International Red River Board
Red River Bioassessment Workshop
Summary and Recommendations

February, 2006

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1.0 Introduction

In 2003, the International Water Institute (IWI) hosted a workshop to begin the process of developing a biological assessment program for the Red River of the North Watershed. The workshop focused implementing a reference condition approach to assess freshwater ecosystems (Bailey et. al 2004). The workshop outcomes enabled the International Red River Board's (IRRB) Aquatic Ecosystem Committee (AEC) to establish a common definition of reference and outline the initial components of a research design for the main stem Red River that would allow reporting of the main stem Red River's health with known statistical confidence (Fritz 2004).

The IWI has published two documents that provide an overview of the ecological principles driving the concepts of biological assessment and the use of a reference condition approach on the mainstem Red River of the North (Fritz 2004, Arscott and Fritz 2003). The scientific rationale for conducting ecological assessments is well documented in the literature. Using biology as a measure of ecological health was initially proposed as early as 1908 (Kolkwitz and Marson 1908). Subsequent years resulted in further development of these concepts that were culminated in the work of Dr. Noel Hynes in 1960 and 1971 (Hynes 1960, 1971). However, it wasn't until the work of Dr. J. Karr and others in the mid 1980s (Karr, et al. 1986 and Karr 1991 and 1994) until biological assessment concepts became widely accepted and applied to water resources in North America and throughout the world (Arscott and Fritz 2003).

Canada first suggested an ecological framework for assessing human impacts in 1983 (Beanlands and Duinker 1983). The U.S. Environmental Protection Agency (USEPA) published the first guidelines for a national biocriteria program in 1990 (USEPA 1990). Today, assessing aquatic ecosystems using measurements of resident biological communities is widely accepted and used by local, state and federal governments in the U.S., Canada, and elsewhere. Until very recently, these efforts have mainly focused on the smaller streams that allow walk-in access using only waders and portable sampling equipment. Sampling biological communities in larger systems (i.e. the Red River of the North) pose some unique logistical and methodological challenges.

In 2005 the IWI was contracted by the International Joint Commission (IJC) to convene a follow-up biological assessment workshop to address some of the known challenges associated with assessment efforts on large rivers and to build on the foundation and conceptual research design components outlined from the first workshop. The Red River Bioassessment Workshop was help in Moorhead, MN on November 3rd and 4th, 2005. Agency staff, university faculty, and others attended (Appendix A) along with invited experts from the US and Canada with expertise in sampling biological communities in large river systems (Appendix B). This report summarizes the outcomes from this workshop and provides a series of implementation recommendations that will ultimately enable the IRRB to fulfill its ecosystem health reporting directives. The primary audience for this report is the membership of the AEC, the IRRB, and the IJC.

2.0 Organizational Background

The IJC was established by the U.S. and Canadian governments in 1909 to resolve water and water quality disputes on international boundary waters and to advise the respective governments on related matters (IJC 2000).

Early in 2001 the IJC formed the IRRB to ensure a more systematic approach to transboundary water issues and to better assist the IJC in preventing and resolving transboundary disputes in the Red River of the North Basin (IJC 2005a). The IRRB membership, which includes representatives from state and provincial agencies, U.S. and Canadian federal agencies, and local stakeholders, was directed by the IJC to:

- Maintain and awareness of basin-wide development activities and condition that may affect water levels and flows, water quality and the ecosystem health of the Red River and its transboundary tributaries and inform the Commission (IJC) of transboundary issues.
- Provide a continuing forum for the identification, discussion, and resolution of existing and emerging water-related issues relevant to the Red River Basin.
- Recommend appropriate strategies to the Commission (IJC) concerning water quality, quantity, and aquatic ecosystem health objectives in the basin.

- The Boards (IRRB) activities shall focus on continuous surveillance over the quality of water and health of the Red River transboundary aquatic ecosystem.
- Keep the Commission (IJC) informed of transboundary aquatic conditions measured by indicators of aquatic ecosystem health (e.g. species diversity).

The need for the IWI was first articulated in 1997 by the International Flood Mitigation Initiative (IFMI). The governments of Canada and the United States jointly sponsored the IFMI to build consensus on a comprehensive set of practical initiatives to mitigate damages from future floods in the Red River of the North Basin. IFMI recommendations established the IWI as an international organization charged with serving as a collaborative medium for research and watershed education that transcends traditional jurisdictional boundaries for the Canadian, U.S., and Tribal governments, the private sector, non-government organizations, and academic/research institutions in the Red River of the North Basin (IFMI 2000).

3.0 IRRB Aquatic Ecosystem Committee Work plan

A number of the IJC directives clearly define the IRRB's responsibility to monitor and report on the "ecosystem health" of the Red River of the North Basin. Accordingly, the IRRB took steps necessary to begin addressing these directives and established the AEC in July 2001. The AEC includes state and federal agency and other stakeholder membership from North Dakota, Minnesota, and Manitoba. The committee was formed to develop basin-wide recommendations and implementation details on:

- Biological monitoring
- Monitoring non-native and invasive species
- Integrated monitoring
- Establishing and maintaining a central water quality database

The AEC developed a work plan that included a series of workshops aimed at developing the understanding and scientific foundations necessary to implement a biological monitoring and assessment program in the Red River Basin. The first workshop hosted by the IWI was held in Moorhead, MN early in 2003 and the most recent in 2005. These workshops brought national and international leaders in the field of biological assessment together to identify and discuss the challenges facing the AEC and the IRRB and explored solutions to meeting the ecosystem health reporting charge given by the IJC.

4.0 Workshop Summary

Following a review of the previous workshop outcomes (Fritz 2005) and background presentations provided by Charles Fritz, IWI Director, and AEC Co-Chairs David Donald, Environment Canada and Dr. Richard Nelson, U.S. Bureau or Reclamation Dakota Areas Office (Nelson and Donald 2005), Dr. Joel Fisher (IJC Senior Science Advisor) provided opening remarks that set the stage for the workshop. Dr. Fisher's remarks were prepared in collaboration with Dr. John Cairns and Dr. Ruth Patrick; two highly respected and published experts in the field of Biological monitoring and assessment. Their collaboration resulted in 11 biological assessment "commandments" outlined by Dr. Fisher that provide guidance for establishing biological monitoring and assessment efforts:

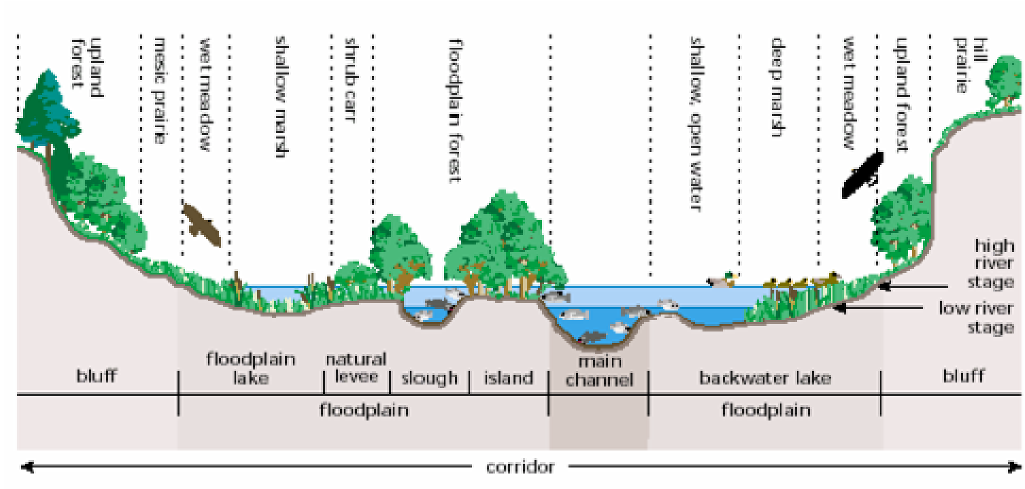
1. Understand the physiology, behavior, and ecology of the targeted biota.
    a. Provides direction regarding where, when, how, and frequency of sampling.
2. Choose sampling equipment accordingly (based on the targeted biota)
    a. Understand the inherent limitations and service needs for the sampling equipment used.
3. Determine feasibility and possibility of incorporating remote sampling technologies.
    a. Remote sensing, commonly used for marine and estuarine assessment efforts, may have applicability in larger river studies.
4. Target sampling effort on entire biological communities, rather than a single component of same.
    a. Analyze results from several different sampling techniques to understand and modify methods to reduce sampling bias.
5. Develop protocols early to address rare, endangered, or unexpected species encountered.
6. Consider a variety of sampling regimes

    a. Nighttime *and* daytime sampling
7. Consider and, if possible, compare results from fixed (i.e. anchored artificial substrates) and free - moving collection mediums.
8. Understand the underlying model of the assessment strategy.
    a. Target sampling efforts and methods and ensure scientific validity of the results.
9. Measuring diversity is important; however:
    a. Do not ascribe theoretical justification to the indices as barometers of ecological health or stability
    b. Quantifying ecosystem attributes requires appropriate analysis and use of multiple indicators and measurements.
10. Incorporate "ground-truthing" protocols into the sampling regime
11. Use common sense when developing a sampling regime while ensuring the empirical validity of the effort (Fisher 2005)

Dr. David Arscott (Stroud Water Research Center) provided an overview of riverine structure and functions in larger systems. The aquatic habitat is not the only aspect of large rivers that can or should be used to evaluate the health of an aquatic ecosystem. There is a lateral dimension to all river floodplains. The extent of this lateral dimension associated with large rivers adds a measure of complexity to biological assessment efforts (Figure 1). For example, floodplains are areas where natural periodic flood events drive biological community and physical habitat heterogeneity. Through time, these flood events have a major influence on vegetative patterns in floodplains which can serve as indicators of healthy functioning floodplains and ultimately health functioning aquatic ecosystems of large rivers. Arscott noted three important points to consider when assessing large river systems:

1. Floodplain patterns (aquatic and terrestrial) result from interplay between vegetation, sediment, and fluvial forces.
2. There is a historic content to observed patters (recent and long-term).
3. Successional processes are important to account for when assessing between community sites (Arscott 2005).

Figure 1. Large River Corridor Features



Source: Arscott 2005

Ted Andgadi (USEPA) reviewed the U.S. Environmental Protection Agency's (USEPA) Environmental Monitoring and Assessment of Great River Ecosystems Program (EMAP-GRE). EMAP-GRE was developed to:

1. Address Clean Water Act (U.S. Gov. Print. Off. 1988) reporting inconsistencies on interstate rivers.
2. Develop better indicators and restoration targets needed to assess progress towards large river naturalization or restoration goals.
3. Establish proven methods, designs and biocriteria for national USEPA Office of Waters-sponsored assessments of large and great rivers.

EMAP-GRE has thee main goals: 1) *demonstrate* the assessment approach, 2) *develop* tools for great rivers condition assessment, and 3) *facilitate* future assessments by others. Angradi provided an overview of the EMAP-GRE's overall design (a probabilistic approach), sampling methods, targeted indicators, and program limitations. Angradi strongly emphasized the need to develop an efficient information management system early in the assessment process. Information management systems are important to ensure the program's credibility and timeliness (Angradi 2005).

EMAP-GRE field sampling in 2004 and 2005 was contracted to the ND Department of Health and the United States Geological Survey (USGS). Robert Lundgren (USGS) provided some "lessons learned" from the perspective of a field technician. Lundgren outlined issues to consider when developing and implementing a large river assessment effort using a probabilistic sampling design. Lundgren noted some of the challenges associated with randomly selecting sampling locations using existing GIS data in assessment programs. Some of the selected reach locations were in a reservoir or near hazardous areas. Other reaches were not accessible given their location on the waterbody (too much or no flow, channel debris, private access denied). Lundgren also noted the importance of carefully planning for data analysis and management (Lundgren 2005).

Fish community indexes will be a component to any aquatic assessment of the Red River mainstem. Dr. William Franzin (Canadian Department of Fisheries) noted that electro-fishing is the most consistently used methods for sampling fish communities in large river systems. However, using electro-fishing equipment to sample fish community structure in a highly turbid system like the Red River is challenging. Franzin provided insights on monitoring species of concern (SOC - invasive) and species at risk (SAR - endangered). Franzin and colleagues conducted fish surveys in the Canadian portion of the Red River from 2003 - 2004. Their work provided a number of conclusions to consider when developing a monitoring and assessment program for the mainstem Red River of the North:

- Stratified random sampling is useful for determining river fish diversity, relative abundance and an indication of biomass
- Electro-fishing, like all other single gear approaches, has significant bias. It favors larger fish, fish that are attracted strongly to the anode, fish with swimbladders, and it works best in clear water.
- Electro-fishing underestimates abundance by more than 2-times, and probably does not provide a reliable representation of fish community structure.
- Productive capacity of total fish habitat in a river reach can be estimated by combining abundance estimates and mean weights of species with production to

biomass ratios but must take account of potential large error in catch-per-unit-effort (CPU) estimates

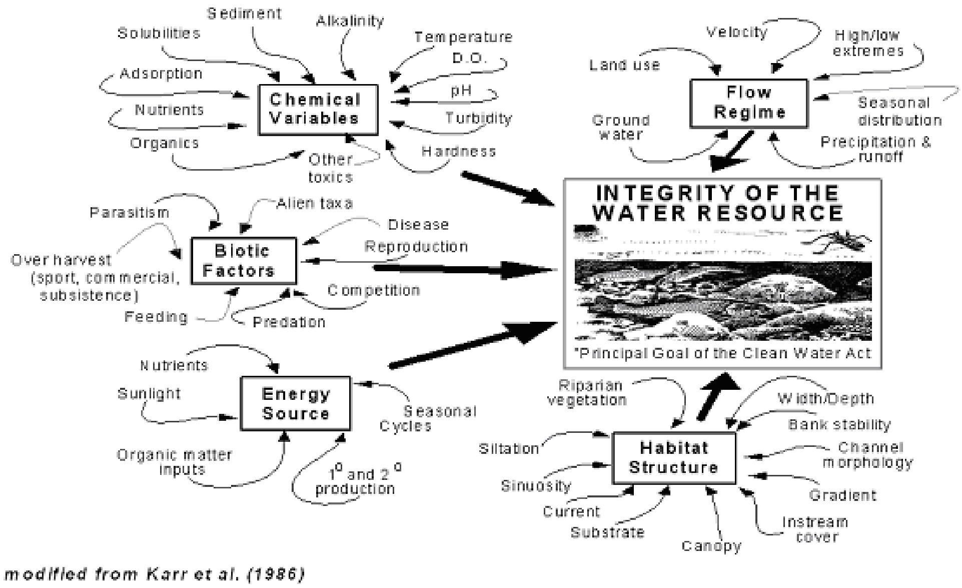
- Telemetry offers a great promise in determining fish use of habitat, especially those systems that offer multi-sensor tags and triangulation hardware
- Fish abundance estimates obtained by electrofishing should be accepted with a healthy amount of skepticism (Franzin and Watkinson 2005).

Larry White, United States Bureau of Reclamation (USBOR), is assessing southwest riparian ecosystems using a variety of biological communities including riparian vegetation, birds (Aves), butterflies (Lepidoptera) and bats (Chiroptera). White reviewed field methods and explored the benefits of using these communities to assess riparian ecosystems. White stressed the importance of developing and reconciling the goals and objectives of the study with the staffing requirements and costs (White 2005).

Ron Sutton (USBOR) provided a comprehensive overview of methods for sampling fish communities on large rivers. Sutton reviewed both passive and active techniques and the benefits and drawback of each. Sutton also explored the possibility of using freshwater mussel community metrics to assess the mainstem Red River. Sutton emphasized the need to clearly define the study objectives, identify the biological community and sampling methods that will be used, and understand the level of effort needed. He also suggested relying heavily on local expertise when developing the plan of study (Sutton 2005).

Chris Yoder (Midwest Biodiversity Institute) explored assessment design and sampling issued for large non-wadable rivers. Yoder outlined the challenges with implementing assessment efforts on large rivers (Figure 2) and emphasized that the essential product from these processes is resources assessment, not simply data collection.

Figure 2. Large River Assessment Challenges



Yoder emphasized the necessity of developing, implementing, and sustaining a monitoring and assessment process that is cost effective and the importance of understanding the assessment project's scope and scale. Specifically, Yoder discussed the importance of using standardized methods, calibrating and validating core indicators, and the need to develop an assessment and monitoring program that supports different water quality and resource management objectives (this may require consideration of multiple study designs). Yoder proposed a systematic assessment process that moves through a logical sequence of steps:

1. Use fundamentals of aquatic ecology and apply readily available science
2. Use concepts and elements of "adequate" watershed monitoring and assessment:
    a. Biological, chemical, and physical indicators
    b. Adherence to stressor, exposure, response roles - avoid the use of surrogates
    c. Data quality objectives adequate for the intended purpose
    d. Design (scale, sequence, intensity) meets management issues and needs
    e. The product of monitoring and assessment is the *assessment*, not just the data (avoid data rich, information poor syndrome).
    f. Professionalism - expertise in key disciplines.

3. Develop and use biological, chemical, and physical indicators and criteria
4. Employ tools via integrated assessments
    a. Stressor → exposure → response (Yoder 2005)

Ted Angradi (USEPA) outlined the EMAP-GRE approach for developing and establishing reference condition on great river systems. Least disturbed condition (LDC) and most disturbed condition (MDC) were used to set thresholds for scoring data and inputs for the predictive models. MDC sites validate metrics and ("t" test statistical approach) and stressor gradients. The EMAP-GRE used a 3-phased approach to establishing reference: 1) using a Geographic Information System model to target likely LDC sites (EMAP-GRE used a geographic information system (GIS) "proximity" model to score sites based on their proximity to known human disturbance), 2) Apply a "filter" to all sites to find sites in LDC and MDC, and 3) verify the approach using biotic indicators. Angradi suggested the following tasks for new assessment programs starting from scratch that plan on using reference condition:

1. Build a GIS framework
2. Create a sample design for assessment
3. Integrate reference site selection and filtering into design
4. Select indicators
5. Build Information management framework
6. Pick methods for each indicator
7. Conduct pilot studies for #4 and #6 (Angradi 2005b).

Following the presentations, invited experts and workshop participants engaged in an open discussion that focused the next steps needed to establish a main-stem Red River monitoring and assessment program. The workshop program included time to discuss targeted biological communities and habitats, sampling methods, details of reference and sample reach selection, and budget considerations. Following the first day of proceedings, workshop leaders and the Co-Chars of the AEC determined it would not be productive at this time to have an open discussion regarding the detailed minutia that must be addressed before actually implementing field work on the Red River mainstem. Instead, workshop participants were asked to provide input and discuss the precursor tasks and deliverables that need to be accomplished before any field work would commence.

5.0 Assessment Program Goals and Objectives

Workshop participants articulated the main goal for the assessment project and re-iterated the need to develop an assessment project that meets multiple management objectives.

The Red River Main Stem Ecological Assessment Program will: "*Determine the Ecological Condition of the Red River of the North.*" Program objectives include:

1. Develop biological criteria (for use at the international boundary).
2. Provide insights to emerging management issues surrounding Lake Winnipeg.
3. Provide information necessary to ensure articles of the Boundary Waters Treaty (IJC 2005b) are met.
4. Acquire biological, chemical, and physical data to assess the current biological condition of the main stem.
5. Assess and report on the status of aquatic life-use attainment on the main stem.
6. Develop reference indices of biological integrity for selected communities
7. Define and investigate potential stressors impairing aquatic life uses
8. Identify and report trends in ecological condition

6.0 Recommendations

Bailey et al. (2005) noted that, in many cases, the need for an ecosystem assessment is primarily articulated by people who are unable to understand or communicate with those who design the study. Making comparisons to this observation and efforts to develop and implement an assessment effort on the mainstem Red River of the North is unavoidable. Defining the specific modeling goals given the chosen theoretical ecological model, carefully defining reference condition, selecting the reference sites, and establishing an index period helps reduce the uncertainty associated with the monitoring results (USEPA 2002). The challenge currently being addressed by the AEC is to develop clear goals and a straightforward, efficient, monitoring and assessment study that answers the management's questions about the health of the aquatic ecosystem.

The workshop outcomes pointed to a logical progression of steps that must be completed before the AEC can report confidently on the ecological health of the Red River of the North main stem. The assessment effort will require a two-phased approach.

Phase I consists of preliminary information gathering and a number of other tasks necessary to develop and appropriate research design. These activities will help gain a better understanding of the processes and stressors affecting the ecosystem. Phase I will also identify data gaps that are important to evaluate existing conditions and trends.

Phase I will require considerable effort to articulate the details of a study design, identify and secure agreements with study participants, and coordinate activities among AEC members, jurisdictions and principle investigators. Phase I tasks must be completed before any field work is undertaken. The final deliverable for the Phase I component of the Red River Bioassessment effort are Quality Assurance Project Plan(s) (QAPPs). QAPPs serve as the monitoring and assessment project's "guidebook" by providing details on:

- Study Design
    - Survey reach selection methods - randomly selected from the target populations.
    - Best Available Condition identification methods – strategically selected with input from the AEC membership and scientific experts.
    - Additional reaches targeted for sampling; strategically selected with input from the AEC membership (I.e. downstream from known point sources of pollution).
- Standard Operating Procedures for sampling/measuring
    - Targeted Biological Communities
    - Physical condition assessment methods (in stream, riparian)
    - Water chemistry parameters and methods

  - Equipment needs
  - Sampling schedule/regime/index period
  - Quality Assurance Quality Control
  - Sample Chain of Custody
  - Voucher collection/species identification

- Data archival and dissemination strategy - Information Management
- Timeline and milestones

Phase II will consist of data collection, data analysis, and reporting (Note: it is not completely clear if the following tasks relate solely to Phase I)

Task 1 - Establish a Bioassessment Research Steering Committee.

Regardless of which entity ultimately implements the monitoring and assessment program, successfully coordinating the effort will require considerable effort and logistical support. Coordination and communication efforts must successfully articulate the study goals and ensure researchers, technicians, and students involved have a solid understanding of the research design specifics, the sampling protocols, methods to ensure data precision and accuracy, and the information management system. A Research Steering Committee (RSC) will serve as the outreach and coordinating mechanism for the study. The RCS could consist of members from the AEC (or their chosen representatives) from each jurisdiction, the project's principle investigators, and the field crew leaders.

Task 2 - Assemble a seamless GIS database.

A GIS database is needed to convey common understanding of the system (and eventually, the research design) and document/quantify the baseline and current condition of the ecosystem. The GIS can also be used to develop the stressor gradient model and to filter potential sampling sites (e.g. reference, test, and other potential reaches of interest) from the sample population(s). The GIS database development effort will require a data gathering component that includes searching, acquiring, and converting the various spatial data used by respective jurisdictions into a common format/projection/coordinate system. Spatial data from the U.S. and Canada would be consolidated and provide a base of available information necessary to assess and report on the ecosystem health of the main stem Red River of the North.

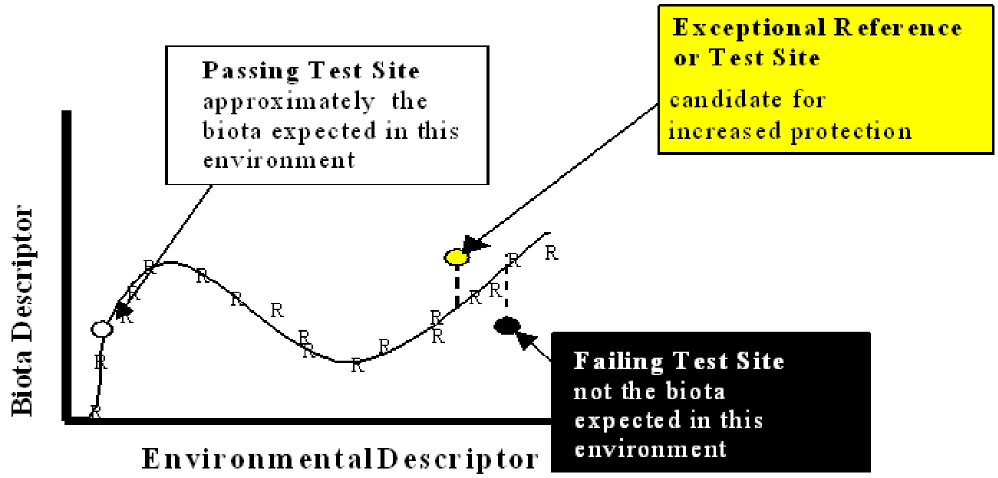
The desire for a seamless GIS database in the Red River Basin was articulated during and after the 1997 flood. The IJC recognized the need for better, more seamless, data as jurisdictions struggled to understand and react in a coordinated fashion during the flood and to better mitigate damages from future events in the Red River Basin. Completing this task would serve to partially meet this unfulfilled need that was identified following the 1997 flood.

Task 3 - Finalize Sample Design

The underlying purpose of any ecological assessment effort is to collect information that reveals the range of dose-response relationships between the biotic component(s) and known stressors to the system. The final research design will be developed in close coordination with the RSC. Study principle researchers and the members of the RSC will also serve as liaison with the various agencies in their respective jurisdictions.

The AEC recommends using the Reference Condition Approach (RCA) to assess and report on the health of the Red River main stem. Establishing a set of reference sites, and clearly understanding how the "condition" varies at these sites is an important consideration in the assessment effort (e.g. quantify the natural variability among reference sites). The RCA quantifies natural variability among the reference sites and uses inherent variation in habitat and community structure to predict biota and habitat condition at the test (survey) sites. Data from "test" sites are compared to sites representing Best Available Condition (Figure 3). Deviation of a test site from the expected range in reference condition is assumed to be caused by impacts of anthropogenic stressors, providing an empirical foundation to objectively quantify the ecological health of the Red River main stem (Bailey et al. 2004).

Figure 3. Using RCA Natural Variability to Assess "Test" Sites.



Source: Bailey 2004

The natural physical condition of rivers changes along a continual gradient from headwaters to mouth. Hence, the biological community structure of riparian systems is not homogenous along a river (Vannote et al. 1980). This natural phenomenon requires certain study design considerations to limit the inherent variability of these systems. The RSC will be tasked with developing the appropriate geomorphologic/ecological basis for stratification. The total population of reaches within the stratified river segments will be filtered using GIS tools to select the most probable reference reaches. Additional filtering will take place through site visits/surveys. Ultimately, the best professional judgment of members of the RSC and others in the Red River Basin will determine reaches with "reference" designation in each of the stratified river segments (Fritz 2004).

Task 4 - Select indicators

Biological indicators are measurements of communities or species that reflect the environmental conditions of their habitat. In other words, they are sensitive to, and correlated with, ecological stressors (Karr 1991).

A good biological indicator is one which responds to small changes in habitat quality. Mammals, birds, amphibians, invertebrates, and vegetation have been suggested for use as indicators in aquatic systems (Adamus 1996). Characteristics of ideal indicators include (Patrick 1994, Johnson et al. 1993, Adamus and Brandt 1990, and Hellawell 1986):

- Narrow and specific environmental tolerances
- Widely distributed
- Limited mobility
- Known biology
- Predictable/reliable response to a stressor
- Short lag time in responding to stressor
- Standardized collection methods
- Easily categorized to a desired level of taxonomic resolution
- Established measures, metrics, and database
- Suitable for laboratory toxicity testing
- Cost effective to sample.

EMAP-GRE uses a series of 10 indicators including physical and chemical water quality, phytoplankton/zooplankton, snag and shoreline invertebrate assemblages, fish tissue contaminants, sediment toxicity, periphyton, riparian vegetation, human disturbance, and aquatic vegetation (Yoder 2005).

At a minimum, we expect to target fish and macroinvertebrate communities for biological sampling in the Red River monitoring and assessment program. Other macroinvertebrate communities (such as freshwaters mussels), riparian vegetation, birds, or even butterflies may also be sampled depending on the study design, available resources, and the guidance of the RSC. The RSC will also determine the methods used for developing the biological indicators.

Task 4 - Establish Standard Methods

Although an obvious empirical caveat to any research effort, all methods used in the Red River Bioassessment Project must be clearly documented and consistent. Standard operating procedures for all facets of the study will be an important component of the

QAPP because the project's scale may require multiple field crews from different agencies/entities sampling along the along the entire Red River main stem.

Standard operating procedures must be developed for each targeted biological assemblages as well as for the physical (e.g. flow, habitat) and chemical components of the study. This will require considerable input from resident experts on the RSC with experience sampling the main stem Red River. Pilot studies may be required to determine the best methods for sampling selected biological communities.

There are numerous accepted and published sampling methods for fish (Sutton 2005 and Franzin and Watkinson 2005) and methodological studies have been completed to compare the precision and accuracy of the various collection methods. Methods for sampling the physical and chemical habitat and other biological assemblages will also need to be established. Angradi (2005) described a dip net-snag collection protocol implemented by EMAP-GRE that may prove useful on the Red River. Angradi (2005) and Sutton (2005) noted that "brailing" can be an effective, but infrequently used method for sampling freshwater mussels. The RSC will review and approve the methods that will be incorporated in the Red River mainstem bioassessment effort.

Task 5 - Develop an Information Management System

A number of the workshop presenters noted the importance of developing an effective information management system early in the assessment and monitoring program (Yoder 2005, Angradi 2005, and Ludgren 2005). The assessment effort envisioned will generate large amounts of information from the reaches sampled. It is imperative to undertake the necessary up-front planning to develop a usable database that incorporated sound data reporting protocols.

Last year, the IWI began hosting the Red River Basin Decision Information Network (RRBDIN) website in partnership with ND State University's Agricultural Communications Department. The RRBDIN website (http://www.rrbdin.org/) was established by the IJC after the 1997 flood to serve as a central locus for water management information in the Red River Basin. RRBDIN is designed to serve as a portal to access established information sources that have been developed and are maintained by the respective jurisdiction/agencies. Once appropriate data reporting and archival standards are developed and adopted by the jurisdictions, the RRBDIN could serve as a platform to collate and disseminate this information eventually serve to track the overall trends in the ecological health of the mainstem Red River and provide a template for standardized reporting to the IRRB and the IJC.

Appendix A. Workshop Participants

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Appendix B. Presenter Biographies

Dr. Theodore Angradi

Dr. Theodore (Ted) Angradi received his PhD from Idaho State University in 1990. His research dissertation research studied various aspects of the ecology of the Upper Snake River in Idaho. Dr. Angradi worked 2 years as a limnologist for the state of Arizona on the Colorado River associated with the Glen Canyon Environmental Study. He then worked as a research biologist for the US Forest Service in WV for 6 years working mostly on ecology of forested headwater streams. Since 1999, Dr. Angradi has been a research biologist with the EPA Office of Research and Development, National Health and Environmental Effects Research Lab in Duluth, MN. He is currently a Principle Investigator on the Environmental Monitoring and Assessment Program for Great River Ecosystems (EMAP-GRE).

Dr. David Arscott

Dr. Arscott is a Research Scientist and Project Coordinator at the Stroud Water Research Center in Avondale, Pennsylvania. The Stroud Water Research Center is a research and education institution dedicated to the study of streams and rivers. Dr. Arscott was involved as primary or co-author on 33 scientific publications, abstracts and presentations on freshwater systems. Dr. Arscott is currently working on watershed water research for potable water supply, fish ecology and management, riparian and wetland ecology, and water resources management.

Dr. Joel L Fisher

Joel L Fisher is the Senior Scientist and Environmental Advisor of the United States Section of the International Joint Commission, United States and Canada. In a career that has spanned four decades, he has done some of the early biological work on the rivers along the route proposed for the Alaska pipeline before its construction, has held research and administrative appointments in the Department of Defense, Department of Interior, and the Environmental Protection Agency, where he worked from its inception in 1969. He was one of the original executive secretaries of the Environmental Protection Agency's Science Advisory Board.

Dr. Fisher holds the Bachelor of Chemical Engineering from the Cooper Union, Master of Science from Vanderbilt University, and the Doctor of Philosophy from the University of Pennsylvania. He carried out his doctoral work in the Limnology Department of the Academy of Natural Sciences of Philadelphia on the physiology of aquatic organisms subjected to thermal stress.

His current program interests include air pollution problems in the region along the United States and Canadian borders, the behavior of radionuclides in the Great Lakes, geochemical and microbiological aspects of groundwater resources and the application of nonequilibrium thermodynamics to the biological and chemical behavior of pollutants in various media and substrates. He belongs to numerous professional and learned societies including the American Geophysical Union and the Society for Integrative and Comparative Biology. He is a veteran of the Armed Services, and is married to the former Valeria Langa, and has two grown children.

Dr. William G. Franzin

Dr. Franzin obtained a B.Sc. (1967) from the University of BC and M.Sc. (1970) and Ph.D. (1974) degrees from the University of Manitoba. He started his career as a biologist in 1973 with the Environment Canada. In 1975, he joined the Freshwater Institute in Winnipeg as a research scientist with Fisheries and Oceans Canada where he continues to work.

He was, until 2005, an adjunct professor in the Zoology Department at the University of Manitoba and has supervised or co-supervised 10 graduate student theses at the masters and doctoral levels.

Dr. Franzin's broad fish/fisheries research interests have included fish biogeography and diversity, effects of heavy metal toxicity on wild fish populations, fish genetics, walleye stocking, instream flow issues, invasive aquatic species and recently, species at risk. Franzin as authored or co-authored 45 published papers and reports, dozens of presentations at scientific meetings and contributed to countless departmental submissions and reviews. Dr. Franzin also has had significant management experience: a few years as a section manager and more than a year as an acting division manager. He is involved as an officer in the American Fisheries Society as well.

Robert F. Lundgren

Robert Lundgren is a hydrologist with the U.S. Geological Survey in Bismarck, ND currently serving as the District Water-Quality Specialist. He was the field data collection project leader for the Environmental Monitoring and Assessment Program for Western Pilot (EMAP-West) from 2000-03, and is currently participating in the Environmental Monitoring and Assessment Program for Great River Ecosystems (EMAP-GRE). He received his Bachelor and Masters of Science Degrees in Civil Engineering from the South Dakota School of Mines and Technology.

Ron Sutton

Ron Sutton has a bachelor's degree in fishery biology from Colorado State University and a master's degree in zoology from Southern Illinois University. He has over 11 years experience as a fisheries biologist in the consulting industry sampling fish populations throughout the United States. He has worked over 10 years for the Bureau of Reclamation as a fishery biologist working primarily with threatened and endangered species issues.

Larry White

Larry White received his bachelor's degree in wildlife biology from University of Nevada. He spent the early years of his career inventorying wildlife populations in the deserts and mountains of eastern California with the Forest Service, BLM and California Department of Fish and Game. For the past 20-years Larry has been with the Bureau of Reclamation specializing in wildlife and habitat in riparian ecosystems of Colorado, New Mexico, Arizona, and other western States. Since the listing of the southwestern willow flycatcher, much of his work involved monitoring riparian birds and evaluating their habitat associations. Larry has also worked with the local Audubon chapter on a long-term monitoring program for a Colorado IBA (Important Bird Area).

Chris Yoder

Chris O. Yoder is involved in the national development of biological assessments and biocriteria, including multimetric index development for wadeable streams and non-wadeable large rivers. He is presently the principal investigator of a cooperative agreement with the U.S. EPA, Office of Water for monitoring and assessment, indicators, and biological criteria development and implementation. He was most recently Manager of the Ecological Assessment Section at Ohio EPA (1989 – 2001) and supervisor and staff member since 1976. His experience also includes service on national, regional, and state working groups and committees dealing with monitoring and assessment, environmental indicators, biological assessment, biological criteria, and WQS development and implementation. Recently he served as a member of the National Research Council committee on the role of science in the TMDL process. He has 35 years of experience in the assessment of fish assemblages and other aquatic organism groups, their associated habitats, and 30 years in water quality management including the integration of multiple indicators of stress, exposure, and response.

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