoring and developmental research.

Group B: Data Generation and Acquisition

B.1: Sampling Design Process
River locations will be sampled once or twice by electrofishing or mini-trawl within a July 1 – September 30 seasonal index period as river flow, water clarity, and weather conditions permit. A brief extension of the fish index period is possible during extended warm weather and low river flows if necessary to complete the planned sampling. General reaches and sampling sites were selected during pre-survey planning (Appendix 1) and will be validated at the time of first sampling. Specific sites will be selected during the sampling runs to include representative environmental conditions and habitats available in the Red River mainstem. A longitudinal design similar to that employed by Gammon (1976), Hughes and Gammon (1987), Ohio EPA (Yoder and Smith 1999; Yoder et al. 2005), and Lyons et al. (2001) will be employed. This consists of locating sites in proximity to major sources of potential stress (major point sources, dams, tributary confluences), major habitat types (free-flowing, impounded), and spatially so that a longitudinal profile of various fish

assemblage attributes and indices can be analyzed and interpreted. Such a design represents a stratified census of the mainstem river fish assemblage and permits the demarcation of meaningful transitions that could influence the designation of TALUs and delineation of varying degrees of impairment.

B.2: Sampling Methods

Methods for the collection of fish will be based on appropriate modifications of those established for boat electrofishing by Ohio EPA (1989). Fish sampling procedures will be performed using boat-mounted pulsed D.C. electrofishing apparatus constructed and maintained by MBI.

Sampling Site Selection and Delineation

A stratified, intensive-based survey design (Yoder et al. 2005) was used in the selection of sampling sites throughout the mainstem (Appendix 1). Individual electrofishing sites will be located along the shoreline with the most diverse habitat features in accordance with established methods (Gammon 1973, 1976; Ohio EPA 1989; Lyons et al. 2001). This is generally along the gradual outside bends of large rivers, but this is not invariable. In free-flowing habitats, a portion of each zone should include run-riffle habitat in addition to shoal and pool habitat as each is available. Sampling distance will be measured with a GPS unit and/or a laser range finder. When using the GPS unit each zone is measured by determining lineal distance using intermediate waypoints to account for non-linear features of the river channel and the sampling track. The sampling track will also be recorded and used as an indicator of the thoroughness of the sampling at each site.

Sampling site locations are delineated using a GPS mechanism and indexed to latitude/longitude and UTM coordinates at the beginning, mid-point, and terminus of each zone and subzone if applicable. Sites will also be delineated by river mile in accordance with U.S. Army Corps of Engineers maps for the Red River. The boundaries of each boat electrofishing zone or subzone are geo-referenced with a GPS unit. A detailed description of the river channel, habitat features, and sampling track is also recorded on the QHEI data sheet. This enables accurate relocation of sites in the event repeat visits are made. If the sampling zone is delineated in disjunct subzones, additional demarcations will be made. A detailed description of the sampling location should also include proximity to a fixed local landmark such as a bridge, road, discharge outfall, railroad crossing, park, tributary, dam, etc. The field crew involved with the sampling is noted on the field sheet with crew duties listed (boat driver, netters, primary I.D., etc.).

Exact sampling locations are determined in the field and include a representative proportion of reaches along the mainstem with respect to pollution sources, habitat modifications (i.e., mostly impounded sections behind dams, channelized and leveed reaches), and relatively unmodified, free-flowing reaches.

Sampling Procedure
A boat-rigged, pulsed D.C. electrofishing apparatus is the predominant gear employed in this study. This consists of a 16' john boat that is specifically constructed and modified for electrofishing. Electric current is converted, controlled, and regulated by a Smith-Root 5.0 GPP alternator-pulsator that produces up to 1000 volts DC at 2-20 amperes depending on the relative conductivity. The pulse configuration consists of a fast rise, slow decay wave that can be adjusted to 30, 60, or 120 Hz (pulses per second). Generally, electrofishing is conducted at 120 Hz depending on which selection is producing the optimum combination of voltage and amperage output and most effectively stunning fish. This is determined on a trial and error basis at the beginning of each survey and the settings will generally hold for all similar reaches. The voltage range is selected based on what percentage of the power range produces the highest amperage readings. Generally, the high range is used at conductivity readings less than 50-100 $\mu S/cm^2$ and the low range is used at higher conductivities up to 1200 $\mu S/cm^2$. Lower conductivities usually produce lower amperage readings.

The electrode array consists of four 8-10' long cathodes (negative polarity; 3/4" diameter flexible steel conduit) which are suspended from the bow and 4 anodes (positive polarity) suspended from a retractable boom, the number being dependent on the conductivity of the water. Each anode consists of a 3/8" woven steel cable strand 4' in length that are spaced equally on the boom cross member. Anodes may be added or detached as conductivity conditions change; anodes are increased at low conductivity and reduced at high conductivity. The anodes are suspended from a retractable boom that extends 2.75 meters in front of the bow. The width of the array is 0.9 meters. Anodes and cathodes are replaced when they are lost, damaged, or become worn. If night sampling is deemed necessary, 100-Watt floodlights are fixed on a guardrail on the netting platform located on the bow. These are powered by the 12-volt DC output of the 5.0 GPP generator. Auxiliary lighting includes headlamps worn by the sampling crew and hand held lamps of 500,000 to 1,000,000 candle power.

A boat electrofishing crew consists of a boat driver and a single bow netter and one assist netter standing behind the primary netter. All 3 crew members have nets and each nets all fish sighted. Reasonable attempts are made to capture all fish sighted including those that appear behind the boat. Limited access to free-flowing segments may necessitate launching at an upstream location and recovering at a downstream location. Put-in and take-out sampling is conducted where navigational barriers preclude contiguous navigation.

The accepted sampling procedure is to slowly and methodically maneuver the electrofishing boat in a ***down current*** direction along the shoreline maneuvering in and around submerged cover to advantageously position the netter(s) to pick up stunned and immobilized fish. This may require frequent turning, backing, shifting between forward and reverse, changing speed, etc. depending on current velocity and cover density and variability. The driver's task is to maneuver the electrofishing boat in a manner that positions the netters advantageously to pick up stunned and immobilized fish. The driver also monitors and adjusts the 5.0 GPP pulsator to provide the maximum, yet safe operational mode in terms of voltage range, pulse setting, and amperage. In areas with extensive woody debris and submergent aquatic macrophytes, it is necessary to maneuver the boat in and out of these "pockets" of habitat and wait for fish to appear within the netters field of view. In moderately swift to fast current the procedure is to electrofish with or slightly ahead of the current through the fast water sections and then return upstream to more thoroughly sample the eddies and side edges of the faster water. It is often necessary to pass over these swift water areas twice to ensure an adequate sample. Electrofishing efficiency is enhanced by keeping the boat and electric field moving with or at a slightly faster rate than the prevailing current velocity. Fish are usually oriented into the current and must turn sideways or swim into the approaching electric field to escape. As such they present an increased voltage gradient making the fish more susceptible to being immobilized by the electric current. Sampling in an upstream direction is prohibited as this compresses the electrical field towards the surface, which significantly diminishes sampling effectiveness. Although sampling effort is measured by distance, the time fished is an important indicator of adequate effort. Time fished can legitimately vary over the same distance as dictated by cover and current conditions and the number of fish encountered. In all cases, there is a minimum time that should be spent sampling each zone regardless of the catch. In our experience this is generally in the range of 2000-2500 seconds for a 0.5 km site, but could range upwards to 3500-4500 seconds where there is extensive instream cover and slack flows.

Safety features include easily accessible toggle switches on the pulsator unit and next to the driver and a foot pedal switch operated by the primary netter. The netters wear jacket style life preservers, rubber gloves, and all crew members wear chest waders. Netters are required to wear polarized sunglasses to facilitate seeing stunned fish in the water during each daytime boat electrofishing run. An exception to this is with night sampling where sunglasses are not worn. Boat nets with a 2.5m long handle and 7.62mm Atlas mesh knotless netting are used to capture stunned fish as they are attracted to the anode array and/or stunned within sight of the netters. A concerted effort is made to capture every fish sighted by both the netters and driver. Since the ability of the netters to see stunned and immobilized fish is partly dependent on water clarity, sampling is conducted only during periods of "normal" water clarity and flows. Periods of high turbidity and high flows are avoided due to their negative influence on sampling efficiency. If high flow conditions prevail, sampling will be delayed until flows and water clarity return to seasonal, low flow norms.

General Cautions Concerning Field Conditions

Electrofishing should be conducted only during "normal" summer-fall water flow and clarity conditions. What constitutes normal can vary considerably from region to region. Generally normal water conditions in the Midwest occur during below annual average river flows. Under these conditions the surface of the water generally will have a placid appearance.

Abnormally turbid conditions are to be avoided as are high water levels and elevated current velocities. In addition to safety concerns, any of these conditions can adversely affect sampling efficiency and may rule out data applicability for bioassessment purposes. Since the ability of the netter to see and capture stunned fish is crucial, sampling should take place only during periods of normal water clarity and flow. Floating debris such as twigs, tree limbs, flotsam, and other trash are usually visible on the surface during elevated flow events. Such conditions should be avoided and sampling delayed until the water returns to a "normal" flow and clarity. High flows should also be avoided for obvious safety reasons in addition to the reductions in sampling efficiency. Boat mounted methods are particularly susceptible as it becomes more difficult to maneuver the boat into areas of cover and the fish assemblage is locally displaced by the elevated flow events. It may take several days or even weeks for the assemblage to return to their normal summer-fall distribution patterns. Thus sampling may need to be delayed by a similar time period if necessary. Knowing this requires local knowledge and a familiarity with flow gage readings and conditions. Generally, these conditions coincide below the seasonal median flows for the period of record. These statistics are available for most Midwest rivers from the U.S. Geological Survey at: http://waterdata.usgs.gov/.

Field Sample Processing Procedures

Captured fish are immediately placed in an on-board live well for processing. Water is replaced regularly in warm weather to maintain adequate D.O. levels in the water and to minimize mortality. Aeration is provided to further minimize stress and mortality. Special handling procedures may be necessary for species of special concern. Fish not retained for voucher or other purposes are released back into the water after they are identified to species, examined for external anomalies, weighed and, if necessary, measured for total length. Every effort is made to minimize holding and handling times. The majority of captured fish are identified to species in the field; however, any uncertainty about the field identification of individual fish requires their preservation for later laboratory identification. Fish are preserved for future identification in borax buffered 10% formalin and labeled by date, river or stream, and geographic identifier (e.g., river mile). Large specimens (>50-100 mm) require visceral incision (lower right abdominal) to permit proper preservation of internal spaces and organs. After an initial fixation period of 3-4 weeks, specimens are washed in plain water and then transferred to increasing dilutions of non-denatured ethyl alcohol and water (35%, 50%) with a final solution of 70% ethyl alcohol. This process takes approximately 4-5 weeks to complete. Identification is performed to the species level at a minimum and it may be necessary to the sub-specific level in certain instances. Regional ichthyology keys are used. Assistance with the verification of voucher specimens has been provided by The Ohio State University Museum of Biodiversity (OSUMB). Representative fish voucher specimens are retained at MBI for the purpose of confirming later identifications and at the OSUMB to serve as a permanent record. Photographs may also used to record species occurrences, particularly larger species that are not as easily preserved and stored. Photographs are maintained by MBI in an archived electronic file.

The sample from each zone or subzone is processed by enumerating and recording weights by species or by species age class when this is distinguished. Fish weighing less than 1000 grams are weighed to the nearest gram on a spring dial scale (1000 g x 2g) or a 1000 g hand held spring scale. Fish weighing more than 1000 grams are weighed to the nearest 25 grams on a 12 kg spring dial scale (12 kg x 50 g) or a 50 kg hand held spring scale. Species with multiple individuals may be batch weighed. Samples comprised of two or more distinct size classes of fish (e.g., y-o-y, juveniles, and adults) are processed separately. These are recorded on the field data sheet by designating an A (adult), B (1+ year), or Y (young-of-year) to the numeric species code. For example, if both adult and juvenile white suckers occur in the same sample the adult numbers and weights are recorded as family-species code 40-016A with juvenile numbers and weights recorded as 40-016B. Although each is listed separately on the fish data sheet they can be treated in the aggregate as a single sample of the same species in any subsequent data analyses or as distinct size class entities. The data management programs used by MBI are designed to calculate relative numbers and biomass data based on the input of weighted subsamples. Total lengths may be recorded for important commercial, recreational, and special interest species. Larval and/or post-larval fish measuring less than 15-20 mm in length are generally not included in the data recording as a matter of practice following the recommendations of Angermeier and Karr (1986).

The incidence of external anomalies is recorded following procedures outlined by Ohio EPA (1989) and refinements made by Sanders et al. (1999). The frequency of DELT anomalies (deformities, eroded fins and body parts, lesions, and tumors) is a good indication of chronic stress caused by biological agents, intermittent stresses, and chemical contaminants. The percentage of DELT anomalies is a metric that is included in most of the large river fish assemblage IBIs that have been developed across the U.S.

A qualitative habitat assessment using an appropriate modification of theQHEI (Rankin 1989; Ohio EPA 1989, 2006) is completed by the crew leader at each electrofishing site (see example in Figure 5). The QHEI is a physical habitat index designed to provide an empirical, qualitative evaluation of the lotic macrohabitat characteristics that are important to fish assemblages. The QHEI was developed as a rapid assessment tool and in recognition of the constraints associated with the practicalities of conducting a large-scale monitoring program, i.e., the need for a rapid assessment tool that yields meaningful information and which takes advantage of the knowledge and insights of experienced field biologists who are conducting biological assessments. This index has been used throughout Regions I and V and parallel habitat evaluation techniques are in widespread existence throughout the U.S. The QHEI incorporates the types and quality substrate, the types and amounts of instream cover, several characteristics of channel morphology, riparian zone extent and quality, bank stability and condition, and pool-run-riffle quality and characteristics. Slope or gradient is also factored into the QHEI score. We followed the guidance and scoring procedures outlined in Ohio EPA (1989, 2006) and Rankin

(1989) with some modifications made for large rivers during 2002 and 2003. A QHEI users guide appears in Appendix 4.

Method Performance Evaluation
The principal investigator will be responsible for evaluating the performance of the methods used in this project and for making decisions about appropriate modifications to those described in this section. In some cases an evaluation will be made based on preliminary data analyses conducted during the field sampling part of the project. In other instances, the assessment of method performance will be a part of any data analysis conducted following each field season. This latter information will be used to better develop and refine the methods prior to their wider application to other rivers in the region or for additional monitoring of the Red River.

B.3: Sampling Handling and Custody
The principal sample product produced by this project will be completed field forms for the boat electrofishing results and the qualitative habitat assessment. All completed field data sheets are logged by the field crew leader to prevent loss and assure that all sites are sampled according to the detailed plan of study. Data is then entered into the Ohio ECOS data management system, which was developed by Ohio EPA for the purpose of storing and analyzing fish relative abundance data. Data are entered in the format presented in the field data sheet (Figures 4 and 5). Each data entry contains the basin-river code, date of entry, GPS coordinates, river mile, and date of sampling. The data sheets are assembled in a notebook along with site description sheets, maps of the sampling sites, the QHEI field sheet, and the final study plan. Each entry is checked and initialed; any subsequent changes that are made to the fish data sheets are also initialed and dated. After all data have been entered into Ohio ECOS the entries are proofread by the data entry analyst for accuracy. All corrections or updates are then entered into the database. The initialed data sheets also serve as a chain-of-custody for the data collection process.

B.4: Analytical Methods
The principal analytical tools used in this project are those associated with data analysis and the biological indices. This will be performed on personal computers using relational databases such as FoxPro, Access, and Excel. MBI currently uses the data storage, retrieval, and calculation routines available in the Ohio ECOS system developed and used by Ohio EPA. Appropriate modifications to those routines have been made as an outcome of the data analysis part of the project.

B.5: Quality Control
Quality control of boat electrofishing includes monitoring the power output variables, which is performed by the crew leader during the sampling. These output variables are recorded on the field sheet and are described in more detail in B.2. Other important measures of adequate effort include time electrofished and the effort made by the netters to capture stunned and immobilized fish. There is an inherent degree of judgment

Table 3. Field analytical instrument calibration specifications.

Instrument	Calibration Activity	Frequency of Calibration	Acceptance Criteria	Corrective Action
Temperature	Check against NIST certified Thermometer	Check prior to beginning of survey	± 1 EC of NIST thermometer	Adjust or replace probe/meter
D.O.	Calibrate with saturated moist air; check with 0.0 D.O. std.	Daily prior to use; check at end of day	±0.5 mg/l from 0.0 std.	If D.O. exceeds criteria prepare fresh 0.0 std., clean probe, change membrane; recalibrate; qualify data.
Conductivity	Calibrate with single point standard; check with standard in range of samples.	Daily prior to use; check calibration at end of day.	10% of true value of check standard	If conductivity exceeds criteria prepare fresh Standard and re-Calibrate; qualify data accordingly.
Secchi Disk	Check reading with second sampler.	10% of locations.	±0.2 meters	Check second sampler readings until agreement is reached; qualify data accordingly.

involved in the assessment of individual crew member performance and this will be performed by the principal investigator. The quality of identifications made in the field will be evaluated by the principal investigator and also based on the retention of voucher specimens that will be verified independent of the field crew by OSUMB. Any samples that are deemed unacceptable will either be repeated or denoted in the database. This latter denotation may limit or disqualify the use of the data in some of the analyses and computations that will be performed later.

B.6: Instrument/Equipment Testing, Inspection, and Maintenance
The electrofishing equipment is evaluated for performance during all phases of sampling as described previously in B.2. All connections and switches must be in good condition to ensure acceptable performance and are inspected through use by the sampling crew. Malfunctioning and worn parts are replaced. All engines undergo maintenance as prescribed by the manufacturer for intensive use. Analytical field meters used by the sampling crew are maintained in accordance with the manufacturer's specifications.

B.7: Instrument/Equipment Calibration and Frequency
The electrofishing equipment is calibrated to local water conditions at the beginning and throughout each sampling zone (see B.2). Field meters are calibrated in accordance with the manufacturer's recommendations and specifications and in accordance with the specifications in Table 3.

B.8: Inspection/Acceptance of Supplies and Consumables
All supplies used in this project undergo an initial inspection for usability and suitability. No chemical reagents or analytical sensitive supplies will be used in this project.

B.9: Non-direct Measurements
We will make an effort to access historical information about the fish fauna of the study rivers. This will be especially valuable in constructing the qualitative attributes of the Biological Condition Gradient. Some expert judgment may be necessary to evaluate the quality and accuracy of this information. It is unlikely that historical data will support the analyses envisioned by this project and its use will likely be restricted to qualitative purposes

B.10: Data Management
MBI uses an adaptation of the Ohio ECOS data management system developed to store, retrieve, and analyze biological and habitat assessment data and information. Fish assemblage data are entered directly via the electronic data entry routine from the field sheets (Figures 4 and 5). All data entry codes follow those specified in Ohio EPA (1987) and those added by MBI for non-Ohio fish species. All entries are proofread by the data entry analyst and corrections are made in the electronic database. All corrections are noted and initialed by the data entry operator and confirmed by the project manager. Other checks on data entry accuracy are made via the routine processing and analysis of the data. The procedure for retaining and filing of data sheets and field notes was described in B.2.

Group C: Assessment and Oversight

C.1: Assessments and Response Actions
Due to the scope and character of the project, much of the assessment and oversight will be the responsibility of the principal investigator and the GLEC work assignment leader. However, the stakeholder organizations can be afforded an opportunity to make

inspections and audits of the field sampling, the equipment, and the results upon request. This will be coordinated by the principal investigator.

C.2: Reports to Management

The principal investigator will file monthly reports with the GLEC work assignment leader who reports to the EPA work assignment manager.

Group D: Data Validation and Usability

D.1: Data Review, Validation, and Verification

Data acceptance will initially be evaluated in the field using the processes described in B.2 and B.5. However, later inspection of the data may also raise issues of acceptance such as identification problems and issues. An attempt will be made to reconcile any inconsistencies or issues prior to disqualifying data.

D.2: Verification and Validation of Methods

Most of the raw data will be field validated in accordance with the processes described in B.2, B.3, B.4, and B.10. Post-sampling validation will entail verification of identifications made in the field and later in the laboratory.

Analyses have already been performed to determine the minimum sampling distance required to generate data and information adequate for producing a consistent assessment of the health and well-being of the fish assemblage (Gammon 1976; Yoder and Smith 1999). This entailed an analysis of the effect of increasing distance on assemblage parameters such as species richness and catch per unit effort both in terms of fish numbers and biomass. This was performed by sequentially adding data from 0.25 km subzones over 1.5 km long test zones and analyzing the effect of the cumulative addition of information on selected assemblage attributes. The influence of time electrofished and variations in physical parameters such as conductivity, temperature, and zone depths was also analyzed by these studies.

D.3: Reconciliation with User Requirements

The sampling and analytical approach used in this project is designed to provide the opportunity to adjust and modify methods as appropriate to obtain results that meet the project goals and objectives. The initial scoping and shakedown sampling produced the data necessary to make adjustments, modifications, and refinements to the methods described in B.2. Other changes and modifications may not be apparent until later during the project and when the data are more fully analyzed and discussed. These changes will be documented in periodic reports and will include a detailed description of all data analyses used.

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Appendix 1

Technical Direction Issued July 21, 2010
and
Work Plan Approval by U.S. EPA, Region VIII

From: Hermann.Karl@epamail.epa.gov
Sent: Tuesday, August 10, 2010 9:09 AM
To: Jamie Saxton; Chris Yoder
Subject: Fw: Contract EP-C-09-001, WA 1-33: Red River of the North - Technical Direction

Here is the 7/21/2010 Technical Direction

In a follow up to this Monday morning's conference call, I am sending this technical direction.

At North Dakota's and the contractor/subcontractor's requests, the Work Assignment specifics asking that the NRSA non-wadeable (boatable) field sampling protocols be used for the fish sampling are being relaxed to allow for the use of the EPA Region V non-wadeable (boatable) field sampling protocols. It is North Dakota's and the contractor/subcontractor's preference that the EPA Region V non-wadeable (boatable) field sampling protocols be used for the fish sampling. This applies to the work plan, the fish sampling, the Fish QA Report and the QAPP. North Dakota still plans to employ the NRSA non-wadeable (boatable) field sampling protocols for the chemistry and macroinvertebrate sampling that they are performing. This technical directive does not change the scope of the Work Assignment and no additional costs will be incurred.

Please note that I am out of the office the remainder of the week on sampling events but, I am monitoring email and voice mail daily. I will be in the office next Monday, 7/26, and then out the remainder of next week on sampling events. I will then be out on vacation from 8/2 through 8/6, returning to the office on 8/9. In my absence from 7/27 -8/6 please coordinate with Tina Laidlaw on any items that need WAM attention.

==

Karl A. Hermann, Regional Coordinator
Monitoring and Assessment Team
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From: Hermann.Karl@epamail.epa.gov
Sent: Monday, July 26, 2010 12:48 PM
To: Jamie Saxton; Harrison.Shirley@epamail.epa.gov ; Bailey.Ellen@epamail.epa.gov; Adams.Tammy@epamail.epa.gov
Cc: Ell, Mike J.; Laidlaw.Tina@epamail.epa.gov; Chris Yoder
Subject: Workplan Approval - Contract EP-C-09-001, WA 1-33: Fish Assemblage Assessment Methods and Biological Criteria Development for the Red River of the North

The workplan for WA 1-33 (Contract EP-C-09-001) submitted by GLEC on 7/16/2010, is approved. While the workplan specifies that the EPA NRSA non-wadeable methods for fish sampling will be employed, it is permissible for the contractor to employ the EPA Region 5 non-wadeable methods for fish sampling (per 7/21/2010 EPA Technical Direction).

==
Karl A. Hermann, Regional Coordinator
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Appendix 2

Estimated sampling locations and major features of the Red River of the North Study Area

Appendix Table 2-1. Estimated sampling locations for biological, habitat, and chemical/physical sampling in the Red River of the North mainstem, 2010. Major features such as point sources, tributaries, and dams are also indicated by river mile.

Red River of the North
Discharger Locations & Proposed Sampling Sites
August 1, 2010

RM	Site Type	Description
1.5	F,H,M,WQ	Bois de Sioux R. - upstream Breckenridge WWTP
1.0	WWTP	Breckenridge WWTP (discharge Bois de Sioux)
0.5	F,H,M,WQ	Bois de Sioux R. - upstream confluence
0.5	F,H,M,WQ	Otter Tail R. - upstream confluence
548.6	Dam	Kidder Dam (rock slopeway)
548.0	WWTP	Wahpeton WWTP
547.5	F,H,M,WQ	Dst. Wahpeton WWTP
540.0	F,H,M,WQ	Ust. Cargill
539.5	Industry	Cargill Corn Milling
539.0	F,H,M,WQ	Dst. Cargill
534.0	F,H,M,WQ	2 mi. dst. Brushvale Rec. Area
525.0	F,H,M,WQ	Ust. Abercrombie WWTP
523.5	WWTP	Abercrombie WWTP
523.0	F,H,M,WQ	Dst. Abercrombie WWTP
513.0	F,H,M,WQ	adjacent U.S. Rt. 75
497.0	F,H,M,WQ	Ust. Christine Dam
496.5	Dam	Christine Dam (low head)
489.0	F,H,M,WQ	Between dams
482.7	Dam	Hickson Dam (low head)
470.2	Trib.	Wild Rice River (ND)
469.5	F,H,M,WQ	Dst. Wild Rice River
458.1	Dam	Fargo South Dam
455.0	F,H,M,WQ	Ust. Fargo; Gooseberry Park
452.2	Dam	Fargo Midtown Dam (rock slopeway)
451.0	F,H,M,WQ	Ust. Moorhead WWTP
450.0	WWTP	Moorhead WWTP
449.5	F,H,M,WQ	Dst. Moorhead WWTP; ust. Fargo WWTP
448.9	Dam	Fargo North Dam (rock slopeway)
448.5	WWTP	Fargo WWTP
448.0	F,H,M,WQ	Dst. Fargo WWTP
445.5	F,H,M,WQ	Dst. Fargo-Moorhead; at MB Johnson park
439.0	F,H,M,WQ	Co. Rt. 22
427.5	Trib.	Sheyenne River
426.0	F,H,M,WQ	Dst. Sheyenne River
415.0	F,H,M,WQ	Hudson's Bay Fur Trading Post Park
404.0	F,H,M,WQ	Co. Rt. 39 near Perley, MN
386.0	F,H,M,WQ	Norman Co. Hwy. 25 Boat Ramp
380.4	Trib.	Wild Rice River (MN)
375.0	F,H,M,WQ	Halstead Boat Ramp
357.2	Trib.	Marsh River (MN)
355.0	F,H,M,WQ	Dst. Marsh River
333.0	F,H,M,WQ	Belmont Park/Frog Pt. Park

Appendix Table 2-1. continued.

Red River of the North
Discharger Locations & Proposed Sampling Sites
Continued

RM	Site Type	Description
318.0	F,H,M,WQ	Thompson Rd. bridge
300.0	F,H,M,WQ	Lincoln Park landing
298.3	Trib.	Red Lake River
298.0	Dam	Red Lake River Dam (rock slopeway)
297.5	F,H,M,WQ	Dst. Red L. River dam; Ust. Grand Forks WWTP
297.2	WWTP	Grand Forks WWTP
296.5	F,H,M,WQ	Dst. Grand Forks WWTP
296.1	Dam	Riverside Dam (rock slopeway)
295.5	F,H,M,WQ	Dst. Riverside Dam; dst. Grand Forks WWTP
290.0	F,H,M,WQ	Dst. Grand Forks WWTP
280.0	F,H,M,WQ	Far-field dst. Grand Forks
270.0	F,H,M,WQ	Oslo City Park; ust. Oslo WWTP
266.5	WWTP	Oslo WWTP
265.0	F,H,M,WQ	Dst. Oslo WWTP
255.0	F,H,M,WQ	Ust. Big Woods
241.0	F,H,M,WQ	Joliet Ferry WMA
225.0	F,H,M,WQ	Ust. Park River Outlet
210.0	F,H,M,WQ	Ust. Hastings Landing; ust. Drayton WWTP
208.0	WWTP	Drayton WWTP
207.0	F,H,M,WQ	Dst. Drayton WWTP
203.4	Dam	Drayton Dam (low head)
202.0	F,H,M,WQ	Drayton Dam Water Access
180.0	F,H,M,WQ	Hwy 175 Boat Ramp
159.0	F,H,M,WQ	Pembina State Park
158.0	Trib.	Pembina River
156.0	F,H,M,WQ	Dst. Pembina-St. Vincent
155.0	Boundary	U.S.-Canada Border

Appendix 3

Description of the Index of Biotic Integrity: Minnesota PCA

Appendix Table 3-1. Metrics included in the Minnesota fish index of biotic integrity applicable to northern rivers including the Red River of the North.

Metric Name	Description	Metric Category
DetNWQXpct	Relative abundance (%) of detritivores	Trophic
SensitiveTXpct	Relative abundance (%) of sensitive sp.	Tolerance
Vtolpct	Relative abundance (%) of very tolerant sp.	Tolerance
Omnivorepct	Relative abundance (%) of omnivores	Trophic
PioneerTXpct	Relative abundance (%) of pioneering sp.	Life History
Nativepct	Relative abundance (%) of native sp.	Composition
SSpnTXpct	Relative abundance (%) of serial spawners	Reproduction
NestNoLithTXpct	Relative abundance (%) of non-lithophilic nest guarders	Reproduction

Appendix 4

Description of and Computational Formula for the Modified Index of Well-Being (Gammon 1976; Gammon et al. 1981; Ohio EPA 1987)

Modified Index of Well-Being

Gammon (1976) and Gammon et al. (1981) originally developed and tested the Index of Well-being (Iwb) as a multiparameter evaluation of large river fish communities. The Iwb is based on four measures of community diversity, abundance, and biomass and is an attempt to produce an integrated evaluation of these important and basic fish community attributes. The individual performance of numbers, biomass, and the Shannon index as consistent indicators of the quality of fish communities has historically been disappointing. However, when combined in the Iwb these individual community attributes work in a more complimentary and intuitively predictable manner. For example, an increase in total numbers and/or biomass caused by one or two predominant species is usually offset by a corresponding decline in the Shannon index. In addition, the $\log_e$ transformation of the numbers and biomass components acts to reduce much of the variability inherent to these parameters alone. Gammon (1976) found the variability of each of the four Iwb components as measured by a coefficient of variation to range from 20-50%, yet the composite variability reflected by the Iwb was only 7%.

High numbers and/or biomass is commonly, and at times inaccurately, perceived as a positive attribute of a fish assemblage. High numbers and biomass result in a high Iwb score provided a relative "evenness" is maintained between the abundance of the common species. However, this is not invariable, especially with environmental perturbations which tend to restructure fish communities without corresponding decreases in diversity (e.g., nutrient enrichment, habitat modification). We have observed fish communities in habitat modified streams to exhibit very high numbers, biomass, and moderate species richness. Such communities are usually predominated by tolerant species. Species intolerant of such disturbances either decline in abundance or are eliminated altogether. A net increase in the relative abundance of tolerant species with only modest declines in species richness can yield higher Iwb values. The increased abundance of tolerant species is not always sufficiently offset by decreases in the Shannon indices because species richness is not proportionately as influenced. The overall result is an Iwb evaluation which is not reflective of the true response of the fish assemblage to these types of degradation. In fact Iwb values at some disturbed sites equaled or exceeded those measured at reference or least impacted sites.

Several modifications of the Iwb were attempted to correct the problem of higher scores at degraded sites. This included the complete elimination of predominant species from the index calculation, selective elimination of species based on their predominance, and a different weighting of the numbers component of the Iwb (Ohio EPA 1987b). None of these modifications functioned in a consistent manner. The fundamental problem is that the predominance and higher abundance of species which are tolerant to environmental degradation is not sufficiently reflected in the aggregate index. Tolerant species either are the last to disappear under the influence of increased environmental degradation and they may respond favorably (i.e., they increase in abundance) to changes in the physical or chemical quality of the environment. Thus the elimination of the highly tolerant species from the numbers and biomass components of the Iwb was attempted. Ohio EPA has designated all fish species known to occur in Ohio as highly tolerant, moderately tolerant, intermediate, moderately intolerant, or highly intolerant (Ohio EPA 1987b) for the purposes of the IBI. This was accomplished by examining a large, statewide data base that included nearly 2000 sites and a wide range of environmental quality. While some past attempts to designate species tolerance rely mostly on the existing technical literature and regional fish reference texts, the Ohio EPA method is based on direct observations of species responses in the field. This requires a comprehensive data base and should be supplemented by information from the technical literature when necessary.

The modified Iwb retains the same computational formula as the conventional Iwb developed by Gammon (1976). The major difference is that any of the species designated as highly tolerant, exotics, and hybrids are eliminated from the numbers and biomass components of the Iwb. However, the tolerant and exotic species are included in the Shannon index calculations. This modification eliminates the "undesired" effect caused by the high abundance of tolerant species, but retains their "desired" influence in the Shannon indices. To illustrate the effect of this modification several comparisons were made between key fish community attributes, the modified Iwb, and the conventional Iwb (Ohio EPA 1987b). In addition results from different streams and rivers subjected to different types and varying levels of environmental degradation (both chemical and physical) demonstrated the influence that this modification had on an evaluation of fish community health and well-being (Ohio EPA 1987b). These analyses showed that the MIwb can be lower than the original Iwb by as much as one third in highly degraded areas, but by as little as 0.1% in high quality rivers and streams. The end result of this modification is an index which is more sensitive to all types of degradation, particularly nutrient enrichment and habitat impacts, which frequently result in an increased abundance and biomass of tolerant species, but which retains the ability to accurately characterize high quality communities. The MIwb is not applied to headwater sites as our analyses showed a very strong effect of drainage area on biomass which made application impractical in these situations (Ohio EPA 1987). The computational formula is as follows:

Modified Index of Well-being (MIwb) = 0.5 ln N + 0.5 ln B + H (no.) + H (wt.);
where:

N = CPUE relative numbers minus species designated highly tolerant (Ohio EPA 1987);

B = CPUE relative biomass minus species designated highly tolerant (Ohio EPA 1987);

H (no.) = Shannon diversity index based on numbers (version which uses $\log_e$);

H (wt.) = Shannon diversity index based on numbers (version which uses $\log_e$).

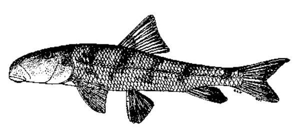
Appendix 5

Methods for Assessing Habitat in Flowing Waters Using the Qualitative Habitat Evaluation Index (QHEI)

State of Ohio
Environmental Protection Agency

Division of Surface Water

Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)



June, 2006

Bob Taft, Governor
Joseph P. Koncelik, Director

Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)

June 2006

OHIO EPA Technical Bulletin EAS/2006-06-1

Revised by the Midwest Biodiversity Institute[1] for:

State of Ohio Environmental Protection Agency
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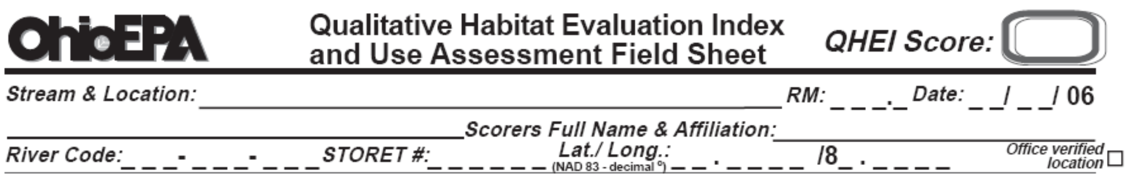
Methods for Assessing Habitat in Flowing Waters: Using the Qualitative Habitat Evaluation Index (QHEI)

Introduction

This document summarizes the methodology for completing a general evaluation of macrohabitat, generally done by the fish field crew leader while sampling each location using the Ohio EPA Site Description Sheet - Fish (Appendix 1). This form is used to tabulate data and information for calculating the Qualitative Habitat Evaluation Index (QHEI). The following guidance should be used when completing the site evaluation form.

Header/Geographical Information

Complete site identification information is critical to making field data useful. Figure 1 illustrates the location information required for the QHEI.


Ohio EPA Qualitative Habitat Evaluation Index and Use Assessment Field Sheet QHEI Score:

Stream & Location: ____ RM: _ _ _._ Date: _ _/ _ _/ 06

____ Scorers Full Name & Affiliation: ____

River Code: _ _ _ - _ _ _ - _ _ _ STORET #: _ _ _ _ _ _ Lat./ Long.: (NAD 83 - decimal °) _ _ . _ _ _ _ /8_ . _ _ _ _ Office verified location ☐

Figure 1. Header of Ohio EPA QHEI Sheet

1) Stream & Location, River Mile (RM), Date. The official stream name may be found in the Gazetteer of Ohio Streams (Ohio DNR 2001) or on USGS 7.5 minute topographic maps. If the stream is unnamed, a name and stream code is assigned by the Ohio ECOS Database Coordinator. Usually the name of a nearby landmark is used for the stream name. The River Mile (RM) designations used are found on 7.5 minute topo maps stored at the Ohio EPA, Division of Surface Water, Lazarus Government Center, Front Street (PEMSO RMI maps), one of five Ohio EPA District offices (maps for that district), and the Ohio EPA, Ecological Assessment Section at Grove City. These maps should soon be available as Adobe PDF files. A brief description of the sampling location should include proximity to a local landmark such as a bridge, road, discharge outfall, railroad crossing, park, tributary, dam, etc.

2) QHEI Scorers Full Name/Institution. The full name of the person who filled out the sheet are listed, along with the institution, company etc. QHEI information is to be completed someone who has successfully completed the QHEI training (e.g., crew leader). Ohio EPA will track the level of qualifications for each scorer. Level 2 QHEI practitioners have completed the two day training and successfully scored an additional site in a manner similar to EPA staff; Level 3 practitioners have additional training and have submitted three sites scored independently which will be verified as similar to EPA staff.

3) River Code, STORET, and Lat/Long. The River Code is Ohio EPA river code (PEMSO system) and the STORET # is the official unique Station Identifier used to link all data collected at a given “site” or “station” deemed to be similar for assessment purposes within a certain spatial area.

Habitat Characteristics: QHEI Metrics

The Qualitative Habitat Evaluation Index (QHEI) is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic macrohabitat characteristics that are important to fish communities. A detailed analysis of the development and use of the QHEI is available in Rankin (1989) and Rankin (1995). The QHEI is composed of six principal metrics each of which are described below. The maximum possible QHEI site score is 100. Each of the metrics are scored individually and then summed to provide the total QHEI site score. This is completed at least once for each sampling site during each year of sampling. An exception to this convention would be when substantial changes to the macrohabitat have occurred between sampling passes. Standardized definitions for pool, run, and riffle habitats, for which a variety of existing definitions and perceptions exist, are essential for accurately using the QHEI. For consistency the following definitions are taken from Platts et al. (1983). It is recommended that this reference also be consulted prior to scoring individual sites.

Riffle and Run Habitats:

Riffle - areas of the stream with fast current velocity and shallow depth; the water surface is visibly broken.

Figure 2. Riffle cross-section.

Figure 3. Run cross-section.

Run - areas of the stream that have a rapid, non-turbulent flow; runs are deeper than riffles with a faster current velocity than pools and are generally located downstream from riffles where the stream narrows; the stream bed is often flat beneath a run and the water surface is not visibly broken.

Pool and Glide Habitats:

Pool - an area of the stream with slow current velocity and a depth greater than riffle and run areas; the stream bed is often concave and stream width frequently is the greatest; the water surface slope is nearly zero.

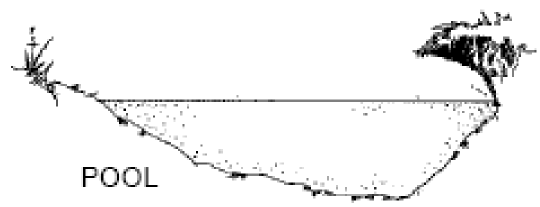


Figure 4. Pool cross-section.

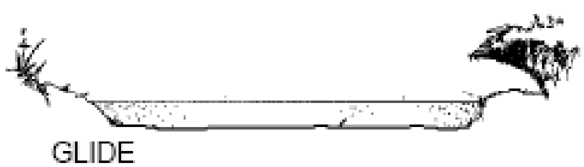


Figure 5. Glide cross-section.

Glide - this is an area common to most modified stream channels that do not have distinguishable pool, run, and riffle habitats; the current and flow is similar to that of a canal; the water surface gradient is nearly zero. HINT: These habitat types typically grade into one another. For example a run gradually changes into a pool. When measuring typical depths of these features take measurements where the feature is clearly of that type, not where they are grading from one type to another. The following is a description of each of the six QHEI metrics and the individual metric components. Guidelines on how to score each is presented. Generally, metrics are scored by checking boxes. In certain cases the biologist completing the QHEI sheet may interpret a habitat characteristic as being intermediate between the possible choices; in cases where this is allowed (denoted by the term "Double-Checking") two boxes may be checked and their scores averaged.

Metric 1: Substrate (Figure 6).

This metric includes two components, substrate type[1] and substrate quality. **Substrate type** Check the two most common substrate types in the stream reach. If one substrate type predominates (greater than approximately 75- 80% of the bottom area OR what is clearly the most functionally predominant substrate) then this substrate type should be checked twice. **DO NOT CHECK MORE THAN TWO BOXES**. Note the category for artificial substrates. Spaces are provided to note the presence (by check marks, or estimates of % if time allows) of all substrate types present in pools (includes pools and glides) and riffles (includes riffles and runs) that each comprise sufficient quantity to support species that may commonly be associated with

[1] We suggest that QHEI practitioners should conduct some pebble count assessments which help calibrate an investigators ability to identify predominant substrates.

that substrate type. This section must be filled out completely to permit future analyses of this metric. If there are more than four or more high quality substrate types in the zone that are present in sufficient amounts (see above) then check the appropriate box for number of best types. This metrics award points to those sites with a diversity of high quality substrate types. Substrate origin refers to the parent material from which the substrate type(s) originated. This can be double-checked if two origin types are common (e.g., tills & limestone). See end of this section for some definitions.

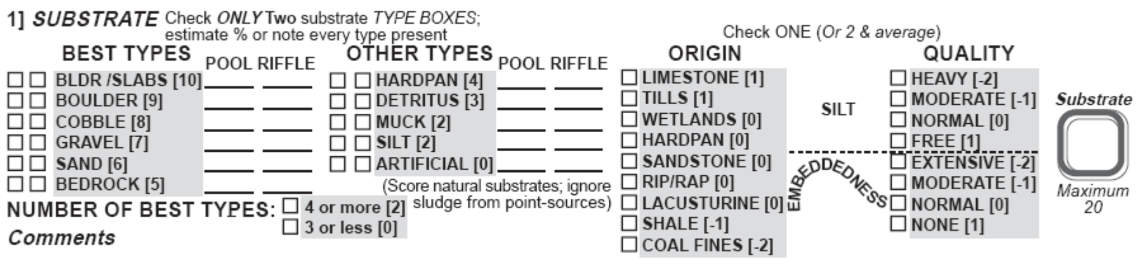


Figure 6. QHEI substrate metric.

Substrate quality.

Substrate origin refers to the "parent" material that the stream substrate is derived from. Check ONE box under the substrate origin column unless the parent material is from multiple sources (e.g., limestone and tills).

Embeddedness is the degree that cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine materials (sand and silt). Substrates should be considered embedded if >50% of surface of the substrates are embedded in fine material. Embedded substrates cannot be easily dislodged. This also includes substrates that are concreted or “armor-plated”. Naturally sandy streams are not considered embedded; however, a sand predominated stream that is the result of anthropogenic activities that have buried the natural coarse substrates is considered embedded. This can be very difficult to perceive. One help is to examine fresh point bars and look at the most common large materials that have been recently moved. According to Kappesser (1993), for gravel-bed rivers, the median of these large pieces should be equivalent to the median of the pieces on a riffle (based on a Wolman pebble count). If the riffles are finer than this, then sediment is aggrading in the reach and is evidence of embedded conditions. In some cases one can dig though the fine surface materials and fine coarser materials buried below. In this metric we are estimating the

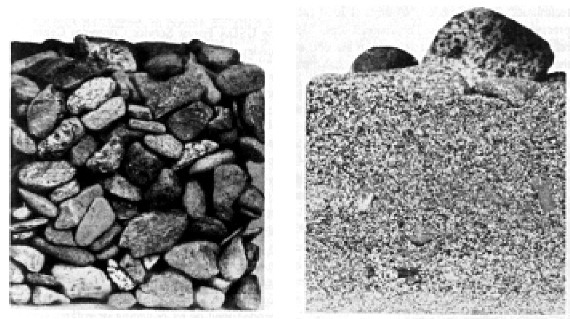


Figure 7. Side view of clearly un-embedded and embedded substrates.

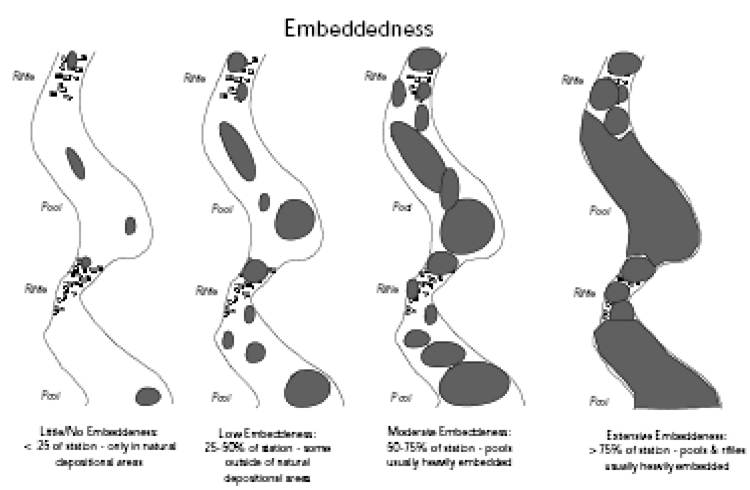


Figure 8. Illustration of example of degrees of pervasiveness of embeddedness for this QHEI component.

pervasiveness of embedded conditions through-out a station. Boxes are checked for extensiveness (*i.e.*, pervasiveness throughout the area of the sampling zone) of the embedded substrates as follows: Extensive — > 75% of site area, Moderate — 50-75%, Normal[2] — 25-50%, None[3] — < 25%.

Silt Cover is the extent that substrates are covered by a silt layer (*i.e.*, a 1 inch thick or obviously affecting aquatic habitats). Silt cover differs from the embeddedness metric in that it only considers the fine silt size particles whereas fine gravels, sands, and other fines are considered in assessing embedded conditions. **Silt Heavy** means that nearly the entire stream bottom is layered with a deep covering of silt. (pool/glides and all but the fastest areas of riffle/runs). **Moderate** means extensive covering by silts, but with some areas of cleaner substrate (*e.g.*, riffles). **Normal** silt cover includes areas where silt is deposited in small amounts along the stream margin or is present as a "dusting" that appears to have little functional significance. If substrates are exceptionally clean the **Silt Free** box should be checked.

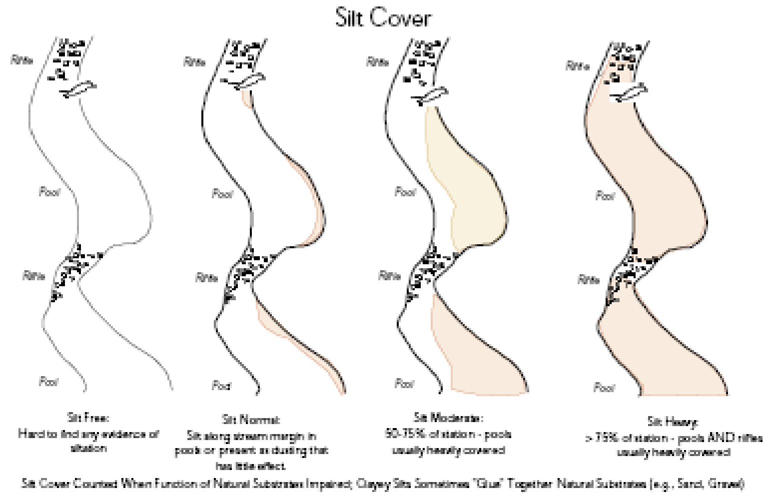


Figure 9. Illustration of example of degrees of pervasiveness of silt cover.

Substrate types are defined as:
a) **Bedrock** - solid rock forming a continuous surface.
b) **Boulder** - rounded stones over 256 mm in diameter (10 in.) or large "slabs" more than 256 mm in length (Boulder slabs)[4].
c) **Cobble** - stones from 64- 256 mm (2 1/2 - 10 in.) in diameter.
d) **Gravel** - mixture of rounded course material from 2-64 mm (1/12 - 2 1/2 in.) in diameter. Note the wide range of sizes included under gravel. In the riffle metric we distinguish between large and fine gravels
e) **Sand** - materials 0.06 - 2.0 mm in diameter, gritty texture when rubbed between fingers.
f) **Silt** - 0.004 - 0.06 mm in diameter, generally this is fine material which feels "greasy" when rubbed between fingers.
g) **Hardpan** - particles less than 0.004 mm in diameter, usually clay, which forms a dense, gummy surface that is difficult to penetrate.
h) **Marl** - calcium carbonate; usually grayish-white; often contains fragments of mollusk shells.
i) **Detritus** - dead, unconsolidated organic material covering the bottom which could include sticks, wood and other partially or un-decayed coarse plant material.
j) **Muck** - black, fine, flocculent, completely decomposed organic matter (does not include sewage sludge).
k) **Artificial** - substrates such as rock baskets, gabions, bricks, trash, concrete etc., placed in the stream for reasons OTHER than habitat mitigation.

Sludge is defined as a thick layer of organic matter that is decidedly of human or animal origin. NOTE: SLUDGE THAT ORIGINATES FROM POINT SOURCES IS NOT INCLUDED; THE SUBSTRATE SCORE IS BASED ON THE UNDERLYING MATERIAL. This scenario is rare today and was done to prevent underestimating stream habitat potential affect by discharges.

Substrate Metric Score: Although the sum of the individual metric scores can be greater than 20 the maximum substrate core allowed for this metric is 20 points.

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[2] In some earlier training materials "normal" was described as "low" (e.g., see Figure 7).
[3] In some earlier training materials "None" was described as "little-no" (e.g., see Figure 7).
[4] A version of the QHEI used in Maine distinguishes large boulders.

Example of stream with heavily embedded substrates.

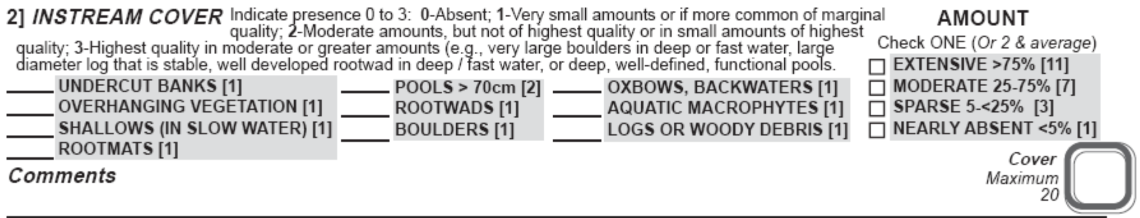
Example of spongy deposits of fine gravels and sands from recent erosion activities.

Substrate Origin Identification Tips:

- Limestone: Often contains fossils, easily scratched with knife, usually bedrock or flat boulders and cobbles
- Tills: Sediments deposited by glaciers; particles often rounded. Can be carried into non-glaciated areas
- Wetlands: Usually organic muck and detritus
- Hardpan: Clay – smooth, usually slippery
- Sandstone: Contains rounded fragment of sand "cemented" together
- Rip/Rap: Artificial boulders
- Lacustrine: Old lake bed sediments
- Shale: "Claystone," sedimentary rock made of silt/clay, soft and cleaves easily
- Coal Fines: Black fragments of coal, generally SE Ohio only

We suggest that QHEI practitioners gain some experience in pebble count procedures. Conducting Wolman or Zig-Zag pebble counts helps to improve the ability to visually estimate predominant substrate sizes and size categories.

Stream characterized by cobble and boulder-size substrates.


2] *INSTREAM COVER* Indicate presence 0 to 3: **0**-Absent; **1**-Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; 3-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

____ UNDERCUT BANKS [1]
____ OVERHANGING VEGETATION [1]
____ SHALLOWS (IN SLOW WATER) [1]
____ ROOTMATS [1]
____ POOLS > 70cm [2]
____ ROOTWADS [1]
____ BOULDERS [1]
____ OXBOWS, BACKWATERS [1]
____ AQUATIC MACROPHYTES [1]
____ LOGS OR WOODY DEBRIS [1]

AMOUNT
Check ONE (*Or 2 & average*)
☐ EXTENSIVE >75% [11]
☐ MODERATE 25-75% [7]
☐ SPARSE 5-<25% [3]
☐ NEARLY ABSENT <5% [1]

Comments

Cover Maximum 20

Figure 10. Instream cover (structure) metric.

Metric 2: Instream Cover (Figure 10).

This metric scores presence of instream cover types and amount of overall instream cover. Ohio EPA has been phasing in an alternative scoring system for this metric, but for this 2006, the total scoring still follows the existing methods. The changes will be discussed later.

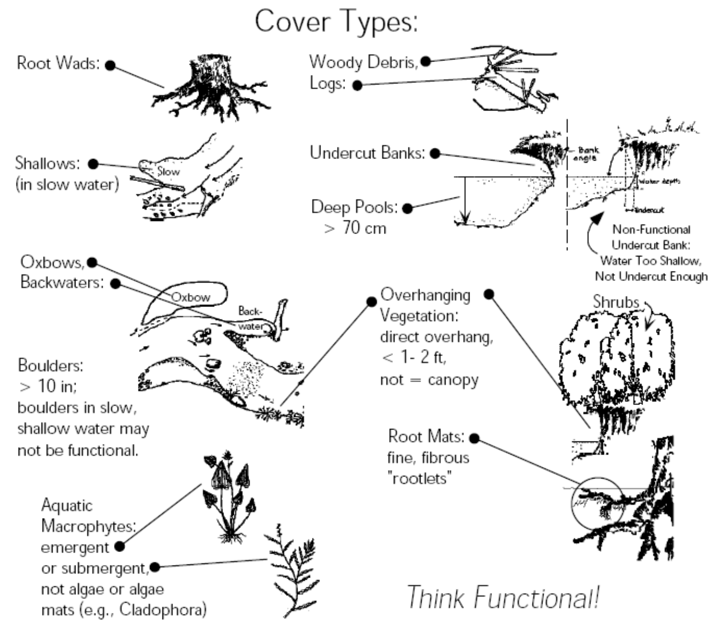


Figure 11. Examples of major cover/structure types measured with QHEI.

Existing Scoring Method:

Each cover type that is present in an amount occurs in sufficient quantity to support species that may commonly be associated with the habitat type should be scored.[5] Cover should not be counted when it is in areas of the stream with insufficient depth (usually < 20 cm) to make it useful. For example a logjam in 5 cm of water contributes very little, if any cover, and at low flow may be dry. Other cover types with limited function in shallow water include undercut banks and overhanging vegetation, boulders, and rootwads. Under amount, one or two boxes may be checked. Extensive cover is that which is present throughout the sampling area, generally greater than about 75% of the stream reach sampled. Cover is moderate when it occurs over 25- 75% of the sampling area. Cover is sparse when it is present in less than 25% of the stream margins (sparse cover usually exists in one or more isolated patches). Cover is nearly absent when no large patch of any type of cover exists anywhere in the sampling area. This situation is usually found in recently channelized streams or other highly modified reaches (e.g. ship channels). If cover is thought to be intermediate in amount between two categories, check two boxes and average their scores. For wide streams cover amount is estimated along the swath of stream sampled (or that would be sampled) with an electrofisher. In smaller streams

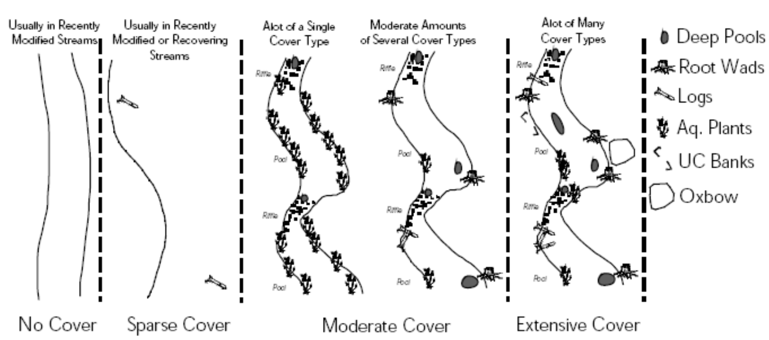


Figure 12. Illustration of the four categories of cover amounts.

[5] We had mentioned a 5% rule of thumb for an amount threshold if biological experience is low – this would be as a linear, not an areal amount.

(smaller wadeable and headwater streams) this generally covers most of the stream width. If a single type of cover is extensive and others are absent or uncommon then the total is scored as moderate because of the low diversity of types.

A desire to investigate and measure variation in amount and quality of individual cover types lead to a change in scoring of this metric. Over the next year or so the existing scoring method (each cover type scored on an presence/absence rating and a cumulative cover amount score) will be replaced with the following scoring method that focuses on scoring each cover type on a gradient of amount and quality. Each cover type would receive a score of 0-3 where:

0 - Absent;
1 - Very small amounts or if more common of marginal quality;
2 - Moderate amounts, but not of highest quality or in small amounts of highest quality;
3 - Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter logs that are stable, well developed rootwads in deep/fast water, or deep, well-defined, functional pools.

The cover ratings have been collected for about the last five years and an assessment of their relation to biological measures will be used to adjust a final scoring for this metric. At present, continue scoring these as present/absent and use the overall cover metric score. Cover types include: 1) undercut banks, 2) overhanging vegetation, 3) shallows (in slow water)[6], 4) logs or woody debris, 5) deep pools (> 70 cm), 6) oxbows, backwaters, or side channels, 7) boulders, 8) aquatic macrophytes, and 9) rootwads (tree roots that extend into stream). Do not check undercut banks AND rootwads unless undercut banks exist along with rootwads as a major component. Although the theoretical maximum score is > 20 the maximum score assigned for the QHEI for the instream cover metric is limited to 20 points.

High quality logs and woody debris in deep water.

High quality rootwad in deep, fast water.

[6] Shallows are habitats that provide nursery areas for small fish.

Example of good quality shallow habitat with aquatic macrophyte bed that acts as nursery habitat.

High quality boulder in fast water

Root Mats

Importance of logs and woody debris in large rivers.

Functional overhanging vegetation

Metric 3: Channel Morphology (Figure 13)

This metric emphasizes the quality of the stream channel that relates to the creation and stability of macrohabitat. It includes channel sinuosity (i.e. the degree to which the stream meanders), channel development, channelization, and channel stability. One box under each should be checked unless conditions are considered to be intermediate between two categories; in these cases check two boxes and average their scores.

3] *CHANNEL MORPHOLOGY* Check ONE in each category (*Or 2 & average*)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
☐ HIGH [4]	☐ EXCELLENT [7]	☐ NONE [6]	☐ HIGH [3]
☐ MODERATE [3]	☐ GOOD [5]	☐ RECOVERED [4]	☐ MODERATE [2]
☐ LOW [2]	☐ FAIR [3]	☐ RECOVERING [3]	☐ LOW [1]
☐ NONE [1]	☐ POOR [1]	☐ RECENT OR NO RECOVERY [1]	

Comments

Channel *Maximum 20*

Figure 13. Channel morphology metric.

a) *Sinuosity* - **No sinuosity** is a straight channel. **Low sinuosity** is a channel with only 1 or 2 poorly defined outside bends in a sampling reach, or perhaps slight meandering within modified banks. **Moderate sinuosity** is more than 2 outside bends, with at least one bend well defined. **High sinuosity** is more than 2 or 3 well defined outside bends with deep areas outside and shallow areas inside. Sinuosity may be more conceptually described by the ratio of the stream distance between two points on the channel of a stream and the straight-line distance between these same two points, taken from a topographic map. This metric measures the formation of pools and increased habitat area as the primary "functions" of sinuosity as related to aquatic life. Check one box or select two and average.

b) *Development* - This refers to the development of riffle/pool complexes. **Poor** means riffles are absent, or if present, shallow with sand and fine gravel substrates; pools, if present are shallow. Glide habitats, if predominant, receive a **Poor** rating. **Fair** means riffles are poorly developed or absent; however, pools are more developed with greater variation in depth. **Good** means better defined riffles present with larger substrates (gravel, rubble or boulder); pools have variation in depth and there is a distinct transition between pools and riffles. **Excellent** means development is similar to the **Good** category except the following characteristics must be present: pools must have a maximum depth of >1 m and deep riffles and runs (>0.5 m) must also be present. In streams sampled with wading methods, a sequence of riffles, runs, and pools must occur more than once in a sampling zone. Check one box or check two and average.

Table 1: Scoring criteria for pool/riffle development metric.

	Excellent	Good	Fair	Poor
Pool	> 1 m deep, well defined	0.7-1.0 m deep, well defined	Some depth variation	Shallow, if present
Glide	Not common	Not common	Common	Predominant
Riffle	Deep, well defined riffles, large substrates	Defined riffles, large substrates	Poorly defined riffles or riffles absent	Absent of shallow with fine substrates
Run	> 0.5 m deep, well defined	Deep, well defined	Usually absent	Absent

This metric can be double-checked. For situations, for example where riffles are excellent and pools are only fair, it is advantageous to check the excellent and the fair box rather than checking the good box as an average to keep information on the variance in quality.

Note how well defined (i.e., distinct) the riffle and pool are in this high quality headwater stream pictured on the left. Also note the large tree in the riparian

c) *Channelization -* This refers to anthropogenic channel modifications. **Natural** refers to no obvious direct moving or alteration of the channel and a natural appearance. **Recovered** refers to streams that have been channelized in the past, but which have recovered most of their natural channel characteristics. **Recovering** refers to channelized streams which are still in the process of regaining their former, natural however, these habitats are still degraded. This category also applies to those streams, especially in the Huron/ Erie Lake Plain ecoregion (NW Ohio), that were channelized long ago and have a riparian border of mature trees, but still have Poor channel characteristics. **Recent** or **No Recovery** refers to streams that were recently channelized or those that show no significant recovery of habitats (e.g. drainage ditches, grass lined or rock rip-rap banks, etc.). The specific type of habitat modification is checked in the last two columns but not scored.

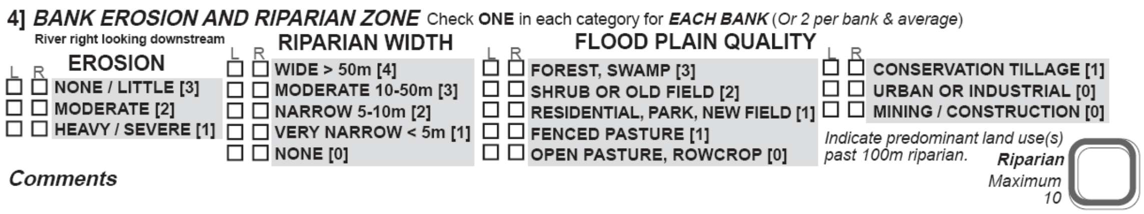
A channelized stream channel starting to revert towards more natural channel features.

Unstable channel features and low stability.

d) *Stability -* This refers to channel stability. Artificially stable (concrete) stream channels receive a High score. Even though they generally have a negative influence on fish assemblages, the negative effects are related to features other than their stability. Channels with **Low stability** are usually characterized by fine substrates in riffles that often change location, have unstable and severely eroding banks, and a high bedload that slowly creeps downstream. Sometimes these unstable riffles form diagonally across the channel (see figure, right). Channels with **Moderate stability** are those that appear to maintain stable riffle/ pool and channel characteristics, but which exhibit some symptoms of instability, e.g. high bedload, eroding or false banks, or shows the effects of wide fluctuations in water level. Channels with **High stability** have stable banks and substrates, and little or no erosion and bedload. e) *Modifications/Other -* Check the appropriate box if impounded, islands present, or leveed (these are not included in the QHEI scoring) as well as the appropriate source of habitat modifications. The maximum QHEI metric score for Channel Morphology is 20 points.

Metric 4: Riparian Zone and Bank Erosion (Figure 14)

This metric emphasizes the quality of the riparian buffer zone and quality of the floodplain vegetation. This includes riparian zone width, floodplain quality, and extent of bank erosion. Each of the three components requires scoring the left and right banks (looking downstream). The average of the left and right banks is taken to derive the component value. One box per bank should be checked unless conditions are considered to be intermediate between two categories; in these cases check two boxes and average their scores.



4] ***BANK EROSION AND RIPARIAN ZONE*** Check **ONE** in each category for ***EACH BANK*** (*Or 2 per bank & average*)

River right looking downstream

L	R	EROSION	L	R	RIPARIAN WIDTH	L	R	FLOOD PLAIN QUALITY	L	R	
☐	☐	NONE / LITTLE [3]	☐	☐	WIDE > 50m [4]	☐	☐	FOREST, SWAMP [3]	☐	☐	CONSERVATION TILLAGE [1]
☐	☐	MODERATE [2]	☐	☐	MODERATE 10-50m [3]	☐	☐	SHRUB OR OLD FIELD [2]	☐	☐	URBAN OR INDUSTRIAL [0]
☐	☐	HEAVY / SEVERE [1]	☐	☐	NARROW 5-10m [2]	☐	☐	RESIDENTIAL, PARK, NEW FIELD [1]	☐	☐	MINING / CONSTRUCTION [0]
			☐	☐	VERY NARROW < 5m [1]	☐	☐	FENCED PASTURE [1]			*Indicate predominant land use(s) past 100m riparian.*
			☐	☐	NONE [0]	☐	☐	OPEN PASTURE, ROWCROP [0]			

Comments

Riparian *Maximum 10*

Figure 14. Bank erosion and riparian zone metric.

Severe bank erosion.

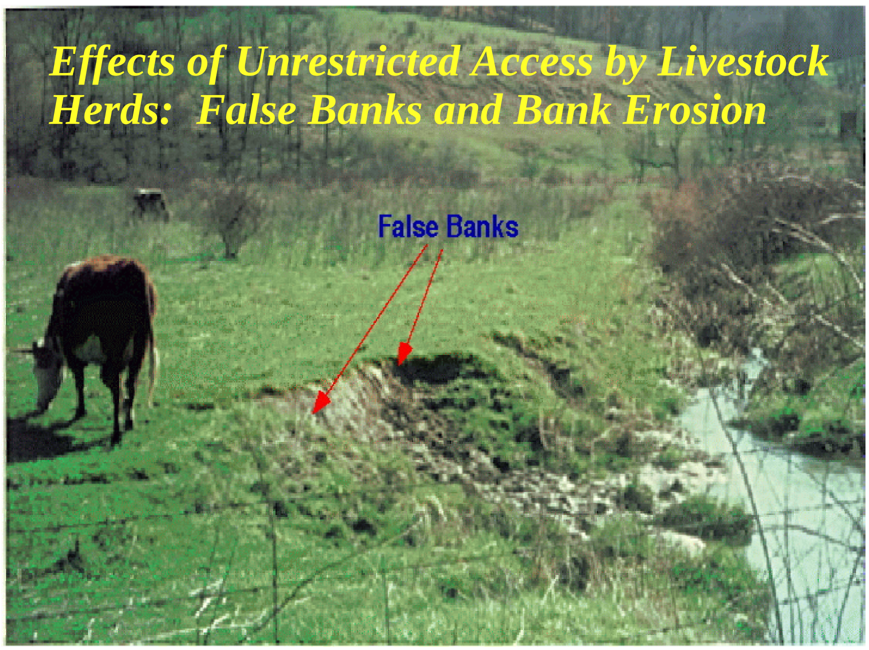
a) *Bank Erosion* – A modified Streambank Soil Alteration Ratings from Platts et al. (1983) is used here; check one box for each side of the stream and average the scores. False banks are used in the sense of Platts et al. (1983) to mean banks that are no longer adjacent to the normal flow of the channel but have been moved back into the floodplain most commonly as a result of livestock trampling. 1) **None** - streambanks are stable and not being altered by water flows or animals (e.g. livestock) - Score 3. 2) **Little** - streambanks are stable, but are being lightly altered along the transect line; less than 25% of the streambank is receiving any kind of stress, and if stress is being received it is very light; less than 25% of the streambank is false, broken down or eroding - Score 3. 3) **Moderate** - streambanks are receiving moderate alteration along the transect line; at least 50 percent of the streambank is in a natural stable condition; less than 50% of the streambank is false, broken down or eroding; false banks are rated as altered - Score 2. 4) **Heavy** - streambanks have received major alterations along the transect line; less than 50% of the streambank is in a stable condition; over 50% of the streambank is false, broken down, or eroding - Score 1. 5) **Severe** - streambanks along the transect line are severely altered; less than 25% of the streambank is in a stable condition; over 75% of the streambank is false, broken down, or eroding - Score 1

b) *Riparian Width* - This is the width of the riparian (stream side) vegetation. Width estimates are only done for **forest, shrub, swamp,** and **old field vegetation** if it has **woody** components (*e.g.*, willows). Old field refers to a fairly mature successional field that has stable, woody plant growth; this generally does not include weedy urban or industrial lots that often still have high runoff potential. Two boxes, one each for the left and right bank (looking downstream), should be checked and then averaged.

c) *Floodplain Quality* - The two most predominant floodplain quality types should be checked, one each for the left and right banks (includes urban, residential, etc.), and then averaged. By floodplain we mean the areas immediately outside of the riparian zone or greater than 100 meters from the stream, whichever is wider on each side of the stream. The concept is to identify land uses that might deliver harmful runoff to the stream. These are areas adjacent to the stream that can have direct runoff and erosion effects during normal wet weather. This is considered a ground truthing exercise and we suggest those interested in estimating of the effects of adjacent or riparian land uses use now well-developed GIS approaches. We do not limit it to the riparian zone and it is much less encompassing than the stream basin.

The maximum score for Riparian Zone and Erosion metric is 10 points.

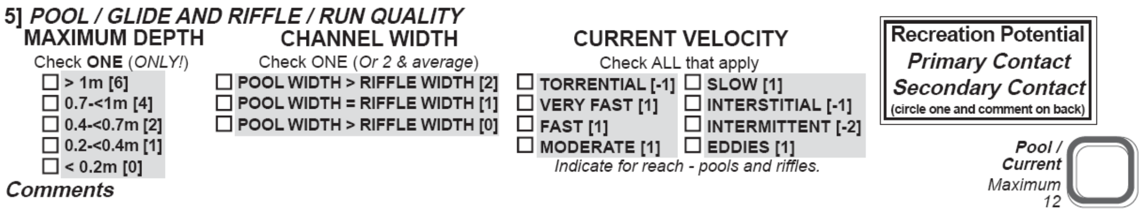
Estimating riparian zone width.



Example of un-restricted livestock access and the formation of "false" banks.

Metric 5: Pool/Glide and Riffle-Run Quality (Figure 15)

This metric emphasizes the quality of the pool, glide and/or riffle-run habitats. This includes pool depth, overall diversity of current velocities (in pools and riffles), pool morphology, riffle-run depth, riffle-run substrate, and riffle-run substrate quality.


5] *POOL / GLIDE AND RIFFLE / RUN QUALITY*

MAXIMUM DEPTH Check ONE (*ONLY!*)	CHANNEL WIDTH Check ONE (*Or 2 & average*)	CURRENT VELOCITY Check ALL that apply	
☐ > 1m [6]	☐ POOL WIDTH > RIFFLE WIDTH [2]	☐ TORRENTIAL [-1]	☐ SLOW [1]
☐ 0.7-<1m [4]	☐ POOL WIDTH = RIFFLE WIDTH [1]	☐ VERY FAST [1]	☐ INTERSTITIAL [-1]
☐ 0.4-<0.7m [2]	☐ POOL WIDTH > RIFFLE WIDTH [0]	☐ FAST [1]	☐ INTERMITTENT [-2]
☐ 0.2-<0.4m [1]		☐ MODERATE [1]	☐ EDDIES [1]
☐ < 0.2m [0]		*Indicate for reach - pools and riffles.*	

Recreation Potential
Primary Contact
Secondary Contact
(circle one and comment on back)

Pool / Current
Maximum 12

Comments

Figure 15. Pool/glide and riffle/run metric

A) Pool/Glide Quality

1) *Maximum depth* of pool or glide; check one box only (Score 0 to 6). Pools or glides with maximum depths of less than 20 cm are considered to have lost their function and the total metric is scored a 0. No other characteristics need be scored in this case.

2) *Current Types* - check each current type that is present in the stream (including riffles and runs; score -2 to 4), definitions are: **Torrential** - extremely turbulent and fast flow with large standing waves; water surface is very broken with no definable, connected surface; usually limited to gorges and dam spillway tailwaters. **Very Fast** – turbulent flow that may make it difficult to stand and creates pulsating effect again leg. **Fast** - mostly non-turbulent flow with small standing waves in riffle/run areas; water surface may be partially broken, but there is a visibly connected surface. Fast current has sufficient energy to flow forcefully over objects. Sharp drop evident on depth rod. **Moderate** - non-turbulent flow that is detectable and visible (i.e. floating objects are readily transported downstream); water surface is visibly connected. With moderate current water flows around rather than over objects. Little drop around depth rod. **Slow** - water flow is perceptible, but very sluggish. **Eddies** - small areas of circular current motion usually formed in pools immediately downstream from riffle-run areas. **Interstitial** - water flow that is perceptible only in the interstitial spaces between substrate particles in riffle-run areas. **Intermittent** - no flow is evident anywhere leaving standing pools that are separated by dry areas. The role of bank erosion in sediment delivery to streams is often underestimated. Higher gradient stream showing typical locations of fast, moderate, and slow areas and eddies.

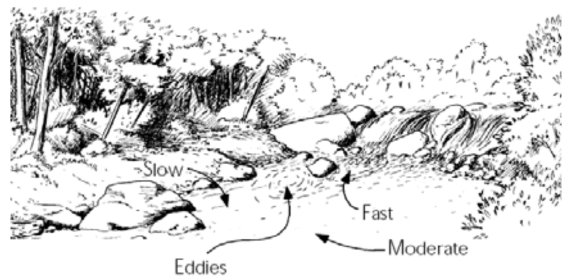


Figure 16. Typical locations of various current velocity types in a stream.

4) *Morphology* - Check **Wide** if pools are wider than riffles, **Equal** if pools and riffles are the same width, and **Narrow** if the riffles are wider than the pools (Score 0 to 2, see Figure 17). If the morphology varies throughout the site average the types. If the entire stream area (including areas outside of the sampling zone) is pool or riffle, then check riffle = pool.

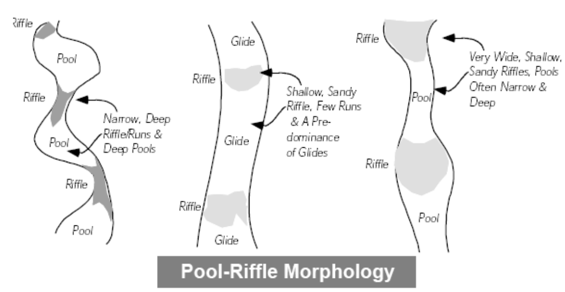


Figure 17. Pool morphology metric categories.

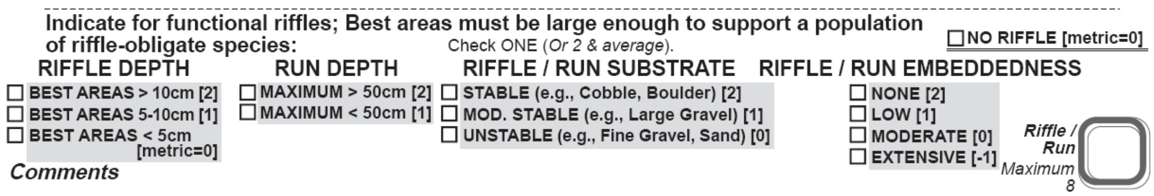
Although the theoretical maximum score for the pool metric is greater than 12 the maximum score assigned for the QHEI for the Pool Quality metric is limited to 12 points.

Illustration of the importance of pool depth to aquatic life

Estimating current velocity, Sharp drop from front to back of rod and boot indicates fast current velocities.

B) Riffle-Run Quality (Figure 18)

This entire metric is scored 0 if no riffles are present.



Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species: Check ONE (*Or 2 & average*). ☐ NO RIFFLE [metric=0]

RIFFLE DEPTH	RUN DEPTH	RIFFLE / RUN SUBSTRATE	RIFFLE / RUN EMBEDDEDNESS
☐ BEST AREAS > 10cm [2]	☐ MAXIMUM > 50cm [2]	☐ STABLE (e.g., Cobble, Boulder) [2]	☐ NONE [2]
☐ BEST AREAS 5-10cm [1]	☐ MAXIMUM < 50cm [1]	☐ MOD. STABLE (e.g., Large Gravel) [1]	☐ LOW [1]
☐ BEST AREAS < 5cm [metric=0]		☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]	☐ MODERATE [0]
			☐ EXTENSIVE [-1]

Comments

Riffle / Run *Maximum* 8

Figure 18. Riffle-run metric.

1)Riffle - select one box that most closely describes the depth characteristics of the best riffle in the zone (Score 0 to 2). The best riffle is selected because we want to identify bottlenecks during harsh periods (*e.g.*, drought). Estimate depths in areas that are clearly riffle, not transitional between a riffle and a run. If the riffle is generally less than 5 cm in depth, riffles are considered to have loss their function and the entire riffle metric is scored a 0.

2) Run Depth - select one box that most closely describes the depth characteristics of the runs (Score 0 to 2). Estimate depth in areas that are clearly run, not transitional between a pool and a run or a riffle and a run.

3) *Riffle/Run Substrate Stability*— select one box from each that best describes the substrate type and stability of the riffle habitats (Score 0 to 2).

4) *Riffle/Run Embeddedness*— Embeddedness is the degree that cobble, gravel, and boulder substrates are surrounded or covered by fine material (sand, silt); here in the riffle/runs only. We consider substrates embedded if >50% of surface of the substrates are embedded in fine material—these substrates cannot be easily dislodged. This also includes substrates that are concreted. Boxes are checked for pervasiveness of (riffle/ run area of sampling zone) embedded substrates: **Extensive** — > 75% of stream area, **Moderate** — 50-75%, **Sparse** — 25- 50%, **Low** — < 25%. The maximum score assigned for the QHEI for the Riffle/Run Quality metric is 8 points.

Metric 6: Map Gradient

Local or map gradient is calculated from USGS 7.5 minute topographic maps by measuring the elevation drop through the sampling area. This is done by measuring the stream length between the first contour line upstream and the first contour line downstream of the sampling site and dividing the distance by the contour interval. If the contour lines are closely "packed" a minimum distance of at least one mile should be used. Some judgment may need to be exercised in certain anomalous areas (e.g. in the vicinity of waterfalls, impounded areas, etc.) and this can be compared to an infield, visual estimate which is recorded next to the gradient metric on the front of the sheet. Scoring for ranges of stream gradient takes into account the varying influence of gradient with stream size, preferably measured as drainage area in square miles or stream width. Gradient classifications (Table V-4-3) were modified from Trautman (p 139, 1981) and scores were assigned, by stream size category, after examining scatter plots of IBI vs. natural log of gradient in feet/mile (see Rankin 1989). Scores are listed in Table 2. The maximum QHEI metric score for Gradient is 10 points

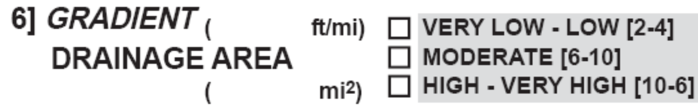


Figure 19. QHEI Stream gradient metric.

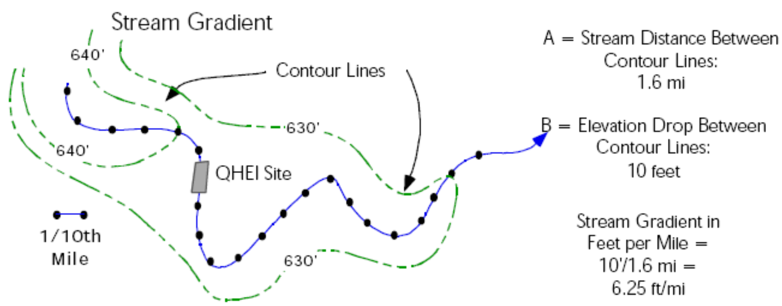


Figure 20. Illustration of methodology for determining stream gradient from topographic maps.

Table 2 Classification of stream gradients for Ohio by stream size. Modified from Trautman (p 139, 1981). Scores were derived from plots of IBI versus stream gradient for each stream size category.

Stream Width	Drainage Area (sq mi)	Gradient (feet/mile)						
		Very Low	Low	Low-Moderate	Moderate	Moderate-High	High	Very High[1]
≤ 4.7	< 9.2	0 - 1.0 **2**	1.1 - 5.0 **4**	5.1 - 10.0 **6**	10.1 - 15.0 **8**	15.1 - 20 **10**	20.1 - 30 **10**	30.1 - 40 **8**
4.8 - 9.2	9.2 - 41.6	0 - 1.0 **2**	1.1 - 3.0 **4**	3.1 - 6.0 **6**	6.1 - 12.0 **10**	12.1 - 18 **10**	18.1 - 30 **8**	30.1 - 40 **6**
9.3 - 13.8	41.7 - 103.7	0 - 1.0 **2**	1.1 - 2.5 **4**	2.6 - 5.0 **6**	5.1 - 7.5 **8**	7.6 - 12 **10**	12.1 - 20 **8**	20.1 - 30 **6**
13.9 - 30.6	103.8 - 622.9	0 - 1.0 **4**	1.1 - 2.0 **6**	2.1 - 4.0 **8**	4.1 - 6.0 **10**	6.1 - 10 **10**	10.1 - 15 **8**	15.1 - 25 **6**
> 30.6	> 622.9		0 - 0.5 **6**	0.6 - 1.0 **8**	1.1 - 2.5 **10**	2.6 - 4.0 **10**	4.1 - 9 **10**	> 9 **8**

[1]Any site with a gradient greater than the upper bound of the "very high" gradient classification is assigned a score of 4.

Computing the Total QHEI Score: To compute the total QHEI score, add the components of each metric to obtain the metric scores and then sum the metric scores to obtain the total QHEI score. The QHEI metric scores cannot exceed the Metric Maximum Score indicated below.

Narrative ranges of QHEI scores

For communicating general habitat quality to the public general narrative categories have been assigned to QHEI scores. Habitat influences on aquatic life, however, occur at multiple spatial scales and these narrative ranges are general and not always definitely predictable of aquatic assemblages are any given site.

Table 2. General narrative ranges assigned to QHEI scores. Ranges vary slightly in headwater (≤ 20 sq mi) vs. larger waters.

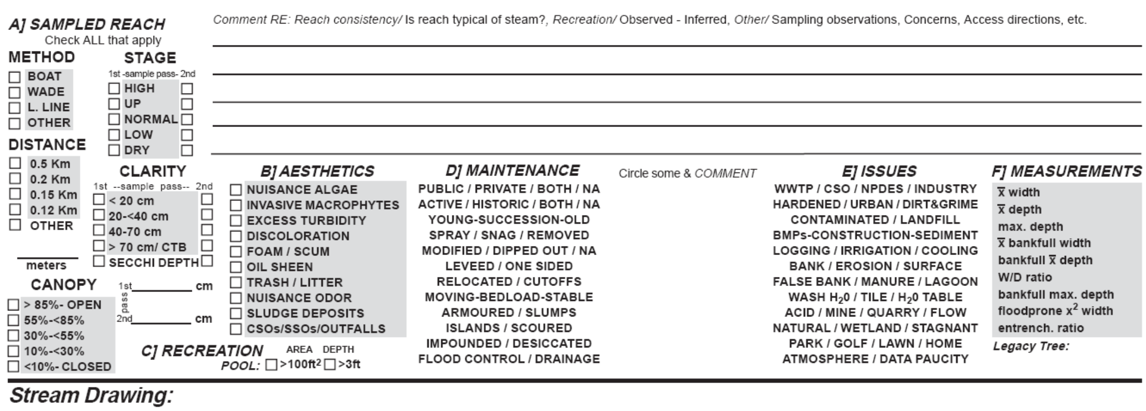
Narrative Rating		QHEI Range	
		Headwaters	Larger Streams
Excellent	(blue)	≥ 70	≥ 75
Good	(green)	55- to 69	60 to 74
Fair	(yellow)	43 to 54	45 to 59
Poor	(orange)	30 to 42	30 to 44
Very Poor	(red)	< 30	< 30

QHEI SCORING (Maximum = 100)

QHEI Metric	Metric Component	Component Scoring Range	Metric Max. Score
1) Substrate	a) Type	0 to 21	20
	b) Quality	-5 to 3	
2) Instream Cover	a) Type	0 to 10	20
	b) Amount	1 to 11	
3) Channel Morphology	a) Sinuosity	1 to 4	20
	b) Development	1 to 7	
	c) Channelization	1 to 6	
	d) Stability	1 to 3	
4) Riparian Zone	a) Width	0 to 4	10
	b) Quality	0 to 3	
	c) Bank Erosion	1 to 3	
5a) Pool Quality	a) Max. Depth	0 to 6	12
	b) Current	-2 to 4	
	c) Morphology	0 to 2	
5b) Riffle Quality	a) Depth	0 to 4	8
	b) Substr Stab.	0 to 2	
	c) Substr Embd.	-1 to 2	
6) Gradient		2 to 10	10

Additional Information/Back of QHEI Sheet

Additional information is recorded on the reverse side of the Site Description Sheet. Several versions of the reverse of the QHEI sheet have been produced over the past 10 years, but this description is based on the most recent revision of the Ohio EPA sheet (Figure 21).


A] SAMPLED REACH
Check ALL that apply
METHOD: ☐ BOAT ☐ WADE ☐ L. LINE ☐ OTHER
STAGE (1st -sample pass- 2nd): ☐ HIGH ☐ ☐ UP ☐ ☐ NORMAL ☐ ☐ LOW ☐ ☐ DRY ☐
DISTANCE: ☐ 0.5 Km ☐ 0.2 Km ☐ 0.15 Km ☐ 0.12 Km ☐ OTHER ____ meters
CLARITY (1st --sample pass-- 2nd): ☐ < 20 cm ☐ ☐ 20-<40 cm ☐ ☐ 40-70 cm ☐ ☐ > 70 cm/ CTB ☐ ☐ SECCHI DEPTH ☐ 1st ____ cm 2nd ____ cm
CANOPY: ☐ > 85%- OPEN ☐ 55%-<85% ☐ 30%-<55% ☐ 10%-<30% ☐ <10%- CLOSED

Comment RE: Reach consistency/ Is reach typical of steam?, Recreation/ Observed - Inferred, Other/ Sampling observations, Concerns, Access directions, etc.

B] AESTHETICS: ☐ NUISANCE ALGAE ☐ INVASIVE MACROPHYTES ☐ EXCESS TURBIDITY ☐ DISCOLORATION ☐ FOAM / SCUM ☐ OIL SHEEN ☐ TRASH / LITTER ☐ NUISANCE ODOR ☐ SLUDGE DEPOSITS ☐ CSOs/SSOs/OUTFALLS

C] RECREATION AREA DEPTH POOL: ☐ >100ft² ☐ >3ft

D] MAINTENANCE: PUBLIC / PRIVATE / BOTH / NA; ACTIVE / HISTORIC / BOTH / NA; YOUNG-SUCCESSION-OLD; SPRAY / SNAG / REMOVED; MODIFIED / DIPPED OUT / NA; LEVEED / ONE SIDED; RELOCATED / CUTOFFS; MOVING-BEDLOAD-STABLE; ARMOURED / SLUMPS; ISLANDS / SCOURED; IMPOUNDED / DESICCATED; FLOOD CONTROL / DRAINAGE

Circle some & COMMENT

E] ISSUES: WWTP / CSO / NPDES / INDUSTRY; HARDENED / URBAN / DIRT&GRIME; CONTAMINATED / LANDFILL; BMPs-CONSTRUCTION-SEDIMENT; LOGGING / IRRIGATION / COOLING; BANK / EROSION / SURFACE; FALSE BANK / MANURE / LAGOON; WASH H_2O / TILE / H_2O TABLE; ACID / MINE / QUARRY / FLOW; NATURAL / WETLAND / STAGNANT; PARK / GOLF / LAWN / HOME; ATMOSPHERE / DATA PAUCITY

F] MEASUREMENTS: $\bar{x}$ width; $\bar{x}$ depth; max. depth; $\bar{x}$ bankfull width; bankfull $\bar{x}$ depth; W/D ratio; bankfull max. depth; floodprone x^2 width; entrench. ratio; Legacy Tree:

Stream Drawing:

A – Sampling Characteristics

1) *Methods Used* – A series of check boxes to record the type of sampling completed in the reach.
2) *Distance* – Distance assessed for the QHEI and/or fish assessment.
3) *Stage* – Estimate of flow stage during assessment. Since some sites are sampled twice, a box is included for each sampling effort.
4) *Clarity* – Estimate of water clarity during assessment. Since some sites are sampled twice, a box is included for each sampling effort. There are also two places to record Secchi depths, if taken.
5) *Canopy* – Estimate of average width of canopy

B. Aesthetics

1) Check all of the boxes that apply in terms of aesthetic characteristics of the site

C. Recreation
1) Record whether there exists, within the area, greater than 100 ft^2 of water greater than three feet in depth. This is used to estimate whether full body immersion is possible or likely.

D. Maintenance
1) Record what types of stream maintenance activities or special features occur in the sampling zone. Some of this information was previously on the front of the sheet and is used as an aid when determining aquatic life uses (e.g., existing on ongoing channel maintenance).

E. Issues
1) Record various potential sources of impact that may occur in or near the site.

F. Measurements
1) If some quantitative measurements of stream channel characteristics are collected they may be recorded here. It is likely, however, that more detailed stream measurements (e.g., geomorphic assessment) will be recorded on separate forms.

G) *Stream Maps and Diagram*
Stream maps for each site can be very important. The act of drawing a map usually helps to identify habitat types scored with the QHEI. It can also help later samples identify sampling sites and determine whether changes have occurred. The level of detail of the drawings will likely vary with the objective. For example, sites assessed for 401 purposes should have as much detail as possible to help in later decisions of habitat limitations or high potential. Two or three cross-sections of the stream can provide useful information on the stream bank, stream bottom, stream channel, and floodplain characteristics.

QHEI Pool/Riffle Development Metric

Excellent Pool/Riffle Development:

Pools - > 1 m Deep
Glides - Only Transitional Habitats
Runs - > 0.5 m Deep
Riffles - Deep, Large Substrates
Morphology - All Habitats Easily Definable, Riffles Narrow and Deep, Pools Wide with Deep and Shallow Sections

Good Pool/Riffle Development:

Pools - > 0.7 m Deep
Glides - Mostly Transitional Habitats
Runs - Deep, but < 0.5 m
Riffles - Some Deep Areas, Large Substrates (At Least Large Gravels)
Morphology - All Habitats Fairly Well Definable, Riffles Typically Narrower Than Most Pools

Fair Pool/Riffle Development:

Pools - Show Some Depth Variation
Glides - Common
Runs - Typically Absent
Riffles - Poorly Defined, Shallow
Morphology - Habitat Types Not As Distinct, Glides Typically Difficult to
Separate From Pools and Riffles

Poor Pool/Riffle Development:

Pools - Shallow if Present
Glides - Predominant
Runs - Absent
Riffles - Absent, Or if Present Unstable and Shallow With Fine Substrates
Morphology - Mostly Glide Characteristics, Riffles Ephemeral if Present

Ohio EPA

Qualitative Habitat Evaluation Index and Use Assessment Field Sheet

QHEI Score: ☐

Stream & Location: ________________ *RM:* _ _ _._ *Date:* _ _/ _ _/ 06

________________ *Scorers Full Name & Affiliation:* ________________

River Code: _ _ _- _ _ _- _ _ _ *STORET #:* _ _ _ _ _ _ *Lat./ Long.:* (NAD 83 - decimal °) _ _ . _ _ _ _ _ /8_ . _ _ _ _ _ *Office verified location* ☐

1] *SUBSTRATE*

Check *ONLY* **Two** substrate *TYPE BOXES*; estimate % or note every type present

BEST TYPES	POOL	RIFFLE	OTHER TYPES	POOL	RIFFLE
☐ ☐ BLDR /SLABS [10]	____	____	☐ ☐ HARDPAN [4]	____	____
☐ ☐ BOULDER [9]	____	____	☐ ☐ DETRITUS [3]	____	____
☐ ☐ COBBLE [8]	____	____	☐ ☐ MUCK [2]	____	____
☐ ☐ GRAVEL [7]	____	____	☐ ☐ SILT [2]	____	____
☐ ☐ SAND [6]	____	____	☐ ☐ ARTIFICIAL [0]	____	____
☐ ☐ BEDROCK [5]	____	____	(Score natural substrates; ignore sludge from point-sources)		

NUMBER OF BEST TYPES: ☐ 4 or more [2] ☐ 3 or less [0]

Comments

Check ONE (*Or 2 & average*)

ORIGIN	QUALITY
☐ LIMESTONE [1]	SILT: ☐ HEAVY [-2]
☐ TILLS [1]	☐ MODERATE [-1]
☐ WETLANDS [0]	☐ NORMAL [0]
☐ HARDPAN [0]	☐ FREE [1]
☐ SANDSTONE [0]	EMBEDDEDNESS: ☐ EXTENSIVE [-2]
☐ RIP/RAP [0]	☐ MODERATE [-1]
☐ LACUSTURINE [0]	☐ NORMAL [0]
☐ SHALE [-1]	☐ NONE [1]
☐ COAL FINES [-2]	

Substrate ☐ *Maximum 20*

2] *INSTREAM COVER*

Indicate presence 0 to 3: **0**-Absent; **1**-Very small amounts or if more common of marginal quality; **2**-Moderate amounts, but not of highest quality or in small amounts of highest quality; **3**-Highest quality in moderate or greater amounts (e.g., very large boulders in deep or fast water, large diameter log that is stable, well developed rootwad in deep / fast water, or deep, well-defined, functional pools.

____ UNDERCUT BANKS [1]	____ POOLS > 70cm [2]	____ OXBOWS, BACKWATERS [1]
____ OVERHANGING VEGETATION [1]	____ ROOTWADS [1]	____ AQUATIC MACROPHYTES [1]
____ SHALLOWS (IN SLOW WATER) [1]	____ BOULDERS [1]	____ LOGS OR WOODY DEBRIS [1]
____ ROOTMATS [1]		

AMOUNT

Check ONE (*Or 2 & average*)

- ☐ EXTENSIVE >75% [11]
- ☐ MODERATE 25-75% [7]
- ☐ SPARSE 5-<25% [3]
- ☐ NEARLY ABSENT <5% [1]

Comments

Cover ☐ *Maximum 20*

3] *CHANNEL MORPHOLOGY*

Check ONE in each category (*Or 2 & average*)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY
☐ HIGH [4]	☐ EXCELLENT [7]	☐ NONE [6]	☐ HIGH [3]
☐ MODERATE [3]	☐ GOOD [5]	☐ RECOVERED [4]	☐ MODERATE [2]
☐ LOW [2]	☐ FAIR [3]	☐ RECOVERING [3]	☐ LOW [1]
☐ NONE [1]	☐ POOR [1]	☐ RECENT OR NO RECOVERY [1]	

Comments

Channel ☐ *Maximum 20*

4] *BANK EROSION AND RIPARIAN ZONE*

Check **ONE** in each category for *EACH BANK* (*Or 2 per bank & average*)

River right looking downstream

EROSION (L R)	RIPARIAN WIDTH (L R)	FLOOD PLAIN QUALITY (L R)	(L R)
☐ ☐ NONE / LITTLE [3]	☐ ☐ WIDE > 50m [4]	☐ ☐ FOREST, SWAMP [3]	☐ ☐ CONSERVATION TILLAGE [1]
☐ ☐ MODERATE [2]	☐ ☐ MODERATE 10-50m [3]	☐ ☐ SHRUB OR OLD FIELD [2]	☐ ☐ URBAN OR INDUSTRIAL [0]
☐ ☐ HEAVY / SEVERE [1]	☐ ☐ NARROW 5-10m [2]	☐ ☐ RESIDENTIAL, PARK, NEW FIELD [1]	☐ ☐ MINING / CONSTRUCTION [0]
	☐ ☐ VERY NARROW < 5m [1]	☐ ☐ FENCED PASTURE [1]	*Indicate predominant land use(s) past 100m riparian.*
	☐ ☐ NONE [0]	☐ ☐ OPEN PASTURE, ROWCROP [0]	

Comments

Riparian ☐ *Maximum 10*

5] *POOL / GLIDE AND RIFFLE / RUN QUALITY*

MAXIMUM DEPTH	CHANNEL WIDTH	CURRENT VELOCITY	
Check **ONE** (*ONLY!*)	Check ONE (*Or 2 & average*)	Check ALL that apply	
☐ > 1m [6]	☐ POOL WIDTH > RIFFLE WIDTH [2]	☐ TORRENTIAL [-1]	☐ SLOW [1]
☐ 0.7-<1m [4]	☐ POOL WIDTH = RIFFLE WIDTH [1]	☐ VERY FAST [1]	☐ INTERSTITIAL [-1]
☐ 0.4-<0.7m [2]	☐ POOL WIDTH > RIFFLE WIDTH [0]	☐ FAST [1]	☐ INTERMITTENT [-2]
☐ 0.2-<0.4m [1]		☐ MODERATE [1]	☐ EDDIES [1]
☐ < 0.2m [0]		*Indicate for reach - pools and riffles.*	

Recreation Potential
Primary Contact
Secondary Contact
(circle one and comment on back)

Comments

Pool / Current ☐ *Maximum 12*

Indicate for functional riffles; Best areas must be large enough to support a population of riffle-obligate species: Check ONE (*Or 2 & average*).

☐ **NO RIFFLE [metric=0]**

RIFFLE DEPTH	RUN DEPTH	RIFFLE / RUN SUBSTRATE	RIFFLE / RUN EMBEDDEDNESS
☐ BEST AREAS > 10cm [2]	☐ MAXIMUM > 50cm [2]	☐ STABLE (e.g., Cobble, Boulder) [2]	☐ NONE [2]
☐ BEST AREAS 5-10cm [1]	☐ MAXIMUM < 50cm [1]	☐ MOD. STABLE (e.g., Large Gravel) [1]	☐ LOW [1]
☐ BEST AREAS < 5cm [metric=0]		☐ UNSTABLE (e.g., Fine Gravel, Sand) [0]	☐ MODERATE [0]
			☐ EXTENSIVE [-1]

Comments

Riffle / Run ☐ *Maximum 8*

6] *GRADIENT* (ft/mi)

DRAINAGE AREA (mi²)

- ☐ VERY LOW - LOW [2-4]
- ☐ MODERATE [6-10]
- ☐ HIGH - VERY HIGH [10-6]

%POOL: ☐ **%GLIDE:** ☐

%RUN: ☐ **%RIFFLE:** ☐

Gradient ☐ *Maximum 10*

A] SAMPLED REACH
Check ALL that apply

Comment RE: Reach consistency/ Is reach typical of steam?, *Recreation/* Observed - Inferred, *Other/* Sampling observations, Concerns, Access directions, etc.

METHOD
- ☐ BOAT
- ☐ WADE
- ☐ L. LINE
- ☐ OTHER

STAGE
1st -sample pass- 2nd
- ☐ HIGH ☐
- ☐ UP ☐
- ☐ NORMAL ☐
- ☐ LOW ☐
- ☐ DRY ☐

DISTANCE
- ☐ 0.5 Km
- ☐ 0.2 Km
- ☐ 0.15 Km
- ☐ 0.12 Km
- ☐ OTHER

______ meters

CLARITY
1st --sample pass-- 2nd
- ☐ < 20 cm ☐
- ☐ 20-<40 cm ☐
- ☐ 40-70 cm ☐
- ☐ > 70 cm/ CTB ☐
- ☐ SECCHI DEPTH ☐

pass 1st ______ cm
pass 2nd ______ cm

CANOPY
- ☐ > 85%- OPEN
- ☐ 55%-<85%
- ☐ 30%-<55%
- ☐ 10%-<30%
- ☐ <10%- CLOSED

B] AESTHETICS
- ☐ NUISANCE ALGAE
- ☐ INVASIVE MACROPHYTES
- ☐ EXCESS TURBIDITY
- ☐ DISCOLORATION
- ☐ FOAM / SCUM
- ☐ OIL SHEEN
- ☐ TRASH / LITTER
- ☐ NUISANCE ODOR
- ☐ SLUDGE DEPOSITS
- ☐ CSOs/SSOs/OUTFALLS

C] RECREATION
AREA DEPTH
POOL: ☐ >100ft^2 ☐ >3ft

D] MAINTENANCE

Circle some & *COMMENT*

PUBLIC / PRIVATE / BOTH / NA
ACTIVE / HISTORIC / BOTH / NA
YOUNG-SUCCESSION-OLD
SPRAY / SNAG / REMOVED
MODIFIED / DIPPED OUT / NA
LEVEED / ONE SIDED
RELOCATED / CUTOFFS
MOVING-BEDLOAD-STABLE
ARMOURED / SLUMPS
ISLANDS / SCOURED
IMPOUNDED / DESICCATED
FLOOD CONTROL / DRAINAGE

E] ISSUES

WWTP / CSO / NPDES / INDUSTRY
HARDENED / URBAN / DIRT&GRIME
CONTAMINATED / LANDFILL
BMPs-CONSTRUCTION-SEDIMENT
LOGGING / IRRIGATION / COOLING
BANK / EROSION / SURFACE
FALSE BANK / MANURE / LAGOON
WASH H_20 / TILE / H_20 TABLE
ACID / MINE / QUARRY / FLOW
NATURAL / WETLAND / STAGNANT
PARK / GOLF / LAWN / HOME
ATMOSPHERE / DATA PAUCITY

F] MEASUREMENTS
- $\bar{x}$ width
- $\bar{x}$ depth
- max. depth
- $\bar{x}$ bankfull width
- bankfull $\bar{x}$ depth
- W/D ratio
- bankfull max. depth
- floodprone x^2 width
- entrench. ratio

Legacy Tree:

Stream Drawing:

References

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Appendix C
Physical Habitat Sampling Methodology

PHYSICAL HABITAT AND WATER CHEMISTRY ASSESSMENT PROTOCOL FOR WADEABLE STREAM MONITORING SITES

I. PURPOSE

To describe the methods used by the Minnesota Pollution Control Agency's (MPCA) Biological Monitoring Program to collect physical habitat and water chemistry information at stream monitoring sites for the purpose of assessing water quality and developing biological criteria.

II. SCOPE/LIMITATIONS

This procedure applies to all wadeable monitoring sites for which an integrated assessment of water quality is to be conducted. An integrated assessment involves the collection of biological (fish and macroinvertebrate communities), physical habitat, and chemical information to assess stream condition.

III. GENERAL INFORMATION

Sites may be selected for assessment for a number of reasons including: 1) sites randomly selected for condition monitoring as part of the Environmental Monitoring and Assessment Program (EMAP), 2) sites selected for the development and calibration of biological criteria, and 3) sites selected to evaluate a suspected source of pollution. Although the reasons for monitoring a site vary, the physical habitat and water chemistry assessment protocols outlined in this document apply to all wadeable stream monitoring sites unless otherwise noted. For our purposes, wadeable sites constitute those that are sampled for fish utilizing a backpack electrofisher or stream electrofisher (see SOP--"***Fish Community Sampling Protocol for Stream Monitoring Sites***").

IV. REQUIREMENTS

A. Qualifications of crew leaders: The crew leader must be a professional aquatic biologist with a minimum of a Bachelor of Science degree in aquatic biology or closely related specialization. He or she must have a minimum of six months field experience in physical habitat sampling methodology. Field crew leaders should also possess excellent map reading skills and a demonstrated proficiency in the use of a GPS (Global Positioning System) receiver and orienteering compass.

B. Qualifications of field technicians/interns: A field technician/intern must have at least one year of college education and coursework in environmental and/or biological science.

C. General qualifications: All personnel conducting this procedure must have the ability to perform rigorous physical activity. It is often necessary to wade through streams and/or wetlands, canoe, or hike for long distances to reach a sampling site.

V. RESPONSIBILITIES

A. Field crew leader: Implement the procedures outlined in the action steps and ensure that the data generated meets the standards and objectives of the Biological Monitoring Program.

B. Technicians/interns: Implement the procedures outlined in the action steps, including maintenance and stocking of equipment, data collection and recording.

VI. QUALITY ASSURANCE AND QUALITY CONTROL

Compliance with this procedure will be maintained through annual internal reviews. Technical personnel will conduct periodic self-checks by comparing their results with other trained personnel. Calibration and maintenance of equipment will be conducted according to the guidelines specified in the manufacturer's manuals.

In addition to adhering to the specific requirements of this sampling protocol and any supplementary site specific procedures, the minimum QA/QC requirements for this activity are as follows:

A. Control of deviations: Deviation shall be sufficiently documented to allow repetition of the activity as performed.

B. QC samples: Ten percent of sites sampled in any given year are resampled as a means of determining sampling error and temporal variability.

C. Verification: The field crew leader will conduct periodic reviews of field personnel to ensure that technical personnel are following procedures in accordance with this SOP.

VII. TRAINING

A. All inexperienced personnel will receive instruction from a trainer designated by the program manager. Major revisions in this protocol require that all personnel be re-trained in the revised protocol by experienced personnel.

B. The field crew leader will provide instruction in the field and administer a field test to ensure personnel can execute this procedure.

VIII. ACTION STEPS

A. Equipment list: Verify that all necessary items are present before commencement of this procedure (Table 1).

B. Data collection method: The location and length of the sampling reach is determined during site reconnaissance (see SOP--"***Reconnaissance Procedures for Initial Visit to Stream Monitoring Sites***"). Sampling is conducted during daylight hours within the summer index period of mid-June through mid-September. Sampling should occur when streams are at or near base-flow. Water chemistry is sampled immediately prior to fish sampling. The physical habitat assessment is conducted after fish sampling, so as not to disturb the fish community.

Habitat within a station is quantified utilizing the transect-point method (modified from: Simonson, T.D., Lyons, J., and Kanehl, P.D. 1994. Guidelines for Evaluating Fish Habitat in Wisconsin Streams. Gen. Tech. Rep. NC-164. St. Paul, MN: U.S. Dept. of Agriculture, Forest Service, North Central Experiment Station. 36 p.). Thirteen transects are established within the reach and four equally spaced points plus the thalweg are located along each transect. Measurements or visual estimates are made to characterize key components of the physical habitat structure important in influencing stream ecology. Key components include: channel morphology, substrate, cover, and riparian condition.

Three data sheets are required for the physical habitat and water chemistry assessment. One copy of the **Station Features** and **Visit Summary** form is needed for each site. One copy of the **Transect** form is needed for each of the thirteen transects (or only seven copies if forms are doubled-sided). Copies of these forms are attached. Guidelines for filling out each data sheet are described in the following pages.

C. Station Features Data Sheet

This data sheet describes the length and location of the major morphological features within a sampling station (bends, pools, riffles, runs, log jams, islands, and beaver dams). The **Station Features** data is collected in conjunction with the **Transect** data as you proceed from the downstream end to the upstream end of the station. The variables on this data sheet are as follows:

1) *Field Number* – A seven-digit code that uniquely identifies the station. The first two digits identify the year of sampling, the second two identify the major river basin, and the last three are numerically assigned in sequential order (example: 02UM001).

2) *Date* – The date habitat sampling is conducted in month/day/year format (MM/DD/YY).

3) *Crew* – The personnel who collected the habitat data.

4) *Distance From Start* (column) – The distance from the downstream end of the station to the downstream end of each *stream feature*. Bends, log jams, and beaver dams are measured only to their midpoint because they are features that are located within one of the channel morphology types (i.e. riffle, run, or pool). Measure distances to the nearest tenth of a meter following the center of the stream channel. The first value is always "0" to indicate the *stream feature* at the beginning of the station. As you proceed upstream it is not necessary to continue to measure from the downstream end of the station, as each successive **Transect** data sheet has the distance of that transect from the downstream end of the station recorded. The last value in this column is the total length of the station.

5) *Stream Feature* (column) – Record the major morphological features encountered as you proceed upstream. If a cross-section of stream contains two or more channel morphology types (i.e. riffle, run, or pool) record the dominant type. Stream features recorded include:

   Riffles: Portions of the stream channel where water velocities are fast, water depths are relatively shallow, and substrates are typically coarse. Steeper stream gradient results in obvious surface turbulence. Areas of high gradient that are deep, fast, and turbulent are called **rapids**.

   Runs: Water velocities may be moderately fast to slow but the water surface typically appears smooth with little or no surface turbulence. Generally, runs are deeper than a riffle and shallower than a pool. Runs with very slow water velocities are sometimes called **glides**. For our purposes, if the channel type is not considered a riffle or pool it is defined as a run.

   Pools: Water is slow and generally deeper than a riffle or run. Water surface is smooth, no turbulence. A general rule that can be used to distinguish a pool is if two or more of the following conditions apply; the stream channel is wider, deeper, or slower than average.

   Bends: A change in the direction of the stream channel of at least 60 degrees.

   Islands: Areas of land within the stream channel that is surrounded on all sides by water and is dry even when the stream is experiencing bankfull flow. Areas with nearly all of the stream's flow on one side and just a trickle of water on the other are not considered islands. Islands usually contain vegetation. **Bars**, channel features below the bankfull flow level that are dry during baseflow conditions, are not recorded.

   Log Jams: Woody material that is of sufficient size to appreciably alter the direction of flow or change the morphology within the stream channel. Large log jams can be similar in effect and appearance to beaver dams.

   Beaver Dams: Structures constructed by beavers that span the entire stream channel and block flow. Beaver dams consist of sticks and mud, but older dams may be overgrown with vegetation.

   Other noteworthy features include: **bridges**, **culverts**, **dams**, and **tributaries**. The last feature noted in this column is the upstream **end of the reach**.

6) *Length* (column) – The length, measured to the nearest tenth of a meter, of each *stream feature* encountered within the reach. The length of bends, log jams, and beaver dams are not recorded. It is not necessary to complete this column while in the field as this information is derived from the *Distance from start* and *Stream feature* columns.

7) *Distance Between Bends* – The distance (m) between successive bends contained within the station. The first row is the distance between the mid-point of the first and second bend. The second row is the distance between the second and third, and so forth. These values can be derived using the information contained in the columns *Distance from start* and *Stream feature*. The "sum" and "mean" rows summarize all the distances between bends within the station.

8) *Distance Between Riffles* – The distance (m) between successive riffles contained within the station. The first row is the distance between the upstream end of the first riffle and the downstream end of the next riffle upstream, and so forth. Distances can be derived using the *Distance from start* and *Stream feature* columns. The “sum” and “mean” rows summarize these distances.

9) *Length of Individual Riffles, Pools, and Runs* – The individual length (m) of each riffle, pool, or run within the station, which can be derived using the *Stream feature* and *Length* columns. The sum of their lengths is also recorded here.

D. Transect Data Sheet

Record the data generated from each of the thirteen transects on this data sheet. One data sheet is needed for each transect. To determine the placement of each of the thirteen transects within the station divide the station length (determined during reconnaissance) by thirteen, this number is the *transect spacing* or distance between transects. The first transect is located one half of the transect spacing distance from the downstream end of the station. Each subsequent transect is then the distance of one transect spacing from the previous transect. All numbers are rounded to the nearest half meter.

For example, if the station length is 150 m, 150 ÷ 13 = 11.5 (equals the transect spacing). The first transect would then be located a distance of 6 m from the downstream end of the station, 11.5 ÷ 2 = 5.75 (equals 6 rounded to the nearest half meter). The second transect would then be located a distance of 17.5 m from the downstream end of the station, 6 + 11.5 = 17.5, and so forth for subsequent transects.

Each transect consists of several measurements or visual estimates, made within 0.3 m x 0.3 m quadrates at set intervals, or along the transect line perpendicular to the stream channel. The variables on this data sheet are as follows:

D.1. Location Information

1) *Field Number* – Same as for **Stream Features** data sheet.

2) *Date* – Same as for **Stream Features** data sheet.

3) *Transect Number* – The number (1-13) of the current transect as you proceed upstream. The downstream most transect is number one, the next transect upstream is two, and so on.

4) *Crew* – Same as for **Stream Features** data sheet.

5) *Distance from Start* – The distance from the downstream end of the station to the current transect following the center of the stream channel, rounded to the nearest half meter.

6) *Stream Width* – The wetted width of the stream channel at the transect, measured to the nearest tenth of a meter. Exposed bars and boulders are included in the wetted width of the stream channel, but islands are not. Backwaters not in contact with the stream at the transect are also excluded. If a channel is split by an island(s), the wetted widths of each side channel should be combined so that a single number is recorded in *stream width*. In low gradient streams the wetted width is the defined portion of the stream channel, it does not include adjacent wetlands and areas of emergent vegetation.

7) *Channel Type* – Circle the predominant channel type at the transect. See the **Station Features** section for riffle, pool, and run definitions.

D.2. Transect Point Measurements: At each transect, measurements or visual estimates are made at five points along the transect. Variables quantified include: *water depth, depth of fines and water, embeddedness, substrate, percent algae, and percent macrophytes*. Four points are equally spaced across the stream channel and the fifth point is the thalweg, or deepest point along the transect line. Divide the *stream width* at the transect by five to determine the 1/5, 2/5, 3/5, and 4/5 locations across the wetted width of the stream channel. Measurements are made at each of these four locations moving from the right bank to the left bank along the transect. The right stream bank is on the right as you are facing downstream. For example, if the stream is 10 m wide, measurements are taken at the thalweg and along the transect at 2.0, 4.0, 6.0, and 8.0 m from the right bank. In some instances, the thalweg will occur at the same location as one of the four other points, in which case their measurement values will be the same.

1) *Water Depth* – The depth of the stream channel at each transect point. Measure the vertical distance of the water column from the streambed to the water surface to the nearest centimeter with a calibrated wading rod or meter stick. If the water depth is over 120 cm, record as >120 cm.

2) *Depth of Fines and Water* – The water depth plus the depth of fine sediments at each transect point. Fine sediments are those that are less than 2.0 mm in diameter and generally consist of sand, silt, clay, or detritus. Without using the weight of your body, push a wading rod into the sediment as far as possible, measure to the water surface to the nearest centimeter. This measurement is later converted to depth of fines by subtracting *water depth*.

3) *Embeddedness of Coarse Substrates* – The extent to which coarse substrates are surrounded by or covered with fine sediments. Coarse substrates consist of gravel, rubble/cobble, and boulders. If the dominant substrate within the quadrate is coarse, embeddedness should be visually estimated to the nearest 25%. Estimate the average percent embeddeness of coarse substrates within the 0.3 m x 0.3 m quadrate centered on the channel position. An embeddedness rating of 0% corresponds to very little or no fine sediments surrounding coarse substrates. Course substrate material completely surrounded and covered with sediment is considered 100% embedded. If the dominant substrate within a quadrate is anything other than gravel, rubble/cobble, or boulder then the column should be left null.

4) *Dominant Substrate* – The predominant substrate type within each quadrate. Visually estimate which substrate type is predominant within each quadrate and place a check mark in the appropriate column. If the stream bottom cannot be seen, use your hands and feet to determine the dominant substrate type. Choose from the following substrate types:

   Bedrock: A solid slab of rock, > 4000 mm in length (larger than a car).

   Boulder: Large rocks ranging from 250 mm to 4000 mm in diameter (basketball to car size).

   Rubble/Cobble: Rocks ranging in diameter from 64 mm to 250 mm (tennisball to basketball).

   Gravel: Rocks varying in diameter from 2 mm to 64 mm (BB to tennisball).

   Sand: Inorganic material that is visible as particles and feels gritty between the fingers. 0.06 mm to 2.0 mm in size.

   Silt: Fine inorganic material that is typically dark brown in color. Feels greasy between fingers and does not retain its shape when compacted into a ball. A person's weight will not be supported if the stream bottom consists of silt.

   Clay: Very fine inorganic material. Individual particles are not visible or are barely visible to the naked eye. Will support a person's weight and retains its shape when compacted.

   Detritus: Decaying organic material such as macrophytes, leaves, finer woody debris, etc. that may appear similar to silt when very fine.

   Other: Any substrate type not listed above, specify the type. Possibilities could include woody debris, culverts, tires, or mussel beds.

5) *Algae (%)* – Visually estimate the amount of algae within the quadrate, to the nearest 5 %. Algae can either be attached to the substrate in the form of a mat or crust; or filamentous algae, which forms dense mats of long, hair-like strands and is usually green in color.

6) *Macrophytes (%)* – Visually estimate the amount of aquatic vegetation within the quadrate, to the nearest 5 %. Aquatic macrophytes can be either submergent or emergent and are defined under *cover for fish.*

D.3. Cover and Land Use Characteristics

1) *Cover for Fish (%)* – The amount of cover or shelter available for fish along the transect. Visually estimate the percentage (nearest 5 %) occupied by each cover type along the transect within a 0.3 m band centered on the transect line. If a cover type is absent, enter a zero. In order to be considered cover, the water depth must be at least 10 cm where the cover type occurs. Cover for fish consists of objects or features dense enough to provide complete or partial shelter from the stream current or concealment from predators or prey.

   Undercut Banks: Stream banks where the stream channel has cut underneath the bank. The bank could overhang the water surface when water levels are low. The undercut bank must overhang (horizontally) the wetted stream channel a minimum of 15 cm and the bottom of the bank must be no more than 15 cm above the water level in order to be considered cover for fish.

   Overhanging Vegetation: Terrestrial vegetation overhanging the wetted stream channel that meets the same criteria for cover as undercut banks.

   Woody Debris: Logs, branches, or aggregations of smaller pieces of wood in contact with or submerged in water.

   Boulders: Large rocks as described under *Substrate.*

   Submergent Macrophytes: Vascular plants that have all of their biomass (except flowers) at or below the surface of the water. Examples include *Vallisneria*, *Elodea*, *Potamogeton*, *Nymphaea* and *Ceratophyllum*.

   Emergent Macrophytes: Vascular plants that typically have a significant portion of their biomass above the water surface. Examples include *Typha, Scirpus,* and *Zizania*.

   Other Debris: Additional objects that meet the criteria of cover, typically of human origin. Examples would include filamentous algae, culverts, docks, tires, discarded appliances, etc. Specify the type.

2) *Bank Erosion* – The amount of the stream bank that is actively eroding. To be considered as erosion, the bank must be actively eroding through break down, soil sloughing, or false banks. False banks are natural banks that have been cut back, usually by livestock trampling. For each bank, along the transect line, use a wading rod or measuring tape to quantify the length (nearest 0.1 m) of bare soil. Measure the amount of exposed soil from the waters edge to the top of the stream bank, up to a maximum of 5 m. If there is no bare soil, record 0.

3) *Riparian Land Use* – The predominant land use within the riparian zone. For each bank, extending along the transect line, visually estimate the predominant land use within 30 m of the waters edge and place a check mark in the corresponding column. Repeat this same procedure for the riparian zone 30 – 100 m from the waters edge. Land use categories are as follows:

   Cropland: Land that is cultivated with crops for forage or cover. Includes those areas under intensive cropping or rotation, or that are regularly mowed for hay.

   Pasture: Land that is regularly grazed by livestock.

   Barnyard: Land associated with farmsteads and the adjoining farmyard area. Includes grain storage facilities, barns, farmhouses, and feedlots (areas used to confine and feed high densities of livestock).

   Developed: Land that has been modified (rural or urban) for commercial, industrial, or residential use. Includes commercial buildings/structures, parking lots, all roads, railroads, and power utilities. Also includes residential buildings, lawns, parks, golf courses, ball fields, etc. Specify the type in the space provided.

Exposed Rock: Natural areas of rock outcrops that lack appreciable soil development or vegetative cover.

Meadow: Land dominated by grasses and forbs with little woody vegetation, which is not subject to regular mowing or grazing.

Shrub: Land consisting primarily of woody vegetation less than 3 m in height. Typical shrubs include alder, dogwood, and willows.

Woodland: Land dominated by deciduous or coniferous tree species, generally taller than 3 m.

Wetland: Low-lying areas that are saturated or inundated with water frequently or for considerable periods of time on an annual basis. Wetlands include bogs, marshes, and swamps and contain vegetation adapted for life in saturated conditions.

Other: If a land use category other than one of those listed above is predominant, specify the type.

4) *Riparian Buffer Width* – The amount of contiguous undisturbed land use within a 10 m buffer zone. For each bank, starting from the waters edge and extending out along the transect line 10 m, measure the width (nearest meter) of contiguous land that is considered undisturbed. Meadow, shrub, woodland, wetland, and exposed rock are considered undisturbed. If no undisturbed land uses are directly adjacent to the stream, then the riparian buffer width is 0 m. If more than 10 m is present, record it as >10 m.

5) *Canopy/Shading* – A measure of overhead canopy cover that is shading the stream channel. A concave spherical crown densiometer is utilized for this measurement. The densiometer must be taped as shown in Figure 1 to limit the number of grid intersections to 17. Hold the densiometer at elbow level in front of you, making sure the instrument is level using the bubble level, count and record the number (0 to 17) of grid intersections that have vegetation covering them. If the reflection of a tree, branch, or leaf overlies any of the intersection points, that particular intersection is counted as having cover. Perform this measurement from the center of the stream channel along the transect line in each of four directions; facing upstream, downstream, towards the left bank, and towards the right bank. In addition, perform the measurement at the wetted edge of both the left and right banks facing the stream bank.

E. Visit Summary Data Sheet

This data sheet contains location information, water chemistry data, and channel characteristics of the station. Some of the data is derived from maps or from the other data sheets. Record the following information on this data sheet:

E.1. <u>Location Information</u>

1) *Field Number* – Same as for **Station Features** data sheet.

2) *Date* – Same as for **Station Features** data sheet.

3) *Stream Name* – The name of the stream as shown on the most recent USGS 7.5" topographic map. Include all parts of the name (i.e. "North Branch", "Creek", "River", "Co. Ditch", etc.).

4) *Location* – A general description of where the sampling station is located. Usually includes the nearest road crossing and town. For example, "0.5 mi. downstream of C.R. 30, 4 mi. SW of Northome".

5) *County* – The county in which the station is located.

6) *Visit Result* – The result of the sampling trip, typically as it pertains to fish collection. Circle only one of the available choices. A visit or sampling trip is considered "reportable" when sampling is conducted for the first time at a station and no problems are encountered that would render the data questionable. If subsequent sampling trips are made to the same station and no sampling problems occur, the *visit result* is considered a "replicate". Circle "other", and explain in the space provided, in the event that the data generated is

questionable or unsuitable for use. Reasons might include equipment problems, poor sampling efficiency, excessive water velocity, poor fish taxis, or other sampling deficiencies.

7) *GPS File Name* – The unique identifier of a rover file assigned by the GPS unit. If a GPS file is taken (to record the location of a sampling site), the unit will assign an eight-digit code consisting of a file prefix, date stamp, and time stamp that uniquely identifies that file. In most instances, it is not necessary to take a GPS file during the sampling visit because sampling sites are located and flagged during site reconnaissance. However, circumstances may occur that necessitate a file be taken during the sampling visit. These include but are not limited to: original reconnaissance file unreliable or inaccurate, flagging cannot be located, initial site location determined to be incorrect, and GPS file not obtained during initial site reconnaissance. If sampling and initial site reconnaissance are conducted at the same time, the GPS information should be recorded as part of the reconnaissance protocol. Consult the GPS user's manual and SOP--"***Reconnaissance Procedures for Initial Site Visit to Stream Monitoring Sites***" for additional guidance on GPS operation and protocol.

8) *Type of GPS Fix* – If a GPS file is taken during the sampling visit, indicate the position mode (3D or 2D) in which the GPS file was recorded.

9) *PDOP* – If a GPS file is taken during the sampling visit, record the approximate Position Dilution of Precision (PDOP) value that was observed while the GPS file was being recorded.

10) *Data Source* – The source or entity that generated the data. For Minnesota Pollution Control Agency (MPCA) staff within the Biological Monitoring Unit this field should be recorded as "MPCA".

11) *Project* – The specific project that the data collection effort is associated with. Some possibilities include EMAP, biocriteria development, problem investigation, and longitudinal survey.

E.2. <u>Field Water Chemistry</u>: Water chemistry parameters should be sampled immediately prior to fish sampling. All water chemistry parameters are measured from the same general location at a representative stream cross-section within the sampling reach. Samples are taken at a point that is judged to represent the water quality of the total instantaneous flow at the cross-section. Avoid sampling areas that are poorly mixed, contain springs, or are upstream of or immediately adjacent to tributaries within the sampling reach. Water chemistry measurements and water samples are taken at an intermediate depth in the water column without disturbing substrate materials or collecting floating materials and constituents from the water surface. Refer to the manufacturer's owners manual for guidance concerning the calibration and operation of water quality meters.

1) *Time* – The time of day (24-hour clock) that field water chemistry parameters are measured.

2) *Air Temp* – The ambient air temperature (ºC) at the time of sampling, measure to the nearest degree with a dry thermometer.

3) *Water Temp* – The water temperature (ºC) of the station at the time of sampling, measure to the nearest tenth of a degree with a thermometer or water quality meter.

4) *Conductivity* – Temperature compensated conductivity, or *specific conductance*, is the parameter actually being determined and is a measure of the ability of water to carry an electrical current. Consult your conductivity meter's manual for guidance measuring specific conductance (measured in µmhos/cm) compensated for temperature to 25 °C.

5) *Dissolved Oxygen* – The amount of oxygen present in a water sample, expressed as milligrams of oxygen per liter of water (mg/L). Two water samples should be taken and measured for dissolved oxygen concentrations using a DO meter or the Winkler Titration Method.

6) *Turbidity* – The light scattering property associated with suspended particles in the water, measured with a turbidimeter in nephelometric turbidity units (NTUs). A turbid sample will appear cloudy. A water sample is taken in a 500-ml plastic bottle rinsed with stream water three times. Due to the sensitivity of the turbidimeter

to road dust and other conditions encountered while in the field, place the sample on wet ice until days end and measure turbidity in a more suitable environment (office or hotel room).

7) *pH* – A measure of the negative log of the hydrogen ion [H^+] concentration in the water. Pure water has a pH of 7.00 and is considered neutral. Measure pH utilizing a temperature compensating pH meter.

8) *Stream Flow* – Also known as discharge, it is the volume of water moving downstream per unit time, and is the product of current velocity and the dimensions of the stream channel. Measure the instantaneous flow rate (cubic meters/second) at a suitable stream cross-section using a current meter. Detailed guidelines for determining stream flow at a station are available from the USGS.

9) *Transparency* – A measure of water clarity, an indicator of the water's ability to transmit light. Stream transparency serves as an indirect measure of the amount of dissolved and suspended materials present. Measure (nearest cm) with a transparency tube, a clear tube 60 cm in length with a secci-type disk at the bottom.

10) *Water Level* – An estimation of water level as it relates to summer base flow expectations. Check the appropriate category and measure the vertical distance (nearest 0.1 m) above or below the normal water line. In most streams, the "normal" water level can be determined with relative ease by observing channel characteristics.

E.3 Lab Water Chemistry: Water samples taken for laboratory analyses typically include total phosphorus (P), total suspended solids (TSS), ammonia nitrogen (NH^3+NH^4), and nitrite-nitrate (NO^2+NO^3). Additional parameters may be measured in special circumstances. Samples taken for laboratory analyses are subject to the same general guidelines concerning sampling location and time as outlined above under *field water chemistry*. Sterilized sample bottles are obtained from the Minnesota Department of Health. Before collecting samples, label the containers with the *date* and *field number* with a waterproof pen or pencil. Collect a 250 ml nutrients sample and a one-liter general chemistry sample for laboratory analysis. The bottles should be lowered mouth down to an intermediate depth and then turned upstream to collect the sample, the Dept. of Health does not recommend rinsing their sample bottles. Immediately after sample collection, 5 ml of 10% sulfuric acid preservative solution is added to the nutrients sample. Both sample bottles must be stored at 4˚C and shipped to the Dept. of Health Water Lab within the minimum holding times.

1) *Collection Time (field sample)* – The time of day (24-hour clock) that water samples for laboratory analysis are collected.

2) *Collection Time (field duplicate)* – A field duplicate is a second sample taken immediately following an initial sample in the same manner and location. Duplicate samples are taken at 10% of all sampling sites for quality assurance and control (QA/QC) purposes. If a duplicate water sample is taken, record the time (24 hour clock) here.

E.4 Channel Characteristics

1) *Transect Spacing* – Document the distance (m) that was used to space transects from one another (see **Transect** data sheet section).

2) *Station Length* – The actual length (m) of the sampling reach as determined during the physical habitat assessment. The station length should be recorded directly from the **Stream Features** data sheet, as measured from the start of the station to the upstream end of the reach, rounded to the nearest meter. This measurement of station length is considered more accurate than the measurement conducted during the initial site reconnaissance.

3) *Channel Condition* – The condition of the stream channel at the station, check the category that best describes the state of the stream channel: natural channel, old channelization, recent channelization, or concrete channel.

4) *Mean Distance Between Bends* – The average distance (m) between successive bends contained within the station. Obtained from the **Station Features** data sheet.

5) *Mean Distance Between Riffles* – The average distance (m) between successive riffles contained within the station. Obtained from the **Station Features** data sheet

6) *Total Length of Riffles, Pools, and Runs* – The sum of the lengths (m) for all riffles, pools, and runs contained within the station. Obtained from the **Station Features** data sheet.

7) *Total Number of Riffles, Pools, Runs, Bends, and Log Jams* – The number of each of these stream features contained within the station. Obtained from the **Station Features** data sheet.

E.5. Comments/Notes: Record any additional information about the station in the space provided.

Table 1. Equipment List – This table identifies all equipment needed in the field in order to implement the sampling protocol as described.

Physical Habitat Sampling

Measuring tape (m) – for measuring distances

Wading rod – for measuring depths and short distances

Spherical crown densiometer (concave) – to measure canopy cover

Water Chemistry Sampling

Thermometer – for measuring air and water temperature

Conductivity meter – for measuring conductivity

Turbidimeter – for measuring turbidity

D.O. meter or Winkler-Titration kit – for measuring dissolved oxygen

pH meter – for measuring pH

Current meter – for measuring stream discharge

Transparency tube – for measuring stream water transparency

1-L plastic bottle – to collect general chemistry sample for lab analysis

250-ml plastic bottle – to collect nutrients sample for lab analysis

500-ml plastic bottle – to collect turbidity sample

5-ml of 10% sulfuric acid – for preserving nutrients sample

Cooler and ice – for holding and preserving water samples

Miscellaneous

Clipboard – to store forms and record data

Forms – for recording data

Pencil – for filling out forms

GPS – to locate and document sampling location (if necessary)

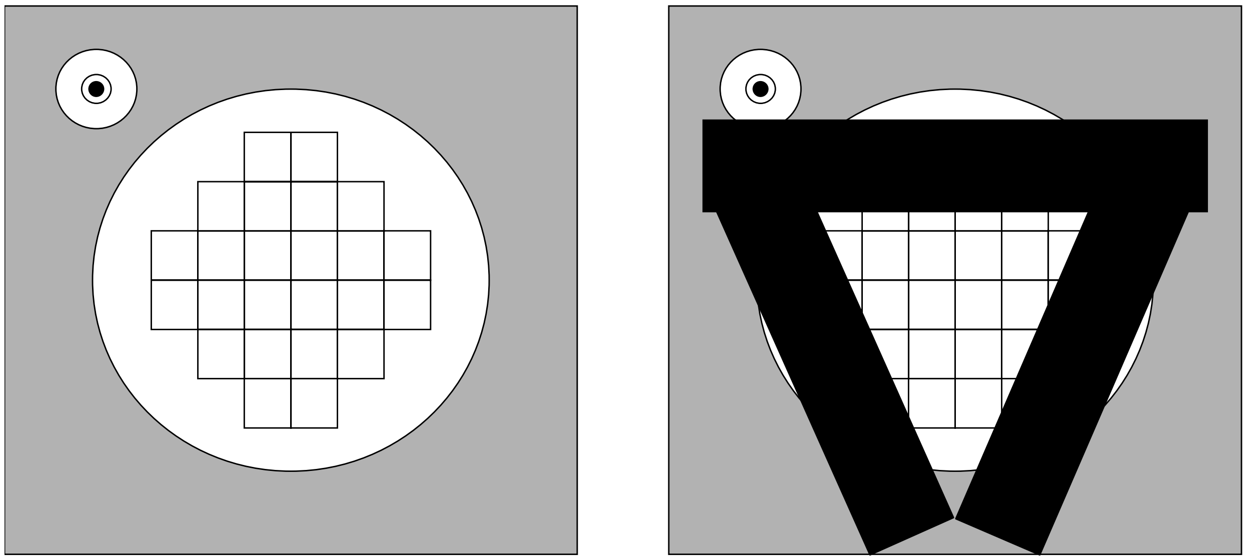

Figure 1. Illustration depicting how a spherical crown densiometer should be taped to limit the number of grid intersections to 17.

STATION FEATURES — MPCA

Field Number:_________________ Date(mm/dd/yy):_______________ Crew:___________________

DISTANCE FROM START (m)	STREAM FEATURE (Riffle, Pool, Run, Bend Log Jam, etc.) *	LENGTH (m)
0		

DISTANCE SUMMARY

Distance Between Bends(m):	Distance Between Riffles(m):
1st - 2nd:______	1st - 2nd:______
2nd - 3rd:______	2nd - 3rd:______
3rd - 4th:______	3rd - 4th:______
4th - 5th:______	4th - 5th:______
5th - 6th:______	5th - 6th:______
6th - 7th:______	6th - 7th:______
7th - 8th:______	7th - 8th:______
8th - 9th:______	8th - 9th:______
9th - 10th:______	9th - 10th:______
10th - 11th:______	10th - 11th:______
11th - 12th:______	11th - 12th:______
12th - 13th:______	12th - 13th:______
13th - 14th:______	13th - 14th:______
14th - 15th:______	14th - 15th:______
Sum:______	Sum:______
Mean:______	Mean:______

Length (m) Of Individual Riffles, Pools, And Runs:

1st Riffle:______	1st Pool:______	1st Run:______
2nd Riffle:______	2nd Pool:______	2nd Run:______
3rd Riffle:______	3rd Pool:______	3rd Run:______
4th Riffle:______	4th Pool:______	4th Run:______
5th Riffle:______	5th Pool:______	5th Run:______
6th Riffle:______	6th Pool:______	6th Run:______
7th Riffle:______	7th Pool:______	7th Run:______
8th Riffle:______	8th Pool:______	8th Run:______
9th Riffle:______	9th Pool:______	9th Run:______
10th Riffle:______	10th Pool:______	10th Run:______
11th Riffle:______	11th Pool:______	11th Run:______
12th Riffle:______	12th Pool:______	12th Run:______
13th Riffle:______	13th Pool:______	13th Run:______
14th Riffle:______	14th Pool:______	14th Run:______
15th Riffle:______	15th Pool:______	15th Run:______
Sum:______	Sum:______	Sum:______

* For riffles, runs, and pools note distance from start at beginning of feature. For bends, log jams, etc., note center-point.

(Revised Dec. 2002)

Station Features Continued:

DISTANCE FROM START (m)	STREAM FEATURE (Bend, Riffle, Pool, Run, Log Jam, etc.) *	LENGTH (m)
0		

TRANSECT **MPCA**

Field Number:______________________ Date (mm/dd/yy):________________ Transect Number (1-13):________

Crew:____ Distance from Start (m):____________

Stream Width (m):_______________________ Channel Type (circle one): Riffle Pool Run

Channel Position (fifths of wetted stream width and deepest point, 0 = rightbank *)	**1/5**	**2/5**	**3/5**	**4/5**	**Deep**
Water Depth (cm)					
Depth of Fines and Water (cm)					
Embeddedness of Coarse Substrates (nearest 25%)					

Check Dominant Substrate Type in Quadrate:

Channel Position (fifths of wetted stream width and deepest point, 0 = rightbank *)	**1/5**	**2/5**	**3/5**	**4/5**	**Deep**
Bedrock (solid slab)					
Boulder (basketball or bigger)					
Rubble/Cobble (tennis ball to basketball)					
Gravel (BB to tennis ball)					
Sand (gritty, visible, < BB)					
Silt					
Clay					
Detritus					
Other (specify)					

Note Amount Observed on Quadrate:

Channel Position (fifths of wetted stream width and deepest point, 0 = rightbank *)	**1/5**	**2/5**	**3/5**	**4/5**	**Deep**
Algae (attached & filamentous., nearest 5%)					
Macrophytes (nearest 5%)					

Cover for Fish: *Percent length of transect* ***(over at least 10 cm water depth)*** *with:*
___Undercut Banks ____Overhanging Vegetation ____Woody Debris ____Boulders
___Submergent Macrophytes ____Emergent Macrophytes ____Other (specify):______________________

Bank Erosion: *Length (nearest 0.1 m) of bare soil,* ***within 5 m of waters edge****, along transect:*
LEFT BANK *: __________(m) RIGHT BANK *: __________ (m)

Riparian Land Use: *Dominant land use* ***within 30 m of stream edge*** *(along transect):* ***(L / R) ****
___/___Cropland ___/___Pasture ___/___Barnyard ___/___Developed ___/___Exposed Rock
___/___Meadow ___/___Shrubs ___/___Woodland ___/___Wetland ___/___Other (specify):___________

Riparian Land Use: *Dominant land use* ***from 30 to 100 m of stream edge*** *(along transect):* ***(L / R) ****
___/___Cropland ___/___Pasture ___/___Barnyard ___/___Developed ___/___Exposed Rock
___/___Meadow ___/___Shrubs ___/___Woodland ___/___Wetland ___/___Other (specify):___________

Riparian Buffer Width: *Length (nearest meter) of undisturbed land use along transect,* ***within 10 m of stream:***
LEFT BANK *: __________(m) RIGHT BANK *: __________ (m)

Canopy/Shading (Densiometer reading, note #/17 that are shaded):

___Center Upstream ___Center Left ___Center Downstream ___Center Right ___Left Bank * ___Right Bank *

* Right Bank and Left Bank identified while facing downstream. (Revised Dec 2002)

VISIT SUMMARY MPCA

LOCATION INFORMATION ==

Field Number:___________ Date (mm/dd/yy):__________ Stream Name:_________________________

Location:____ County:_________________

Visit Result (circle one): Reportable - Replicate - Other (explain)___________________________

GPS File Name:_______________________ Type of GPS Fix: ☐ 2D ☐ 3D PDOP:__________
(only if GPS taken during visit)

Data Source:_______________________________ Project:_____________________________________

FIELD WATER CHEMISTRY ==

Time (24 hr clock):______________ Air Temp.(°C):_____________ Water Temp.(°C):_____________

Conductivity (umhos@25°C):___________________ Dissolved Oxygen (mg/l):___________________

Turbidity (ntu):_________________ pH:_______________ Stream Flow (m^3/s):________________

Transparency Tube (cm):______ Water Level: ☐ Normal ☐ Below______(m) ☐ Above______(m)

LAB WATER CHEMISTRY ==

Collection Time (field sample):_______________ Collection Time (field duplicate):_______________

CHANNEL CHARACTERISTICS ==

Transect Spacing (m):___________ Station Length (m) (from stream features form):______________

Channel Condition (check appropriate box):

☐ Natural Channel ☐ Old Channelization ☐ Recent Channelization ☐ Concrete Channel

Mean Distance Between Bends (m):____________ Mean Distance Between Riffles (m):____________

Total Length (Sum) of All (m): Riffles:_____________ Pools:_____________ Runs:_____________

Total Number of: Riffles:_______ Pools:_______ Runs:_______ Bends:_______ Log Jams:______

COMMENTS/NOTES: ____

____

____

(Revised Dec. 2002)

Appendix D
Macroinvertebrate Sampling in Wadeable Streams

7.17
STANDARD OPERATING PROCEDURES FOR THE COLLECTION OF A MACROINVERTEBRATE SAMPLE FROM WADEABLE RIVERS AND STREAMS

Summary

Benthic macroinvertebrates inhabit the sediment or live on the bottom substrates of streams. This group of organisms is an important component for measuring the overall biological condition of an aquatic community. Populations in the benthic assemblage respond to a wide array of stressors in different ways. By monitoring assemblage status it is possible to detect trends in ecological condition and often determine the type of stress that has affected a macroinvertebrate community (e.g., Klemm et al., 1990). Because many macroinvertebrates have life cycles of a year or more and are relatively immobile, the structure and function of the macroinvertebrate assemblage is a response to exposure of past or present conditions.

This benthic macroinvertebrate protocol is intended to evaluate the biological condition of wadeable streams in North Dakota for the purpose of detecting stresses on community structure and assessing the relative severity of these stresses. It is based on the updated Rapid Bioassessment Protocols (RBPs) and Wadeable Streams Assessment (WSA), both published by the U.S. Environmental Protection Agency (Barbour et al., 1999), and adopted for use by many states. The protocol's use of a D-frame kick net (Figure 7.17.1) for benthic macroinvertebrate collection is versatile for varying habitat type and is the preferred macroinvertebrate collecting method for streams with flowing water.

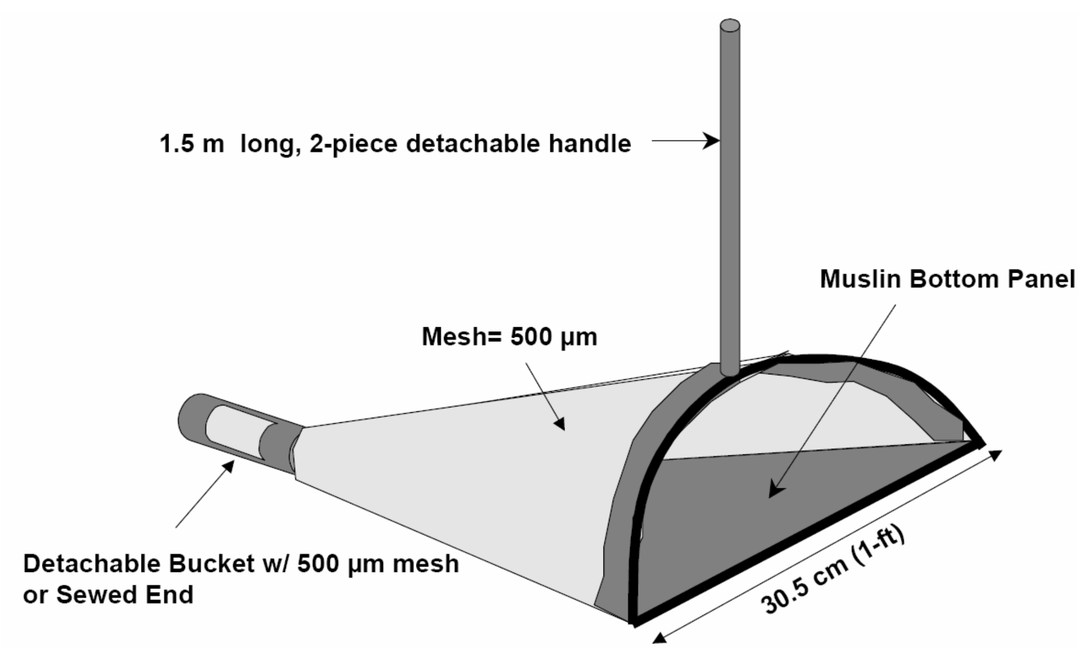

Figure 7.17.1. Modified D-frame Kick Net (Not drawn to scale)

Sampling Period

The index period for macroinvertebrate collection is July-September of each year. This index period will allow macroinvertebrate collections to be taken during normal, stable flow conditions each season.

Equipment and Supply Checklist

All supplies listed should be considered required unless otherwise noted. During the project planning phase, inventory and organize field equipment and supplies. To conduct activities efficiently, examine the list prior to leaving for a stream site.

Equipment List

√	ITEM	QTY
	Surveyor's rod, tape measure, or laser range finder	1
	Modified kick net (D-frame with 500 μm mesh) and 4-ft handle (Wildco #425-C50)	1
	Buckets, plastic, 8- to 10-qt capacity	2
	Hand sieve with 500 μm mesh openings	1
	Watchmakers' forceps	2
	Wash bottle, 1-L capacity labeled "STREAM WATER"	1
	Small spatula, spoon, or scoop to transfer sample	1
	Funnel, with large bore spout	1
	Sample jars, HDPE plastic with screw caps, 500-mL and 1-L capacity, suitable for use with ethanol	1 to 3
	95% Ethanol, in a proper container	2 gal
	Rubber gloves, heavy rubber	2 pr.
	Cooler (with suitable absorbent material) for transporting ethanol and samples	1
	Composite Benthic sample labels, with preprinted ID numbers (barcodes)	2
	Composite Benthic sample labels without preprinted ID numbers	4
	Blank labels on waterproof paper for inside of jars	3
	Sample collection form for site	1
	Clear mailing tape (strips or roll)	1 pkg.
	Pocket knife	1
	Scissors	1
	Pocket-sized field notebook (optional)	1
	Field operations and methods manual	1 copy
	Laminated sheets of procedure tables and/or quick reference guides for benthic macroinvertebrates	1 set
	Spare net(s) and/or spare bucket assembly for end of net	Optional
	Sieve-bottomed bucket, 500 μm mesh openings	Optional
	Soft (#2) lead pencils	
	Fine-tip indelible markers	

Procedures

Lay Out of the Sampling Reach

1. Use a surveyor's rod, tape measure, or laser range finder to determine the wetted width of the channel at 5 places of "typical" width within approximately 5 channel widths upstream and downstream from the X-site. Average the 5 readings together and round to the nearest 1 m. If the average width is <4 m, use 150 m as a minimum reach length. If the average width is >12.5 m, use 500 m as a maximum reach length. *For channels with "interrupted flow", estimate the width based on the unvegetated width of the channel (again, with a 150 m minimum and 500 m maximum).*

2. Check the condition of the stream about the X-site by having one team member go upstream and one downstream. Each person proceeds until they can see the stream to a distance of 20 times the average channel width (equal to one-half the sampling reach length) determined in Step 1.

3. Determine if the reach needs to be adjusted about the X-site due to confluences with higher order streams (downstream), a change to a lower order streams (upstream), impoundments (lakes, reservoirs, ponds), physical barriers (e.g., falls, cliffs), or because of access restrictions to a portion of the initially-determined sampling reach.

4. Starting at the X-site (or the new midpoint of the reach if it had to be adjusted as described in Step 3), measure a distance of 20 channel widths down one side of the stream using a GPS unit, laser rangefinder, or tape measure. Be careful not to "cut corners". Enter the channel to make measurements only when necessary to avoid disturbing the stream channel prior to sampling activities. This endpoint is the downstream end of the reach, and is flagged as Transect "A".

5. At Transect A, use the seconds display on a digital watch to select the initial sampling station for standard transect samples: 1-3="Left", 4-6="Center", 7-9=Right. Mark "L", "C", or "R" on the transect flagging; the 3 potential collection points are roughly equivalent to 25%, 50%, and 75% of the channel width, respectively.

6. Measure 1/10 of the required reach length upstream from transect A. Flag this spot as transect B. Assign the sampling station systematically after the first random selection (Figure 4-6 & Table 4-6).

7. Proceed upstream with the tape measure and flag the positions of 9 additional transects (labeled "C" through "K" as you move upstream) at intervals equal to 1/10 of the reach length. Continue to assign the sampling stations systematically.

Sample Collection

The transect sample design for collecting benthic macroinvertebrates is shown in Figure 7.17.2. This design was used in the Environmental Monitoring & Assessment Program (EMAP) - Western Pilot stream study in the western U.S., which provides continuity for nationwide assessments.

A sample is collected from **1 meter downstream** of each of eleven cross-section transects (Transects “A” through “K”) at an assigned area (Left, Center, or Right in the stream). The sampling point at Transect “A” is assigned at random using a die or other suitable means (e.g., digital watch). Once the first sampling point is determined, points at successive transects are assigned in order (Left, Center, Right). At transects assigned a “Center” sampling point where the stream width is between one and two net widths wide, pick either the “Left” or “Right” sampling point instead. If the stream is only one net wide at any transect, place the net across the entire stream width and consider the sampling point to be “Center”. If a sampling point is located in water that is too deep or otherwise unsafe to wade, select an alternate sampling point on that transect.

The procedure for sample collection at each transect is described below. For each sampling site, first establish that the majority of the river reach is wadeable. Next determine if the habitat is a “riffle/run” or a “pool/glide”. Any area where water current is not sufficient to extend the net is operationally defined as a pool/glide habitat. As sampling proceeds upstream from transect to transect, combine all samples into a bucket or similar container.

Do not fill out the collection form or labels until wadeablity is confirmed at the site and samples are collected.

1. At **1 m downstream** of each cross-section transect, beginning with Transect “A”, locate the assigned sampling point (Left, Center, or Right facing downstream) at 25%, 50%, and 75% of the wetted width, respectively. If a sample cannot be collected at the designated point because of deep water or unsafe conditions, relocate to another random point on the same transect.

2. Make sure that the D-frame net is securely tightened to the pole as the net may become twisted in a strong current, causing the loss of sample materials.

3. Determine if there is sufficient current in the area at the sampling point to fully extend the net. If so, classify the habitat as “riffle/run” and proceed to Step 4. If not, use the sampling procedure described for “pool/glide” habitats, Step 9.

   NOTE: If large rocks prevent the sampler from seating the net properly on the stream bottom, spend 30 seconds hand picking a sample from about 0.09 m^2 (1 ft^2) of substrate at the sampling point. For vegetation-choked sampling points, sweep the net through the vegetation within a 0.09 m^2 (1 ft^2) quadrat for 30 seconds. Place the contents of this hand-picked sample directly into the sampling container.

Riffle/Run Habitats:

4. With the net opening facing upstream, position the net quickly and securely on the stream bottom to eliminate gaps under the frame. Avoid large rocks that prevent the sampler from seating the net properly on the stream bottom.

   NOTE: If there is too little water to collect the sample with the D-frame net, randomly pick up 10 rocks from the riffle. Wash anything attached to the rocks (e.g. sand, insects, vegetation, etc.) into the closed or sieve bottomed bucket and pick any remaining organisms off and place them into the bucket.

5. While holding the net in position on the substrate, visually define a rectangular quadrat that is one net width wide and one net width long upstream of the net opening. The area within this quadrat is 0.09 m^2 (1 ft^2).

6. Check the quadrat for heavy organisms, such as mussels and snails. Remove these organisms from the substrate by hand and place them into the net. Pick up any loose rocks or other larger substrate particles in the quadrat. Use hands or a small scrub brush to dislodge organisms so that they are washed into the net. Scrub all rocks that are golf ball-sized or larger and which are over halfway into the quadrat. Large rocks that are less than halfway into the sampling area should be pushed aside. After scrubbing, place the substrate particles outside of the quadrat.

7. Keep holding the D-net securely in position. Start at the upstream end of the quadrat; vigorously kick the remaining finer substrate within the quadrat for 30 seconds (use a stopwatch).

   NOTE: For samples located within dense beds of long, filamentous aquatic vegetation (e.g., algae or moss), kicking within the quadrat may not be sufficient to dislodge organisms in the vegetation. Usually these types of vegetation are lying flat against the substrate due to current. Use a knife or scissors to remove **only the vegetation that lies within the quadrat** (i.e., not entire strands that are rooted within the quadrat) and place it into the net.

8. Pull the net up out of the water. Immerse the net in the stream several times to remove fine sediments and to concentrate organisms at the end of the net. Avoid having any water or material enter the mouth of the net during this operation. **Go to Step 13**.

Pool/Glide habitats:

9. Visually define a rectangular quadrat that is one net width wide and one net width long at the sampling point. The area within this quadrat is -0.09 m^2 (1 ft^2).

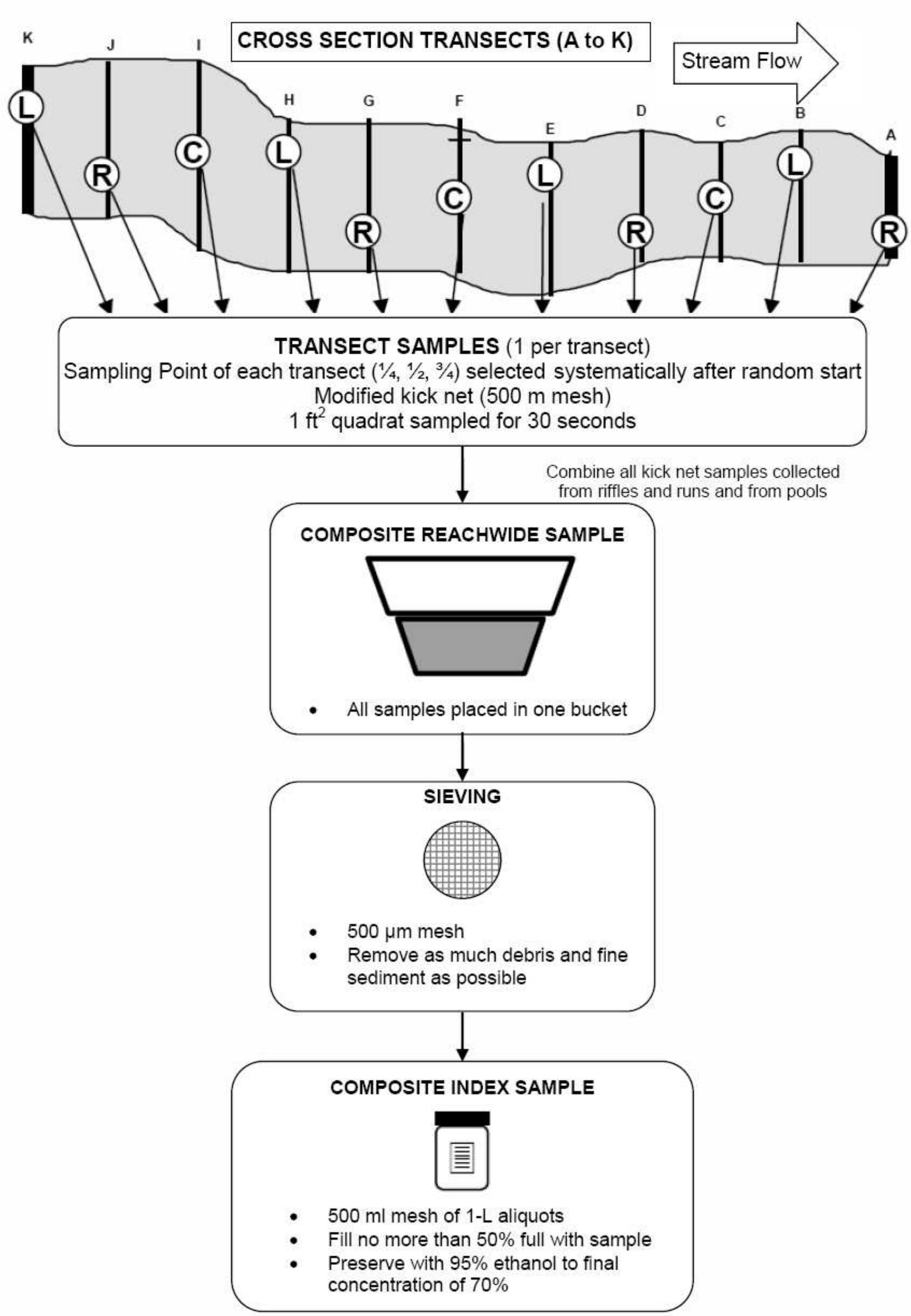

Figure 7.17.2. Transect Sampling Design for the Benthic Macroinvertebrate Sample

10. Inspect the stream bottom within the quadrat for any heavy organisms, such as mussels and snails. Remove these organisms by hand and place them into the net or bucket. Pick up any loose rocks or other larger substrate particles within the quadrat and hold them in front of the net. Use hands (or a scrub brush) to rub any clinging organisms off of rocks or other pieces of larger substrate (especially those covered with algae or other debris) into the net. After scrubbing, place the larger substrate particles outside of the quadrat.

    NOTE: If the water is too deep to effectively "kick" the substrate in front of the net, face upstream and jab/sweep the net through the $0.09m^2$ quadrat. So that individuals from previous jabs do not escape the net after each sequence, remove the net completely from the water and replace it at the start of the quadrat. Three series of jabs/sweeps through the quadrat should be sufficient to obtain a sample at each transect.

11. Vigorously kick the remaining finer substrate within the quadrat while dragging the net repeatedly through the disturbed area just above the bottom. Keep moving the net all the time so that the organisms trapped in the net will not escape. Continue kicking the substrate and moving the net for 30 seconds.

    NOTE: If there is too little water to use the kick net, stir up the substrate with gloved hands and use a sieve with 500 µm mesh size to collect the organisms from the water in the same way the net is used in larger pools.

12. After 30 seconds, remove the net from the water with a quick, net surfacing motion to wash the organisms to the bottom of the net.

All samples:

13. Invert the net into a bucket and transfer the sample. Inspect the net for any organisms clinging to the mesh and use forceps to deposit them into the bucket. Carefully inspect any large objects (e.g. rocks, sticks, or leaves) in the bucket and wash any organisms into the bucket. Discard as much rocks, sediments and detritus as possible without losing any organisms.
14. Thoroughly rinse the net before proceeding to the next sampling location. Proceed upstream to the next transect (including Transect K, the upstream end of the sampling reach) and repeat Steps 1 through 14. Combine all kick net samples from riffle/run and pool/glide habitats into the bucket.

Sample Processing

Use a closed bottom or sieve bottom bucket while sampling to carry the composite sample to the next transect. Alternatively, place each sample in a five-gallon bucket and use a soil sieve (500 µm = 0.5 mm) to cull-down the sample before it is packed and preserved in a Nalgene container(s) upon completion (Figure 7.17.2). Record the composite sample tracking information on a field recording form shown in Figure 7.17.3.

1. Pour the entire contents of the bucket through a sieve (or into a sieve bucket) with 500 µm mesh size. Remove any large objects and wash any clinging organisms back into the sieve before discarding.

2. Use a wash bottle filled with stream water to rinse all the organisms from the bucket into the sieve. This is the composite reach-wide sample for the site.

3. Estimate the total volume of the sample in the sieve and determine how large a jar will be needed for the sample (500-mL or 1-L) and how many jars will be required.

4. Wash the contents of the sieve to one side by gently agitating the sieve in the water. Wash the sample into a jar using as little water from the wash bottle as possible. Use a large-bore funnel if necessary. If the jar is too full pour off some water through the sieve until the jar **is not more than ½ full**, or use a second jar if a larger one is not available. Carefully examine the sieve for any remaining organisms and use watchmakers' forceps to place them into the sample jar.

5. Completely fill the jar(s) with 95% ethanol (no headspace). It is very important that sufficient ethanol be used or the organisms will not be properly preserved.

   NOTE: Prepared composite samples can be transported back to the vehicle before adding ethanol if necessary. Fill the jar with stream water, which is then drained using the net across the opening to prevent loss of organisms, and replaced with ethanol.

6. Place a waterproof label (Figure 7.17.4), with the following information, inside of each jar. **Use a lead pencil when writing waterproof label as ink will deteriorate in Ethanol.**

   • Project Code
   • Type of sample
   • Sample container size
   • Date of collection
   • Sampler Name
   • Site Identification number
   • Number of transect samples composited (Jar N of X)
   • Preservation fixative
   • Time of collection

   NOTE: Write "Jar *N* of *X*" on each sample label using a waterproof marker ("*N*" is the individual jar number, and "*X*" is the total number of jars for the sample).

7. Replace the cap on each jar. Slowly tip the jar to a horizontal position, and then gently rotate the jar to mix the preservative. Do not invert or shake the jar.

8. Fill in outside jar labels with the stream information listed in step 6. Attach the completed label to the jar and cover it with a strip of clear mailing tape. Record the sample information for the composite sample on the Sample Log Form (Figure 7.17.5). For each composite sample, make sure the number on the form matches the number on the label.

9. Store labeled composite samples in a container with absorbent material that is suitable for use with 95% ethanol until transport or shipment to the laboratory.

LITERATURE CITED

Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish*. Second Edition. EPA/841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Assessment and Watershed Protection Division, Washington, D.C.

Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. 1990. *Macroinvertebrate Field and Laboratory Methods for Evaluating the Biological Integrity of Surface Waters.* EPA/600/4-90/030. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Cincinnati, Ohio.

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Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish.* EPA/440/4-89/001. U.S. Environmental Protection Agency, Assessment and Watershed Protection Division, Washington, D.C.

Field Recording Form for Biological Monitoring
North Dakota Department of Health
Division of Water Quality-SWQMP
Telephone: 701.328.5210
Fax: 701.328.5200

SITE ID:______________________________ **DATE:** ________/ ________/ ____________

FIELD NUMBER:______________________________ **SAMPLERS:** ______________________

STATION DESCRIPTION:____

____

LATITUDE: ______________________________ **LONGITUDE:** ______________________________

ECOREGION (circle one)**:** 43 42 46 48

INVERTEBRATE COLLECTION METHOD (circle one): D-NET OTHER __________

REACH LENGTH:______________ **M**

STREAM HABITAT TYPE (%):	RIFFLE:__________	POOL:_______	SNAG:__________	UNDERCUT BANK:__________
	AQUATIC VEG: ___________	OVERHANG VEG:________	OTHER:______________________________	

FIELD WATER CHEMISTRY	**SITE PHOTOS**
TEMP:	UPSTREAM:
DO:	DOWNSTREAM:
pH:	
COND:	

WEATHER CONDITIONS (Temp., Wind, etc.): ____
COMMENTS: ____

Figure 7.17.3. Macroinvertebrate Field Collection Data Recording Form

SITE DRAWING (Show direction of water flow and north)

COMMENTS:

Figure 7.17.3 ctd. Macroinvertebrate Field Collection Data Recording Form (reverse).

Project Code_________ Site ID#:_________

Site#:_____________ Field#:____________

Analysis: Macroinvertebrates Jar_____ of _____
Container: 1L Preservation: 95% Ethanol

Date_____/_____/_____ Time_____:_____

Sampler:

Project Code_________ STORET#:_________

Site#:_____________ Field#:____________

Analysis: Macroinvertebrates Jar_____ of _____
Container: 1L Preservation: 95% Ethanol

Date_____/_____/_____ Time_____:_____

Sampler:

Project Code_________ STORET#:_________

Site#:_____________ Field#:____________

Analysis: Macroinvertebrates Jar_____ of _____
Container: 1L Preservation: 95% Ethanol

Date_____/_____/_____ Time_____:_____

Sampler:

Project Code_________ STORET#:_________

Site#:_____________ Field#:____________

Analysis: Macroinvertebrates Jar_____ of _____
Container: 1L Preservation: 95% Ethanol

Date_____/_____/_____ Time_____:_____

Sampler:

Figure 7.17.4. Macroinvertebrate Sample Jar Labels (both inside and outside).

Sample Log Form for Biological Monitoring
North Dakota Department of Health
Division of Water Quality-SWQMP
Telephone: 701.328.5210
Fax: 701.328.5200

Field Number	Station ID and Description	Date/Time	Collection Method	Comments

Figure 7.17.5. Macroinvertebrate Sample Log.

Appendix E
Macroinvertebrate Sampling in Non-Wadeable Streams

United States Environmental Protection Agency
Office of Water
Office of Environmental Information
Washington, DC
EPA-841-B-07-009

National Rivers and Streams Assessment

Field Operations Manual

April 2009

TABLE OF CONTENTS

5.4 Benthic Macroinvertebrates

5.4.1 Summary of Method

Collect benthic macroinvertebrate composite samples using a D-frame net with 500 µm mesh openings. Take the samples from the sampling stations at the 11 transects equally distributed along the targeted reach. Composite all sample material and field-preserve with ~95% ethanol.

5.4.2 Equipment and Supplies

Table 5.4-1 shows the checklist of equipment and supplies required to complete the collection of benthic macroinvertebrates at non-wadeable sites. This checklist is similar to the checklist presented in Appendix A, which is used at the base location to ensure that all of the required equipment is brought to the site.

Table 5.4-1. Equipment and supplies list for benthic macroinvertebrate collection at non-wadeable sites

For collecting samples	▪ Modified kick net (D-frame with 500 µm mesh) and 4-5 ft handle ▪ Spare net(s) and/or spare bucket assembly for end of net ▪ Buckets, plastic, 8- to 10-qt ▪ Sieve bucket with 500 µm mesh openings (U.S. std No. 35) ▪ Watchmakers' forceps ▪ Wash bottle, 1-L capacity labeled "STREAM WATER" ▪ Funnel, with large bore spout	▪ Small spatula, spoon, or scoop to transfer sample ▪ Sample jars, 1-L HDPE plastic suitable for use with ethanol ▪ 95% ethanol, in a proper container ▪ Cooler (with absorbent material) for transporting ethanol & samples ▪ Plastic electrical tape ▪ Scissors ▪ Field Operations Manual or laminated Quick Reference Guide
For recording measurements	▪ Composite benthic sample labels with & without preprinted ID numbers ▪ Blank labels on waterproof paper for inside of jars	▪ Soft (#2) lead pencils ▪ Fine-tip indelible markers ▪ Clear tape strips ▪ Sample Collection Form

5.4.3 Sampling Procedure

Collect benthic macroinvertebrate samples at the 11 transects and within the sampling stations for non-wadeable streams. The process for selecting the sample stations is described in the Initial Site Procedures Section (Section 4). Collect all benthic samples at non-wadeable sites from the dominant habitat type within the 10 m x 15 m randomly selected sampling station at each transect (Figure 5.4-1). Take 1 linear meter sweep at the dominant habitat type. Record the benthic macroinvertebrate collection data on the Sample Collection Form, Side 1 as seen in Figure 5.1-2.

The sampling process for collecting benthic samples from non-wadeable sites is illustrated in Figure 5.4-2 and described in Table 5.4-2.

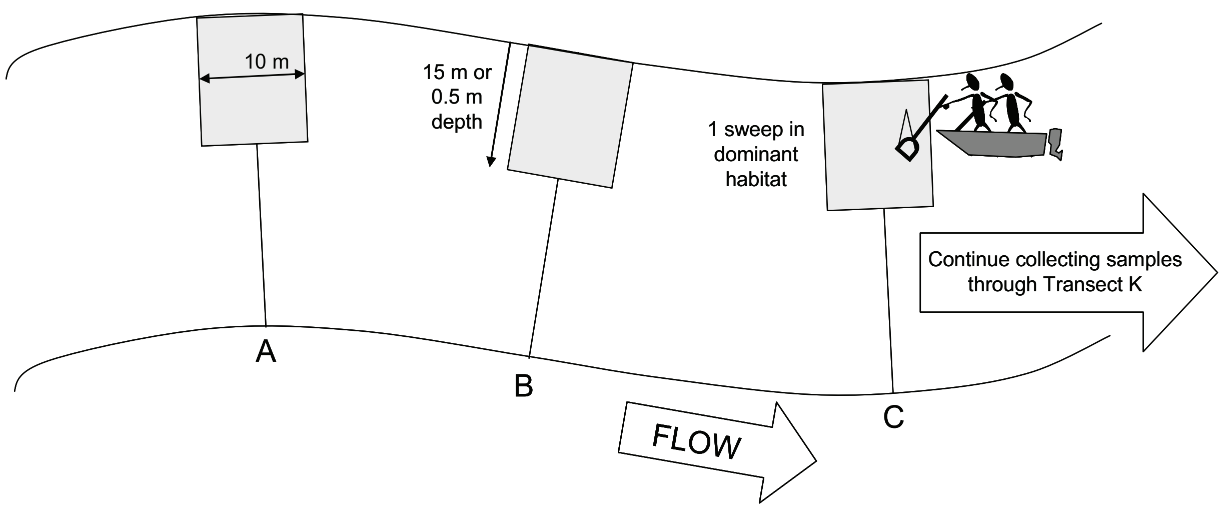

Figure 5.4-1. Transect sample design for collecting benthic macroinvertebrates at non-wadeable sites.

5.4.4 Sample Processing in Field

Use a 500 μm mesh sieve bucket placed inside a larger bucket full of site water while sampling to carry the composite sample as you travel around the site. It is recommended that teams carry a sample bottle containing a small amount of ethanol with them to enable them to immediately preserve larger predaceous invertebrates such as helgramites and water beetles. Doing so will help reduce the chance that other specimens will be consumed or damaged prior to the end of the field day. Once the sample from all stations is composited, sieved and reduced in volume, store in a 1-liter jar and preserve with 95% ethanol. Multiple jars may be required if detritus is heavy (Table 5.4-3). It is suggested that no more than 5 1-L jars be used at any site. If more than one jar is used for a composite sample, use the “extra jar” label provided; record the SAME sample ID number on this “extra jar” label. **DO NOT use two different sample numbers on two jars containing one single sample**. Remove any inorganic material (rocks, debris, etc) before preserving sample. Cover the labels with clear tape. The sample ID number is also recorded with a No. 2 lead pencil on a waterproof label that is placed inside each jar. Be sure the inside label and outside label describe the same sample. If there is a large amount of organic material in the sample, or there are adverse field conditions (i.e. hot, humid weather), place sample in a 1-L jar with ethanol after each station.

Record information for each composite sample on the Sample Collection Form as shown in Figure 5.1-2. If a sample requires more than one jar, make sure the correct number of jars for the sample is recorded on the Sample Collection Form. **Do not fill out the collection form until you have collected (or confirmed at the site that you will collect) samples.** If forms are filled out before you arrive at the site, and then no samples are collected, a lot of time is wasted by others later trying to find samples that do not exist. If you are unable to collect a sample at any station, make note of it on the sample collection form. Place the samples in a cooler or other secure container for transporting and/or shipping to the laboratory (see Appendix C).

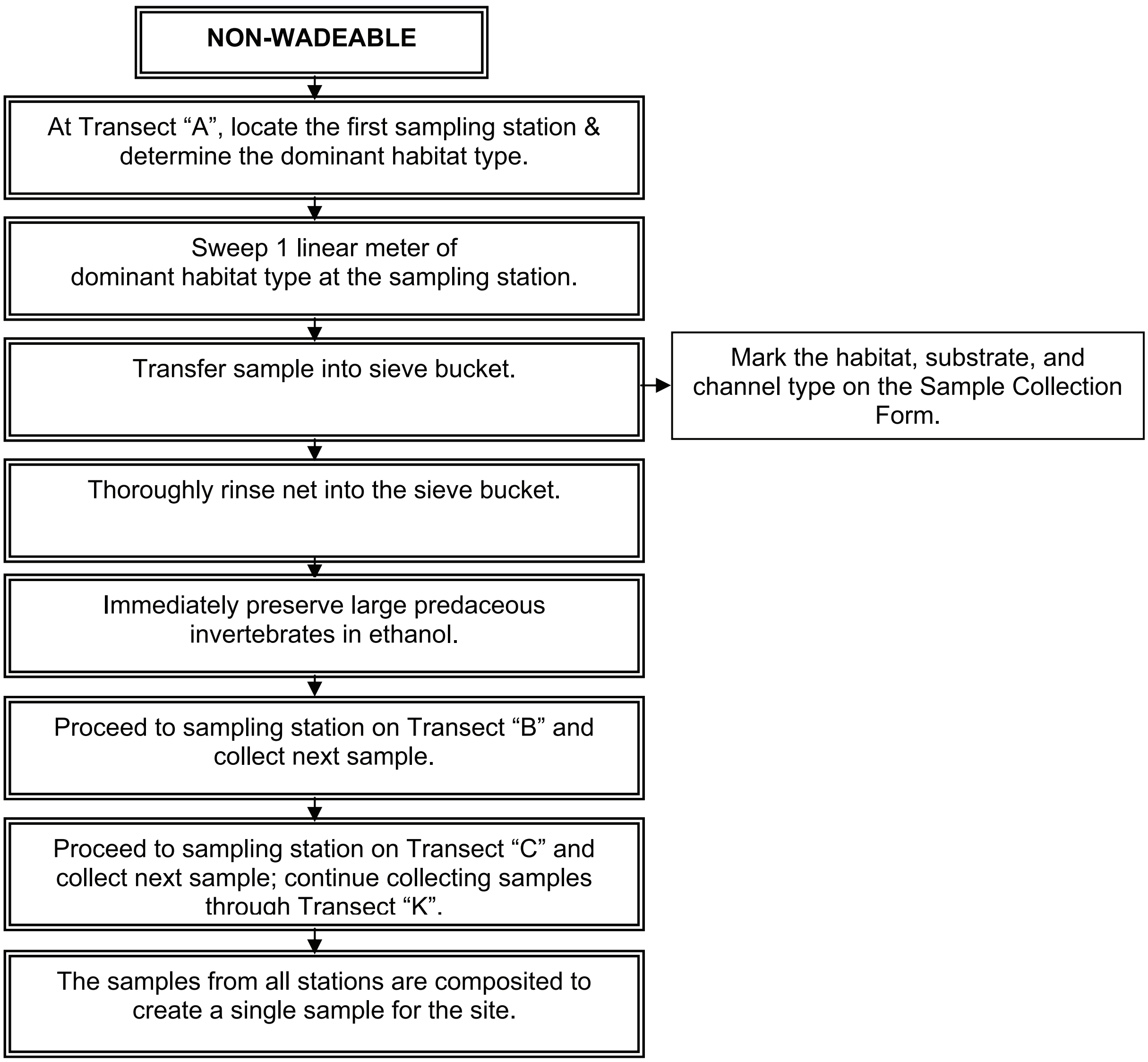

Figure 5.4-2. Benthic macroinvertebrate collection at non-wadeable sites.

Table 5.4-2. Procedure for benthic macroinvertebrate sampling at non-wadeable sites

1. After locating the sampling station site according to procedures described in the physical habitat section, identify the dominant habitat type within the plot:
    - Rocky/cobble/gravel/large woody debris
    - Organic fine mud or sand
    - Macrophyte beds
    - Leaf Pack
2. Use the D-frame dip net (equipped with 500 µm mesh) to sweep through 1 linear meter of the most dominant habitat type within the 10m x 15m sampling station, making sure to disturb the substrate enough to dislodge organisms.
    - If the dominant habitat is rocky/cobble/large woody debris it may be necessary to exit the boat and disturb the substrate (e.g., overturn rocks, logs) using your feet while sweeping the net through the disturbed area.
    - Because a dip-net is being used for sampling, the maximum depth for sampling will be approximately 0.5 m; therefore, in cases in which the depth of the river quickly drops off it may be necessary to sample in the nearest several meters to the shore.
3. After completing the 1 linear meter sweep, remove all organisms and debris from net and place them in a bucket following sample processing procedures described in the following section.
4. Record the sampled habitat type on the Sample Collection Form.
    a) **F**ine/sand: not gritty (silt/clay/muck <0.06 mm diam.) to gritty (up to ladybug sized 2 mm diam.)
    b) **G**ravel: fine to coarse gravel (ladybug to tennis ball sized; 2 mm to 64 mm diam.)
    c) **C**oarse: Cobble to boulder (tennis ball to car sized; 64 mm to 4000 mm)
    d) **O**ther: bedrock (larger than car sized; > 4000 mm), hardpan (firm, consolidated fine substrate), wood of any size, aquatic vegetation, etc.). Note "other" substrate in comments on field form.
5. Identify the channel habitat type where the sampling sweep was located. Mark the appropriate channel habitat type for the transect on the Sample collection Form.
    a) **P**ool; Still water; low velocity; smooth, glassy surface; usually deep compared to other parts of the channel
    b) **GL**ide: Water moving slowly, with smooth, unbroken surface; low turbulence
    c) **RI**ffle: Water moving, with small ripples, waves, and eddies; waves not breaking, and surface tension is not broken; "babbling" or "gurgling" sound.
    d) **RA**pid: Water movement is rapid and turbulent; surface with intermittent "white water" with breaking waves; continuous rushing sound.
6. Proceed to the next sampling station and repeat steps 1-5. The organisms and detritus collected at each station on the river should be combined in a single bucket to create a single composite sample for the river. After sampling at all 11 stations is completed, process the composite sample in the bucket according to procedures described in the following section.
7. If the sample contains primarily organic material, or if adverse weather conditions exist (i.e. hot humid weather) process the sample at each station by placing it in a 1-L nalgene jar with ethanol. Follow instructions in Table 5.4-3.
8. Immediately preserve larger predaceous invertebrates such as helgramites and water beetles in ethanol.

Table 5.4-3. Procedure for compositing samples for benthic macroinvertebrates at non-wadeable sites

Estimate the total volume of the sample in the sieve and determine how large a jar will be needed for the sample (500-mL or 1-L) and how many jars will be required. It is suggested that no more than 5 1-L jars are used at each site.

Fill in a sample label with the Sample ID and date of collection. Attach the completed label to the jar and cover it with a clear tape strip. Record the Sample ID for the composite sample on the Sample Collection Form. For each composite sample, make sure the number on the form matches the number on the label.

Wash the contents of the sieve to one side by gently agitating the sieve in the water. Wash the sample into a jar using as little water from the wash bottle as possible. Use a large-bore funnel if necessary. If the jar is too full pour off some water through the sieve until the jar is not more than 1/3 full, or use a second jar if a larger one is not available. Carefully examine the sieve for any remaining organisms and use watchmakers' forceps to place them into the sample jar. Remove any inorganic material, such as gravel, by rinsing the material, examining it and removing it from the sample.

- If a 2nd jar is needed, fill in a label that does not have a pre-printed ID # on it. Record the ID # from the pre-printed label prepared above in the "SAMPLE ID" field of the label. Attach the label to the 2nd jar and cover it with a strip of clear tape. Record the number of jars on the Sample Collection Form. **Make sure the number you record matches the actual number of jars used.** Write "Jar *N* of *X*" on each sample label using a waterproof marker. **Try to use no more than 5 jars per site.**

Place a waterproof label inside each jar with the following information written with a #2 lead pencil:

- Site ID
- Type of sampler and mesh size used
- Name of site
- Date of collection
- Collectors initials
- Number of stations sampled
- Jar "N" of "X"

Completely fill the jar with 95% ethanol (no headspace). It is very important that sufficient ethanol be used, or the organisms will not be properly preserved. Existing water in the jar should not dilute the concentration of ethanol below 70%.

- NOTE: Composite samples can be transported back to the vehicle before adding ethanol if necessary. In this case, fill the jar with stream water, then drain using the net (or sieve) across the opening to prevent loss of organisms, and replace with ethanol at the vehicle.

Replace the cap on each jar. Slowly tip the jar to a horizontal position, then gently rotate the jar to mix the preservative. Do not invert or shake the jar. After mixing, seal each jar with plastic tape.

Store labeled composite samples in a container with absorbent material that is suitable for use with 70% ethanol until transport or shipment to the laboratory.

Appendix F
Sample Sorting, Processing and Identification of Macroinvertebrate Samples

7.18

STANDARD OPERATING PROCEDURES FOR LABORATORY PROCESSING OF MACROINVERTEBRATE SAMPLES

Summary

Macroinvertebrate samples collected in the field by either the single or multi-habitat method are best processed in the laboratory under controlled conditions. Aspects of laboratory sample processing include washing, rinsing, sub-sampling, sorting, identification, and enumeration of organisms.

The following protocol describes a method to sub-sample macroinvertebrates collected from a site. In cases where the sample contains large numbers of organisms, sub-sampling reduces the effort required for sorting and identification. The following protocol is based on a 500 organism sub-sample, but it can be used for any size sub-sample (100, 200, 300, etc.).

Equipment list

√	**Item**
	Laboratory sample log in forms (Figure 7.20.1)
	Laboratory bench sheets for sorting and identification (Figure7.20.1)
	Sorting Pans (surface area of pan should be divided into grids of equal size for picking)
	Forceps (both fine tipped, medium tipped and curved)
	Dissecting Probes and Needles
	Watch Glasses
	Dissecting Scope (9X to 110X for final IDs)
	Dissecting Scope (7X to 30X to aid in sorting)
	Compound Microscope (4X, l0X, 40X, and 100X oil objectives and phase contrast optics)
	Specimen Vials (assorted sizes of 1, 2, and 4 drams and larger with screw cap vials for voucher specimens)
	Squeeze bottles (1 liter for 70% ethanol)
	Eyedroppers
	Tally counter
	Hot plate
	Microscopes slides
	Microscope cover slips 1 oz. Round
	Magnifying lens with light source for picking samples
	Taxonomic keys
	70% Ethanol
	Euparol and/or CMC 10 mounting media
	Potassium Hydroxide (KOH) 10% by volume
	Illuminator compatible with dissecting scope
	Deck of numbered cards

Procedures

1. Sample Login In

Upon receipt by laboratory personnel, record all samples on the laboratory sample log in form (Figure 7.18.1). Include the date received and all information from the sample container label. If more than one container was used, record the number of containers per sample. All samples should be sorted in the same laboratory to enhance quality control.

2. Washing and Preparing the Sample for Sorting

Thoroughly rinse the sample in a 500 µm-mesh sieve to remove preservative and fine sediment. Large organic material (whole leaves, twigs, algae, or macrophyte mats, etc.) not removed in the field should be rinsed, visually inspected, and discarded. If the samples have been preserved in alcohol, it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms. This will prevent them from floating on the water surface during sorting. If the sample was stored in more than one container, the contents of all containers for a given sample should be combined at this time. Gently mix the sample by hand while rinsing to make the entire sample homogeneous.

After washing, spread the sample evenly across a pan marked with numbered grids approximately 6 cm × 6 cm. Along the sides and top of the gridded pan, line up numbered specimen vials, which will hold the sorted organisms. Start with vials 1-15 set up and have vials 16-30 available, if needed. If the sample is to be identified that day, these jars can contain water. If it is towards the end of the day and they will not be identified in the next twelve hours the jars should contain 70 percent ethanol.

3. Sample Sorting and Counting

Using a deck of cards that contains numbers corresponding to the numbered grids in the pan, draw a card to select a grid within the gridded pan. This is done to make sure a random sample is carried out. Begin picking organisms from that square and placing them in the numbered vials. Any organism that is lying over a line separating two grids is considered to be on the grid containing its head. In those instances where it may not be possible to determine the location of the head (worms for instance), the organism is considered to be in the grid containing most of its body. Each numbered vial should contain one taxon of organisms. Use a tally counter to keep track of the total number of organisms. The tally counters can also be used to keep track of specific taxa (i.e., scuds or corixids) that may be in high abundance. When all organisms have been removed from the selected grid, draw another card and remove all the organisms from that grid in the same manner. If new taxa are found, place them in the next empty vial. Continue this process of drawing cards and picking grids. After 10 grids have been picked, determine the average number of organisms per grid and determine approximately how many total grids will be picked to reach 500 organisms. When approaching that number of grids, monitor the total count of organisms. A sample should not be stopped in the middle of picking a grid, so stop on a grid that will give a number of 500 organisms or more. This is done to eliminate any bias as to which organisms would be picked in the last grid. Rarely will the final count be exactly 500 organisms. Note on the bench data sheet how many grids were picked to get the final count. Save the remaining unsorted sample debris residue in a separate container labeled "sample residue"; this container should include the original sample label.

On the laboratory bench data sheet (Figure 7.18.1) write down the tentative identifications and total numbers of organisms for each vial. Examine vials under a 10X dissecting scope to count organisms and ensure that all organisms are of the same taxon. Do not try and separate taxa that are hard to differentiate, this will be done under higher power during the final identification. Once all vials have been recorded on the bench sheet, place screw tops on the vials, place the vials and bench sheet into a designated tray and bring it to the final identification station.

After laboratory processing is complete for a given sample, all sieves, pans, trays, etc., that have come in contact with the sample will be rinsed thoroughly, examined carefully, and picked free of organisms or debris; organisms found will be added to the sample residue.

4. **Sample Identification**

Final organism identifications should be done to the lowest taxonomic level practicable (genus/species preferred). In order to provide accurate taxonomic identification, midge (Chironomidae) larvae and pupae will be mounted on slides in an appropriate medium (e.g., Euparal, CMC-10); slides will be labeled with the site identifier, date collected, and the first initial and last name of the collector. As with midges, worms (Oligochaeta) must also be mounted on slides and should be appropriately labeled. All slides should be archived so further levels of identification can be done at a later date. Each taxon found in a sample is recorded and enumerated on the laboratory bench sheet (Figure 7.18.1). Any difficulties encountered during identification (e.g., missing gills) are noted on these sheets.

Record the identity and number of organisms in each taxonomic group on the laboratory bench sheet. Also, record the life stage of the organisms and the taxonomist's initials. After each taxon is identified, the organisms will be placed in a container. A label with the site number, location, date of the sample, and taxonomic identification should also be placed in the container.

5. **Sample Vouchers and Storage**

In order to ensure accuracy and precision it is recommended that a voucher collection be established for each set of samples, which are enumerated and identified by a specific laboratory. A voucher collection is established by extracting individual specimens of each taxon from the sample collection. These individuals will be placed in specimen vials and tightly capped. A label that includes site, date, taxon, and identifying taxonomist will be placed inside the vial. Slides that are to be included in the voucher collection must be initialed by the identifying taxonomist. A separate label may be added to slides to include the taxon (taxa) name(s) for use in a voucher or reference collection.

For archiving samples, specimen vials (grouped by voucher collection station and date) are placed in jars with a small amount of denatured 70 percent ethanol and tightly capped. The ethanol level in these jars must be examined periodically and replenished as needed, before ethanol loss from the specimen vial takes place. A stick-on label is placed on the outside of the jar indicating sample identifier, date, and preservative (denatured 70 percent ethanol). Voucher collections will be cataloged and placed in the North Dakota River and Stream Macroinvertebrate Collection located at Valley City State University by Dr. Andre DeLorme, Ph.D.

Macroinvertebrate Laboratory Bench Data Sheet
North Dakota Department of Health
Division of Water Quality- SWQMP
Telephone: 701.328.5210
Fax: 701.328.5200

Site:	Sample #:	Date sampled:
No. of Squares picked:	Date ID:	Picker(s):

Vial #	Phylum/ Order	Family	Genus Species	Final Count	Life Stage	Notes
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						

Figure 7.18.1. Macroinvertebrate Laboratory Bench Data Sheet.

Field Recording Form for Biological Monitoring
North Dakota Department of Health
Division of Water Quality-SWQMP
Telephone: 701.328.5210
Fax: 701.328.5200

SITE ID:____ **DATE:** _________/ _________/ _______________

FIELD NUMBER:_______________________________________ **SAMPLERS:** ______________________________

STATION DESCRIPTION:____

____

LATITUDE: ____ **LONGITUDE:** _____________________________________

ECOREGION (circle one)**:** 43 42 46 48

INVERTEBRATE COLLECTION METHOD (circle one): D-NET OTHER _____________

REACH LENGTH:_________________ **M**

STREAM HABITAT TYPE (%):	RIFFLE:____________	POOL:________	SNAG:_____________	UNDERCUT BANK:____________
	AQUATIC VEG: ______________	OVERHANG VEG:_________	OTHER:__________________________________	

FIELD WATER CHEMISTRY	**SITE PHOTOS**
TEMP:	UPSTREAM:
DO:	DOWNSTREAM:
pH:	
COND:	

WEATHER CONDITIONS (Temp., Wind, etc.): ____

____

COMMENTS: ____

____

Figure 7.18.2. Macroinvertebrate Field Collection Data Recording Form.

SITE DRAWING (Show direction of water flow and north)

Figure 7.18.2 ctd. Macroinvertebrate Field Collection Data Recording Form (reverse).

Geomorphology Monitoring Plan

Fargo-Moorhead Flood Risk Management Project

Prepared for Minnesota Environmental Impact Statement
By Geomorphology Monitoring Team

DRAFT
Minnesota Final Environmental Impact Statement
Vs. 2 May 2016

U.S. ARMY CORPS OF ENGINEERS,
ST. PAUL DISTRICT, ST. PAUL, MINNESOTA

MONITORING COMPONENTS

Riverine systems can be divided into five inter-related components: hydrology, geomorphology, water quality, connectivity, and biology. The Fargo-Moorhead Flood Risk Management Project (the Project) is designed to directly alter the hydrology of the Red River and tributaries in the project area by partially diverting high flows. This change in hydrology has the potential to affect the geomorphology of the river channel, and lateral connectivity between the river and its floodplain within the city and for some distance upstream of the diversion. Water quality, as it relates to geomorphology, will be included in this assessment. Biota and biological connectivity will be addressed in other monitoring plans.

The monitoring program is tailored to the parameters to be measured. Sediment and other measures of water quality and geomorphic changes may be monitored in the same locations but at different time intervals. Location selections are also driven in part by the questions the monitoring will address.

For the purposes of this Plan, pre-construction is defined as the time period prior to construction and during construction activities. Post-construction is defined as the time period following construction completion of all the Project features. This includes any planned mitigation projects that have been proposed, permitted, and/or funded.

This draft monitoring plan was developed in collaboration by experts representing key local, state, and federal organizations referred to herein as the Geomorphology Monitoring Team (GMT). The draft monitoring plan will be improved by the GMT as Project details are further refined and as local, state, and federal permits require. Once Project details are defined and permit conditions are established, the monitoring plan will be finalized and will then follow the adaptive management framework as outlined in the Adaptive Management and Monitoring Plan.

MONITORING PLAN GOALS

Monitoring how the hydrology, geomorphology, and water quality for each of the river reaches change through time provides the necessary empirical data for assessment of the Project's impacts. One goal of the monitoring plan is to understand what the natural and adaptive range of geomorphic changes is for each river reach and to recognize and measure changes over time. Pre-construction and pre-Project operation surveys and other supporting data will be collected to allow for the establishment of these baseline ranges.

Another goal of the monitoring plan will be relating measured geomorphic changes outside the natural and adaptive ranges to causes that may or may not include and are not limited to the Project. Identifying contributing factors other than those due to the Project will likely require obtaining additional data in addition to that which is included as part of this monitoring plan such as land use, drainage change information, and precipitation records. Evaluating the contributing factors against Project influences may also require modifications to the monitoring plan in order to support interpretation of gathered data.

It is acknowledged that geomorphic changes could result in adverse effects to water quality. A goal of the monitoring plan will be to assess the degree to which geomorphic changes relate to and contribute to water quality changes within the system. Water quality parameters that may be affected by geomorphic changes will be monitored post-construction and compared to pre-construction data (new and existing water monitoring sites will be utilized). It should be noted it may be difficult to assess causal relationships between changes in water quality and Project effects as water quality is affected by numerous variables and experience natural variability within systems.

Adopting a framework to maintain clear and effective communication between other adaptive management work groups, agencies, the authority, and stakeholders/ affected parties for information specific to the geomorphic aspects of monitoring, mitigation and adaptive management is also recommended.

HYDROLOGY/HYDRAULICS MONITORING

Red River hydrology/hydraulics will be monitored from the United States Geological Survey (USGS) gages shown in Figure 1. Data can be accessed at the USGS's 'Stream gages in the Red River of the North Basin' website (http://nd.water.usgs.gov/floodinfo/red.html). These gages are continuous. The USGS website is updated hourly with the latest information. Most gages record stage only (discharge is often then calculated), but three gages in the area record more data: Red River of the North (Red River) at Fargo records dissolved oxygen, temperature of the water, specific conductivity at 25C, pH and turbidity; Buffalo River at Sabin records temperature of the air and turbidity; and Sheyenne River at Horace records temperature of the water and specific conductivity at 25C. Three new gages will be added at the three control structures; channel inlet, Red River, and Wild Rice River. The new gages at the control structures will most likely be continuous USGS gages but that has yet to be decided.
Discharge down the diversion channel will be calculated using the pool elevation at the Diversion Inlet Gates and gate settings. Sizing of the gates is not finalized; therefore a rating curve is not available at this time.

Discharges through Fargo will change once this Project is put into operation. The expected differences can be seen on Table 1.

Table 1: Flows on the Red River Through Fargo

Event Frequency Recurrence Interval	Percent Chance exceedance flood[1]	Existing Flows (cfs)	With-Project Flows (cfs)
IBOE or AS[1],		~3,200	~3,200
1.5[2]	67	~3,500	~3,500
2	50	5,000	5,000
5	20	12,000	12,000
10	10	17,000	17,000
100	1	34,700	17,000
500	0.2	61,700	27,000
[3]		100,000	27,000

Sources: NWS website: http://water.weather.gov/ahps2/hydrograph.php?wfo=fgf&gage=fgon8, USGS ratings website: http://waterdata.usgs.gov/nwisweb/get_ratings?site_no=05054000&file_type=exsa

[1]The Incipient Bank Overtopping Elevation (IBOE) is estimated for this table by the National Weather Services' (NWS) action stage (AS) of 17 feet which equates to a flow of ~3,200 cubic feet/second (cfs) (USGS ratings website for Fargo gauge). This is the stage that "water rises to the edge of the bike path (approx 876 feet) at El Zagel bowl along Elm Street North between 14th and 15th Avenues. Bankfull Stage." [+]As required for documents by ER1110-2-1450.
[2]Using 1.5 yr ~67% and the Wet cycle and curve on page 34 of "The use of Synthetic Floods for Defining the Regulated Flow Frequency Curve for the Red River at Fargo" of February 2010, United States Corps of Engineers (USACE) HEC.
[3]Currently the Project is designed to be able to manage floods up to a total inflow of 100,000 cfs.

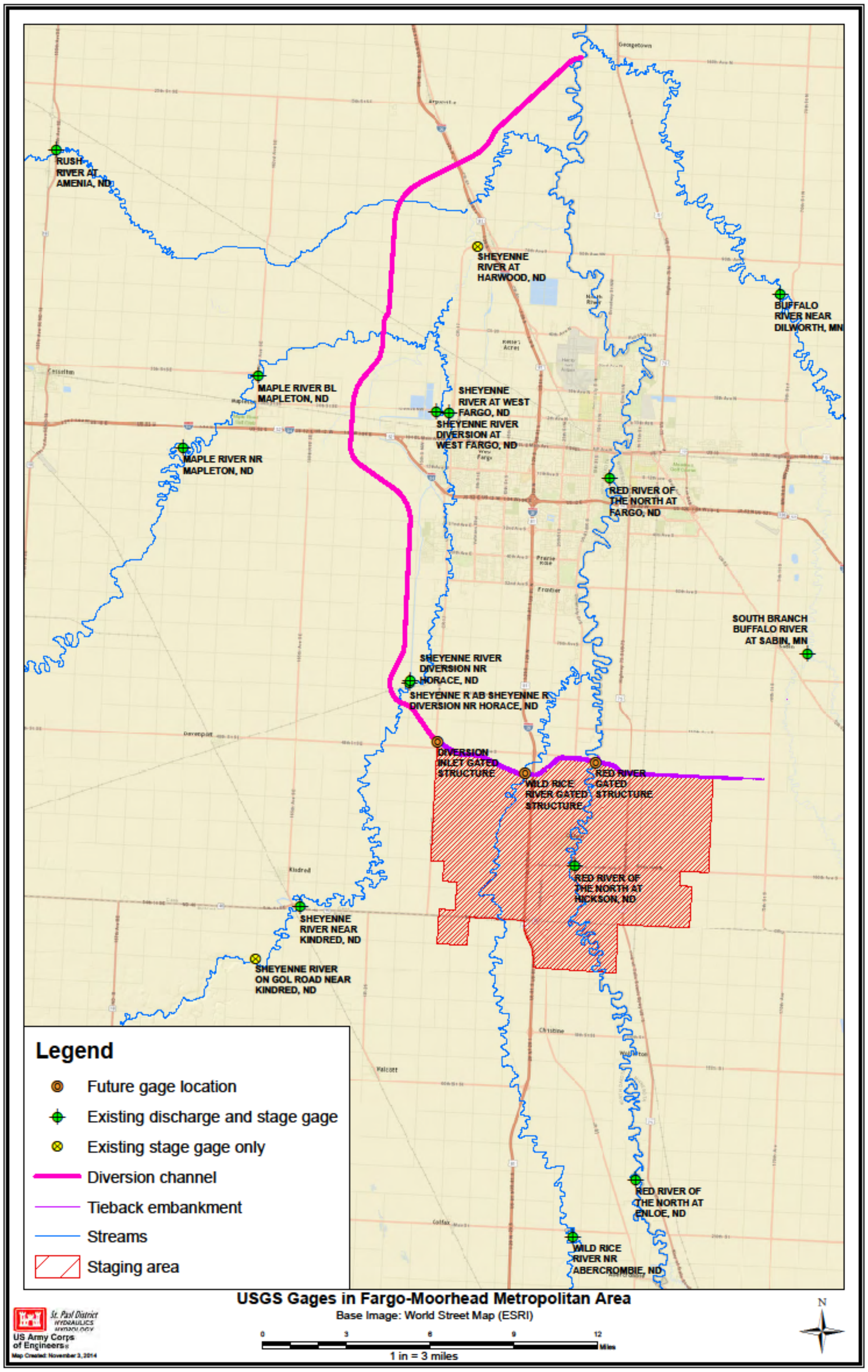

Figure 1. USGS Gages in Fargo-Moorhead Metropolitan Area

GEOMORPHOLOGY MONITORING

Changes to geomorphology driven by the hydrologic changes of the Project could lead to altered erosion and sedimentation, which could in turn have secondary and tertiary effects on water quality and biology. The focus of this monitoring plan is to measure the changes in channel geomorphology in the Project area to determine Project effects to these riverine systems and to support a process to identify, if necessary, modifications to mitigation and any additional mitigation or Project operation changes needed to address adverse effects.

Current Condition and Expectations

The work completed by WEST Consultants, Inc. documented in the October 25, 2012 Geomorphology Study of the Fargo, North Dakota & Moorhead, Minnesota Flood Risk Management Project Vol 1 (West report), is referenced here to outline the current condition of the river system and expectations for changes related to the Project.

From the Future Conditions section 10.6:

> "Results of the geomorphic assessment indicate that the involved study reaches are not prone to significant change in morphology over short or even moderate periods of time. Channel migration rates are on the order of a few inches per year. The erosion resistant nature of the cohesive glacial lake bed soils and the very flat gradient of the channels prevent significant changes in channel cross section geometry and results in very low rates of lateral migration. Further, the sediment supply from upstream and the surrounding landscape is generally composed of silt- and clay sized material with only minor amounts of sand-sized material. The study streams appear to have sufficient capacity to transport nearly all of the sediment supplied to them in suspension as wash load…"

The scope of this monitoring plan, while more extensive than that suggested in the WEST report, is reflective of the complexity and uncertainty associated with sediment and hydrologic channel interactions in a large system with many driving variables that are not completely understood. The nature of Project operation (which may not occur for years or occur sequentially for several years in a row), and the fact that impacts in river systems (e.g., to channels, riparia, and biota) are not necessarily gradual, but can occur abruptly are examples of the stochasticity inherent in the system which make monitoring essential in the absence of validated predictability.

The monitoring plan is designed to be supportive of the anticipated long term operation of the Project and Adaptive Management guidelines. Monitoring the river through time provides necessary empirical data for valid assessment of the Project's impacts – a fundamental principle of Adaptive Management and informs appropriate scoping for adaptation of the monitoring plan through time.

Geomorphic Monitoring Station Selection

The GMT started with the previous geomorphic assessment data collection effort and worked to optimize data collection site choices and methods to answer the questions of Project-related impacts on the river system.

The Wenck Geomorphic Assessment and Monitoring Locations map was revised by the GMT to document recommended cross section and data collection locations (Figure 2) for this monitoring plan. It is the best judgment of the GMT, based on their knowledge of available information, that the current list of data collection sites includes those areas most likely to show impacts from the Project. The sampling locations support Rosgen Classification (Rosgen, 2006) and other geomorphic assessment methods with sampling locations in stratified valley types, stream types, and the in stream habitat types represented by crossings/riffles and pools.

> ***Terminology Note:*** The Red River exhibits a Crossing and Pool pattern of in-channel features where the crossings represent the zone where the direction of current crosses the channel center point as it flows in a meandering pattern from one bank to the other. Because the term "riffle" is used in classification systems of rivers with coarser bed material that cause "riffles" in the water surface at crossings, the term "crossing" and "riffle" might be used somewhat interchangeably. On the Red River and fine grained tributaries, "crossing" is used as being more descriptive of the actual river feature.

Some of the sites are in areas of current active erosion or deposition. In the future, it will be important to complement existing locations with locations where changes become evident and that both the Minnesota (MN) and North Dakota (ND) sides of the rivers and proposed projects be monitored for change.

The section on Map and Site Selection below describes each of the Geomorphic Monitoring Stations (GMS) recommended for the monitoring plan. Each of the monitoring stations is referenced within a geomorphic distinct Reach (Figure 3) as defined and numbered in the WEST Geomorphic Assessment report. Most of the stations were utilized for data collection in 2011 for the early geomorphic assessment for the Project. A few stations are recommended for movement or added to supplement those already established. Each station is comprised of permanent cross section locations for replicate data collection with more detail on the permanent cross sections and other data collected at each station provided in paragraphs below.

Map and Site Selection:
The Geomorphic Monitoring Station (GMS) notes below reference the revised fluvial geomorphology monitoring locations for the Red River and tributaries in the area around the diversion project. GMS codes (R1, WR1, etc.) used below now match the "FM_Diversion_FG_Monitoring_Final_021815.mxd" ArcMap project and Figure 2. Stream classification reaches (Figure 3) have not changed and are referred to in the GMS notes.

Cross sections that were added or modified in this plan are located approximately with only the cross section's midpoint coordinates included in the attribute tables of the added cross section shape files. No LiDAR or field observations were used when doing so. Therefore, each cross section's final position and left and right end points will need to be determined in the field by investigators trained to recognize crossing/riffle, pool, bankfull, terrace, flood prone area, valley geometry, erosion, and riparian features. Cross sections must be positioned at the best facet location (i.e. mid crossing, deepest part of pool) and are perpendicular to the channel up to bankfull (channel forming flows), and then perpendicular to the valley line beyond that point. Additional or changed cross sections were placed in likely crossing and pool locations based on inflection points and outside bends visible in the aerial photography. The need for expert classification of features and placement of permanent cross section monuments supports the requirement for field verification of field investigators riverine system data collection qualifications.

Geomorphic Study Monitoring Stations
Red River:

- **R1** - Farthest downstream station - located in stream classification reach 1. One pool and one riffle cross section were added and the long pro was extended to cover the study reach. Important monitoring station just downstream of all diversion and retention features.
- **R2** - Station was extended to cover the area immediately above and below the downstream diversion confluence - all within stream classification reach 2. Five cross sections (three riffle and two pools) were added and the longitudinal profile was extended to cover the station. Check location of upper two existing cross sections in the field for facet type and keep one representative of that type and delete the other.
- **R3** - This study station is located within stream classification reach 3, adjacent to Trollwood Park, just downstream of Edgewood Golf Course, and upstream of Broadway N. One pool cross section was added to five existing cross sections. No changes to existing longitudinal profile.
- **R4** - Located just downstream of Interstate 94, bounded on the west by Lindenwood Park in Fargo and Gooseberry Mound Park in Moorhead. Study station is located in stream classification reach 4. he longitudinal profile was extended to include the farthest existing upstream cross section just downstream of I94.
- **R5 -** Located in stream classification reach 5. One pool cross section was added and the longitudinal profile was extended to cover the station.
- **R6** - Located in stream classification reach 5 and 6 this study station now spans the area above and below the Wild Rice confluence. Six cross sections (3 pool, 3 riffle) were added below the confluence and one pool cross section was added to the five existing cross sections above the confluence. The longitudinal profile was extended to cover the modified study station.
- **R7** - Located in stream classification reach 6, this new study station is located just below the footprint of the diversion structure and just upstream of 110th Ave S in Fargo. Six cross sections and a longitudinal profile added.
- **R8** - Located just upstream of the diversion structure and within the staging area in stream classification reach 6. Three riffle and two pool cross sections were added to an existing pool cross section for this study station. A longitudinal profile spans the study station.
- **R9** - Station is located in upper staging area and stream classification reach 7. One pool cross section was added to the five existing cross sections and longitudinal profile.
- **R10** Option 2 - Group discussed moving the upper Red Station to somewhere downstream of the existing R10 (Option 1). It is suggested that the original upper station be kept in favor of this station if it represents a better reference reach. Five cross sections were added to an existing cross section for this study station located in stream classification reach 8.
- **R10** Option 1 - Located in stream classification reach 8. This is the original furthest upstream study station. Station was extended to include the existing riffle cross section upstream of the original station extent. The longitudinal profile was extended to cover all cross sections. Alternatively, an additional pool or riffle (whichever is needed) could be added within the original study station extent.

Wild Rice River:

- **WR1** - First study station upstream of confluence with Red River. Changed one pool to riffle to have 3 riffles and 3 pools. No change to long pro. Located in stream classification reach 1.

- **WR2** - This study station is located in stream classification reach 2 downstream of 100th Ave S. Moved cross section that was farthest upstream to meet the study station and long pro end. One pool cross section added to five existing cross sections.
- **WR3** - New study station added in stream classification reach 2, just below the diversion structure and retention dam. Six cross sections and a long pro were added.
- **WR4** - New study station added just above diversion structure within the retention area. Five cross sections (3 riffle, 2 pool) were added to an existing pool cross section for this study station. A long pro was added to extend through the station.
- **WR5** - This study station is located in the upper retention footprint in stream classification reach 3. One pool cross section was added to the five existing cross sections and existing long pro.
- **WR6** - Upstream of retention footprint in stream classification reach 4. No changes to long pro or five cross sections.
- **WR7** - Located in stream classification reach 5. No changes to the six existing cross sections and long pro.
- **WR8** - Located in stream classification reach 6 upstream of County Road 4. No changes to the seven existing cross sections and long pro.

Sheyenne River:

- **S1** - Located in stream classification reach 1, upstream from the confluence with the Red River, this is the farthest downstream study station on this river. Long pro was extended downstream and one riffle cross section added at the downstream end of reach for riffle to riffle study station coverage.
- **S2** - Located in-between the two Rush River's confluences with the Sheyenne in stream classification reach 2. One pool cross section was added to the study station.
- **S3** - Located just downstream of the Maple River confluence in stream classification reach 3. One pool cross section was added to five existing cross sections and existing longitudinal profile.
- **S4** - Located downstream of Sheyenne Diversion in stream classification reach 4. One pool cross section was added and long pro was extended upstream to cover all cross sections.
- **S5** - Located in stream classification reach 5. One pool cross section added to five existing cross sections. No change to longitudinal profile.
- **S6** - This station was moved to its current location from further downstream in stream classification reach 6 to locate it close to the USGS sediment monitoring station just downstream of Wall Street in Horace. This repositioned study station includes three riffle and three pool cross sections and a longitudinal profile through the station.
- **S7** - Located just above diversion and aqueduct in stream classification reach 7. Check cross section placements to ensure outside of rip-rapped segments and for presence of three riffles and three pools. One pool cross section added to existing cross sections to sample three pools and three riffles. Use if needed. It may be possible to eliminate two of the eight located cross sections and shorten the longitudinal profile if three representative pool and riffle cross sections are available.
- **S8** - Located the furthest upstream in stream classification reach 8. Nothing added - original six cross section and long pro.

Maple River:

- **M1** - Most downstream study Station located between the confluence with Sheyenne and the diversion aqueduct in stream classification reach 1. One pool cross section added. Could eliminate one of what appears to be two adjacent existing riffle cross sections in SE corner of study station. No changes to longitudinal profile.

- **M2** - New station in stream classification reach 1 just above diversion and aqueduct. Five cross sections added to one existing cross section. Long pro added to cover study station.
- **M3** - Near Mapleton, this is the furthest upstream station on the Maple River. Located in stream classification reach 2. One riffle cross section added to five existing cross sections and long pro extended to cover study station.

Lower Rush River:

- **LR1** - Located above diversion in stream classification reach 2. Station downstream of diversion dropped. One pool cross section added to five existing cross sections. Only study station on LR.

Rush River:

- **R1** - Located above diversion in stream classification reach 2. Station downstream of diversion dropped. Two pool cross sections added to five existing (looked like four riffle and one pool cross sections existing). Could drop the 1st riffle upstream from the furthest downstream end of station (XS2DID "11" and HydroID "73" in Rush_1_Existing_Cross_Sections shape file attribute table). As in all other study stations, three pool and three riffle cross sections are called for.

Diversion Channel:

- **D1** - Located furthest downstream, above confluence with Red River and downstream of Rush Rivers and Highway 29. This is an added station and should include three pool and three riffle cross sections, and a longitudinal profile that follows the thalweg of the meandered bankfull channel within the diversion channel. Length of the longitudinal profile in this study station will increase when it actually follows the channel meanders that are created in this station.
- **D2** - Middle diversion study station. This is a new study station moved from its preliminary location to just below Drain 14, downstream of Interstate 94, and upstream of the Maple River aqueduct.
- **D3** - Upper diversion channel study station. New study station, modified from its preliminary location, that spans upstream and downstream of the Sheyenne River aqueduct.

Wolverton Creek:

- **W1** - Downstream study reach located in stream classification reach 1 between 130th Ave S and 3rd St S. No changes from existing cross sections. Longitudinal profile extended downstream to cover all six existing cross sections.
- **W2** - Upstream study reach located in stream classification reach 2, downstream of Highway 75 and upstream of 130th Ave S. Two riffle cross sections added to four existing cross sections to make a full complement of three riffle and three pool cross sections. Longitudinal profile remains unchanged.

Buffalo River:

- **B1** - Only study station located on the Buffalo River located just on the western edge of Georgetown, downstream of Mason Street in stream classification reach 1. One riffle cross section added to five existing cross sections. The existing longitudinal profile remains the same.

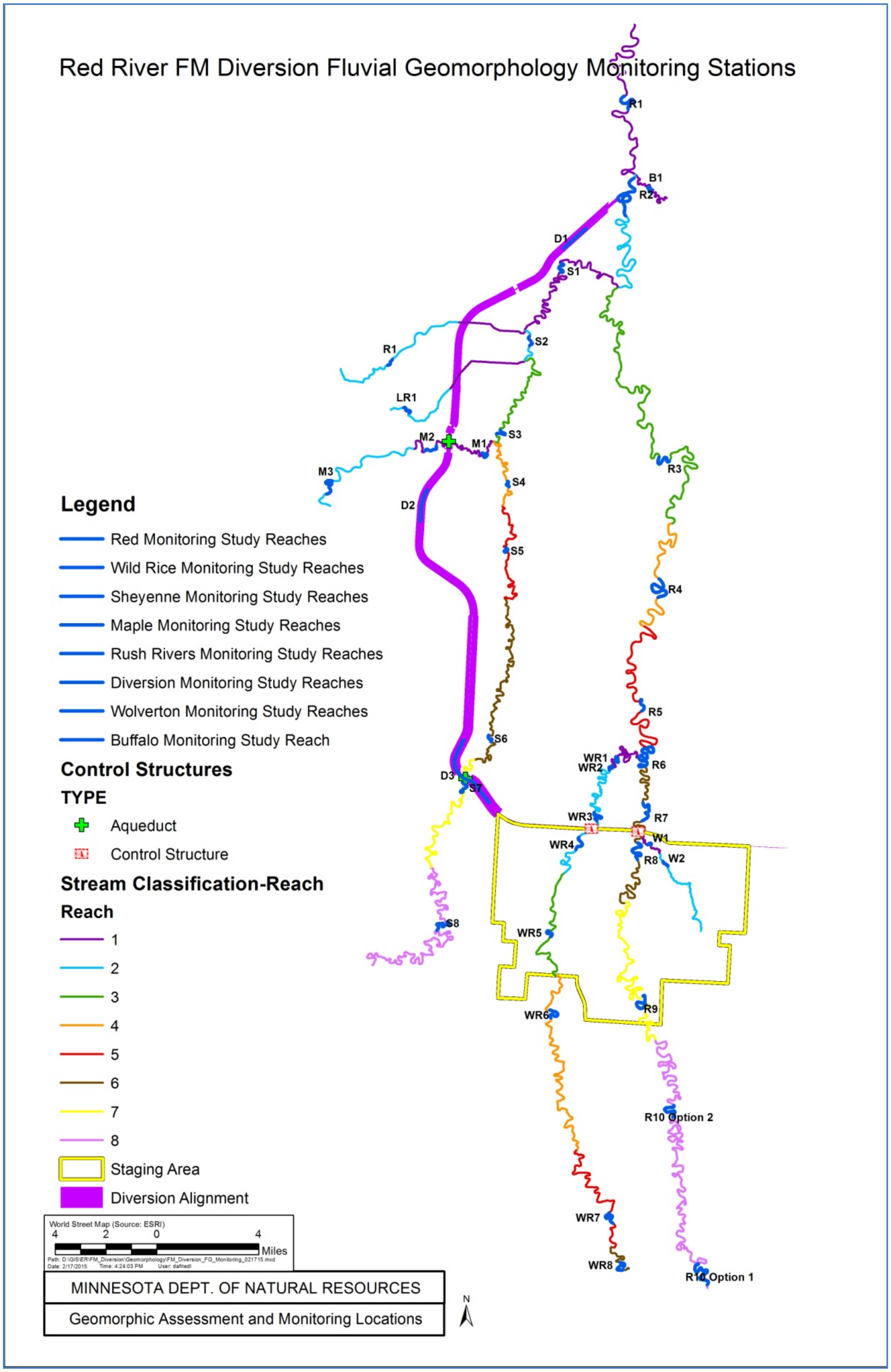

Figure 2: Red River FM Diversion Fluvial Geomorphology Recommended Monitoring Stations

Notes about Site Selections and Geomorphology:

1. Diversion Structure
    - Include a meandering low flow channel in the diversion channel (Extent and dimensions of meander to be determined.).
    - For sediment conveyance purposes need the meandering planform.
    - The diversion channel sections would be based on crossing/pool locations or relative to channel width as self-forming flows have characteristics based on that width.
    - Have 3 or 4 downstream of Sheyenne and US of I-94, and more downstream of the Drain 14 inlet that is bigger than the Rush. The location moves north and south of the 94 crossing.
    - Put in tentative locations that will be finalized with final plans.
    - This is operation and maintenance monitoring: Recommend 1/year to survey and see what is going on.
    - Part of concept of meandering channel low flow design is to reduce the sediment that would be mobilized in creating a self-forming meander and protect the diversion channel.
    - Offer the geomorphic equivalent of the "meander" pattern changes in sampling placement.
2. Rush Rivers
    - All stations on Rush and Lower Rush Rivers downstream of the diversion channel from previous surveys were deleted (10 total cross sections eliminated) from the current monitoring plan due to their flow being captured entirely within the diversion channel.
3. Reference Reach Monitoring Stations on Wild Rice River
    - Cross section stations 6, 7 & 8 (Figure 2), in the geomorphic classification reaches 4,5, &6 respectively (Figure 3), are further upstream on the Wild Rice than the zone of impact and will be monitored as reference reaches for comparing other local driving variables and effects as part of the BACI method. Two different stream classifications are represented by these reaches with one classification replicated, according to the WEST geomorphic analysis, and have the following Rosgen Classification/Potential Stream Type/Modified Stability rating: **Reach 4:** B6c/B6c/Fair: **Reach 5:** E6/E6/Fair; **Reach 6:** E6/E6/Fair. See Appendix K (West, 2012): Level III Rosgen Worksheets for more detail.

Permanent Cross Sections

Geomorphology cross sections provide data to evaluate whether the stream is aggrading, degrading, depositing, or eroding laterally at a specific location. Pre-construction cross section data were collected and are documented in the WEST Report, Wenck analysis and others (Larson—Wild Rice, etc.) Repeating surveys of monumented and GPS located cross sections over time provides topographic information for measuring change useful for assessing channel processes and stability.

The long term nature of the studies will require professional surveys and good monumentation that can be reset from the national network if and when disturbed or displaced. Many field access conditions can change over 5 and 10 year periods. Therefore, cross sections are recommended to be permanently, either physically or by GPS, "monumented" for accuracy and reproducibility of survey lines for data collection and comparisons. The best practice for locating survey endpoints permanently for each cross section is site dependent and will be determined on a case by case basis. It is very important to maintain accurate vertical and horizontal controls. Each monitoring effort should verify they are using the same controls for comparability of data.

Note:
Final locations of cross sections are subject to access to the sites. This has been problematic in some locations in the past. This monitoring plan's goal is to recommend the best possible locations for data sampling based on geomorphology with the understanding that some adjustments are likely during the field work.

The final detailed monitoring planning document should include cross section locations and endpoint documentation from the WEST report for each of these stations and the field crews should try to surveys to the exact locations of the WEST cross sections that are duplicated in the monitoring plan.

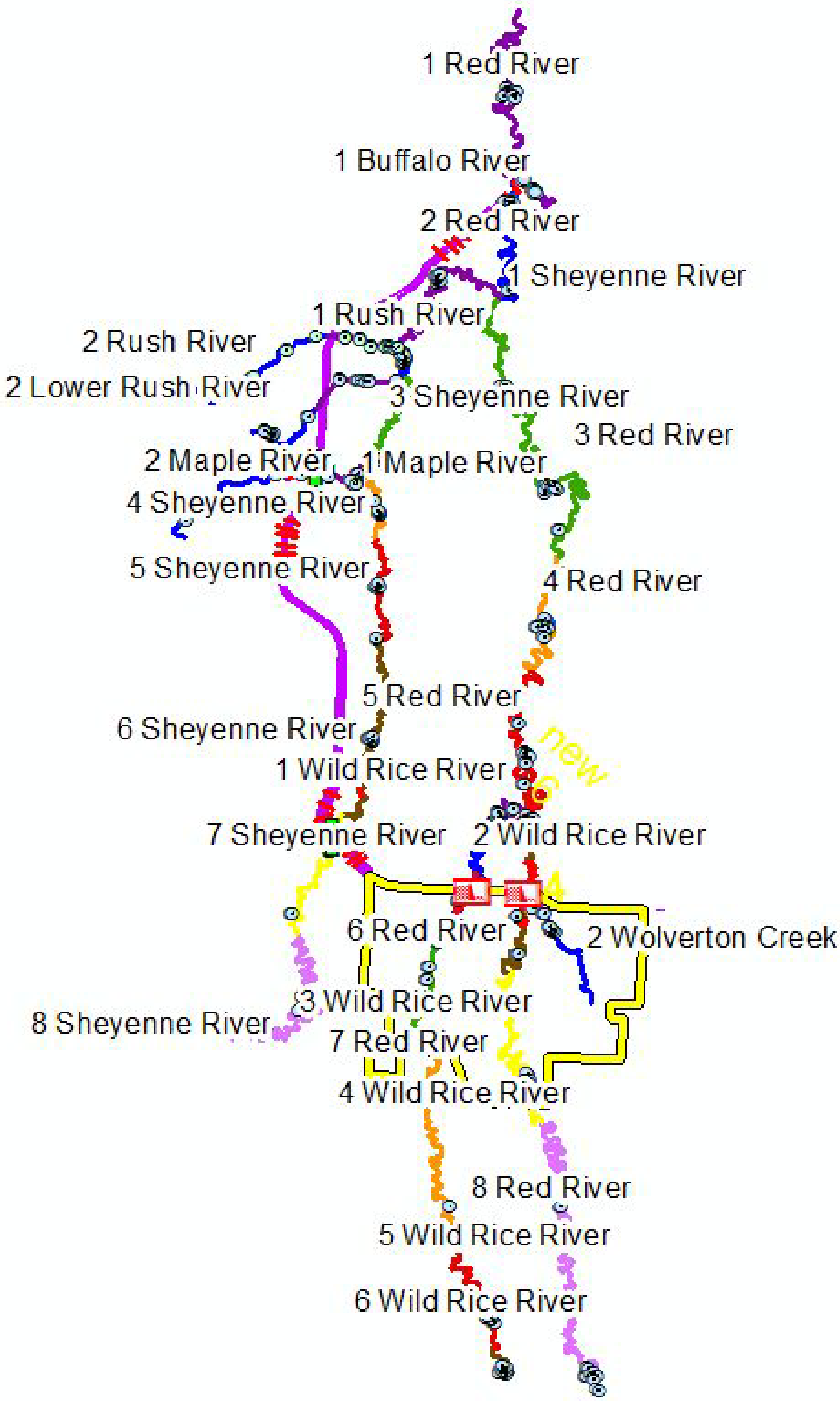

Figure 3: Wenck Complete map of Monitoring Area with WEST Reach Number ID's.

METHODS

The initial pre-construction Geomorphic Assessment data collection (WEST, 2011) produced adequate coverage in the pool and transition/crossing geomorphic features in most of the reaches, however additional cross sections and relocation of some of the stations within reaches to better capture anticipated impact zones from the Project are recommended in this monitoring plan.

Sampling Design

Using the Before-After Control-Impact (BACI) (Smith, 2002) accounting method for monitoring Project features has been suggested. The BACI sampling framework is to examine the *before* (pre-construction condition using baseline data) condition to the *after* (post-Project operation) condition of the area. To account for changes that may occur within the system that are natural changes, the area of impact is compared to another area, which is referred to as the control or reference site. This is a site that is not expected to be impacted by Project operations, but is within close proximity of the project area and is representative of the reach/sites in which changes may be observed due to Project activities. To establish baseline conditions, sampling is carried out on a number of occasions before Project operation and a number of occasions following. The sampling design discussed by the GMT has incorporated BACI methods by recommending sampling areas both inside and outside the impact area on the Red River and the Wild Rice River and further to sample several times before Project operation as well as after. This approach should help to establish a statistical basis as a means for assessing if an impact occurs.

Recommended Cross section Sampling Design:

1. Collect a minimum of three transects each through 3 crossings (narrowest, shallowest, inflection point, riffle), and 3 pool habitats for each Reach/Station location listed in the Geomorphic Study Monitoring Stations.
2. Extend cross section transects beyond the top of bank to capture riparian area and possible overbank deposition, slumping, vegetation surveys etc.
3. Identify and record the incipient bank overtopping elevations using methodology from USACE Geomorphology Study October 25, 2012 by WEST Consultants, Inc. Appendix S: Incipient Bank Overtopping Analysis.
4. Establish long-term photo stations for monitoring change at cross sections and post-operative photo sampling each time the Project is operated. These are complimentary to the cross section measurement and provide additional contextual information on the location.

Longitudinal Profiles

Longitudinal profiles collect bed topography data in the down-channel direction and provide additional points to capture changes in the thalweg and channel slope that might otherwise be missed between the monumented cross sections and is a cost effective way of capturing that data. As referenced above in the Cross Section definition, it is critical that horizontal and vertical control be established and the same as for the cross sections and other monitoring efforts. This is an issue when data is collected by different methods or teams of people and at different times.

There is a link to Minnesota Pollution Control Agency (MPCA) guideline which specifies a longitudinal profile has to be 35 times top channel width or 20-40 times the bank full width or 2 full meanders. For the purposes of this plan the group recommends that longitudinal profiles be collected from the upstream most cross section to the downstream most cross section for each of the Stations listed.

This data will provide the maximum depth of individual bed features and spacing between bed features. Criteria for each of the longitudinal profile surveys will include the following:

1. Three features measured along the profile: thalweg, water surface, and incipient bank overtopping elevations.
2. Elevation measurements at major changes in the bed topography.
3. Recorded locations (station distance) of cross sections.

Longitudinal profiles could be sampled with acoustic Doppler current profilers coupled with GPS-grade survey gear covering multiple paths (simply following the thalweg or in the case of deeper water using a zig-zag pattern or point cloud sampling approach that the thalweg could be picked out of for example). Deeper pool cross sections could be sampled the same way for the deeper underwater portions.

Bathymetry

Bathymetry can be collected in a variety of ways and usually consists of a continuous record of distance from the measuring device to the reflective bottom of the water body, in this case the channel bed. The frequency and spacing of the data points representing the bed depends on the tool used and its operation. Bathymetry collects data only in the channel portions that are of sufficient depth to support the boat and/or instrumentation and so thereby exclude information close to the banks, in very shallow water and obviously information from the channel sides and overbanks. Bathymetry is more expensive to collect and process for interpretation than longitudinal profiles and channel cross sections but does provide a higher density of information. Also, even with current technology bathymetric measurements are more difficult to repeat verifiably for specific locations.

Bathymetry for this monitoring plan is recommended to be referenced directly to specific cross sections and monuments for ground truth/verification and should be conducted in the same year that cross section and longitudinal profile data are collected. Due to the expense, it is recommended that Bathymetry be collected every 10-20 years in the absence of a large geomorphic change event or in conjunction with the cross sections and longitudinal profile in case of such an event.

Sediment Sampling

Sediment sampling related to the geomorphology of rivers is conducted both in the flow itself and in the physical features that surround the flow including the stream bed, bars, banks, and overbanks. Both instream and bed and bank samples are part of the proposed monitoring plan sampling program.

In Stream Sediment Sampling

In stream sediment sampling is typically divided into categories based on type of transport in the channel. Suspended Sediment and Bedload are two major categories based on type of transport (see the USGS definition). Wash load and Bed Material load is a way to categorize sediment based on whether or not it makes contact with the river channel bed. Turbidity is an optical property of the water based on the scattering of light in the water column. Total Suspended Solids (TSS) can include both organic matter and inorganic sediments suspended in the flow. TSS is a good descriptor of Water Quality and is not the same as Suspended Sediment. Sediment sampling can include measurements of the load and/or concentration of material in the sample and then an analysis of the grain size and organic or other non-mineral content in that load. Finally, the bed material itself can be sampled at different depths (surface, subsurface, etc.) and locations in the plan form of the channel (thalweg, pointbar, overbank, etc.) to provide grain size information about sources and deposits of material available for transport by the stream.

As a starting point, the following Table from the WEST report is included to show as a reference of locations of existing data and initial pre-GMT discussion recommendations for sediment monitoring. The recommendations were that sediment samples representative of the size of bedload that is transported at bankfull stage be collected from and used to calculate sediment competence and determine bed stability at the following locations.

Table 2: West Report Provisional Data on Stream flow and Sediment Data Collection Sites

PROVISIONAL DATA, SUBJECT TO REVISION

Table 1. Streamflow and sediment data collection sites for the Red River of the North and selected tributaries near Fargo, North Dakota, during the 2011 spring high-flow event.

[SS, suspended sediment; BL, bedload; P, point samples]

Site identi-fication number (fig. 1)	USGS station number	Site Description	Data Collected
1	463421096451000	Red River of the North near Christine, ND	SS, BL
2a	05054000	Red River of the North at Fargo, ND	SS, BL
2	465603096472900	Red River of the North at County Road 20 near Fargo, ND	SS
3	05059300	Sheyenne River above diversion nr Horace, ND	SS, BL, P
4	05059330	Sheyenne River at Horace, ND (below diversion)	SS, BL, P
5	05060100	Maple River below Mapleton, ND	SS, BL, P
6	464243096495100	Wild Rice River near St. Benedict, ND	SS, BL
7	05060550	Rush River near Prosper, ND	SS
8	465752096573000	Lower Branch Rush River east of Prosper, ND	SS
10	5053000	Wild Rice River near Abercrombie, ND	SS, BL
11	5058980	Sheyenne River on Gol Road near Kindred, ND	SS, BL, P
12	463749096432500	Wolverton Creek at County Road 50 near Comstock, MN	SS

Table 2 of Appendix C of the Meandering Belt Width Analysis provides additional information on the available sediment data and duration of collection for the Project area and pre-Project sampling to date and provides a good characterization of the baseline conditions for sediment.

Table 3 below is another source of monitoring data information downloaded from the MPCA website and lists Sediment load monitoring sites with the gaging entity or agency responsible for the data.

Table 3: Sediment Load Monitoring Sites for Red River and Tributaries

Watershed	Stream	EQuIS	Site Description	Hydstra ID	Latitude	Longitude	AIS	Gaging Entity	Tribal Land
Mustinka	Mustinka	S000-681	Mustinka River nr Wheaton, CSAH9	H55060002	45.813804	96.50878		MNDNR	
Mustinka	Mustinka	S002-001	Mustinka River nr Norcross, MN9	H55044003	45.887126	96.213407		ACOE-Stage	
Mustinka	Twelve Mile	S003-124	Twelvemile Creek nr Wheaton, CSAH14	H55065001	45.860700	96.358600		ACOE-Stage	
Bois de Sic	Bois de Sioux	S000-553	Bois de Sioux River nr Doran, CSAH6	E54018001	46.152335	96.579456		USGS	
Bois de Sic	Bois de Sioux	S003-107	Bois de Sioux River nr White Rock, SD, CSAH10	E54034001	45.862500	96.573611		USGS	
Bois de Sic	Rabbit	S001-029	Rabbit River nr Campbell, US75	H54017002	46.111722	96.493056		ACOE-Stage	
Otter Tail	Otter Tail	S002-000	Otter Tail River at Breckenridge, CSAH16	H56105001	46.274485	96.579919	Zebra Mussel	MNDNR	
Otter Tail	Otter Tail	S005-142	Otter Tail River nr Elizabeth, CSAH10	E56050001	46.369743	96.017579		USGS	
Otter Tail	Pelican	S000-556	Pelican River nr Fergus Falls, MN210	H56048002	46.291470	96.143420	Zebra Mussel	MNDNR	
Red River (	Red River of the Nor	S002-097	Red River of the North River nr Kragnes, CSAH26	H57026001	46.976761	96.820069		USGS at Fargo	
Buffalo	Buffalo	S002-125	Buffalo River nr Georgetown, CR108	H58033001	47.049780	96.753688		MNDNR	
Buffalo	Buffalo	S003-152	Buffalo River nr Hawley, CSAH31	E58059001	46.850165	96.330854		USGS	
Buffalo	Buffalo	S007-586	Buffalo River nr Glyndon, CSAH19	H58048002	46.896996	96.576876		MNDNR	
Buffalo	S. Branch Buffalo	S004-148	S. Branch Buffalo River nr Glyndon, CSAH79 (28th Ave. S.)	H58050001	46.847919	96.614904		MNDNR	
Wild Rice	Wild Rice	S002-102	Wild Rice nr Hendrum, CSAH25	E60112001	47.266713	96.796894		USGS	
Wild Rice	Wild Rice	S007-619	Wild Rice River nr Mahnomen, CSAH25 (230th St)	H60029001	47.311097	95.952178		MNDNR	Yes
Wild Rice	Wild Rice	S001-155	Wild Rice River at Twin Valley, CSAH29	E60088001	47.265785	96.246613		USGS	
Wild Rice	S. Branch Wild Rice	S003-309	S. Branch Wild Rice nr Felton, CR27	E60124001	47.113126	96.385776		USGS	
Marsh	Marsh	S002-127	Marsh River nr Shelly, CR113	W59007001	47.444622	96.815188		USGS nr Shelly	
Sand Hill	Sand Hill	S002-099	Sand Hill River at Climax, US75	E61039001	47.612055	96.814755		USGS	
Sand Hill	Sand Hill	S003-136	Sand Hill River nr Fertile, 450th St. SW	H61006002	47.514108	96.341687		MNDNR	
Red River (	Red River of the Nor	S000-008	Red River at Grand Forks, Riverside Bridge	E61046001	47.943278	97.050139		USGS	
Red Lake	Red Lake	S000-031	Red Lake River nr Fisher, CSAH15	E63078001	47.800522	96.809407		USGS	
Snake	Snake	S000-185	Snake River nr Big Woods, MN220	H68011001	48.413943	97.107158		MNDNR at Alvarado	
Snake	Snake	S003-101	Snake River nr Warren, CSAH34	E68031002	48.209796	96.717949		USGS	
Snake	Middle	S000-700	Middle River at Argyle, CSAH4	E68017001	48.340201	96.816483		USGS	
Lower Red	Tamarac	S002-100	Tamarac River nr Robbin, MN220	H69051002	48.492813	97.107270		MNDNR nr Stephen	
Lower Rec	Kittson County Ditch	S007-587	Kittson CD27 nr Kennedy, CSAH1	H69014001	48.673274	97.041314		MNDNR	
Two	Two	S000-569	Two Rivers nr Hallock, CSAH16	H70012001	48.796722	97.105780		MNDNR nr Northcote and at Hallock	
Two	N. Branch Two	S007-588	N. Branch Two Rivers nr Northcote, CSAH4	H70021001	48.861760	96.958636		MNDNR	
Two	S. Branch Two	S005-387	S. Branch Two Rivers at Hallock, MN175	H70018001	48.775611	96.937354		MNDNR	
Red River (	Red River of the Nor	S007-127	Red River of the North River at Emerson, Manitoba, Manitol	E69001002	49.002711	97.222158		Environment Canada	
Thief	Thief	S002-079	Thief River nr Thief River Falls, 140th Ave NE	E65014001	48.186964	96.173228		USGS	
Thief	Thief	S002-088	Thief River nr Holt, CSAH7	H65017001	48.300320	96.070830		MNDNR	
Thief	Mud	S002-078	Mud River nr Grygla, MN89	H65041001	48.325305	95.743281		MNDNR	
Clearwate	Clearwater	S002-118	Clearwater River at Red Lake Falls, Bottineau Ave	E66050001	47.888080	96.274540		USGS	
Clearwate	Lost	S002-133	Lost River nr Brooks, CR119	H66048001	47.843194	96.010000		MNDNR	
Clearwate	Clearwater	S002-124	Clearwater River at Plummer, CR126	E66041001	47.923292	96.046418		USGS	
Red Lake	Red Lake	S003-172	Red Lake River at Red Lake Falls, CR13	H63025001	47.896919	96.274326		MNDNR	
Red Lake	Red Lake	S002-077	Red Lake River at Highlanding nr Goodridge, CSAH24 (310th /	H63007001	48.048478	95.808828		USGS/ACOE-Stage	
Lower Rec	Tamarac	S006-994	Tamarac River nr Florian, CSAH1	H69036001	48.426249	96.627660		MNDNR	
Two	S. Branch Two	S002-365	S. Branch Two Rivers at Lake Bronson, US59	E70033001	48.732529	96.667493		USGS	
Roseau	Roseau	S000-115	Roseau River at Caribou, CR53	E71005001	48.983056	96.449444		USGS	

Ref: MPCA

Suspended Sediment Concentrations (SSC)

Suspended sediment samples are composited across the cross section from 10 locations for a cross section averaged load. Often ADCP is run across the section for a full profile of velocities. For the Project Geomorphology Monitoring Plan, Suspended Sediment Concentration (SSC) is the primary measurement variable recommended for regular in-stream sediment sampling and analysis. It is recommended SSC be collected at each of the water quality monitoring sites identified in the Water Quality monitoring section of the Monitoring Plan.

The GMT could examine if there are existing SSC, TSS, and turbidity data that could be used to determine if there are statistically valid relationships between these parameters or if there would be value and cost savings in collecting this type of paired data. Given the characteristics of the sediment load on these rivers, which is silts and clays, perhaps the cheaper TSS measurements could be used to supplement the more expensive SSC measurements. This might allow for the development of a continuous daily sediment record.

Point Sampling (P)
The point sampling listed in the table above is done at 3 lateral locations on a cross section and are discrete samples at 3 discrete depths at each location that unlike SSC samples are not combined and averaged. They are collected and analyzed separately. Often an Acoustic Doppler Current Profiler (ADCP) is run across the section for a full profile of velocities. The ADCP also provides some information on how variable sediment concentrations are in the water column.
Point sampling data, while not as high a priority as SSC sampling, is useful for describing the variability of sediment in the water column.

Point sampling is recommended to be a part of the monitoring program for the Red River initially once pre-construction and once post-construction to determine what the distribution of sediment is in the water column and if there are project effects. If the GMT determines it is providing valuable information then it could be collected every 5 years or related to very large flood events. For the Sheyenne and Wild Rice Rivers, the GMT recommends conducting the vertical profile point sampling during the 3 sampling events pre- and post-construction to verify whether the Project is affecting the relative concentration of sediment in the water column. This data will be part of the 3 sampling event/5 year GMT analysis and Monitoring Plan scoping evaluation.

Bed Load Sampling (BL)
Bedload data collection is only recommended on the Sheyenne River, if at all. The USGS found less than 1 % of the sediment transport in the Red River and tributaries was bedload material and so bedload is an insignificant proportion of the overall sediment. The only Red River site with coarse material is near Christine, ND during a large flow event.

There should be a tie between the results of post-construction monitoring and potential recommendations for sampling bedload. If changes are seen in the bed and banks in areas other than the Sheyenne River, it is recommended to include in this monitoring plan, that there would be an opportunity to look at additional bedload sampling throughout the reaches of concern as indicated by the empirical results of significant channel changes.

In Stream sediment sampling locations and schedule are included as a part of the Water Quality Monitoring and covered in detail in a later section.

Bed Material Sampling
Bed material can be sampled at different depths (bed surface, subsurface, etc.) and locations in the plan form of the channel (thalweg, pointbar, etc.) to provide grain size gradations, density, organic and water content information about those instream sources and deposits of material available for transport by the stream. The GMT should determine whether existing bed material sample data is available and sufficient or whether it should be collected prior to project construction to create a baseline. Bed material sampling would compliment some of the other data that is being collected like SSC and cross section change.

Overbank Sedimentation
Specific surveying and measurements of overbank sedimentation in the natural levee and back channel or overbank areas would be recommended including sediment coring to quantify the sedimentation due to Project overbank flow deposition. This recommendation is relevant for the staging area. Protocols for this type of sampling will need to be reviewed and defined for this specific effort by the GMT. A

stratified random sampling approach should be looked at to avoid the common problem of sampling only in obvious deposition zones which gives a distorted view of the amount of deposition at a reach scale. Particle size distributions would also be beneficial for understanding the flow sediment deposition dynamics.

THE SEDIMENT SAMPLING SECTION HAS NOT HAD INDEPTH DEBATE OR DISCUSSION SO NEEDS DETAILS AND ADDITIONAL SECTIONS ADDED.

Aerial Photography

Aerial photography is useful for observing changes and early information of possible changes. It is especially useful for capturing surface changes during and after major flood events that might not be recognizable at the ground level.

Aerial photo analyses can capture trends in the land surface that show up in the data over periods as short as 5 -10 years. For example, changes in the way land is worked that may be important contributing factors to changes that occur in the channels. Often nothing happens in channels until the big event so the aerial photography helps with interpretation of what drivers contributed to the changes precipitated by events.

The Fargo-Moorhead area has a standard for collection of aerial photography every 3 years but the authority that collects the photos does not provide for the post processing analysis. These photos have been taken every three years since 1995 of the Red River in the metro area but the flight path has not included coverage of the area of the diversion channel. The full extent and degree that all of the areas of interest are covered is currently being cataloged. There is no known sunset for the aerial photography sampling.

The Diversion Authority is initiating activity to have the aerial photography coverage include the diversion channel in the future. It is recommended that the Red River, diversion channel, and associated tributaries (i.e. Wild Rice River and Wolverton Creek in the inundation area) be flown for photography following events where changes to the channel shape are evident.

From the WEST Geomorphology Study Chapter 8-1 Monitoring Plan Aerial Photography:

> "Future aerial photography should be compared with previous aerial photography and bank line delineation shape files (included in Appendix Q). The United States Department of Agriculture (USDA) National Agricultural Imagery Program (NAIP) obtains new photography about every 1 to 2 years that covers the Project area. The data can be obtained from http://datagateway.nrcs.usda.gov/. The imagery is already rectified and geo-referenced so it can be easily overlain in GIS for comparison purposes.

Aerial photos don't provide information on bed change, floodplain or height changes but can provide qualitative information on channel migration. It is useful to use aerial photos when have corroborated evidence from cross sections to quantify accuracy so photography and evaluation of the photos should coincide with the cross section data collection.

The photographic analysis effort should focus on locating areas where obvious lateral shifts in the bank location have occurred compared to previous data sets. Significant shifts in channel locations with a rate of change greater than previously estimated should be flagged for further investigation and the bank lines should be delineated for comparison with future imagery data.

Changes in vegetation type and density should also be evaluated both in the riparian zone and as a measure of some land use changes. Although, there does not appear to be a direct link between riparian vegetation and lateral channel stability for the Red River based on earlier geomorphic assessment (West 2012), this evaluation could help identify areas where the geotechnical stability of the banks may have changed. Again, areas with significant changes in vegetation should be flagged for further investigation.

Following completion of the Project, the aerial photography evaluation should occur at the same frequency as the availability of new aerial photography (every 1 to 2 years). If no significant changes have occurred after 5 years, the evaluation frequency can be reduced to every 4 to 5 years. If no significant changes have occurred after 15 years, the frequency can be reduced to every 10 years. This evaluation should be repeated at a minimum of every 10 years. It should also be conducted following significant flood events and coincide with the cross section sampling for data comparison purposes in the monitoring program.

While aerial photography is good for capturing land use and vegetation which might very helpful for interpretation, Light Detecting and Ranging (LIDAR) imaging is a better tool for analysis of landforms.

Field Reconnaissance Activity

Adopted from the West report.

An *interagency* reconnaissance of the detailed study reaches should be conducted immediately prior to the Project construction completion and of the diversion channel immediately following construction (to establish baseline conditions) and every 5 years thereafter for the first 10 years. If no significant changes in the channel morphology are noted, the frequency can be reduced to every 10 years. At a minimum, a color photographic log with GPS locations should be created to document the reconnaissance observations for comparison with previous documentation. Further, if significant changes are found to be occurring along certain streams or stream reaches, future reconnaissance efforts could be focused on only these locations.

For each of the areas flagged for further investigation by the aerial photography evaluation, a site specific field reconnaissance should be conducted to understand the local conditions of the site and to help understand the causation for the noted changes. At a minimum, color photographs should be taken to document the conditions of the site. Subsequent visits to the site can be made at a frequency consistent with the magnitude and rate of the noted changes and the significance of the potential consequences resulting for those changes.

LIDAR

The first LIDAR was taken in 2001 and covered portions of the Project area. Currently, LIDAR data is collected when deemed necessary by specific jurisdictions and individual year coverage do not always encompass the entire Project area. Barr Engineering is creating a database of coverage for the Project Proposer that is expected to be completed and available spring 2015 (currently delayed).

As a complementary surrogate for cross section data in un-monumented areas of the Project it would be beneficial to fly LIDAR at the same frequency and year that bathymetry and cross section data is collected in the channels. While the ground elevations typically do not change that much in the area, LIDAR data can be linked with the bathymetry data to provide some estimate of change that can be linked to the longitudinal profiles and inform adaptive changes to the monitoring plan as needed.

The frequency of LIDAR surveys should complement the cross section data on the reaches in the areas not being surveyed. Once every 3 years focused in the river corridor. Sampling extents and frequencies are important to discuss and plan carefully. If capturing all of the change in a few areas of a river and the rest of the river is not changing then you over estimate the amount of change. If you are not capturing the change on the monunmented cross sections then you also don't have an accurate picture for interpreting affects due to the project.

- Adaptive management might mean bringing these and other technologies (LIDAR) into the monitoring process.
- Fly over's and comparing time series of data sets would give a better assessment of the whole river. Should be tied to the ground data for verification and other information.

To explore LIDAR as a monitoring tool, LIDAR flights that focused on just the channel and Project area might be cost effective for monitoring at a 2 year interval coordinated with cross section surveys for validation. LIDAR collection during periods of low flow common in the late fall when coupled with GIS based measurement might provide a good idea of how banks would be changing over time and could be documented as GIS data layers once protocols and accuracy are determined based on the joint field measurements and LIDAR analyses.

Also, reach scale analyses should be conducted with the support of the LIDAR and aerial photography data. The scope of the reach scale analyses will be developed as part of the the GMT analysis activities.

A LIDAR viewing tool for the basin showing elevations mapped over land surface can be accessed at: http://gis.rrbdin.org/LIDARviewer/

GEOMORPHOLOGY AND WATER QUALITY INTER-RELATIONSHIPS

Broadly defined, water quality is described by the physical, chemical, and biological characteristics and properties of the river and its floodplain. Under this broad definition of water quality, geomorphology is useful in describing the physical characteristics and properties of the riverine system, while the chemical quality of a river is represented by the concentrations or flux of major ions, nutrients, trace elements and organic compounds in the water and sediment. A river's biological community is more often seen as the integration of the physical and chemical quality of the river. In other words, the biological communities of a river respond to changes in both the physical and chemical qualities of the river. Conversely, the state of vegetation can significantly impact the changes in river morphology. Uncertainty about whether vegetation planted as part of the project will become well established before Project operation leaving a potential risk of significant non-beneficial changes to the river that might need to be addressed.

When viewing water quality under this broad definition, changes in a river's geomorphology can also be seen as affecting the chemical characteristics of a river. For example,

- Connectivity of the floodplain is key to uptake of nutrients.
- Changes in sediment impact biological functioning and benthic processes from light and filtering.

- Changes in pattern and profile of river can affect aeration and oxygenation.
- Morphology changes can affect energy pathways for sources of organic matter, changes in productivity and can also have an impact on oxygen values in the rivers.
- In turn, nutrients also respond to dissolved oxygen and energy inputs to the system.
- Increased connectivity of the rivers to currently disconnected landscape may introduce new chemicals and concentrations.
    - The diversion channel may induce secondary impacts from Metro area flow discharges being concentrated within the diversion channel.
    - Disconnected wetlands serve as buffers, so if they are connected to the system there is a potential loss of ecosystem services related to water quality.
- Upstream storage may have impacts on sediment, Dissolved Oxygen (DO), and nutrients.

These inter-relationships mean that the monitoring of Water Quality needs to be integrated with the geomorphic sites and results interpreted within the context of if and how the chemical character of the water is affected by the geomorphology. While the same geographic area should be monitored for both the geomorphic and water quality parameters, the water quality monitoring should be more continuous to capture the range in variation for diurnal and other variables.

Many design and operational elements of the Project are tied to avoiding problems that might affect the stability of the sediments and water quality. One such element is the planned meandering channel in the diversion channel from the Maple River confluence downstream. The meandering channel will be beneficial for reducing erosion as the water in the channel would seek to form its own meanders and establish a more natural and stable pattern. This should reduce erosion in the diversion channel and prevent some increased suspended load and nutrients to those connected channels downstream. Careful design of the low flow channel is needed to minimize the Project added portion of suspended sediment concentrations. Basic assessments such as turbidity monitoring that is widely and easily done would be instrumental in early detection of changes. Changes above thresholds (to be determined) might require an O&M response when in the diversion channel area.

Note: Water Quality monitoring is also done for understanding biotic systems. Biotic monitoring for Water quality usually encompasses TSS, Turbidity, and Dissolved Oxygen and usually does NOT include Nutrients.

WATER QUALITY MONITORING

Construction will likely cause some short-term water quality variance, but the Final Feasibility Report and Environmental Impact Statement (USACE July 2011) concluded that no long-term impacts of the Project itself are anticipated. However, water quality monitoring should be considered due to land use changes potentially affecting the water quality due to routing of water with less residency time before entering the rivers. Also, increased connectivity (the diversion channel and inlets into the diversion channel), additional channel length exposed to flow (the diversion channel), and changes to depth/duration of flood particularly upstream of the embankment are the reasons for water quality monitoring. There is significant historical data and on-going water quality testing already being conducted, which can be utilized and supplemented with additional measures and/or frequency in some locations. Monitoring pre- (before and during) and post-construction will help to illustrate any impacts that occur as a result of the Project. Data collection upstream and downstream of the Project would be necessary. A minimum period of sampling would encompass 5 years to capture the full hydrograph, then intermittent monitoring seasonally, tailored depending on events such as snowmelt and heavy summer rainfalls. Monitoring results for water quality may be an early indicator of developing issues in the other areas of interest such as the biological communities.

Possible drivers for changes in water quality are impoundment effects on anoxidization and stagnation through re-routing and holding water. Another might be the changing use of the Diversion by landowners for capturing more runoff than previously was routed into the stream systems. Because of these factors it is not clear how much the Project itself will influence water quality separate from other anthropomorphic changes in behavior in the watershed.

Water quality parameters to measure including the following:

1. Dissolved oxygen- can fluctuate during an average day
2. Suspended sediment concentrations
3. TSS to link to other historic data (It is more the lab method that creates the difference)
4. Turbidity
5. Nutrients
6. Specific conductance (which Indicates changes in water quality and then Ions and trace metals give what the source of the change is)
7. pH
8. Ions (Possibly: Would do at all sites consistently if going to since they are not expensive or difficult to sample.)
9. Trace Metals (possibly?)

Note: Sampling for Mercury and methylization stimulated by flooding when water goes anoxic was discussed by the GMT as a possible parameter to measure. Information from previous discussions was provided that with the plans for fewer operations of the Project (i.e. increased flow through town), the reduced risk of the waters going anoxic didn't warrant the much higher level of sophistication and cost in sampling that Mercury monitoring required. It is further noted that changes in trace metals may be indicators for sampling for Mercury methyliziation as a possible cause for those other changes. This requires further discussion.

Nutrient Monitoring Note: Even though there is a history of water quality monitoring in the area, the focus has not been on nutrients and it is unknown how the Red River responds to nutrients now. The DNR monitors nutrients on a restoration projects and some elements are taken at gauges.

Continuous Dissolved Oxygen Monitoring Considerations:

- If there is continuous sampling, then that would allow for a better understanding and more accurate estimate of loading in the stream.
- Dissolved oxygen can fluctuate a great deal on a daily basis. If there is a lot of biological activity, then there will be more oxygen at the sunniest part of the day and subsequently it would drop during the night.
- It is uncertain how the man-made channel will affect the water quality.
- Reducing sediment in water downstream of impoundment will impact the biotic components that could change the dissolved oxygen concentrations.
- The work on the Sheyenne may help inform the changes we might see on the Red River.
    - There currently isn't Dissolved Oxygen data for that area on the Sheyenne River.

- Consider continuous collection on a shorter term basis since it is more expensive to see how fluctuations change throughout the day.

EXISTING DATA SETS

- USGS is doing flow monitoring and Water Quality with the ND Department of Health (NDDH). There are three "Levels" of monitoring by the USGS & NDDH on the Red River and its tributaries in North Dakota ambient water quality monitoring program:
  - Level 1 –8 times/year
  - Level 2 –6 times/year
  - Level 3 –4 times/year

- MPCA is monitoring water quality at some locations.
- There is an interactive map for the International Joint Commission (IJC) with all of the data interactive at: Http://ijc.org/en_/Red_River_Basin
- There are some limitations on nutrient data availability earlier than 90's and 2000's. More data on trace metals exists prior to these times.
- See Figure 4 below for locations of MPCS and NDDH sites.

Water Quality Monitoring Locations and Site Specific Information & Recommendations

Table 4: Water Quality Monitoring Locations by River and Location

River	Location	Gage ID	Current Frequency	Historical Records
1.Red	Hickson	05051522	6 times per year	Yes
2.Wild Rice	Abercrombie	05053000	8 times per year	Yes
3.Sheyenne	Above Diversion	05059300	2 times per year	Yes
4.Maple	Mapleton	05060100	8 times per year	Yes
5.Buffalo	County Road 8		25 times per year	
6.Red	County Road 36			
7.Red	Halstead	05064500	6 times per year	Yes
8.Sheyenne	Hardwood	05060600		
9. Red	Fargo	05054000	8 times per year	Yes

1. Red River at Hickson, ND Upstream of the diversion channel
   - Significant historical data exists, completed for water commission.
   - Currently collected 6 times per year, needs to be increased to 8 times per year increasing the data collection in the spring.
   - Trace metals major ions and nutrients, not continuous DO. There is one with each sample.
   - Recommend taking continuous DO and turbidity in advance of the Project to understand background water quality.
   - No sediment currently collected. Start collecting SSC and conduct a sand/ fines analysis.
   - Recommended for upstream monitoring of the Project.
   - Include specific conductance and pH if doing continual data collection.

2. Wild Rice River near Abercrombie, ND
   - Note: There are no major tributaries between this gage and Hickson gage on the Red River.

- Has the most historic data in area.
    - Full flow gage, historic water quality data exists.
- This site needs to be maintained for sediment.
- Needs SSC monitored also.
- Turbidity is not measured as part of ambient water quality monitoring.
- NDDH is sampling 8 times a year for water quality but not currently doing SSC but are doing TSS.
- Recommendation: Do SSC 8 times a year to match water quality monitoring frequency.
    - Minimum period of sampling:
    - Over period of 5 years capture full hydrograph then do intermittent seasonally.
- Tailor measurement program to what the parameter you are measuring.
- Cannot assume that Project operation is limited to spring flood events because we have these summer storms now.
- SSC relationships are developed in 3 years or more of data. Spot sample validation is necessary. Dependent on range of flows.

3. Sheyenne River above Diversion Channel
    - There is historic data with a 2 times a year frequency.
    - Historic data exists, however this location is affected by frequent siltation.
    - This site recommended for monitoring impacts of the Project.
    - This station would need additional maintenance due to siltation.

4. Maple River below Mapleton, ND
    - No sedimentation data currently being collected. This should be added here for the monitoring effort. Previously this site was part of the sediment study with lots of SSC collected. There were both continuous monitoring for a season and other spot data.
    - Also Turbidity and Conductivity were measured here.
    - This gage can be seasonal due to near zero flows during winter months.
    - There is quite a bit of historical data.
    - A Level 1 sampling site.

5. Buffalo River at County Road 8
    - Possible 25 samples a year since 2007

6. Red River at County Road 36
    - Downstream of confluence with the Buffalo River

7. Halstead, ND
    - Should there be one closer to where the diversion reconnects with the Red River?
    - Currently water quality monitoring is limited.
    - There is a flow gage here some distance downstream of the Project.
    - This is a Level 2 monitoring site such as Hickson, ND. Keep existing monitoring program.

8. Sheyenne River at Harwood, ND
    - Captures both the Maple and Sheyenne Rivers.
    - Use time data before the Project to establish baseline conditions.
    - Bridge crossing site downstream of the Project.

9. Red River at Harwood, ND
    - NDDH conducts sampling 6 times per year. Not tied to flow gauging. Just a water quality monitoring site.

10. Red River at Fargo, ND
    - Fargo gage is cooperative gage MPCA and NDDH, USGS and cities of Fargo, ND and Moorhead, MN.
    - Sampling Frequency: 8 times/year by USGS
    - Relationship of Turbidity to SSC is being developed by USGS site specific.
    - Established in 2003 for continuous monitoring, with sampling back to 80's by the NDDH. Located in the middle of the Project.
    - There is a typical Fish kill areas just downstream of the city when get ½ inch of rain flushing out chemical and oxygen issues.
        i. Good location for water quality. Link with water quality, biology, and hydrology after draughts followed by heavy rains.
    - Use the data from this gage as the Baseline Data for the monitoring.
    - Parameters
        i. Surrogate measures of sediment
        ii. Ions
        iii. Dissolved nutrients: sulfate, total dissolved solids, pH, nitrate
        iv. 5 field parameters: DO, turbidity, water temperature, specific conductance, pH

11. Sample Locations on tributaries with State Water Commission by USGS.
    - Rush River at Amenia, ND - 05060500
    - Confluence of Rush River and Lower branch of Rush River near prosper Hwy 18 North of Castleton.

Other information considered while making above recommendations for water quality site selections:

- Current downstream sampling sites on the Sheyenne River are underwater during the spring so are not accessible during that time.
- Sheyenne River Diversion will partially operate with the Red River Diversion.
- Sheyenne River Diversion, City shuts off flow when operating. Will that change or be superseded with the Red River Diversion.
- Question is: Are the diversions affecting the sediment transport downstream of the diversion because the Project removes water and sediment.
- Maple River: Would be very difficult to get good samples. Suggest collecting at the Sheyenne River at Harwood, ND. Would capture both the Maple and Sheyenne Rivers.
- Collect now to establish baseline conditions
- MPCA has 3 load monitoring sites for pollution load monitoring at Fargo, Grand Forks, and at the Canadian Border where they collect 35 samples a year at a rate of 2/month and additional for storm events including:
    - TSS
    - T-tube
    - Turbidity
    - Total Nitrogen

        - Total Carbon
        - Nitrogen reported as TKN, NO2 and NO3
        - Total Phosphorous
        - Dissolved orthophosphate

    - MN's other water quality work is done at the 8 digit HUC level including:
        - Buffalo River Subwatershed site S007-586, 1.75 mi N of Glyndon, CSAH19
        - Buffalo River at Co Rd 8
            - 25 samples a year since 2007.
        - Red River Site S002-097 at CSAH26, 7 mi N of Fargo/Moorhead. Upstream of the confluence with the Buffalo River
            - 35 samples /year
        - Red River at Road 36 just downstream of the confluence with the Buffalo River
        - Buffalo River: WPLMN sampling site (S002-125) at CR108, 2.5 mi SE of George town.
        - Buffalo pour point
            - Co Rd XX
        - Wild Rice Pour point confluence WPLMN site: S002-102, Wild Rice River 0.5 mi E of Hendrum, CSAH25.
- Rush Rivers
    - Because they are small and their entire contribution will be going to the diversion channel it is recommended that it is not necessary to monitor the Rush.

Sheyenne River at Kindred, ND is not recommended for this monitoring plan

- It is in the glacial delta so may not be representative of the Diversion.
- Has good historical data
- Level 1 Monitoring site

Water Quality Sampling and Testing
Need consistency of analysis of constituents for comparisons so it is recommended that the monitoring effort leverage existing sampling programs and take steps to define, determine and maintain comparability of sampling protocols and analyses.

- NDDH:
    - Enhanced Water Quality Monitoring is currently on the ND Side of the river and samples are sent here for analysis.
    - Nutrients and general cation analysis and trace elements are analyzed here.
    - TSS
- USGS Labs:
    - For SSC
    - Composite and grab samples collected.
    - Protocol for Turbidity is to be measured in the field and not analyzed in the lab.
- MPCA:
    - Water quality data (TP, TKN, NO2NO3, TSS, Turbidity, Carbon?, Ortho P?)
    - Grab samples for above mentioned parameters.
    - Hand held units for DO, pH , conductivity, water temperature

- Lab analysis is performed through a master contract with the Minnesota Department of Health (MDH) and contracted local partners use any of the 8 labs on the master contract.
- Turbidity is analyzed in the lab and not in the field anymore.

For quality control, occasionally spot checking and documenting the laboratory results by sending the same sample split to two labs to verify consistency of analysis is needed. Results will be obtained by already existing methods of collection and laboratory arrangements.

The issue of who or what agencies will have primary monitoring responsibility and data management of each or all of the Water Quality components will need to be resolved before water quality monitoring for this Project begins. While each of the existing programs hope to maintain their activities there is no guarantee they will be funded into perpetuity. This reinforces the value of planning, sampling, and laboratory protocols through this monitoring plan that are explicit and comparable if responsibilities are shifted or shared through time.

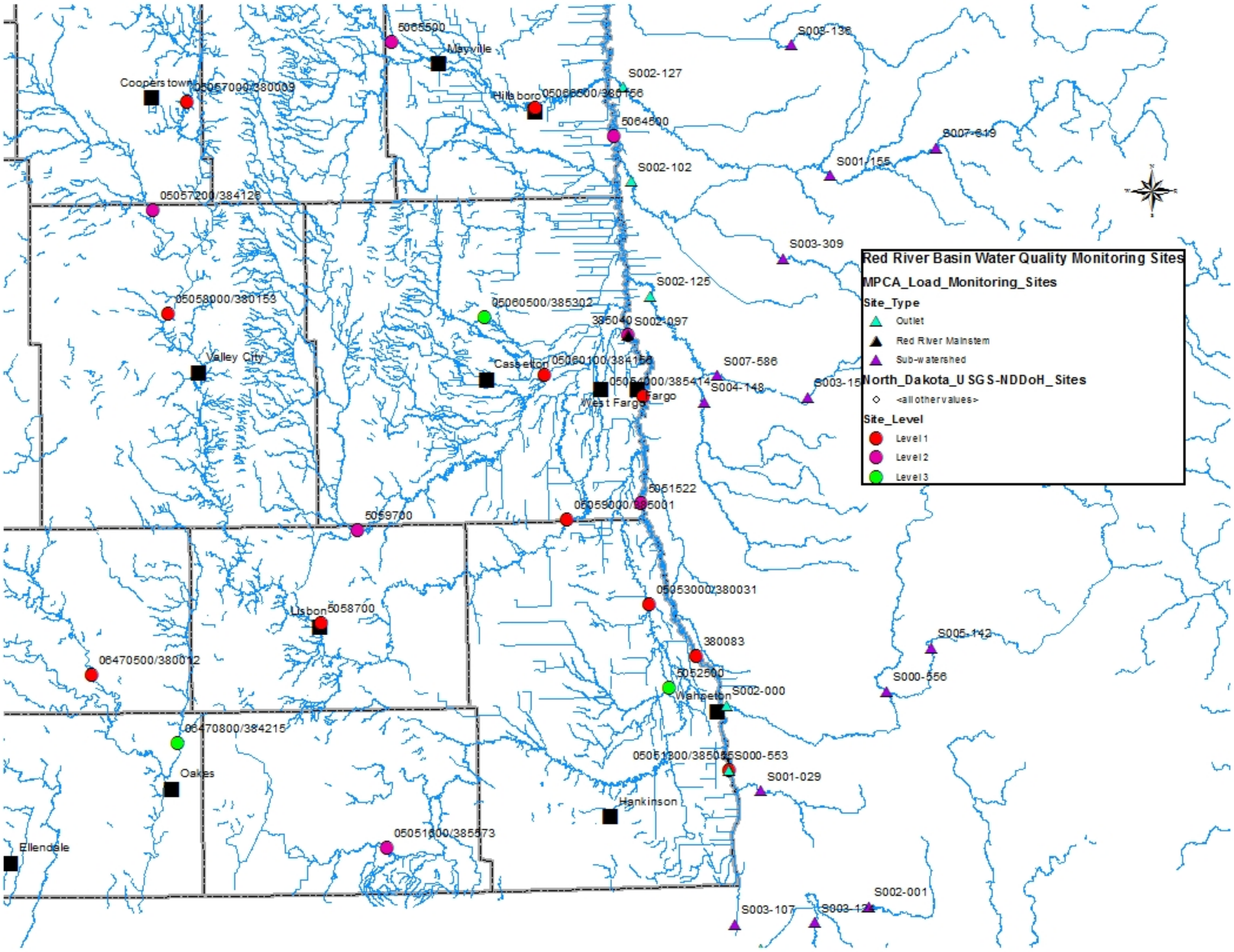

Figure 4 Red River Basin Water Quality Monitoring Sites (MPCA Load Monitoring and North Dakota USGS and ND DoH Sites)

GEOMORPHOLOGY & WATER QUALITY MONITORING SCHEDULE

Tying monitoring data collection to a single metric such as event size (100 yr) or year interval may not provide the flexibility required to monitor changes in the system capturing both natural and human induced responses. This proposed monitoring schedule provides event response plans and checkpoints for evaluating the monitoring plan to optimize sufficient data collection for verification and support cost efficiencies when changes in monitoring frequency are warranted by evidence of rates of channel change.

In mobile bed rivers geomorphic change is a function of both flow and flow frequency. While the Red River is not a typical mobile bed stream with active sand and gravel transport but is generally of finer grain size and slower rate of meander and bedform migration, it is not yet known the significance of 5-10 year events on bank stability. Also, any effects are likely to be Reach dependent to some degree.

The tributaries to the Red River and those that will be captured by the diversion channel such as the Rush River during events lower than those that require operation of the gates may show initial adjustments to the Project, especially until vegetation is re-established.

Having a monitoring interval of not more than 5 years will help capture base changes that are occurring between events with flows larger than 17,000 cfs when the Project is expected to go into operation.

Pre-Construction Monitoring

Establish monumented cross sections and begin monitoring pre-construction. Segments could be started right away and others could occur after construction begins in other sections of the basin.

Post-construction & Pre-operation: (Assumes no events that require diversion operation)

Recommend doing 3 surveys over the first 10 years to provide a good basis of information for defining natural changes in the absence of large events and diversion operation. Then move to surveying every 5 years and re-evaluate the cross section sampling interval after 25 years or 6 sets of surveys including 2 sets of bathymetry.

Sampling Frequency & Timing

It is recommended that sampling occur before, during and after construction and operation of the Project. Leverage how to do that based on the construction schedule with some areas rising to the top as time sequenced priorities based on earlier construction dates to capture the pre-construction data. For example, there is a plan for cutting off the Rush River right away so sections that would be impacted in that area would be sampled earlier.

Complete cross section data sets for each of the listed Geomorphic Monitoring Stations should be obtained three times in the next 5 years before the Project is constructed to help establish the pre-Project condition. If construction proceeds on the anticipated schedule, this would be followed by sampling every 2 years post-construction for 3 sampling cycles. Following each set of 3 sampling cycles the GMT will meet to assess the monitoring data as described below. This would give sampling symmetry before and after commissioning with samples every 2 years for 3 cycles. In the event the Project is operated to handle flooding, sampling would follow as soon as feasible so perhaps earlier than the second year but not later than the 2 year schedule.

Water quality sampling of some characteristics at some of the locations will be monitored continuously as noted in the section previously.

It is recommended that monitoring results be analyzed by the GMT after the first 3 monitoring sequences are completed and again after the 2nd set of 3 monitoring cycles post commissioning of the Project, noting percentages and directions of change. This analysis will inform the monitoring schedule in the future for different reaches and identify what frequency of sampling is needed to establish range of variability. For instance, the Red River may be more stable than the tributaries and so the tributaries may need more frequent monitoring than the Red River etc.

Table 5. Survey Schedule Matrix **2015 pre-construction monitoring was postponed until after EIS process is complete.*

		Required Surveys							***Conditional***
	Pre-Monitoring Plan	Pre-Project	2017	2019	During and Post-Construction 2021	2023	2025	Sampling interval TBD by GMT post analysis	Year of. or After - event Project operation
Cross Sections	2011 not all plan sites	Y	Y	Y	Y	Y	Y	Y	Y
Longitudinal Profile	None	Y	Y	Y	Y	Y	Y	Y	Y
Sediment Samples	2011, some sites	Y	Y	Y	Y	Y	Y	Y	Y
Bathymetry	Some	Y	Y	Y	Y	Y	Y	Y	Y
Aerial Photography	multiple	Y	Y	Y	Y	Y	Y	Y	Y
LIDAR	2001-others	Y	Y	Y	Y	Y	Y	Y	As needed and tied with Bathymetry and Cross Section
Water Quality (Some sampling will be continuous, others as associated with sediment sampling).	Multiple but not at all plan sites	Y	Y	Y	Y	Y	Y	Y	Y

DATA COLLECTION PROTOCOLS AND STANDARDS

Quality Assurance and Quality Control

Rigor and consistency of data collection techniques and standards is critical for quality assurance and verifiable quantification of change. A system for identifying qualified people for data collection and analysis is needed for quality control and assurance for this Project. Protocols should be documented for each of the data collection parameters listed in the plan including: cross sections, longitudinal profiles, bathymetry, LIDAR, Aerial Photography, Sediment Sampling, Water Quality sampling, etc. If protocols exist and accepted as standard operating procedures they should be discussed by the GMT to promote a shared understanding and implementation of the principles.

The GMT will work together to evaluate the standards of experience and sampling protocols that make sense in the study area. Developing a common field understanding and language for concepts such as bankfull or incipient bank overtopping elevations, will provide a basis for consistency and quality in data collection and interpretation. This will include opportunities for AMMPT to participate in field data collection at key points in the process and will require schedule and personnel coordination.

Data Management and Analysis

The RIVERMORPH data management software package (Software and Worksheets http://www.wildlandhydrology.com/html/RiverStability.html) associated with the Rosgen Stream assessments is a DNR preferred storage format. If another software package is used, data should be in a format that is transferable to RIVERMORPH. This should be part of the data management and analysis package supported by the monitoring plan implementation. Once raw data is input into the package the features of the software provide tables that help with data analysis. It incorporates standard graph outputs that have been reviewed for accuracy.

Other data management software packages like, but not limited to, DSS (Data Support System) used widely by the USACE and other agencies for converting data into model ready formats will be considered in the more detailed monitoring plan development.

Data Standards, Internal Reporting, and Storage

The Project Proposer is the final authority on the data standards, internal reporting and data storage components of any monitoring plan. This section makes recommendations for the framework so that the data is available and useable for future geomorphic analyses by the geomorphic working group members, adaptive management team, and others.

As mentioned, data has already been collected prior to and during the completion of the Minnesota State Environmental Impact Statement (EIS). Additional pre-construction data and post-construction data will be collected as proposed in this plan as well as data needed to further refine Project design and to meet permitting requirements. The following addresses data standardizations and data storage needs for the Project.

Data Standards

The data has been and will be likely continue to be collected by one or more contractor or agency. As this data will be used to assess Project impacts and Project modeling predictions as well mitigation effectiveness, it is vital that the data be collected and analyzed consistently.

The USGS has established protocols for some of the data proposed to be collected for this monitoring plan. This would include stream flow data, sediment, and water quality parameters. The USGS should be involved in the detailed conversations to follow this draft monitoring plan and documentation of the site specific protocols to be used by any agency or contractor collecting the data.

The MNDNR standard for qualification in cross section and geomorphic sampling and analysis is for the raw data collected for the geomorphic aspects of the assessment to be collected by practitioners trained specifically in Rosgen III channel stability assessment, received from accepted sources (e.g., Wildland Hydrology, Minnesota DNR). There may be additional peer reviewed references that should be considered in addition to the Rosgen method for a comprehensive analysis of the system.

Basic protocols included within the monitoring plans have already been discussed and agreed upon by key organization participants in the GMT. Any deviations to specific protocols developed for this monitoring plan would require the monitoring team approval, monitoring plan updates, and would need to be reported back to the AMMPT. In turn, any modifications made by the AMMPT would need to be agreed upon by the AMMPT and GMT, if applicable, and would need to be reflected in updates to the monitoring plans.

Data Management and Storage

The data will need to be accessible and shared for redundancy and analysis purposes as well as stored as part of the monitoring record and for future data needs. The AMMP recommends that the local sponsors manage and host the official repository of all of the data sets and completed analysis related to the Project into perpetuity.

Some data might be in long term storage with the USGS and other agencies as part of their regular sampling efforts. The data management and storage system established should utilize to the extent practical, these existing databases; however, there are several interdisciplinary needs for data streams associated with the Project that dictate the need for links to other servers so that there can be both a repository and a gateway to data sets with accessibility from a single point.

To aid in data accessibility, the local sponsors would establish a file and record naming system for all anticipated data file types. The file and record naming system would be applied to all documents Project related.

Data Reporting

It is critical that there be an established timeline for data sharing so that is made available for analysis as soon as possible after each sampling event. In the near future the GMT needs to outline expectations for the data report in terms of delivery timelines and formats. A straightforward data collection, data management, analysis, and reporting set of standards needs to be recommended and tied logically to the other aspects of the monitoring plan.

One recommendation from the GMT is that data would be available to members of the GMT in the raw form as soon as collected and post processing reports sent to the team as soon as available.

Monitoring Plan Adaptive Updates

In addition to updating monitoring plans, any modifications to data collection, reporting or analyzing would be documented in a master document. This document would track versions of the adaptive management and monitoring plans and would include descriptions or highlights of modifications. The local sponsor would be responsible for the master document and may utilize a QAQC team for this task.

EFFECTS DETERMINATION AND RESPONSE

A first step for evaluating the system and rates of change is to use existing data to start describing typical types of change and what types and scales of impacts would trigger a need for action. The AMMP will develop a basis for agreement on different thresholds of change for different Project or channel features. This will help lay the groundwork for a process to follow to determine appropriate action in the event there are changes post-construction outside an acceptable level of change.

Establishing Pre-Project Condition

A complete analysis will include establishing a data base that can support identification and character of change. Existing geomorphic assessments will help inform the description of the current range of variability. One preliminary task for the GMT is to become familiar with and carefully consider all of the existing data and monitoring analyses. Towards this end, Barr Engineering supplied a series of maps and figures (Figs 5-28 below) documenting part (not all) of the rich dataset that has been collected and analyzed for the Project already. Figures 5-9 are the maps that define where the data from the subsequent figures is derived. This is included here to give a more quantitative sample of variability in terms of river planform and channel geometry characteristics for the Red River of the North, Wild Rice River (ND), Sheyenne River, Maple River, and Rush River.

Included are plots of streamwise (river) slope, channel top width, meander amplitude, and curvature (as a surrogate for meander dominant wavelength). Please refer to the Meander Belt Width Report listed in the reference for all the term definitions. Also available are additional plots on sinuosity and channel aspect ratio, in the latter case only for the Red River of the North where bathymetry was available to define channel depth.

This monitoring plan is designed to build on the existing data and contribute to the shared understanding of the whole system. Because some of the existing data is taken with different protocols then are recommended by this current plan, all data should be reviewed for level of rigor in advance of comparative analyses.

The Red River and tributaries are dynamic river systems and are expected to show movement of their mobile boundaries. Sites that already show changes in response to existing processes need to be monitored as well as sites that are expected to show change in response to the Project construction and operation. Test sites outside of the Project impact area will also be monitored to help establish rates of change and natural variability in response to drivers other than the Project. Getting reference and pre-Project (pre-construction) data will help establish reference ranges of change rather than singular thresholds for delineating accelerated change outside of the range of norms.

Key stability indices/ parameters of change would include but may not be limited to:

- Cross sectional area
- Bed slope
- Width to Depth Ratio
- Thalweg elevation trends toward aggradation or degradation/incising
- Bank Height and slope

Explicit drivers to monitor and consider include but may not be limited to:

- Precipitation changes in duration, frequency, and volumes.
- Project operation variables
- Vegetation changes—Riparian Corridor, Trees, Power lines
- Overbank deposition
- Sediment
- Debris
  - Rotation into center of channel affects flows and can direct flow into banks.
  - Can also serve as bank protection
- Levees
  - Put weight on bank and increase potential for failure
- Hydraulic Drivers –Flow due to
  - Land use changes
  - Drainage

Significance of the changes will depend on the context of the change including: location, rates, secondary impacts of the change on: channel stability, ecosystem values, flood and infrastructure protection and other.

Some discussion of the importance of trees in the riparian zone and influences on channel geomorphology will be important for interpreting the monitoring data collected it is noted by the GMT that:

- Trees typically rotate into outer 3rd of channel
- Some were alive until recently, some were dead since 60's from Dutch Elm So dead trees could be mapped for changes in extent over time.
- In tall banks the roots are above the river shear stress zone and so don't necessarily provide toe or bank protection.
- When banks fail they lessen slope and vegetation can reestablish and become more stable creating a Bankfull Bench.
- The value place on the importance of woody vegetation for biological habitat functions is sometimes in water conveyance. In other words, to keep flood levels within prescribed ranges there are often maintenance requirements to remove vegetation that slows the flow and raises water levels. This same vegetation if left provide important riparian biological habitat functions.

PARAMETERS

The critical parameters for defining impacts and response action levels need to be defined. The GMT has started developing a list that will need to be more fully developed and defined:

- % of action
- Characteristics of bank and over bank areas/Riparian and other
- The fraction of total study area experiencing a given impact
- Human induced changes
- Status of boundary conditions
  - Vegetative
  - Outside of radius of curvature
  - Others
- Natural meander migration

- Decreases in sinuosity:
  - Driven by changes in hydrology, land use changes, precipitation
- Changes in Channel Migration and Rates

CHARACTERIZATION OF NATURAL VARIABILITY

The GMT recommends that a map with boxes and graphs of channel planform statistics be produced to work from as a visual aid that can be updated with additional GIS layers as information is collected and analyzed.

It would be useful to include a GIS layer in the Geomorphic Monitoring documentation the information provided above as well as where there are bank failures due to different mechanisms with percentages of the whole reach that each failure mechanism represents. By documenting changes in reaches of similar sinuosity labeled by river mile the bigger picture will emerge and be helpful for the characterization of natural variability.

The GMT completed an exercise utilizing aerial photography starting upstream and progressing downstream to highlight areas that might be important to consider for defining impact and thresholds. In general some of those areas had some common characteristics when large bank failures were evident.

Areas of really tall banks with Rotational Failures

- Occurring almost exclusively where the riparian corridor is modified with less trees so have evapo-transpiration lower.
- Some projects put in to drain water through river bank and greatly increased the failure rate by the pipes.
- Drainage swales and pipes that outlet on the bank and exacerbate the change.

CHARACTERIZATION OF EXISTING STRESSORS, PROBLEM AREAS, AND AREAS THAT WILL BE MORE SUSCEPTABLE TO PROJECT IMPACTS.

<u>Upstream of Staging Area</u>:
Wolverton Creek/Christine Dam:
This area is the starting point of high stream banks that are more susceptible to rotational failures due to their height and when fail contribute more sediment to the channel and larger changes to the riparian area.

- Driver: Structures like Hwy 2 measured sediment transport, a lot of bank failure by bridge.
  - o Flow and sediment in bridge areas are worse due to the bridge than the rest of the channel.
- Christine Dam - Modified rock arch rapids for fish passage. Completed in the last few years.
  - o It was surveyed pre-Project.
  - o Post Project monitoring is unknown at this time.
  - o Bank protection was placed on the right descending bank and left descending bank after there was a rotational failure from the aftermath of conditions of perpendicular low head dam.
  - o Now the flow vectors converge to center and don’t rotate around and impact bank.
  - o This is a response area to investigate.

- Defining cutoff between moderate to high banks to be defined later.

Red River Staging Area:

- Overbank sedimentation on floodplain potential to decrease bank stability and deposition in the staging area is a possible issue of concern.
    - Results presented at January 2013 meeting:
        - The maximum depth of sediment deposition on the overbank if everything drops out and is deposited close to the channel is one foot. The existing bank height is 20-30 feet high in n this area.
    - Jobson Park, boat landing areas with backwater of several feet might add some inches of sediment.
    - Most conservative estimate for all sediment deposited immediately adjacent to channel and not spreading out in the floodplain.

Retention Areas:

- Over sedimentation the banks won't be as high as in the staging area.
- Flow is never shut down, there will be flow that can mobilize
- Been in deep sediment in single flow areas.

Cemetery area:

- Erosion started in 1997 flood
- Triggered by flood

Oxbow/Hickson/Bakke:

- Meander cutoff about to happen.
    - Cutoff will serve as a driver due to slope change.
    - Need notes about the geomorphic changes due to the cut off.
    - Could the operation of the Project accelerate the cut off?
    - Relatively slow velocities in Red even at flooding and low grain sizes and hard to erode.
- Banks that are just slumping but not rotating can put toe wood bank protection.

Benefited Area:

- Lower bank heights than upstream.
- Still banks slumping but more localized because there is more vegetation.
- Less rotational failures.

Wild Rice River:

- Dam removal as part of mitigation.
- There are some major rotational failures evident.
- Abandoned bridge.
- One cross section in Staging Area.
- Half dam in the benefit area/ groin pushing flow from outside of meander bend.
- Staging Area:
    - Culvert under road—constriction
    - Bridge with Debris
- Top width seems pretty constant—needs to be verified.
- As move upstream the channel width might be more variable.

- Bridge with skeleton remaining.
- Road created meander cutoff and straight reach.

Red River downstream of Wild Rice River:
- Rose Coulee - Large drainage for storm water.
- Dam retrofitted for fish passage.
- Interstate
- Road bridges
- Dam—Midtown
- Levees near existing levee areas. Some areas will have more levees added.
- Investigate if there is a Dam in the meander cutoff just south of 32nd Ave NE. Is it a High Water bypass Dam?
- Dam in another cutoff
- Active drain south of Sheyenne River Inlet.

Sheyenne River:
- Devils Lake waters coming in will be another driver to consider.
    - Near bank full conditions with outlets running.
- Tougher to get baseline with changing hydrology from outlets suggestion to repeat 2001 survey and see if the flow changes have made changes.
- Also data collected for bio-assessment study on Sheyenne River with cross-sectional information.
- Determining if there is more pre-outlet information available.
- Determine sediment flux of Sheyenne River.

Upstream of Buffalo River Confluence—Entrance of Diversion:
- None identified yet.

Maple River:
- Abandoned bridge with downstream scour hole.
- Numerous cultural resources in the area.

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GEOMORPHOLOGY MONITORING TEAM COMMUNICATON PLAN

To successfully implement a Geomorphology Monitoring Plan will require coordinated communication between the agencies and stakeholders key to the planning, funding, and executing the plan components. The AMMP will contain much of the structure needed to support the study overall. This section highlights the critical intersections of data needs and collaborations that would support effective and efficient data collection and analysis specific to the geomorphic facets of an adaptive management effort.

IDENTIFICATION OF KEY ORGANIZATIONS AND POC'S

1. United States Geologic Survey, United States Army Corps of Engineers, Local Sponsors, Minnesota Department of Natural Resources, Minnesota Pollution Control Agency, United States Fish and Wildlife Service, North Dakota State Water Commission, and North Dakota Department of Health. Refer to Master Roster.
2. Participation with local watershed district or watershed organizations is anticipated to be coordinated by the Local Sponsors.

AGREEMENT AND IMPLEMENTATION OF PROTOCOLS

A method for discussing protocols and keeping them up to date with changing contractors and agency personnel is critical for ensuring accuracy and comparability of data sets over time.

1. Needs to happen in advance of field work, post-event situation, change in organizations/contractors, and change in protocol or technologies.
2. May require field visits to go over field methodologies, protocol.
3. Any changes or update to protocols agreed on by the key organizations technical experts will be shared with the larger adaptive management team through the representative to that group and the documentation will be updated and shared immediately for accountability.

SCHEDULING DATA COLLECTION EFFORTS

1. The geomorphology monitoring schedule will set a lapsed time and event basis for monitoring different characteristics of the Project system. Coordination between the identified technical experts/organizations shall be done in advance of the actual field work to allow for schedule adjustments/plan modifications.
2. It is acknowledged that the AMMPT will be sent the recommended schedule and any deviations based on the geomorphic needs. In turn, the adaptive management team will be communicate well in advance of the field season any suggested changes or necessary deviations based on other criteria like funding or changes in Project operation and other unanticipated changes.

DATA EXCHANGE

Data will and may be collected by more than one contractor or agency and that data needs to be shared for redundancy and analysis purposes.

1. Recommend that the local sponsors be the official repository/host of all of the data sets and completed analysis from the beginning of the monitoring program into perpetuity with a web-based system to share and post data and discussions.
2. Raw data shall be shared with other requesting agencies after collection.
3. Post-Processed data can be shared with all of the agency participants on a regular basis.
4. Data from the watershed districts and others may be included in this data base.

5. Data needs to be shared within 2 months of the end of the data collection.
6. Results need to be shared with the AMMPT by the end of the calendar year or 3 months prior to the next anticipated field season.

EVENT RESPONSE

The adaptive management team will communicate the schedule and budget allocated for event response in advance and whenever substantive changes are made. In turn, the GMT will communicate recommendations to the AMMPT in anticipation of events or as soon as possible in response to events.

1. Pre-Event: Implement Photographic or other surveys, engage sediment and flow monitoring for anticipated events.
2. During the event geomorphologists will visit the site and determine if high water marks and other surveys are needed during the event. This may be covered in the O&M portion of the Project responsibilities. This may be a requirement under the MNDNR Public Waters and Dam Safety Permit.
3. A geomorphologist specialist will be a part of the recon team to recognize impacts that are significant.
4. There needs to be specific decision rules for when actions can be initiated through the geomorphology specialists group.
5. The types of data collected and response should be the responsibility of the GMT.

STABILITY ANALYSIS

1. The meetings for interpreting the analyzed data with regards to geomorphic stability will be open and scheduled for participation by all of the interested agencies. The meetings will be the responsibility of the GMT and external facilitation might be a beneficial approach.
2. The interpretation and any recommendations based on the results will be shared with the AMMPT.
3. The AMMPT will be responsible for determining appropriate responses based on the geomorphic specialist group recommendations.

MITIGATION AND RESPONSE ACTION PLANNING

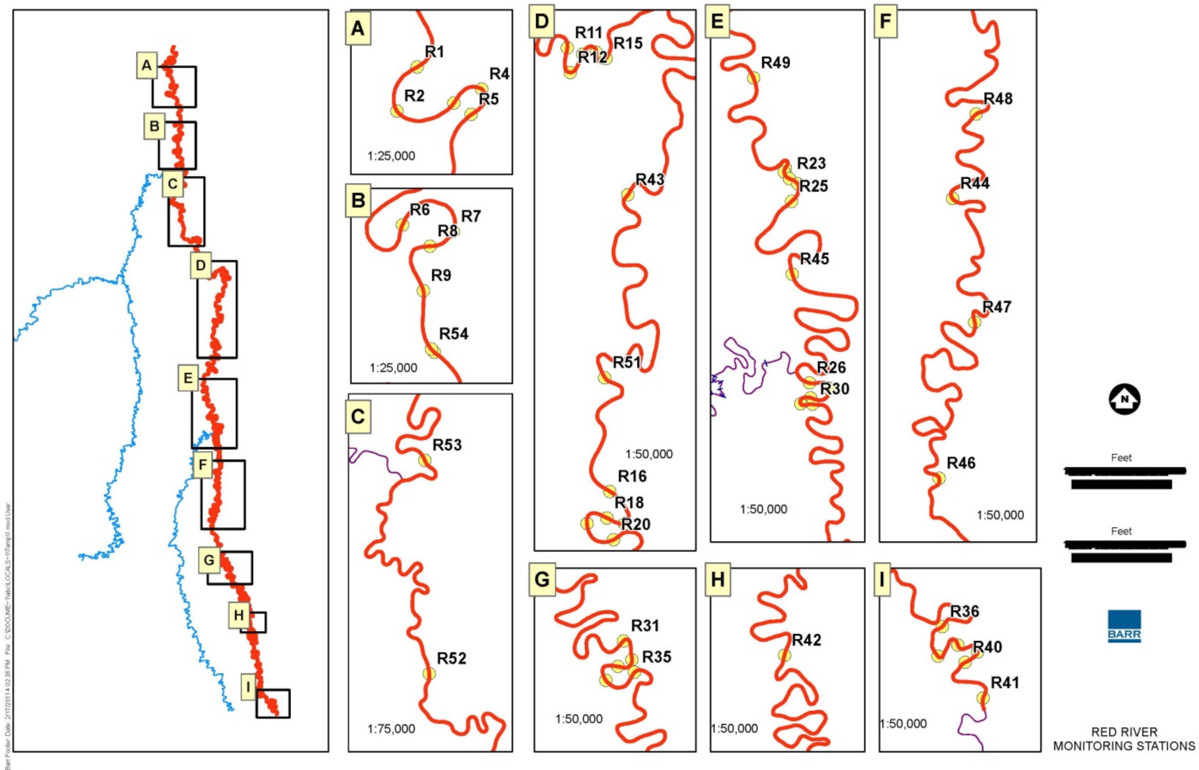
1. The monitoring plan results will inform what future mitigation or response actions are necessary.
2. The GMT provide to the AMMPT any recommendations based on analyzed data that would be useful for the AMMPT in collaboration with the GMT to develop mitigation or response actions for unforeseen impacts to the geomorphology of the system.
3. It will be up to the greater Project Agency group to approve a recommended plan for implementation.

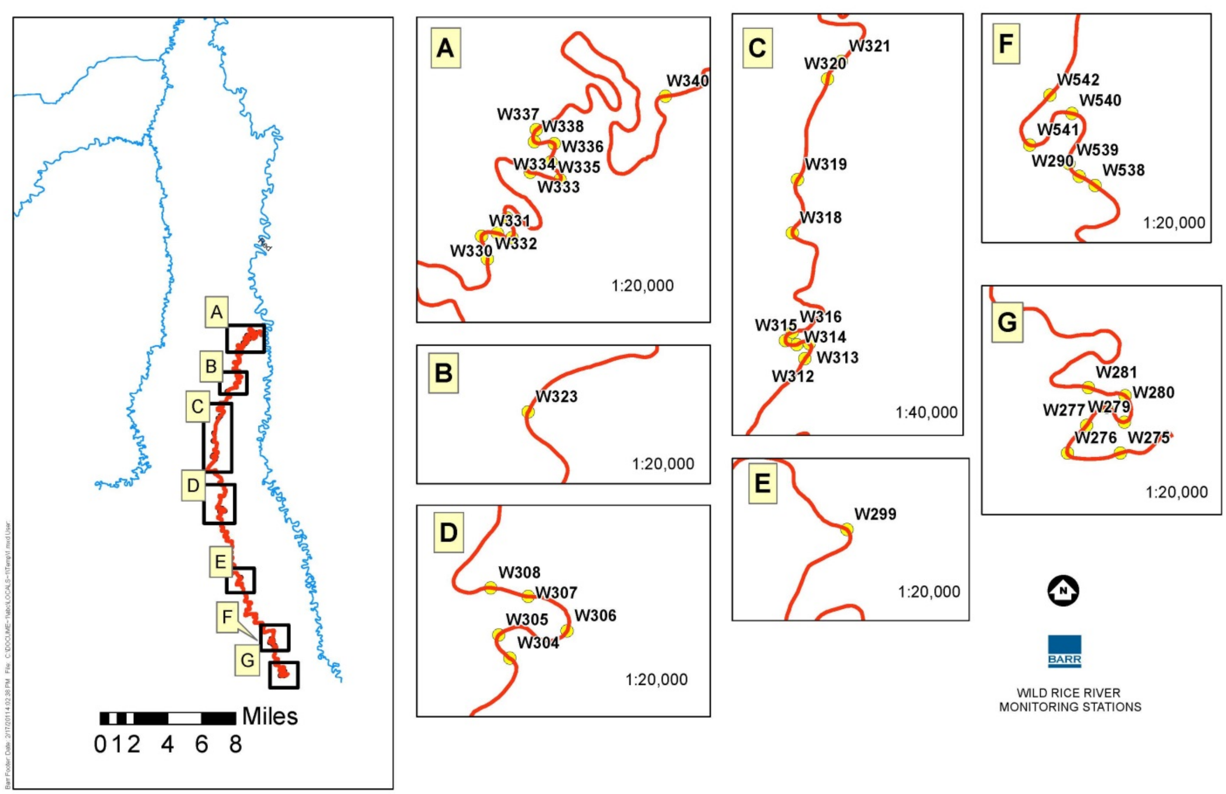
Communication with Local Agencies

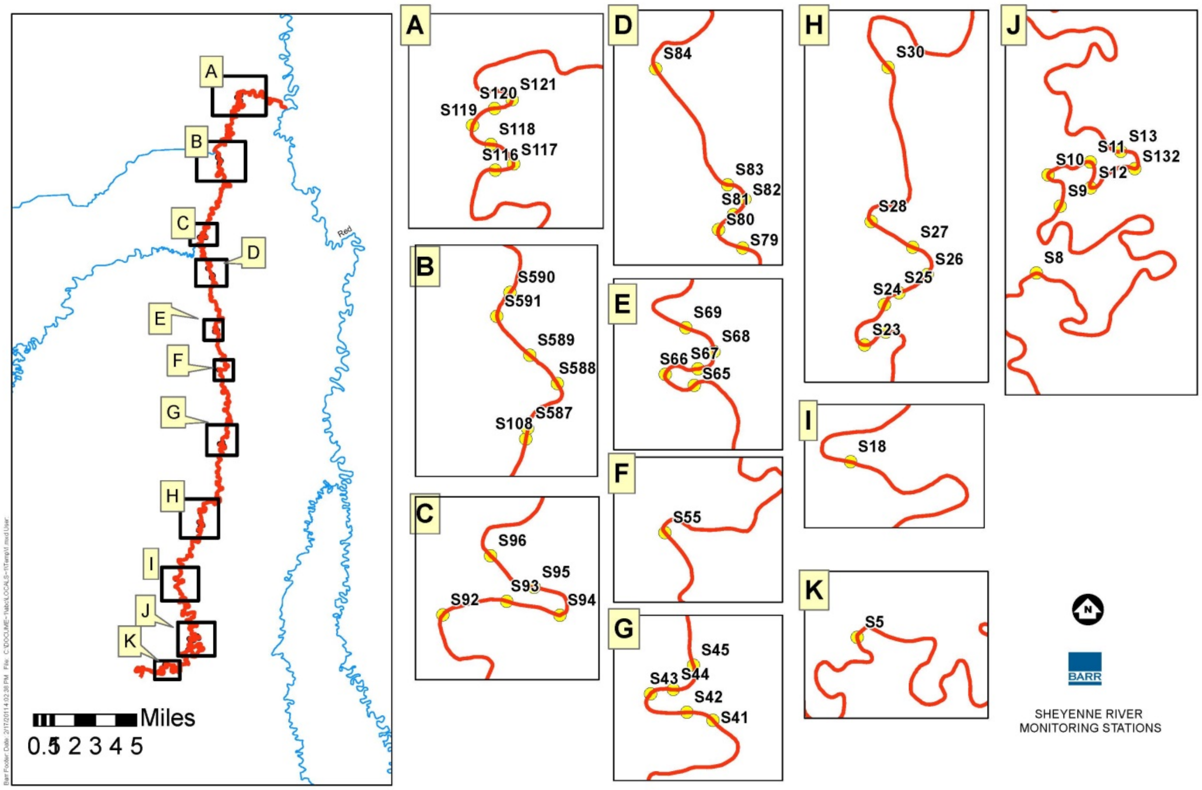
Included from WEST report as a place holder for future revision.

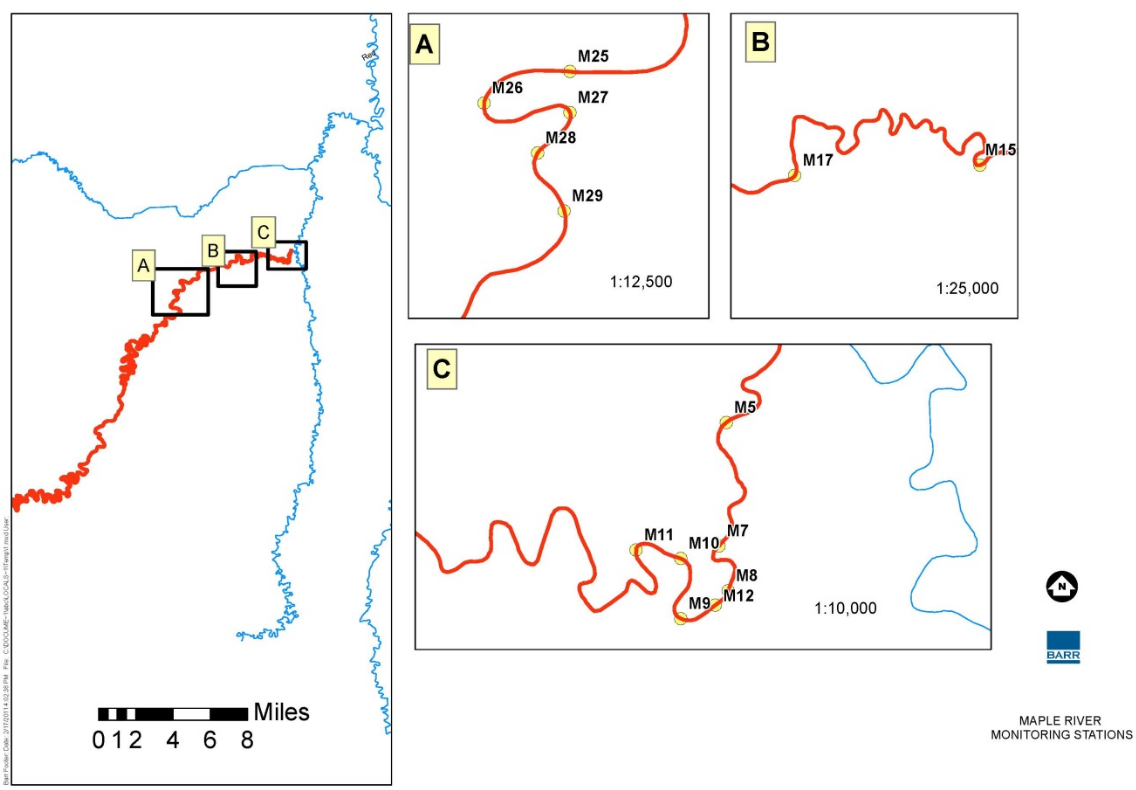
Regularly scheduled annual or more frequent communication should be established with representatives from local agencies with regard to channel morphology. Interested stakeholders in channel morphology would include the involved counties and cities, farming co-ops, USDA-NRCS, North Dakota and Minnesota Fish and Game agencies, USGS, US Fish and Wildlife, USACE, college extension services and involved irrigation and drainage districts. Such communication efforts would allow for the real or perceived changes in channel morphology identified by these agencies and/or their constituents to be documented and flagged for further evaluation. Regular communications would help focus the previously mentioned monitoring efforts and allow for concerns to be documented and appropriately addressed.

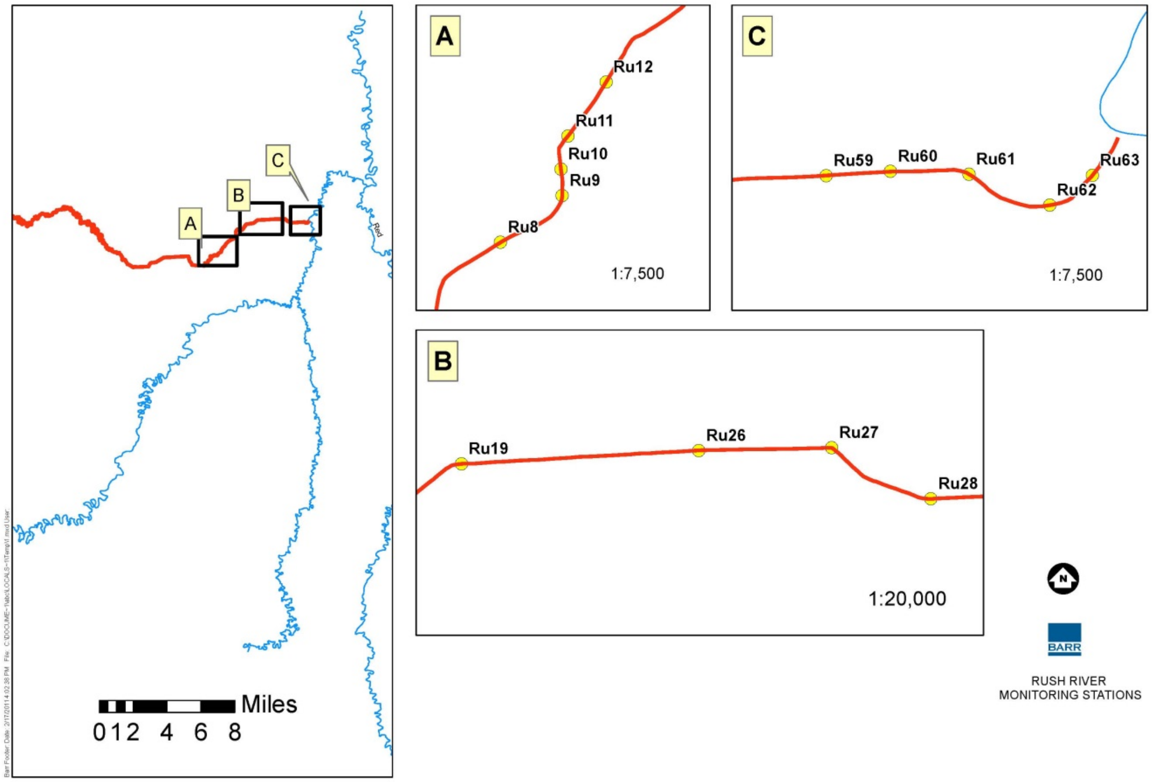
Figures 5-9 Barr Engineering Maps locating data in Data Analysis Figures






A
B
C
D
E
F
G
H
I
J
K
Red
Miles
0.5 1 2 3 4 5
A
S121
S120
S119
S118
S116
S117
B
S590
S591
S589
S588
S587
S108
C
S96
S95
S93
S92
S94
D
S84
S83
S81
S82
S80
S79
E
S69
S68
S67
S66
S65
F
S55
G
S45
S43
S44
S42
S41
H
S30
S28
S27
S26
S25
S24
S23
I
S18
J
S13
S11
S132
S10
S12
S9
S8
K
S5
BARR
SHEYENNE RIVER
MONITORING STATIONS


Red
A
B
C
Miles
0 1 2 4 6 8
A
M25
M26
M27
M28
M29
1:12,500
B
M17
M15
1:25,000
C
M5
M7
M11
M10
M8
M9
M12
1:10,000
BARR
MAPLE RIVER
MONITORING STATIONS



Figures 10-28 are attached as a pdf titled Amp-Curv-Slope-Width produced by Barr Engineering.

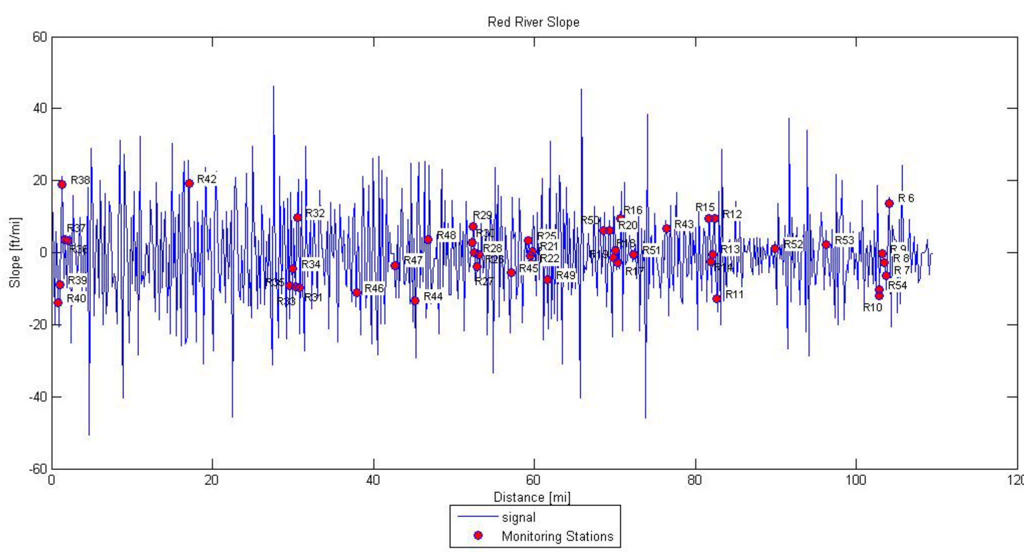
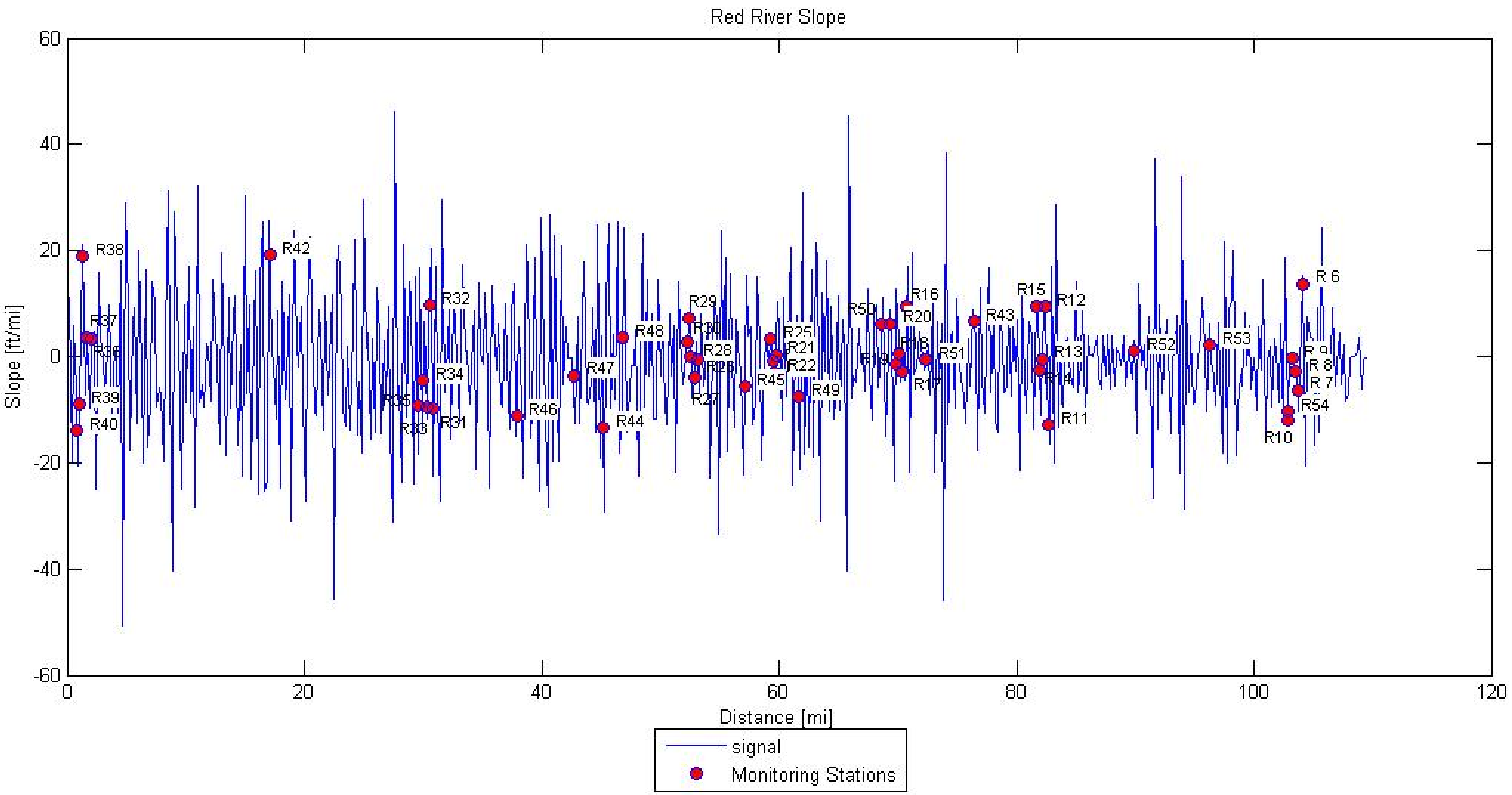


Figure 10 Red River Slope Amp-Curv-Slope-Width



Red River Slope
Slope [ft/mi]
Distance [mi]
60
40
20
0
-20
-40
-60
0
20
40
60
80
100
120
signal
Monitoring Stations
R38
R42
R32
R37
R39
R40
R34
R31
R46
R47
R44
R48
R29
R28
R27
R25
R21
R22
R45
R49
R50
R16
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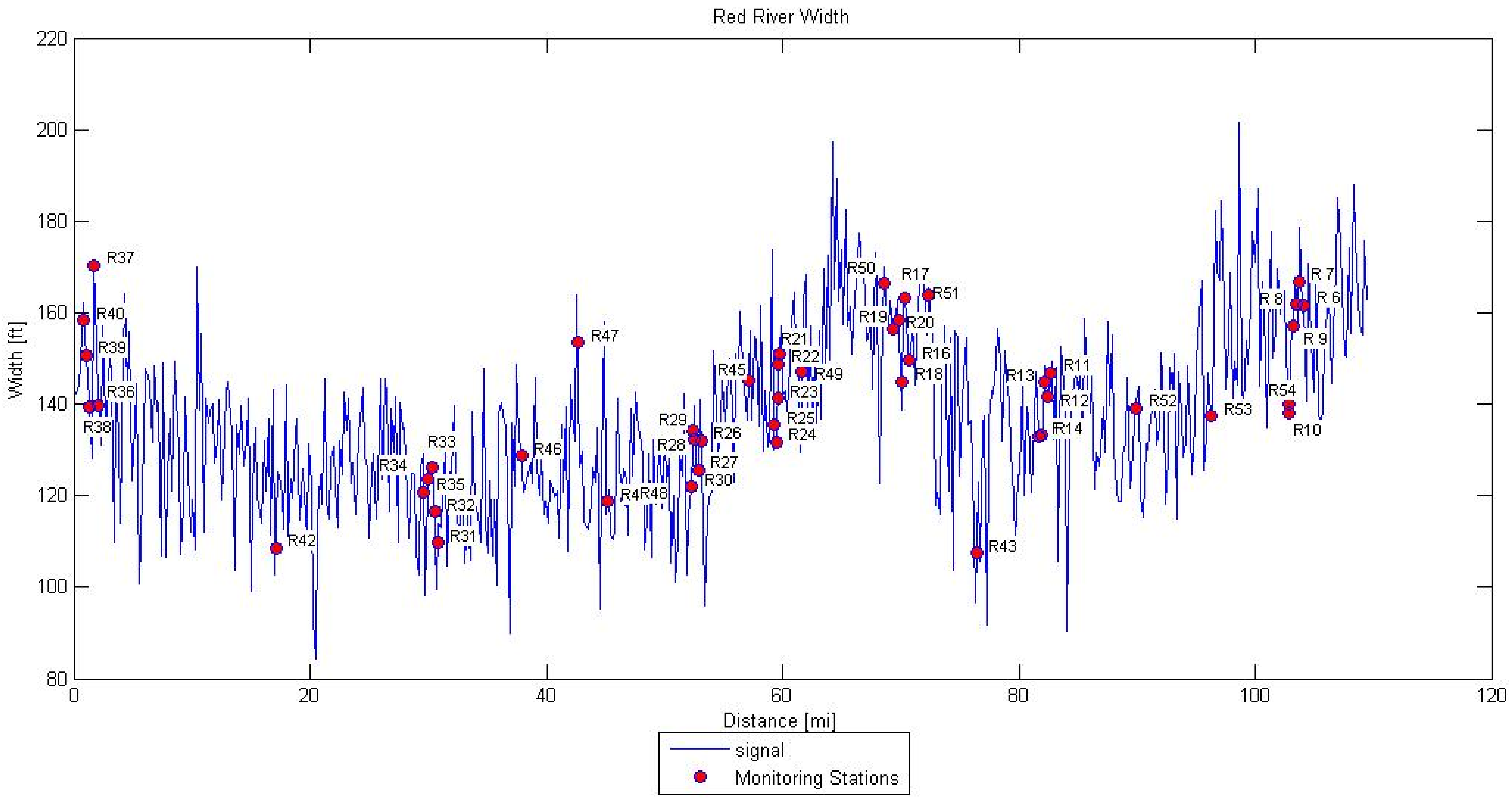
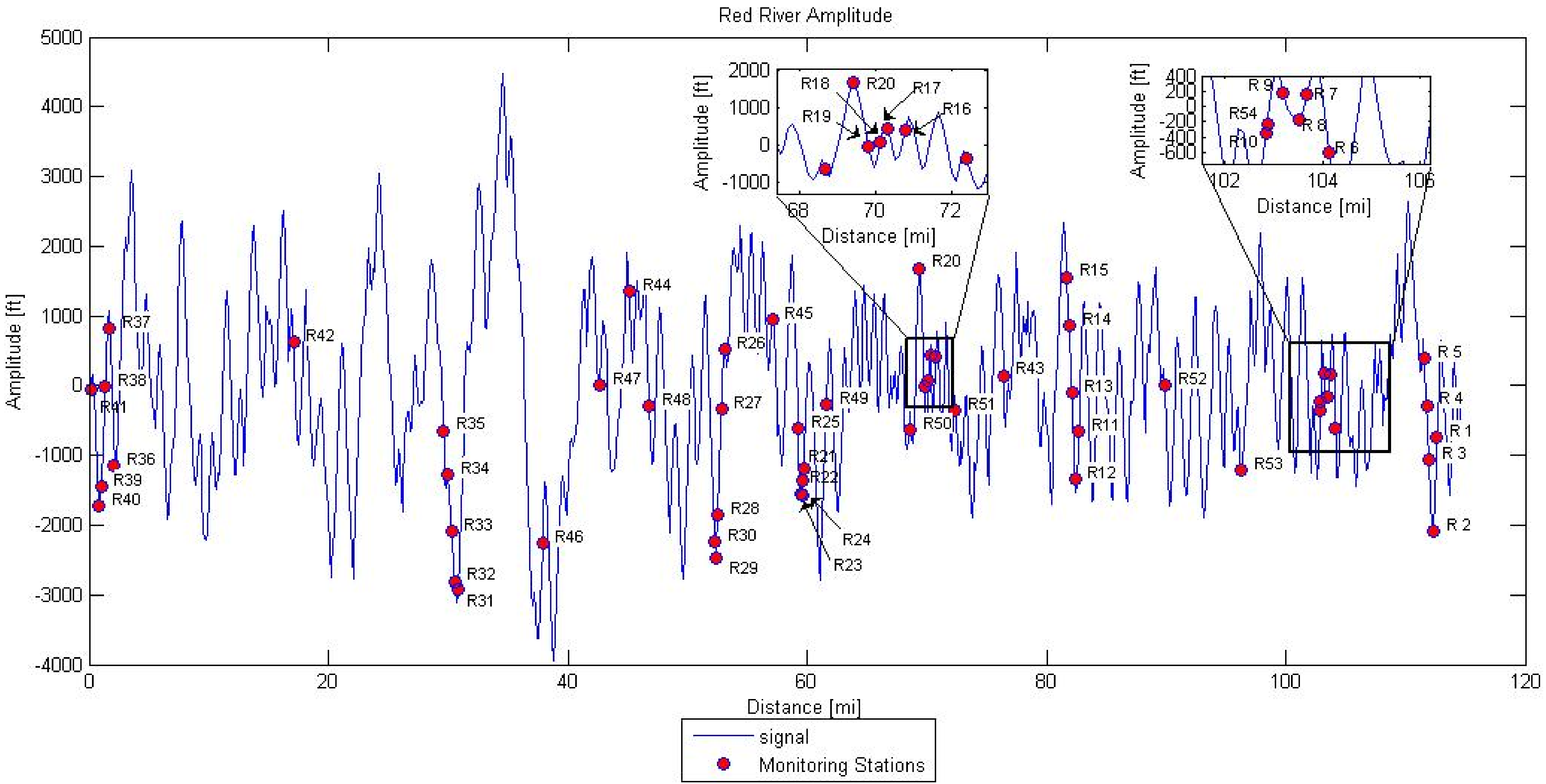
R11
R52
R53
R 6
R 8
R 7
R54
R10

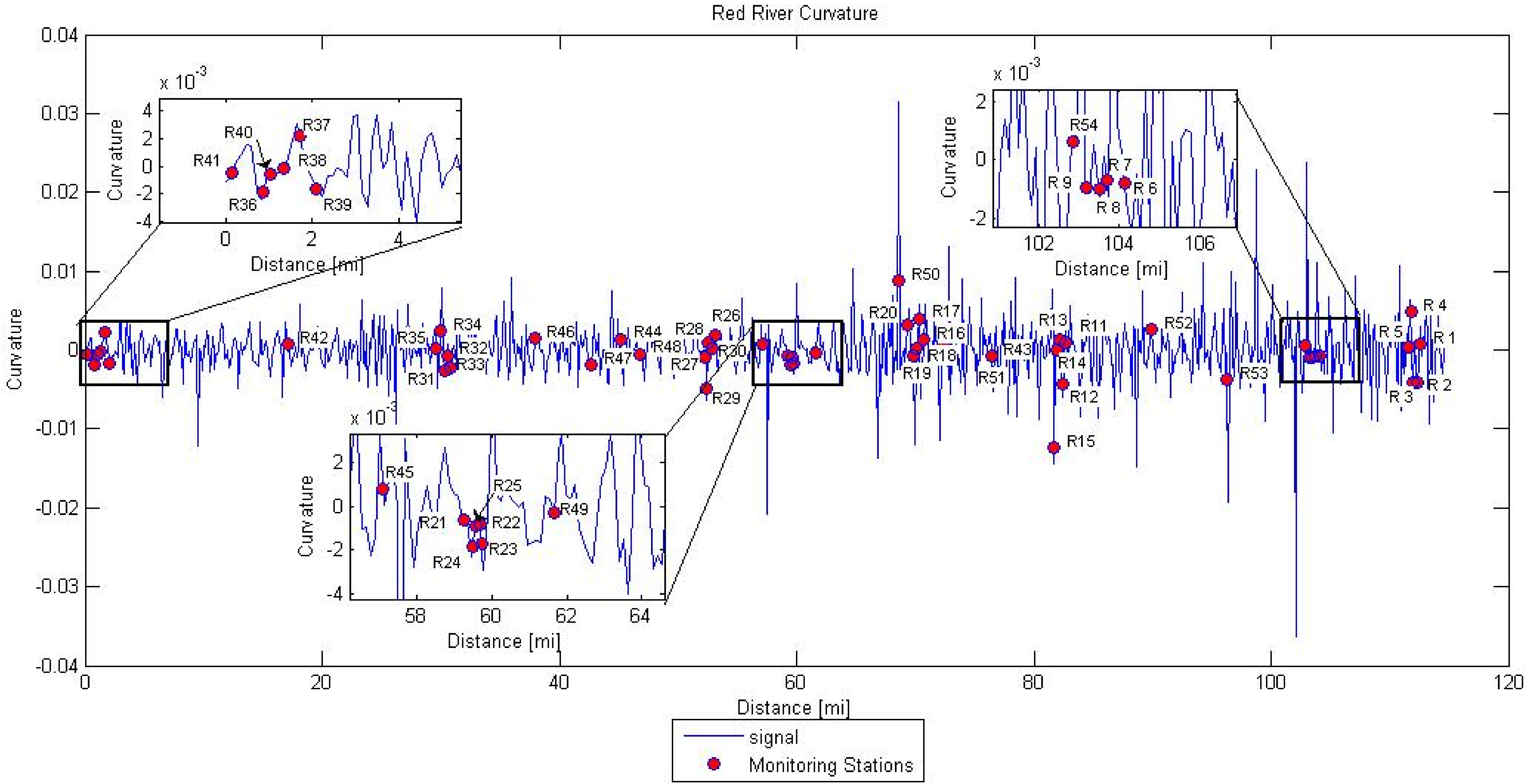


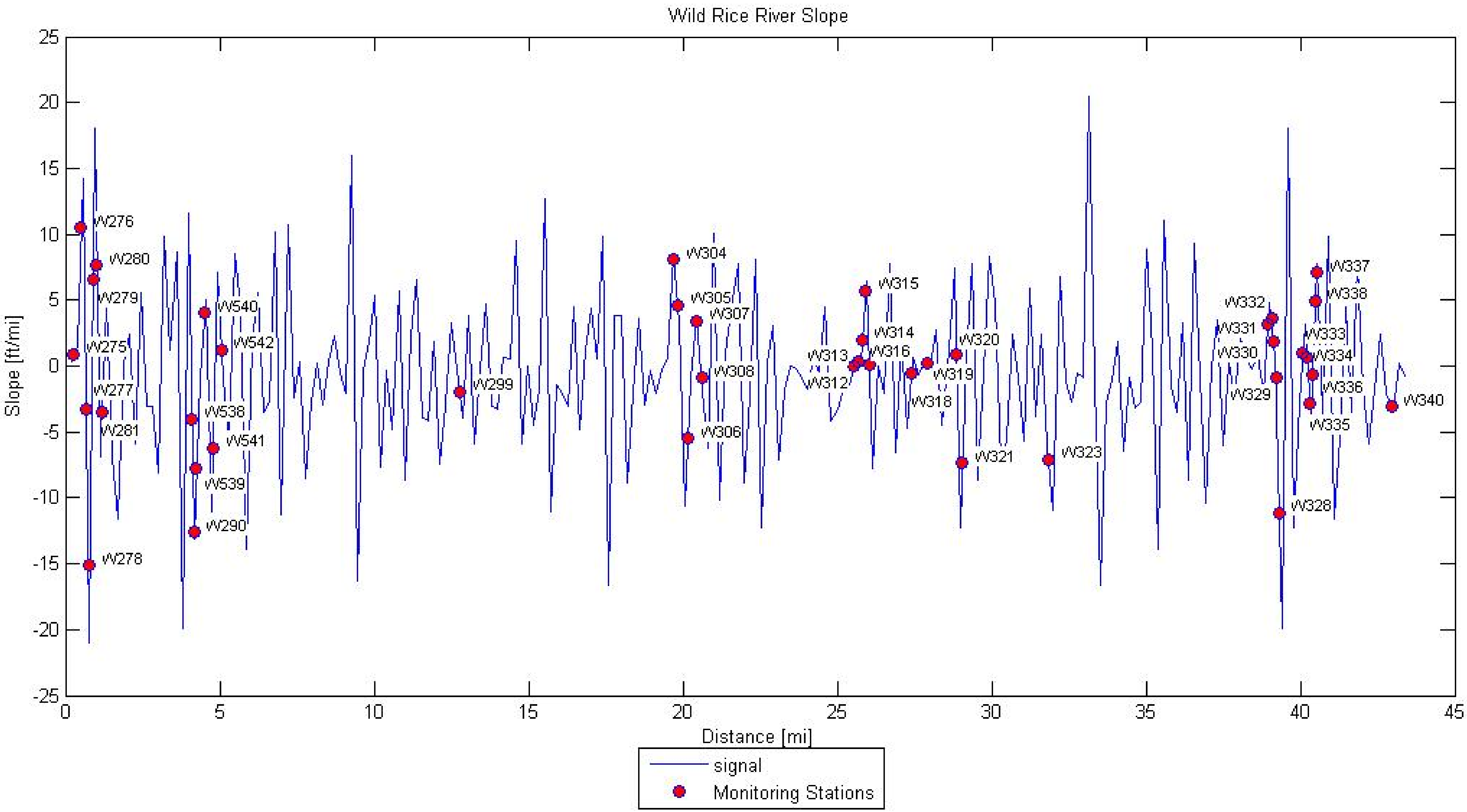
Red River Width
Width [ft]
Distance [mi]
220
200
180
160
140
120
100
80
0
20
40
60
80
100
120
R37
R40
R39
R36
R38
R42
R34
R33
R35
R32
R31
R46
R47
R4R48
R29
R28
R26
R27
R30
R45
R21
R22
R49
R23
R25
R24
R50
R17
R51
R19
R20
R16
R18
R43
R13
R11
R12
R14
R52
R53
R 8
R 7
R 6
R 9
R54
R10
signal
Monitoring Stations

51

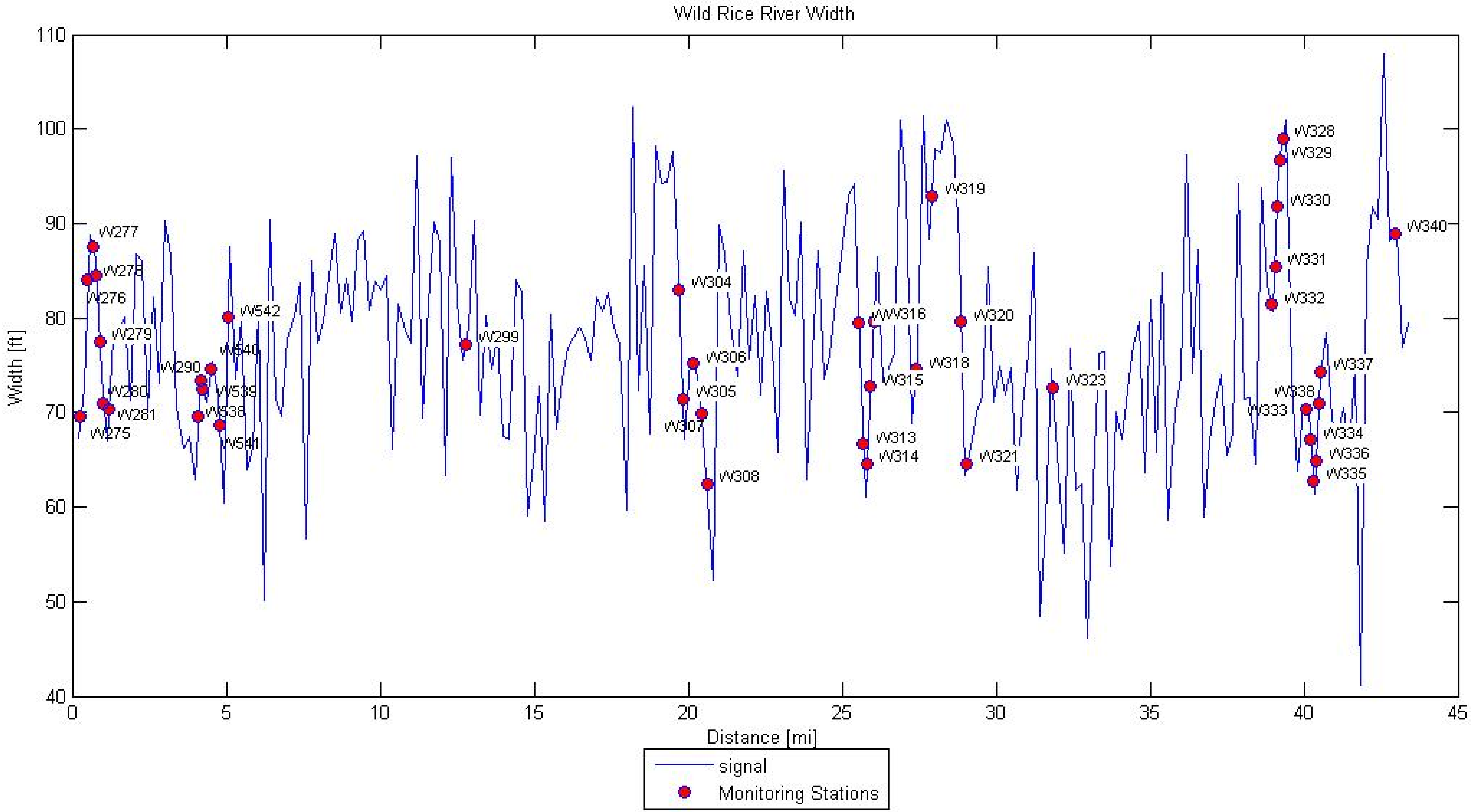


Red River Amplitude
Amplitude [ft]
Distance [mi]
signal
Monitoring Stations


Red River Curvature
Curvature
Distance [mi]
signal
Monitoring Stations
R1 R2 R3 R4 R5 R6 R7 R8 R9 R11 R12 R13 R14 R15 R16 R17 R18 R19 R20 R21 R22 R23 R24 R25 R26 R27 R28 R29 R30 R31 R32 R33 R34 R35 R36 R37 R38 R39 R40 R41 R42 R43 R44 R45 R46 R47 R48 R49 R50 R51 R52 R53 R54



Wild Rice River Slope
Slope [ft/mi]
Distance [mi]
25
20
15
10
5
0
-5
-10
-15
-20
-25
0
5
10
15
20
25
30
35
40
45
W275
W276
W277
W278
W279
W280
W281
W290
W538
W539
W540
W541
W542
W299
W304
W305
W306
W307
W308
W312
W313
W314
W315
W316
W318
W319
W320
W321
W323
W328
W329
W330
W331
W332
W333
W334
W335
W336
W337
W338
W340
signal
Monitoring Stations



Wild Rice River Width
Width [ft]
Distance [mi]
110
100
90
80
70
60
50
40
0
5
10
15
20
25
30
35
40
45
signal
Monitoring Stations
W275
W276
W277
W279
W280
W281
W290
W539
W542
W299
W304
W305
W306
W308
W313
W314
W315
W316
W318
W319
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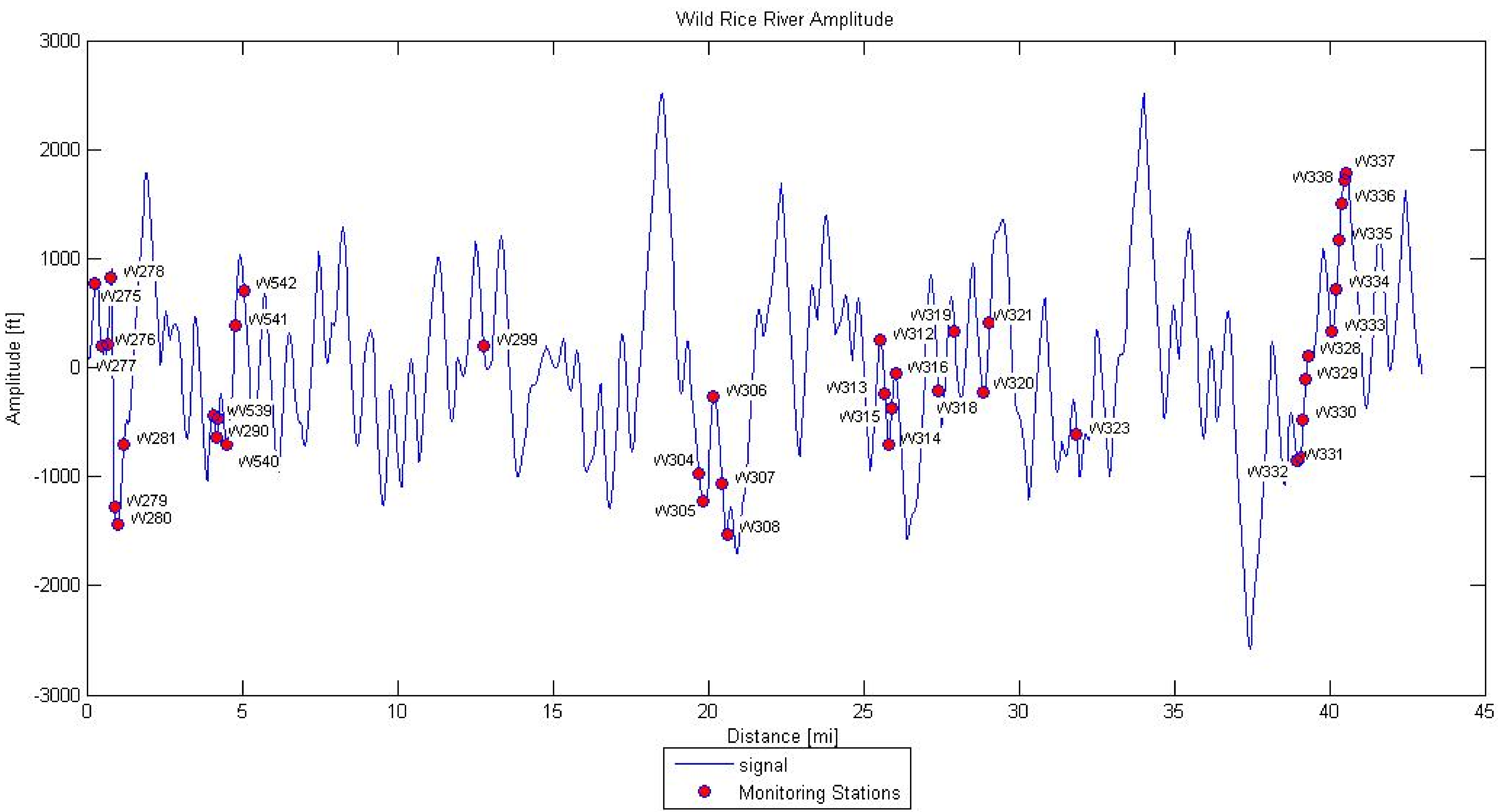
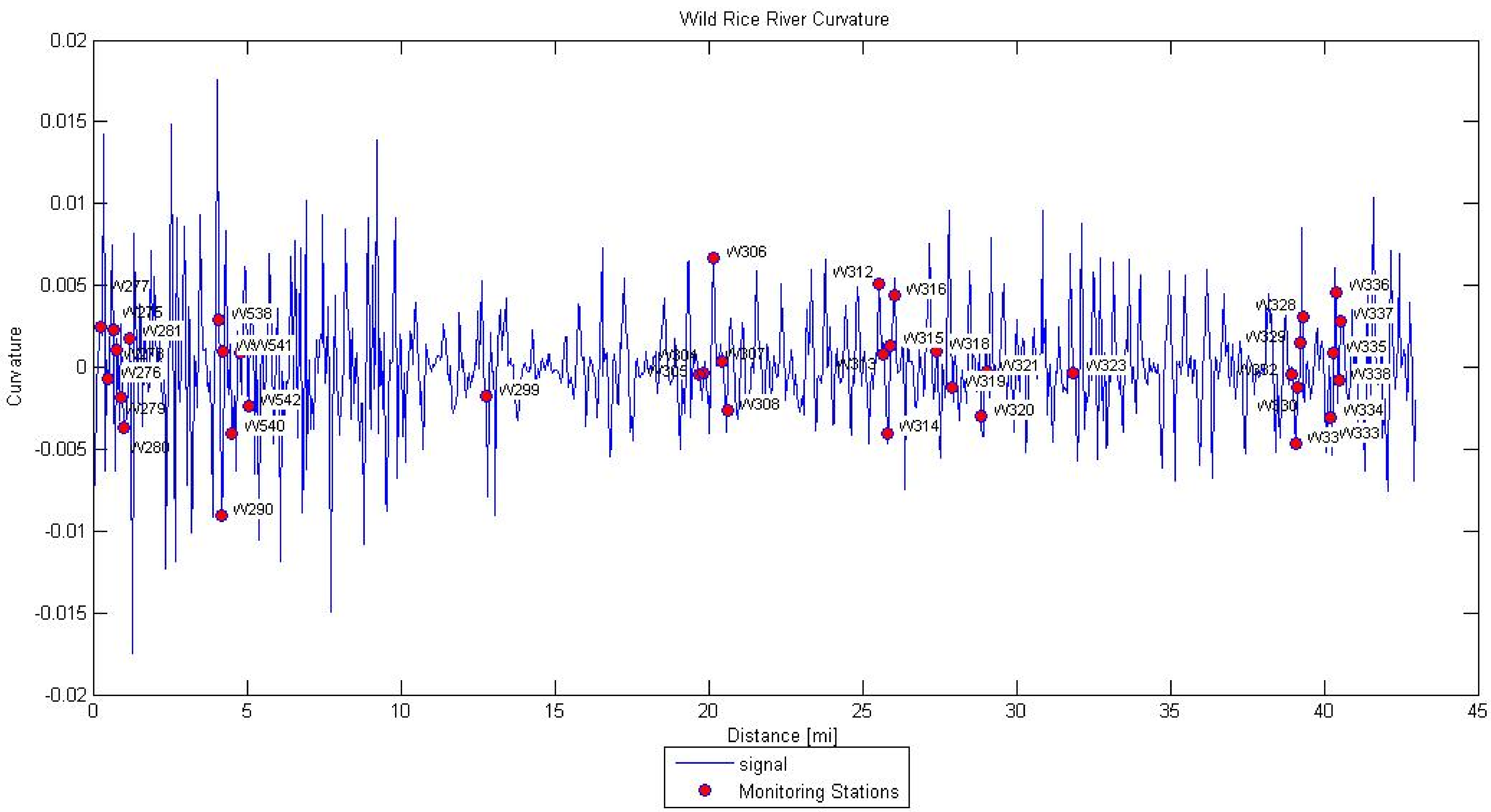
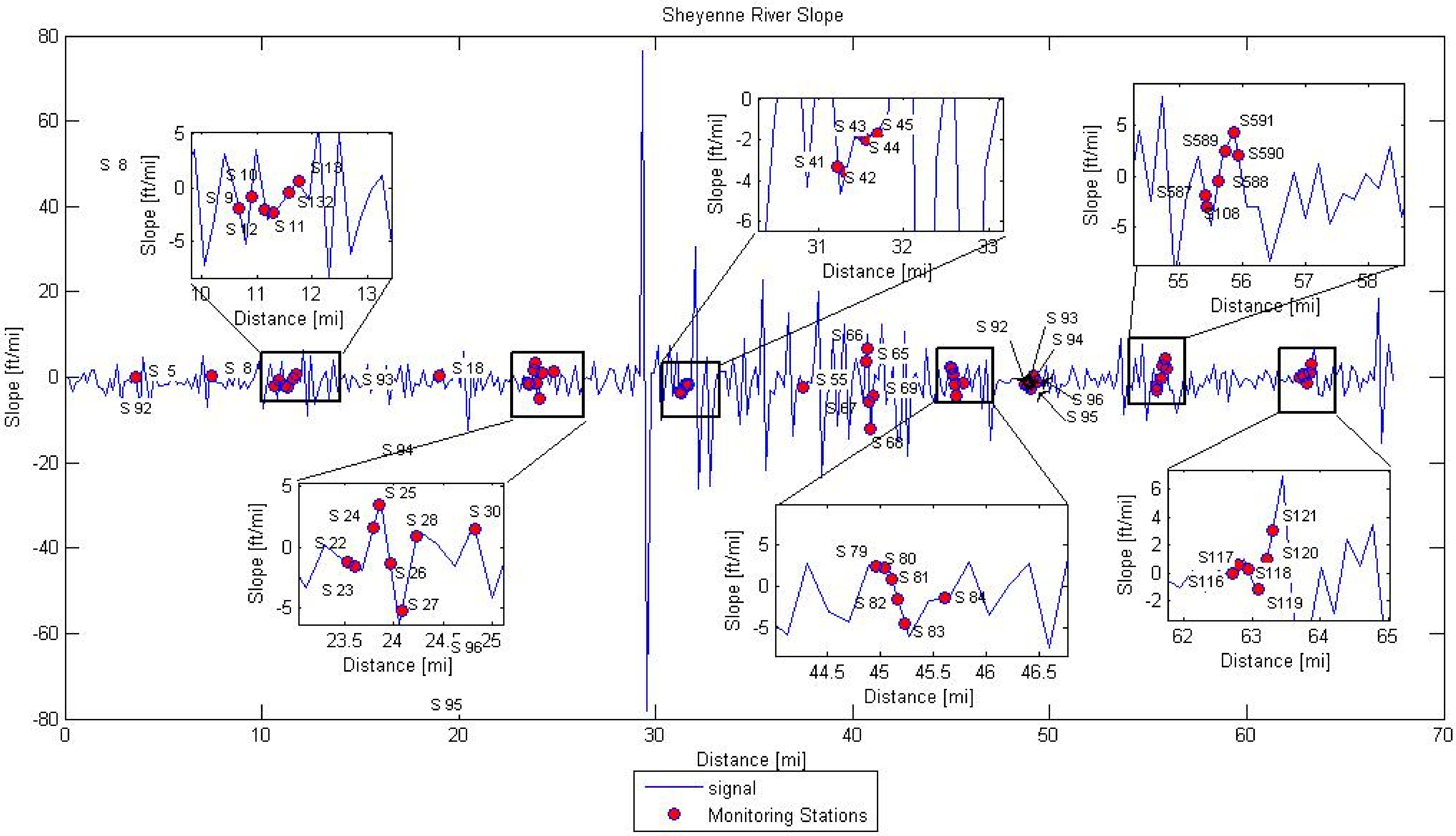
W336
W337
W338
W340



Wild Rice River Amplitude
Amplitude [ft]
Distance [mi]
3000
2000
1000
0
-1000
-2000
-3000
0
5
10
15
20
25
30
35
40
45
W275
W276
W277
W278
W279
W280
W281
W290
W299
W304
W305
W306
W307
W308
W312
W313
W314
W315
W316
W318
W319
W320
W321
W323
W328
W329
W330
W331
W332
W333
W334
W335
W336
W337
W338
W539
W540
W541
W542
signal
Monitoring Stations



Wild Rice River Curvature
Curvature
Distance [mi]
signal
Monitoring Stations


Sheyenne River Slope
Slope [ft/mi]
Distance [mi]
signal
Monitoring Stations
S 5
S 8
S 92
S 93
S 94
S 95
S 96
S 18
S 55
S 65
S 66
S 67
S 68
S 69
S 9
S 10
S 11
S 12
S 13
S 132
S 22
S 23
S 24
S 25
S 26
S 27
S 28
S 30
S 41
S 42
S 43
S 44
S 45
S 79
S 80
S 81
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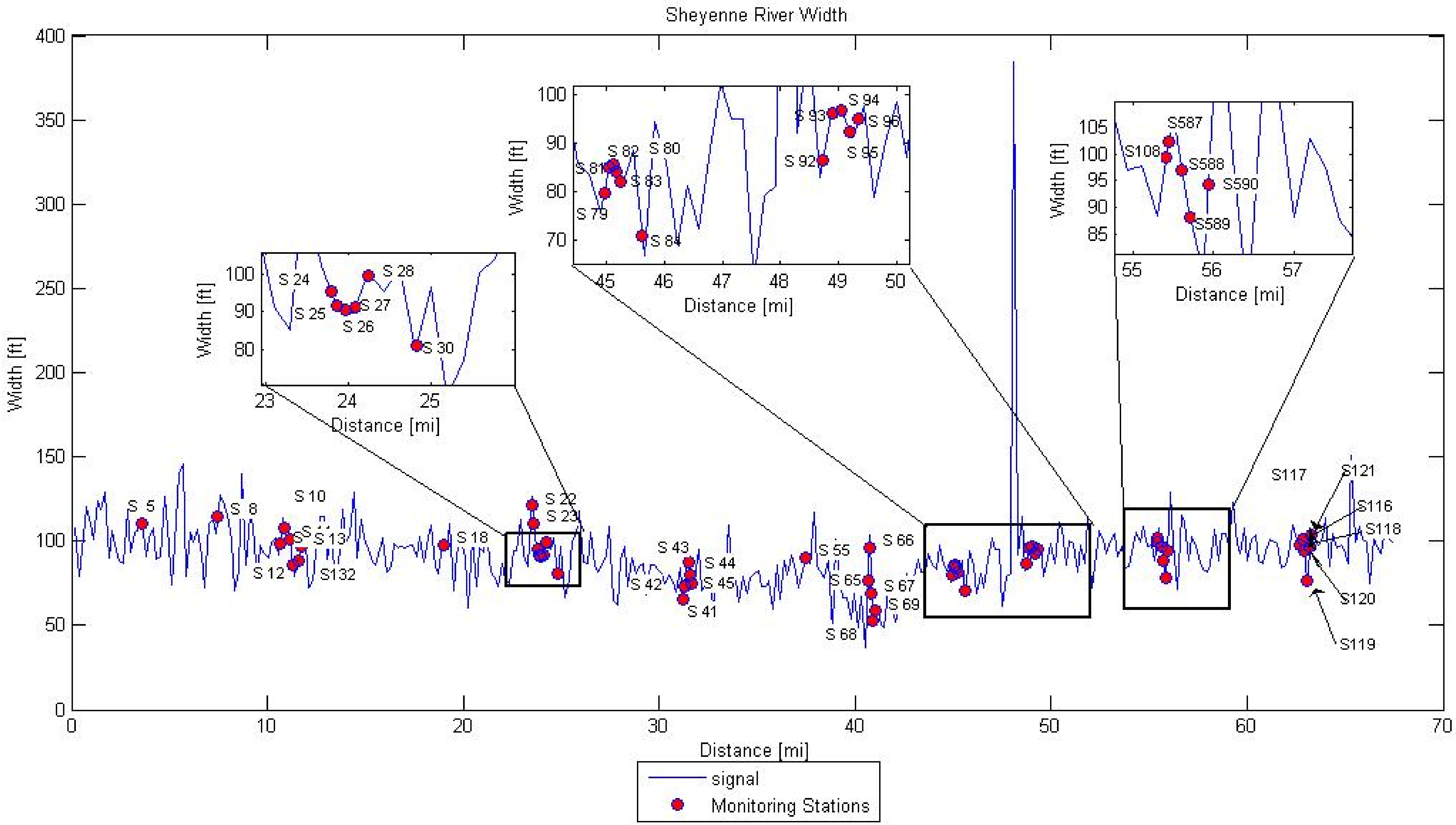
S118
S119
S120
S121



Sheyenne River Width
Width [ft]
Distance [mi]
signal
Monitoring Stations
S 5
S 8
S 10
S 12
S 13
S132
S 18
S 22
S 23
S 24
S 25
S 26
S 27
S 28
S 30
S 41
S 42
S 43
S 44
S 45
S 55
S 65
S 66
S 67
S 68
S 69
S 79
S 80
S 81
S 82
S 83
S 84
S 92
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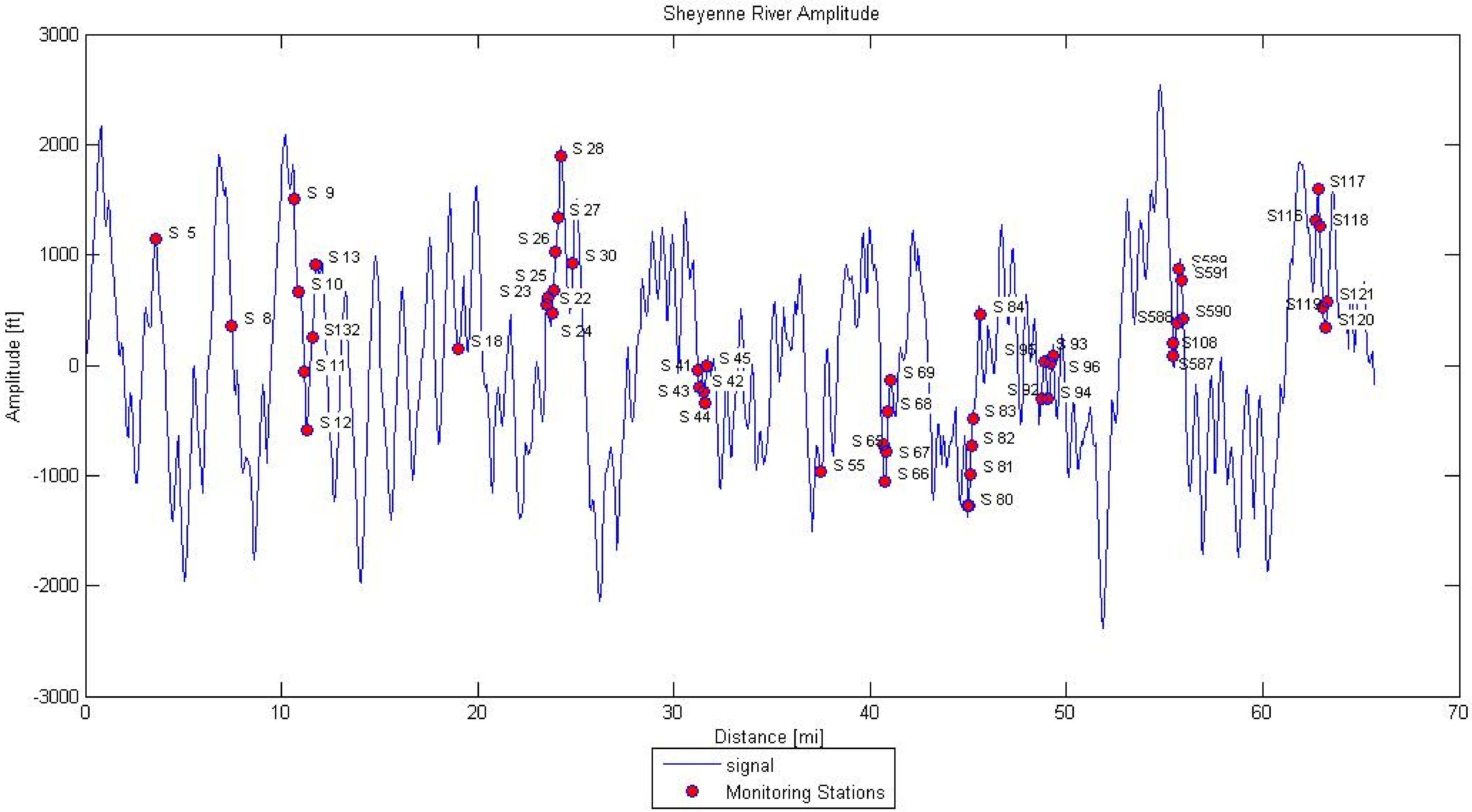
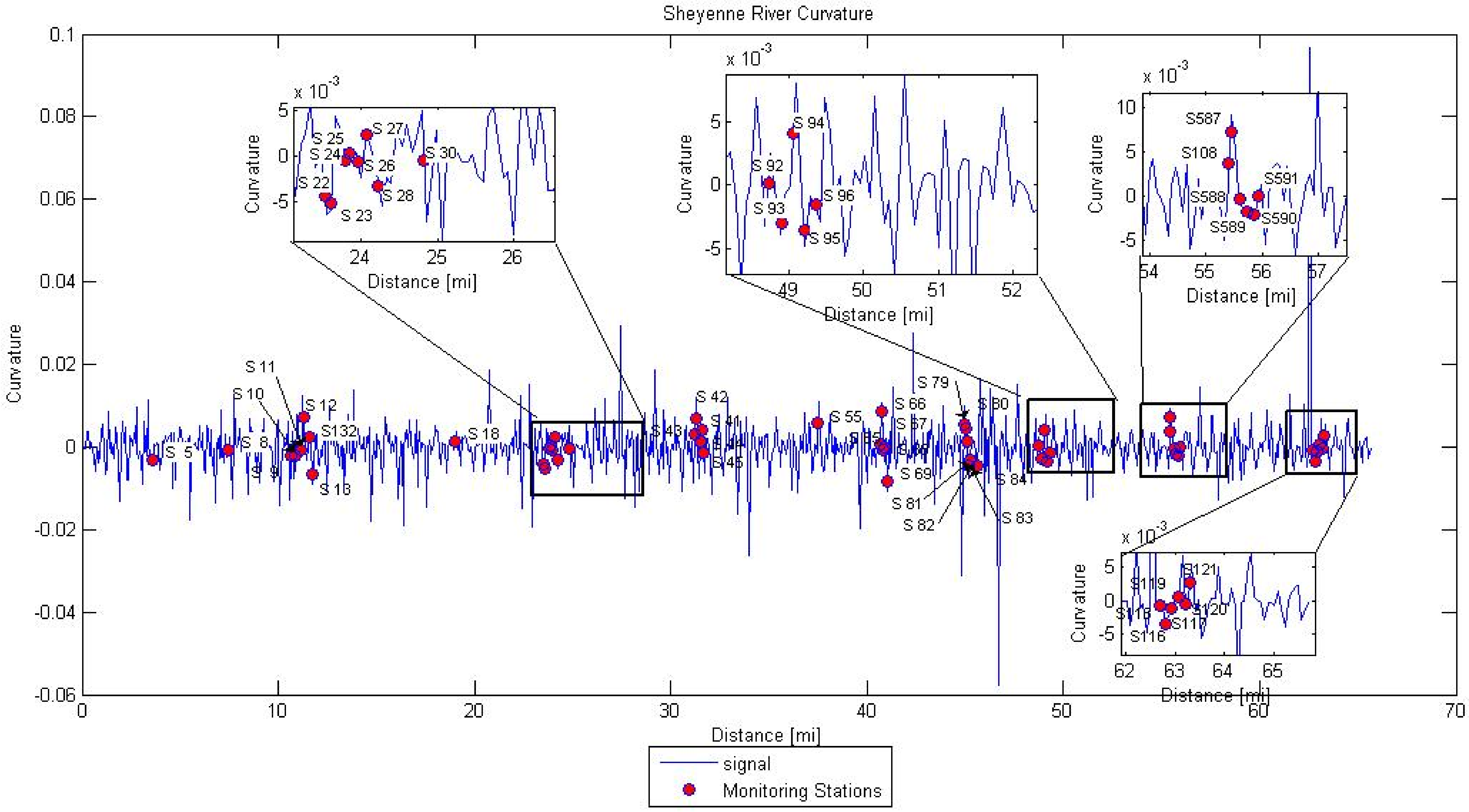
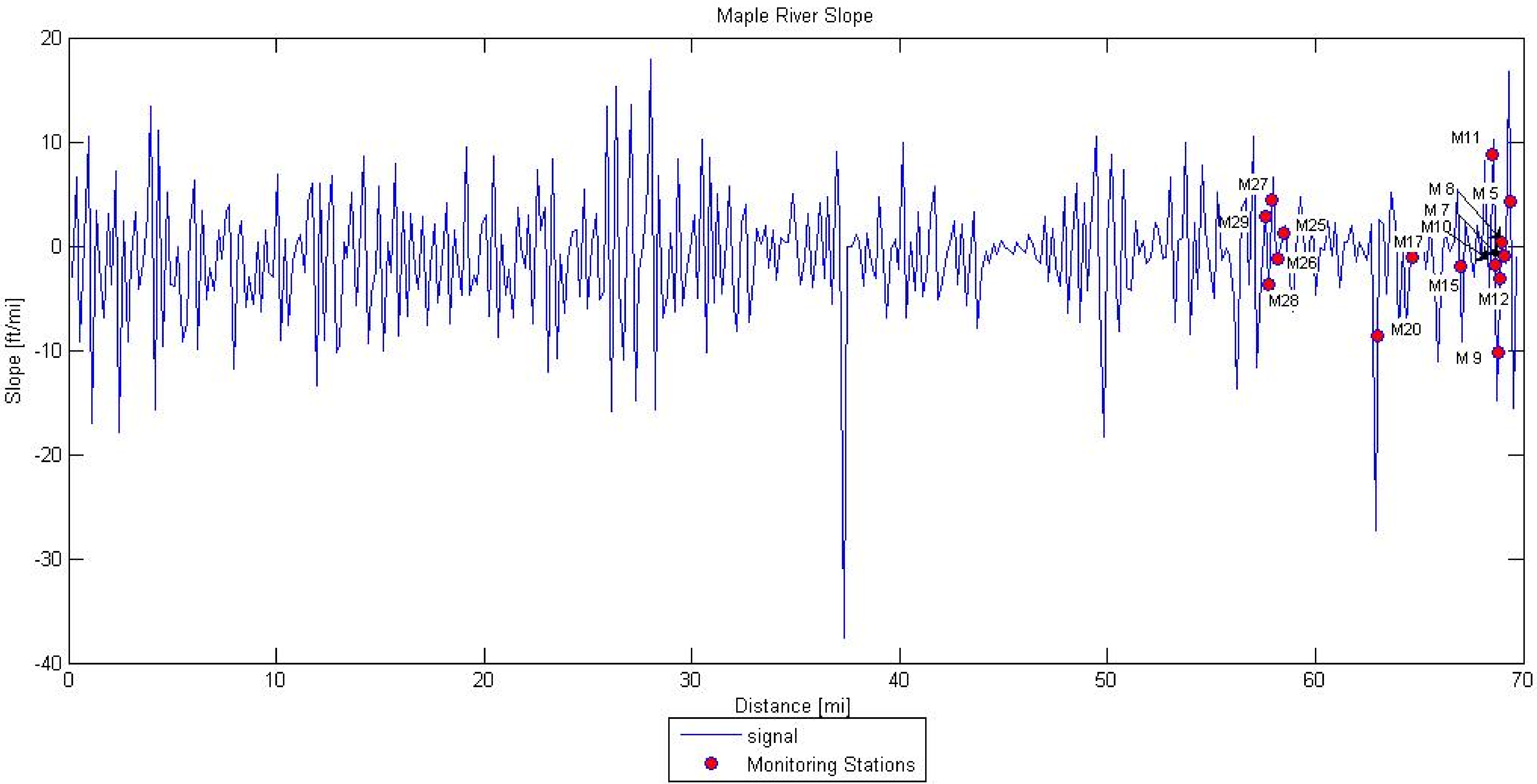
S118
S119
S120
S121

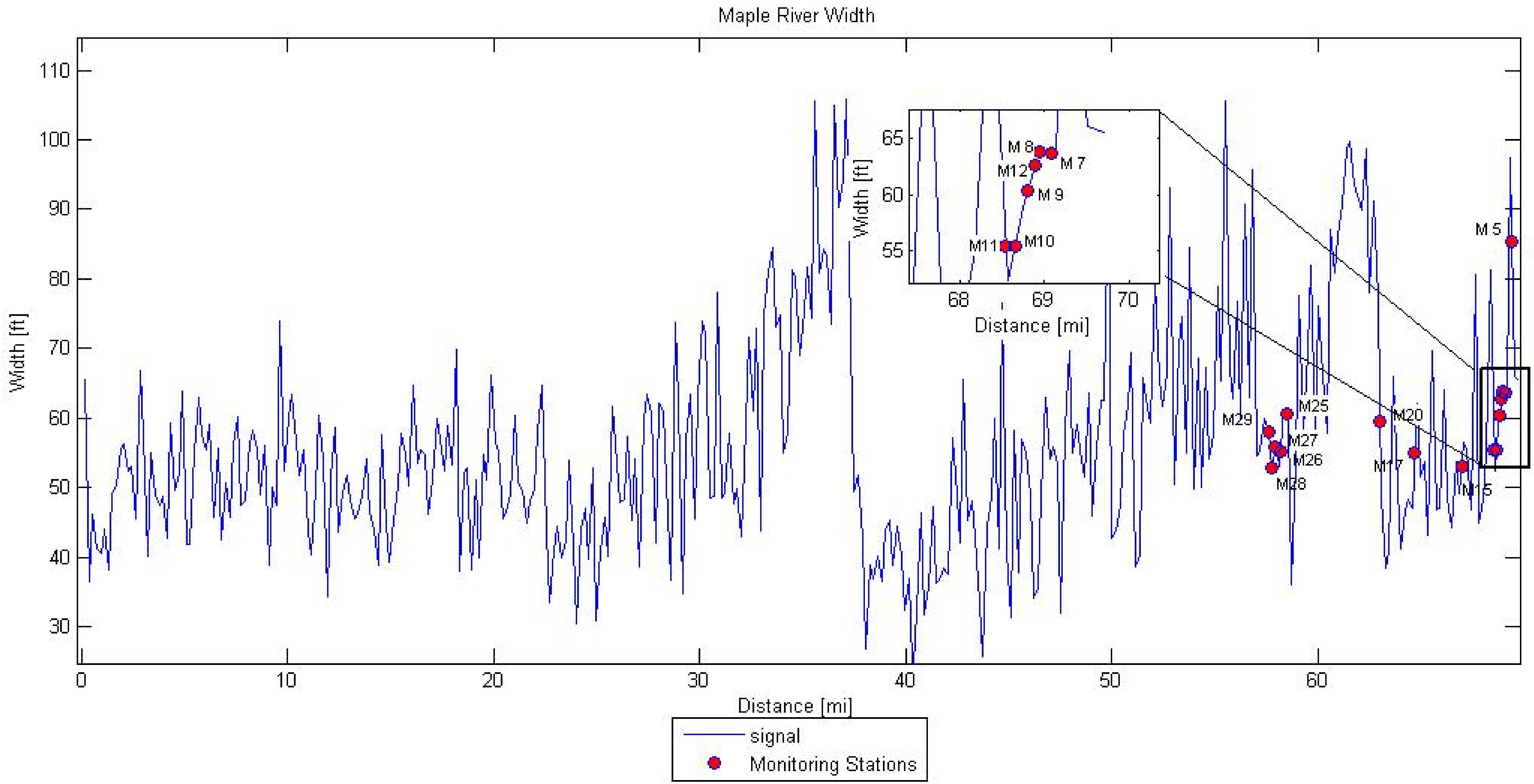


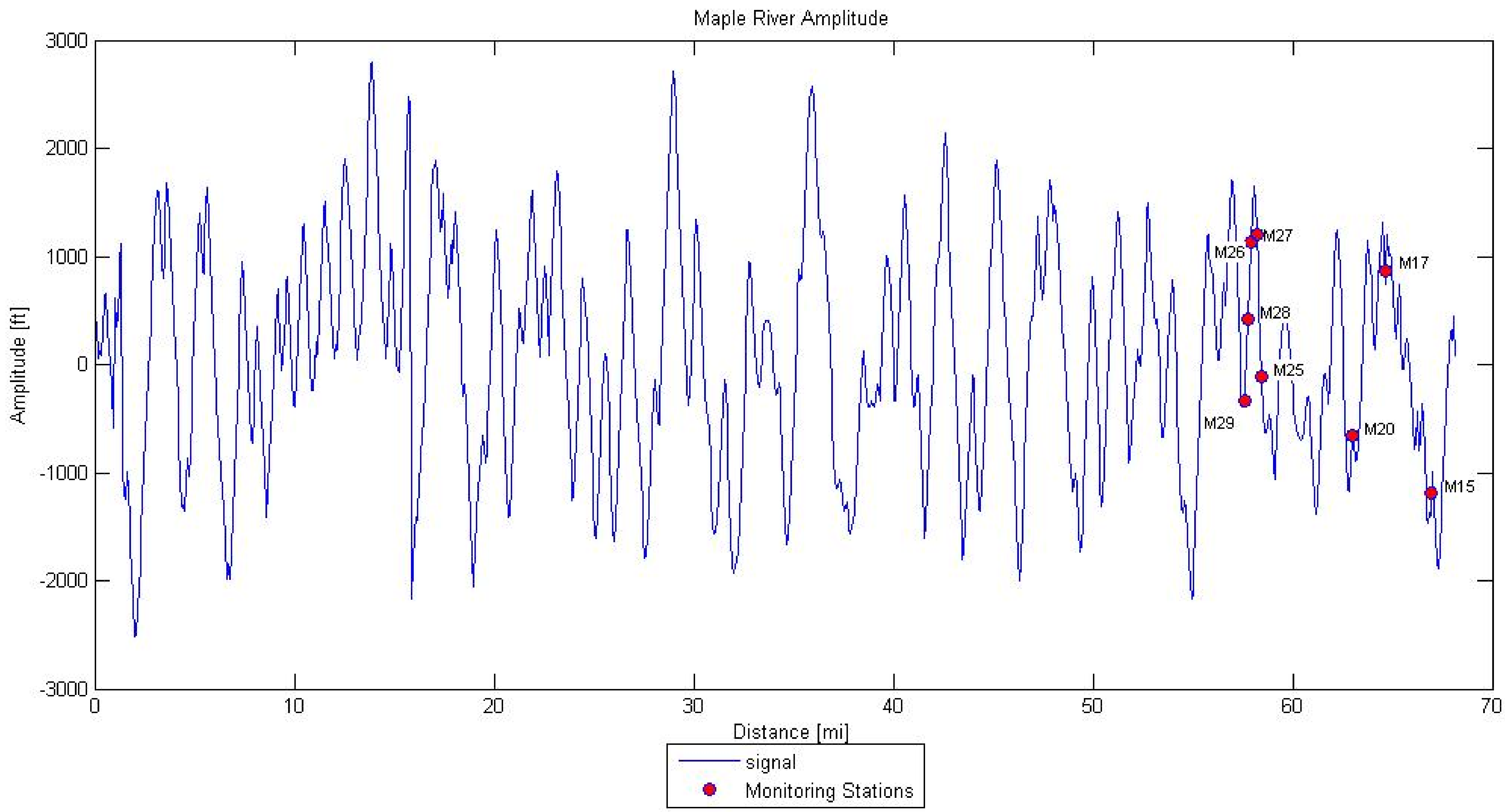
Sheyenne River Amplitude
Amplitude [ft]
Distance [mi]
signal
Monitoring Stations
3000
2000
1000
0
-1000
-2000
-3000
0
10
20
30
40
50
60
70
S 5
S 8
S 9
S 10
S 11
S 12
S 13
S132
S 18
S 22
S 23
S 24
S 25
S 26
S 27
S 28
S 30
S 41
S 42
S 43
S 44
S 45
S 55
S 66
S 67
S 68
S 69
S 80
S 81
S 82
S 83
S 84
S 93
S 94
S 96
S108
S587
S588
S590
S591
S117
S118
S120
S121

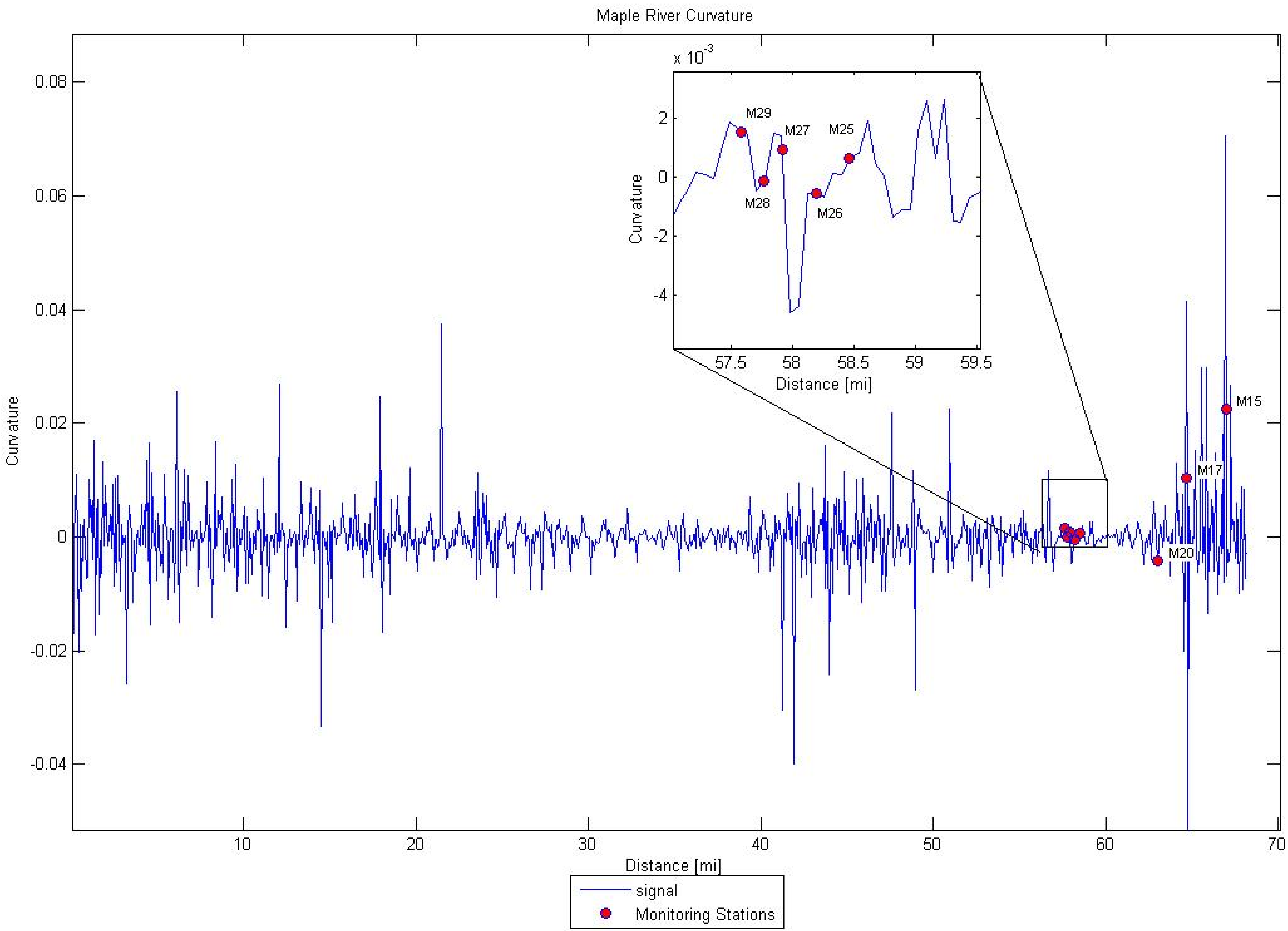


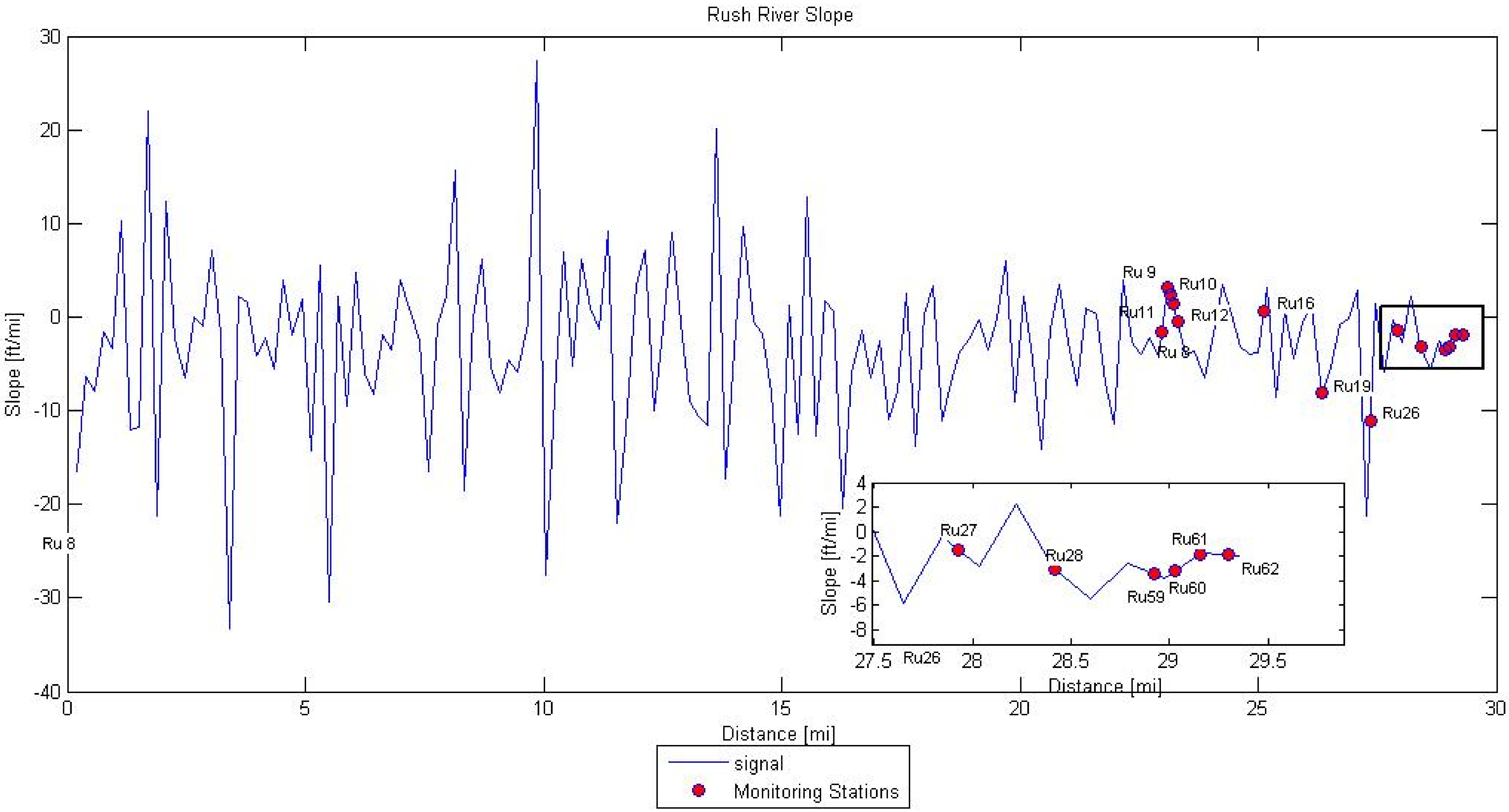
Sheyenne River Curvature
Curvature
Distance [mi]
signal
Monitoring Stations
S 5
S 8
S 9
S 10
S 11
S 12
S132
S 13
S 18
S 22
S 23
S 24
S 25
S 26
S 27
S 28
S 30
S 42
S 43
S 45
S 55
S 66
S 69
S 79
S 80
S 81
S 82
S 83
S 84
S 92
S 93
S 94
S 95
S 96
S587
S108
S588
S589
S590
S591
S121
S119
S120
S116


Maple River Slope
Slope [ft/mi]
Distance [mi]
20
10
0
-10
-20
-30
-40
0
10
20
30
40
50
60
70
M11
M27
M29
M25
M26
M28
M 8
M 5
M 7
M10
M17
M15
M12
M20
M 9
signal
Monitoring Stations

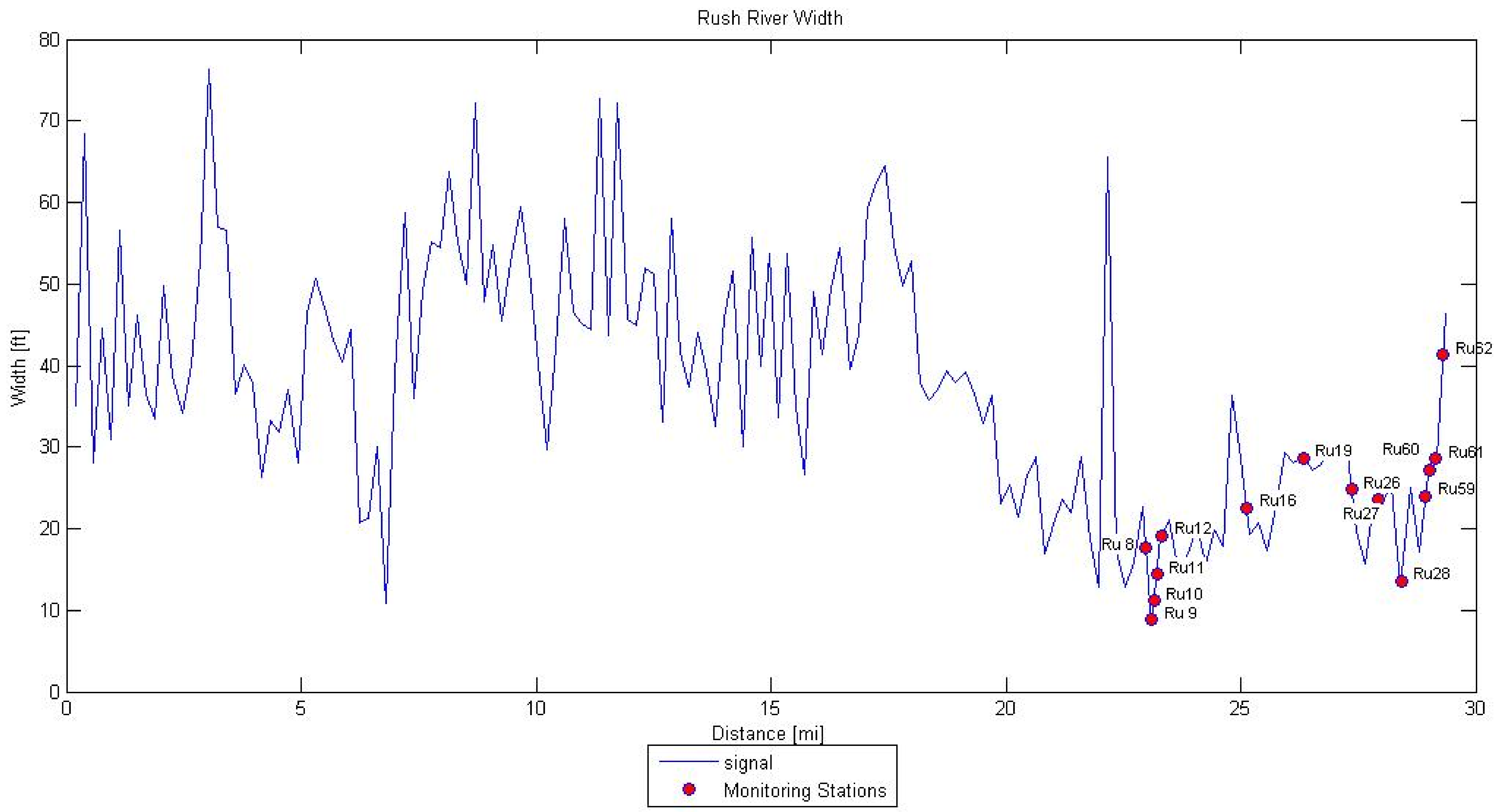

Maple River Width
Width [ft]
Distance [mi]
signal
Monitoring Stations
M 5
M29
M25
M27
M26
M28
M20
M17
M15
M 8
M 7
M12
M 9
M11
M10


Maple River Amplitude
Amplitude [ft]
3000
2000
1000
0
-1000
-2000
-3000
0
10
20
30
40
50
60
70
Distance [mi]
M27
M26
M17
M28
M25
M29
M20
M15
signal
Monitoring Stations

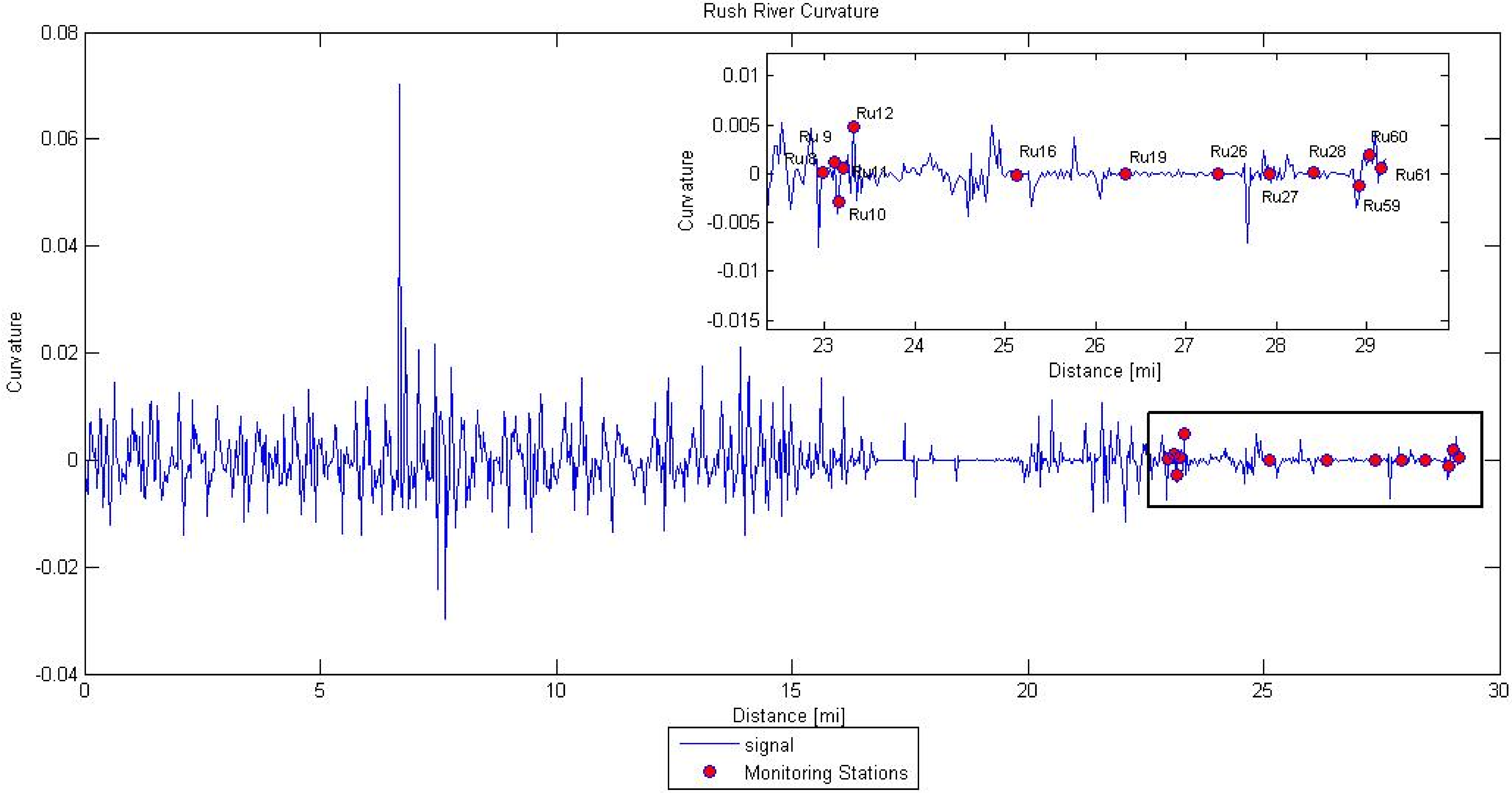

Maple River Curvature
Curvature
Distance [mi]
0.08
0.06
0.04
0.02
0
-0.02
-0.04
10
20
30
40
50
60
70
x 10^-3
2
0
-2
-4
57.5
58
58.5
59
59.5
M29
M27
M25
M28
M26
M15
M17
M20
signal
Monitoring Stations



Rush River Slope
Slope [ft/mi]
Distance [mi]
Ru 8
Ru 9
Ru10
Ru11
Ru12
Ru 8
Ru16
Ru19
Ru26
Ru27
Ru28
Ru59
Ru60
Ru61
Ru62
Ru26
signal
Monitoring Stations



Rush River Width
Width [ft]
Distance [mi]
0
10
20
30
40
50
60
70
80
0
5
10
15
20
25
30
Ru 8
Ru 9
Ru10
Ru11
Ru12
Ru16
Ru19
Ru26
Ru27
Ru28
Ru59
Ru60
Ru61
Ru62
signal
Monitoring Stations



Rush River Curvature
Curvature
Distance [mi]
0.08
0.06
0.04
0.02
0
-0.02
-0.04
0
5
10
15
20
25
30
signal
Monitoring Stations
Ru12
Ru 9
Ru8
Ru11
Ru10
Ru16
Ru19
Ru26
Ru27
Ru28
Ru60
Ru61
Ru59
0.01
0.005
-0.005
-0.01
-0.015
23
24
25
26
27
28
29

SUPPORTING REFERENCES

Water Science Glossary of Terms
http://water.usgs.gov/edu/dictionary.html

Water Quality Monitoring References
http://ijc.org/en_/Red_River_Basin
http://pubs.usgs.gov/sir/2014/5064/
http://pubs.usgs.gov/sir/2012/5111/
http://pubs.usgs.gov/sir/2011/5178/
http://pubs.usgs.gov/sir/2011/5134/
http://pubs.usgs.gov/sir/2011/5064/
http://pubs.usgs.gov/sir/2012/5216/

The link to access the North Dakota Water Quality Monitoring Data and locations:
http://www.ndhealth.gov/WQ/SW/Z8_SWData/index.html

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4. Technical Memorandum AWD-00001 Ammendment1: Meander Belt Width Analysis. Houston – Moore Group and Flood Diversion Authority. June 19, 2013. 487pp.
5. Walters, C.J. (1986) *Adaptive Management of Renewable Resources.* MacMillan Pub. Co., New York, NY, 3668 pp. ISBN 0-02-947970-3.

To be completed when sections are finalized.

Fargo-Moorhead Flood Risk Management Project

Wetland Monitoring Plan

Fargo, North Dakota
Moorhead, Minnesota

Prepared for Minnesota Environmental Impact Statement
By the U.S. Army Corps of Engineers

DRAFT UNDER DEVELOPMENT

Adopted from Final Feasibility Report and
Environmental Impact Statement, July 2011

US Army Corps of Engineers
St. Paul District

U.S. ARMY CORPS OF ENGINEERS,
ST. PAUL DISTRICT, ST. PAUL, MINNESOTA

**Appendix F provides supporting information for information provided.*

The National Wetland Inventory was used as a preliminary method to identify impacted wetlands; this information is what was reported in the DEIS. For the FEIS, a more detailed wetland determination has been conducted along the alignments for the diversion channel alternatives and included a MNRAM functionality assessment. This information was used to verify the mitigation approach for these wetlands. Surveys of the diversion channel will be performed to verify that wetland type and function present are offsetting wetland areas lost through construction.

Annual mitigation monitoring reports shall be submitted on the status of the mitigation. The reports shall be submitted by December 31 following each of the first five growing seasons. The reports shall, at a minimum, include the following information:

1. All plant species along with their percent cover, identified by meandering through each vegetative community, including upland buffers, and list commonly encountered – or dominant and co-dominant species observed. In addition, the presence, location and percent cover of invasive, noxious and/or non-native species in any of plant communities shall be noted.
2. Vegetation cover maps at an appropriate scale shall be submitted for each reported growing season.
3. Photographs showing all representative areas of the mitigation site taken at least once each reported growing season during the period of July 1 to September 30. Photographs shall be taken from a height of approximately five to six feet from at least one location per acre. Photos shall be taken from the same reference point and direction of view each reporting year. Location of the photographs should be mapped on a GPS unit.
4. Surface water and groundwater elevations in representative areas (e.g., at least one sample point in each plant community) recorded at least once each week for the first 10 weeks of each growing season, thereafter taken monthly for the remainder of each growing season. The location of each monitoring site shall be shown on a plan view of the site.
5. If non-compliance activities are occurring on the site, make note of the activity, photograph the activity and map the location of the location of the noncompliance activity on a GPS unit. Use your best professional judgment to determine if the activity is not compliance with easement or mitigation site plan.

A wetland delineation of the site applying the Corps of Engineers Wetlands Delineation Manual, Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Great Plains Region (current version) and guidance shall be submitted at the close of the monitoring period. This delineation shall be prepared by a wetland professional.

Over two-thirds of the wetlands that are impacted are seasonally flooded wetlands or farmed wetlands; these wetlands have very poor function. It is not environmentally preferable to compensate for impacts to degraded wetlands by deliberately providing degraded compensatory mitigation projects. A compensation project should result in high quality wetlands that provide optimum functions within its landscape context, taking into account unavoidable constraints. Typically the Corps requires impacts to even the most degraded wetlands to be mitigated at 1:1 (compensation acres: impact acres). In rare situations, the minimum compensation ratio can be lowered if it is determined that the impacted wetland is so degraded that it provides minimal wetland functions. Even though the wetlands impacted by the Project are generally highly degraded they should be mitigated for by restoring equal acres of wetland or by restoring functions that are lacking in the Red River Basin watershed.

Fargo-Moorhead Flood Risk Management Project

Floodplain Forest Monitoring Plan

Fargo, North Dakota
Moorhead, Minnesota

Prepared for Minnesota Environmental Impact Statement
By the U.S. Army Corps of Engineers

DRAFT UNDER DEVELOPMENT
Vs. 2 June 2015

Adopted from Final Feasibility Report and
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US Army Corps of Engineers
St. Paul District

U.S. ARMY CORPS OF ENGINEERS,
ST. PAUL DISTRICT, ST. PAUL, MINNESOTA

**Appendix F provides supporting information for information provided.*

The majority of baseline data needed to quantify existing habitat value of floodplain forest impact areas has been collected (Appendix F). Additional surveys could be performed prior to construction; however these efforts would likely be small in scope. Following construction, survey transects would likely be established in floodplain forest mitigation areas to determine the condition of these habitat types and the overall effectiveness of their mitigation.

Vegetation will be monitored annually for the first 5 years following planting using stratified random sampling. At each randomly generated point within the areas planted, plots of 0.01 acre will be surveyed. An average of at least one plot per acre will be surveyed. Tree survival and composition will be monitored every 10 years and following major flooding. Trees will be replanted as needed to meet the target vegetation cover (see Performance Standards below). Invasive and/or non-native plant species will be controlled for 3 full growing seasons. Control will consist of mowing, burning, disking, mulching, biocontrol and/or herbicide treatments as needed. By the third growing season, any planted areas one-half acre in size or larger that have greater than 50 percent areal cover of invasive and/or non-native species will be treated (e.g., herbicide) and/or cleared (e.g., disked) and then replanted with trees.