Midwest Biodiversity Institute
Center for Applied Bioassessment & Biocriteria
P.O. Box 21561
Columbus, OH 43221-0561

Upper Mississippi River Clean Water Act Monitoring Strategy 2013-2022, Part 1: Options and Considerations

June 30, 2013

Midwest Biodiversity Institute
Center for Applied Bioassessment & Biocriteria
P.O. Box 21561
Columbus, OH 43221-0561
Chris O. Yoder, Principal Investigator
cyoder@mwbinst.com

photo courtesy of Wisconsin DNR

Upper Mississippi River Clean Water Act Monitoring Strategy 2013-2022
Part 1: Options and Considerations

June 30, 2013

by

Chris O. Yoder
Mick Micacchion
Benjamin Bond
Vickie L. Gordon
Edward T. Rankin
Center for Applied Bioassessment and Biocriteria
Midwest Biodiversity Institute
P.O. Box 21561
Columbus, OH 43221-0561

and

David K. Hokanson
Upper Mississippi River Basin Association
415 Hamm Building, 408 St. Peter Street
St. Paul, Minnesota 55102

This project was led by the Upper Mississippi River Basin Association's Water Quality Task Force. Funding for this project provided by the Illinois Environmental Protection Agency through Section 106 of the Clean Water Act (Financial Assistance Agreement 1060001).

Table of Contents

Appendices

List of Figures

List of Tables

List of Acronyms

BCG	Biological Condition Gradient
CWA	Clean Water Act
EMAP – GRE	(U.S. EPA) Environmental Monitoring and Assessment Program - Great River Ecosystems
EWH	Exceptional Warmwater Habitat
IA DNR	Iowa Department of Natural Resources
IBI	Index of Biotic Integrity
IL DNR	Illinois Department of Natural Resources
IL EPA	Illinois Environmental Protection Agency
ITFM	Intergovernmental Task Force on Monitoring Water Quality
LRW	Limited Resources Waters
LTRMP	(UMRR-EMP) Long Term Resource Monitoring Program
MBI	Midwest Biodiversity Institute
MCES	(Twin Cities) Metropolitan Council Environmental Services
MN DNR	Minnesota Department of Natural Resources
MN PCA	Minnesota Pollution Control Agency
MO DNR	Missouri Department of Natural Resources
MO DoC	Missouri Department of Conservation
MRBI	Mississippi River Basin Healthy Watersheds Initiative
MWH	Modified Warmwater Habitat
NASQAN	National Stream Accounting Network
NPDES	National Pollution Discharge Elimination System
NRC	National Research Council
NRCS	(USDA) Natural Resources Conservation Service
NRSA	National Rivers and Streams Assessment
SAV	Submersed Aquatic Vegetation
TALU	Tiered Aquatic Life Uses
UMESC	Upper Midwest Environmental Sciences Center
UMR	Upper Mississippi River
UMRBA	Upper Mississippi River Basin Association
UMRCC	Upper Mississippi River Conservation Committee
UMRR-EMP	(USACE) Upper Mississippi River Restoration Environmental Management Program
UMRS	Upper Mississippi River System
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
U.S. EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WI DNR	Wisconsin Department of Natural Resources
WQEC	(Upper Mississippi River Basin Association) Water Quality Executive Committee
WQS	Water Quality Standards
WQTF	(Upper Mississippi River Basin Association) Water Quality Task Force
WWH	Warmwater Habitat

Acknowledgements

This project was made possible by the Upper Mississippi River Basin Association (UMRBA) and is the result of its support and vision for the Upper Mississippi River. The Illinois Environmental Protection Agency provided project funding under a CWA Section 106 monitoring initiative grant from U.S. EPA. Dave Hokanson served as the principal technical and project contact for UMRBA. Members of the UMRBA Water Quality Task Force (WQTF) provided input, comment, and feedback in the drafting of this document. We also acknowledge the input from other individuals, agencies, and organizations that participated in project working sessions throughout 2012. A list of all project participants follows:

Name	Organization
Gregg Good	Illinois EPA
Matt Short	Illinois EPA
John Olson	Iowa DNR
Mary Skopec	Iowa DNR
Shannon Lotthammer	Minnesota PCA
Mike Feist	Minnesota PCA
Glenn Skuta	Minnesota PCA
Mohsen Dkhili	Missouri DNR
John Ford	Missouri DNR
Mark Osborn	Missouri DNR
Jim Fischer	Wisconsin DNR
John Sullivan	Wisconsin DNR
Karen Hagerty	USACE, Rock Island District
Linda Holst	U.S. EPA, Region 5
Ed Hammer	U.S. EPA, Region 5
John DeLashmit	U.S. EPA, Region 7
Paul Sweeny	USDA, NRCS
Barry Johnson	USGS, UMESC
Charlie Peters	USGS, Wisconsin Water Science Center
Kevin Richards	USGS, Iowa Water Science Center
Dale Robertson	USGS, Wisconsin Water Science Center
Mike Woodside	USGS, National Water Quality Assessment Program
Doug Yeskis	USGS, Illinois Water Science Center
Chris Jones	Iowa Soybean Association
Barb Naramore	UMRBA
Dave Hokanson	UMRBA

Introduction

The Upper Mississippi River Basin Association (UMRBA) is a regional interstate organization formed by the Governors of its member states (Illinois, Iowa, Minnesota, Missouri, and Wisconsin) to coordinate the states' programs and to work with federal agencies that have River responsibilities. UMRBA is involved with programs related to aquatic nuisance species, commercial navigation, ecosystem restoration and monitoring, flood risk management, hydropower, spill planning and response, and water quality. In regard to water quality, UMRBA supports two work groups, the Water Quality Executive Committee (WQEC) and the Water Quality Task Force (WQTF), which exist as forums of consultation and interaction among the five member states and U.S. EPA Regions 5 and 7.

The WQEC and WQTF seek to improve implementation of Clean Water Act (CWA) programs on the Upper Mississippi River (UMR). Specific outcomes from their efforts to date have included adoption of common CWA assessment reaches, enhanced collaboration with ecosystem restoration programs, numerous reports on UMR water quality issues and, most recently, efforts to examine aquatic life use designations, biological assessment, and nutrient monitoring, occurrence, and impacts. Moreover, the WQEC and WQTF recognize that collaborative efforts need to move beyond simple coordination to the development of shared tools, including a comprehensive CWA-focused monitoring strategy for the UMR.

This *Monitoring Options and Considerations* document, developed by the Midwest Biodiversity Institute (MBI), is one of two reports that comprise UMRBA's 2013-2022 UMR CWA Monitoring Strategy. The second document is the WQTF's *Recommended Monitoring Plan*, which will be completed by September 30, 2013. Ultimately, it is expected that the Strategy, as embodied in these two documents, will lead to annual monitoring work plans and coordinated, interstate monitoring implementation as funding allows.

Chapter 1: Rationale and Need for a CWA-Focused UMR Monitoring Strategy

Presently, there is no unified or comprehensive Clean Water Act (CWA)-focused monitoring strategy for the Upper Mississippi River (UMR). What exist now are the statewide CWA monitoring strategies of the five UMR states, where each treats the UMR with a differing level of coverage and emphasis. The result is a monitoring effort by the states for CWA purposes consisting primarily of a limited number of main channel fixed stations where chemical and/or physical data is collected at varying frequencies.

Federal, regional, and local entities also conduct water quality monitoring on the UMR for their own purposes and program objectives. These programs produce important and extensive data sets, but none are expressly designed for CWA purposes and therefore are limited in their ability to meet the states' CWA program needs.

Data from existing UMR monitoring programs is used to varying degrees by the states to perform assessments of status as required by the CWA. These status assessments are produced independently by each state, using state-specific methodologies. The result is a characterization of the UMR's condition that is neither comprehensive nor consistent among the states.

Given the evolution in CWA monitoring programs over the past 30 years, this is simply an inadequate approach in terms of spatial sampling design, indicators, and the rigor of the assessment process. Moreover, the scale of the River, not only in terms of its physical size, but also in its ecological diversity and significance, demands a tailored and well-designed CWA-focused monitoring program significantly beyond what is currently in place.

In sum, shortcomings in current UMR CWA monitoring and assessment include the following:

- There is no shared strategy among the UMR states, leading to inconsistencies and differential effort among the states;
- The full spatial extent of the River, both longitudinally and laterally, is not assessed;
- Much of the available data comes from programs not specifically designed for CWA purposes, and therefore may not focus on CWA-relevant parameters or achieve consistency with CWA assessment protocols;
- Current CWA-based monitoring is generally limited to chemical and physical constituents and does not incorporate biological monitoring;
- There are not commonly shared data sets used among the states in making CWA assessments; and,
- As a result of the above, CWA assessments and impairment listings for the UMR are neither consistent between the states nor do they fully characterize the status of CWA designated use attainment.

Recent reviews of UMR monitoring and CWA programs have highlighted some of these same issues, and offer further elaboration about the limitations in current UMR CWA monitoring as follows:

- The 2008 National Research Council review (NRC 2008) of Mississippi River water quality focused on the lack of coordination by the states along the entire length of the Mississippi River and a lack of leadership by U.S. EPA. A major conclusion of this review was that the Mississippi River is an "orphan" from a water quality monitoring and assessment perspective. The NRC acknowledged the coordinating function of UMRBA as a positive element and recommended a similar coordinating function for the lower river. They also concluded that the Mississippi River states will need to be more proactive and cooperative in their water quality programs if marked improvements in water quality of the river are to be realized.
- A subsequent NRC review (NRC 2009) of Mississippi River nutrient issues highlighted the need for better integration of monitoring and assessment stating that "Adequate monitoring and proper management of Mississippi River water quality, including its effects that extend in the northern Gulf of Mexico, represent important national water management challenges."
- The Upper Mississippi River Basin Association's comprehensive 2004 report on UMR state CWA programs (UMRBA 2004) found that "Water quality monitoring data on the Upper Mississippi River are currently inadequate for assessing use support and impairments. There are deficiencies in the amount of data, number of monitoring stations, and spatial coverage of existing monitoring. These shortcomings are the combined result of a variety of factors, including the challenges associated with assessing large rivers, data suitability, limited resources, lack of priority, and a lack of a comprehensive water quality monitoring strategy."
- In regard to fish tissue monitoring specifically, UMRBA's 2005 report on UMR fish consumption advisories (UMRBA 2005) recommended that "A minimum suite of contaminants, fish species, size classes, sampling locations, sampling periods, sampling frequencies, and sample preparation procedures for fish consumption advisories should be established for the Upper Mississippi River and implemented by all five states."
- The Upper Mississippi River Conservation Committee (UMRCC), in its 2002 summary of Upper Mississippi River monitoring (Sullivan et al. 2002) identified numerous gaps and shortcomings in existing UMR monitoring. This report recommended that "State, federal, and local agencies need to continue to coordinate their monitoring efforts to more effectively monitor the entire length of the Mississippi River." UMRCC's *A River That Works and a Working River* (McGuiness 2000) also calls for more coordinated water quality programs across agencies.

- The USDA NRCS Mississippi River Basin Healthy Watersheds Initiative (MRBI) has highlighted the need for more integrated monitoring. A 2010 MRBI fact sheet (NRCS 2010) states that "The MRBI Initiative is adopting a three-tiered monitoring and evaluation approach designed to assess environmental outcomes at the field, 12-digit and 8-digit watershed scales. Higher priority will be given to projects that adopt this three-tiered approach where the partner can provide resources or services or conduct activities to monitor water quality and evaluate effects of conservation practices/systems and activities implemented through the project on a field or edge-of-field scale as well as at selected downstream monitoring points." This initiative highlights the need to coordinate mainstem monitoring with monitoring efforts in UMR tributaries, potentially via pour point sampling of major watersheds as part of the CWA strategy. This has already been identified by the WQEC and WQTF as an issue to address in monitoring strategy development.

UMRBA's Board, WQEC, and WQTF recognize the challenges of UMR CWA monitoring and assessment. Together, they have begun to address related issues including designated uses, the need to incorporate bioassessments, and contemporary challenges such as nutrient pollution. A unified and comprehensive monitoring strategy is not only a venue for carrying forward these initiatives, but also provides a blueprint for a more dedicated and coordinated CWA approach on the UMR as a whole.

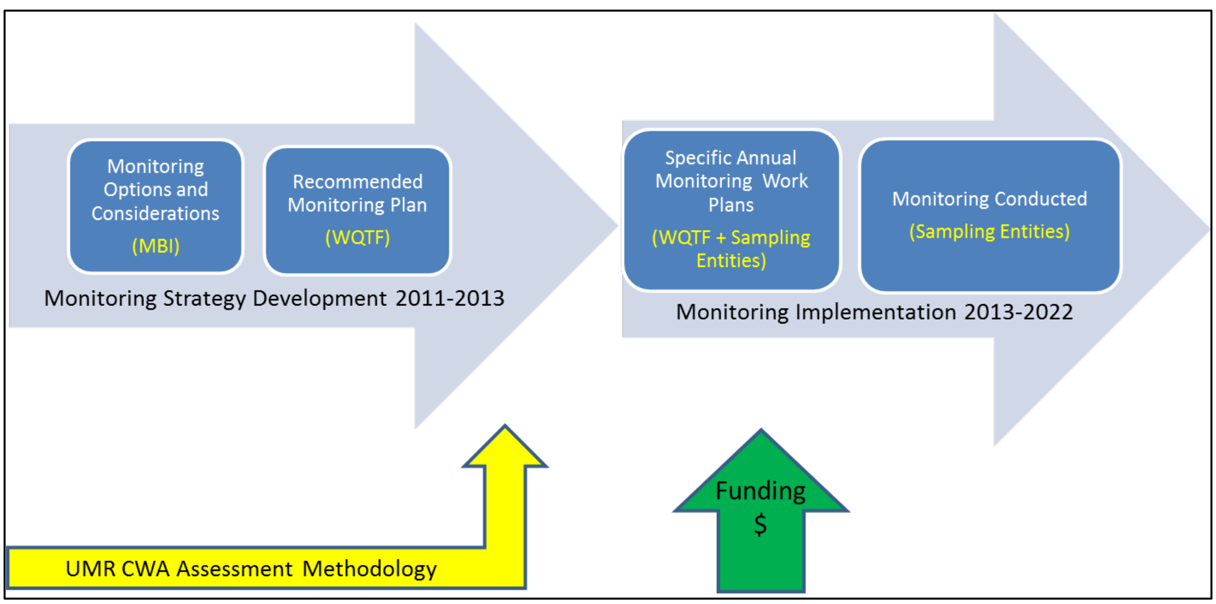
Chapter 2: Monitoring Strategy Development Approach

UMR CWA Monitoring Strategy Project

In recognition of the need for a UMR CWA monitoring strategy, UMRBA and its interagency Water Quality Task Force (WQTF) embarked on a project to develop and implement improved CWA monitoring and assessment on the Upper Mississippi River (UMR) mainstem. The resulting Monitoring Strategy (referred to hereafter as the "Strategy") will be used by the states as they pursue more consistent and comprehensive UMR CWA monitoring.

The Strategy is made up of two components: 1) a *Monitoring Options and Considerations* document (this document) developed by the Midwest Biodiversity Institute, Inc. (MBI) in consultation with the WQTF, and 2) a *Recommended Monitoring Plan* authored by the WQTF. The function of the *Monitoring Options and Considerations* document is to provide the WQTF with comprehensive information to aid their selection of preferred monitoring approach(es) for the UMR. This includes documenting strategy goals, discussion of various candidate monitoring designs (including how well they support strategy goals), indicator selection, implications for CWA assessment and impairment listing, quality control, and data management, as well as cost estimates for monitoring options. In the *Recommended Monitoring Plan*, the WQTF will express its preferences for UMR CWA monitoring, as informed by the *Options and Considerations* document. Ultimately, it is expected that the Strategy, as embodied in these two products, will lead to annual monitoring work plans and monitoring implementation, as funding allows. Additionally, as indicated in Figure 1, the WQTF is developing a UMR CWA assessment methodology alongside the monitoring strategy.

Figure 1: UMR CWA monitoring strategy development and implementation process.



Further, the project's *Scope of Work* (MBI 2011) described the major elements of the multi-agency collaborative process by which this Strategy is developed as follows:

- Examine technical information regarding monitoring approaches to inform strategy development, taking into account existing UMR monitoring and previous WQTF recommendations;
- Work directly with the states, U.S. EPA, and other project participants to gather their input as the Strategy is developed;
- Review existing state CWA monitoring strategies and U.S. EPA guidelines to ensure compatibility of a UMR CWA monitoring strategy with these; and,
- Complete reports and deliverables as scheduled, including a *Scoping Report*, draft and final *Options and Considerations* document and a *Recommended Monitoring Plan*.

Multiple Jurisdiction Considerations

The Strategy addresses the interstate UMR from the St. Croix River confluence at Prescott, Wisconsin to the Ohio River confluence at Cairo, Illinois. The interstate UMR forms a border among UMRBA's five member states. Hence the interests and needs of these states are primary considerations, as the states are directly responsible for CWA programs and how they are applied to the UMR. In part, it is these multiple jurisdictions that contribute to the current variations in CWA implementation among states. As such, the consistency of monitoring and assessment approaches, as well as their technical content, is among the issues to be addressed in the Strategy.

Conceptual Underpinnings

The content and design of the Strategy are chiefly informed by the following:

- The outcomes of recently-completed WQTF projects as they are relevant to the Strategy.
- Existing U.S. EPA guidance, including the *Elements of a State Water Monitoring and Assessment Program* (U.S. EPA 2003).
- The principles of adequate monitoring and assessment (Yoder 1998).

These conceptual underpinnings are briefly described in the following text. This Strategy also draws on a review of current UMR monitoring activities found in the project's *Scoping Report* (MBI 2012).

Recent UMRBA WQTF Projects

Three major, recent UMRBA WQTF work products either directly or indirectly address the development of a comprehensive, system-wide CWA monitoring strategy. These are the aquatic life designated uses (ALDU) report (UMRBA 2012), the UMR CWA biological assessment guidance document (Yoder et al. 2011), and the UMR nutrient report (UMRBA 2011). Each highlights the need for a unified UMR CWA monitoring strategy in its findings and suggests elements to be incorporated into a strategy. As such, work on a UMR CWA monitoring strategy both builds on and is informed by these recently completed efforts.

UMR Aquatic Life Designated Uses (ALDU) Report

The ALDU report (UMRBA 2012) establishes a UMR classification structure to guide ongoing CWA program implementation on the River. This framework includes four longitudinal reaches and four lateral strata as shown in Figure 2.

Figure 2: UMR spatial classification structure including longitudinal and lateral strata (after UMRBA 2012).

		Lateral Strata			
Longitudinal Reaches		**Main Channel**	**Side Channel**	**Impounded**	**Contiguous Backwater**
	St. Croix River				
	Upper Impounded to Chippewa River *CWA Assessment Reach 1*	**X**	**X**	**X**	**X**
	Chippewa River (base of Lake Pepin)				
	Upper Impounded below Chippewa River *CWA Assess. Reaches 2-6*	**X**	**X**	**X**	**X**
	Lock and Dam # 13				
	Lower Impounded *CWA Assess. Reaches 7-11*	**X**	**X**	**X**	**X**
	Missouri River				
	Unimpounded (Open River) *CWA Assess. Reaches 12-13*	**X**	**X**	**[Not Applicable]**	**X**
	Ohio River				

The WQTF and WQEC envision that this structure will be employed in multiple CWA program elements and in the development of a UMR monitoring strategy in particular. The ALDU report states:

> *"Developing a comprehensive CWA assessment-focused monitoring strategy for the UMR is a top priority for the states. Such a strategy is a critical element if this*

> *report's recommendations are to have their desired effect in improving UMR assessment and protection . . . Chemical, physical, and biological metrics should all be considered within a monitoring strategy, as they are all key components of ecosystem function. The states will also need to specifically address the type and extent of monitoring that is appropriate to fully assess all of the proposed UMR classes. This should include consideration of probabilistic monitoring, intensive strata monitoring, and fixed-site monitoring. Further, the monitoring strategy should be developed and implemented not only for the purposes of CWA assessment and impairment listing, but to support other CWA management functions, including further criteria development. In addition, sample collection and analytical methods, frequency of sampling, and data storage all need to be considered in developing a comprehensive monitoring strategy for the UMR. "*

<u>UMR CWA Biological Assessment Implementation Guidance Document</u>

The biological assessment guidance (Yoder et al. 2011) has perhaps the most specific set of recommendations regarding monitoring strategy development, as follows:

> *"Developing a sustained UMR CWA assessment program based on the principles outlined herein brings the focus on providing a measurement framework that can assess current conditions, but also detects changes in increments of condition and serves as a feedback to the various management programs that are working to restore and maintain the biological quality of the UMR. While the development of thresholds is a critical component of this framework, it is a result of the quality and characteristics of the overall monitoring and assessment program that will eventually be applied to the UMR. Developing a comprehensive strategy that actually leads to the execution of this type of monitoring and assessment program is an essential next step.*
>
> *As the states move forward utilizing the recommendations made in the report, numerous challenges remain. These challenges include identifying an appropriate entity or entities to conduct monitoring, gathering financial resources to support monitoring, managing data, coordinating assessment methodologies, and addressing the policy implications of adopting biological assessment. However, this project has demonstrated that a UMR CWA assessment incorporating biology is feasible given readily available tools. As such, the states are encouraged to continue their efforts by utilizing the information provided in this guidance to:*
>
> 1. *Develop a UMR-wide CWA monitoring strategy that the follows the principles outlined herein.*
> 2. *Utilize a modification of the EMAP-GRE design as the baseline spatial sampling design, i.e., execute an intensive, longitudinal "intensive pollution survey" design.*

3. *Examine programmatic and organizational options for implementing such a strategy outlining the costs of each and the technical pros and cons.*
4. *Use the biological assemblage, biological index, and biocriteria threshold recommendations included herein as the basis for an initial biological assessment of the UMR main channel and future assessments based on a new monitoring strategy.*
5. *Develop and utilize a data management system that is easy to use, easy to access, and which delivers sampling data and transformed data in a portable and relational format."*

Notably, the first recommendation of the biological assessment guidance is the development of a comprehensive and system-wide monitoring strategy. The biological assessment guidance project actually performed a preliminary assessment of the UMR main channel including biology, reporting the stressor relationships that explained observed biological impairments. This required the use of available chemical/physical and biological data and as such it highlighted gaps in both spatial design and parameter coverage, two essential monitoring strategy components.

<u>UMR Nutrients Report</u>

The UMR Nutrients Report (UMRBA 2011) also contained several recommendations relevant to monitoring strategy development, including:

- "*Pursue more consistent and comprehensive monitoring protocols among water quality programs, including:*
  - *Identifying a standard, minimum set of nutrient-related parameters to monitor;*
  - *Establishing a minimum sampling frequency for fixed sites;*
  - *Expanding the lateral and longitudinal monitoring of the UMR mainstem to address its full spatial extent (but not at the expense of basinwide nutrient monitoring); and*
  - *Considering how to integrate U.S. Army Corps of Engineers (USACE) Upper Mississippi River Restoration Environmental Management Program (EMP) Long Term Resource Monitoring Program (LTRMP) stratified random sampling (SRS) data with existing or proposed monitoring schemes.*
- *Integrate continuous monitoring for nutrient-related variables into monitoring programs.*
- *Develop a UMR-wide, CWA-focused monitoring strategy, as this will address many of the needs listed above.*
- *Harmonize data reporting and sharing; at minimum by documenting data standards and retrieval protocols.*
- *Consider establishing a tributary load monitoring network.*

- *Identify mutually-accepted methods of tracking and reporting algal blooms and fish kills. This may include:*
    - *Expanded chlorophyll-a monitoring to estimate sestonic algae blooms;*
    - *Expanded implementation of metaphyton quantification efforts, as initiated by LTRMP and Wisconsin Department of Natural Resources (DNR); and*
    - *More uniform mechanisms for reporting and tracking fish kills, including a water quality sampling protocol to follow when a kill is reported."*

<u>Implications</u>
Taken in sum, the outcomes of these projects have the following implications for UMR CWA monitoring strategy development:

- A strategy is definitely needed, as all three initiatives resulted in strong recommendations advocating the development and implementation of a comprehensive, CWA-focused monitoring strategy.
- The monitoring strategy should address the UMR's full spatial extent (i.e., the longitudinal reaches and lateral strata identified by the ALDU report).
- Chemical, physical, and biological indicators should all be included in the monitoring strategy. The choices of biological indicators should be informed by the recommendations of the biological assessment guidance document. The selection of nutrient parameters should be informed by the recommendations of the UMR nutrient report.
- Multiple monitoring designs (e.g., fixed site, probabilistic, pollution survey) should be considered as candidates for inclusion in the monitoring strategy. The monitoring strategy should support 305(b) assessment and 303(d) impairment listing and aid other CWA management functions (e.g., water quality standards development, NPDES permits, TMDLs).
- The strategy should be designed to help address nutrient-related questions, including the impacts of nutrients on aquatic life and nutrient loading from tributaries.
- Data management and compatibility with other programs are important considerations in strategy development.

U.S. EPA Elements of a Monitoring and Assessment Program
In March 2003, U.S. EPA published *Elements of a State Water Monitoring and Assessment Program* (U.S. EPA 2003) to recommend the basic elements of a state water monitoring program and to serve as a tool to help U.S. EPA and the states determine whether a monitoring program meets the prerequisites of CWA Section 106[e][1]. This guidance is also intended to provide a framework for states to clearly articulate their programmatic and resource needs and a reasonable time line for meeting those needs. U.S. EPA also expected that the guidance would help identify efficiencies to be gained through a holistic approach to program

implementation. The ten basic elements of a monitoring and assessment program identified by U.S. EPA in this guidance are summarized as follows:

1) **Monitoring Strategy.** A long-term and detailed implementation plan not to exceed ten years.
2) **Monitoring Objectives.** These are critical to the design of a monitoring program that is efficient and effective in generating data that serves management decision needs.
3) **Monitoring Design.** An approach and rationale for the selection of monitoring designs and sample sites that best serves the monitoring objectives.
4) **Core and Supplemental Indicators.** A tiered approach to monitoring that includes core indicators selected to represent each applicable designated use, plus supplemental indicators selected according to site-specific or project-specific decision criteria.
5) **Quality Assurance.** Quality management plans and quality assurance program/project plans are established, maintained, and peer reviewed to ensure the scientific validity of monitoring and laboratory activities, and to ensure that state reporting requirements are met.
6) **Data Management.** An accessible electronic data system for water quality, fish tissue, toxicity, sediment chemistry, habitat, biological data that has timely data entry, data description, and public access standards.
7) **Data Analysis and Assessment.** Methodologies for assessing attainment of water quality standards based on analysis of various types of data (chemical, physical, biological, land use) from various sources, for all waterbody types and all state waters are developed and used.
8) **Reporting**. Timely and complete water quality reports and lists called for under Sections 305[b], 303[d], 314, and 319 of the Clean Water Act and Section 406 of the Beaches Act are published.
9) **Programmatic Evaluation.** The state, in consultation with its EPA Region, conducts periodic reviews of each aspect of its monitoring program to determine how well the program serves its water quality decision needs for all state waters, including all waterbody types.
10) **General Support and Infrastructure Planning.** The state identifies current and future resource needs it requires to fully implement the monitoring program strategy.

The design of this Strategy will in general follow the U.S. EPA ten recommended elements, but is not rigidly bound by this approach.

Adequate Monitoring and Assessment

While being developed within the general guidelines of elements described above, this Strategy also relies on the more detailed concepts of “adequate monitoring and assessment” (Yoder

1998) as described in the project *Scoping Report* (MBI 2012). In brief, adequate monitoring and assessment includes the following key attributes and principles:

- Indicator development, position, and selection adhere to commonly accepted theoretical concepts (i.e., Karr's five factors [Karr et al. 1986]; NRC position of the standard [NRC 2001]);
- Indicators are cost-effective to develop and use, yet are comprehensive;
- Indicators are used within their *most appropriate* roles (stress, exposure, or response);
- Indicators are directly tied to water quality standards (WQS) via designated uses and numerical or narrative criteria;
- Measurement and data quality objectives (MQO/DQO) are defined by the WQS and are adequate to support accurate assessments and perform diagnostic tasks;
- The overall program can adapt quickly to improved science and technology;
- The program is supported by adequate resources, facilities, and professionalism;
- The spatial design(s) match the scale at which management is applied; and,
- The end product is an integrated assessment, not just the data.

An important component of an adequate monitoring and assessment approach is developing indicators such that they can operationally determine the status of aquatic resources, multiple designated uses, and the effectiveness of water quality management by utilizing the concept of core and supplemental indicators. It also includes a comprehensive approach to developing indicators and endpoints, leading to appropriately detailed and refined criteria and standards that both guide management programs and measure their effectiveness. It may also reveal where WQS need to be adjusted and revised, which in the case of the UMR includes:

- refining their applicability to the spatial strata;
- including biological criteria and tiered aquatic life uses; and,
- highlighting inconsistencies between states with shared jurisdictional boundaries.

It is a fundamental premise of the adequate monitoring and assessment framework that ambient monitoring and assessment should function to support all relevant CWA management programs[1], in addition to its more commonplace role of supporting status assessments. Determining the potential linkages to state WQS and reporting (305[b], 303[d]) obligations are especially emphasized, as these are fundamental to the broader use of environmental data in

[1] "Relevant" CWA programs include the management programs that are in-common to most states in addition to reporting and listing (e.g., Water Quality Standards including designated uses and criteria, TMDL development and implementation, NPDES permitting, NPS planning & implementation, 401 certification, etc.). It can also include any CWA program that could be influenced by monitoring and assessment data and information. This certainly includes programs that are considered to be "water quality based", i.e., those that are driven and influenced by the WQS.

management decision-making. If properly designed and executed, a comprehensive strategy that prioritizes the baseline function of assessing status (e.g., 305[b], 303[d]) should also fulfill the support of other CWA programs at the same time. In addition, non-CWA programs may find value in the data generated by the monitoring program if its focus is on an adequate characterization of aquatic resources.

Key Steps in Drafting the UMR CWA Monitoring Strategy

In recognition of the conceptual underpinnings outlined above, this project's *Scoping Report* (MBI 2012) concluded by detailing the following key steps to be taken in drafting the Strategy (abbreviated here, see the *Scoping Report* for full original text). The structure of this *Options and Considerations* document reflects these key steps, as well.

1) **Start with a "Clean Slate."** While there are many extant and recent UMR monitoring efforts none of them individually or collectively provide for a systematic, consistent, and comprehensive CWA assessment. While results from some of these programs will likely "plug into" a comprehensive UMR CWA monitoring strategy, it is essential that the UMR states first independently define what they need in a CWA monitoring program. Without this clarity and separation of purpose, the states could easily be weighed down discussing existing programs without ever defining what is needed for CWA purposes.

2) **Utilize the U.S. EPA Ten Recommended Elements and Adequate Monitoring and Assessment Framework.** All of the UMR states utilize the ten recommended elements (U.S. EPA 2003) in their existing monitoring strategies, so use of this framework on the UMR is consistent with current state approaches. However, the ten elements lack important details that are needed to develop a monitoring strategy and do not provide for the necessary connections between indicators and the assessment of designated uses. As such, the adequate monitoring and assessment framework (Yoder 1998) will also be considered as a unifying conceptual approach for monitoring strategy development.

3) **Begin by clearly documenting monitoring goals.** At the outset of monitoring strategy work, it is critical for all participants to agree on and clearly document UMR CWA monitoring goals.

4) **Determine monitoring design(s).** The project must delineate the monitoring design(s) that are needed to address key assessment needs including status and trends, ascertaining the extent and severity of impairments, and supporting day-to-day CWA management needs. Multiple designs (e.g., fixed site, probabilistic, intensive survey) may be needed to meet monitoring strategy goals.

5) **Identify the indicators to be monitored.** This follows the adequate monitoring framework in terms of identifying indicators for the major designated uses to be assessed, including both core and supplemental indicators. Indicators will include those

that are currently lacking in UMR CWA programs (i.e., biological monitoring, key physical and chemical parameters, and habitat measures).

6) **Consider the implications for assessment methodology development and impairment listings.** While beyond the scope of the Strategy *per se*, a shared UMR assessment methodology, or guidance to the states in conducting assessments, will ultimately need to accompany the monitoring Strategy. Therefore, the implications for assessment methodology development, as well as future impairment listings, will be considered as part of Strategy development.

7) **Document implementation options and costs.** Exploring implementation issues and costs is a critical aspect of this project. This includes describing tiers of different monitoring designs and an assessment of the capacity needed to execute each. The estimated costs of the various options are estimated, and the pros and cons of each approach described in Chapter 11.

Chapter 3: Monitoring Strategy Scope and Goals

Per the key steps described in the *Scoping Report* and summarized in the preceding chapter, the WQTF began its project work by defining the Strategy's scope and goals. These express the WQTF's synthesis of the strategy's conceptual underpinnings into a UMR-specific context and are as follows:

Monitoring Strategy Scope

In terms of both spatial and content scope, the Strategy will:

- Address the full longitudinal extent of Upper Mississippi River (UMR). This includes the interstate portion of the UMR from the St. Croix River confluence at Prescott, Wisconsin to the Ohio River confluence at Cairo, Illinois and incorporates all four of the longitudinal reaches identified in UMRBA's February 2012 aquatic life designated uses (ALDU) report. This scope also includes all of the 13 CWA assessment reaches currently utilized by the UMR states.
- Address the four lateral strata – main channel, side channel, impounded, and contiguous backwater - identified in the 2012 ALDU report, to the extent monitoring tools exist for these strata. If tools do not exist for particular strata, development needs will be identified. The main channel is the highest priority for strategy development.
- Address all four major UMR designated uses - aquatic life, drinking water, recreation, and fish consumption – where these uses are assigned and to the extent monitoring tools exist for these uses.
- Include chemical, physical, and biological parameters.

Monitoring Strategy Goals

The goals of the Strategy are as follows:

- A central goal of the Strategy is to support improved assessment of the UMR under the CWA. Specifically, this means the Strategy will be explicitly designed to collect biological, chemical, and physical data for use in more consistent and comprehensive 305[b] assessments and 303[d] impairment listings. Achieving this goal will encourage progress toward a unified UMR CWA assessment and inform whether unified 303[d] listings may be feasible in the future.
- Data collected under the Strategy will also aid other key CWA program functions including water quality standards development, NPDES permits, TMDLs, nonpoint source assessment and management, and measurement of nutrient loading from UMR tributaries (i.e., "pour points"). In addition, data produced by monitoring under the Strategy may be of value for non-CWA programs on the UMR.

Monitoring designs are evaluated in this *Options and Considerations* document (see Chapter 5) according to their ability to meet Strategy goals, with particular emphasis on the support of improved 305[b] assessments and 303[d] impairment listings.

Chapter 4: Approach to Designated Uses and Multiple Spatial Strata

The UMR represents a multidimensional challenge in terms of its diverse ecological setting, spatial complexity, temporal variation, multiple uses, and the resulting array of CWA management goals. This multidimensional nature greatly influences the design of monitoring needed to achieve Strategy goals. This chapter explores two particular challenges – multiple designated uses and spatial complexity – that must be considered in UMR monitoring design.

The Strategy seeks to support the assessment of four primary designated uses on the UMR (i.e., aquatic life, recreation, drinking water, and fish consumption). This is consistent with an "adequate monitoring and assessment" approach, which is principally driven by monitoring to assess and manage for designated uses. This chapter provides an overview of the primary designated uses assigned to the River by the states. Later, Chapter 7 includes an analysis of how various candidate monitoring designs support the assessment of these uses.

This Strategy also addresses the full spatial extent of the UMR. Specifically, it seeks to assess the four major UMR designated uses in *each* of longitudinal reaches and lateral strata (main channel, side channel, impounded, backwaters) described in the UMR classification structure presented in the ALDU report (UMRBA 2012) to the extent each of these uses is designated for a particular stratum.

Designated Uses

Designated uses are the core of state WQS in that they describe the beneficial uses of water bodies and lead to chemical, physical, and biological criteria that are utilized in the protection and restoration of those water bodies. Ideally, designated uses are described in sufficient detail so as to result in the best possible outcomes from CWA management programs. Narrative or numeric water quality criteria are established by each state to describe the conditions needed to support designated uses.

The Strategy considers four primary designated uses as described below. While individual states assign additional uses to the UMR, these four are most commonly assigned. Technically, the current uses and criteria assigned by the states apply to the full spatial extent of the UMR within their borders. In current practice, however, assessments of these uses are largely limited to the UMR's main channel.

1. **Aquatic Life** – This category of use is focused on the "protection and propagation of fish, shellfish, and wildlife in and on the water." The entirety of the UMR is designated for aquatic life use by the five states, with specific definitions varying somewhat between the states. States' numeric criteria for aquatic life use protection are primarily expressed as chemical levels and include conventional parameters such as dissolved oxygen (D.O.), temperature, pH, and toxic chemicals for both chronic and acute thresholds. Specific criteria values for individual parameters can vary among the states. Aquatic life use criteria are commonly used for determining water quality based

requirements for NPDES discharges and in TMDLs, with these criteria frequently resulting in the most stringent requirements among applicable criteria. The WQTF has recognized the need to make aquatic life uses more detailed (UMRBA 2012) and also measurable by biological indicators. As such, the *Biological Assessment Guidance* (Yoder, et al. 2011) was developed as a start towards biologically assessing aquatic life uses. This project also highlighted the need to consider tiered aquatic life uses for the UMR.

2. **Recreation** – This category is focused on the protection of human contact with the water and specifically on waterborne pathogenicity. Human contact recreation use is assigned by the states to essentially the entirety of the UMR with the exception of small segments in Illinois and (currently) Missouri. The primary indicator used to assess recreation use is typically a fecal bacterial measure indicative of the possible presence of pathogens, with *Escherichia coli* often utilized. Specific criteria vary by the degree of expected contact with the water via an activity such as swimming, wading, or boating and are generally expressed as a geometric mean and a maximum count.
3. **Drinking Water** – This use is intended to protect drinking water and assure quality sufficient to be treatable by a water treatment plant. As such, the primary criteria are chemical and focused on human health concerns. Illinois and Missouri assign this use to the entirety of the UMR within their borders. Iowa designates its public water supply use at water supply intakes only. Minnesota and Wisconsin do not assign this use to the interstate UMR as there are no drinking water intakes on their sections of the River.
4. **Fish Consumption** – This use is intended to protect for the safe human consumption of fish taken from a water body. It focuses primarily on that route of exposure to humans and assessment addresses the presence of carcinogenic substances and those that affect cognitive functioning. Certain age and gender groups are believed to be the most at risk to exposure to these types of substances via fish consumption. The results of fish tissue analysis form the basis for consumption advisories that are issued by the states. All five states assess the fish consumption use on the UMR, with all states except Missouri relying on fish consumption advisories in making impairment determinations.

Under an adequate monitoring and assessment framework, each designated use either directly or indirectly informs which indicators and parameters will be monitored at a specific location in the UMR. Further, each use carries with it a different spatial and temporal aspect to the type of sampling regime that will be considered by the Strategy. As such, different candidate designs may offer varying abilities to assess various uses, as explored in more detail in Chapter 7.

Longitudinal Reaches and Lateral Strata

UMRBA's aquatic life designated uses (ALDU) project (UMRBA 2012) identified distinct longitudinal reaches and lateral strata and on the UMR (see Figure 2). Longitudinal strata were delineated by the ALDU project as follows:

1. **Upper Impounded Reach (above the Chippewa River)** – starts at the St. Croix River and goes downstream to the Chippewa River (base of Lake Pepin); includes CWA assessment reach 1 and encompasses river miles 812-763.
2. **Upper Impounded Reach (below the Chippewa River)** – starts at the Chippewa River (base of Lake Pepin) and goes downstream to Lock and Dam 13; includes CWA assessment reaches 2-6 and encompasses river miles 763-523.
3. **Lower Impounded Reach** – starts at Lock and Dam 13 and goes downstream to the confluence with the Missouri River; includes CWA assessment reaches 7-11 and encompasses river miles 523-196.
4. **Unimpounded Reach** – this reach starts at the Missouri River confluence and goes downstream to the Ohio River confluence; it includes CWA assessment reaches 12-13 and encompasses river miles 196-0. This is also known as the Open River reach.

These longitudinal reaches encompass the 13 existing UMR CWA assessment reaches. There are shared breakpoints between the two sets of reaches (e.g., CWA assessment reach 7 starts at the same point as the Lower Impounded Reach). See Table 1 for further details.

Lateral distinctions identified in the ALDU report are based on differences among strata for a number of chemical and physical parameters, and in some cases between groups of strata (e.g., contiguous backwater and impounded versus main channel and side channel). Biological communities, both fish and vegetation, also demonstrate differences among strata for several metrics (e.g., species richness, frequency of occurrence). Additionally, lateral strata definitions match those used by the Upper Mississippi River Restoration-Environmental Management Program Long Term Resource Monitoring Program (LTRMP). Lateral strata are defined by UMRBA (2012) as follows:

1. **Main channel** – the navigation channel and its border.
2. **Side channel** – channels other than the main channel.
3. **Impounded** – large, mostly open-water off-channel areas located in the downstream portion of the navigation pools, upstream of a dam.
4. **Contiguous Backwater** – off-channel areas with apparent surface water connection with the main channel and side channels.

In terms of this Strategy, lateral strata represent features of the UMR complex to be considered in selecting spatial sampling designs and indicators. While the highest priority for Strategy development is on the main channel, all four lateral strata are to be addressed, per the Strategy's scope as described in Chapter 3, to the extent measurement tools exist for these strata.

Table 1. UMR longitudinal strata and assessment reaches (after UMRBA 2012).

Floodplain Reach	Physical Feature	CWA Interstate Assessment Reach	River Miles	ALDU Recommended Longitudinal Reach
Upper Impounded	*St. Anthony Falls*	Non-Interstate UMR		
	Lock and Dam #1			
	Lock and Dam #2			
	St. Croix River	**Assessment Reach 1 (Rush-Vermillion)** (St. Croix River to Chippewa River/ HUC 07040001)	**812-763**	**Upper Impounded (above Chippewa River)**
	Lock and Dam #3			
	Chippewa River			
	Lock and Dam #4	**Assessment Reach 2 (Buffalo-Whitewater)** (Chippewa River to Lock and Dam 6/ HUC 07040003)	**763-714**	**Upper Impounded (below Chippewa River)**
	Lock and Dam # 5			
	Lock and Dam #5a			
	Lock and Dam #6			
	Lock and Dam #7	**Assessment Reach 3 (La Crosse-Pine)** (Lock and Dam 6 to Root River/HUC 07040006)	**714-694**	
	Root River			
	Lock and Dam #8	**Assessment Reach 4 (Coon-Yellow)** (Root River to Wisconsin River/HUC 07060001)	**694-631**	
	Lock and Dam #9			
	Wisconsin River			
	Lock and Dam #10	**Assessment Reach 5 (Grant-Maquoketa)** (Wisconsin River to Lock and Dam 11/ HUC 07060003)	**631-583**	
	Lock and Dam #11			
	Lock and Dam #12	**Assessment Reach 6 (Apple-Plum)** (Lock and Dam 11 to Lock and Dam 13/ HUC 07060005)	**583-523**	
	Lock and Dam #13			
Lower Impounded	*Locks and Dam #14*	**Assessment Reach 7 (Copperas-Duck)** (Lock and Dam 13 to Iowa River/ HUC 07080101)	**523-434**	**Lower Impounded**
	Locks and Dam #15			
	Lock and Dam #16			
	Lock and Dam #17			
	Iowa River			
	Lock and Dam #18	**Assessment Reach 8 (Flint-Henderson)** (Iowa River to Des Moines River/ HUC 07080104)	**434-361**	
	Lock and Dam #19			
	Des Moines River			
	Lock and Dam #20	**Assessment Reach 9 (Bear-Wyaconda)** (Des Moines River to Lock and Dam 21/ HUC 07110001)	**361-325**	
	Lock and Dam #21			
	Lock and Dam #22	**Assessment Reach 10 (The Sny)** (Lock and Dam 21 to Cuivre River/ HUC 07110004)	**325-237**	
	Lock and Dam #24			
	Lock and Dam #25			
	Cuivre River			
	Lock and Dam #26 (Melvin Price)	**Assessment Reach 11 (Peruque-Piasa)** (Cuivre River to Missouri River/HUC 07110009)	**237-196**	
	Missouri River			
Unimpounded	*Kaskaskia River*	**Assessment Reach 12 (Chaokia-Joachim)** (Missouri River to Kaskaskia River/ HUC 07140101)	**196-118**	**Unimpounded (Open River)**
	Thebes Gap	**Assessment Reach 13 (Upper Miss-Cape Girardeau)** (Kaskaskia River to Ohio River/HUC 07140105)	**118-0**	
	Ohio River			

In summary, this Strategy addresses all four major designated uses in all longitudinal reaches and lateral strata. This means that indicator groups should be identified in all of these contexts and monitoring designs developed to cover all spatial areas. However, it is recognized that appropriate assessment tools, particularly biological indicators, may not yet exist for all strata. In these cases, developmental needs are identified (see Chapter 9).

Chapter 5: Spatial Monitoring Designs

Spatial design considerations for the interstate UMR pertain to the determination of sampling locations and how the allocation of sampling sites affects what can be accomplished in meeting Strategy goals. As such, and in keeping with the adequate monitoring and assessment framework, this chapter considers how the spatial aspects of monitoring affect the quality and comprehensiveness of the assessments that result, and how different designs support various CWA program components. Functions of candidate monitoring designs, as well as their relative advantages and disadvantages in light of Strategy goals, are explored in detail. The list of options examined here includes designs recommended for consideration by MBI, as well as those specifically requested for inclusion by the WQTF.

Spatial design directly affects how data are used in making assessments and how this also supports planning, effectiveness evaluation, and making management decisions. Design will determine the level of assessment that can be supported, ranging from a one-dimensional determination of status (e.g., the proportion of the entire UMR that is in good, fair, or poor condition), to more detailed and presumably more accurate determinations of status in the different spatial strata, to detailed site-specific determinations with an accompanying diagnosis of impairments. Further, design dictates how the goals of the strategy will be met – i.e., all of the designs presumably meet the 305[b] and 303[d] goal at some level, but not all provide for the goal of supporting water quality management programs. Spatial design plays a critical role in how effectively these tasks and desired outcomes can be accomplished.

The discussion of spatial designs that follows separates out mainstem network options from a tributary loading network, the latter serving a very specific function in measuring nutrient and sediment loadings to the UMR. The mainstem network options seek to support CWA assessment and a broader set of CWA program functions. For the mainstem, four general types of monitoring designs are considered – fixed stations, probabilistic, stratified random sampling, and longitudinal surveys. In the case of the tributary loading network, only a fixed station design is considered applicable.

Description of Mainstem Spatial Monitoring Design Options

Fixed Station Design

<u>Design Description</u>: A fixed station is just that, a fixed location where samples are collected at prescribed intervals (e.g., monthly, quarterly). Fixed station monitoring networks have been employed by state and federal agencies for several decades, with some networks dating back more than 70 years. The most notable of these networks is the National Ambient Water Quality Monitoring Network (NAWQMN) principally operated by the states in compliance with the early program requirements of U.S. EPA under the CWA. The U.S. Geological Survey operates the National Stream Quality Accounting Network (NASQAN) which essentially serves the same function and purpose of NAWQMN and coincides with USGS flow gaging stations. Other fixed station networks include state monthly and quarterly water quality stations, a few

select programs operated by industries and municipalities, and on the UMR, the fixed site sampling element of the UMRR-EMP LTRMP.

What all of these networks have in common is that the stations are established at convenient access points where water samples can be quickly obtained and/or fixed sampling equipment can be located. They are sampled at regular intervals (monthly, quarterly, or with continuous monitoring equipment) and their spatial density is comparatively sparse along a given stream or river. In addition, the indicators and parameters are predominately chemical/physical with a prescribed list of parameters to be analyzed. For example, most monthly sites are sampled for field parameters such as temperature, dissolved oxygen (D.O.), pH, and conductivity, and grab samples are analyzed for a suite of conventional and demand parameters such as biochemical oxygen demand (BOD), suspended solids, nutrients, ionic strength parameters, and in some cases fecal bacteria. Toxicants such as heavy metals and pesticides are typically sampled either less frequently (i.e., quarterly) or only at locations where these pollutants are an issue of concern. These stations generally do not include biological monitoring, but can include fish tissue and sediment chemistry sampling.

Functions: Fixed stations, termed Eulerian networks by Blevins and Fairchild (2001), function best to provide a long term record for specific parameters over a long period of time. They were not designed for ecological assessment, yet they currently form the basis of assessing aquatic life use attainment in the UMR. The data derived from these sites has thus far been used by the UMR states to support 305[b] assessment and 303[d] impairment determinations for the main channel lateral stratum.

Current/Recent Use on the UMR: As of 2011, there were 65 active fixed locations on the UMR main channel that are sampled by multiple entities (Appendix Table A-1). The UMRR-EMP LTRMP currently samples 43 of the fixed stations with the remaining 22 being sampled by individual states and/or supported by the USGS NASQAN program. This network currently supports CWA assessment for aquatic life, recreation, and water supply uses.

Probabilistic Designs

Design Description: Under a probabilistic approach, all potential sampling sites within a region, waterbody, other geographic area are identified and enumerated. A smaller subset of sites or the “sample” are randomly selected from the “population” and these sites are then sampled (Olsen et al. 1999). This design assumes that aquatic resources are simply too large to conduct more intensive sampling. Hence, a subset of sites is randomly selected to represent the entire population. It is the random selection of the sampling sites that provides the statistical validity necessary to extrapolate the results of the sampled sites to the entire population. U.S. EPA has typically implemented such surveys so that one set of samples is collected during a monitoring cycle (i.e., typically each site is visited only once). However, alternate approaches are possible where some indicators are sampled more than one time at each site.

Design Function: In this design each sampling site is a “member” of the overall population and its individual role as a discrete sample is deemphasized. As such, results are used primarily to infer the overall condition of the resource strata population that is included in the base draw of sites, including all segments and sites that were not sampled. This sampling design was developed to answer questions related to the status and trends of water resources at regional and national scales of resolution. It functions best in providing a statistically valid assessment of the overall condition or state of the "population" of the resource being assessed, in this case the strata of the UMR that are included in a probabilistic design.

Current/Recent Use on the UMR: Probabilistic designs include those employed by the U.S. EPA Environmental Monitoring and Assessment Program (EMAP) and more recently by the National Aquatic Resource Surveys (NARS) of which the National Rivers and Streams Assessment (NRSA) is the applicable part of the NARS program to the UMR mainstem. The EMAP-Great Rivers Ecosystems program employed a probabilistic design on the UMR main channel during 2004-6 and this data served as the basis for the UMR CWA *Biological Assessment Guidance* (Yoder et al. 2011). LTRMP's probabilistic monitoring is discussed in the following section on Stratified Random Sampling.

Possible Levels of Probabilistic Design for UMR: The probabilistic design can be spatially scaled to match a desired level of detail in the resulting assessment. Four levels of probabilistic design (referred to as Probabilistic A through Probabilistic D) appear potentially applicable to the UMR as described below. The resolution of longitudinal strata that can be assessed increases with each probabilistic option from A through D. The number of total sites likewise increases and is a consideration in how each option could be implemented both in terms of resources and the number of years each would take to complete one full assessment cycle through the UMR. A request for a UMR-specific "site draw" would need to be made of U.S. EPA for each of the following candidate probabilistic designs.

For any level of probabilistic design, the basic unit of assessment is the aggregate condition of the population of sites within the selected spatial scale. Put another way, the principal assessment product of any of the probabilistic design options is the overall or average condition of the spatial unit that was originally considered in the base draw of sites.

The probabilistic designs described below are focused primarily on the main channel. Including the side channels could be accomplished by adding them as a distinct strata (which would further increase the number of sites) or by collapsing the side channel strata with the main channel strata in the base design.

1. **System-Level (Probabilistic A):** This is a minimum probabilistic design that treats the UMR main channel as a single-dimension homogenous resource and allocates approximately 30-50[2] randomly selected sites river-wide. This includes biological, chemical, and physical parameters following an "NRSA type" of approach where one visit would be made to each site with a summer-fall seasonal index period. It would

[2] A minimum of 50 sites is the typically accepted "standard" for statistical rigor among monitoring practitioners, while 30 is viewed as a "minimum" sample size. Sample size affects the power of the overall conclusions affecting the "±" or confidence interval around the mean derived for a "population" of sites.

likely be repeated at regular intervals (e.g., every 5 years) and as such it would presumably make sense to integrate it with the recurrence interval of the NRSA. Accomplishing this in tandem with the NRSA would require an intensification of the site allocation to meet the minimum number of sites for a valid mainstem assessment. In addition, other lateral strata could also be included, but each would require an equal number of sites as the main channel. This design supports 305(b) assessment and 303(d) impairment determination at the system (river-wide) scale.

2. **Four Major Longitudinal Reach-Level (Probabilistic B):** This is a probabilistic design that stratifies the UMR by the major longitudinal strata identified in the ALDU report (UMRBA 2012) and requires approximately 30 sites per reach, giving a total of 120+ sites. This effectively multiplies the number of sites in the Probabilistic A option by four.
3. **State-Level (Probabilistic C):** This option follows the U.S. EPA GRE design in that the allocation of sites is done so that each state has an assessment of the UMR main channel within its borders and also an assessment of the entire UMR main channel. With approximately 30 sites per state, this results in roughly 150 sampling sites.
4. **13 CWA Assessment Reach-Level (Probabilistic D1 and D2):** This option provides an assessment of each of the 13 CWA assessment reaches and, at the request of the WQTF, has been subdivided into two options which vary in their spatial intensity. Under *Probabilistic D1*, 30 sites per reach are sampled, a total of 390 sites for the UMR as a whole. At a 95% level of confidence, this yields a confidence interval (i.e., "margin of error") ranging would result in confidence intervals from ±13.3% for the shortest assessment reach to ±17.5% for the longest assessment reach[3]. A less intensive approach, termed *Probabilistic D2,* would employ 15 sites per CWA assessment reach for a total of 195 sites. This approach would increase the assessment margin of error to a range of ±22.9-25.7% (for shortest and longest reach, respectively) at the 95% level of confidence. A slight gain in the confidence interval can be obtained if a 90% level of confidence is utilized (±11.13-14.7% for n = 30 and ±19.2-21.5% for n = 15). The Probabilistic D1 design could be stratified to include the four longitudinal reaches and the state borders, thus it incorporates the attributes of all of the preceding probabilistic designs. The Probabilistic D2 design could also be stratified to include the four longitudinal strata, but whether it could also provide a state-level assessment is dependent on how sites are distributed under the site draw.

Stratified Random Sampling

Design Description: While this design can be considered a probabilistic design it is treated as a discrete candidate design for the purposes of this Strategy. Sampling sites are randomly selected from a two-dimensional "grid" that is derived with respect to both the longitudinal and lateral properties of a water body. While this design could be applied to the main and side channels, its strength seems to be in addressing the impounded and contiguous backwater

[3] See Piface website http://homepage.stat.uiowa.edu/~rlenth/Power/. Version 1.76 for information regarding calculations.

strata due to their lake-like properties of generally slower, less linear flow and greater surface area.

Design Function: The results of stratified random sampling represent an unbiased sample of a particular stratum yielding a condition assessment of that stratum. This is not unlike the function of the probabilistic design options except that it acts in both a longitudinal and a lateral direction.

Current/Recent Use on the UMR: A stratified random sampling (SRS) design is presently employed by the LTRMP on the UMR. Sampling with a random stratified design began in 1993 in five pools of the UMR. The strata from which sampling sites are selected are based on enduring geomorphic features (Wilcox 1993). The aquatic strata that are sampled are defined as follows: main channel (the navigation channel and its border), side channels (channels other than the main channel), contiguous backwaters (off-channel areas with apparent surface water connection with the main channel), and impounded areas (large, mostly open-water off-channel areas located in the downstream portion of the navigation pools). All of these lateral strata are not always present in the LTRMP pools and an additional stratum occurs in Pool 4 (Lake Pepin, a tributary delta lake formed by the Chippewa River delta) and Pool 26 (Swan Lake).

Sampling sites are selected from a modification of a spatial database of aquatic areas (i.e., the strata; Owens and Ruhser 1996). These strata are partitioned into 50-m^2 grids for backwater and side channel areas and 200-m^2 sampling grids for main channel and impounded areas. Sampling is conducted for biological, chemical, and physical indicators and parameters at a maximum 150 sites in each of four seasonal sampling events in each of the six pools. Each sampling event is usually completed over a 14-day period. The LTRMP design for stratified random sampling (SRS) requires that each day of sampling is centered on the 1200 hour period and that the order of site visits within each sampling day is randomized to the extent feasible within operational constraints.

Nonrandom Longitudinal Survey Design

Design Description: This design allocates sampling sites at a roughly equal distance along the main channel UMR in order to get a sense of the condition of a particular assessment unit similar to the probabilistic designs, but it would also allow the initiation of a more focused stressor identification process as part of a follow-up set of assessments. While sampling would occur at intervals of roughly “every 5 miles” and along the “best” bank, the specific locations of sampling sites would be determined based on local conditions (natural or otherwise) and other relevant factors, i.e., access for sampling, point sources, habitat alterations, and existing monitoring sites (where co-location is accomplished to build upon the existing databases). Sampling site and left or right bank placement would involve up front planning via desktop analysis (e.g., GIS) and site reconnaissance. A site every 5 miles yields just over 160 sampling sites and pairing or matching to existing fixed stations could add approximately 20 additional sites for a total of 180. Follow-up surveys would be attempted where the baseline assessment indicated problems and this would presumably be a more intensive and targeted effort to better delineate causes and sources.

Design Function: The primary function of this design is to complete a system-wide sampling of the UMR main channel as an initial inventory of designated use attainment status in fulfillment of the 305(b)/303(d) goals of the Strategy. This would then be followed by more focused follow-up assessments in reaches or assessment units where problems (i.e., impairments of one or more designated uses) are identified and in support of the water quality management program support goal of the Strategy.

Design Applied to UMR: This type of design has not yet been applied to the UMR. It is more intensive in terms of the number of sites than the GRE design, but less intensive than the Intensive Pollution Survey design (see below) with an estimated 180 total main channel sites and an unspecified number of follow-up sites. This design could be implemented as a "rotating panel" approach on the UMR over a five year period where contiguous longitudinal reaches are sampled such that the entire mainstem is covered in the first 2 years with follow-up assessments of similar annual effort in the following 3 years. It could be made applicable to all of the lateral strata by allocating additional sites to each within the context of the UMR pools and assessment reaches, but its strength is in application to the main channel strata. It can also address the four designated uses by following the assignment of core and supplemental indicators (see Table 5 of Chapter 6). Further, this design could be blended with any of the other designs by also utilizing their sites as longitudinal survey sites, thus building in cost-effectiveness to the overall Strategy.

Intensive Pollution Survey

Design Description: An Intensive Pollution Survey is defined as a spatially intensive sampling design of a contiguous river reach over an extended distance. This design is spatially more intensive than the fixed station and three of the four probabilistic design options. Its spatial intensity is similar to that of the Probabilistic D1 and Non-random Longitudinal Survey options (when follow up sampling for the latter is included). This design employs multiple sampling sites within defined reaches of the main and side channel strata depending on the occurrence and position of sources of stress and influence. While it includes an *a priori* inventory of known and suspected stressors as part of the initial allocation of sampling sites, it ultimately relies on the observation of responses in the indicators and parameters to reveal the presence *and* the effect of a stressor or stressors. As such this design is initially dependent on an inventory of potential sources of human influence prior to allocating sampling sites. Hence the spatial density of sites within a reach will vary in accordance with the corresponding density of sources of potential stress and influence. This may result in fewer sampling sites in less dense concentrations of stressors or more densely located sites in reaches with multiple stressors.

An important aspect of this design is the longitudinal depiction and interpretation of monitoring results in spatial relation to the sources of potential stress and influence. The concepts of Bartsch (1948) and Doudoroff and Warren (1951), which demonstrated how the influence of pollution changes along the length of a flowing water body (i.e., pollution zones), give rise to this design. Thus it includes positioning sites that are upstream from sources of potential impact, in areas of immediate impact and potentially acute effects, through zones of increasing and lessening degradation, and zones of eventual recovery. Sites are initially cast as representing zones of impact, zones of recovery, and far-field sites that represent ambient conditions. Among the options considered in this report, this design uniquely measures the pollutional impacts from a direct spatial context along the riverine continuum yielding information about the severity and extent of both single and aggregate sources of impact. Unlike the other design options each sampling site represents an interval along the pollution impact continuum that can then be visualized in both space and time. At the same time the information about condition over intervals of river distance is continuous as opposed to being restricted to estimates about an average or proportional condition over defined reaches or segments. By positioning sites along this continuum, changes in impacts from the diverse sources can be observed through time and in response to management actions taken at specific sources. The analysis of the GRE design for the biological assessment project (Yoder et al. 2011) emulated this design, but simply lacked the density of sites (especially impact zone sites) that would be needed to execute a more complete and supportive assessment of the UMR mainstem. While it includes sites situated immediately downstream from point sources, it is not biased towards those sources as it includes sites that address other major stressors and more importantly includes sites to gauge the recovery from the point sources along the riverine continuum.

The basic unit of assessment is the sampling site, which also distinguishes it from the other candidate designs. The results from multiple sites can be aggregated to reflect the linear condition of a reach or river segment, with the results expressed as the aggregate distance of river that is attaining or not attaining a desired state or condition. Again, this distinguishes this design as providing an assessment of the quantitative proportional condition of a defined or otherwise descried reach of mainstem expressed as the aggregated distance of attainment/non-attainment or varying levels of condition as opposed to a purely proportional assessment expressed as the percentage of the assessment reach or segment that is in attainment or non-attainment. It can also convey the severity of departures from a desired condition and it can be expressed in quantitative terms.

Implementation includes the development of a detailed plan of study that is produced immediately prior to the field season and includes the detailed delineation of sampling sites and refining the lists of parameters that will be sampled at each site. Further, monitoring under an Intensive Pollution Survey design typically involves multiple samples within a single sampling cycle, particularly for chemical parameters (i.e., several visits to each site within each sampling season).

Design Function: The fundamental goal of this design is to comprehensively assess all possible sources of stress and influence within localized river reaches. It accomplishes this by having a sufficient longitudinal coverage so that responses elicited by the indicators and parameters can adequately signal an effect at a particular place along the river. Because it focuses on documented concepts of how pollution affects flowing waters, this design is uniquely able to support water quality management at the site-specific and reach scales. It also includes elements of "upstream/downstream" assessment, but adds to that by locating additional "recovery" and "far field" sites in successive order downstream from pollution sources. Also inherent in this design is the goal of developing an understanding of how different indicators change in an upstream to downstream direction and in proximity to specific sources of stress. As such it yields a pollution effect profile that depicts the extent and severity of an indicator response to a pollution source. This includes attempting to determine the role of specific sources as well as the accumulation of effects by multiple sources. As such, the Intensive Pollution Survey design provides full CWA program support that includes 305[b] assessments, 303[d] impairment determinations, cause and source delineation, and other program functions such as the development of tiered aquatic life uses. It also supports assessment at the system, state, CWA assessment reach, pool, and local reach levels. When this information is sequenced with stressor and exposure indicators using the hierarchy of indicators process described in the Project Scoping report (MBI 2012), the results and effectiveness of water quality management programs through time more clearly emerges.

<u>Design Applied to UMR</u>: Similar to the Nonrandom Longitudinal Survey design option described above, an Intensive Pollution Survey design has never previously been applied to the UMR. Therefore, to illustrate the application of this design to the River, a specific UMR intensive pollution survey design was developed as part of this Strategy and is detailed in Appendix C. A comprehensive pollution source/stressor inventory was conducted for the purpose of developing a list of sites and for allocating indicators and parameters, as is detailed in Appendix C. The UMR master survey design also includes the side channels in the initial inventory of sampling sites and as such treats this as a distinct stratum in addition to the primary focus on the main channel. A summary of stressors and Intensive Pollution Survey sites in the UMR design is displayed in Appendix C.

This design could be implemented as a "rotating panel" approach on the UMR where contiguous longitudinal reaches are sampled such that the entire mainstem is covered every 4-5 years. It could be applicable to all of the lateral strata by allocating sites to each within the context of the UMR pools and assessment reaches, but its strength is in application to the main and side channel strata. It can also address the four designated uses by following the assignment of core and supplemental indicators (see Table 5 of Chapter 6). Further, this design could be blended with any of the other designs by also utilizing their sites as intensive survey sites, thus building in cost-effectiveness to the overall Strategy.

Index Sites

<u>Design Description</u>: A network of index sites is a design that would be appended to the more spatially intensive design options (i.e., Probabilistic B, C, D, Nonrandom Longitudinal, and Intensive Pollution Survey). The purpose of these sites is to provide an assessment of conditions in major mainstem tributaries some of which may approximate "least" or "minimally" impacted conditions following the definitions of Stoddard et al. (2006) relative to major riverine systems in the Upper Midwestern U.S. Initially these sites will be located in the lower reaches of major tributaries until enough data is collected on the UMR to determine if

any of those sites can also serve this purpose as least" or "minimally" impacted. Approximately 30 index sites are recommended in order to provide a systemwide representation (see end of Appendix Table C-1). All chemical, physical, and biological indicators for the main and side channel strata are to be collected at the index sites. This includes both core and supplemental parameters, at least initially, for the aquatic life, recreation, and fish consumption uses and to represent the main and side channel strata. The concept of index sites can also be incorporated into the networks for the impounded and contiguous backwater strata, but those sites would be identified as the spatial design for those strata is populated.

Design Function: Index sites are intended to supply data for all indicators and to represent "background" conditions for the main and side channel strata. This data is important in the calibration of biological indices, for establishing attainable thresholds for chemical, physical, and biological parameters, and anchoring the "upper" portions of the BCG for the determination of stress/response relationships that can be applied to stressor and impairment diagnoses on a site-specific, reach scale, and systemwide basis. As such, it is seen as an integral part of this Strategy.

Design Applied to UMR: This concept was previously used in the Biological Assessment Guidance project to evaluate biological indices and to develop assessment thresholds. It is a part of major regional and national monitoring efforts on the UMR including EMAP and the NRSA.

Summary of Mainstem Design Options

The key characteristics of the different mainstem design options (along with the Tributary Loading Network) are summarized in Table 2. These characteristics include a general description of each option, the approximate number of sampling sites, the implementation cycle, the lateral strata that are included in each, the function and role of the sampling sites, the different scales of assessment that are supported, and the basic unit of assessment and how it is expressed.

Table 2. Summary and characteristics of UMR monitoring design options.

Design Option	Description	Number of Sites (Approx.)	Suggested Implementation Cycle	Lateral Strata Assessed	Sampling Site Function	Scale(s) of Assessment Supported	Unit of Assessment – "Expressed As"
Fixed Station	Current network	65	Annual (monthly/ quarterly)	Main Channel	Chemical WQ Criteria Exceedances	CWA Assessment Reach	Sampling Site; %Exceedence of WQC
Probabilistic A	System-level assessment, Intensification of NRSA	50	Once every 5 years	Main Channel[2]	Member of population of data	Systemwide	Population of sites; expressed as %Good, Fair, Poor (±CI[1])
Probabilistic B	Major longitudinal reach level assessment, Four-fold increase of Probabilistic A	120+	Once every 5 years	Main Channel[2]	Member of population of data	Systemwide + 4 longitudinal reaches	Population of sites by long. strata; expressed as %Good, Fair, Poor (±CI)
Probabilistic C	State-level assessment, Follows EMAP-GRE design	150-200+	Once every 5 years; plus follow-up[3] if desired	Main Channel[2]	Member of population of data	Systemwide + 4 longitudinal reaches, state-specific	Population of sites by long. strata & state; expressed as %Good, Fair, Poor (±CI)
Probabilistic D1	Thirteen UMR Reach-Level Assessment	390	3-5 year rotation; 1/3 to 1/5 of UMR per year, plus follow-up[3] if desired	Main Channel[2]	Member of population of data	Systemwide, longitudinal reaches, state-specific, + 13 CWA Assessment Reaches	Population of sites by strata & CWA reach; expressed as %Good, Fair, Poor (±CI)
Probabilistic D2	Thirteen UMR Reach-Level Assessment	195	3-5 year rotation; one-half of UMR per year, plus follow-up[3] if desired	Main Channel[2]	Member of population of data	Systemwide, longitudinal reaches, state-specific, + 13 CWA Assessment Reaches	Population of sites by strata & CWA reach; expressed as %Good, Fair, Poor (±CI)
Stratified Random Survey	LTRMP design	30+ per pool or CWA Reach	Five year rotation; 1/5 of UMR per year, plus follow-up[3] if desired	Impounded & Contiguous Tributary strata	Member of population of data	Systemwide + Navigation Pools	Population of sites by pool/lateral strata; expressed as %good, fair, poor (±CI)

Table 2. (continued)

Design Option	Description	Number of Sites (Approx.)	Implementation Cycle	Lateral Strata Assessed	Sampling Site Function	Scale(s) of Assessment Supported	Unit of Assessment – "Expressed As"
Nonrandom Longitudinal Survey	Longitudinal sampling "every 5 miles" along "best bank"	≈180 baseline over 2 years; ≈80/year follow-up over 3 years (≈240); total ≈420	5 year rotation; 2 year baseline, then 3 years of follow-up[3]	Main Channel[3]	Member of segment and assessment unit for baseline; site-specific condition for follow-up	Systemwide, 4 longitudinal reaches, state-specific, 13 assessment reaches (partial); partial site-specific scale	Average condition per assessment reach or unit on a one-dimensional basis (irrespective of bank) for baseline; sampling site condition for follow-up; localized lineal distance of attainment.
Intensive Pollution Survey	Intensive sampling based on the presence of stressors	≈400	Four year rotation; ¼ of UMR each year	Main and Side Channels	Site-specific condition; impact, recovery, & ambient condition; can be aggregated to various strata.	Systemwide, 4 longitudinal reaches, state-specific, 13 assessment reaches; site-specific scale	Sampling site and respective of bank (L or R); continuous along pollution gradients along either bank (L or R); can be aggregated "upwards" to reach or assessment unit; expressed as lineal distance of UMR in attainment/non-attainment &/or increments of condition expressed by indicator (km, ADV/AAV).
Index Sites	Representative sites selected in lower parts of largest mainstem tributary rivers – supplementary to other design options.	≈30	Same as baseline design option	Tributaries	Provide off-UMR conditions in large rivers as "background" and/or as reference.	Systemwide, 4 longitudinal reaches, state-specific, 13 assessment reaches; site-specific scale	Supports establishing thresholds for biological, chemical, and physical indicators at all scales.
Tributary Loading Network	Measures loadings of nutrients and sediment – independent of other design options.	44	Annual (flow weighted)	NA	Loadings (kg/day) of pollutants	NA	Loadings (kg/day)

[1] CI – confidence interval; [2] Index sites apply to any option except fixed stations and tributary loadings with proportionate modifications to match the scale of that option; [3] Follow-up option applies to any option except fixed stations and Probabilistic A with proportionate modifications to match the scale of the selected option.

Table 3 shows how the sample sites from each main channel/side channel design option are distributed across CWA assessment reaches and as compared to the occurrence of stressors. In addition Figures 3 and 4 are included to illustrate the spatial site density among the main/side channel design options showing the differences between the least effort option (Probabilistic A) and the highest effort options (Intensive Pollution Survey and Probabilistic D1).

Discussion of UMR Mainstem Spatial Design Options

As described in the preceding text, mainstem design options are applicable to the UMR's lateral strata as follows:

- *Main channel/side channel options*: Fixed Station, Probability A, Probability B, Probability C, Probability D1/D2, Non-Random Longitudinal Survey, and Intensive Pollution Survey.
- *Backwater/impounded strata option:* Stratified Random Sampling

Each design option fulfills monitoring Strategy goals to differing degrees of spatial resolution and accuracy. As such, a matrix (Table 4) was developed to compare and illustrate how the different design options address the CWA assessment goals and the in common needs of the UMR states' CWA programs as identified in the Strategy's goals.

Of note, none of the design options alone can meet the full extent of the Strategy's goal of assessing all four of the lateral strata. For example, the Stratified Random Sampling design fulfills the assessment goal for only two of the four lateral strata while the main channel/side channel focused options fulfill some or all of the strategy goals to varying levels for the remaining strata. As such, a combination of these design options would be needed to fully meet all of the Strategy's goals depending on the scale of the assessment that each entails. .

Additionally, financial resources to implement monitoring will undoubtedly limit which options can realistically be implemented. Hence, what each design can accomplish and at what cost are important considerations in determining what is actually implemented. See Chapter 11 for a detailed discussion of costs associated with monitoring options.

Table 3. The occurrence of stressors and public water intakes with the four probabilistic design and intensive pollution survey sites (by role and function) within the 13 CWA assessment reaches for the interstate UMR. Probabilistic sites are apportioned to the longitudinal strata included in each design.

CWA Assessment Reach	NPDES Major/ Minor	Public Water Supply	Fixed Stations	Prob. A Sites[1]	Prob. B Sites[2]	Prob. C Sites[3]	Prob. D1 Sites	Prob. D2 Sites	NR Long. Survey[4]	Intensive Pollution Survey Sites[5]				
										Impact Sites	Recovery Sites	Far-field Sites	Side Channel	Total IPS Sites
1 St. Croix to Chippewa R. (RM 763-812) 49 mi.	3/8	0	12	50	30	30	30	15	16	8	2	15	0	25
2 Chippewa R. to L&D 6 (RM 714-763) 49 mi.	1/5	0	7		30	50	30	15	11	8	1	21	2	32
3 L&D 6 to Root R. (RM 694-714) 20 mi.	1/4	0	8				30	15	6	6	1	6	1	14
4 Root R. to Wisconsin R. (RM 631-694) 63 mi.	3/8	0	5				30	15	15	10	5	11	1	27
5 Wisconsin R. to L&D 11 (RM 583-631) 48 mi.	1/6	0	1				30	15	10	8	5	3	1	17
6 L&D 11 to L&D 13 (RM 523-583) 60 mi.	1/11	0	7				30	15	15	12	7	6	3	28
7 L&D 13 to Iowa R. (RM 434-523) 89 mi.	12/27	5	3		30	50	30	15	18	32	9	10	14	65
8 Iowa R. to Des Moines R. (RM 361-434) 73 mi.	4/13	5	3				30	15	14	13	2	11	3	29
9 Des Moines R. to L&D 21 (RM 325-361) 36 mi.	1/5	2	1				30	15	7	5	0	7	3	15
10 L&D 21 to Cuivre R. (RM 237-325) 88 mi.	4/9	2	1				30	15	17	11	3	19	9	42
11 Cuivre R. to Missouri R. (RM 196-237) 41 mi.	5/16	3	8				30	15	10	8	2	9	4	23
12 Missouri R. to Kaskaskia R. (RM 118-196) 78 mi.	9/26	4	1		30	50	30	15	15	14	4	11	3	32
13 Kaskaskia R. to Ohio R. (RM 0-118) 118 mi.	5/5	2	10				30	15	28	4	3	19	4	30
TOTALS	50/143	23	67	50	120	180	390	195	182	139	44	148	48	379

[1] – based on 2013-14 NRSA site draw intensified to n = 50; [2] – draw will be based on n = 30 for longitudinal strata; [3] – draw will be based on longitudinal strata & state borders; [4] – Nonrandom Longitudinal Survey option includes baseline locations only; [5] – this design can function as a follow-up to any of the other design options as a follow-up survey applied to specific reaches or in multiple panels.

Table 4. The relative degree to which the different UMR spatial monitoring design options can be expected to support UMR Strategy goals. This applies most uniformly to the main channel border, but also includes other lateral strata as the management programs apply to those habitats.

Spatial Design Option	**Basic Reporting[1]**		**Refined Assessment[2]**		**WQS**				**TMDL**				**Nonpoint Source**		**NPDES/Other Permitting**							
Name	Status[3]	Trends[4]	Status[5]	Causal Assoc.[6]	Tiered Uses[7]	UAA[8]	Refined WQC[9]	Anti-deg.[10]	TMDL Dev.[11]	303d Listing[12]	Ad-vanced TMDL[13]	TMDL Effect-iveness[14]	Loadings	BMP Effective-ness	WQBEL[15]	Priority Setting[16]	Wet Weather[17]	Storm-water[18]	WET Limits/ Cond.[19]	Severity/ Extent[20]	Enforce-ment[21]	404/401 Dredge & Fill[22]
Fixed Stations	⊙	⊙	-	-	-	-	-	-	○	○	-	○	⭘	○	⊙	-	-	-	-	-	-	-
Probabilistic A	⭘	⭘	-	-	-	-	-	-	⊙	⊙	-	⊙	-	-	-	-	-	-	-	-	-	-
Probabilistic B	⭘	⭘	-	-	-	-	-	-	⊙	⊙	-	⊙	-	-	-	-	-	-	-	-	-	-
Probabilistic C	●	●	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	-	-	⊙	⭘	⭘	⭘	⊙	⊙	⊙	⊙
Probabilistic D1	●	●	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	-	-	⊙	⭘	⭘	⭘	⊙	⊙	⊙	⊙
Probabilistic D2	●	●	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	-	-	⊙	⭘	⭘	⭘	⊙	⊙	⊙	⊙
Stratified Random Sampling (SRS)[23]	●	●	●	●	●	●	●	●	●	●	⭘	⭘	-	-	-	-	-	-	-	-	-	●
Nonrandom Longitudinal Survey	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	⭘	-	-	⊙	⭘	⭘	⭘	⊙	⊙	⊙	⊙
Intensive Pollution Survey	●	●	●	●	●	●	●	●	●	●	●	●	⊙	⭘	●	●	●	●	●	●	●	●

● - Comprehensively fulfills program support function by providing robust, spatially relevant, and statistically valid assessment of status, causal associations, and/or related issues including scientific certainty and accuracy of condition assessments.

⭘ - Generally fulfills program support, but may not provide spatially robust, accurate, or statistically valid assessment information at all scales or for assessment of magnitude and severity in specific enough places or reaches.

⊙ - Supports only partial or indirect assessment of program area, e.g., may be useful only for pollutant-specific assessment at a single scale.

○ - Minimally fulfills program function based on current acceptance of assessments by U.S. EPA.

Table 4 Footnotes:

---

[1]Consists of reporting on general status for designated uses, most commonly entails “pass/fail” conclusions;

[2]Consists of detailed reporting about status of designated uses including relative degree of attainment or non-attainment including incremental assessment;

[3]General delineation of attainment/non-attainment for designated use status only – no specific diagnoses of impairment;

[4]Sufficient information generated to report trends in general status over at least a 10 year period - includes analysis of fixed station chemical trends;

[5]Status assessments of designated uses including an assessment of the degree of non-attainment;

[6]Proximate causes of non-attainment are delineated and are at least categorical;

[7]Tiered uses developed from biological assemblage assessments and which are assigned within specific ecotypes and on a reach-specific basis - does not include fishery based or general uses;

[8]Includes uses of ambient monitoring data to change designated uses, includes “upgrades” and “downgrades”;

[9]Ambient data and stress/exposure/response relationships are sufficient to confirm or improve water quality criteria and/or influence the application or implementation of WQC (exclusive of pH, hardness, and other single-dimension modifiers);

[10]Ambient data is used to develop and apply antidegradation concepts and policies;

[11]Includes using ambient data to support all aspects of TMDL development beyond baseline calibration data;

[12]Ambient data is used to develop 303d lists consistent with the rigor of the methodology;

[3]Ambient data is sufficient to assess the effectiveness of TMDL implementation;

[4]Advanced TMDLs include all factors related to identified impairments to include all forms of pollution including flow and habitat;

[15]Water quality based effluent limits – ambient data is used to develop permit limits based on an assessment of the overall effect of the subject discharge on the receiving waters beyond WLA calibration data;

[16] Ambient data is sufficient to determine priority setting for NPDES permitting and/or SRF funding priorities;

[17]Ambient data is sufficient to detect and identify wet weather impacts;

[18]Ambient data is sufficient to support stormwater permitting;

[19]Ambient survey data is used to develop WET testing requirements and/or effluent limits in NPDES permits;

[20]Assessment framework allows for determination of incremental departures and changes beyond pass/fail and communicates severity of problem over space & time; [21] Direct use of ambient survey data to support enforcement in terms of demonstrating that action is both legal and reasonable;

[22]Direct support of general policy and site-specific decisions for the 401 certification of 404 dredge and fill permits;

[23]Assignments are made assuming this design is applied systemwide to one or more lateral strata.

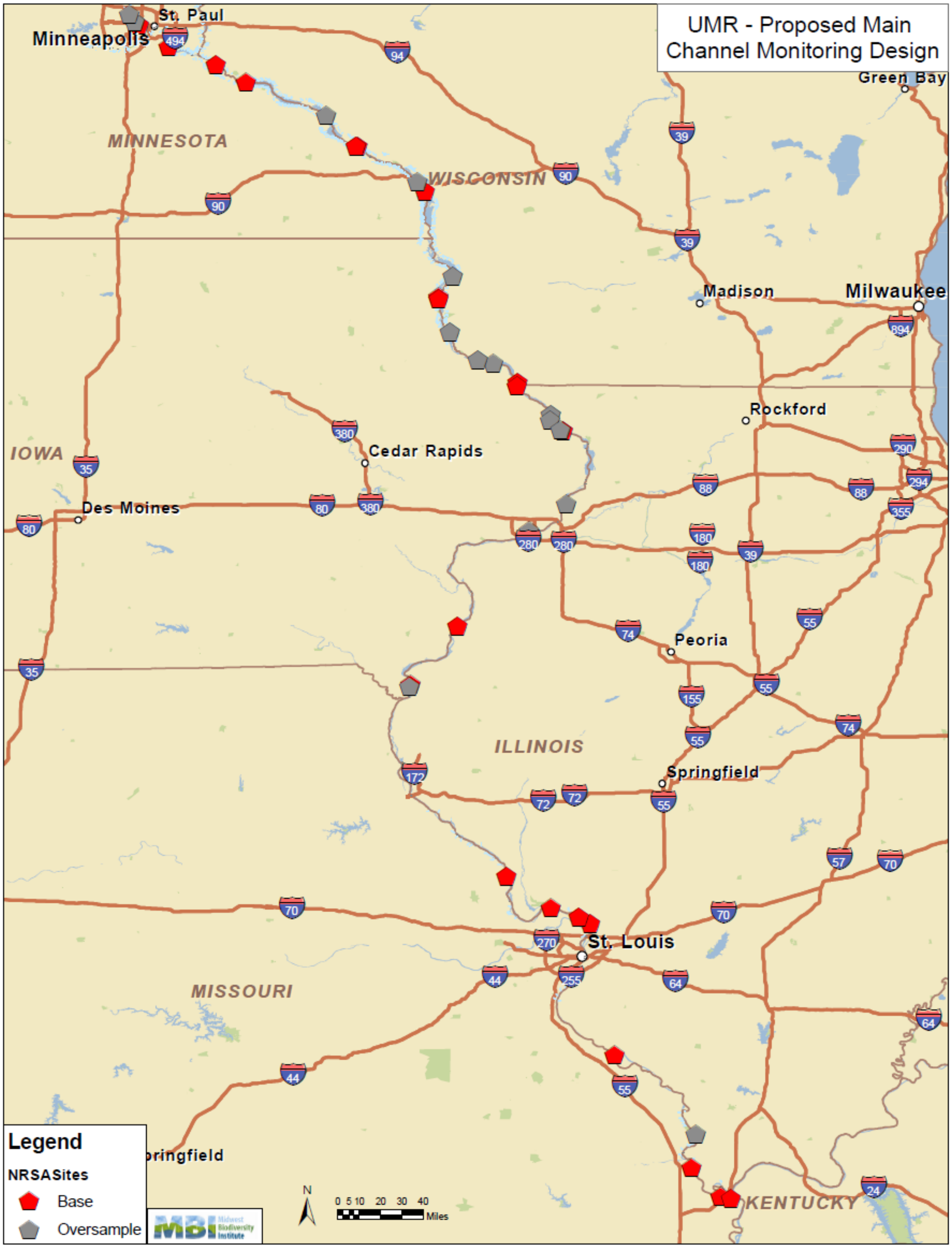


Figure 3. Probabilistic A design option sites based on the 2013-14 NRSA draw and including 50 sites for the UMR main channel.

Figure 4. Intensive Pollution Survey design option sites based on site location methodology and also including 2004-6 GRE and existing fixed station sites as a part of the design and to show a comparison of site density. This includes main channel and side channel sites.

Fixed Stations

Use of existing fixed stations (65 sample sites as of 2011) is the current approach to CWA assessment by the states for the main channel UMR. Assessment is conducted for all four designated uses by comparing chemical and fish tissue sampling results to chemical water quality criteria. This necessitates extrapolating the results from fixed stations to the UMR CWA assessment reaches and as such it is a very coarse approximation of the status of the UMR solely for 305[b] and 303[d] purposes. The low number of sample sites in several of the 13 CWA assessment reaches (see Table 3) severely limits the validity of the conclusions drawn from this extrapolation. Further, the existing Fixed Station Network does not meet the Strategy's goals as it does not include biological assessment, does not address other lateral strata, and does not support other CWA management functions (see Table 4).

Despite the severe limitations of the current Fixed Station Network in meeting this Strategy's goals, incorporating at least parts of this network in future monitoring would preserve a long term database in order to examine historical trends for specific parameters. As such, utilizing these sites has value beyond CWA assessment purposes *per se*. Further, they can function as part of the Intensive Pollution Survey design and have been incorporated in an initial approximation of that design (see Appendix C). They could also be integrated into the Nonrandom Longitudinal Survey or used in support of other designs. Therefore, while the Fixed Station Network is in some regards a standalone network, it could potentially contribute directly to the Strategy's goals by integration into other survey designs.

Probabilistic Designs

Each of the five probabilistic designs delivers to varying levels of detail and accuracy on the Strategy's goals (see Table 4). For example, the level of detail within each option determines how the objectives of assessing the longitudinal strata and the 305[b]/303[d] goals can be met, with the more spatially intensive options best supporting all of the strategy goals. Probabilistic C and D are the best able of these options to support the 305[b] and 303[d] goals across the longitudinal strata, and in the case of Probabilistic D1 and D2, the 13 assessment reaches.

Of note, the Probabilistic C (EMAP-GRE) design served as the basis for the *Biological Assessment Guidance* (Yoder et al. 2011) which completed a condition assessment using various biological impairment thresholds and a delineation of associated causes of impairments based on those thresholds. While this design can yield a fairly rigorous assessment of the UMR main channel in terms of biological condition, it was comparatively weak in terms of providing data for the assessment of the non-aquatic life designated uses primarily due to the low frequency of chemical/physical sampling (i.e., one sample per site). However, it does provide valuable insights about where gaps in spatial coverage exist and where the delineation of associated causes should be strengthened and made more detailed.

However, even the most spatially intense variant of the probabilistic designs can only indirectly deliver on the goal of supporting CWA programs such as WQS, NPDES permitting, and to some extent TMDLs. This type of design is inherently limited by the spatial scope of the "population" that is represented by the strata that are included in the base site draw. In addition, the inclusion of relevant parameters and indicators could be limited if the "typical" EMAP approach is followed by visiting a site only once. This would particularly affect the chemical parameters by limiting the resulting utility of that database to serve its primary role as an exposure assessment and the recreational use assessment because of the frequency needs of this designated use. Some of these are weaknesses that were previously identified by the *Biological Assessment Guidance* project (MBI 2011).

As described previously, the variability in the confidence interval between CWA assessment reaches for probabilistic monitoring results from the varying lengths of each CWA reach, which in turn defines the finite population. Specifically, the varying lengths result in different finite populations of possible mainstem sites in each CWA assessment reach. As such, a fixed number of sample sites per reach comprise a greater proportion of the population for shorter reaches and a lesser proportion of the population in longer reaches, which in turn affects the confidence interval. Therefore, an alternate approach is recommended that consists of a weighted design taking into account the variable lengths of the CWA assessment reaches. However, presuming the WQTF wishes to achieve a ±5% margin of error at the 95% level of confidence, more than 30 sites will be needed for even the shortest of CWA reaches. Therefore, it is likely that by the time enough sites are accumulated to result in the desired confidence interval the number of sites needed in some reaches will be similar to, or even greater than, the more intensive non-probabilistic designs that offer the additional capabilities beyond assessing 305[b] status at the UMR assessment reach scale. For these reasons, it appears increasingly inefficient to employ a probabilistic approach at a scale smaller than the systemwide, state boundary, or longitudinal reach level, as more functionality can be garnered for a similar level of sampling effort under other designs.

The Probabilistic B, C and D2 options do have a distinction in that they provide an assessment of the UMR main channel (and side channels if these are included in the base draw of sites) in a shorter time frame than the Probabilistic D1, the Nonrandom Longitudinal Survey, or the Intensive Pollution Survey designs. If only a system-wide assessment is desired, the Probabilistic A option may be feasible as an initial and more "doable" step by simply intensifying the 2013-14 NRSA draw to include enough of the overdraw sites to achieve a sample size of 50 sites provided that the sampling protocols of GRE are used. This is depicted in Figure 3.

Stratified Random Sampling (SRS)

The Stratified Random Sampling (SRS) design, with modifications appropriate to incorporate the methodological development needs (as described in Chapter 10) seems the best fit for the impounded and contiguous backwater lateral strata. This is primarily because these strata are "lentic-like" and thus more amenable to the surface gridding of sampling points. In addition, an existing program (LTRMP) has demonstrated its applicability to these strata. The probabilistic and intensive survey design options could also be applied to these lentic-like areas, but their design and typical site selection process are more amendable to the flowing, longitudinal context of the main and side channel strata. If the SRS design were to be implemented for CWA purposes, coordination should take place with the LTRMP to the extent possible so that data from LTRMP study reaches and non-LTRMP reaches is compatible, thereby providing for efficiency in monitoring. It is also suggested that the data needed to support methodological development be collected as part of implementing this design as opposed to a distinct pilot project.

Nonrandom Longitudinal Survey

The Nonrandom Longitudinal Survey design consists of a longitudinally stratified baseline assessment of the main channel followed by more intensive follow-up surveys consisting of more focused assessments of selected reaches. The baseline aspect of this design can at least partially fulfill the 305[b] and 303[d] goals of the strategy. This design differs from the Probabilistic options in that site selection is stratified by lineal distance (i.e., approximately every five miles) and located along the left or right shoreline that best fulfills the monitoring objectives.

Similar to the Probabilistic options, it constitutes a one-dimensional representation of the UMR main channel in that left and right bank considerations are homogenized. Nevertheless, it yields a stratified sampling of the main channel. With regard to the existing 13 CWA assessment reaches, this design effectively weights the number of sites by the length of the UMR assessment reach, as these vary from 20 to 118 miles in length. One result is that in the shortest CWA assessment reaches the sample size is small and raises issues of statistical rigor and spatial coverage reminiscent of those identified in using the GRE design to assess the CWA reaches (Yoder et al. 2011). As such, it may not fully assess CWA reaches unless the allocation of sampling sites is increased for smaller reaches or the short reaches are consolidated.

Intensive Pollution Survey

The Intensive Pollution Survey design uniquely fulfills all of the Strategy goals for the main channel/side channel strata and for the entire interstate UMR and by the longitudinal and CWA assessment reach strata, as shown in Table 4, and as a standalone design. It is calibrated to the unique features of each reach, in terms of stressors and other data needs, per Table 3, but also providing for the inclusion of ambient or background conditions in each reach. The indicators and parameters utilized under this approach are also more detailed (see Chapter 6 and Table 5) with the addition of supplemental indicators (especially for chemical parameters) being apportioned based on the presence of stressors in proximity to the sampling sites and reaches. This addresses the issue of sampling frequency for the indicators that rely on multiple samples at each site (e.g., chemical quality, bacterial) and strengthens the delineation of causes and sources. This would be executed as a "rotating panel" where contiguous reaches of the UMR are sampled in consecutive years beginning upstream and working downstream coinciding with the boundaries of the longitudinal strata and CWA assessment reaches. A four year cycle seems to be a reasonable approach in balancing the recentness of data vs. annual costs, though cost/resource considerations could extend this time period.

Follow-up Options

A follow-up option is highlighted here to provide a way to focus on specific UMR segments and reaches that are identified for more detailed investigation by the findings of one of the baseline survey options just discussed. As indicated previously, follow-up surveys could be conducted in selected reaches[1] as determined by the impairments revealed in the baseline monitoring of the probabilistic and non-random longitudinal design. Presumably this would include spatially more intensive sampling and analysis aimed at determining and highlighting specific sources of impairment in order to better determine causes and sources. As such it is recommended that follow-up surveys utilize the Intensive Pollution Survey design in discrete reaches. Follow-up surveys would be conducted after one of the baseline UMR surveys being completed over one or two years and the follow-up surveys in the following three to four years for a five-year cycle. In fact, the follow-up option could be applied to any of the system to reach-wide survey designs as these dwell primarily on mean condition in each stratum leaving more detailed site and reach-specific assessment to be fulfilled by this design. Sequencing the follow-up surveys after one of the baseline options would better fulfill all of the goals of the Strategy.

Tributary Loading Network

The Tributary Loading Network is a distinctive design apart from the main stem options in its spatial make-up, parameters, and the endpoints it is intended to produce. As such, it is discussed here separately from the other spatial design options. Unlike the mainstem options described previously, the primary function of this network is neither CWA assessment nor supporting of a broader suite of CWA support functions per se, but rather to monitor sediment and nutrient loading and trends. Because of the distinctiveness of its design objective, parameters, physical location, flow weighting, and monitoring frequency, this network will not have strong logistical connections to the other UMR survey designs. In addition, the Tributary Loading Network may largely, if not fully, be composed of existing sites. Therefore, the "establishment" of this network may largely be an exercise in coordination, harmonization of parameters sampled, data sharing, and "branding".

Design Description: Sites in the Tributary Loading Network are similar in their spatial context to fixed stations, but they differ in that they function as a specifically-purposed, supplementary design augmenting the primary, assessment-focused network. In the context of this Strategy, the Tributary Loading Network is focused on the sampling on *major* tributaries, near their confluences with the UMR, to ascertain the quantitative contributions from each to the mainstem UMR. Because each site is tied to specific tributary location, it is by definition a fixed site. As such, other design approaches were not considered for this network. Monitoring would consist primarily of flow weighted sampling purposed to determine the annual loadings of suspended sediments and nutrients. This network must be aligned with tributary flow gaging sites to allow for the accurate calculation of loading estimates. Sites need to be located far enough upstream in the tributary to avoid any backwater effects from the UMR mainstem which would confound any loading estimates. As such, the tributary loading network is physically separate and distinct from the main channel monitoring networks. An initial recommendation for tributary loading network sites, based on input from the WQTF, is

[1] Reach as used here is not limited to the CWA assessment reach concept, but rather reaches that are suggested by the findings of an assessment based on the parent mainstem design option.

included as Appendix Table A-2 and depicted in Figure 5. Of note, nearly all of these locations have existing USGS gages and most are currently being monitored by state and/or federal water quality agencies.

Design Function: The function of the Tributary Loading Network is to document nutrient and suspended sediment loadings, and trends in loading, from the major tributaries to the UMR.

Current/Recent Use on the UMR: A number of state and USGS sites are already in position and being monitored in tributaries, as illustrated in Figure 5 and Appendix Table A-2. However, some may not have the desired *paired* parameter and flow monitoring needed to calculate loadings. As such, defining a Tributary Loading Network will largely consist of an effort to address gaps and harmonize parameters sampled, as opposed to the creation of a brand new network. Of note, the Gulf Hypoxia Task Force has initiated a Monitoring Collaborative effort to identify key water quality monitoring locations throughout the basin for the purposes of assessing loading and impacts on Gulf Hypoxia. As such, the WQTF plans to work closely with this initiative to encourage consistency between the sites it recommends be part of a Tributary Loading Network and the recommendations of the Monitoring Collaborative.

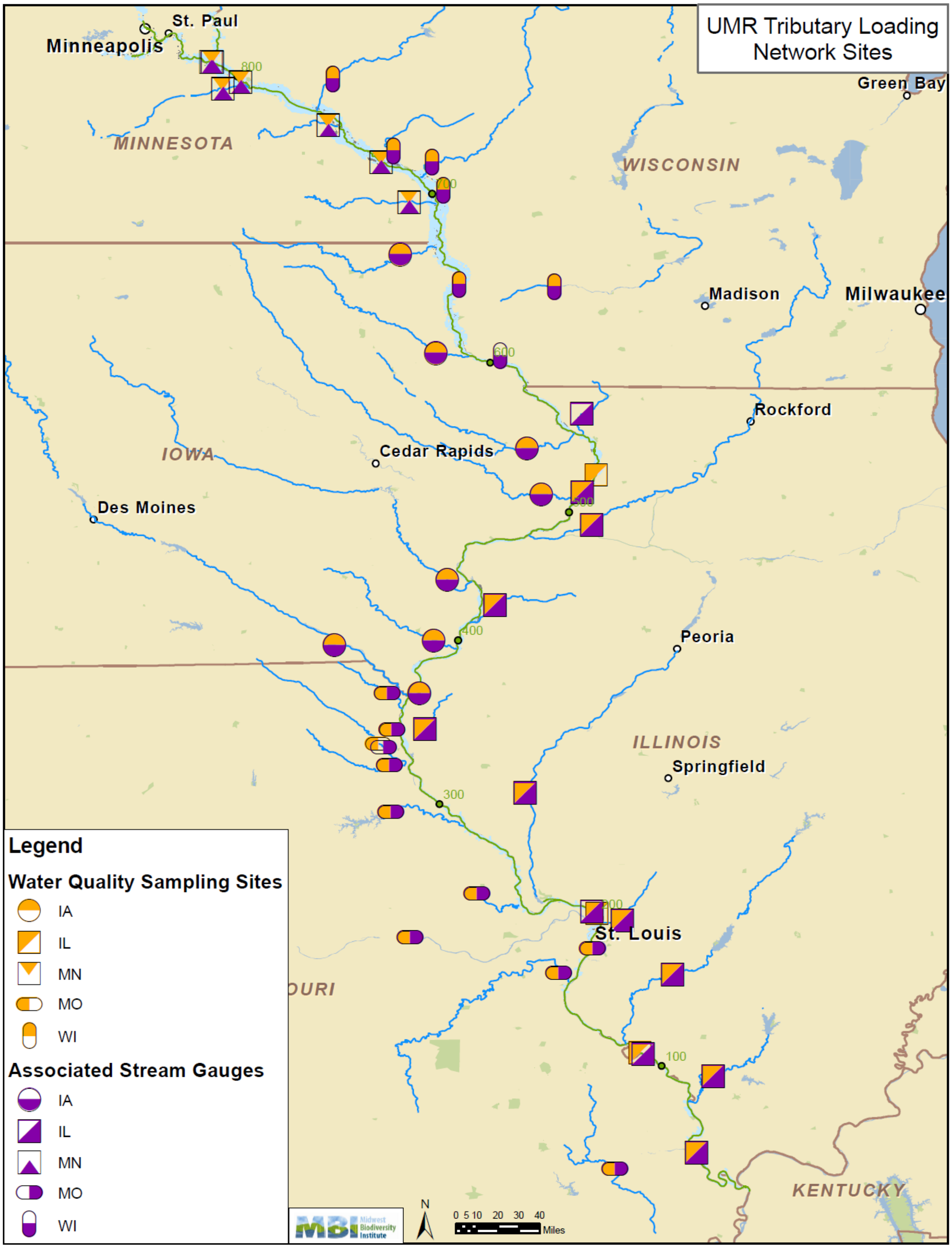


Figure 5. Locations of recommended tributary loading network sites by state and in relation to existing flow gaging stations (see Appendix Table A-2).

Chapter 6: Indicator Selection

Considerations for UMR Indicator Selection

Several important considerations guide the selection of indicators and parameters to be monitored under this Strategy. An indicator is a measure of aggregated data that conveys the condition or state of a sample or site. Biological and habitat indices are examples of indicators. A parameter is a discrete measure of a substance and generally pertains to chemical water quality parameters, but could also include specific attributes of other physical and biological data. For the purposes of this Strategy, the term “indicator” is inclusive of both indicators and parameters as described above.

Indicators should be cost-effective, accurate and precise, and used in their appropriate roles as indicators of stress, exposure, and response. Additionally, indicators in this Strategy are classified herein as “core” and “supplemental” to provide a systematic approach for determining when and where they will be collected. This chapter discusses the important considerations for indicator selection as it relates to their inclusion in the candidate monitoring designs discussed in Chapter 5.

Cost-Effective Indicators

Cost-effective indicators are those based on proven sampling methods and assessment procedures that can be executed in a “reasonable” time frame and with “reasonable” effort. We define “reasonable” here to mean indicators and parameters that can be measured at a sampling site in a few hours, allowing several sites to be sampled each day, tens of sites per week, and hundreds of sites per year by a dedicated field crew[2]. Additionally, chemical parameters especially may be collected at varying frequencies throughout a seasonal index period based on detailed knowledge of the types of stressors that could be impacting a particular site. The development of this Strategy assumes a cost-effective approach that samples multiple sites in a field day by dedicated field crews, given the spatial design options and the scope of the Strategy’s goals. In many ways, choosing to use a cost-effective approach governs other aspects of indicator and parameter selection, as it establishes bounds regarding the scope and cost of the monitoring program.

Accuracy and Precision

The indicators selected for inclusion in the Strategy must be sufficiently developed, calibrated, and proven so as to ensure both accuracy and precision. Accuracy includes the minimization of type I and II assessment errors, i.e., the under- or over-estimation of a condition or state. Precision pertains to the reliability of the measure and its ability to signal a gradient of response and exposure to include incremental effects and multiple states of condition. This issue was at

[2] A field crew is a 2-3 person team dedicated to the collection of data for a specific indicator category (chemical, physical, biological) and led by a trained professional in that particular discipline.

least partially addressed for biological indicators on the UMR via the *Biological Assessment Guidance* (Yoder et al. 2011) and is generally well known by monitoring practitioners for common chemical parameters. Any newly developed indicators will need to be evaluated for the properties of accuracy and precision.

Appropriate Roles of Indicators

An important factor in achieving the cost effective approach is using chemical, physical, and biological indicators in their *most appropriate* roles as stressor, exposure, or response indictors. The inappropriate substitution of stressor and exposure indicators in the surrogate role of response indicators is at the root of the national problem of widely divergent 305[b] and 303[d] statistics reported among the states (NRC 2001) and water quality policy issues regarding "conflicting" assessments between surrogate and direct measures of aquatic life status.

Mapping chemical, physical, and biological indicators to their functional role in monitoring and assessment is also visualized in the hierarchy of indicators for ambient indicators depicted in Table 5 and which is described in more detail in the project *Scoping Report* (MBI 2012). Definitions in this hierarchy follow:

Administrative Indicators (Level 1) generally include actions taken by regulatory and management agencies and by entities subject to the regulations and actions of those agencies. These include measures that quantify actions such as the issuance of NPDES permits, the development of plans, awarding grants, and the adoption of WQS and also the responses of entities to these actions. While these are not environmental measures per se, they can be enhanced by the confirmation that any one or more of these actions was followed by measurable changes in the level 2-6 indicators – thereby judging administrative actions by the results they achieve in the receiving environment as measured by environmental indicators. Level 1 indicators fall outside the immediate scope of this Strategy and are therefore not included in Table 5.

Stressor Indicators (Levels 2-3) generally include activities and phenomena that impact, but which may or may not degrade or appreciably alter, key environmental processes and attributes. These include point and nonpoint source pollutant loadings, land use changes, and other broad-scale influences that most commonly result from anthropogenic activities. Stressor indicators provide the most direct measure of the activities that water quality management attempts to regulate. These are not depicted in Table 5 as they are generally not comprised of ambient measurements, but they do play an important role for the design options that include a determination of causes and sources. These variables are commonly included in the development of stressor gradients and stressor indices, and example of which was developed by the U.S. EPA-GRE program for the UMR (Angradi et al. 2009a). U.S. EPA-GRE and the LTRMP each contribute vital information and techniques to better assess causes and sources, permitting their more routine application as stressor indicators.

Table 5. Core and supplemental indicator groups for the Upper Mississippi River organized by the four primary designated uses and the four lateral strata. These are arranged by indicator role and level in the hierarchy of indicators.

UMR Core and Supplemental Indicators																
	Designated Uses															
Indicators by Level[3]	**Aquatic Life**				**Recreation**				**Water Supply**				**Fish Consumption**			
	M	S	I	B	M	S	I	B	M	S	I	B	M	S	I	B
Response Indicators (Level 6)																
Macroinvertebrates	**C**	**C**	[C]	[C]												
Fish	**C**	**C**	**C**	[C]												
Indicators of Pathogenicity					**C**	**C**	**C**	**C**	S	S	S					
Periphyton	[S]	[S]	[S]	[S]												
Aquatic Plants (impounded UMR)	**C**	**C**	**C**	**C**												
Chemical Exposure Indicators (Levels 4&5)																
Field Parameters	**C**	**C**	**C**	**C**												
Demand Parameters	**C**	**C**	**C**	**C**												
Nutrient Parameters	**C**	**C**	**C**	**C**					**C**	**C**	**C**					
Metals Parameters	S	S	S	S					**C**	**C**	**C**					
Organic Parameters	S	S	S	S					S	S	S					
Chlorophyll a	**C**	**C**	**C**	**C**					S	S	S					
Odor/taste									S	S	S					
Sediment chemistry	S	S	S	S												
Tissue chemistry	S	S	S	S					S	S	S		**C**	**C**	**C**	**C**
Biochemical markers	S	S	S	S												
Emerging Contaminants	S	S	S	S					S	S	S					
Physical Habitat/Hydrological Indicators (Levels 3&4)																
Flow (at existing USGS gages)	**C**	**C**	**C**	**C**												
Geomorphology	S	S	S	S												
Habitat quality (Qualitative)	**C**	**C**	**C**	**C**												
Habitat quality (Quantitative)	S	S	S	S												

Key: M – main channel; S – side channel; I – impounded; B – backwater
C – core indicator/parameter; S – supplemental indicator/parameter; [C], [S]– desirable, not yet fully developed

[3] The levels pertain to the hierarchy of indicators that was described in the project Scoping Report (MBI 2012).

Exposure Indicators (Levels 3-5) include chemical-specific measures, whole effluent toxicity, tissue residues, chlorophyll a, and biochemical markers, each of which suggest or provide evidence of an exposure to stressor agents. These also include habitat and hydrologic indicators. Fecal bacteria are technically exposure indicators, but function as surrogates for the response of human contact with the water and as an indicator for the recreational use. Exposure indicators are based on specific measurements that are taken either in the ambient environment or in discharges and effluents, either point or nonpoint source in origin, and that reveal the level or degree of an exposure to a potentially deleterious substance or effect that is produced by a stressor event. These are depicted in Table 5 as they are comprised of ambient measures.

Response Indicators (Level 6) are measures that most directly relate to an endpoint of concern, i.e., ecological and human health. They are most commonly represented by the biological indicators, e.g., aquatic assemblage measures for aquatic life uses and human health for recreational uses, and they are the most direct measures of the status of these designated uses. For aquatic life uses the assemblage and population response parameters that are represented by the biological indices that comprise biological criteria are examples of response indicators. For the UMR this presently includes indices for fish, macroinvertebrates, and submersed aquatic vegetation. For other designated uses such as recreation and drinking water, symptoms of deleterious effects exhibited by humans would serve as the most direct response indicator, albeit these have proven to be difficult to develop and interpret. Response indicators represent the synthesis of stress and exposure and are most commonly used to represent overall condition or status, but also can be analyzed to yield indications of responses to categorical stressors. This latter function is critical in closing the gaps left by an *a priori* approach to characterizing stressor gradients in any aquatic system.

Core and Supplemental Indicators

Another aspect of a cost-effective approach is determining which indicators are measured in a given situation. The ITFM (1992, 1995) process arranged indicators according to their role and value for first determining the characteristics and state of an aquatic ecosystem (*core* indicators) and then adding other parameters in accordance with specific designated uses and the complexity of the setting (*supplemental* indicators). Indicator selection must also consider the ability to extract meaningful diagnoses of observed responses using multiple chemical, physical, and biological parameters and measures, with each used in their most appropriate role as indications of stress, exposure, and response.

Core Indicators

Core parameters are collected in *all* situations regardless of the assessment, regulatory, and management questions and issues of concern. These represent the essential chemical, physical, and biological elements of water resource integrity (Karr et al. 1986) and reflect the basic components of aquatic ecosystems (biota, habitat, and primary water quality). This approach fulfills the need to first characterize the condition and status of these baseline attributes.

Research approaches to monitoring and assessment attempt to formulate the assessment questions prior to deciding what to measure. In contrast, the adequate monitoring approach generates data and information about core and supplemental indicators in order to determine what the assessment questions should be, some of which cannot be sufficiently formulated without such information and feedback. Furthermore, core parameters directly represent the fundamental attributes of aquatic ecosystems and, as such, comprise the baseline of information needs for common and recurring assessment questions such as use attainment status, use attainability, delineation of associated causes/sources of threat and impairment, and basic reporting (305[b] report) and listing (303[d] listings). Table 5 displays proposed core indicators for the four designated uses and the four lateral strata of the UMR, with notes about their applicability to the longitudinal strata.

Supplemental Indicators

Supplemental indicators are added as specific informational needs (or questions) occur and generally coincide with the diversity, quantity, and complexity of the assessment setting. As the complexity of the assessment setting increases in terms of stressors and uses, the list of parameters will increase to include the addition of supplemental parameters, but also the frequency of their collection and analysis. This is a reasoned and stepwise selection of additional measurements, most of which require laboratory analysis and which add cost to the program. It can also include media in addition to the water column such as bottom sediments. This is typically dealt with in the initial planning of a given year's monitoring via the development of a detailed plan of sampling.

Core and Supplemental Indicators within UMR Strata

The assignment of core and supplemental indicators in Table 5 resulted from WQTF discussions and takes into account the anticipated application of the indicators as part of the spatial design options. As stated above a core indicator is sampled at all locations for the each designated use within applicable lateral strata. Hence, these are the baseline indicators for those strata. Supplemental parameters and indicators may be added in specific situations where the circumstances merit their inclusion and within the constraints of the spatial design.
For example, metals are a supplemental indicator for aquatic life across all four lateral strata. As such, they are not presumed to be collected at any location except where pre-survey planning has identified a need to include them based on stressors that are known or suspected to impact a particular river reach or lateral strata. Furthermore these decisions can be lateral strata specific in that an indicator can be core in one stratum, but supplemental in another, again depending on the need to include it based on site-specific information.

UMR Core and Supplemental Indicator Specifics

Specific choices will need to be made as the monitoring of core and supplemental indicators proceeds on the UMR. As an example, Figure 6 supplements Table 5 in providing a visual representation of the indicators that must be identified for the UMR for aquatic life use assessment. A description of the specifics of indicator selection for the UMR follows.

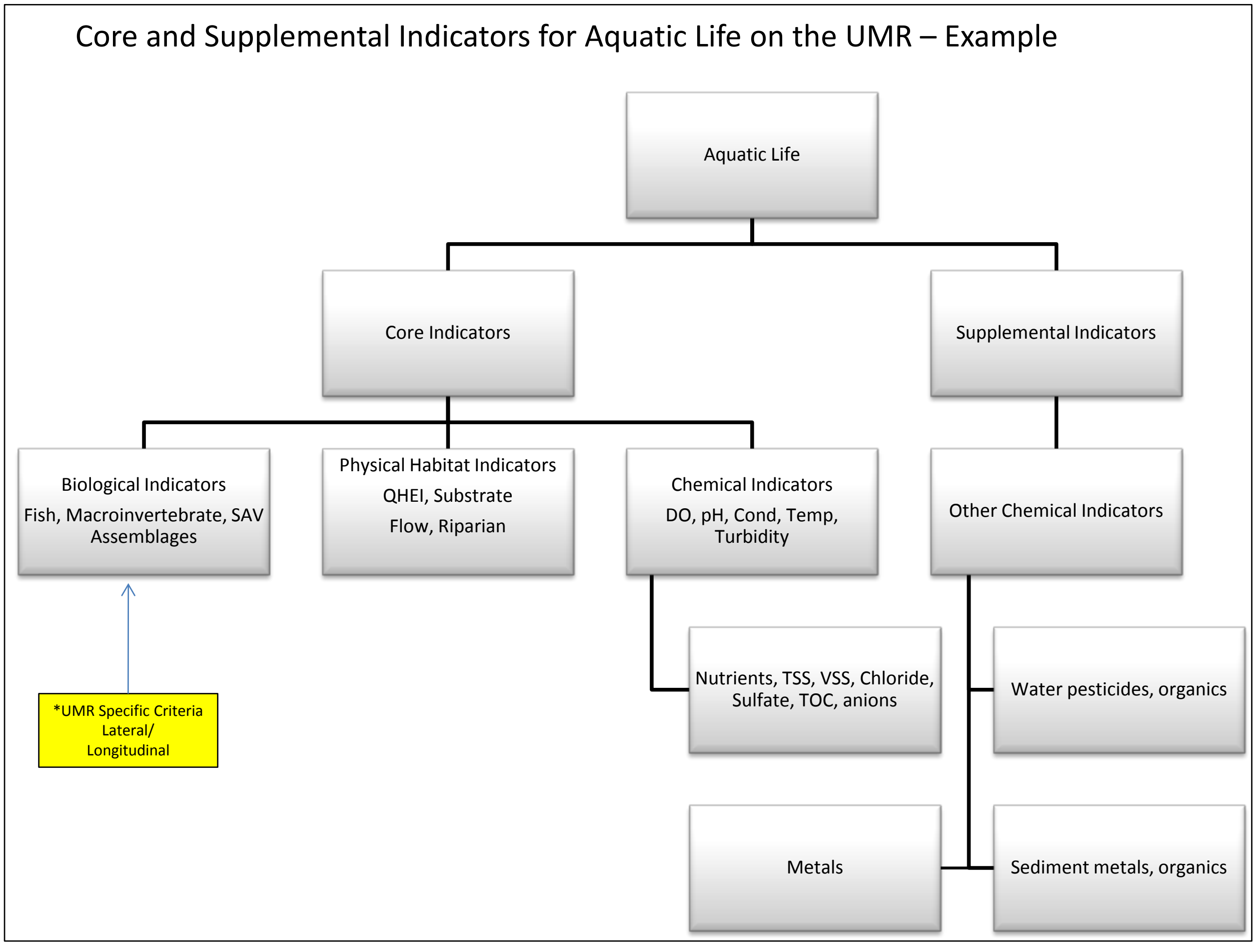


Figure 6: Core and Supplemental Indicators for aquatic life in the main and side channel strata of the UMR.

Bacterial Indicators

Bacterial indicators of pathogenicity (e.g., *E. coli)* are core indicators for the recreation use. They functionally serve as a response indicator even though they technically are an exposure indicator. Herein they are serving as a surrogate for the risk of human exposure to waterborne pathogens and as such have been elevated in their role as an indicator of response. For the drinking water use, indicators of pathogenicity are supplemental and only for the lateral strata that have water intakes present.

Biological Indicators

The biological indicators for the main and side channels are based on the recommendations of the *Biological Assessment Guidance* (Yoder et al. 2011) and reflect longitudinal aspects as well as lateral aspects (i.e., SAV applies to the impounded longitudinal reach only). For the impounded and contiguous backwater stratum, fish and macroinvertebrates are listed as core indicators, but are in need of further development before becoming a full-fledged core indicator. SAV methods have already been developed for the impounded and backwater lateral strata and as such function as a core indicator for those strata. Developmental needs associated with adding indicators for specific strata are discussed further in Chapter 10. Periphyton is included as a supplemental indicator as it is anticipated to be forthcoming from both the U.S. EPA-GRE and NRSA efforts. Figure 7 illustrates an application of biological indicators across UMR strata for aquatic life use assessment purposes.

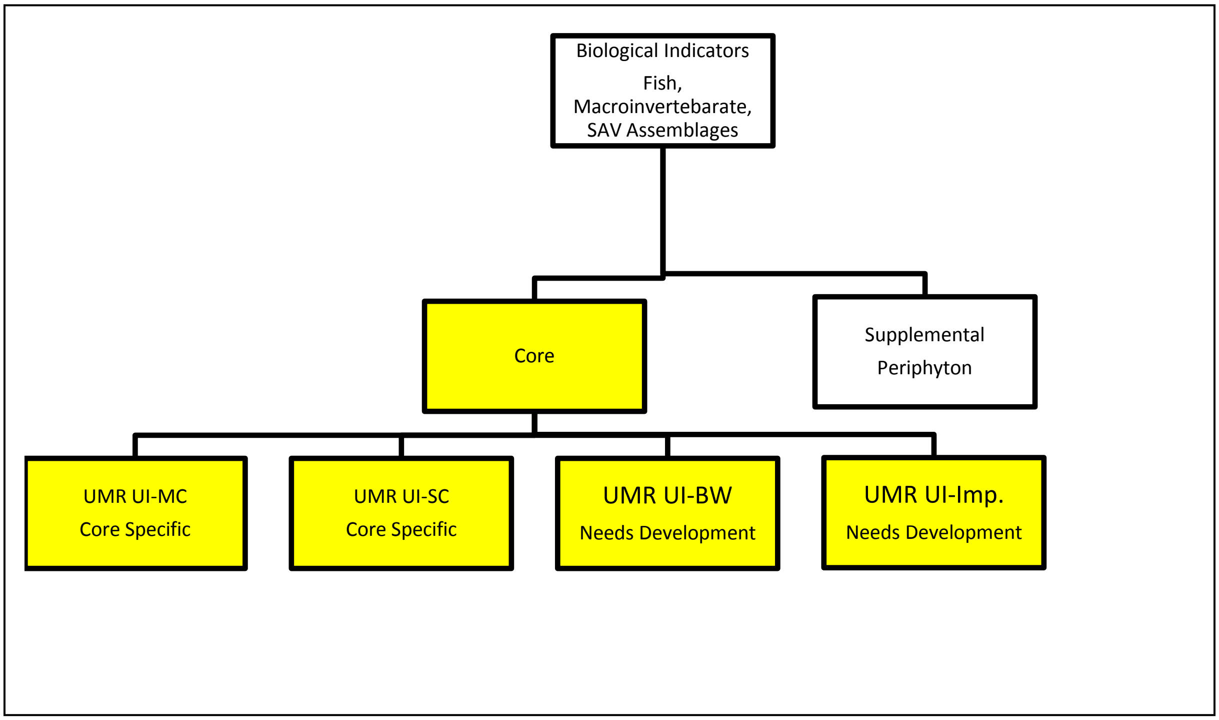


Figure 7: Example of Core and Supplemental Biological Indicators for the UMR Upper Impounded lateral strata.

Chemical and Physical Indicators

Recommended core and supplemental chemical indicator groupings in Table 5 are detailed as follows below. Chemical parameters are grouped in accordance with the similarity of how they are measured and analyzed in the field and laboratory.

Field Parameters – These include dissolved oxygen (D.O.), temperature, pH, and conductivity as core indicators, and may include additional parameters as supplemental indicators depending on the capabilities of the instrumentation.

Demand Parameters – These include 5-day biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), sulfates (SO_4), chlorides, total dissolved solids (TDS), total suspended solids (TSS), total suspended sediment (TSS), specific conductance, and lab pH as core indicators.

Nutrient Parameters – These include nitrate (NO_3), nitrite (NO_2), total Kjeldahl nitrogen (TKN), total phosphorus (TP), ammonia (NH_3), and chlorophyll a as core indicators. Various forms of nitrogen and phosphorus can be included as supplemental indicators.

Metals Parameters – These can include a core of "common" heavy metals such as iron (Fe), copper (Cu), cadmium (Cd), lead (Pb), zinc (Zn), calcium (Ca), and magnesium (Mg), the latter two being used to compute hardness as $CaCO_3$ for the application of metals criteria. Additional metals/metalloids such as arsenic (As), chromium (Cr as Cr^{+3} or Cr^{+6}), nickel, selenium (Se), can be added as the likelihood of their presence increases. These are analyzed in both water and sediment samples as a supplemental indicator.

Table 6. Proposed UMR Indicator groupings showing core and supplemental indictors for each as they apply to the main channel for all designated uses.

Indicator Grouping	Core Indicators	Supplemental Indicators
Biological	Fish (GRFIN)* *Macroinvertebrates (Ad hoc* GRMIN)* Vegetation (SMI)	Periphyton
Bacterial	*E. coli*	Other pathogens
Field Chemistry	D.O., temperature, conductivity, pH	Additional as delivered by instrumentation
Demand	BOD, chloride, sulfate, TSS, TDS, specific conductance, pH	
Nutrients	NO_3+NO_2, TKN, TP, NH_3-N, Chlorophyll *a*	Other forms of N and P
Metals	Fe, Cu, Cd, Pb, Zn, Ca, Mg	As, Ni, Cr, Se, others, plus sediment media
Organic (water & sediment)		Pesticides, BNA, PAH, PCB, volatile, semi-volatiles, water & sediment media
Tissue Chemistry	PCB, Pesticides, Hg	Scan for other organics, selected metals
Physical Habitat/Hydrological	Flow, Habitat Quality (Qualitative), Suspended Sediment	Geomorphology, Habitat Quality (Quantitative), Bed Sediment
Other Chemical		Emerging contaminants, taste & odor

* Main channel and side channel only.

Organic Parameters – These include detectable organic compounds and include a wide variety of substances within the following classes of analytes – BNA (Base Neutral Acid), VOCs (Volatile Organic Compounds), pesticides (organochlorine and new generation compounds), PAHs (polycyclic aromatic hydrocarbons), and PCBs (polychlorinated biphenyls) as supplemental indicators. These are rarely targeted, compound specific analyses, but rather result from scans of either water or sediment samples.

Tissue Chemistry – This includes parameters from the analysis of fish flesh following an adopted methodology that has yet to be determined. Choices are whole body, skin on fillets, and skin off filets and these depend on the objectives of the tissue sampling to support the documentation of organic chemicals and metals and/or to support fish consumption advisories. Parameters are derived from the types of scans that are performed and generally include PCBs, pesticides, BNAs, and metals of concern to human and wildlife ingestion including Hg and Se.

Physical Habitat/Hydrological – These measures include flow volume and qualitative habitat as core indicators. Flow will be obtained from existing USGS flow gages and is measured in terms of cubic feet per second. Qualitative habitat is a measure of the quality and extent of habitat for aquatic life. More quantitative measures of habitat and geomorphology are listed as supplemental indicators as these would be needed only in specific places as opposed to throughout the mainstem.

Other Parameters – Other parameters could include taste and odor for public water supplies, and emerging contaminants as part of the supplemental organic parameter analysis where these are feasible and of concern.

Final Indicator Selection Process

Core indicators are considered essentially fixed across sampling rounds. However, final decisions regarding specific supplemental indicators to be monitored during a given round of sampling are typically made during pre-survey planning and by those who are implementing the sampling in consultation with the CWA programs that would benefit from the outcomes of the assessment (i.e., during the development of annual monitoring work plans, per Figure 1). Additionally, the design options can have an influence on which supplemental indicators and even some of the core indicators that are included with each, as described below.

Fixed Stations

For this design the core chemical parameters have been included and supplemented by selected heavy metals at specific stations (Appendix Table A-1). If this design is retained the same approach to parameter selection seems reasonable. In addition this design clearly focuses on samples of the water column hence the inclusion of supplemental parameters should be done on a case-by-case basis.

Probabilistic and Stratified Random Designs

The core indicators depicted in Table 6 (as they apply to the four designated uses) should be utilized in the probabilistic designs for the main channel and side channel, as well as for the SRS design in impounded and backwater strata. However, the inclusion of supplemental parameters will be driven by the spatial characteristics of each design and the frequency of sampling. If the EMAP tradition is followed then one chemical grab sample per site per cycle will be collected at the probabilistic sites. Hence the inclusion of supplemental parameters will need to consider the probability of actually detecting these substances in the sampling that is conducted. If water quality is limited to the water column then the inclusion of supplemental chemical parameters especially for the lower density options (A and B) may be ill advised. The GRE program approximates the sampling density of the B and C options and it produced chemical data that had comparatively low utility in the analyses conducted as part of the *Biological Assessment Guidance* (Yoder et al. 2011). Probability D options seem to require the consideration of supplemental parameters given the higher site density, but again if this is limited to a single grab sample the same consideration may need to be applied. If however the chemical sampling frequency is increased to multiple samples over the index period, or follow-up sampling is employed, then consideration of supplemental parameters seems to make more sense. Adding sediment chemistry as a supplemental indicator also seems to make more sense given the longer term record it represents and the greater likelihood of detecting metals and organics in sediments.

Nonrandom Longitudinal Survey

The selection of indictors for this design will include many of the same considerations as for the probabilistic designs which include the considerations for chemical parameters and sampling frequency. However, the details of this will likely vary between the baseline and follow-up aspects of this design option. The follow-up aspect of this design presents the most realistic inclusion of supplemental parameters including sediment chemistry. This design has most of the same characteristics of the process described below for the Intensive Pollution Survey design.

Intensive Pollution Survey

This design is amenable to the judicious addition of supplemental indicators, chemical parameters in particular, on a site-specific or reach scale basis. In keeping with the concept of core indicators and parameters, these will be collected at all sites. Supplemental parameters will be added at selected sites depending on the expectation of actually detecting such parameters and also in consideration of the proximity to water intakes for the water supply use. These decisions are made during annual pre-survey planning and take into account the inventory of stressors and general knowledge of the local and reach scale settings. Sediment chemistry is likewise judiciously allocated in a similar manner.

Tributary Loading Network

Because of its function in measuring loading for specific parameters (i.e., those related to nutrients and sediment), the tributary loading network has essentially only a fixed set of core indicators as follows:

Nutrients: This includes the nitrogen series (nitrates [NO_3], nitrite [NO_2], total Kjeldahl nitrogen [TKN], ammonia [NH_3]) and total phosphorus [TP] at a minimum. Supplemental parameters would consist primarily of the biologically available forms of phosphorus.

Sediment: This includes total suspended sediment as a measure of inorganic sediment delivery and for calculating loadings to the UMR.

Flow and Field Measurements: Flow consists of instantaneous measurements of total water volume per unit of time as it is customarily measured at USGS gages. Field measurements consist of parameters that are instantaneously measured by portable water quality meters and include parameters such as temperature, D.O., pH, conductivity, turbidity, and other selected parameters depending on the meter and probes that are used.

In general, the indicators monitored at Tributary Loading Network sites will not change over time.

Chapter 7: Assessment Methodology and Impairment Listing Considerations and Implications

The effectiveness of a CWA assessment is the combined result of the indicators and monitoring design(s) it relies on. While it is not the purpose of this *Options Document* to develop a CWA assessment methodology, the integration of the monitoring options described in Chapter 5 and the indicators described in Chapter 6 will influence both the characteristics and outcomes of the assessment of the UMR's four major designated uses. As such, this chapter focuses on the assessment considerations leading to and the implications of selecting indicators and monitoring designs. The options are evaluated for their effectiveness and resolution in assessing the UMR mainstem, specifically for supporting the 305[b] and 303[d] goals of the Strategy. However, the goal of supporting other CWA program functions is also considered, and the degree to which each option is actually capable of providing that support is evaluated.

Indicator Considerations

The choice of indicators has a significant influence on the outcome of an assessment. They comprise not only the representative measures of the status of a designated use, but also influence the detection and understanding of stressor effects. This discussion assumes that the issue of how the indicators for each use should function and which indicators best represent the overall status of each designated use has already been settled in Chapter 6 via the selection of core and supplemental indicators for each designated use. It also assumes that the assessment of the four designated uses should be addressed as much as is possible by dovetailing the spatial and temporal considerations and within each of the design options such that the acquisition of data is harmonized and made more cost-effective as a result. Therefore, considerations for indicators as they are described Chapter 6 and applied within the spatial characteristics of each spatial design option are as follows:

Aquatic Life

Per the outcome of the *Biological Assessment Guidance* (Yoder et al. 2011) project, *the recommended biological assemblage indicators and their attendant indices will serve as the arbiters of aquatic life use attainment status* within this Strategy. Therefore, the remainder of the discussion in this chapter proceeds with an understanding that biological information is the primary driver of aquatic life assessment outcomes. With this understanding in mind, the following are some major considerations for assessment utilizing biological information:

- The issue of independent applicability needs to be explicitly addressed. This deals with the role of surrogate chemical/physical indicators in determining an assessment outcome – e.g., defining attainment status when response (biological) and exposure (chemical) indicators give differing information about status.
- Melding the assessment outcomes from the different assemblage groups (e.g., fish, macroinvertebrates) will need to be dealt with in a UMR CWA Assessment Methodology.

- It is assumed that biological and chemical/physical measures will be paired at each sampling site and within the seasonal index period specified for the biological indices in order to allow for the diagnosis of impairment causes.
- The frequency at which the chemical/physical measures are sampled is an important consideration for dealing with exceedance thresholds and in using the chemical results to indicate the severity and magnitude of stress and exposure.
- How the biological and chemical/physical indicators and parameters are used in an integrated assessment, including adhering to the key indicator roles to which each is assigned in Chapter 6 is an important consideration for an assessment methodology.

Recreation
The status of the recreation use will be based on the frequency and magnitude of exceedances of fecal bacterial measures such as *E. coli.* In this case, bacterial indicators serve as a surrogate for human responses, which are both difficult and impractical to measure directly. While this seems a straightforward process, the locations and frequency of sample collection is a critical consideration for an assessment methodology, specifically:

- For this indicator, sampling frequency at a site is important since the assessment is typically based on a geometric mean and a “maximum” that considers an allowable exceedance frequency (i.e., 10%). A literal interpretation of this would result in the need to collect a minimum of 10 samples per site, which is far in excess of the chemical/physical sampling regime envisioned for any of the spatial design options. As with many issues involved in developing an assessment methodology, the competing needs to meet the literal interpretation of measuring compliance with this use vs. the practical considerations of operating a cost-effective and systemwide program on the UMR are in potential conflict. The result of the former (literal interpretation) is the need for a dedicated crew to collect the additional bacteria samples needed to measure compliance. The implication of the latter approach is the need to develop an assessment method that infers exceedances from a lower number of samples at a site. This is already practiced by some states.
- The location of bacterial sampling may also be an important consideration especially if the locations of currently sanctioned recreational body contact activities are a consideration. State parks that provide facilities for public bathing are one such example. The levels of acceptable exposure are generally the lowest for bathing waters.

Drinking Water
The assessment of this use is based on primarily on exceedances of chemical pollutant thresholds against water quality criteria designed to protect a human ingestion route of exposure. The two key principles in an assessment of use support are the location of the sample and the frequency of exceedance considerations. Again, both the spatial and temporal

aspects of the respective sampling design affect each. For the UMR specifically, the following issues need to be considered:

- The differences between states in the definition and applicability of the drinking water use in terms of a point-of-withdrawal vs. uniform application to the entire UMR must be considered and may influence which design option(s) is preferable.
- As a year-round use, the monitoring and assessment of this use outside of the typical sampling index period must also be addressed. Because monitoring will need to occur outside of the summer-fall seasonal index period within which data for the other 3 uses is collected, additional sampling will need to take place outside of this period. The implications are additional field effort and possibly coordination with public water utilities especially for the point-of-withdrawal application.

Fish Consumption

The assessment of this use generally entails estimating the risks and benefits of consuming sport fish caught from surface waters of interest and using that information to develop consumption advisories. The same data can also be used to determine the impairment status of a water body based on fish tissue analytical data. Specific goals of fish tissue monitoring programs can include:

- Producing analyses of fish fillet and/or whole body samples to determine the potential for human health and adverse environmental effects associated with elevated levels of chemical contaminants.
- Establishing a comprehensive, historical database to evaluate contaminant concentrations, which affect the issuance or removal of sport fish consumption advisories and/or chemical exposure assessments. This can also include tissue banking (i.e., the archiving of frozen tissue samples from each year of monitoring for potential future analysis).
- Identifying the extent and magnitude of chemical contaminants in fish to enable anglers to make informed decisions about where to fish and how to safely consume their catch.
- Screening for the presence and bioaccumulation of toxic substances.
- Supporting 303[d] listing determinations.

Currently fish tissue is collected and analyzed by multiple state agencies along the UMR. There is considerable variation among the states in how sampling locations are determined, what types of samples are collected (i.e., skin-on or skin-off filets, whole body composites), and how the resulting data is used to make determinations of fish consumption use support (UMRBA 2005). Fish tissue data collected from the UMR is used primarily to support determining fish consumption advisories (FCA) at the UMR pool level and the process usually involves other state agencies beyond the CWA-implementing agency. Some states use the FCA process to determine impairments of the fish consumption use. Other states use fish tissue data more directly in determining use support. In short, disparities exist in how fish tissue data are generated and used in the UMR. Some examples include:

- Illinois, Minnesota, and Wisconsin sites are selected via an interagency process including DNRs, EPAs, and Health Departments, depending on the state. Sites for Iowa and Missouri are determined by their participation in the Region 7 RAFT (Regional Ambient Fish Tissue) monitoring program.
- Great Lakes states (Illinois, Minnesota, and Wisconsin) use skin-on filets, the Region 7 states (Iowa and Missouri) use skin-off filets.
- RAFT (used in Iowa and Missouri) has up to 27 analytes, Wisconsin has 23, Illinois has 14, and Minnesota two. The two in common analytes are mercury and PCBs. Analysis methods and associated detection methods vary (see Table 6 in UMRBA 2005).

While it is acknowledged that the collection of fish tissue data in the UMR will likely continue outside of the exclusive purview of CWA monitoring needs, the 2005 fish consumption advisory report (UMRBA 2005) made the following recommendation:

> *"A minimum suite of contaminants, fish species, size classes, sampling locations, sampling periods, sampling frequencies, and sample preparation procedures for fish consumption advisories should be established for the UMR and implemented by all five states."*

The opportunity to standardize the collection and analysis of fish tissue data for determining fish consumption use support is presented by a unified monitoring strategy. Making the resultant 305[b] and 303[d] determinations more consistent among the states along the UMR mainstem is an important goal for the strategy.

How the Design Options Provide for Assessment of the Four Major Designated Uses

The extent to which the four principal UMR designated uses are assessed varies by each design option, according to the spatial characteristics of the option and how each employs the key indicators. Each spatial design option brings with it a set of assumptions about how the data collected will be extrapolated to the full extent of the UMR mainstem to support assessment of the four designated uses. The following discussion summarizes how the monitoring design options provide for the assessment of the UMR's four major designated uses. The discussion is focused on the main channel for purposes of comparison, but is also representative of use assessment in other strata to the extent designs are applied and uses assigned in these strata.

Aquatic Life

Applicability: The aquatic life use has been the primary focus of this Strategy's consideration of how each spatial design option provides an assessment of the UMR mainstem. This was done in recognition of its systemwide applicability and management program relevance throughout the UMR (i.e., aquatic life use applies to all of the longitudinal and lateral strata and is a driver of most CWA management actions). Hence aquatic life is the most universally occurring and influential of the four UMR designated uses. However, this is not to assert that it is more important than the other uses, but rather is recognition of its typically predominant role in CWA implementation.

Assessment: Based on the WQTF's support for integrating biological assessment and the recommendations of the *Biological Assessment Guidance* (Yoder et al. 2011) project, aquatic life use will be assessed in this Strategy primarily using a "biocriteria" approach where the aquatic assemblage indices are used to assess attainment and non-attainment of the use. Hence the collection of the biological data necessary to support the calculation of the biological indices is an essential sampling consideration. The results are generally expressed as exceedances of the applicable biological index thresholds (see Yoder et al. 2011 for preliminary UMR biological thresholds) and this is then reduced to a declaration of attainment or non-attainment of the aquatic life use. This is the most basic expression of the assessment of this use and it minimally meets the CWA assessment goal of the strategy. Meeting this goal *and* broader program support goals also requires paired sampling for chemical/physical indicators as described in Chapter 6. Additionally, the possibilities for refined assessments are numerous within this use designation and include tiered assessment thresholds, incremental assessment, and taxa and species-based assessments.

Design Considerations: The spatial characteristics of monitoring design options principally determine the level of detail in the resulting assessment, ranging from systemwide to the site-specific scale. In turn, the scale at which this use is assessed also affects the quality of assessment itself (e.g., statistical strength, ability to detect changes in condition along pollution gradients, etc.) as well as the ability to support multiple management issues at increasingly refined spatial scales.

Continued use of the existing fixed station network alone to assess aquatic life use condition is not advised, due to its spatial limitations and lack of a biological component, as described in Chapter 5. While the Probabilistic A option technically yields a statistically valid systemwide assessment, this accomplishment alone has little value for spurring anything in the way of enhancing the management of CWA programs on the UMR. At a minimum, it would seem that the level of detail provided by the Probabilistic B option is needed given that UMRBA's ALDU project identified the four major longitudinal reaches as being distinctive in their aquatic classification characteristics and therefore worthy of being recognized in how the UMR is assessed and managed. The remaining Probabilistic options C, D1, and D2 provide a more detailed focus and, as applied to the UMR they would each meet the CWA assessment goal of the strategy. However, they have the inherent limitations of all of the probabilistic designs in that they cannot produce an assessment of individual sites. This is also true of the Nonrandom Longitudinal Survey baseline design. As applied to the UMR, they would each meet the CWA assessment goals of the strategy to varying degrees of detail and stratification.

Meeting the full programmatic needs of CWA management inherently requires a resolution at the site-specific scale. The design options that offer this capability are the Nonrandom Longitudinal Survey follow up and the Intensive Pollution Survey. Each provides the data needed to meet site-specific assessment needs and the data can be aggregated "upwards" at the local reach scale to support management program needs. The Intensive Pollution Survey uniquely fulfills both the 305[b] reporting and 303[d] listing goals while also meeting program support needs and with the same database.

Recreation

Applicability: This use is focused on the protection of human contact with the water and specifically on waterborne pathogenicity. A human contact recreation use is assigned by the states to the entirety of the UMR with the exception of small segments in Illinois and (currently) Missouri. Hence it is essentially applicable to all of the longitudinal and lateral strata similar to aquatic life. While the plausibility of the same intensity or types of recreation along the UMR may vary (i.e., actual recreation in the Open River may be different from the Impounded Reaches) it seems reasonable for the purposes of this Strategy to assume that full body contact could occur at any point along the UMR.

Assessment: As described previously, the primary indicator for this use is a usually a fecal bacterial measure, with *Escherichia coli* typically utilized. Sampling is accomplished in accordance with standard methods and the results are generally expressed as a geometric mean and a maximum count of *E. coli* expressed as the number of colonies/100 ml. Specific criteria vary by the degree of expected contact with the water via an activity such as swimming, wading, or boating. Depending on the frequency and magnitude of any exceedances of *E. coli* criteria an assessment is generally expressed as attainment or non-attainment of the recreational use. More detailed assessments beyond a pass/fail status are possible and include analyzing for more specific pathogens as the management needs may dictate. However, these are generally done as part of specialized studies and not as a baseline monitoring effort.

Design Considerations: There are two important considerations for assessing this use in light of the spatial characteristics of the monitoring design options. One is the relevance of the scale of assessment to how the use occurs along the river. Presumably, recreational users of the River are interested in water quality at rather localized scales. As such the relevance of assessing this use at the systemwide, longitudinal reach, and statewide scales may be limited. The CWA reach scale would appear to be the "minimum" scale at which attainment of this use would be reported to fulfill the 305[b] and 303[d] goals. As with aquatic life, the most detailed and potentially utilitarian assessment is at the site-specific scale, particularly in light of the public's likely interest in more localized information. Both the Intensive Pollution Survey and the Nonrandom Longitudinal Survey (with follow up sampling) provide this level of support.

The second important consideration is how attainment and non-attainment are to be determined and how this dictates data needs. As was described earlier in this chapter, if the geometric mean and the 90th percentile maximum are to be assessed in a literal sense then multiple samples will need to be collected at each sampling site regardless of the spatial design option. An important tenet of the strategy is to have the sampling that supports the assessment of all four uses coordinated as much as is possible. In this case, a chemical water sampling crew would collect water samples for parameters that support the aquatic life, recreation, and where it applies, the drinking water uses. However, none of the options involve the frequency of sampling that is required by a literal interpretation of the bacterial criterion. As a result, a literal assessment of this use would require additional sampling and likely a dedicated crew, which would add to the overall cost of strategy implementation. However, it would not be unprecedented to reduce the frequency of fecal bacterial samples to be in line with the other water sampling and accomplishing the recreational use assessment based on exceedances of maximum values as a surrogate approach. More focused follow up sampling where non-attainment is revealed in the baseline sampling could be accomplished in specific localized reaches. In this case, the more spatially intense probabilistic options, the Nonrandom Longitudinal Survey (follow up), and Intensive Pollution Survey would be the most likely to provide enough coverage in baseline sampling to detect problems requiring further sampling. The Nonrandom Longitudinal Survey (follow up) and Intensive Pollution Survey sample sites could also potentially be adjusted to occur at places of particular interest (e.g., riverside parks and swimming areas).

Drinking Water

Applicability: This use is intended to protect for drinking water uses and assure water quality sufficient to be treatable by a public water supply plant. Illinois and Missouri assign this use to the entirety of the UMR within their borders. Iowa designates its public drinking water use at intakes only. Minnesota and Wisconsin do not assign this use to the interstate UMR along their borders, as there are no drinking water intakes on this segment of the UMR. As such, this use essentially applies to the entirety of the UMR mainstem from the upriver Iowa state line boundary downstream to the Ohio River. However, water intakes have been inventoried (Appendix Table B-2) thus “point of withdrawal” could potentially be conducted to assess attainment of this use.

Assessment: Assessment of this use is focused principally on chemical criteria for the protection of human health and as these are adopted in state WQS. Water sample results are compared to these criteria and assessment status is typically categorized as in attainment or non-attainment. Traditionally, this use is not widely assessed across the U.S., except where actual drinking water withdrawal occurs such as on the UMR as described above.

Design Considerations: The ability of the design options to assess the drinking water use is primarily determined by the spatial resolution that each option offers. For this use, the differing spatial assignment of the use by the states directly influences how well the various designs match the state-specified use. For Iowa, the designs that include site-specific consideration of water intakes would be necessary to assess this use. As such, only the Intensive Pollution Survey design as structured would be sufficient as sampling sites are specifically allocated to each water intake (Appendix Table C-1). Other designs would need to be modified to meet a point-of-withdrawal assessment. For Illinois and Missouri, the options are more open since the entire UMR within their borders is designated for this use, hence a less spatially intense design could be an option for supporting 305[b] and 303[d]. However, it may be worth considering that water quality at or near an intake may be of the most interest to water supply utilities. This would make the probabilistic options less useful in that having a sampling site in close proximity to an intake would not be assured. An additional consideration for this use is that it occurs on a year-round basis thus sampling outside of the summer-fall index period for aquatic life and recreation would likely be needed. This would be in addition to that baseline sampling regardless of the spatial design.

Fish Consumption

Applicability: This use is intended to protect for the safe human consumption of fish from the UMR. It focuses primarily on the consumption route of exposure to humans and includes carcinogenic substances and those that affect cognitive functioning. The results of fish tissue analysis form the basis for consumption advisories that are issued by the states. All five states assess the fish consumption use on the UMR.

Assessment: Assessment of this use involves the collection of fish tissue samples and analyzing for an array of chemicals focusing on those that pose a risk to humans. The mechanism is the ingestion of fish flesh hence measuring the level of contaminants is required to determine the relative risks. Based on measured levels of carcinogens and other chemicals that can interfere with cognitive functioning, advisories are issued as recommendations for limiting the intake of fish flesh in terms of meals per week, per month, per year, up to outright bans on any consumption. These are also detailed to at risk segments of the population such as expectant and nursing females and children. Concentrations of substances that are harmful to fish eating wildlife (birds and mammals) can also be determined. These can then be factored into determinations of use attainment and non-attainment for 305[b] and 303[d] purposes.

Presently, fish consumption advisories have been issued for all of the interstate UMR by the respective states and generally at the "pool" level and these largely support the current assessment of this use. The EPA Region 5 states (Illinois, Minnesota, and Wisconsin) use advisories to accomplish 303[d] listing while the two Region 7 states (Iowa and Missouri) also look directly at tissue contaminant data. These are based on available sampling data some of which date back to the 1990s and which followed an interagency process within each state. These data are the result of a number of independent sampling efforts conducted by various state agencies and as such it is not under the control of the state CWA program alone. An assessment of fish tissue sampling was made by UMRBA (2005) with a recommendation to analyze for a minimum suite of contaminants, fish species, size classes, sampling locations, sampling periods, sampling frequencies, and sample preparation procedures for fish consumption advisories for the UMR and to be implemented by all five states.

Design Considerations: The impact of the spatial design options on the assessment of this use is somewhat different than those for the aquatic life and recreational uses in terms of spatial resolution and detail and how well the CWA assessment and CWA management support goals are met. Simply put, because of the mode of uptake of chemicals by fish, tissue samples can be collected at a spatially less intensive scale to yield an assessment that applies to a major reach such as a pool.

Additionally, there is an important logistical consideration that links this use more firmly to aquatic life use-focused sampling, in that it makes sense for fish tissue to be collected by the same crew that is collecting the fish assemblage data. Hence, whatever design is used for the fish assemblage assessment will potentially affect the fish tissue assessment design. As such, fish tissue sampling would likely piggyback on assemblage monitoring. This could be done at an intensity less than that of the assemblage monitoring for the more intensive designs, while matching the assemblage monitoring under the "coarser" options such as Probabilistic A and B. Additionally, it should be kept in mind that fish consumption advisories are typically issued at the pool level – although data produced by the strategy will not necessarily be the only data set available to agencies setting consumption advisories. This caveat does not rule out the use of fish tissue at a more detailed level in support of source assessment at a local reach or site-specific scale. However, the inherent properties of this use tend towards pool level applicability at least for meeting the 305[b] reporting and 303[d] listing goals.

Summary

In light of the preceding discussion, how the design options address each designated use is summarized symbolically in Table 7. This is based primarily on the spatial applicability and specificity that each design would contribute to an assessment of each designated use. It is also framed within the applicability of each of the design options to the different longitudinal strata, e.g., systemwide, the four longitudinal strata, the 13 CWA assessment reaches, and site-specific "levels of resolution."

Table 7. Summary of how the spatial design options support the assessment of each of the four major designated uses. This applies most uniformly to the main channel border, but can also include other lateral strata as each option assesses those strata.

Design Option	Aquatic Life	Recreation	Water Supply	Fish Consumption
Fixed Station	na	na	na	na
Probabilistic A	◖	na	na	◖
Probabilistic B	⊙	na	na	⊙
Probabilistic C	⊙[1]/**O**	na	na	⊙[1]/**O**
Probabilistic D1	**O**	**O**	**O**	**O**
Probabilistic D2	**O**	**O**	**O**	**O**
Longitudinal Survey - baseline	**O**/⊙[1]	**O**/⊙[1]	**O**/⊙[1]	**O**/⊙[1]
Longitudinal Survey – follow up	●	●	●	●
Intensive Pollution Survey	●	●	●	●

● - Most spatially detailed assessment of the designated use at the site-specific level. **O** - Assessment of designated use at CWA assessment reach scale. ⊙ - Assessment of designated use at longitudinal reach scale. ◖ - Assessment of designated use at systemwide scale. na – assessment at this scale is "not advised" given the spatial characteristics of the use. [1] – option assesses at the CWA reach scale in selected reaches.

Key Assessment Outcomes of Monitoring Design Options

The purpose of the following discussion is to focus on how the assessments from the different spatial design options can be derived and reported for the main channel UMR. While this Strategy's goal is to assess all four of the lateral strata, the best working examples of CWA assessment for the UMR are in the main channel. The lessons conveyed by these experiences should be applicable to the Stratified Random design, but applying that design in the impounded and contiguous backwater strata for CWA assessment purposes presents a developmental need (see Chapter 10).

The results of the analysis of the GRE dataset from the main channel UMR that supported the determination of biological thresholds (Yoder et al. 2011) are used in the majority of the following examples. However, examples of analyses accomplished in other large river systems of the Midwest U.S. are also used to illustrate the possible assessment products from designs for which no examples presently exist for the UMR. These examples illustrate the assessment products that can result from monitoring under each of the design options.

Systemwide (Probabilistic A)

The Probabilistic A design is applicable only at the systemwide scale and it would simply produce an overall estimate of the proportion of the UMR that is in attainment and non-attainment of a designated use. Depending on the indicator being used, it could also be reported as the proportion of quality ranges (i.e., good, fair, poor). The former is expressed in Figure 8 as a bivariate expression of aquatic life status for the UMR mainstem utilizing the results of the 2004-6 GRE survey, even though the GRE itself approximates the Probabilistic C design in terms of the longitudinal strata that were assessed. This approach illustrates the utility of each succeeding design to aggregate their results "upwards", but it also exposes the limitations of the less intensive designs. As was discussed previously regarding the application of the Probabilistic A design to the UMR, it would be applicable for the aquatic life use only, and even then it would fall short of the current levels of stratification of the main channel as determined by the ALDU report (UMRBA 2012). In addition, any of the successive (i.e., more intensive) design options could also yield a systemwide assessment in addition to the more spatially detailed assessments at the scale of each successive design. While a systemwide only design is not advised for the UMR CWA strategy, it can yield an overall assessment that minimally meets 305[b] and 303[d] goals and in the shortest time frame of one year. This design could also yield general patterns in the correspondence of any observed non-attainment to general causal categories. However, any specificity beyond the systemwide scale would not be possible making the utility of these determinations to CWA management programs both indirect and non-specific.

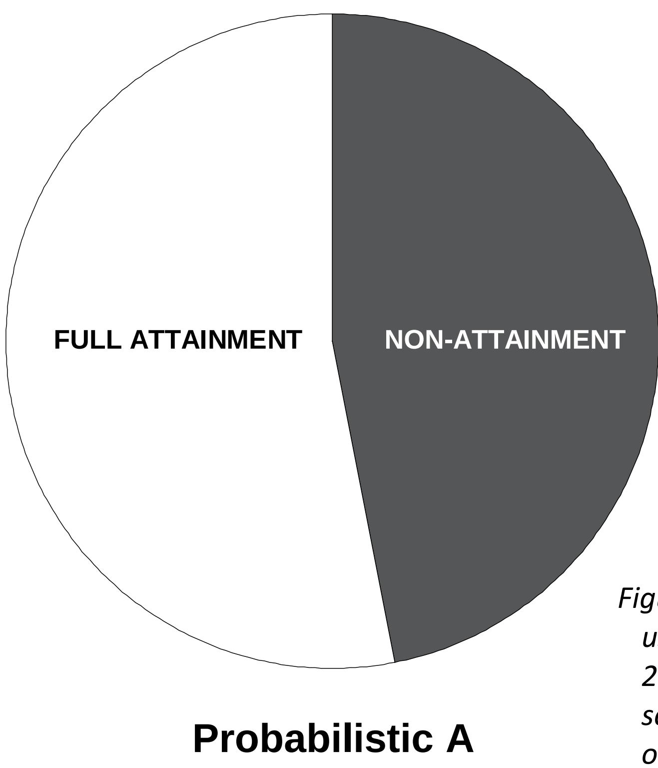


Figure 8. The status of the aquatic life designated use in the Upper Mississippi River based on the 2004-6 GRE results aggregated to the systemwide scale. This simulates the principal assessment output of the Probabilistic A design option.

UMR Major Longitudinal Reach (Probabilistic B)

The Probabilistic B option is based on the four major longitudinal reaches identified by the ALDU report (UMRBA 2012). To illustrate the likely output of this design the assessment accomplished by Miltner et al. (2011) using the 2004-6 GRE database and the biological thresholds developed by the Biological Assessment Guidance project (Yoder et al. 2011) were utilized. Table 8 shows the status of the aquatic life use in terms of a bivariate attainment and non-attainment approach. In addition, proximate stressors that were most closely associated with the non-attainment based on the causal analyses accomplished by Miltner et al. (2011) are also included to illustrate that aspect of this level of assessment. The current UMR assessment based on the fixed station network was included for comparison purposes. Again, this is an aggregation of the assessment in the *Biological Assessment Guidance* (Yoder et al. 2011) to the major longitudinal reach level of stratification. Note that it is possible that a monitoring design based on the Probabilistic B design would likely yield different results because the site density (and therefore the number of data points) would be less than the GRE dataset (which was at a Probability C level of intensity). This could influence not only the assessment of status, but also the stressor identification output of that design. However, while informative, the output of this design is limited even in its indirect application to CWA management programs along the UMR. It does, however, yield a more detailed assessment for 303[d] purposes than does the systemwide option (Probabilistic A).

Statewide Assessment Scale (Probabilistic C)

Another stratum of interest for 305[b] reporting and 303[d] listing is at the state border level and this was also accomplished by the GRE assessment. Expected outputs of the Probabilistic C option for the UMR mainstem would include the condition and status of the main channel along the boundaries of the five UMR states. The 2004-6 GRE survey included an allocation of sites along these strata in addition to the UMR itself. The results of aquatic life attainment status using the approach developed by Miltner et al. 2011 are depicted in Table 9. While this example shows the results for status only, an analysis of proximate stressors similar to that provided in Table 8 would also be possible. As with the preceding options, application of this level of spatial assessment would yield 305[b] and 303[d] outcomes, but broader support of CWA programs is only indirect.

Table 8. Simulation of the assessment output of the Probabilistic B design option depicting aquatic life use attainment apportioned by miles of full and non-attainment of biological thresholds for an assessment of the major longitudinal reaches of the Upper Mississippi River main channel based on the GRE weighted probability design. Categorical causes of non-attainment are labeled as proximate stressors and were determined by a battery of statistical tests (modified from Yoder et al. 2011).

Longitudinal Reach	GRE River Miles[1]	Reach Length (mi.)	ALU Assessment[2]		Proximate Stressors[3]	States' 2008 303(d) ALU Attainment[4]
			Full (mi.) (percent)	Non (mi.) (percent)		
Upper Impounded to Chippewa River	812 – 763	49	3.50 (7%)	45.5 (93%)	Habitat[5] TN[6]	Turbidity/ TSS
Upper Impounded below Chippewa River	763 – 523	240	151.0 (63%)	89.0 (37%)	Habitat Nutrients	Full
Lower Impounded	523 – 196	327	121.2 (37%)	205.8 (63%)	Habitat TN	Al & Nutrients
Open River	196 – 0	196	107.1 (45%)	88.9 (55%)	Conductivity Nutrients	Pb & Zn
Total Length	870.5 - 0	870.5	411.1 (47%)	459.4 (53%)		

[1] EMAP-GRE river miles – these are different from the USACE river mile system.
[2] Aquatic life use (ALU) attainment based on biological thresholds developed by Yoder et al. (2011).
[3] Proximate stressors were defined by statistical associations between stressors and biological indicators.
[4] Aquatic life use attainment reported by states based on chemical/physical indicators.
[5] Habitat includes either channel complexity, substrate quality, or both.
[6] Total nitrogen (TN) was strongly correlated with total dissolved solids along the entire interstate UMR.

CWA Assessment Reach Scale (D1, D2, and Nonrandom Longitudinal Survey baseline)

Probabilistic D1, D2, and the Nonrandom Longitudinal Survey design (baseline) options can all produce assessments at the 13 UMR CWA assessment reach level. While sampling of the UMR has not been conducted at this density systemwide, Miltner et al. (2011) produced an initial 13 CWA reach-level assessment utilizing the GRE database (a Probabilistic C level of design). One finding of this analysis was that the assessment of some reaches was limited in terms of the number of sampling sites offered by the GRE design that simulates the Probabilistic C option in terms of its applicability. Nonetheless, and with the noted exception about sample size concerns in selected reaches, the output of an assessment under the Probabilistic D1, D2, or Nonrandom

Table 9. Percentages of miles of full attainment and non-attainment of a general aquatic life use for the Upper Mississippi River apportioned by state borders. Based on EMAP-GRE weighted probability design (after Miltner et al. 2011).

State	GRE River Miles[1]	Length (mi)	Full (mi.)	Non (mi.)
MN	870.5-695.2	175.3	69.8	105.50
WI	834.8-598.8	236.0	135.8	100.24
IA	695.2-372.0	323.2	166.8	156.44
IL	598.8-0.0	598.8	269.9	328.91
MO	372.0-0.0	372.0	169.1	202.91

[1] EMAP-GRE river miles – these are different from the typically utilized USACE system.

Longitudinal Survey would be structurally similar to the results of the GRE analysis, as depicted in Table 10. The results depicted in Table 10 utilized a dual indicator (fish and macroinvertebrate) approach to determine assessment and corresponding physical/chemical data to preliminary identify proximate stressors.

Sampling at the D1, D2, or Nonrandom Longitudinal Survey level also begins to support a more detailed and potentially more accurate and informative approach to causal diagnosis via the correspondence of key indicator endpoints (in this case the UMR relevant biological indices). This is further supported when detailed stressor/response analyses are conducted and interpreted which enhances the assignment of causes for 303[d] listing purposes. These analyses promote a better understanding of the limiting stressors some of which are directly dealt with by existing CWA management programs. While it does not offer an analysis of specific sources, it at least indirectly supports the categorical management of classes of stressors. Figure 9 provides an example of one of several analyses that assists in the identification of which stressors are most closely associated with biological impairments. As was demonstrated with the Biological Thresholds Analysis the GRE design provided as sufficiently detailed enough dataset to support this level of analysis and the identification of categories of stressors. The same level of analysis could be accomplished for recreation and drinking water uses at a minimum.

A key aspect that affects virtually any CWA management program is water quality standards (WQS). While none of the UMR states presently have adopted tiered uses and biocriteria in their WQS, partial groundwork for their eventual development and adoption is provided by the ALDU (UMRBA 2012) and *Biological Assessment Guidance* (Yoder et al. 2011) projects. One potential future application of these projects includes assigning tiered aquatic life designated uses to the UMR.

Table 10. Aquatic life use attainment status apportioned by CWA assessment reaches of the Upper Mississippi River main channel based on the GRE weighted probability design. Segments with >50% non-attainment of the most disturbed/intermediate disturbed biological thresholds are shaded.

Assessment Reach	GRE River Miles[1]	Reach Length (mi)	MBI Assessment Full (mi.) (percent)	MBI Assessment Non (mi.) (percent)	Proximate Stressors[2]	2008 303(d) ALU Attainment[3]
Non-interstate UMR	870.5 – 812	58.5	0.00 (0%)	58.5 (100%)	Ammonia Habitat[4] TN[5] Conductivity	Turbidity
1 St. Croix River to Chippewa River	812 – 763	49	3.50 (7%)	45.5 (93%)	Habitat TN	Turbidity/ TSS
2 Chippewa River to Lock and Dam 6	763 – 714	49	38.1 (78%)	10.9 (22%)	Habitat Nutrients	Full
3 Lock and Dam 6 to Root River	714 – 694	20	15.0 (75%)	5.0 (25%)	None Detected	Full
4 Root River to Wisconsin River	694 – 631	63	40.5 (64%)	22.5 (36%)	Habitat	Full
5 Wisconsin River to Lock and Dam 11	631 – 583	48	34.3 (71%)	13.7 (29%)	Habitat	Full
6 Lock and Dam 11 to Lock and Dam 13	583 – 523	60	23.1 (38%)	36.9 (62%)	Habitat	Full
7 Lock and Dam 13 to Iowa River	523 – 434	89	34.2 (38%)	54.8 (62%)	Habitat	Al & Nutrients
8 Iowa River to Des Moines River	434 – 361	73	39.8 (55%)	33.2 (45%)	Habitat TN	Al
9 Des Moines River to Lock and Dam 21	361 – 325	36	12.0 (33%)	24.0 (67%)	Habitat TN	Full
10 Lock and Dam 21 to Cuivre River	325 – 237	88	35.2 (40%)	52.8 (60%)	Habitat TN	Full
11 Cuivre River to Missouri River	237 – 196	41	0.0 (0%)	41.0 (100%)	Habitat TN	Full
12 Missouri River to Kaskaskia River	196 – 118	78	26.0 (33%)	52.0 (67%)	Conductivity	Pb & Zn
13 Kaskaskia River to Ohio River	118 – 0	118	81.1 (69%)	36.9 (31%)	Conductivity Nutrients	Full
Total Length	870.5 - 0	870.5	411.1 (47%)	459.4 (53%)		

[1] EMAP-GRE river miles – these are different from the typically utilized USACE river mile system.
[2] Proximate stressors were defined by statistical associations between stressors and biological indicators.
[3] Aquatic life use attainment reported by states based on chemical/physical indicators.
[4] Habitat includes either channel complexity, substrate quality, or both.
[5] Total nitrogen was strongly correlated with total dissolved solids along the entire mainstem; however, in the non-interstate reach, TN was also associated with common wastewater constituents such as chloride and ammonia-nitrogen. Conductivity was not strongly associated with TDS.

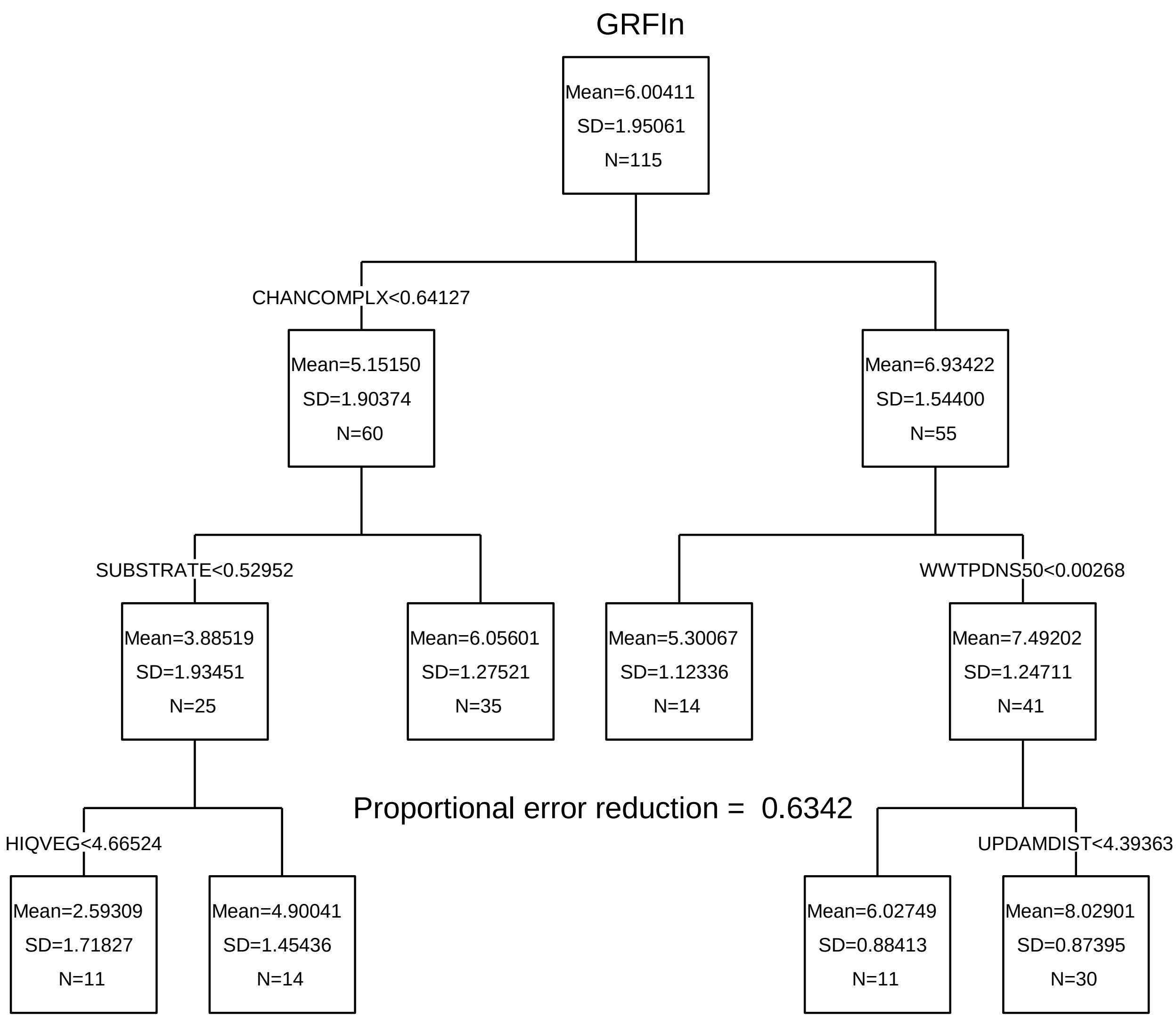


Figure 9. An example of an analysis of Probabilistic C level data that could be done to support more refined 303[d] listing and indirect support of CWA programs. This example depicts a regression tree for GRFIn scores in the impounded UMR based on a Probabilistic C design option. The mean GRFIn score listed at the top of each box is the mean after portioning by the variable forming the split (after Miltner et al. 2011).

Figure 10 shows a longitudinal profile of GRFIn results along the UMR mainstem using the GRE database. This graphic illustrates an example of using differing levels of biological condition as expressed by GRFIn along the mainstem for the main channel border and a potential scheme for not only narrative condition descriptions, but tiered thresholds for the support of more refined CWA assessment thresholds. These could also double as tiered aquatic life use biocriteria and as a basis for tiered uses in the WQS of each state. This is an example of a direct and more relevant CWA program support example than has been possible with any of the preceding designs. The preceding examples of CWA reach based outputs are representative of what can be expected from the Probabilistic D (D1 and D2) and Nonrandom Longitudinal Survey baseline options. While these will offer higher site density generally and within the CWA assessment reaches in particular as compared to the GRE survey, they will have the same limitations that are in common to all of the spatially stratified design options regarding direct support of CWA management about specific sources and other site-specific management needs along the UMR, as they lack the ability to assess on a site-specific basis.

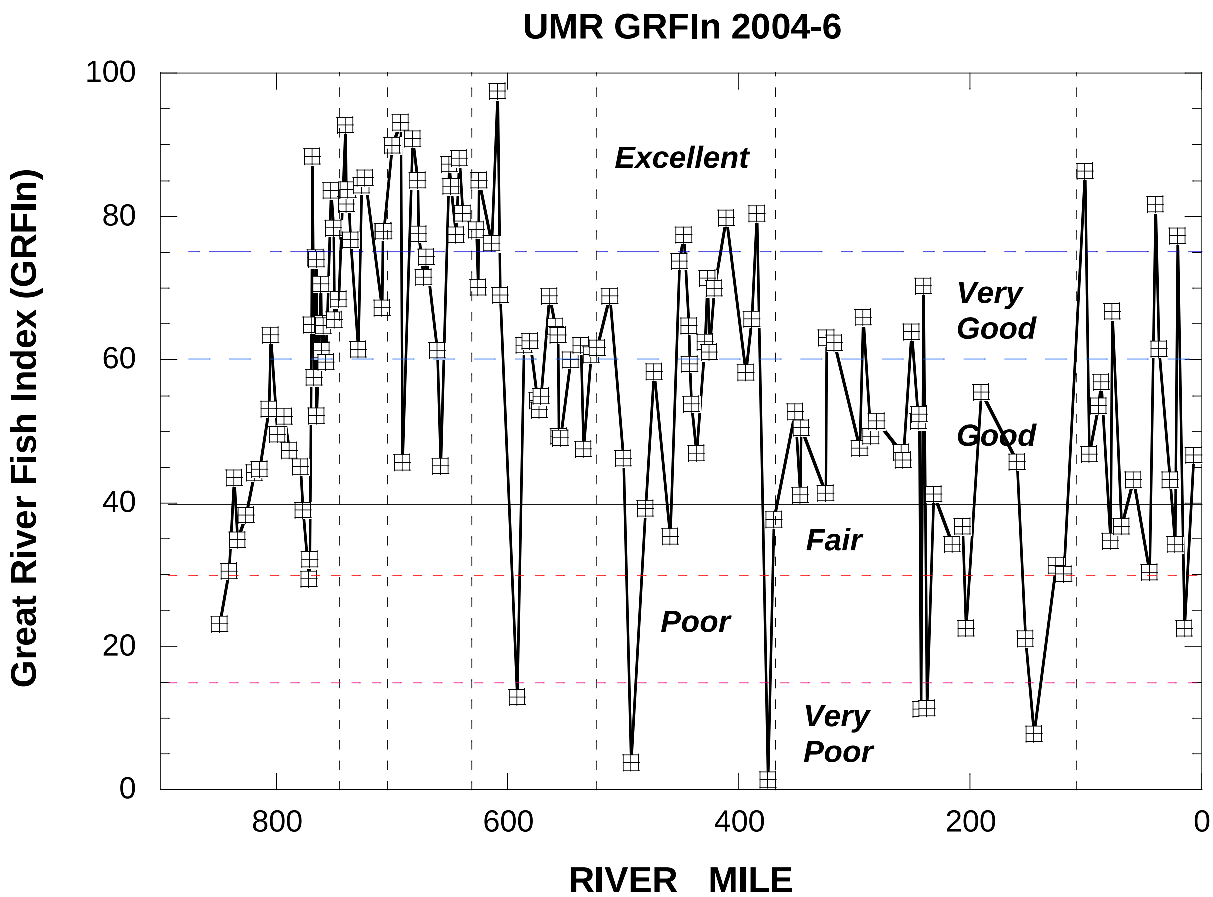


Figure 10. An example of potential tiered assessment thresholds based on fish (GRFIN) index scores for GRE data (2004-2006) in the UMR. Attainment classes are narrative ranges indexed to the CWA minimum threshold (solid black line). The narrative descriptions of excellent, very good, and good are potential thresholds for tiered aquatic life use based biocriteria. Adapted from Figure 6 in Yoder et al. 2011.

Site-Specific Scale (Intensive Pollution Survey & Nonrandom Longitudinal Survey follow-up)
This assessment scale involves sampling at a higher density of sites along the mainstem than what is offered by any of the preceding design options. As described in Chapter 5, the Intensive Pollution Survey design and presumably the follow-up part of the Nonrandom Longitudinal Survey design, are uniquely able to support this level of assessment. They are also able to better support CWA management programs at this scale as a result of their inherent design features including the allocation of sampling sites along suspected pollution gradients (Figure 11).

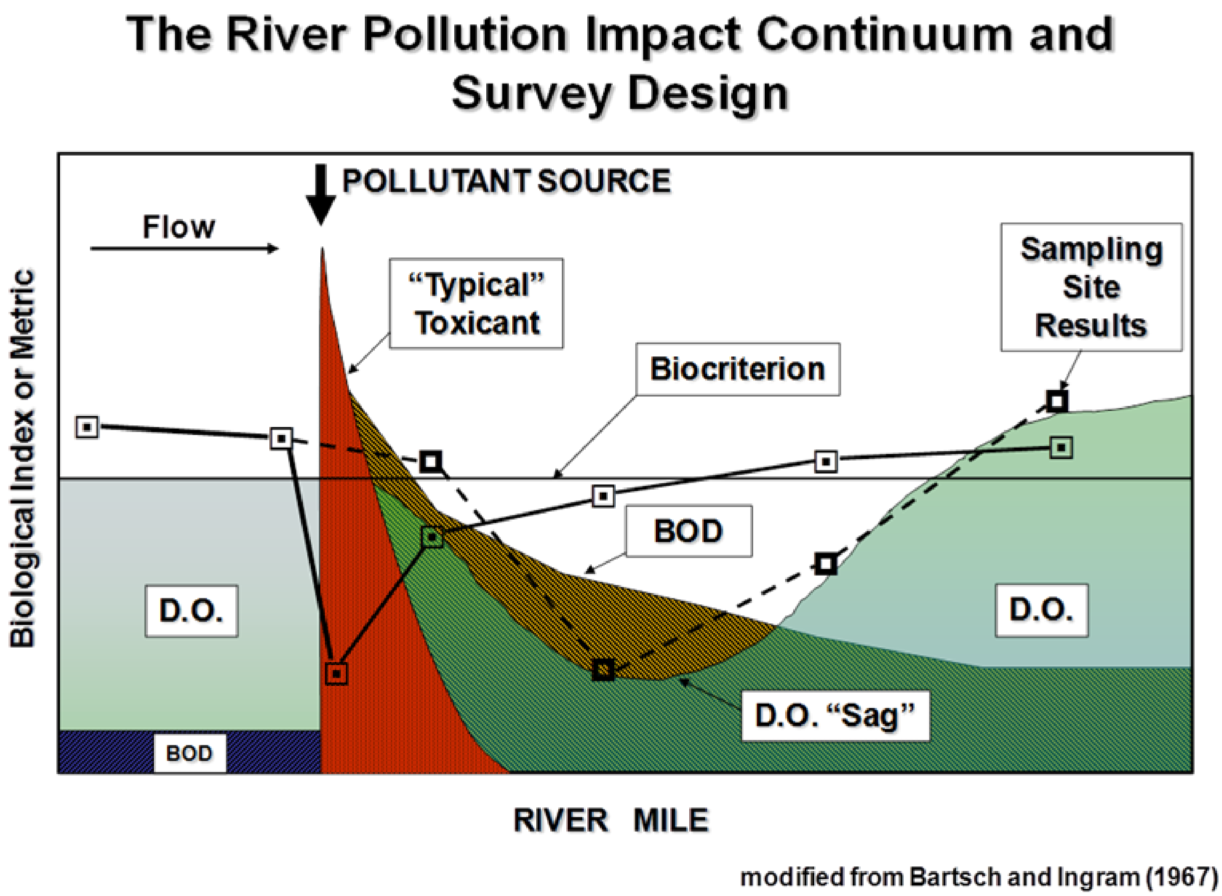


Figure 11. The river pollution impact continuum and survey design adapted from the original description of pollution zonation by Bartsch (1948). In addition to how pollutants typically react when discharged in a lotic system, suggested sampling design and two different biological responses are depicted (toxic response – solid line; D.O. response – dashed line). This applies to pollution beyond the D.O. and toxicant pollutant impacts depicted in the graphic.

Sampling sites are treated as the fundamental unit of assessment which also distinguishes the design. The unidirectional flow of water in the main channel means that sites are linearly related which represents a spatial autocorrelation such that serial sites in the same local reach (and along the same bank) are likely to not be independent. In the UMR the longitudinal aspects of these gradients are not one-dimensional, but include the lateral aspects across the main channel and in some cases into the impounded lateral stratum as well. The left/right bank allocation of sites that is also unique to this design is done with respect to where pollution from specific sources emanates which requires a bank-specific allocation of sites. The allocation of sites to either bank assures the level of detail that is needed to support the direct assessment of specific sources within CWA management programs. Assessment outputs are nested in the site-specific characteristics of this design in that the condition of each site is the common "currency" of the assessment. By contrast the role of a site in a probabilistic design based assessment is as a member of a target population of sites that supports an overall condition assessment of the population. In this approach the results at any single site are deemphasized.

While sampling and assessment have not been conducted at the Intensive Pollution Survey or Nonrandom Linear Survey (follow up) level on the UMR, GRE results were used again to illustrate two examples (Table 11 and Figure 12) of how similar data from the UMR might be used to develop assessments under these two design options.

In Table 11 the GRE results were sequentially organized from upstream to downstream using river mile as the index of site location. GRFIn scores are presented along with the corresponding narrative assignment of relative quality from excellent, very good, good, fair, poor, and very poor for corresponding ranges of the GRFIn. This constitutes an assessment of the data at the site-specific level where indications of attainment and non-attainment would be made. Additional information could easily be added in appended columns about the results for macroinvertebrates and submersed aquatic vegetation (where it applies), habitat, and proximate stressors. This is a characteristic of the assessment output of the Intensive Pollution survey design. Figure 12 shows a longitudinal plot including the same results depicted in Table 11 (and adding in results from reach 2).

Table 11. GRE results for GRFIn sequenced by river mile in CWA assessment reaches 0 and 1. Site specific GRFIn results are highlighted and assigned a narrrative rating following the approach used in Figure 9. Mean GRFIn, %Attainment, and Average Rating are calculated across both reaches to simulate a reach level assessment.

RIVER MILE	Reach	GRFin	X_GRFIn	Rating	%Attain.	Avg. Rating
849.6	0	23.2		Poor		
841.5	0	30.5		Fair		
837.1	0	43.5		Good		
834.0	0	34.9		Fair		
826.4	0	38.3		Fair		
819.6	0	44.3		Good		
814.8	1	44.8		Good		
806.9	1	53.2		Good		
805.6	1	63.5		Very Good		
799.7	1	49.6		Good		
793.2	1	52.1		Good		
789.0	1	47.4		Good		
779.5	1	45.1		Good		
777.0	1	39.1		Fair		
772.2	1	29.4		Poor		
771.3	1	32.2		Fair		
770.2	1	64.9		Very Good		
769.1	1	88.4		Excellent		
767.7	1	57.5		Good		
766.5	1	74.3	47.8	Very Good	65%	Fair

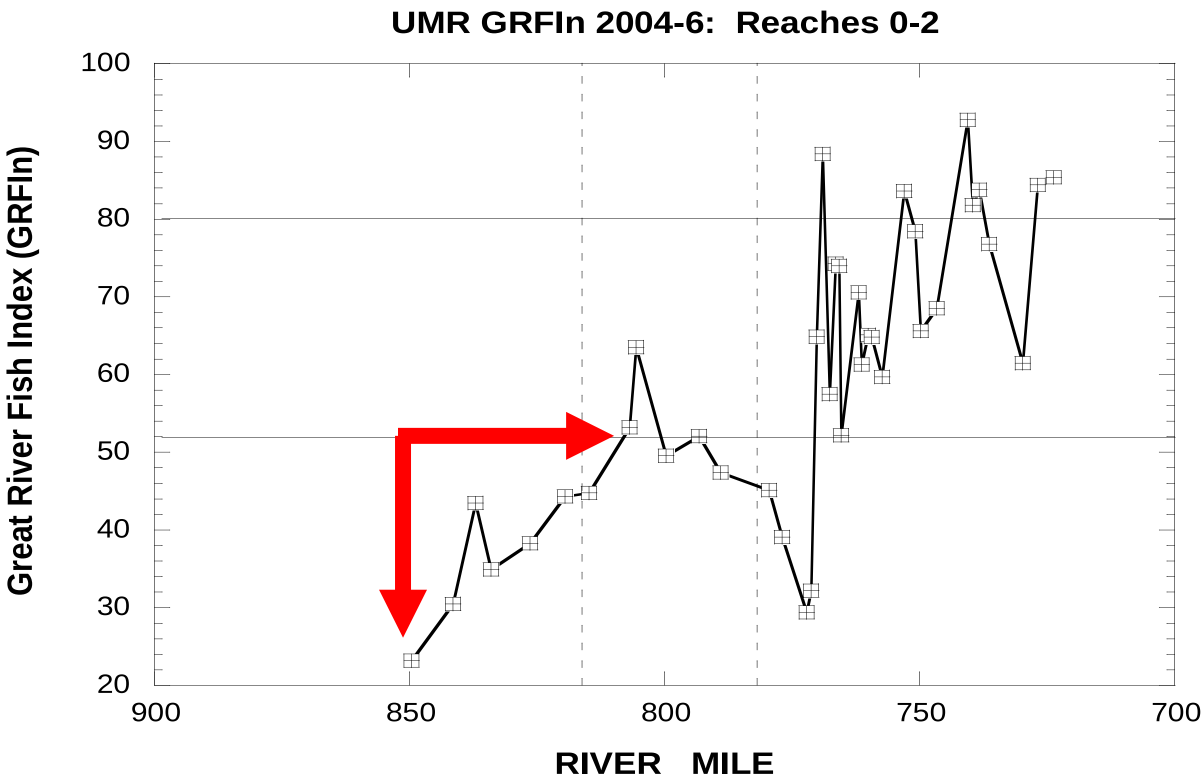


Figure 12. GRE results for GRFIn plotted by river mile in UMR CWA assessment reaches 0, 1 and 2. Horizontal lines indicate general and exceptional quality thresholds suggested by Yoder et al. 2011. The red arrows indicate incremental assessment depicting extent (horizontal arrow) and severity (vertical arrow) of departures from suggested thresholds for UMR aquatic life use attainment thresholds.

Figure 12 illustrates how lineal interpretations of status can be observed and calculated. In addition, terms such as the Area of Degradation and Attainment Values (ADV/AAV; Yoder et al. 2005) can be calculated to convey the magnitude and severity of impairments, as well as the extent of values above the CWA minimum thresholds. This is depicted in more detail in Figure 13 from the Scioto River in Ohio which illustrates the source specific assessment and a trend assessment between years. While the mechanics of this level of assessment could be accomplished with a less dense allocation of sites, the non-linear characteristics of pollutional impacts along the UMR would likely render such as potentially less accurate portrayals of the extent and dynamics of the extant pollution gradients. Table 11 also provides a contrast between the "mechanics" of the Intensive Pollution Survey assessment and reach-based assessment that would be characteristic of the Probabilistic C and D designs. The latter would base the status assessment on a reach average as is depicted in Table 11 under the X_GRFIn column[4]. The proportion of attaining sites is then translated to a reach narrative which is the basis for a reach level assessment. The reach level assessment produces an average condition of the population of sites in keeping with the underpinnings of probabilistic designs. In contrast to the site level assessment, more seriously impaired sites would be overlooked by the reach

[4] This example uses data from UMR reach 1 and adds reach 0 to increase the n for a reach level analysis; reach 0 is the non-interstate mainstem in Minnesota below St. Anthony Falls.

level averaging approach of the probabilistic designs. In addition, higher quality sites would likewise be missed resulting in a loss of valuable information about this level of resource quality and the potential opportunities for additional protections.

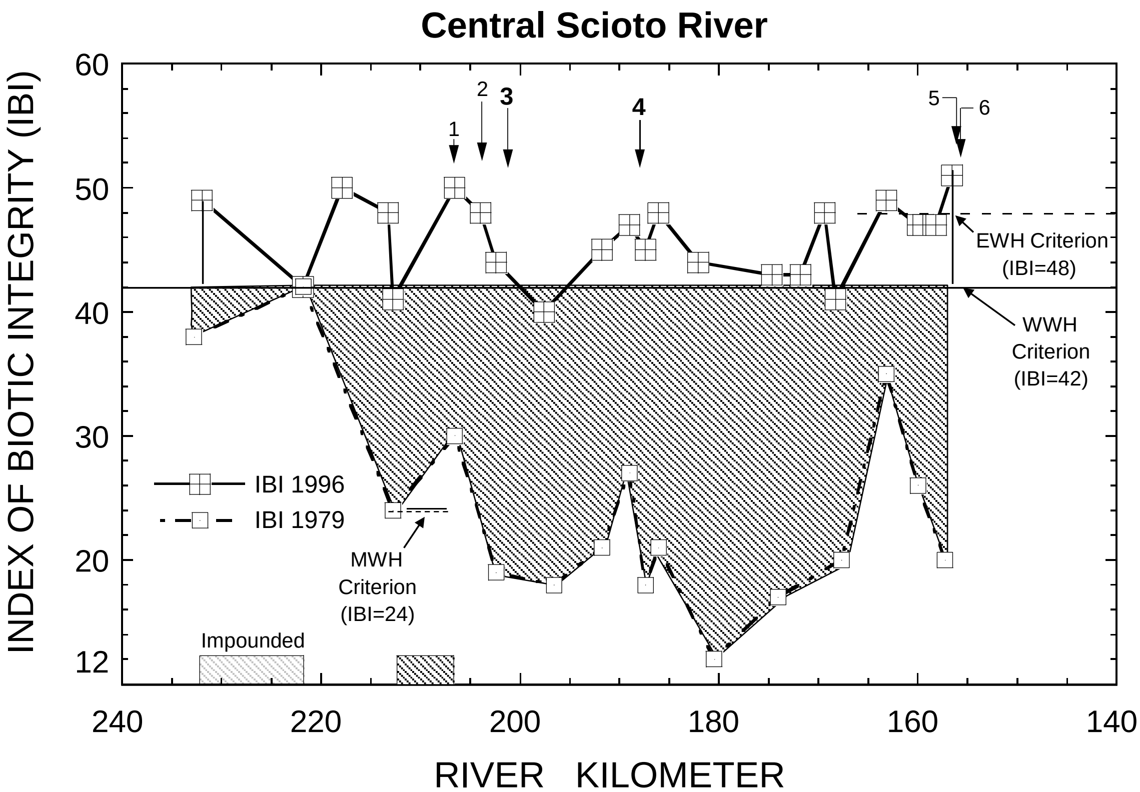


Figure 13. Emulation of an analysis that demonstrates severity and extent of impacts from multiple sources based on IBI results from two years of electrofishing at multiple locations in a 64 km long segment of the Scioto River between Columbus and Circleville, Ohio. The biological criteria for the Warmwater Habitat (WWH) and Exceptional Warmwater Habitat (EWH) use designations and major pollution sources are shown (1 = Whittier Street Combined Sewer Overflow; 2 = Techneglass; 3 – Jackson Pike Wastewater Treatment Plant; 4 = Columbus Southerly Wastewater Treatment Plant; 5 = Jefferson Smurfitt Corp.; 6 = Circleville Wastewater Treatment Plant). The shaded area below the WWH biocriterion yields the negative area of degradation value (ADV) and the unshaded area above the WWH biocriterion yields the positive area of degradation value (ADV). After Yoder et al. 2005.

Summary

Table 12 summarizes how each of the main channel design options address the systemwide to CWA reach assessment needs for 305[b]/303[d] and how (and if) each addresses reach to local scale issues for supporting CWA management programs. As spatial detail increases from systemwide, to longitudinal reach, to CWA assessment reach, to site-specific designs the resolution of both CWA assessment and CWA program support improves in terms of detail and relevance. All of the design options can support 305[b] and 303[d] to varying levels of resolution as has been described. However, the goal of providing CWA management program support is not evident until the reach scale assessment designs and then only indirectly. Direct CWA management program support that is specific to sources of impact and stress are possible only at the site-specific scale.

Table 12. Assessment related characteristics of UMR monitoring design options. Each successive design assumes the scale(s) of assessment and cause/source delineation characteristics of the preceding designs.

Design Option	Scale(s) of Assessment	Status Assessment			Reach & Local Scale Assessment					
		% or Miles Attaining	% or Miles Narrative Condition[1]	Severity and Extent[2]	L or R Bank[3]	Side Channels	Point Sources[4]	Water Intakes	Dam Influence[5]	Cause/Source Delineation[6]
Probabilistic A	Systemwide	YES	YES	NO	NO	NO	NO	NO	NO	Systemwide
Probabilistic B	Major longitudinal reaches	YES	YES	NO	NO	NO	NO	NO	NO	Major longitudinal reaches
Probabilistic C	State-level assessment; 13 CWA Reaches (partial)	YES	YES	Reach Level (partial)	NO	NO	NO	NO	NO	Statewide; CWA Reaches
Probabilistic D1	13 CWA Reaches (n =30)	YES	YES	Reach Level (reduced)	NO	NO	NO	NO	NO	CWA Reaches
Probabilistic D2	13 CWA Reaches ("minimum" n)	YES	YES	Reach Level (complete)	NO	NO	NO	NO	NO	CWA Reaches
Nonrandom Longitudinal Survey - Baseline	13 CWA Reaches (non-random, low n for some)	YES	YES	Reach level (partial)	NO	NO	NO	NO	NO	CWA Reaches
Nonrandom Longitudinal Survey – with Follow-up	Site-specific in selected reaches	YES	YES	Local scale (partial)	YES	NO	YES (partial)	NO	NO	Local Scale
Intensive Pollution Survey	Site-specific in all reaches	YES	YES	Local Scale (complete)	YES	YES	YES (complete)	YES	YES	Local scale

[1] – Narrative condition expressed as excellent, good, fair, poor, and very poor; [2] – expression of magnitude and length of departure from use arbiter; [3] – left (L) and right (R) banks are distinguished; [4] – design directly assesses point source discharges to include near and far-field effects; [5] – upstream impoundment, downstream tailwaters, and flow diversion effects are assessed; [6] – the spatial scale at which cause/source is accomplished, each successive design includes the scale of all the preceding designs.

Chapter 8: Data Management

General Considerations

A reliable, well designed, and quality assured relational data management system is fundamental to any monitoring and assessment program and in assuring that data and assessments are effectively used to support management decision-making. A relational database offers major advantages in terms of efficiency of multi-user access and editing, quality control, integration with spatial data, and web-based access to data provided that queries are also equally developed. This mode of data and information management should assure a systematic approach for aggregating data and performing the necessary quality control checks.

Monitoring programs collect data over years and decades in contrast to research projects that are typically designed to address research questions where the necessary data can be collected in one to a few years. The value of long-term datasets to all users depends upon well-documented and properly implemented quality assurance protocols that ensure data integrity, and a relational data management system that allows efficient and transparent statistical and graphical analysis of the data. A strong geographic information system (GIS) linked to a well-designed relational database moves a program toward a more comprehensive systemwide perspective in interpreting monitoring data and improves the ability of biological, chemical, and physical data to meet the increasing information demands of State and EPA programs, as well as interested stakeholders and the public. U.S. EPA has articulated the following goal for state data management which encapsulates the considerations listed above; *"The State uses an accessible electronic data system for water quality, fish tissue, toxicity, sediment chemistry, habitat, and biological data (following appropriate metadata and State/Federal geo-locational standards) with timely data entry and public access."* (U.S. EPA 2003)

Data Management Goals and Functions for UMR CWA Strategy

Data management goals for the UMR CWA monitoring strategy should be to:

- utilize a fully developed electronic relational database for entry, storage, and retrieval;
- include metadata and strong data validation and verification functions;
- ensure clean data through rigorous QA/QC;
- ensure that ancillary data are readily accessible for aggregation and for supporting integrated analyses.

The UMR data management system will also need to support all of the surface water quality monitoring functions performed by the UMR states, and as such should be compatible with the state data management systems. The system will also need to be compatible with the U.S. EPA database structure ensuring that the data is stored in a consistent format that can be shared internally and externally.

The major functions for the UMR data management system are:

- **Data Entry/Verification/Review/Approval** - includes the process of organizing data for entry into the various databases, verifying the data, and a process for management review and oversight.
- **Site Recognition and Reconciliation** - a consistent convention for designating individual sampling sites that assures the consistent pairing of chemical, physical, and biological data will need to be developed and followed.
- **Assessment Indices Analysis and Calculation** - the data system should include routines for calculating indices and expressions of the chemical, physical, and biological data that are needed to perform essential assessment functions for assessing the applicable UMR spatial strata and the designated uses.
- **Reporting and Listing** - the data system should support reporting for 305[b] and 303[d] and conform to U.S. EPA's Assessment Database format.

Note that field data is usually recorded by field crews on paper field sheets and is entered into the electronic database after a field season is completed. However, it can also be recorded electronically in the field, but these systems and the attending hardware and software are still being perfected. Laboratory data is now typically transferred electronically from the analytical instruments to an electronic storage system (e.g., LIMS).

UMR-Specific Data Considerations and Challenges
The UMR's interjurisdictional setting and large geographic scope pose a number of challenges that must be considered in determining how data resulting from implementation of the UMR CWA monitoring strategy will be managed. Two of these include:

- **Centralized data repository in a multi-institutional environment** – The goals and functions of UMR CWA data management are likely the most simply and "cleanly" addressed by creating a single, stand-alone database and management process. However, if this is done it must be executed in a way that does not conflict with or duplicate existing data management systems. Communication with UMR water quality (and other) agencies must ensure that the role of this database is made clear and that access to the data is made available to interested agencies and stakeholders.

- **Institutional home for UMR CWA database** – Currently, there is no enduring UMR CWA database nor is there a defined institutional home and infrastructure to support such a database. Options for an institutional home may include one of the UMR state CWA agencies, a federal agency (U.S. EPA or USGS), UMRBA, or a third party. The institutional home will need to not only house the data, but also be responsible for data quality, accessibility, and maintaining external interfaces. The WQTF will need to consider these and other institutional options, keeping in mind limited resources and the possibilities for best leveraging existing institutions and data systems.

Chapter 9: Quality Assurance/Quality Control

In a CWA monitoring context, quality assurance/quality control programs examine sampling techniques, data analysis techniques, and data management and reduction to assure that results of monitoring are accurate, relevant, and generated in a consistent manner. The specific details of a QA/QC program for the UMR will ultimately be determined by the level of the monitoring and assessment design that is adopted and how it is implemented. The following discussion includes the general structure of a QA/QC program based on broad principles that are followed in developing QA/QC programs and approaches (U.S. EPA 1998). In general, U.S. EPA has stated that *"Quality Management Plans and Quality Assurance Project Plans are developed, maintained, and peer reviewed in accordance with EPA policy to ensure the scientific validity of monitoring and laboratory activities." (U.S. EPA 1998)*

Most state CWA monitoring, and presumably future UMR CWA monitoring, is funded at least in part with federal funds. Any federally funded project involving the collection and submittal of environmental data requires a project Quality Assurance Project Plan (QAPP) that is submitted to U.S. EPA for review and approval. It very likely that a future UMR CWA monitoring program will need to develop a QAPP that is in line with U.S. EPA requirements.

A project QAPP should include the following:

- a title page with the project title, project manager(s), institution(s), and date(s) including all subsequent revisions;
- a formal sign-off page indicating signed approval of the QAPP by the project manager(s), representatives of all entities, and the attending QA officers (state and/or EPA);
- a header that includes the QAPP version number and date;
- a description of the project organization including the identification of all applicable personnel and entities and their relationship (includes an organizational chart);
- a concise description of project goals and objectives;
- an introduction (i.e., a general description of the project and relevant background information);
- the identification of methods used in the project, either by reference (U.S. EPA methods and/or methods identified in project relevant methods manuals) or specifically described if not included in the identified methods manuals;
- the identification of numerical data quality objectives (DQOs);
- the identification of project staffing and the responsibilities and professional/technical requirements/certifications of each;
- a clear description of the chain-of-custody for each type of data and sample;

- a tentative schedule that identifies key project target dates and a project completion date;
- all forms used in the project including field sheets, data sheets, laboratory forms, and chain-of custody forms; and,
- detailed references to methods for any data collection or analytical processes used in the project.
- DQOs for physical, chemical, and biological data; and,
- a list of all parameters and their DQOs to be included in the QAPP appendices.

Initially, any monitoring project or program is required to submit a QAPP to U.S. EPA for review and approval prior to initiating data collection. However, it is also possible to request delegation for project specific QAPP review and approval. This means that a Quality Assurance (QA) program would need to be developed and implemented by the coordinating entity or agency. Most commonly this consists of a Data Quality Manager (DQM) who provides the oversight and coordination of all QA related needs and activities. The DQM reviews QAPPs submitted by a Project Manager who is responsible for the technical design of a project, for ensuring professional execution of a project plan, for all data quality aspects, coordinating with the field and laboratory activities, and for responding to the review of the DQM. Technical personnel are those who actually carry out the sampling and analytical activities and they are responsible for following the methods and QA/QC processes such that quality data is assured.

Training and Certifications

Expectations for the level of training and certifications should also be part of the UMR strategy. The overall program should reflect a high level of rigor for each aspect of planning, sampling, data management, data analysis, assessment, and reporting. The program should be overseen and executed by sufficiently qualified personnel with certifications for specific managerial and technical skills as each is available (e.g., Society for Freshwater Science (SFS) certification for macroinvertebrate taxonomists). In addition, the biological assessment should conform to Level 4 as defined by the U.S. EPA Critical Technical Elements of a Bioassessment Program (U.S. EPA 2013).

UMR-Specific QA/QC Considerations and Challenges

As was described for data management in Chapter 8, QA/QC is particularly challenging in the UMR's multi-jurisdictional environment for reasons including:

- **Centralized or non-centralized process:** A typical QA/QC process is performed as a specific assignment by staff within a water quality agency. In the case of the UMR, it is not yet clear who would have the responsibility for QA/QC. This could rest with the sampling entity or entities (having multiple sampling entities conduct the M&A is plausible) or centralized to a single entity. However, if centralized, there would need to be a process for coordinating with the UMR states.

- **Varying data quality standards:** While data standards and data quality objectives may vary by state, the need to produce a unified dataset for the UMR will need to be addressed by a QAPP process.

- **Multiple samplers, laboratories:** A non-centralized implementation of the strategy will necessitate adherence to the QAPP by multiple sampling and analytical entities. This is accomplished by involving each entity in the required QAPP signoff and as specified by the QAPP table of organization.

Chapter 10: Developmental Needs

Recent UMRBA projects, specifically the *Biological Assessment Guidance* (Yoder et al. 2011) and the *Aquatic Life Designated Uses (ALDU) Report* (UMRBA 2012), identified gaps in the readiness of the various indicators described in Chapter 6. These are summarized in the following discussion and need to be addressed as UMR CWA monitoring implementation is pursued and expanded. Importantly, the WQTF does not feel that these developmental needs preclude moving forward with UMR CWA monitoring at this time. Rather, these are areas which can be addressed as implementation proceeds and then the associated monitoring will be brought "on line" over time.

Indicators for Specific UMR Lateral Strata

The lateral strata defined by the ALDU report (UMRBA 2012) include the main channel, side channels, off main channel impounded areas, and contiguous backwaters. The need for indicator development primarily involves the establishment of biological indicators in more lentic, off main channel strata (i.e., impounded areas and contiguous backwaters).

Fish, macroinvertebrates, and submersed aquatic vegetation (SAV) are listed as core indicators for the impounded and contiguous backwater lateral strata in Table 5, but are also encased in brackets indicating that a full bioassessment methodology is not yet available. A full methodology includes all aspects of using an indicator including a systematic sampling methodology and an accompanying assessment index. The need is greatest for the contiguous backwater as all three of the core biological indicators are in need of further development in this strata. SAV is available for the impounded strata, but a second assemblage is not yet available and could include fish and/or macroinvertebrates. Fish are sampled in impounded and contiguous backwater strata by the LTRMP, but the same issues that were identified in the *Biological Assessment Guidance* (Yoder et al. 2011) with using these protocols in the main channel may well exist in these strata. This included the applicability of the current LTRM protocols due to differences in site selection and the sampling protocol for fish and SAV. How these protocols could be adapted to provide the data needed for a CWA assessment is currently being discussed and this will need to be a part of the developmental process.

Sampling equipment is likely the least of the developmental issues as analogous methods exist in other large river systems, but the development of indices represents a more significant technical task and may take several years to accomplish. However, the data collection necessary to support fuller development would be a logical part of the Strategy. Partial analyses of the data are also possible as an interim measure while the fuller development is in progress. Hence in the development of the indicators for the lateral strata as part of the monitoring design, these data considerations should be described and included as part of the Strategy.

Main/Side Channel Macroinvertebrate Methodology

Recently, discussions have taken place within the WQTF regarding the efficacy of the U.S. EPA-GRE multihabitat macroinvertebrate methodology that was used in the *Biological Assessment Guidance* (Yoder et al. 2011). This emanates from the perception that the methodology and its attendant index, the Great River Macroinvertebrate Index (GRMIn; Angradi et al. 2009b), did not work well. However, the *Biological Assessment Guidance* (Yoder et al. 2011) provided an alternate "ad hoc" index that functioned better than GRMIn in terms of providing a sufficient response range to assess the various stressors analyzed therein. This points out that a methodology can be sufficient in producing raw data, but the attendant index may need improvement.

What is being discussed in the WQTF (and other UMR venues) is the potential use on the UMR of an artificial substrate methodology developed for application to Wisconsin large rivers (Weigel and Dimick 2011). A portion of their calibration and development study included selected sites on the UMR bordering Wisconsin. In addition, ORSANCO is in the process of developing an artificial substrate method and they have compared it to a multihabitat method similar to that used by the GRE sampling in the UMR in 2004-6. The considerations for the Strategy ultimately include a recalibration of the existing macroinvertebrate assessment provided by the *Biological Assessment Guidance* (Yoder et al. 2011) and the costs of implementing a new methodology. It is quite possible that both methods will be needed as the original artificial substrate methodology on which Weigel and Dimick (2011) relied includes a sample from the natural substrates at the time of artificial substrate retrieval. Minnesota and Wisconsin are currently exploring the possibilities for a UMR study which compares EMAP-GRE and artificial substrate methods (and indices) on the UMR. The study may take place in 2013 and involve other UMR states. If completed, it will provide important information to the WQTF in how macroinvertebrate monitoring is executed under the UMR CWA monitoring strategy.

Periphyton

Periphyton could function as a supplemental indicator (see Table 5) and is widely employed by state and federal monitoring programs throughout the United States. It was collected under the EMAP-GRE program and is currently being sampled by the National Rivers and Streams Assessment (NRSA). Further developing periphyton as a baseline assemblage indicator has merit and should be included in the list of UMR developmental needs.

Chapter 11: Implementation Options and Costs

The implementation of any of the spatial design options described in this Strategy involves the consideration of the logistics of planning and executing the field sampling and data collection, data management and analysis, and the synthesis and reporting aspects of each. While there are a number of different ways to actually accomplish these tasks, in order to develop comparative costs for each option certain assumptions about logistics were necessarily made. ***The one key assumption made in developing the comparative estimates in this chapter is that a single entity is responsible for planning, sampling, data management/analysis, and assessment and reporting.*** While this may not be the institutional arrangement by which UMR CWA monitoring is eventually implemented, it is done here to allow for comparisons across monitoring options while holding institutional considerations constant. Presumably, the relative scale of costs among options will hold true regardless of the particular institutional method of implementation. Additionally, these estimates focus on the execution of key tasks of the major main/side channel design options (i.e., impounded and contiguous backwater monitoring is not addressed). For some of the "simpler" design options (e.g., Probabilistic A) a "one-off" approach was assumed, but for others that require multiple years to execute (e.g., Probabilistic B, C, D, Nonrandom Longitudinal Survey, Intensive Pollution Survey) a more sustained effort over multiple years was assumed. Furthermore, this discussion does not consider the logistics for implementing the Fixed Station and Tributary Loading networks as these involve the comparatively straightforward collection of chemical samples at fixed locations. For these fixed stations, any modifications resulting from this strategy would presumably incur comparatively minor changes in cost.

Overall Scope and Organization

The execution of the Strategy is approached herein as the integration of planning, data collection, data management, data analysis, synthesis, and reporting with the latter including the assessment of the results for CWA program support purposes. A template for an annual systemwide monitoring and assessment process is depicted in Table 13. It spans the initial identification of UMR reaches and segments for assessment through detailed study planning, field sampling, data management, data analysis, and completing an assessment with each described in their respective sequence. This is most applicable to the multi-year options and it works to encourage a sustained program that addresses all of the strategy goals on a continuing basis.

Sampling Logistics

For the purposes of conducting the cost comparisons, it was assumed that sampling will be conducted by dedicated field crews in accordance with the indicators included in each design option. Dedicated refers herein to a particular discipline such as biological or chemical sampling. Further, it distinguishes between assemblage groupings for the biological indicators and with respect to crew size and equipment needs. Hence, the division of sampling effort consists of a fish and habitat assemblage crew, a chemical/physical crew, and a combined macroinvertebrate and SAV sampling crew. The respective crew leaders in turn form the

Table 13. Important timelines and milestones in the planning and execution of a systemwide monitoring and assessment process on an annual basis in support of CWA programs on the UMR. This sequence represents the total effort to support one year of data collection – activities to support multiple years of data collection coincide.

Timeline (Months)	Milestone
December – February (1-3):	Initial screening of the major UMR reaches takes place by soliciting input from the various program offices and other stakeholders.
February – March (3-4):	Final prioritization of issues and definition of specific study reaches. Resource allocation takes place and study team assignments are made.
March – May (4-5):	Detailed study planning takes place and consists of detailed map reconnaissance, review of historical monitoring efforts, and sampling site confirmation by the study team. Final study plans are reviewed and approved.
May – June (5-6):	Final study plans are used to develop final logistics for each field crew. Preparations are made for full-scale field sampling.
June – October (6-10):	Field sampling takes place with field crews operating somewhat independently on a day-to-day basis, but coordinated by the study plan and the team leader. Study team communication takes place as necessary, especially to resolve unexpected situations.
October – February (10-14):	Laboratory sample analysis takes place for chemical and biological indicators. Raw data is entered into databases for reduction and analysis. The study team meets to review the information base generated by the field sampling and to coordinate the data analysis and reporting efforts.
November – May (11-17):	Information about chemical, physical, and biological indicators is retrieved, compiled, and used to produce analyses that will support the evaluation of status and trends and causal associations within the study area. Integration of the information (i.e., the assessment) is initiated.
May – December (17-24):	The assessment process is completed by producing working drafts of the assessment for review by the study team and a final edit for an internal peer review. A final assessment is approved by management oversight and for use by all stakeholders. It is used to support 305[b]/303[d], NPDES permitting, water quality standards (*e.g.,* use designation revisions), and other programs where surface water quality is a relevant concern.

nucleus of the study team that is referenced in Table 13 with the additional participation and oversight by a project manager. Presumably this team and its manager will report in some fashion to the states and EPA (via UMRBA and the WQTF) throughout the process.

The implementation of the different options assumes one set of crews and a single study team such that approximately ≈100 sites can be sampled and assessed in a single year. This would maximize each crew thus occupying their respective efforts for the entire year. For the multi-year design options, work would be occurring on any one of 3 different years depending on the time of year and the sequencing of tasks within a particular option. The only option that requires a partial effort is Probabilistic A and that could be completed in about one year. All of the other options require multi-year commitments with the most complex designs essentially equating to a five-year rotational program. This approach also offers the opportunity to make the monitoring and assessment information more useful to CWA management programs.
It would theoretically be possible to accomplish any of the options more quickly by simply increasing the number of field crews and study teams, but this would not come without an effect on a more sustained flow of assessment information to the CWA management programs.

<u>Fish Assemblage & Habitat</u>: This crew consists of a trained crew leader assisted by two field technicians. The crew leader must be proficient in the field identification of UMR fish, the identification and enumeration of external anomalies, and the organizational skills required to attain data quality and chain-of-custody requirements. The field technicians should also be proficient in the general identification of fish species and with fish handling and enumeration practices. The fish crew will also be responsible for assessing habitat within the fish sampling site using a qualitative approach and with the collection of fish tissue samples where these are allocated. Equipment consists of an electrofishing boat rigged to safely and effectively collect fish assemblage and fish tissue samples. A 4WD vehicle is assumed for commuting to and between access points and performing off-road when necessary. The annual level of effort is assumed to be 1 FTE for a crew leader and 0.5 FTE each for two or three technicians.

<u>Macroinvertebrate & SAV Assemblages</u>: This crew consists of two trained crew leaders assisted by one field technician. One crew leader must be proficient in the field collection of UMR macroinvertebrates, the identification and enumeration of UMR macroinvertebrate taxa, and the organizational skills required to attain data quality and chain-of-custody requirements. The other crew leader must be proficient in the field identification of UMR submersed aquatic vegetation and the organizational skills required to attain data quality and chain-of-custody requirements. The field technician should also be proficient in the general conduct of aquatic field and biological sampling techniques. The macroinvertebrate/SAV crew will also be responsible for assessing the physical attributes within the macroinvertebrate and SAV sampling sites using a qualitative approach. Equipment consists of a boat rigged to safely and efficiently navigate the UMR main channel and which is trailered between access points. A 4WD vehicle is assumed for commuting to and between access points and performing off-road when necessary. The annual level of effort is assumed to be 1 FTE for each of the two crew leaders and 0.5 FTE for each technician.

Chemical-Physical Water Quality Crew: This crew consists of a trained crew leader assisted by two field technicians. The crew leader must be proficient in the collection of water samples, operation of water quality instrumentation, and the organizational skills required to attain data quality and chain-of-custody requirements. The field technicians should also be proficient in the general conduct of water quality sampling techniques. The collection of water samples is done by this crew at each site. In the designs that employ multiple chemical/physical samples at each site this crew will function in that capacity as well. Equipment consists of a boat rigged to safely and efficiently navigate the UMR and which is trailered between access points. A 4WD vehicle is assumed for commuting to and between access points and performing off-road when necessary. The annual level of effort is assumed to be 1 FTE for the crew leader and 0.5 FTE each for each of the two technicians.

Data Analysis and Synthesis

Tasks associated with the processing, storage, retrieval, and analysis of data are included in months 10-24 on the sequence in Table 13. Data is handled and processed in accordance with the project QAPP (Chapter 8) and managed via an electronic database that supports the entry, proofing, retrieval, and analysis of the chemical, physical, and biological data. The development of databases to support these tasks may be an ancillary task that needs to be supported outside the scope of the assessment and will need to be part of the consideration of project costs. The scope of this task may vary by design option presumably requiring less time and effort for the simpler design options.

Laboratory tasks are involved with the analysis of water, sediment, and fish tissue samples, the processing of macroinvertebrate samples, processing of aquatic vegetation samples, and verification of fish vouchers. This step is followed by an organization of the resulting data for entry into an electronic database. Conventions about the identification of sites by a unified site code will need to be established in addition to the formats to be followed for taxonomic identifications and nomenclature. It is assumed that chemical laboratory analyses will be transmitted via a LIMS (Laboratory Information Management System).

Once the data is entered and proofed, analysis of the data takes place. This will be done by each crew leader for their respective discipline (e.g., fish, habitat, macroinvertebrates, water quality, etc.) applying the available tools for each in the UMR. For the biological indicators this will follow the recommendations of the *Biological Assessment Guidance* (Yoder et al. 2011). Assessing the data will be affected most by the sampling design, but each will produce an assessment of baseline condition for each of the four designated uses and with the longitudinal and lateral strata that were sampled. Each of the design options has this task in common, but the manner in which each is reported is inherently affected by the properties of each design. For example, the probabilistic options will report the average condition (± a standard deviation) of each indicator for each designated use over the longitudinal strata that are included in each of those four options. General causal associations for the biological condition assessment are plausible only for the more detailed Probabilistic Options C and D. Intensive Pollution Survey results will be reported as the relative condition by increments of river length and also in assessment units that convey the extent and severity of departures from the biological thresholds. More detailed causal analysis is made possible by the more detailed spatial context across all possible stressors. For the non-aquatic life uses the results will likewise be reported in a lineal context.

The final product of the process is a comprehensive report that details the methods and analyses and the conclusions based on the assessment of the indicators for each of the four designated uses. This meets the goal of supporting the 305[b] assessment with the causal analyses further supporting the 303[d] goal, with that specificity inherently related to the detail of the spatial design. Furthermore, specific recommendations about how CWA management programs can address relevant impairments can be included and this is enhanced with stakeholder participation in assessing those results.

The logistics of the post-sampling activities are critically influenced by the spatial design. The Probabilistic A and B options are amenable to a “one-off” approach where the sampling and analysis are completed in one or two years. The principal product is the assessment of condition for the four designated uses and in a format that allows the states to report them to U.S. EPA in fulfillment of 305[b] reporting and 303[d] listing. Utilizing the results for other CWA functions would be unlikely due to the lack of related analyses and then would be at the discretion of the states and their programs. The Probabilistic C and D design options entail multiple years of effort thus they will necessitate a comparatively sustained effort that inherently results in a longer term engagement of the UMR monitoring and assessment with the state CWA programs. However, the focus of these probabilistic designs remains primarily on reach-scale condition assessments thus fulfilling the 305[b] and to some extent the 303[d] obligations of the states. General causal diagnosis is possible with these designs, but is unlikely to be specific to individual sources. The Intensive Pollution Survey design is likewise a multiple year effort that can fulfill the 305[b] and 303[d] obligations and additionally supports more detailed an place-relevant diagnoses of impairments, which has the potential to support specific CWA programs. Furthermore, the generation of a systemwide database will ultimately lead to the better development of stress-response relationships that can affect CWA programs such as WQS and permitting. The more complex monitoring designs thus distinguish themselves as contributing beyond status reporting to informed support of all CWA programs.

Relative Costs of Options

The assessment of comparative costs was done for main channel chemical/physical and biological sampling by considering the resources that would be needed to fully execute each design option. This involved making some informed assumptions about the expected production of samples collected and processed and the content for each design option. These assumptions, which are summarized in Table 14, are based on our familiarity with projects of similar scope and size. The baseline data in Table 14 was then used to develop the estimates of

Table 14. Critical assumptions about the logistics of conducting chemical, physical, and biological sampling in the main/side channel strata of the UMR in support of cost and resource estimates for each monitoring design option. A summer-early fall index period is assumed.

Logistical Aspect	**Chemical WQ Crew**	**Macroinvertebrate/ SAV Crew**	**Fish & Habitat Crew**	**Project Management**
Crew composition	Crew leader (*Chem./Phys. Specialist*) & 2 field technicians	Crew leaders (Benthic biologist/ taxonomist & aquatic botanist) & 1 field technician	Crew leader (Fish biologist/ taxonomist) & 2 field technicians	Project Manager & Database Manager
FTEs (annual)[1]	1.0 full time 1.0 part-time	2.0 full time 0.6 part-time	1.0 full time 1.0 part-time	1.0 full time
Sites/samples per day[2]	4-8 WQ sites + sediment 1X	2-4 macro-invertebrate & SAV sites	2-4 fish/habitat sites + fish tissue	NA
Vehicle	1 – 4WD	1 – 4WD	1 – 4WD	NA
Boat	18’ boat	18’ boat	18-20’ electro-fishing boat	NA
Other Equipment	WQ Meter	WQ Meter	Electrofishing unit; WQ meter	NA
Field Days[3]	90	75	75	NA
Average Sites/Samples[4]	540 samples	225 samples	225 sites	NA
Lab Effort[5]	Minimal	12 hrs./sample (inverts.) 4 hrs./sample (SAV)	Three weeks (vouchers)	NA
Data Management	Crew leader & 1 technician	Crew leaders	Crew leader	Database Manager
Data Analysis	Crew leader	Crew leaders	Crew leader	Database Manager or Project Manager
Synthesis & Reporting	Crew leader	Crew leaders	Crew leader	Database Manager

[1] 1.0 FTE is 2080 full time hours (overtime included in field technician estimates);
[2] range based on design option being executed and distance between sites;
[3] available productive field days within a mid-June to mid-October seasonal index period (18 weeks = 90 week days); includes contingencies for weather & equipment down time;
[4] based on sites/day times available field days;
[5] lab effort includes processing of macroinvertebrate and SAV samples and fish vouchers; does not include chemical laboratory analyses.

effort and resource commitments required for each main channel design option which appears in Table 15. In Table 15, additional assumptions were made including how any of the designs are stratified in terms of the number of years required to complete a single assessment cycle. With the exception of the Probabilistic A option, all of the options require multiple years to cover the entirety of the interstate UMR main channel. It was assumed that a maximum of approximately 100 sites could be sampled in a single year hence this is the common denominator for determining the number of years required for a complete assessment of the UMR.

These assumptions were then used to develop detailed cost estimates for each design option. Itemized costs appear in Appendix Table D-1 and these are summarized in Table 16. It was also assumed that the effort required to execute each design option is affected by sampling site density with daily productivity increasing as sites are more closely spaced. As a result the resources required for each design option are influenced by factors other than the total number of sites and the numbers and types of samples required for each. The unit cost (cost/site or sample produced) for field sampling is affected by the productivity of a crew becoming greater as the number of sites and samples produced per day increases. By comparison, laboratory analyses are assumed to be more of a fixed cost.

It should also be noted that samples for all of the designated uses are simultaneously collected at the same time and by a single crew as much as is possible. For example, the chemical/physical crew collects water and sediment samples for chemical and bacteriological analysis which addresses the aquatic life, recreation, and water supply uses. The fish crew simultaneously collects habitat and fish tissue samples along with the fish assemblage indicator which addresses aquatic life and fish consumption. However, this is all accomplished within the confines of the seasonal index period. Sampling outside that period would incur additional costs that are not accounted for here. The water supply use is a case in point where samples are needed outside of the summer-fall index period since this use requires year-round sampling. Extending the chemical/physical crew to year-round status will require additional effort at the field, laboratory, data management, and reporting levels. A potential solution is to have the water utilities assist by collecting samples at their respective water intakes, which would presumably be a more cost-effective approach to this aspect of the strategy. Even though the other three uses also apply year-round, either the representativeness of the indicator (e.g., aquatic life and fish tissue) extends their results through the year or the practicalities of the use actually occurring (e.g., recreation) preclude the need for year round sampling.

Cautions about the Cost Estimates

The costs depicted herein are generalized and they assume a centralized implementation. Other ways of implementing the sampling and analysis are plausible and each could affect the costs of managing and implementing a strategy. Depending on how a decision is made to implement any one of the options, the costs could vary in accordance with the personnel and overhead costs of individual organizations and more importantly, by differences in sampling

Table 15. Key logistical aspects and first order resource needs estimated for each of the main channel UMR design options.

Logistical Aspect	Probabilistic A	Probabilistic B	Probabilistic C	Probabilistic D2	Nonrandom Longitudinal Survey (baseline)	Nonrandom Longitudinal Survey (with follow-up)	Prob. D1/Intensive Survey
Total Sites	50	120 (+ 10 index)	180 (+ 15 index)	200 (+ 15 index)	200 (+ 30 index)	160 (+ 0 index)	410 (+ 30 index)
Frequency[1]	Chem. WQ: 1X Sed. Chem.: 1X Fish Tissue: 1X Macroinvert: 1X SAV: 1X Fish&Hab: 1X	Chem. WQ: 3X Sed. Chem.: 1X Fish Tissue: 1X Macroinvert: 1X SAV: 1X Fish&Hab: 1X	Chem. WQ: 3X Sed. Chem.: 1X Fish Tissue: 1X Macroinvert: 1X SAV: 1X Fish&Hab: 1X	Chem. WQ: 3X Sed. Chem.: 1X Fish Tissue: 1X Macroinvert: 1X SAV: 1X Fish&Hab: 1X	Chem. WQ: 4X Sed. Chem.: 1X Fish Tissue: 1X Macroinvert: 1X SAV: 1X Fish&Hab: 1X	Chem. WQ: 4-8X Sed. Chem.: 1X Fish Tissue: 1X Macroinvert: 1X SAV: 1X Fish&Hab: 1X	Chem. WQ: 4-8X Sed. Chem.: 1X Fish Tissue: 1X Macroinvert: 1X SAV: 1X Fish&Hab: 1X
Total Samples[2]	50 initial + 5 resample = 55 total Chem. WQ: 55 Macroinv: 55 SAV: 55 Fish&Hab: 55	120 initial + 12 resample = 132 total Chem. WQ: 396 (3x) Macroinv: 132 SAV: 132 Fish&Hab: 132	180 initial + 18 resample = 198 total Chem. WQ: 594 (3x) Macroinv: 198 SAV: 198 Fish&Hab: 198	200 initial + 20 resample = 220 total Chem. WQ: 660 (3x) Macroinv: 220 SAV: 220 Fish&Hab: 220	200 initial + 0 resample = 200 total Chem. WQ: 800 (4x) Macroinv: 200 SAV: 200 Fish&Hab: 200	169 initial + 0 resample = 160 total Chem. WQ: 640 (4x) Macroinvert: 160 SAV: 160 Fish&Hab: 160	410 initial + 0 resample = 410 total Chem. WQ: 1640 (4x) Macroinvert: 410 SAV: 410 Fish&Hab: 410
Sampling Cycle	One year	Two Years	Two years	Two years	Two years (yrs. 1&2 baseline)	2 yrs. (yrs. 3&4 post-baseline)	Four Years
Samples/Yr.	Chem. WQ: 55 All Others: 55	Chem. WQ: 198 All Others: 66	Chem. WQ: 297 All Others: 99	Chem. WQ: 330 All Others: 110	Chem. WQ: 400 All Others: 100	Chem. WQ: 320 Macroinvert: 80 SAV: 80 Fish&Hab: 80	Chem. WQ: 410 Macroinvert: 103 SAV: 103 Fish&Hab: 103
Samples/day/year[3]	3 WQ sites; 2 macro. & SAV sites; 2 fish sites	3 WQ sites; 2-3 macro. & SAV sites; 2-3 fish sites	4 WQ sites; 2-3 macro. & SAV sites; 3 fish sites	5 WQ sites; 2-3 macro. & SAV sites; 3 fish sites	5 WQ sites; 2-3 macro. & SAV sites; 3 fish sites	6 WQ sites; 4 macro. & SAV sites; 4 fish sites	8 WQ sites; 4 macro. & SAV sites; 4 fish sites

Table 15. continued.

Logistical Aspect	Probabilistic A	Probabilistic B	Probabilistic C	Probabilistic D2	Nonrandom Longitudinal Survey (baseline)	Nonrandom Longitudinal Survey (follow up)	Prob. D1/Intensive Survey
Total Field Days	Chem. WQ: 19 Macroinvert. & SAV: 28 Fish: 28	Chem. WQ: 60 Macroinvert. & SAV: 24 Fish: 24	Chem. WQ: 75 Macroinvert. & SAV: 40 Fish: 34	Chem. WQ: 65 Macroinvert. & SAV: 47 Fish: 39	Chem. WQ: 92 Macroinvert. & SAV: 51 Fish: 42	Chem. WQ: 80 Macroinvert. & SAV: 22 Fish: 40	Chem. WQ: 77 Macroinvert. & SAV: 30 Fish: 50
Total Lab Days/Yr.[4]	Macroinvert: 83 SAV: 28 Fish: 5	Macroinvert: 90 SAV: 30 Fish: 7	Macroinv: 150 SAV: 50 Fish: 10	Macroinv: 176 SAV: 59 Fish: 12	Macroinv: 189 SAV: 63 Fish: 15	Macroinv: 132 SAV: 44 Fish: 7	Macroinvert: 182 SAV: 61 Fish: 15
Total Annual Field & Lab Crew Days	181	235	359	398	449	325	415
% of Effort[5]	40%	52%	80%	89%	100%	72%	92%
FTEs (annual)[6]	2.0 full time 1.1 part-time	2.5 full time 1.4 part-time	4.0 full time 2.2 part-time	4.5 full time 2.5 part-time	5.0 full time 2.8 part-time	3.6 full time 2.0 part-time	4.6 full time 2.6 part-time

[1] frequency of sample collection at each site within the index period;
[2] assumes a 10% resample/site for all indicators for the first four options;
[3] assumed production of samples/day considering travel and logistics for getting between adjacent sites;
[4] includes processing of macroinvertebrate (12 hr./sample) and SAV (4 hrs./sample) samples and fish vouchers (gross day estimate) - does not include chemical laboratory analyses;
[5] % of effort based on number of sampling sites/year for the Intensive Survey design option;
[6] proportioned by %effort.

Table 16. Summary of estimated costs for each of the UMR main channel design options. Detailed costs and calculations are in Appendix Table D-1.

Logistical Aspect	**Probabilistic A**	**Probabilistic B**	**Probabilistic C**	**Probabilistic D1**	**Probabilistic D2**	**Nonrandom Longitudinal Survey[1] (baseline/ Follow-up)**	**Intensive Pollution Survey**	**Index Sites[2]**
Annual Personnel Costs	$352,460	$418,330	$545,590	$601,870	$601,870	$601,870 (yrs 1&2) $418,330 (yrs 3&4)	$576,870	$151,315
Annual Other Direct Costs	$106,250	$169,250	$169,250	$169,250	$169,250	$169,250 (yrs 1&2) $144,250 (yrs 3&4)	$169,250	$53,050
Annual Chemical Analytical Costs	$156,000	$240,000	$340,000	$435,000	$485,000	$485,000 (yrs 1&2) $228,000 (yrs 3&4)	$435,000	$168,000
Annual Total Cost	$614,710	$827,580	$1,054,840	$1,206,120	$1,256,120	$1,256,120 (yrs 1&2) $790,580 (yrs 3&4)	$1,185,120	$372,365
Time to Complete & Total Cost (Annual X Number of Years)	**1 year $614,710**	**2 years $1,655,160**	**2 years $2,109,680**	**4 years $4,824,480**	**2 years $2,512,240**	**4 years $4,093,400**	**4 years $4,724,480**	**1 year $372,365**

[1] Assumes 2 years of baseline monitoring, then 2 years of follow up monitoring. The follow-up option could be applied to any other option except IPS where it already exists.
[2] Index sites can accompany any of the spatial design options as an added task – index sites could be sampled over the term of each option over a period of up to 4 years.

productivity that would likely accompany a multi-jurisdictional approach to executing a survey. Another possibility is to implement two or more options over time, employing one of the simpler options to gain an overall assessment of the UMR and building into one of the more complex options as experience is gained in conducting a systematic assessment of the UMR.

What is presented here is a range of design options that can meet, each to substantially varying degrees, the goals of the strategy to support 305[b] and 303[d] and CWA management programs to the extent desired. These are intended primarily for comparison and they should be used in a comparative sense. However, these costs should be indicative of the scale of a program and also provide a way to assess what is to be gained by an added effort from the least cost to the highest costs options.

References

Angradi, T. R., M. S. Pearson, D. W. Bolgrien, T. M. Jicha, D. L. Taylor, D.W. Bolgrien, M.M. Moffet, K.A. Blocksom, and B. H. Hill. 2009a. Using stressor gradients to determine reference expectations for great river fish assemblages. Ecological Indicators 9 (2009): 748–764.

Angradi, T. R., M. S. Pearson, D. W. Bolgrien, T. M. Jicha, D. L. Taylor, and B. H. Hill. 2009b. Multimetric macroinvertebrate indices for mid-continent US great rivers. Journal of the North American Benthological Society 28:785-804.

Bartsch, A. F. 1948. Biological aspects of stream pollution. Sewage Works Journal 20 (1948): 292-302.

Blevins, D. and J. Fairchild. 2001. Applicability of NASQAN data for ecosystem assessments of the Missouri River. Hydrol. Process. 15: 1347-1362.

Doudoroff, P. and C. E. Warren. 1951. Biological indices of water pollution with special reference to fish populations, pages 144-153. Biological Problems in Water Pollution, U.S. Public Health Service, Robt. A. Taft Sanitary Engineering Center, Cincinnati, OH.

ITFM (Intergovernmental Task Force on Monitoring Water Quality). 1995. The strategy for improving water-quality monitoring in the United States. Final report of the Intergovernmental Task Force on Monitoring Water Quality. Interagency Advisory Committee on Water Data, Washington, D.C. + Appendices.

ITFM (Intergovernmental Task Force on Monitoring Water Quality). 1992. Ambient water quality monitoring in the United States: first year review, evaluation, and recommendations. Interagency Advisory Committee on Water Data, Washington, D.C.

Karr, J.R. and C.O. Yoder. 2004. Biological assessment and criteria improve TMDL planning and decision making. Journal of Environmental Engineering 130(6): 594-604.

Karr, J. R., K. D. Fausch, P. L. Angermier, P. R. Yant, and I. J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Natural History Survey Special Publication 5: 28 pp.

Midwest Biodiversity Institute (MBI). 2012. Upper Mississippi River Clean Water Act Monitoring Strategy Scoping Report. Report to the Upper Mississippi River Basin Association, St. Paul, MN. 58 pp.

McGuiness, D. 2000. A River That Works and a Working River. Upper Mississippi River Conservation Committee, Rock Island, IL. 40 pp.

Miltner, R.J., Yoder, C.O., and E.T. Rankin. 2011. Preliminary Analysis of Biological Assessment Thresholds for Determining Aquatic Life Use Attainment Status in the Upper Mississippi River Mainstem. Midwest Biodiversity Institute, Columbus, Ohio.

National Research Council (NRC). 2009. Nutrient Control Actions for Improving Water Quality in the Mississippi River Basin and Northern Gulf of Mexico. Committee on the Mississippi River and the Clean Water Act Water Science and Technology Board Division on Earth and Life Studies. The National Academies Press, Washington, DC. 79 pp.

National Research Council (NRC). 2008. Mississippi River Water Quality and the Clean Water Act: Progress, Challenges, and Opportunities. Committee on the Mississippi River and the Clean Water Act: Scientific, Modeling, and Technical Aspects of Nutrient Pollutant Load Allocation and Implementation. The National Academies Press, Washington, DC. 239 pp.

National Research Council (NRC). 2001. Assessing the TMDL Approach to Water Quality Management. National Academy Press, Washington, DC., 109 pp.

National Research Council (NRC) 2000. Ecological Indicators for the Nation. Washington, DC: National Academy Press. http://www.nap.edu/catalog/9720.html.

Natural Resources Conservation Service (NRCS). 2010. Mississippi River basin healthy watersheds initiative. USDA, Washington, DC. 2 pp.

Olsen, A.R., J. Sedransk, D. Edwards, C.A. Gotway, W. Ligget, S. Rathbun, K.H. Reckhow, L.J. Young. 1999. Statistical issues for monitoring ecological and natural resources in the United States. Environmental Monitoring and Assessment 54: 1–45.

Owens, T., and J. J. Ruhser. 1996. Long Term Resource Monitoring Program standard operating procedures: Aquatic areas database production. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1996. LTRMP 95-P008-6. 4 pp. + Appendix. (NTIS PB96-172267)

Scientific and Technical Advisory Committee (STAC). 2005. Final report of the Chesapeake Bay Scientific and Technical Advisory Committee's workshop: Evaluating the Design and Implementation of the Chesapeake Bay Shallow Water Monitoring Program. STAC Publ. 05-003. 28 pp.

Sullivan, J.S., D. Stoltenberg, S. Manoyan, J. Huang, R. Zdanowicz, and W. Redmon. 2002 Upper Mississippi River Water Quality Assessment. Summary Report, Chicago: Upper Mississippi River Conservation Committee/U.S. EPA, Chicago, IL.

The Heinz Center. 2002. The State of the Nation's Ecosystems, Measuring the Lands, Waters, and Living Resources of the United States. New York, NY: Cambridge University Press. http://www.heinzctr.org/ecosystems.

Upper Mississippi River Basin Association (UMRBA). 2012. Upper Mississippi River Aquatic Life Designated Uses: Improving Protection under the Clean Water Act. Upper Mississippi River Basin Association, Water Quality Task Force. St. Paul, MN. 123 pp.

Upper Mississippi River Basin Association (UMRBA). 2011. Upper Mississippi River Nutrient Monitoring, Occurrence, and Local Impacts: A Clean Water Act Perspective. Upper Mississippi River Basin Association, Water Quality Task Force. St. Paul, MN. 98 pp.

Upper Mississippi River Basin Association (UMRBA). 2005. Upper Mississippi River Fish Consumption Advisories: State Approaches to Issuing and Using Fish Consumption Advisories on the Upper Mississippi River. Upper Mississippi River Basin Association. St. Paul, Minnesota. 70 pp.

Upper Mississippi River Basin Association (UMRBA). 2004. Upper Mississippi River Water Quality: The States' Approaches to Clean Water Act Monitoring, Assessment, and Impairment Decisions. Upper Mississippi River Basin Association. St. Paul, MN. 75 pp.

U.S. EPA. 2013. Biological Assessment Program Evaluation: Assessing Technical Rigor and Program Implementation to Support Water Quality Management. EPA XXX-X-XX-XXX. Office of Water, OST-HECD (in preparation).

U.S. EPA. 2003. Elements of a state water monitoring and assessment program. EPA 841-B-03-003. Office of Wetlands, Oceans, and Watersheds, Assessment and watershed Protection Division, Washington, DC. 25 pp.

U.S. EPA. 1998. 1998. Guidance for quality assurance project plans. Office of Research and Development, Washington, DC. EPA/600/R-98/018.

U.S. Environmental Protection Agency. 1995a. Environmental indicators of water quality in the United States. EPA 841-R-96-002. Office of Water, Washington, DC 20460. 25 pp.

U.S. Environmental Protection Agency. 1995b. A conceptual framework to support development and use of environmental information in decision-making. EPA 239-R-95-012. Office of Policy, Planning, and Evaluation, Washington, DC 20460. 43 pp.

Weigel, B.M. and Dimick, J.J. 2011. Development, validation, and application of a macroinvertebrate based Index of Biotic Integrity for nonwadeable rivers of Wisconsin. J. N. Am. Benthol. Soc., 2011, 30(3):665–679

Wilcox, D. B. 1993. An aquatic habitat classification system for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, May 1993. EMTC 93-T003. 9 pp. + Appendix A. (NTIS PB93-208981)

Yoder, C.O., R.J. Miltner, V.L. Gordon, E.T. Rankin, N.B. Kale, and D.K. Hokanson. 2011. Improving Water Quality Standards and Assessment Approaches for the Upper Mississippi River: UMR Clean Water Act Biological Assessment Implementation Guidance. Upper Mississippi River basin Association, St. Paul, MN. 95 pp. + Appendices.

Yoder, C.O. and 9 others. 2005. Changes in fish assemblage status in Ohio's non-wadeable rivers and streams over two decades, pp. 399-429. *in* R. Hughes and J. Rinne (eds.). Historical changes in fish assemblages of large rivers in the America's. American Fisheries Society Symposium Series.

Yoder, C.O. 1998. Important Concepts and elements of an adequate state watershed monitoring and assessment program, pp. 615-628. *in* Proceedings of the NWQMC National Conference Monitoring: Critical Foundations to Protecting Our Waters. U.S. EPA, Washington, DC, 663 pp. + app.

Appendix Table A-1. Current chemical/physical sampling locations in the Upper Mississippi River arranged from upstream to downstream by river mile. These inlcude fixed stations only.

MCES - Metropolitan Council Environmental Services
MPCA - Minnesota Pollution Control Agency
WDNR- Wisconsin Department of Natural Resources
LTRM - (USACE) UMRR-EMP- Long Term Resource Monitoring
IL EPA - Illinois Environmental Protection Agency
USFWS - US Fish and Wildlife Service

ID	River Mile	Agency	Site	LTRM Start*	LTRM Last*	Pool	HUC	DO mg/L	Temp C	Cond. uS/cm	pH field	pH lab	Turb ntu	Flow cfs	TSS mg/L	NHx mg/L	NOx mg/L	TN mg/L	TP mg/L	SRP mg/L	Si mg/L	Cl mg/L	CHLA_Q	Chla ug/L	UNH3 mg/L	Fecal coliforms	Metals -Hg,Cd,Cu	SO4	Phenols	PCBs	Organics
	812.8	MCES	Prescott, WI			3	7040001						x		x		x		x			x									
	796.9	WDNR	L&D 3			3	7040001	x	x		x		x		x		x	x	x	x			x			x	x			x	
M796.9M	796.9	LTRM	L&D 3	1993	2004	3	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M796.9N	796.9	LTRM	L&D 3	1990	2004	3	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
	796.6	MCES	L&D 3			3	7040001	x	x	x	x		x		x		x	x	x	x			x			x	x				x
CN00.1M	795.7	LTRM	Tributary	1990	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
VM00.1M	795.7	LTRM	Tributary	1990	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M787.6H	787.6	LTRM	Bay City, WI	2004	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M786.2C	786.2	LTRM	Bay City, WI	1993	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M781.2O	781.2	LTRM	Maiden Rock, WI	1990	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
WC00.8M	778.5	LTRM	Tributary	1999	2004	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M775.6Q	775.6	LTRM	Lake Pepin	1990	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M771.2P	771.2	LTRM	Lake Pepin	1993	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M766.0I	766	LTRM	Lake Pepin	1990	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M764.3A	764.3	LTRM	Lake Pepin	1993	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
CH00.1M	763.5	LTRM	Tributary	1990	2011	4	7040001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M757.2Z	757.2	LTRM	Alma, WI	1993	2011	4	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M753.1X	753.1	LTRM	Kellogg, MN	1993	2004	4	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
	752.8	WDNR	L&D 4			4	7040003	x	x		x		x		x		x	x	x	x			x			x	x				
M752.9Z	752.9	LTRM	L&D 4	2004	2011	4	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M752.9M	752.9	LTRM	L&D 4	2004	2011	4	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M752.9Y	752.9	LTRM	L&D 4	2004	2011	4	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
ZM00.1M	750.2	LTRM	Tributary	1993	2004	5	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M747.3R	747.3	LTRM	Buffalo City, WI	1993	2008	5	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
WW01.3M	743.7	LTRM	Tributary	1993	2008	5	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							

Appendix Table A-1. Current chemical/physical sampling locations in the Upper Mississippi River arranged from upstream to downstream by river mile. These inlcude fixed stations only.

ID	River Mile	Agency	Site	LTRM Start*	LTRM Last*	Pool	HUC	DO mg/L	Temp C	Cond. uS/cm	pH field	pH lab	Turb ntu	Flow cfs	TSS mg/L	NHx mg/L	NOx mg/L	TN mg/L	TP mg/L	SRP mg/L	Si mg/L	Cl mg/L	CHLA_Q	Chla ug/L	UNH3 mg/L	Fecal coliforms	Metals -Hg,Cd,Cu	SO4	Phenols	PCBs	Organics
M743.0E	743	LTRM	Minnieska, MN	1997	2008	5	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M738.2T	738.2	LTRM	L&D 5	2000	2008	5	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M738.2M	738.2	LTRM	L&D 5	2000	2008	5	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M738.2F	738.2	LTRM	L&D 5	1993	2008	5	7040003	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
S000-287	738	MPCA	L&D 5			5	7040003	x	x	x		x	x		x	x	x		x			x	x	x	x						
	728	MPCA	Winona, MN			6	7040003	x		x	x				x	x			x												
S000-095	714	MPCA	L&D 6 - Tremp.			6	7040003	x	x	x		x	x			x	x								x						
M702.7T	702.7	LTRM	L&D 7	1993	2011	7	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M702.5B	702.5	LTRM	L&D 7	2004	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M701.1F	701.1	LTRM	Onalaska, WI	2000	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M701.1D	701.1	LTRM	Onalaska, WI	2000	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M701.1B	701.1	LTRM	Onalaska, WI	1991	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
BK01.0M	698.3	LTRM	Tributary	1993	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
BK04.3Z	698.3	LTRM	Tributary	2008	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
BK14.2M	698.3	LTRM	Tributary	1993	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
LX00.1M	698.3	LTRM	Tributary	1991	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
S000-067	698	MPCA	US-14 Lax			8	7040006	x	x	x		x	x			x	x	x	x	x	x	x		x	x						
M696.5D	696.5	LTRM	De Soto, WI	1988	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
RO00.1M	696.4	LTRM	Tributary	1988	2011	8	7040006	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M691.3B	691.3	LTRM	Brownsville, MN	1988	2011	8	7060001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M690.8B	690.8	LTRM	Brownsville, MN	1988	2011	8	7060001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M686.1W	686.1	LTRM	Lansing, MN	2008	2011	8	7060001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
CC00.6M	684.4	LTRM	Tributary	1993	2011	8	7060001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M681.3B	681.3	LTRM	Ferryville, WI	1993	2011	8	7060001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
	679.5	WDNR	L&D 8			8	7060001	x	x		x		x		x		x	x	x	x			x			x					
M679.5Z	679.5	LTRM	L&D 8	2000	2004	8	7060001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M679.5X	679.5	LTRM	L&D 8	2000	2004	8	7060001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M679.5V	679.5	LTRM	L&D 8	1988	2004	8	7060001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M679.2Z	679.2	LTRM	L&D 8	2004	2011	8	7060001	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
	648	WDNR	L&D 9			9	7060001	x	x		x		x		x		x	x	x	x			x			x					
M-13	583	IL EPA	L&D 11			12	7060005	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		

Appendix Table A-1. Current chemical/physical sampling locations in the Upper Mississippi River arranged from upstream to downstream by river mile. These inlcude fixed stations only.

ID	River Mile	Agency	Site	LTRM Start*	LTRM Last*	Pool	HUC	DO mg/L	Temp C	Cond. uS/cm	pH field	pH lab	Turb ntu	Flow cfs	TSS mg/L	NHx mg/L	NOx mg/L	TN mg/L	TP mg/L	SRP mg/L	Si mg/L	Cl mg/L	CHLA_Q	Chla ug/L	UNH3 mg/L	Fecal coliforms	Metals -Hg,Cd,Cu	SO4	Phenols	PCBs	Organics
M563.9T	563.9	LTRM	St Donatus, IA	1993	2011	12	7060005	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M556.4A	556.4	LTRM	L&D 12	1990	2011	13	7060005	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
MQ02.1M	548.6	LTRM	Tributary	1993	2011	13	7060005	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M545.5B	545.5	LTRM	Apple River Island, IL	1989	2011	13	7060005	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
AL02.3M	545.2	LTRM	Tributary	1993	2011	13	7060005	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M540.2T	540.2	LTRM	Savanna, IL	1991	2011	13	7060005	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M532.3T	532.3	LTRM	Sabula, IA	1991	2011	13	7060005	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M525.5L	525.5	LTRM	Clinton, IA	1988	2011	13	7060005	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M12	522.5	IL EPA	L&D 13			14	7080101	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		
M508.1F	508.1	LTRM	Camanche, IA	1993	2011	14	7080101	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M-02	482.9	IL EPA	L&D 15			15	7080101	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		
L-04	437	IL EPA	L&D 17			18	7080101	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		
	431	USFWS	New Boston, IL			18	7080104	x	x	x	x						x	x	x												
K-22	364.6	IL EPA	L&D 19			19	7080104	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		
K-17	325	IL EPA	L&D 21			21	7110004	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		
K-21	273.5	IL EPA	L&D 24			24	7110004	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		
M241.4K	241.4	LTRM	L&D 25	1990	2011	26	7110004	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M237.2G	237.2	LTRM	Cuivre Island, MO	1988	2004	26	7110004	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
CU11.6M	236.9	LTRM	Tributary	1993	2011	26	7110004	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M235.5D	235.5	LTRM	Cuivre Island, MO	1990	2004	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
PE01.8M	233	LTRM	Tributary	1993	2011	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
I005.7M	219.2	LTRM	Tributary	1988	2011	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
I007.0M	219.2	LTRM	Tributary	1988	2011	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
PI00.2M	209.5	LTRM	Tributary	1993	2011	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M206.1T	206.1	LTRM	Godfrey, IL	1988	2004	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M206.0S	206	LTRM	Godfrey, IL	1988	2004	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M203.5R	203.5	LTRM	Alton, IL	1988	2004	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M202.6T	202.6	LTRM	Alton, IL	1995	2011(?)	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M202.6V	202.6	LTRM	Alton, IL	1999	2011	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M202.6X	202.6	LTRM	Alton, IL	1999	2011	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M202.2N	202.2	LTRM	Alton, IL	1990	2004	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							

Appendix Table A-1. Current chemical/physical sampling locations in the Upper Mississippi River arranged from upstream to downstream by river mile. These inlcude fixed stations only.

ID	River Mile	Agency	Site	LTRM Start*	LTRM Last*	Pool	HUC	DO mg/L	Temp C	Cond. uS/cm	pH field	pH lab	Turb ntu	Flow cfs	TSS mg/L	NHx mg/L	NOx mg/L	TN mg/L	TP mg/L	SRP mg/L	Si mg/L	Cl mg/L	CHLA_Q	Chla ug/L	UNH3 mg/L	Fecal coliforms	Metals -Hg,Cd,Cu	SO4	Phenols	PCBs	Organics
M201.7Q	201.7	LTRM	Alton, IL	1993	2011	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
J-98	200.8	IL EPA	Mel Price, L&D 26			26	7110009	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		
WD00.2M	199.3	LTRM	Tributary	1993	2004	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M196.9Q	196.9	LTRM	Hartford, IL	1993	2004	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
MO00.2M	195.2	LTRM	Tributary	1993	2004	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
CA00.4M	194.3	LTRM	Tributary	1993	2004	26	7110009	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
J-36	162.2	IL EPA	UPS Meramec R.			OR	7140105	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		
I-05	111	IL EPA	Chester, IL			OR	7140105	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		
M078.0B	78	LTRM	Grand Tower, IL	1991	2011	OR	7140105	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
BM00.7S	75.7	LTRM	Tributary	1991	2011	OR	7140105	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M070.2A	70.2	LTRM	Hanging Dog Island, IL	1991	2011	OR	7140105	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M066.4C	66.4	LTRM	Mocassin Springs, MO	1991	2011	OR	7140105	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M066.3B	66.3	LTRM	Mocassin Springs, MO	1995	2011	OR	7140105	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M066.3A	66.3	LTRM	Mocassin Springs, MO	2000	2011	OR	7140105	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M059.5I	59.5	LTRM	Devils Island, IL	1991	2011	OR	7140105	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
M056.0I	56	LTRM	Cape Girardeau, MO	1991	2011	OR	7140105	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
HD00.9M	48.8	LTRM	Tributary	1991	2011	OR	7140105	x	x	x	x		x		x	x	x	x	x	x	x		x	x							
I-84	44	IL EPA	Thebes, IL			OR	7140105	x	x	x	x					x	x	x	x			x		x	x	x	x	x	x		

*From LTRM web-based graphical browser.

Appendix Table A-2. Sites for a UMR tributary loading network comprised of existing state fixed stations with the exception of proposed sites listed as "Not Established".

Waterbody	UMR River Mile/ Tributary Confluence	Water Quality Site Location Name	State	Existing Water Quality Station - Agency	Existing Water Quality Station - ID	Existing WQ Site LatDD	Existing WQ Site LongDD	Associated USGS Gage*	Gage LatDD*	Gage LongDD*	8digit_Huc*	Total Watershed Drainage (sq. miles)*	Suggested By
Mississippi River-Lock and Dam 2	815.3	Prescott (Beginning of Mainstem UMR)	MN	MCES	UMR 815.6	44.765300	92.870560	05344500	44.747836	-92.813099	07040001	39,990	MN
St. Croix River	811.3	Near Prescott (MCES)	MN	MCES/WDNR	SC 0.3	44.749167	-92.804444	05344490	44.749167	-92.804444	07030005	7,650	WI, IL
Mississippi River-Lock and Dam 3	796.9	Near Red Wing (MCES) Gage at Prescott	MN	MCES/WDNR	UM 796.9	44.610000	-92.610278	05344500	44.61	-92.610278	07040002	45,170	WI
Cannon River	795.5	Welch	MN	MPCA	MN S000-003	44.564490	-92.731703	05355200	44.56449	-92.731703	07040002	1,340	MN
Chippewa River	763.5	At Durand	WI	WDNR	473008	44.631000	-91.971333	05369500	44.631	-91.971333	07050005	9,010	WI, IL,
Zumbro River	750.0	Kellogg	MN	MPCA	MN S004-384	44.312173	-92.003869	05374900	44.312173	-92.003869	07040004	1,408	MN
Mississippi River-Winona	725.5	Winona	MN	MPCA	MN S000-096	44.056685	-91.637093	05378500	44.056685	-91.637093	07040003	59,200	IL
Trempealeau River	717.0	At Dodge	WI	WDNR	623039	44.131667	-91.552778	05379500	44.131667	-91.552778	07040005	643	WI
Black River	708.0	Near Galesville	WI	WDNR	623001	44.060278	-91.287222	05382000	44.060278	-91.287222	07040007	1,756	WI, IL
La Crosse River	698.4	At La Crosse	WI	WDNR/LTRMP	323017	43.860833	-91.210278	05383075	43.860833	-91.210278	07040006	471	WI, IL
Root River	693.7	Near Mound Prairie	MN	MPCA	MN S004-858	43.781374	-91.446473	05386070	43.781374	-91.446473	07040008	1,664	MN, ILI
Upper Iowa River	671.2	New Albin	IA	IA DNR	IA 15030012	43.421111	-91.508611	05388250	43.4211111	-91.508611	07060002	770	IA, IL
Mississippi River-Lock and Dam 9	647.9	Near Lynxville (gage at McGregor, Iowa)	WI	WDNR	123016	43.210028	-91.100583	05389500	43.210028	-91.100583	07060001	66,610	WII
Wisconsin River	630.6	At Muscoda	WI	WDNR	223282	43.198056	-90.443333	05407000	43.198056	-90.4433333	07070005	10,400	WI, IL
Turkey River	608.0	Garber	IA	IA DNR	IA 10220001	42.740000	-91.261667	05412500	42.74	-91.261667	07060004	1,545	IA
Grant River	593.5	At Burton	WI	None	Not Established	N/A	N/A	07060004	42.720278	-90.819167	07060004	269	WI
Maquoketa River	548.0	Maquoketa	IA	IA DNR	IA 10490002	42.083333	-90.632778	05418500	42.083333	-90.632778	07060006	1,553	IA
Apple River	544.5	Near Elizabeth	IL	IL EPA	IL MN-03	41.898300	-90.155300	05418950	42.31882	-90.25432	07060005	207	IL
Mississippi River-Clinton	520.0	Clinton	IL	IL EPA	IL M-12	41.780556	-90.251944	05420500	41.780556	-90.251944	07080101	85,600	IL
Wapsipinicon River	506.8	Near DeWitt	IA	IA DNR	IA 10820001	41.766944	-90.534722	05422000	41.766944	-90.534722	07080103	2,336	IA, IL
Rock River	479.1	Near Joslin	IL	IL EPA	IL P-04	41.556111	-90.185278	05446500	41.556111	-90.185278	07090005	9,549	IL
Iowa River	433.5	Wapello	IA	IA DNR	IA 10580003	41.178056	-91.181944	05465500	41.178056	-91.181944	07080209	12,500	IA, IL
Henderson Creek	409.9	Near Bald Bluff	IL	IL EPA	IL LD-02	41.001910	-90.853430	05469000	41.00191	-90.85343	07080104	451	IL
Skunk River	396.0	Near Augusta	IA	IA DNR	IA 10560002	40.753611	-91.276944	05474000	40.7536111	-91.276944	07080107	4,312	IA, IL
Mississippi River-Keokuk	364.0	Keokuk	IA	IL EPA	IL K-22	40.392200	-91.376000	05474500	40.393611	-91.374167	07080104	119,000	IL
Des Moines River	361.5	Keosauqua	IA	IA DNR	IA 10890001	40.727780	-91.959444	05490500	40.72778	-91.959444	07100009	14,038	IA
Fox River	354.0	Near Wayland	MO	MO DNR	38/2.6	40.392693	-91.598270	05495000	40.392417	-91.597889	07110001	400	MO
Wyconda River	337.0	Above Canton	MO	MO DNR	47/7	40.142100	-91.565799	05496000	40.142111	-91.565694	07110001	393	MO
Bear Creek	331.0	Near Marcelline	IL	IL EPA	IL KI-02	40.142778	-91.337222	05495500	40.142778	-91.337222	07110001	349	IL
North Fabius River	323.0	Near Ewing	MO	MO DNR	56/17.5	40.045200	-91.659301	05497150	40.018889	-91.621944	07110002	471	MO
South Fabius River	321.0	Near Taylor	MO	MO DNR	71/5.1	39.896938	-91.580281	05500000	39.896639	-91.580167	07110003	620	MO
Salt River	284.1	Near Center	MO	MO DNR	91/41	39.573904	-91.571503	05507800	39.574056	-91.571806	07110007	2,350	IL
Cuivre River	232.0	Near Troy	MO	MO DNR	152/29.8	39.009737	-90.977912	05514500	39.009737	-90.977912	07110008	903	MO
Illinois River	218.0	At Valley City	IL	IL EPA	IL D-32	39.703333	-90.645278	05586100	39.703333	-90.645278	07130011	26,743	IL
Mississippi River-Alton	200.8	Alton	IL	IL EPA	IL J-98	38.870300	-90.152300	05587550	38.886444	-90.182547	07110009	171,500	IL
Missouri River	195.5	At Hermann, 80 miles above mouth	MO	MO DNR	1604/97.9	38.710000	-91.439097	06934500	38.709806	-91.4385	10300200	522,500	MO, IL
Mississippi River-Below St. Louis	180.0	Below St. Louis	MO	MO DNR	1707.02/19.3	38.629000	-90.180998	07010000	38.629	-90.179778	07140101	697,000	IL
Cahokia Creek	174.0	At Edwardsville	IL	IL EPA	IL JQ-05	38.824444	-89.974722	05587900	38.824444	-89.974722	07140101	212	IL
Meramec River	160.5	Near Paulina Hills	MO	MO DNR	2183/10.2	38.462802	-90.414895	07019280	38.462778	-90.414722	07140102	3,980	MO, IL
Kaskaskia River	117.6	Near Okawville	IL	IL EPA	IL O-20	38.450556	-89.627500	05594100	38.450556	-89.6275	07140204	4,393	IL
Mississippi River-Chester	110.0	Chester	IL	IL EPA	IL I-05	37.910800	-89.853600	07020500	37.900742	-89.830211	07140105	708,600	IL
Big Muddy River	75.7	At Murphysboro	IL	IL EPA	IL N-12	37.748056	-89.346667	05599500	37.748056	-89.346667	07140106	2,169	IL
Castor River	49.0	At Greenbriar	MO	MO DNR	2288/6.6	37.108655	-90.025103	07021020	37.108833	-90.025	07140107	423	MO
Mississippi River-Thebes	44.0	Thebes	IL	IL EPA	IL I-84	37.221600	-89.462975	07022000	37.2216	-89.462975	07140105	713,200	IL

* Data from USGS National Water Information System when available.

Appendix Table B-1. List of NPDES permitted discharges, dams, and major tributaries to the Upper Mississippi River mainstem.

River Mile	Type	Source	Description	Characteristics	Latitude	Longitude	NPDES #	River R or L	Permit	State	CWA Reach	Pool
811.3		**ST. CROIX RIVER**	**River Mouth**	**Major Tributary**	44.747184	-92.803427		L	**Trib**	WI	1	3
810.7	WWTP	Prescott Wastewater Treatment	Municipal WWTP	Direct Discharge to Mississippi	44.743102	-92.793269	WI0022403	L	Non-major	WI	1	3
800.0	WWTP	Prairie Island Indian Community WWTF	Municipal WWTP	Sturgeon Lake to Mississippi	44.629559	-92.660322	MN0061336	R	Non-major	MN	1	3
798.0	Nuclear	Xcel Energy NSP-Prairie Island Plant	Nuclear energy plant	Lagoon to Mississippi	44.622278	-92.635194	MN0004006	R	Major	MN	1	3
796.9	Dam	**Lock & Dam 3**	Dam	**Major Impoundment**	44.743102	-92.793269		R&L	**L&D**	MN/WI	1	4
791.1	WWTP	Red Wing WWTP	Municipal WWTP	Direct Discharge to Mississippi	44.571389	-92.528194	MN0024571	R	Major	MN	1	4
791.0	Nuclear	Xcel Energy NSP-Red Wing Plant	Nuclear energy plant	Direct Discharge to Mississippi	44.569528	-92.516444	MN0000850	R	Non-major	MN	1	4
790.5	WWTP	Maiden Rock WWTF	Municipal WWTP	Direct Discharge to Mississippi	44.5673	-92.31987	WI0032361	L	Non-major	WI	1	4
772.0	Plant	Federal Mogul Powertrain Systems	Motor Vehicle Parts and Accessories	Direct Discharge to Mississippi	44.445861	-92.275889	MN0001147	R	Non-major	MN	1	4
772.0	Electric	Dairyland Power Coop Power Plant	Electric Power Generation	Direct Discharge to Mississippi	44.304167	-91.911389	WI0040223	L	Non-major	WI	1	4
771.5	WWTP	Lake City WWTP	Municipal WWTP	Piped to Miss.	44.437944	-92.261528	MN0024571	R	Major	MN	1	4
771.3	Plant	Cytec Engineered Materials	Coated Fabrics	Direct Discharge to Mississippi	44.05	-91.6	MN0003441	R	Non-major	MN	1	4
767.5	WWTP	Pepin Wastewater Treatment Plant	Municipal WWTP	Direct Discharge to Mississippi	44.433333	-92.133333	WI0022811	L	Non-major	WI	1	4
763.5		**CHIPPEWA RIVER**	**River Mouth**	**Major Tributary**	44.407279	-92.083435		L	**Trib**	WI	2	4
751.8	WWTP	Alma Wastewater Treatment Plant	Municipal WWTP	Direct Discharge to Mississippi	44.325	-91.916667	WI0022101	L	Non-major	WI	2	5
752.8	Dam	**Lock & Dam 4**	Dam	**Major Impoundment**	44.324657	-91.922226		R&L	**L&D**	MN/WI	2	5
738.1	Dam	**Lock & Dam 5**	Dam	**Major Impoundment**	44.324657	-91.809663		R&L	**L&D**	MN/WI	2	5
729.5	WWTP	Fountain City WWTP	Municipal WWTP	Direct Discharge to Mississippi	44.133333	-91.716667	WI0024040	L	Non-major	WI	2	5A
728.5	Dam	**Lock & Dam 5A**	Dam	**Major Impoundment**	43.996433	-91.441324		R&L	**L&D**	MN/WI	2	5A
724.7	Plant	RTP Co.	Compounding of Plastic Resins	Direct Discharge to Mississippi	44.05	-91.619833	MN0053350	R	Non-major	MN	2	6
723.6	Plant	Peerless Chain Co.	Chain Manufacturing Plant	Direct Discharge to Mississippi	44.03775	-91.605056	MN0001325	R	Non-major	MN	2	6
721.9	WWTP	Winona WWTP	Municipal WWTP	Wetlands to Mississippi	44.032194	-91.603361	MN0030147	R	Major	MN	2	6
714.1	WWTP	Trempealeau WWTP	Municipal WWTP	Lagoon to Mississippi	44.002778	-91.430556	WI0020966	L	Non-major	WI	2	6
714.1	Dam	**Lock and Dam 6**	Dam	**Major Impoundment**	43.996440	-91.441418		R&L	**L&D**	MN/WI	2	6
706.6	Plant	Metallics Inc.	Metal Coating Plant	Direct Discharge to Mississippi	43.916389	-91.268333	WI0054500	L	Non-major	WI	3	7
702.5	Dam	**Lock and Dam 7**	Dam	**Major Impoundment**	43.866937	-91.307242		R&L	**L&D**	MN/WI	3	7
700.5	Hatchery	National Biological Service	Fish Hatchery	Direct Discharge to Mississippi	43.8	-91.245	WI0045756	L	Non-major	WI	3	8
699.5	Electric	French Island Power	Electric Power Generation	Lagoon to Mississippi	43.833333	-91.25	WI0070785	L	Non-major	WI	3	8
698.2		**BLACK RIVER**	**River Mouth**	**Major Tributary**	43.827596	-91.258098		L	**Trib**	WI	3	8
698.2		**LA CROSSE RIVER**	**River Mouth**	**Major Tributary**	43.818597	-91.255956		L	**Trib**	WI	3	8
697.6	WWTP	Barron Island Wastewater Treatment Facility	Municipal WWTP	Direct Discharge to Mississippi	43.75	-91.116667	WI0028487	L	Non-major	WI	3	8
697.0	WWTP	La Crosse WWTP	Municipal WWTP	Direct Discharge to Mississippi	43.800556	-91.257222	WI0029581	L	Major	WI	3	8
693.6		**ROOT RIVER**	**River Mouth**	**Major Tributary**	43.780903	-91.251452		R	**Trib**	MN	4	8
688.7	WWTP	Brownsville Wastewater Treatment Plant	Municipal WWTP	Direct Discharge to Mississippi	43.691889	-91.277139	MN0053562	R	Non-major	MN	4	8
685.3	WWTP	Stoddard Wastewater Treatment Plant	Municipal WWTP	Direct Discharge to Mississippi	43.661111	-91.213889	WI0028304	L	Non-major	WI	4	8
679.2	WWTP	Genoa Wastewater Treatment Plant	Municipal WWTP	Direct Discharge to Mississippi	43.577778	-91.225	WI0022284	L	Non-major	WI	4	8
679.2	Dam	**Lock and Dam 8**	Dam	**Major Impoundment**	43.570498	-91.232707		R&L	**L&D**	MN/WI	4	8
678.3	Electric	Dairyland Power Coop Genoa Power Plant	Coal Powered Electricity Generation	Direct Discharge to Mississippi	43.559167	-91.231944	WI0003239	L	Major	WI	4	9
667.3	WWTP	DeSoto Wastewater Treatment Plant	Municipal WWTP	Direct Discharge to Mississippi	43.422222	-91.2	WI0029793	L	Non-major	WI	4	9
662.4	WWTP	Lansing City of STP	Municipal WWTP	Direct Discharge to Mississippi	43.349486	-91.207219	IA0024597	R	Non-major	MN	4	9
662.0	Electric	Lansing Power Station	Electric Power Generation	Lagoon to Mississippi	43.334954	-91.167075	IA0003735	R	Major	IA	4	9
657.9	WWTP	Ferryville Wastewater Treatment Plant	Municipal WWTP	Direct Discharge to Mississippi	43.266667	-91.116667	WI0020974	L	Non-major	WI	4	9
651.0	WWTP	Valley Ridge Clean Water Commission WWTF	Municipal WWTP	Direct Discharge to Mississippi	43.240861	-91.062083	WI0036854	L	Non-major	WI	4	9

Appendix Table B-1. List of NPDES permitted discharges, dams, and major tributaries to the Upper Mississippi River mainstem.

River Mile	Type	Source	Description	Characteristics	Latitude	Longitude	NPDES #	River R or L	Permit	State	CWA Reach	Pool
647.9	Dam	**Lock and Dam 9**	Dam	**Major Impoundment**	43.218337	-91.108906		R&L	**L&D**	IO/WI	4	9
645.7	WWTP	Harpers Ferry STP	Municipal WWTP	Direct Discharge to Mississippi	43.197319	-91.150806	IA0070564	R	Non-major	IA	4	10
633.5	WWTP	Prairie Du Chien WWTF	Municipal WWTP	Direct Discharge to Mississippi	43.030278	-91.147222	WI0020257	L	Major	WI	4	10
633.0	WWTP	McGregor City of STP	Municipal WWTP	Direct Discharge to Mississippi	43.024597	-91.172242	IA0028614	R	Non-major	IA	4	10
630.6		**WISCONSIN RIVER**	**River Mouth**	**Major Tributary**	42.988953	-91.155564		L	**Trib**	WI	5	10
623.0	Quarry	Pattison Sand Co. LLC - Clayton	Industrial Sand Mining	Direct Discharge to Mississippi	42.898748	-91.38935	IA0080624	R	Non-major	IA	5	10
615.0	Dam	**Lock and Dam 10**	Dam	**Major Impoundment**	42.787658	-91.082218		R&L	**L&D**	IO/WI	5	10
614.0	WWTP	Guttenberg City of STP	Municipal WWTP	Direct Discharge to Mississippi	42.776622	-91.093272	IA0022284	R	Non-major	IA	5	11
607.8	Electric	WI Power and Light - Nelson Dewey Power Plant	Coal Powered Electricity Generation	Direct Discharge to Mississippi	42.708333	-90.983333	WI0002381	L	Non-major	WI	5	11
606.6	Electric	Dairyland Power Coop Cassville Power Plant	Coal Powered Electricity Generation	Direct Discharge to Mississippi	42.713889	-90.988889	WI0002020	L	Non-major	WI	5	11
605.9	WWTP	Cassville Wastewater Treatment Plant	Municipal WWTP	Tributary to Mississippi	42.715	-90.988333	WI0021423	L	Non-major	WI	5	11
592.1	WWTP	Potosi-Tennyson WWTP	Municipal WWTP	Wetland to Mississippi	42.694444	-90.708333	WI0021547	L	Non-major	WI	5	11
586.2	Plant	John Deere Dubuque Works	Farm Equipment Manufacturing Plant	Lagoon to Mississippi	42.564750	-90.69275	IA0000051	R	Major	IA	5	11
583.0	Dam	**Lock and Dam 11**	Dam	**Major Impoundment**	42.541663	-90.655097		R&L	**L&D**	IO/WI	5	11
581.4	Foods	Systems Bio Industries Inc.	Food Preparation	Direct Discharge to Mississippi	42.523242	-90.648026	IA0002984	R	Non-major	IA	6	12
581.3	Casino	Dubuque Greyhound Park and Casino	Casino	Direct Discharge to Mississippi	42.516797	-90.640344	IA0080233	R	Non-major	IA	6	12
581.2	Cement	Flynn Ready Mix Concrete Company	Concrete Plant	Direct Discharge to Mississippi	42.514412	-90.653816	IA0077020	R	Non-major	IA	6	12
580.0	Electric	Dubuque Power Plant	Coal Powered Electricity Generation	Direct Discharge to Mississippi	42.502462	-90.65601	IA0001767	R	Non-major	IA	6	12
579.2	WWTP	East Dubuque STP	Municipal WWTP	Direct Discharge to Mississippi	42.491667	-90.65	IL0025186	L	Non-major	IL	6	12
578.0	WWTP	Dubuque Water Pollution Control Plant	Municipal WWTP	Direct Discharge to Mississippi	42.470083	-90.6529	IA0044458	R	Major	IA	6	12
573.0	Fertilizer	Rentech Energy Midwest Corporation	Nitrogenous Fertilizer Manufacturing	Direct Discharge to Mississippi	42.44	-90.561667	IL0003930	L	Non-major	IL	6	12
557.0	WWTP	Bellevue City of STP	Municipal WWTP	Direct Discharge to Mississippi	42.266521	-90.426014	IA0029009	R	Non-major	IA	6	12
556.7	Dam	**Lock and Dam 12**	Dam	**Major Impoundment**	42.261394	-90.420346		R&L	**L&D**	IA/IL	6	12
555.8	WWTP	IA DNR Bellevue State Park	Park WWTP	Direct Discharge to Mississippi	42.261394	-90.417164	IA0066010	R	Non-major	IA	6	13
548.6		**MAQUOKETA RIVER**	**River Mouth**	**Major Tributary**	42.188700	-90.308606		R	**Trib**	IA	6	13
536.8	WWTP	Savanna WWTP	Municipal WWTP	Savanna Slough to Mississippi	42.09	-90.156667	IL0020541	L	Non-major	IL	6	13
534.4	WWTP	Sabula City of STP	Municipal WWTP	Lower Sabula Lake to Mississippi	42.261394	-90.172422	IA0032867	R	Non-major	IA	6	13
529.0	WWTP	Thompson Municipal STP	Municipal WWTP	Direct Discharge to Mississippi	41.968056	-90.121111	IL0073890	L	Non-major	IL	6	13
522.6	Dam	**Lock and Dam 13**	Dam	**Major Impoundment**	41.898455	-90.157216		R&L	**L&D**	IA/IL	6	13
519.5	WWTP	Fulton City of STP	Municipal WWTP	Direct Discharge to Mississippi	41.856667	-90.168333	IL0028860	L	Non-major	IL	7	14
516.2	Electric	ADM Clinton Cogeneration Plant	Coal Powered Electricity Generation	Beaver Slough to Mississippi	41.822749	-90.204819	IA0080543	R	Non-major	IA	7	14
516.0	Plant	ADM Polymers	Plastic Materials and Resins	Beaver Slough to Mississippi	41.822749	-90.204819	IA0082279	R	Non-major	IA	7	14
515.8	Plant	ADM Corn Processing	Wet Corn Milling	Beaver Slough to Mississippi	41.822749	-90.204819	IA0003620	R	Non-major	IA	7	14
515.5	Plant	Darling International Inc.	Animal and Marine Fats and Oils	Beaver Slough to Mississippi	41.815411	-90.217421	IA0000914	R	Non-major	IA	7	14
515.5	Plant	Sethness Products Inc.,	Cane Sugar Refining	Beaver Slough to Mississippi	41.815411	-90.217421	IA0000183	R	Non-major	IA	7	14
513.8	Chemicals	Vertex Chemical Corporation	Industrial Inorganic Chemicals	Beaver Slough to Mississippi	41.809320	-90.229674	IA0068101	R	Non-major	IA	7	14
513.7	Electric	M L Kapp Generating Station	Electric Power Generation	Beaver Slough to Mississippi	41.806884	-90.231668	IA0001759	R	Non-major	IA	7	14
513.5	WWTP	Clinton City of STP	Municipal WWTP	Beaver Slough to Mississippi	41.807960	-90.238472	IA0035947	R	Major	IA	7	14
510.8	WWTP	Comanche City of STP	Municipal WWTP	Direct Discharge to Mississippi	41.776447	-90.273634	IA0021261	R	Non-major	IA	7	14
509.0	Plastics	3M - Cordova	Plastic Materials and Resins	Direct Discharge to Mississippi	41.754444	-90.288333	IL0003140	L	Major	IL	7	14
506.8		**WAPSIPINICON RIVER**	**River Mouth**	**Major Tributary**	41.729680	-90.319859		R	**Trib**	IA	7	14
506.7	Nuclear	Quad Cities Nuclear Power Station	Nuclear energy plant	Direct Discharge to Mississippi	41.726389	-90.310278	IL0005037	L	Major	IL	7	14
503.0	WWTP	Princeton City of STP	Municipal WWTP	Direct Discharge to Mississippi	41.680819	-90.338545	IA0033227	R	Non-major	IA	7	14
502.2	WWTP	Cordova STP	Municipal WWTP	Lagoon to Mississippi	41.67	-90.33	IL0025356	L	Non-major	IL	7	14
499.2	WWTP	Port Bryon Village of STP	Municipal WWTP	Lagoon to Mississippi	41.626694	-90.33	IL0023507	L	Non-major	IL	7	14

Appendix Table B-1. List of NPDES permitted discharges, dams, and major tributaries to the Upper Mississippi River mainstem.

River Mile	Type	Source	Description	Characteristics	Latitude	Longitude	NPDES #	River R or L	Permit	State	CWA Reach	Pool
497.0	MS4	LeClaire City of MS4	Stormwater System	Direct Discharge to Mississippi	41.599426	-90.342435	IA0078824	R	Non-major	IA	7	14
495.4	WWTP	LeClaire City of WWTP	Municipal WWTP	Direct Discharge to Mississippi	41.582914	-90.366497	IA0022012	R	Non-major	IA	7	14
493.4	Dam	**Lock and Dam 14**	Dam	**Major Impoundment**	41.572502	-90.398445		R&L	**L&D**	IA/IL	7	14
491.5	Warehouse	Americold Bettendorf	Refrigerated Warehouse and Storage	Direct Discharge to Mississippi	41.555147	-90.431175	IA0073695	R	Non-major	IA	7	15
490.2	WWTP	East Moline Wastewater	Municipal WWTP	Sugar Creek to Mississippi	41.533611	-90.426667	IL0028550	L	Major	IL	7	15
490	PWS	E. Moline Water Department	Public Water System	Direct Withdrawal of Mississippi	41.530845	-90.438319		L	PWS	IL	7	15
489.8	Electric	MidAmerican Energy Co. - Rivers	Coal Powered Electricity Generation	Direct Discharge to Mississippi	41.538620	-90.452267	IA0003611	R	Major	IA	7	15
487.2	Petroleum	Amoco Oil - Bettendorf Terminal	Petroleum Bulk Stations and Storage	Direct Discharge to Mississippi	41.521805	-90.48515	IA0001198	R	Non-major	IA	7	15
486	PWS	Moline Water Department	Public Water System	Direct Withdrawal of Mississippi	41.512538	-90.514844		L	PWS	IL	7	15
485.0	Plant	John Deere Seeding and Cylinder	Farm Equipment Manufacturing Plant	Direct Discharge to Mississippi	41.51	-90.521667	IL0003000	L	Non-major	IL	7	15
484.2	WWTP	North Slope Treatment Plant	Municipal WWTP	Sylvan Slough to Mississippi	41.510556	-90.538056	IL0029947	L	Major	IL	7	15
484	PWS	Iowa-American Water, Davenport	Public Water System	Direct Withdrawal of Mississippi	41.528249	-90.54285		R	PWS	IA	7	15
483	PWS	Rock Island Water Department	Public Water System	Direct Withdrawal of Mississippi	41.518938	-90.56474		L	PWS	IL	7	15
483	PWS	Rock Island Arsenal	Public Water System	Direct Withdrawal of Mississippi	41.51852	-90.566017		L	PWS	IL	7	15
482.9	Dam	**Lock and Dam 15**	Dam	**Major Impoundment**	41.518853	-90.568815		R&L	**L&D**	IA/IL	7	15
480.4	WWTP	Rock Island Main STP, City of	Municipal WWTP	Direct Discharge to Mississippi	41.499444	-90.597222	IL0030783	L	Major	IL	7	16
479.1	WWTP	Davenport, City of STP	Municipal WWTP	Direct Discharge to Mississippi	41.491680	-90.6286	IA0043052	R	Major	IA	7	16
479.0		**ROCK RIVER**	**River Mouth**	**Major Tributary**	41.482699	-90.616231		L	**Trib**	IL	7	16
475.8	Freight	Blackhawk Fleet LLC	Water Transportation Services	Direct Discharge to Mississippi	41.462750	-90.679519	IA0075604	R	Non-major	IA	7	16
475.6	Petroleum	Flint Hill Resources LLC Pine Bend	Petroleum Bulk Stations and Storage	Direct Discharge to Mississippi	41.463886	-90.667572	IA008292	R	Non-major	IA	7	16
475.5	Petroleum	Texpar Energy LLC	Petroleum Bulk Stations and Storage	Direct Discharge to Mississippi	41.463287	-90.677757	IA0001180	R	Non-major	IA	7	16
475.3	Cement	LaFarge North America LLC	Cement Quarry	Direct Discharge to Mississippi	41.460993	-90.683482	IA0063525	R	Non-major	IA	7	16
473.7	WWTP	Andalusia City of WWTP	Municipal WWTP	Lagoon to Mississippi	41.446667	-90.708333	IL0021202	L	Non-major	IL	7	16
473.0	WWTP	Buffalo City of STP	Municipal WWTP	Direct Discharge to Mississippi	41.457030	-90.725038	IA0020800	R	Non-major	IA	7	16
473.0	MS4	Buffalo City of MS4	Stormwater System	Direct Discharge to Mississippi	41.457030	-90.725038	IA0078760	R	Non-major	IA	7	16
472.0	RV Park	Camp Abe Lincoln	RV Parks and Campsites	Direct Discharge to Mississippi	41.453767	-90.742766	IA0067059	R	Non-major	IA	7	16
467.6	Electric	Central IA Power Cooperative	Coal Powered Electricity Generation	Lagoon to Mississippi	41.457144	-90.825016	IA0001562	R	Non-major	IA	7	16
466.4	WWTP	Riverview Subdivision Package Plant	Municipal WWTP	Direct Discharge to Mississippi	41.457941	-90.852966	IA0077453	R	Non-major	IA	7	16
457.2	Dam	**Lock and Dam 16**	Dam	**Major Impoundment**	41.246550	-91.015202		R&L	**L&D**	IA/IL	7	16
453.7	Grain	Grain Processing Corporation	Grain Milling	Lagoon to Mississippi	41.397204	-91.059281	IA0003441	R	Major	IA	7	17
453.0	Electric	Muscatine Power and water	Coal Powered Electricity Generation	Lagoon to Mississippi	41.389954	-91.056083	IA0001082	R	Major	IA	7	17
452.0	Natural Gas	Natural Gas Pipeline Company of America	Natural Gas Transmission	Direct Discharge to Mississippi	41.379167	-91.046111	IL0079120	L	Non-major	IL	7	17
449.9	Chemicals	Monsanto Company	Pesticides and Agricultural Chemicals	Direct Discharge to Mississippi	41.350845	-91.07238	IA0000205	R	Major	IA	7	17
448.0	Electric	MidAmerican Energy Co. - Louisa	Coal Powered Electricity Generation	Lagoon to Mississippi	41.316941	-91.082505	IA0063282	R	Major	IA	7	17
437.2	Dam	**Lock and Dam 17**	Dam	**Major Impoundment**	41.188582	-91.063995		R&L	**L&D**	IA/IL	7	17
434.0		**IOWA RIVER**	**River Mouth**	**Major Tributary**	41.603306	-91.024748		R	**Trib**	IA	8	18
432.0	WWTP	New Boston STP	Municipal WWTP	Direct Discharge to Mississippi	41.161667	-90.991667	IL0074926	L	Non-major	IL	8	18
410.4	Dam	**Lock and Dam 18**	Dam	**Major Impoundment**	40.884315	-91.02717		R&L	**L&D**	IA/IL	8	18
405.0	Plant	CNH America LLC	Construction Machinery	Direct Discharge to Mississippi	41.827687	-91.100076	IA0000787	R	Non-major	IA	8	19
405	PWS	Burlington Municipal Water Works	Public Water System	Direct Withdrawal of Mississippi	40.82043	-91.097192		R	PWS	IA	8	19
389.8	WWTP	Dallas City of WWTP	Municipal WWTP	Direct Discharge to Mississippi	40.633333	-91.181667	IL0028312	L	Non-major	IL	8	19
384	PWS	Fort Madison Municipal Water Works	Public Water System	Direct Withdrawal of Mississippi	40.62735	-91.313757		R	PWS	IA	8	19
382.0	WWTP	Fort Madison, City of STP	Municipal WWTP	Direct Discharge to Mississippi	40.621480	-91.334878	IA0022219	R	Major	IA	8	19
381.5	Health Care	The Kensington	Residential Care	Direct Discharge to Mississippi	40.628335	-91.311207	IA0077143	R	Non-major	IA	8	19
379.0	Fertilizer	Chevron Chemical Co	Nitrogen Fertilizers	Direct Discharge to Mississippi	40.622997	-91.33328	IA0003387	R	Non-major	IA	8	19

Appendix Table B-1. List of NPDES permitted discharges, dams, and major tributaries to the Upper Mississippi River mainstem.

River Mile	Type	Source	Description	Characteristics	Latitude	Longitude	NPDES #	River R or L	Permit	State	CWA Reach	Pool
376.4	WWTP	Nauvoo WWTP	Municipal WWTP	Direct Discharge to Mississippi	40.551667	-91.401667	IL0062391	L	Non-major	IL	8	19
376.4	WWTP	Fort Madison, City of WTP	Municipal WWTP	Direct Discharge to Mississippi	40.551794	-91.427701	IA0081001	R	Non-major	IA	8	19
376	PWS	Nauvoo Water Department	Public Water System	Direct Withdrawal of Mississippi	40.549059	-91.40233		L	PWS	IL	8	19
375.2	WWTP	Nauvoo STP	Municipal WWTP	Direct Discharge to Mississippi	40.541667	-91.398333	IL0023531	L	Non-major	IL	8	19
373.0	School	Nauvoo-Colusa High School	Elementary and Secondary Schools	Direct Discharge to Mississippi	40.529276	-91.372167	IL0060453	L	Non-major	IL	8	19
371.0	Freight	Hendricks River Logistics	Marine Cargo Handling	Lagoon to Mississippi	40.49646	-91.373495	IA0063045	R	Non-major	IA	8	19
368.7	WWTP	Sandusky Mobile Home Village	Package Plant	Direct Discharge to Mississippi	40.468718	-91.381469	IA0065391	R	Non-major	IA	8	19
368.6	Camp	Camp Eastman	Recreation and Sports Camp	Direct Discharge to Mississippi	40.46	-91.361667	IL0043117	L	Non-major	IL	8	19
365	PWS	Keokuk Municipal Water Works	Public Water System	Direct Withdrawal of Mississippi	40.403025	-91.374301		R	PWS	IA	8	19
364.2	Sewers	Hamilton City of STP	Sewerage System	Direct Discharge to Mississippi	40.463333	-91.355	IL0024911	L	Non-major	IL	8	19
364.0	WWTP	Hamilton City of WTP	Municipal WWTP	Direct Discharge to Mississippi	40.396694	-91.358306	IL0047651	L	Non-major	IL	8	19
364	PWS	Hamilton Water Department	Public Water System	Direct Withdrawal of Mississippi	40.390493	-91.366847		L		IL	8	19
364.5	Dam	**Lock and Dam 19**	Dam	**Major Impoundment**	40.390982	91.372644		R&L	**L&D**	IA/IL	8	19
364.0	Electric	Ameren UE Keokuk Plant	Electric Power Generation	Lagoon to Mississippi	40.392535	-91.376597	IA0033600	R	Non-major	IA	8	20
362.9	WWTP	Keokuk, City of STP	Municipal WWTP	Direct Discharge to Mississippi	40.386065	-91.385001	IA0042609	R	Major	IA	8	20
362.8	Corn	Roquette America, Inc.	Wet Corn Milling	Direct Discharge to Mississippi	40.387900	-91.397	IA0000256	R	Major	IA	8	20
361.3		**DES MOINES RIVER**	**River Mouth**	**Major Tributary**	40.380669	-91.421992		R	**Trib**	IA	9	20
360	PWS	Warsaw Water Department	Public Water System	Direct Withdrawal of Mississippi	40.365866	-91.436123		L	PWS	IL	9	20
342.3	WWTP	Quincy STP, City of	Municipal WWTP	Lagoon to Mississippi	39.901389	-91.432222	IL0030503	L	Major	IL	9	20
342.2	Dam	**Lock and Dam 20**	Dam	**Major Impoundment**	40.144077	-91.510848		R&L	**L&D**	MO/IL	9	20
341.2	WWTP	Canton City of WWTF	Municipal WWTP	Lagoon to Mississippi	40.114917	-91.513806	MO0056278	R	Non-major	MO	9	21
338.7	Golf Course	River Valley Country Club	Membership Sports and Recreation Club	Direct Discharge to Mississippi	40.079639	-91.507028	MO0087513	R	Non-major	MO	9	21
335.5	WWTP	Lagrange WWTF	Municipal WWTP	Direct Discharge to Mississippi	40.035806	-91.499417	MO0041203	R	Non-major	MO	9	21
327	PWS	Quincy Water Department	Public Water System	Direct Withdrawal of Mississippi	39.933523	-91.416054		L	PWS	IL	9	21
326.4	RR Terminal	BNSF West Quincy Yard	Railroad Yard	Direct Discharge to Mississippi	39.928218	-91.425018	MO0124770	R	Non-major	MO	9	21
325.5	Grain	Archer Daniels Midland Quincy	Soybean Processing	Lagoon to Mississippi	39.908333	-91.415	IL0003590	L	Non-major	IL	9	21
325.0	Dam	**Lock and Dam 21**	Dam	**Major Impoundment**	39.905701	-91.431148		R&L	**L&D**	MO/IL	9	21
324.7	WWTP	City of Quincy WWTF	Municipal WWTP	Lagoon to Mississippi	39.901389	-91.432222	IL0030503	L	Major	IL	10	22
321.0	Fertilizer	CF Industries Inc. Palmyra Terminal	Fertilizers - Mixing Only	Direct Discharge to Mississippi	39.8445559	-91.442556	MO0001821	R	Non-major	MO	10	22
319.7	Chemicals	BASF Hannibal Plant	Pesticides and Agricultural Chemicals	Direct Discharge to Mississippi	39.835028	-91.42875	MO0001716	R	Major	MO	10	22
309	PWS	Hannibal Water Department	Public Water System	Direct Withdrawal of Mississippi	39.708374	-91.358482		R		MO	10	22
308.8	WWTP	Hannibal WWTP	Municipal WWTP	Bear Creek to Mississippi	39.703167	-91.359	MO0085391	R	Non-major	MO	10	22
305.7	Cement	Continental Cement Company	Cement Manufacturing	Direct Discharge to Mississippi	39.6794439	-91.315694	MO0111686	R	Non-major	MO	10	22
301.2	Dam	**Lock and Dam 22**	Dam	**Major Impoundment**	39.638829	-91.244599		R&L	**L&D**	MO/IL	10	22
283	PWS	Louisiana Water Department	Public Water System	Direct Withdrawal of Mississippi	39.448496	-91.042308		R	PWS	MO	10	24
282.2	Water	Louisiana WTP	City WTP	Tributary to Mississippi	39.44525	-91.041611	MO0001597	R	Non-major	MO	10	24
282.2	WWTP	Louisiana WWTP	Municipal WWTP	Tributary to Mississippi	39.4454999	-91.04275	MO0023124	R	Non-major	MO	10	24
281.8	Quarry	SSS Inc.	Construction Sand & Limestone Mining	Direct Discharge to Mississippi	39.4362779	-91.030361	MO0127132	R	Non-major	MO	10	24
281.0	Fertilizer	Dyno Nobel Inc., Nitrogen Division	Nitrogenous Fertilizer Manufacturing	Direct Discharge to Mississippi	39.430417	-91.022556	MO0105783	R	Major	MO	10	24
281.0	Chemicals	MO Chemical Works	Industrial Organic Chemicals	Direct Discharge to Mississippi	39.431944	-91.018611	MO0000311	R	Major	MO	10	24
275.5	Cement	Holcim (US) Inc.	Cement Manufacturing	Lagoon to Mississippi	39.3789719	-90.941194	MO0000159	R	Non-major	MO	10	24
273.4	Dam	**Lock and Dam 24**	Dam	**Major Impoundment**	39.376091	-90.904587		R&L	**L&D**	MO/IL	10	24
272.0	WWTP	Clarksville WWTF	Municipal WWTP	Tributary to Mississippi	39.3575279	-90.892028	MO0039632	R	Non-major	MO	10	25
241.7	WWTP	US Army Corps of Engineers	Federal Government WWTP	Direct Discharge to Mississippi	39.003667	-90.715861	MO0029955	R	Non-major	MO	10	25
241.6	Dam	**Lock and Dam 25**	Dam	**Major Impoundment**	39.005963	-90.68426		R&L	**L&D**	MO/IL	10	25

Appendix Table B-1. List of NPDES permitted discharges, dams, and major tributaries to the Upper Mississippi River mainstem.

River Mile	Type	Source	Description	Characteristics	Latitude	Longitude	NPDES #	River R or L	Permit	State	CWA Reach	Pool
237.0		**CUIVRE RIVER**	**River Mouth**	**Major Tributary**	38.934319	-90.687014		R	**Trib**	MO	11	26
226.0	WWTP	Mississippi Wastewater Treatment Plant	Regional WWTP	Direct Discharge to Mississippi	38.876333	-90.519278	MO0058343	R	Major	MO	11	26
225.4	Club	Yacht Club of St. Louis	Amusement and Recreation Services	Direct Discharge to Mississippi	38.8887499	-90.503333	MO0101303	R	Non-major	MO	11	26
221.3	Club	Duck Club Marina	Amusement and Recreation Services	Direct Discharge to Mississippi	38.9351109	-90.473583	MO0111627	R	Non-major	MO	11	26
218.2	WWTP	Grafton STP	Municipal WWTP	Direct Discharge to Mississippi	38.968333	-90.426667	IL0029025	L	Non-major	IL	11	26
217.5		**ILLINOIS RIVER**	**River Mouth**	**Major Tributary**	39.985855	-91.432026		L	**Trib**	IL	11	26
217.0	Waterpark	Raging Rivers Waterpark	Amusement Park	Rice Hollow Creek to Mississippi	38.970833	-90.408333	IL0067971	L	Non-major	IL	11	26
214.0	WWTP	Principia College WWTP	School WWTP	Direct Discharge to Mississippi	38.95	-90.356667	IL0045462	L	Non-major	IL	11	26
212.5	WWTP	Portage Des Sioux	Municipal WWTP	Direct Discharge to Mississippi	38.928028	-90.344583	MO0107328	R	Non-major	MO	11	26
210.2	Club	Lockhaven Country Club	Membership Sports and Amusement Club	Direct Discharge to Mississippi	38.935	-90.298333	IL0044971	L	Non-major	IL	11	26
210	PWS	Ameren UE - Sioux Plant	Public Water System	Direct Withdrawal of Mississippi	38.920557	-90.042308		R	PWS	MO	11	26
209.7	Electric	Ameren MO Sioux Energy Center	Coal Powered Electricity Generation	Direct Discharge to Mississippi	38.909417	-90.292972	MO0000353	R	Major	MO	11	26
207.8	WWTP	Godfrey STP, City of	Municipal WWTP	Tributary to Mississippi	38.930833	-90.226944	IL0036421	L	Major	IL	11	26
205.0	Water	IL American Water Co. - Alton Plant	Water Supply	Direct Discharge to Mississippi	38.898889	-90.203056	IL0000299	L	Non-major	IL	11	26
204	PWS	Illinois-American Water, Alton	Public Water System	Direct Withdrawal of Mississippi	38.889892	-90.190486		L	PWS	IL	11	26
201.4	Steel	Alton Steel Inc.	Steel and Iron Mill	Lagoon to Mississippi	38.883889	-90.154722	IL0000612	L	Major	IL	11	26
200.7	Dam	**Mel Price Lock and Dam (26)**	Dam	**Major Impoundment**	38.869288	-90.153004		R&L	**L&D**	MO/IL	11	26
200	PWS	Olin Corp. - East Alton Plant	Public Water System	Direct Withdrawal of Mississippi	38.862518	-90.13647		L	PWS	IL	11	27
199.3	Water	East Alton WTP	Water Supply	Old Wood River to Mississippi	38.8775	-90.125833	IL0051357	L	Non-major	IL	11	27
199.3	Fertilizer	Koch Nitrogen - Wood River Terminal	Special Warehousing and Storage	Old Wood River to Mississippi	38.873333	-90.12	IL0070173	L	Non-major	IL	11	27
198.0	WWTP	Wood River STP, City of	Municipal WWTP	Direct Discharge to Mississippi	38.851667	-90.100556	IL0031852	L	Major	IL	11	27
197.8	Petroleum	BP Products - Wood River	Petroleum Bulk Storage and Terminals	Lagoon to Mississippi	38.841667	-90.108333	IL0000035	L	Non-major	IL	11	27
197.5	Petroleum	Buckeye Terminals LLC - Hartford Terminal	Petroleum Bulk Storage and Terminals	Direct Discharge to Mississippi	38.831699	-90.087097	IL0076465	L	Non-major	IL	11	27
197.5	Petroleum	Premier Refining Group Inc.	Petroleum Bulk Storage and Terminals	Tributary to Mississippi	38.8315	-90.082	IL0001244	L	Non-major	IL	11	27
197.5	WWTP	Hartford CSO	Municipal WWTP	Direct Discharge to Mississippi	38.831667	-90.106667	IL0021423	L	Non-major	IL	11	27
196.7	Freight	Marathon Pipeline LLC	Marine Cargo Handling	Direct Discharge to Mississippi	38.826667	-90.108056	IL0079669	L	Non-major	IL	11	27
195.1	Petroleum	Conoco Inc. - Wood River Terminal Tank	Petroleum Bulk Storage and Terminals	Cahokia Channel to Mississippi	38.813889	-90.091667	IL0071803	L	Non-major	IL	11	27
195.0		**MISSOURI RIVER**	**River Mouth**	**Major Tributary**	38.814675	-90.121717		R	**Trib**	MO	12	27
192	PWS	Illinois-American Water, Granite City	Public Water System	Direct Withdrawal of Mississippi	38.778496	-90.147173		L		IL	12	27
191.4	Refuse	Chain of Rocks Recycling and Disposal	Refuse Systems	Chouteau Slough to Mississippi	38.76214	-90.129514	IL0075523	L	Non-major	IL	12	27
191.2	Water	Chain of Rocks Water Treatment Plant	Water Supply	Direct Discharge to Mississippi	38.755556	-90.188806	MO0000604	R	Non-major	MO	12	27
190	PWS	City of St. Louis Water Department	Public Water System	Direct Withdrawal of Mississippi	38.662768	-90.185411		R	PWS	MO	12	27
186.2		**Lock and Dam 27**	Dam	**Major Impoundment**	38.703002	-90.181296		R&L	**L&D**	MO/IL	12	27
185.0	Railroad	Norfolk Southern Railway Co. - Luther Yard	Railroad Yard	Lagoon to Mississippi	38.6914719	-90.211444	MO0115568	R	Non-major	MO	12	27
185.0	Refuse	St. Louis Disposal Systems	Refuse Systems	Dardenne Creek to Mississippi	38.6905901	-90.216366	MO0136786	R	Non-major	MO	12	27
183.8	Electric	Center Point Energy Miss. River Transmission	Coal Powered Electricity Generation	Ditch to Mississippi	38.676111	-90.178889	IL0078794	L	Non-major	IL	12	27
183.8	WWTP	MSD - Bissell Point WWTP	Municipal WWTP	Lagoon to Mississippi	38.6763059	-90.191028	MO0025178	R	Major	MO	12	27
183.5	Water	IDOT District 8 Venice Pump Station	Water Supply	Direct Discharge to Mississippi	38.669444	-90.18	IL0071765	L	Non-major	IL	12	27
182.5	Electric	Ameren UE - Venice Power Plant	Coal Powered Electricity Generation	Direct Discharge to Mississippi	38.666667	-90.166667	IL0000175	L	Non-major	IL	12	27
181.7	Petroleum	The Kiesel Co. - Kiesel Marine	Petroleum Bulk Storage and Terminals	Direct Discharge to Mississippi	38.65789	-90.18562	MO0111805	R	Non-major	MO	12	27
181.7	WWTP	Saint Louis Terminals Co.	Municipal WWTP	Direct Discharge to Mississippi	38.651112	-90.183861	MO0113328	R	Non-major	MO	12	27
181.5	Power	Tractebel Power Inc.	Combination Utilities	Direct Discharge to Mississippi	38.636391	-90.181084	MO0000345	R	Non-major	MO	12	27
181	PWS	Illinois-American Water, East St.Louis	Public Water System	Direct Withdrawal of Mississippi	38.661737	-90.179252		L	PWS	IL	12	27
179.2	Freight	American River Transportation Co.	Marine Cargo Handling	Direct Discharge to Mississippi	38.621406	-90.191635	MO0134741	R	Non-major	MO	12	27
178.8	WWTP	East Saint Louis CSOS	Municipal WWTP	Direct Discharge to Mississippi	39.588333	-90.805	IL0033472	L	Non-major	IL	12	27

Appendix Table B-1. List of NPDES permitted discharges, dams, and major tributaries to the Upper Mississippi River mainstem.

River Mile	Type	Source	Description	Characteristics	Latitude	Longitude	NPDES #	River R or L	Permit	State	CWA Reach	Pool
177.4	WWTP	Sauget - ABRTF	Municipal WWTP	Direct Discharge to Mississippi	38.591944	-90.183889	IL0065145	L	Non-major	IL	12	27
177.2	Refuse	Veolia ES Technical Solutions	Refuse Systems	Tributary to Mississippi	38.586111	-90.186111	IL0071552	L	Non-major	IL	12	27
175.9	Petroleum	JD Streett and Co.	Petroleum Bulk Storage and Terminals	Direct Discharge to Mississippi	38.5819169	-90.218444	MO0121169	R	Non-major	MO	12	27
172.5	Freight	Louisiana Dock Co. LLC	Marine Cargo Handling	Direct Discharge to Mississippi	38.5389719	-90.2565	MO0001601	R	Non-major	MO	12	27
171.3	WWTP	MSD - Lemay WWTP	Municipal WWTP	Direct Discharge to Mississippi	38.5236939	-90.267083	MO0025151	R	Major	MO	12	27
171.3	Paint	Rockwood Pigments Inc.	Inorganic Pigments	Tributary to Mississippi	38.529873	-90.272431	MO0117307	R	Non-major	MO	12	27
168.6	Petroleum	JB Marine	Marine Gasoline Service	Direct Discharge to Mississippi	38.4859719	-90.279806	MO0119733	R	Non-major	MO	12	27
161.1	Electric	Ameren MO - Mermec Power Plant	Coal Powered Electricity Generation	Lagoon to Mississippi	38.401083	-90.332611	MO0000361	R	Major	MO	12	27
159.0	WWTP	Kimmswick WWTP	Municipal WWTP	Direct Discharge to Mississippi	38.3686939	-90.359778	MO0106461	R	Non-major	MO	12	27
158.7	WWTP	Glaize Creek Sewer District	Municipal WWTP	Direct Discharge to Mississippi	38.334194	-90.37525	MO0056162	R	Major	MO	12	27
153.5	RV Park	Teamsters Local 688	RV Parks and Campsites	Direct Discharge to Mississippi	38.2874999	-90.380583	MO0046736	R	Non-major	MO	12	27
151.6	Smelting	Doe Run Herculaneum Smelting	Smelting/Refining-Nonferrous Metal	Direct Discharge to Mississippi	38.261861	-90.37275	MO0000281	R	Major	MO	12	27
151.5	WWTP	Herculaneum WWTP	Municipal WWTP	Joachim Creek to Mississippi	38.254556	-90.374306	MO0027111	R	Non-major	MO	12	27
145.6	Cement	River Cement Co. - Selma	Cement Manufacturing	Cliffdale Hollow to Mississippi	38.1787779	-90.336944	MO0000035	R	Non-major	MO	12	27
144.5	Fertilizer	Laroche Industries Crystal City Nitrogen	Nitrogenous Fertilizer Manufacturing	Direct Discharge to Mississippi	38.163611	-90.321111	MO0000817	R	Major	MO	12	27
143.0	Electric	Ameren MO Rush Island Energy Center	Coal Powered Electricity Generation	Lagoon to Mississippi	38.133028	-90.262889	MO0000043	R	Major	MO	12	27
142.9	Cement	Holcim (US) Inc. STE Genevieve Plant	Cement Manufacturing	Tributary to Mississippi	38.104558	-90.299456	MO0133787	R	Major	MO	12	27
140	PWS	Ameren UE - Rush Island	Public Water System	Direct Withdrawal of Mississippi	38.139018	-90.265103		R	PWS	MO	12	27
127.2	Lime	Chemical Lime Co.	Lime Manufacturing	Direct Discharge to Mississippi	38.015333	-90.091167	MO0124044	R	Major	MO	12	27
127.0	Quarry	Tower Rock Stone Company	Crushed and Broken Limestone	Direct Discharge to Mississippi	38.00975	-90.095222	MO0135399	R	Non-major	MO	12	27
125.5	Freight	Kaskaskia Regional Port District	Marine Cargo Handling	Tributary to Mississippi	38.013056	-90.058056	IL0079545	L	Non-major	IL	12	27
120.5	Freight	Bigfield Terminal	Inland Water Freight Transportation	Lagoon to Mississippi	37.95925	-89.987472	MO0129186	R	Non-major	MO	12	27
122.5	WWTP	Ste Genevieve Sewage Treatment Plant	Municipal WWTP	N Gobouri Creek to Mississippi	37.9792779	-90.038222	MO0052159	R	Non-major	MO	12	27
117.5		**KASKASKIA RIVER**	**River Mouth**	**Major Tributary**	37.974899	-89.957538		L	**Trib**	IL	13	27
110	PWS	Chester Water Department	Public Water System	Direct Withdrawal of Mississippi	37.905587	-89.836664		L	PWS	IL	13	27
107.0	WWTP	Chester STP	Municipal WWTP	Direct Discharge to Mississippi	37.8875	-89.788333	IL0072931	L	Major	IL	13	27
103.0	Docking	Kinder Morgan Bulk Terminals	Port and Harbor Operations	Direct Discharge to Mississippi	37.806667	-89.671667	IL0060674	L	Non-major	IL	13	27
81.9	Electric	Ameren Corp Grand Tower Power Station	Coal Powered Electricity Generation	Direct Discharge to Mississippi	37.658056	-89.511667	IL0000124	L	Major	IL	13	27
75.7		**BIG MUDDY RIVER**	**River Mouth**	**Major Tributary**	37.573311	-89.517462		L	**Trib**	IL	13	27
69.8	Paper	Proctor & Gamble Paper Products	Paper Mill	Tributary to Mississippi	37.479028	-89.508611	MO0044121	R	Major	MO	13	27
54	PWS	Alliance Water Resources, Cape Girardeau	Public Water System	Direct Withdrawal of Mississippi	37.325	-89.497431		R	PWS	MO	13	27
50.1	WWTP	Cape Girardeau Waste Water Treatment Plant	Municipal WWTP	Direct Discharge to Mississippi	37.2769719	-89.527306	MO0050580	R	Major	MO	13	27
50.0	Herbs	Biokyowa	Medicinal and Botanical Manufacturing	Direct Discharge to Mississippi	37.271889	-89.528694	MO0102474	R	Non-major	MO	13	27
49.0	Cement	Buzzi Unicem USA - Cape Girardeau	Cement Manufacturing	Direct Discharge to Mississippi	37.2546669	-89.536194	MO0000809	R	Major	MO	13	27
48.5	Freight	SE MO Regional Airport	Marine Cargo Handling	Direct Discharge to Mississippi	37.24675	-89.506	MO0120421	R	Non-major	MO	13	27
48.0	Mill	MO Fibre Corporation	Wood Products	Direct Discharge to Mississippi	37.246083	-89.491806	MO0120642	R	Non-major	MO	13	27
44.4	Petroleum	Cape Girardeau Terminal	Pipeline Transfer of Petroleum Products	Direct Discharge to Mississippi	37.2278609	-89.48075	MO0119300	R	Non-major	MO	13	27

Appendix Table B-2. Public water utilities that draw water directly from the UMR (adapted from UMR Water Suppliers Coaltion Summary, 2006).

Facility	State	Inerstate Assessment Reach	Approximate River Mile	Est. Population Served*	Data Source
St Cloud WTP	MN	N/A	928	59,107	2
St Paul Water Services	MN	N/A	863	287,151	2
Minneapolis Water Works	MN	N/A	859	382,618	2
E. Moline Water Department	IL	7	490	20,333	2
Moline Water Department	IL	7	486	43,678	1
Iowa-American Water, Davenport	IA	7	484	138,024	1
Rock Island Water Department	IL	7	483	39,684	2
Rock Island Arsenal	IL	7	483	7,800	3
Burlington Municipal Water Works	IA	8	405	35,000	1
Fort Madison Municipal Water Works	IA	8	384	10,715	2
Nauvoo Water Department	IL	8	376	1,063	2
Keokuk Municipal Water Works	IA	8	365	11,427	2
Hamilton Water Department	IL	8	364	3,029	2
Warsaw Water Department	IL	9	360	1,793	2
Quincy Water Department	IL	9	327	40,366	2
Hannibal Water Department	MO	10	309	17,757	2
Louisiana Water Department	MO	10	283	3,863	2
Ameren UE - Sioux Plant	MO	11	210	*(Not determined -single facility)*	
Illinois-American Water, Alton	IL	11	204	85,000	1
Olin Corp. - East Alton Plant	IL	11	200	3,000	1
Illinois-American Water, Granite City	IL	12	192	31,301	2
City of St. Louis Water Department	MO	12	190	348,169	2
Illinois-American Water, East St.Louis	IL	12	181	31,542	2
Ameren UE - Rush Island	MO	12	140	*(Not determined - single facility)*	
Chester Water Department	IL	13	110	8,702	3
Alliance Water Resources, Cape Girardeau	MO	13	54	35,349	2
Total				1,646,471	

(1) Water Utility

(2) 2000 US census

(3) SDWIS

*Does not include populations of indirectly served systems.

Appendix C: Upper Mississippi River Intensive Pollution Survey Design Delineation

As described in Chapter 5, an intensive pollution survey is defined in the UMR Strategy as a spatially intensive sampling design of a contiguous river reach over an extended distance. In this appendix, a pollution survey design is detailed for the UMR. This design is dependent on an initial inventory of potential sources of human and natural influences prior to allocating sampling sites and allocating indicators and parameters. As such, a comprehensive inventory was conducted for the UMR and used to developing an initial allocation of sampling sites (Appendix Table C-1). A final allocation is confirmed during the development of a detailed plan of study that takes place immediately prior to initiating sampling on an annual basis. This process also follows the allocation of core and supplemental indicators in Table 4 of Chapter 6 of the Strategy, but also uses the results of the detailed stressor inventory so that supplemental indicators can be added in a more judicious manner.

MBI used the U.S. EPA Enviromapper[1] tool for an initial inventory of point sources. Locks and dams and tributaries were also included and all sources are indexed to the U.S. Army Corps of Engineers river mileage available from the Upper Mississippi River navigation charts[2]. These were then positioned in order from upstream to downstream with notations as to position in terms of coordinates and left or right bank (looking downstream). NPDES permit numbers are included for permitted point sources (from Appendix B-1 of the Strategy). Public water supply intakes (from Appendix B-2 of the Strategy) were also included as sampling upstream of these facilities fulfills addressing the public water supply use and can affect the inclusion of supplemental parameters. The UMR navigation pool and CWA assessment reach is also indicated for each site.

The result of this process is the UMR Master Survey Design table (Appendix Table C-1) that represents the initial allocation of intensive pollution survey sites for the main and side channel strata. Each site is assigned an alpha-numeric site code that is ordered from upstream to downstream for the entirety of the UMR. The initial allocation resulted in 395 sites and these are depicted in accordance with their role and function and by CWA assessment reach in Appendix Table C-1. These will potentially be refined via the detailed study planning phase that precedes the actual sampling on an annual basis. When resources are estimated for this design it will include a 10% contingency for adding sites (≈40 sites) based on the detailed study planning in which the sources will be verified and refined. As a result this design is expected to include more than 400 total sites.

The Master Survey Design table deliberately incorporated the existing fixed station network and the 2004-6 GRE sites. The fixed stations were included to supply chemical/physical data so as to maintain that design and add the pollution survey design. The 2004-6 GRE sites were included as an approximation of the site density expected for the Probabilistic B and C options

[1] http://www.epa.gov/emefdata/em4ef.home
[2] http://www2.mvr.usace.army.mil/NIC2/mrcharts.cfm

and to demonstrate the flexibility to co-mingle aspects of the probabilistic designs for pollution survey purposes. Pollution survey sites were positioned immediately downstream from individual point sources and clusters of closely packed multiple point sources and along the side of the river that the discharges most influence. These sites were characterized as impact and recovery sites. In some reaches sites were positioned on the opposite bank to serve as a more representative far-field or "control" site for that reach. It was also apparent that some sites would need to be positioned in the impounded lateral strata and that will be addressed in the detailed study planning phase of implementation. Core biological, physical, and chemical parameters are denoted under the Site Type column in Appendix Table C-1. This phase of the design does not yet address the issue of supplemental indicators, but their inclusion will be influenced by the number and types of sources of stress and influence.

Maps of the pollution survey sites and sources of stress and influence were produced for each pool and for several sections of the Open River at a 1:250000 scale and are included as Figures C-1 through C-18. Sampling sites are indicated by triangles and are color coded by fixed station, GRE, or pollution survey site designation. Sources of stress and influence are indicated by diamond symbols and are color coded for dams, tributaries, public water supply, and major and non-major permitted point sources. Sites are currently positioned along the centerline of the navigation channel thus right and left bank assignments are indicated only in the UMR Master Survey Design table.

The allocation of sites is non-random and was done to populate the expected and/or potential pollution gradients in the UMR main channel. Side channel sites were added in accordance with the occurrence of this lateral stratum, which also was non-random in its occurrence along the UMR. The following summarizes the membership and characteristics of the intensive pollution survey design option (after Table 1):

- 50 major and 143 minor NPDES permitted discharges were determined to discharge to the UMR main or side channel strata; 23 public water supply intakes were determined and sites are positioned to assess indicators and parameters of importance to the water supply use;
- 16 sites are located in major tributaries and will be located within 2 km of the UMR confluence – these do not necessarily correspond to the Sentinel Sites network locations;
- 67 sites are at fixed stations - not all fixed stations were used especially where there were multiple fixed stations in close proximity;
- 126 sites are 2004-6 GRE sites and most of these function as far-field sites;
- 139 sites are direct impact sites being located immediately downstream from a point source, urban influence, or a dam tailwater;
- 44 sites are depicted as recovery sites and are located downstream from impact sites along the expected recovery continuum;
- 148 sites are depicted as far-field sites and are outside the immediate influence of known sources and complete the longitudinal aspect of the river continuum; and,

Table 1. The occurrence of stressors and intensive pollution survey sites by role and function within the 13 CWA assessment reaches for the interstate UMR.

CWA Assessment Reach	NPDES Major	NPDES Minor	Major Tributary	Public Water Supply	Fixed Stations *	GRE Sites	Impact Sites	Recovery Sites	Far-field Sites	Side Channel Sites
1 St. Croix to Chippewa R. (RM 763-812) 49 mi.	3	8	1	0	12	12	8	2	15	0
2 Chippewa R. to L&D 6 (RM 714-763) 49 mi.	1	5	1	0	7	19	8	1	21	2
3 L&D 6 to Root R. (RM 694-714) 20 mi.	1	4	2	0	8	4	6	1	6	1
4 Root R. to Wisconsin R. (RM 631-694) 63 mi.	3	8	1	0	5	13	10	5	11	1
5 Wisconsin R. to L&D 11 (RM 583-631) 48 mi.	1	6	1	0	1	7	8	5	3	1
6 L&D 11 to L&D 13 (RM 523-583) 60 mi.	1	11	1	0	7	14	12	7	6	3
7 L&D 13 to Iowa R. (RM 434-523) 89 mi.	12	27	2	5	3	11	32	9	10	14
8 Iowa R. to Des Moines R. (RM 361-434) 73 mi.	4	13	1	5	3	12	13	2	11	3
9 Des Moines R. to L&D 21 (RM 325-361) 36 mi.	1	5	1	2	1	3	5	0	7	3
10 L&D 21 to Cuirve R. (RM 237-325) 88 mi.	4	9	0	2	1	14	11	3	19	9
11 Cuirve R. to Missouri R. (RM 196-237) 41 mi.	5	16	2	3	8	5	8	2	9	4
12 Missouri R. to Kaskaskia R. (RM 118-196) 78 mi.	9	26	1	4	1	6	14	4	11	3
13 Kaskaskia R. to Ohio R. (RM 0-118) 118 mi.	5	5	2	2	10	16	4	3	19	4
TOTALS	50	143	16	23	67	126	139	44	148	48

*Not all existing fixed stations included, as some were in very close proximity to others that were included.

- 48 sites are located in side channels to represent an assessment of that lateral stratum.

Defining the role of each survey site is important for post-survey data analysis purposes and provides a degree of flexibility in reporting at multiple scales. For example, concerns about this design being biased towards impacted sites could be tested by excluding the impact sites from reach or pool level assessments of condition. This is in contrast with the probability design options that would only include impact sites if the random site draw actually included them. Another observation with the pollution survey design and the inventory of stressors that supports it is the non-random occurrence of stressors and side channel sites throughout the UMR (Appendix Table C-1). For example, 23 of the 48 side channel sites occur in two CWA reaches (7 and 10) and one reach had 0 sites, an indication of the non-random occurrence of this stratum. NPDES permitted discharges showed a similar pattern with 21 of 50 major discharges occurring in two assessment reaches (7 and 9). These inherently reflect the character of the UMR and the concentration of anthropogenic impacts which is what this design is intended to quantify.

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
		812.5	UMR	F,M,S,H,C	UMR 1[a]	UMR - ust. St. Croix confluence	Background site	44.750489	-92.824903	R	MN	0	3
811.3		811.3	UMR	F,M,S,H,C	SCR 1[b]	St. Croix R. at mouth	Within 2.0 km of mouth	44.747184	-92.803427	L	WI	1	3
1335.660593		811.0	EPA	F,M,S,H,C	UMR 2	GRE Site[c] - dst. St. Croix	Assess St. Croix influence on UMR	44.74593	-92.802622	L	WI	1	3
WI0022403	Non-major	810.7		WWTP		Prescott (WI) WWTP	Municipal WWTP	44.743102	-92.793269	L	WI	1	3
		810.5	UMR	F,M,S,H,C	UMR 3	Dst. Prescott WWTP	WWTP impact zone	44.738002	-92.789565	L	WI	1	3
1322.764957		803.0	EPA	F,M,S,H,C	UMR 4	GRE Site	Far-field survey site	44.675199	-92.679289	L	WI	1	3
1320.713349		802.0	EPA	F,M,S,H,C	UMR 5	GRE Site	Far-field survey site	44.661244	-92.662645	R	MN	1	3
MN0061336	Non-major	800.0		WWTP		Prairie Is. Tribal WWTP	Municipal WWTP	44.629559	-92.660322	R	MN	1	3
MN0004006	Major	798.0		EGS		Xcel Energy NSP-Prairie Island EGS	Nuclear energy plant	44.622278	-92.635194	R	MN	1	3
		797.6	UMR	F,M,S,H,C	UMR 7	Across channel from Prairie Island EGS	Cross channel site from EGS	44.614306	-92.621356	L	MN	1	3
		797.5	UMR	F,M,S,H,C	UMR 6	Dst. Prairie Island EGS	EGS impact zone	44.613286	-92.61998	R	MN	1	3
		796.9	UMR	F,M,S,H	UMR 8	Immediately ust. L&D 3	EGS impact & recovery site	44.609204	-92.605919	R	MN	1	3
		796.9	WDNR	C		Fixed Sta.[d]	Fixed station provides chemical data	44.611944	-92.61	L	WI	1	3
M796.9M		796.9	LTRMP	C		Fixed Sta.	Not included in polllution survey	44.61161	-92.60872	R	MN	1	3
M796.9N		796.9	LTRMP	C		Fixed Sta.	Not included in polllution survey	44.61289	-92.60929	R	MN	1	3
796.9		**796.9**		**Dam**		**Lock & Dam 3**	**Dam**	**44.743102**	**-92.793269**	**R&L**	**MN/WI**	**1**	**3**
		796.6	MCES	C	UMR 8	Fixed Sta.	Fixed station provides chemical data	44.609204	-92.605919	R	MN	1	4
1310.985139		796.0	EPA	F,M,S,H,C	UMR 9	GRE Site; dst. L&D 3 (tailwaters)	Tailwater site assessment	44.606696	-92.592461	R	MN	1	4
CN00.1M		795.7	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	44.601526	-92.593345			1	4
VM00.1M		795.7	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	44.510538	-92.323947			1	4
		793.2	UMR	F,M,S,H,C	UMR 9.1	Side channel survey site	Side channel lateral strata assessment	44.593363	-92.553885			1	4
		792.0	UMR	F,M,S,H,C	UMR 10	Ust. 3 discharges	Far-field survey site; ust. Discharges	44.574988	-92.549985	R	MN	1	4
MN0024571	Major	791.1		WWTP		Red Wing WWTP	Municipal WWTP	44.571389	-92.528194	R	MN	1	4
MN0000850	Non-major	791.0		EGS		Xcel Energy NSP-Red Wing EGS	Nuclear energy plant	44.569528	-92.516444	R	MN	1	4
		790.9	UMR	F,M,S,H,C	UMR 11	Dst. Red Wing WWTP & EGS	WWTP & EGS impact zone	44.567173	-92.539342	R	MN	1	4
		790.8	UMR	F,M,S,H,C	UMR 12	Across channel Red Wing WWTP&EGS	Cross channel site from WWTP & EGS	44.56787	-92.537563	L	WI	1	4
WI0032361	Non-major	790.5		WWTP		Maiden Rock WWTF	Municipal WWTP	44.5673	-92.31987	L	WI	1	4
		790.0	UMR	F,M,S,H,C	UMR 13	Dst. Maiden Rock WWTP	WWTP impact zone	44.574797	-92.52397	R	MN	1	4
M787.6H		787.6	LTRMP	C	UMR 14	Fixed Sta.	Fixed station provides chemical data	44.568158	-92.479878	L	WI	1	4
		787.6	UMR	F,M,S,H	UMR 14	Far-field survey site - at fixed station	Far-field survey site	44.568158	-92.479878	L	WI	1	4
M786.2C		786.2	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	44.56235	-92.44873	L	WI	1	4
1300.247187		785.0	EPA	F,M,S,H,C	UMR15	GRE Site - far-field survey site	Far-field survey site	44.578748	-92.497028	L	WI	1	4
M781.2O		781.2	LTRMP	C	UMR 16	Fixed Sta.	Fixed station provides chemical data	44.54377	-92.355539	L	WI	1	4
		781.2	UMR	F,M,S,H	UMR16	Far-field survey site - at fixed station	Far-field survey site	44.54377	-92.355539	L	WI	1	4
WC00.8M		778.5	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	44.510538	-92.323947			1	4
1277.881843		776.0	EPA	F,M,S,H,C	UMR 17	GRE Site - far-field survey site	Far-field survey site	44.493018	-92.298988	L	WI	1	4
M775.6Q		775.6	LTRMP	C	UMR 18	Fixed Sta.	Fixed station provides chemical data	44.489741	-92.28504	L	WI	1	4
		775.6	UMR	F,M,S,H	UMR18	Far-field survey site - at fixed station	Far-field survey site	44.489741	-92.28504	L	WI	1	4
1273.85232		774.0	EPA	F,M,S,H,C	UMR 19	GRE Site - far-field survey site	Far-field survey site	44.46776	-92.264594	R	MN	1	4
MN0001147	Non-major	772.0		Industry		Federal Mogul Powertrain Systems	Motor Vehicle Parts and Accessories	44.445861	-92.275889	R	MN	1	4
WI0040223	Non-major	772.0		EGS		Dairyland Power Coop Power Plant	Electric Power Generation	44.304167	-91.911389	L	WI	1	4
MN0024571	Major	771.5		WWTP		Lake City WWTP	Municipal WWTP	44.437944	-92.261528	R	MN	1	4
		771.5	UMR	F,M,S,H	UMR 20	Dst. 1 discharge - WI side	Discharge impact zone	44.449254	-92.22634	L	WI	1	4
MN0003441	Non-major	771.3		Industry		Cytec Engineered Materials	Coated Fabrics	44.05	-91.6	R	MN	1	4
M771.2P		771.2	LTRMP	C	UMR 20	Fixed Sta.	Fixed station provides chemical data	44.449254	-92.22634		MN	1	4
		771.2	UMR	F,M,S,H	UMR 21	Dst. 3 discharges - MN side	Discharge impact zone - MN side	44.449254	-92.22634	R	MN	1	4
1265.888831		769.0	EPA	F,M,S,H,C	UMR 22	GRE Site - dst. MN discharges	Recovery zone dst. MN discharges	44.431613	-92.185254	R	MN	1	4
1264.359019		768.0	EPA	F,M,S,H,C	UMR 23	GRE Site - far-field survey site	Far-field survey site	44.42855	-92.16727	R	MN	1	4
WI0022811	Non-major	767.5		WWTP		Pepin Wastewater Treatment Plant	Municipal WWTP	44.433333	-92.133333	L	WI	1	4
1262.626157		767.0	EPA	F,M,S,H,C	UMR 24	GRE Site - dst. Pepin WWTP	WWTP impact zone	44.42522	-92.14661	L	WI	1	4
M766.0I		766.0	LTRMP	C	UMR 25	Fixed Sta.	Fixed station provides chemical data	44.41878	-92.133532	L	WI	1	4
1260.822611		766.0	EPA	F,M,S,H	UMR 25	GRE Site - far-field survey site	Far-field survey site	44.4228	-92.12445	L	WI	1	4
M764.3A		764.3	LTRMP	C	UMR 26	Fixed Sta.	Fixed station provides chemical data	44.410644	-92.099024	R	MN	1	4
1258.554291		764.0	EPA	F.M.S.H	UMR 26	GRE Site - ust. Chippewa R.	Far-field survey site	44.41336	-92.10059	R	MN	1	4
CH00.1M		763.5	LTRMP	C	CHP 2	Chippewa R. at mouth	Fixed station provides chemical data	44.407097	-92.084844	L	WI	2	4
763.5		763.5	UMR	F,M,S,H	CHP 2	Chippewa R. at mouth	Within 2.0 km of mouth	44.407279	-92.083435	L	WI	2	4
1256.577575		763.0	EPA	F,M,S,H,C	UMR 27	GRE Site - dst. Chippewa R.	Assess Chippewa R. influence on UMR	44.40597	-92.07935	L	WI	2	4
1255.396229		762.0	EPA	F,M,S,H,C	UMR 28	GRE Site - far-field survey site	Far-field survey site	44.40479	-92.06539	L	WI	2	4
1254.692704		761.9	EPA	F,M,S,H,C	UMR 29	GRE Site - far-field survey site	Far-field survey site	44.40361	-92.05703	R	MN	2	4

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
1249.121698		759.0	EPA	F,M,S,H,C	UMR 30	GRE Site - far-field survey site	Far-field survey site	44.377	-92.00164	L	WI	2	4
1248.262693		758.0	EPA	F,M,S,H,C	UMR 31	GRE Site - far-field survey site	Far-field survey site	44.371431	-91.993333	R	MN	2	4
M757.2Z		757.2	LTRMP	C	UMR 32	Fixed Sta.	Fixed station provides chemical data	44.368405	-91.978936	L	WI	2	4
1246.137696		757.0	EPA	F,M,S,H,C	UMR 32	GRE Site - at fixed sta.	Far-field survey site	44.36553	-91.96919	R	MN	2	4
1244.97997		756.0	EPA	F,M,S,H,C	UMR 33	GRE Site - far-field survey site	Far-field survey site	44.35861	-91.95885	L	WI	2	4
1241.640471		754.0	EPA	F,M,S,H,C	UMR 34	GRE Site - far-field survey site	Far-field survey site	44.33442	-91.936548	L	WI	2	4
M753.1X		753.1	LTRMP	C	UMR 35	Fixed Sta.	Fixed station provides chemical data	44.32916	-91.92144	R	MN	2	4
		753.1	UMR	F,M,S,H	UMR 35	Far-field survey site - at fixed station	Far-field survey site	44.32916	-91.92144	R	MN	2	4
		752.8	WDNR	C	UMR 38	Fixed Sta.	Fixed station provides chemical data	44.325114	-91.918904	L	WI	2	4
		752.8	UMR	F,M,S,H	UMR 36	Far-field survey site - at fixed station	Far-field survey site; impounded effect	44.325114	-91.918904	L	WI	2	4
M752.8Z		752.8	LTRMP	C			Not included in polllution survey	44.32458	-91.91929	L	WI	2	4
M752.8M		752.8	LTRMP	C			Not included in polllution survey	44.41092	-92.11186	L	WI	2	4
M752.8Y		752.8	LTRMP	C			Not included in polllution survey	44.32458	-91.91929	L	WI	2	4
752.8	**L&D**	**752.8**		**Dam**		**Lock & Dam 4**	**Dam**	**44.324657**	**-91.922226**	**R&L**	**MN/WI**	**2**	**4**
		752.7	UMR	F,M,S,H,C	UMR 37	Dst. L&D 4 - tailwaters	Tailwater site assessment	44.323802	-91.918145	R	MN	2	5
WI0022101	Non-major	751.8		WWTP		Alma Wastewater Treatment Plant	Municipal WWTP	44.325	-91.916667	L	WI	2	5
1234.657495		750.0	EPA	F,M,S,H,C	UMR 38	GRE Site - dst. Alma WWTP	WWTP impact zone	44.284561	-91.916124	L	WI	2	5
		748.8	UMR	F,M,S,H,C	UMR 39.1	Side channel survey site	Side channel lateral strata assessment	44.272395	-91.915695			2	5
M747.3R		747.3	LTRMP	C	UMR 39	Fixed Sta.	Fixed station provides chemical data	44.261573	-91.895133	L	WI	2	5
		747.3	UMR	F,M,S,H	UMR 39	Far-field survey site - at fixed station	Recovery zone dst. WWTP	44.261573	-91.895133	L	WI	2	5
1230.927904		747.0	EPA	F,M,S,H,C	UMR 40	GRE Site - far-field survey site	Far-field survey site	44.2608	-91.89359	R	MN	2	5
1229.218131		746.0	EPA	F,M,S,H,C	UMR 41	GRE Site - far-field survey site	Far-field survey site	44.24703	-91.88846	R	MN	2	5
M743.0E		743.0	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	44.203481	-91.880297	R	MN	2	5
1224.057724		743.0	EPA	F,M,S,H,C	UMR 42	GRE Site - at fixed sta.	Far-field survey site	44.203832	-91.875472	L	WI	2	5
M738.2T		738.2	LTRMP	C		Fixed Sta.	Not included in polllution survey	44.161739	-91.806996			2	5
M738.2M		738.2	LTRMP	C		Fixed Sta.	Not included in polllution survey	44.159903	-91.808784			2	5
M738.2F		738.2	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	44.16033	-91.81136	R	MN	2	5
		738.2	UMR	F,M,S,H	UMR 43	Far-field survey site - at fixed station	Far-field survey site; impounded effect	44.160535	-91.812727	R	MN	2	5
738.1	**L&D**	**738.1**		**Dam**		**Lock & Dam 5**	**Dam**	**44.324657**	**-91.809663**	**R&L**	**MN/WI**	**2**	**5**
S000-287		738.0	MPCA	C	UMR 44	Fixed Sta.	Fixed station provides chemical data	44.15530697	-91.8005805	R	MN	2	5A
		737.5	UMR	F,M,S,H	UMR 44	Dst. L&D 5 - tailwaters	Tailwater site assessment	44.15530697	-91.8005805	R	MN	2	5A
1214.109358		737.0	EPA	F,M,S,H,C	UMR 45	GRE Site - far-field survey site	Far-field survey site	44.1507	-91.78376	L	WI	2	5A
1212.446553		736.0	EPA	F,M,S,H,C	UMR 46	GRE Site - far-field survey site	Far-field survey site	44.14305	-91.76677	L	WI	2	5A
1210.261036		734.0	EPA	F,M,S,H,C	UMR 47	GRE Site - far-field survey site	Far-field survey site	44.1349	-91.74322	R	MN	2	5A
1207.204011		732.0	EPA	F,M,S,H,C	UMR 48	GRE Site - far-field survey site	Far-field survey site	44.121515	-91.711402	L	WI	2	5A
WI0024040	Non-major	729.5		WWTP		Fountain City WWTP	Municipal WWTP	44.133333	-91.716667	L	WI	2	5A
		729.3	UMR	F,M,S,H,C	UMR 49	Dst. Fountain City WWTP	WWTP impact zone	44.096926	-91.68038	L	WI	2	5A
728.5	**L&D**	**728.5**		**Dam**		**Lock & Dam 5A**	**Dam**	**43.996433**	**-91.441324**	**R&L**	**MN/WI**	**2**	**5A**
		728.4	UMR	F,M,S,H	UMR 50	Dst. L&D 5A - tailwaters	Tailwater site assessment	44.082142	-91.664169	R	MN	2	6
		728.0	MPCA	C	UMR 50	Fixed Sta.	Fixed station provides chemical data	44.082142	-91.664169	R	MN	2	6
		726.6	UMR	F,M,S,H,C	UMR 50.1	Side channel survey site	Side channel lateral strata assessment	44.068558	-91.644728	L	WI	2	6
1196.416437		726.0	EPA	F,M,S,H,C	UMR 51	GRE Site - ust. Industries	Ust. Discharges	44.057492	-91.639499	R	MN	2	6
MN0053350	Non-major	724.7		Industry		RTP Co.	Compounding of Plastic Resins	44.05	-91.619833	R	MN	2	6
MN0001325	Non-major	723.6		Industry		Peerless Chain Co.	Chain Manufacturing Plant	44.03775	-91.605056	R	MN	2	6
1191.56243		723.0	EPA	F,M,S,H,C	UMR 52	GRE Site - dst. industries	Discharge impact zone	44.033512	-91.595479	R	MN	2	6
MN0030147	Major	721.9		WWTP		Winona WWTP	Municipal WWTP	44.032194	-91.603361	R	MN	2	6
		721.7	UMR	F,M,S,H,C	UMR 53	Dst. Winona WWTP	WWTP impact zone	44.026661	-91.575021	R	MN	2	6
1186.452595		720.0	EPA	F,M,S,H,C	UMR 54	GRE Site - far-field survey site	Far-field survey site	44.021736	-91.536239	L	WI	2	6
		719.0	UMR	F,M,S,H,C	UMR 55	Far-field site - dst. Winona WWTP	Far-field survey site	44.021372	-91.521483	R	MN	2	6
		714.5	UMR	F,M,S,H,C	UMR 56	Far-field site - ust. L&D 6; WWTP	Far-field survey site	44.001814	-91.441497	L	WI	2	6
WI0020966	Non-major	714.1		WWTP		Trempealeau WWTP	Municipal WWTP	44.002778	-91.430556	L	WI	2	6
714.1	**L&D**	**714.1**		**Dam**		**Lock and Dam 6**	**Dam**	**43.996440**	**-91.441418**	**R&L**	**MN/WI**	**2**	**6**
S000-095		714.0	MPCA	C	UMR 57	Fixed Sta.	Fixed station provides chemical data	43.997321	-91.433298	R	MN	3	7
		714.0	UMR	F,M,S,H	UMR 57	Dst. L&D 6 - tailwaters	Tailwater site assessment	43.997321	-91.433298	R	MN	3	7
		713.9	UMR	F,M,S,H,C	UMR 58	Dst. L&D 6; Trempealeau WWTP	WWTP impact zone	43.996413	-91.431956	L	WI	3	7
		709.0	UMR	F,M,S,H,C	UMR 59	Far-field site - dst. Trempealeau WWTP	Recovery from WWTP impacts	43.941677	-91.373706	L	WI	3	7
WI0054500	Non-major	706.6		Industry		Metallics, Inc.	Metal Coating Plant	43.916389	-91.268333	L	WI	3	7
		706.4	UMR	F,M,S,H,C	UMR 60	Dst. Metallics, Inc.	Discharge impact zone	43.911954	-91.346898	L	WI	3	7
1162.75483		705.0	EPA	F,M,S,H,C	UMR 61	GRE Site - far-field survey site	Far-field survey site	43.89605	-91.33334	R	MN	3	7

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
1161.547125		704.0	EPA	F,M,S,H,C	UMR 62	GRE Site - far-field survey site	Far-field survey site	43.888981	-91.322061	R	MN	3	7
1159.94569		703.0	EPA	F,M,S,H	UMR 63	GRE Site - ust. L&D 7	Far-field survey site; impounded effect	43.876427	-91.313031	R	MN	3	7
M702.7T		702.7	LTRMP	C	UMR 63	Fixed Sta.	Fixed station provides chemical data	43.868335	-91.312101	R	MN	3	7
M702.5B		702.5	LTRMP	C		Fixed Sta.	Not included in polllution survey	43.867167	-91.307406			3	7
702.5	**L&D**	**702.5**		**Dam**		**Lock and Dam 7**	**Dam**	**43.866937**	**-91.307242**	**R&L**	**MN/WI**	**3**	**7**
		702.3	UMR	F,M,S,H	UMR 63.1	Dst. L&D 7 - tailwaters	Tailwater site assessment	43.86363	-91.3068	L	WI	3	8
M701.1F		701.1	LTRMP	C	UMR 63.1	Fixed Sta.	Fixed station provides chemical data	43.847503	-91.297045	L	WI	3	8
M701.1D		701.1	LTRMP	C	UMR 63.1	Fixed Sta.	Fixed station provides chemical data	43.847476	-91.295241	L	WI	3	8
M701.1B		701.1	LTRMP	C	UMR 63.1	Fixed Sta.	Fixed station provides chemical data	43.84868	-91.29332	L	WI	3	8
		701.1	UMR	F,M,S,H	UMR 64	Far-field survey site - at fixed station	Far-field survey site	43.849329	-91.295572	L	WI	3	8
WI0045756	Non-major	700.5		WWTP		National Biological Service	Fish Hatchery	43.8	-91.245	L	WI	3	8
WI0070785	Non-major	699.5		EGS		French Island Power EGS	Electric Power Generation	43.833333	-91.25	L	WI	3	8
		699.0	UMR	F,M,S,H,C	UMR 65	Dst. French Island EGS	EGS impact zone	43.826044	-91.269781	L	WI	3	8
		698.9	UMR	F,M,S,H,C	UMR 64.1	Side channel survey site	Side channel lateral strata assessment	43.820885	-91.273799	R	MN	3	8
698.2		698.2	UMR	F,M,S,H,C	BLR1	Black R.	Within 2.0 km of mouth	43.827596	-91.258098	L	WI	3	8
698.2		698.2	UMR	F,M,S,H,C	LCR1	La Crosse River	Within 2.0 km of mouth	43.818597	-91.255956	L	WI	3	8
S000-067		698.0	MPCA	C	UMR 66	Fixed sta.	Fixed station provides chemical data	43.81528	-91.257998	R	MN	3	8
		698.0	UMR	F,H,M,H	UMR 66	Far-field survey site - at fixed station	Far-field survey site	43.81528	-91.257998	R	MN	3	8
WI0028487	Non-major	697.6		WWTP		Barron Island WWTP	Municipal WWTP	43.75	-91.116667	L	WI	3	8
WI0029581	Major	697.0		WWTP		La Crosse WWTP	Municipal WWTP	43.800556	-91.257222	L	WI	3	8
M696.5D		696.5	LTRMP	C	UMR 67		Fixed station provides chemical data	43.794288	-91.262625	L	WI	3	8
		696.5	UMR	F,M,S,H	UMR 67	Dst. WWTPs - at fixed sta.	WWTP impact zone	43.794288	-91.262625	L	WI	3	8
M696.3B		696.3	LTRMP	C	UMR 67	Fixed sta.	Fixed station provides chemical data	43.79212	-91.261657	L	WI	3	8
1147.834506		696.0	EPA	F,M,S,H,C	UMR 68	GRE Site - far-field survey site	Far-field survey site	43.785499	-91.255207	L	WI	3	8
693.6		693.6	UMR	F,M,S,H,C		Root River	Within 2.0 km of mouth	43.780903	-91.251452	R	MN	4	8
M691.3B		691.3	LTRMP	C	UMR 69	Fixed Sta.	Fixed station provides chemical data	43.726236	-91.256056	R	MN	4	8
		691.3	UMR	F,M,S,H	UMR 69	Far-field survey site - at fixed station	Far-field survey site	43.726236	-91.256056	R	MN	4	8
M690.8B		690.8	LTRMP	C		Fixed Sta.	Not included in polllution survey	43.719294	-91.270291	R	MN	4	8
MN0053562	Non-major	688.7		WWTP		Brownsville WWTP	Municipal WWTP	43.691889	-91.277139	R	MN	4	8
1135.828555		688.0	EPA	F,M,S,H,C	UMR 70	GRE Site - dst. Brownsville WWTP	WWTP impact zone	43.688379	-91.264627	R	MN	4	8
M686.1W		686.1	LTRMP	C	UMR 71	Fixed Sta.	Fixed station provides chemical data	43.663345	-91.24609	R	MN	4	8
1132.721676		686.0	EPA	F,M,S,H,C	UMR 71	GRE Site - Ust. Stoddard WWTP	Ust. WWTP impacts	43.669543	-91.243615	L	WI	4	8
WI0028304	Non-major	685.3		WWTP		Stoddard WWTP	Municipal WWTP	43.661111	-91.213889	L	WI	4	8
		685.3	UMR	F,M,S,H,C	UMR 72	Dst. Stoddard WWTP	WWTP impact zone	43.653281	-91.242272	L	WI	4	8
M681.3B		681.3	LTRMP	C	UMR 73	Fixed Sta.	Fixed station provides chemical data	43.600004	-91.227367	L	WI	4	8
		681.3	UMR	F,M,S,H	UMR 73	Far-field survey site - at fixed station	Recovery from WWTP impacts	43.600004	-91.227367	L	WI	4	8
		679.5	WDNR	C		Fixed Sta.	Not included in polllution survey	43.574328	-91.229818			4	8
M679.5Z		679.5	LTRMP	C		Fixed Sta.	Not included in polllution survey	43.572348	-91.229513			4	8
M679.5X		679.5	LTRMP	C		Fixed Sta.	Not included in polllution survey	43.572376	-91.231345			4	8
M679.5V		679.5	LTRMP	C		Fixed Sta.	Not included in polllution survey	43.572542	-91.233903			4	8
M679.2Z		679.2	LTRMP	C	UMR 74	Fixed Sta.	Fixed station provides chemical data	43.56982853	-91.23010014	L	WI	4	8
		679.2	UMR	F,M,S,H	UMR 74	Ust. L&D 8; Genoa WWTP	Ust. WWTP impacts; impounded effect	43.56982853	-91.23010014	L	WI	4	8
WI0022284	Non-major	679.2		WWTP		Genoa Wastewater Treatment Plant	Municipal WWTP	43.577778	-91.225	L	WI	4	8
679.2	**L&D**	**679.2**		**Dam**		**Lock and Dam 8**	**Dam**	**43.570498**	**-91.232707**	**R&L**	**MN/WI**	**4**	**8**
		679.1	UMR	F,M,S,H,C	UMR 75	Dst. L&D 8; Genoa WWTP	WWTP impact zone; tailwater site	43.568369	-91.230313	L	WI	4	9
WI0003239	Major	678.3		EGS		Dairyland Power - Genoa EGS	Coal Powered Electricity Generation	43.559167	-91.231944	L	WI	4	9
		678.1	UMR	F,M,S,H,C	UMR 76	Dst, Dairyland Power-Genoa EGS	EGS impact zone	43.556084	-91.239647	L	WI	4	9
1119.407898		678.0	EPA	F,M,S,H,C	UMR 77	GRE Site - far-field survey site	EGS recovery site	43.560565	-91.235098	R	MN	4	9
		677.3	UMR	F,M,S,H,C	UMR 76.1	Side channel survey site	Side channel lateral strata assessment	43.546136	-91.23989	L	WI	4	9
1111.037755		673.0	EPA	F,M,S,H,C	UMR 78	GRE Site - far-field survey site	Far-field survey site	43.489598	-91.217044	R	MN	4	9
1110.49366		673.0	EPA	F,M,S,H,C	UMR 79	GRE Site - far-field survey site	Far-field survey site	43.49499	-91.21819	L	WI	4	9
1103.275611		669.0	EPA	F,M,S,H,C	UMR 80	GRE Site - far-field survey site	Far-field survey site	43.433406	-91.215431	R	MN	4	9
WI0029793	Non-major	667.3		WWTP		DeSoto Wastewater Treatment Plant	Municipal WWTP	43.422222	-91.2	L	WI	4	9
1099.543198		666.0	EPA	F,M,S,H,C	UMR 81	GRE Site - dst. DeSoto WWTP	WWTP impact zone	43.40403	-91.19944	L	WI	4	9
IA0024597	Non-major	662.4		WWTP		Lansing WWTP	Municipal WWTP	43.349486	-91.207219	R	MN	4	9
IA0003735	Major	662.0		EGS		Lansing EGS	Electric Power Generation	43.334954	-91.167075	R	IA	4	9
		661.8	UMR	F,M,S,H,C	UMR 82	Dst. Lansing discharges	WWTP & EGS impact zone	43.348258	-91.197339	R	IA	4	9
WI0020974	Non-major	657.9		WWTP		Ferryville WWTP	Municipal WWTP	43.266667	-91.116667	L	WI	4	9
1083.752197		657.0	EPA	F,M,S,H,C	UMR 83	GRE Site - dst. Ferryville WWTP	WWTP impact zone	43.313282	-91.106618	L	WI	4	9

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
1078.54983		654.0	EPA	F,M,S,H,C	UMR 84	GRE Site - far-field survey site	WWTP impact recovery site	43.27173	-91.09012	L	WI	4	9
WI0036854	Non-major	651.0		WWTP		Valley Ridge WWTP	Municipal WWTP	43.240861	-91.062083	L	WI	4	9
		650.8	UMR	F,M,S,H,C	UMR 85	Dst. Valley Ridge WWTP	WWTP impact zone	43.242334	-91.062542	L	WI	4	9
		648.0	WDNR	C	UMR 86	Fixed Sta.	Fixed station provides chemical data	43.21203	-91.098591	L	WI	4	9
		648.0	UMR	F,M,S,H	UMR 86	Ust. L&D 9 - at fixed station	WWTP impact recovery; impounded	43.21203	-91.098591	L	WI	4	9
647.9	**L&D**	**647.9**		**Dam**		**Lock and Dam 9**	**Dam**	**43.218337**	**-91.108906**	**R&L**	**IO/WI**	**4**	**9**
		647.7	UMR	F,M,S,H,C	UMR 87	Dst. L&D 9 - tailwaters	Tailwater site assessment	43.208977	-91.103018	L	WI	4	10
1067.395156		646.0	EPA	F,M,S,H,C	UMR 88	GRE Site - far-field survey site	Far-field survey site	43.19364	-91.123668	R	IA	4	10
IA0070564	Non-major	645.7		WWTP		Harpers Ferry WWTP	Municipal WWTP	43.197319	-91.150806	R	IA	4	10
		645.5	UMR	F,M,S,H,C	UMR 89	Dst. Harpers Ferry WWTP	WWTP impact zone	43.184347	-91.127035	R	IA	4	10
1065.105752		645.0	EPA	F,M,S,H,C	UMR 90	GRE Site - far-field survey site	WWTP impact recovery	43.17551	-91.13431	L	WI	4	10
1057.700737		640.0	EPA	F,M,S,H,C	UMR 91	GRE Site - far-field survey site	Far-field survey site	43.123162	-91.178448	R	IA	4	10
1052.436528		637.0	EPA	F,M,S,H,C	UMR 92	GRE Site - far-field survey site	Far-field survey site	43.07749	-91.1772	L	WI	4	10
1048.208953		635.0	EPA	F,M,S,H,C	UMR 93	GRE Site - far-field survey site	Far-field survey site	43.043777	-91.157424	L	WI	4	10
		634.2	UMR	F,M,S,H,C	UMR 93.1	Main channel far-field survey site	Far-field survey site	43.035955	-91.173823	R	IA	4	10
WI0020257	Major	633.5		WWTP		Prairie Du Chien WWTP	Municipal WWTP	43.030278	-91.147222	L	WI	4	10
IA0028614	Non-major	633.0		WWTP		McGregor WWTP	Municipal WWTP	43.024597	-91.172242	R	IA	4	10
630.6	Trib	630.6	UMR	F,M,S,H,C	WSC 3	Wisconsin R.	Within 2.0 km of mouth	42.988953	-91.155564	L	WI	5	10
IA0080624	Non-major	623.0		Quarry		Pattison Sand Co. LLC - Clayton	Industrial Sand Mining	42.898748	-91.38935	R	IA	5	10
1028.684538		623.0	EPA	F,M,S,H,C	UMR 94	GRE Site - dst. Pattison Sand	Discharge impact zone	42.889768	-91.120581	R	IA	5	10
1026.131739		622.0	EPA	F,M,S,H,C	UMR 95	GRE Site - far-field survey site	Discharge recovery zone	42.87437	-91.09996	R	IA	5	10
1024.787868		621.0	EPA	F,M,S,H,C	UMR 96	GRE Site - far-field survey site	Discharge recovery zone	42.862136	-91.096601	L	WI	5	10
		618.3	UMR	F,M,S,H,C	UMR 96.1	Side channel survey site	Side channel lateral strata assessment	42.830106	-91.098283	R	IA	5	10
		615.5	UMR	F,M,S,H,C	UMR 97	Ust. L&D 10	Far-field survey site; impounded effect	42.791887	-91.095667	R	IA	5	10
615.0	**L&D**	**615.0**		**Dam**		**Lock and Dam 10**	**Dam**	**42.787658**	**-91.082218**	**R&L**	**IO/WI**	**5**	**10**
		614.8	UMR	F,M,S,H,C	UMR 98	Dst. L&D 10 - tailwaters	Tailwater site assessment	42.780695	-91.093372	R	IA	5	11
IA0022284	Non-major	614.0		WWTP		Guttenberg WWTP	Municipal WWTP	42.776622	-91.093272	R	IA	5	11
		613.8	UMR	F,M,S,H,C	UMR 99	Dst. Guttenberg WWTP	WWTP impact zone	42.769909	-91.081917	R	IA	5	11
1007.121623		610.0	EPA	F,M,S,H,C	UMR 100	GRE Site - far-field survey site	WWTP recovery zone	42.729106	-91.046441	R	IA	5	11
WI0002381	Non-major	607.8		EGS		WP&L - Nelson Dewey EGS	Coal Powered Electricity Generation	42.708333	-90.983333	L	WI	5	11
		607.5	UMR	F,M,S,H,C	UMR 101	Dst. Nelson Dewey EGS	EGS impact zone	42.717882	-91.005892	L	WI	5	11
		607.5	UMR	F,M,S,H,C	UMR 102	Dst. Cassville EGS	EGS impact zone	42.717882	-91.005892	L	WI	5	11
WI0002020	Non-major	606.6		EGS		Dairyland - Cassville EGS	Coal Powered Electricity Generation	42.713889	-90.988889	L	WI	5	11
WI0021423	Non-major	605.9		WWTP		Cassville WWTP	Municipal WWTP	42.715	-90.988333	L	WI	5	11
998.8628287		605.0	EPA	F,M,S,H,C	UMR 103	GRE Site - dst. Cassville WWTP	WWTP impact zone	42.693256	-90.965763	L	WI	5	11
994.4064736		602.0	EPA	F,M,S,H,C	UMR 104	GRE Site - far-field survey site	WWTP recovery zone	42.6841	-90.9166	R	IA	5	11
		593.0	UMR	F,M,S,H,C	UMR 105	Ust. Potosi-Tennyson WWTP	Ust. WWTP impacts	42.646162	-90.750151	L	WI	5	11
WI0021547	Non-major	592.1		WWTP		Potosi-Tennyson WWTP	Municipal WWTP	42.694444	-90.708333	L	WI	5	11
		591.9	UMR	F,M,S,H,C	UMR 106	Dst. Potosi-Tennyson WWTP	WWTP impact zone	42.642199	-90.72929	L	WI	5	11
970.8349996		589.0	EPA	F,M,S,H,C	UMR 107	GRE Site - far-field survey site	WWTP recovery zone	42.610153	-90.681009	L	WI	5	11
IA0000051	Major	586.2		Industry		John Deere Dubuque Works	Farm Equipment Manufacturing Plant	42.56475	-90.69275	R	IA	5	11
		586.0	UMR	F,M,S,H,C	UMR 108	Dst. John Deere Dubuque Works	Discharge impact zone	42.57568	-90.671382	R	IA	5	11
M-13		583.0	IL EPA	C	UMR 109	Fixed Sta.	Fixed station provides chemical data	42.539464	-90.645484	L	IL	5	11
		583.0	UMR	F,M,S,H	UMR 109	Ust. L&D 11	Far-field survey site: impounded effect	42.539464	-90.645484	L	IL	5	11
583.0	**L&D**	**583.0**		**Dam**		**Lock and Dam 11**	**Dam**	**42.541663**	**-90.655097**	**R&L**	**IO/WI**	**5**	**11**
960.8617664		582.0	EPA	F,M,S,H,C	UMR 110	GRE Site - dst. L&D 11 tailwaters	Tailwater site assessment	42.531648	-90.641175	R	IA	6	12
IA0002984	Non-major	581.4		Industry		Systems Bio Industries Inc.	Food Preparation	42.523242	-90.648026	R	IA	6	12
IA0080233	Non-major	581.3		WWTP		Dubuque Greyhound Park & Casino	Casino	42.516797	-90.640344	R	IA	6	12
IA0077020	Non-major	581.2		Industry		Flynn Ready Mix Concrete Company	Concrete Plant	42.514412	-90.653816	R	IA	6	12
		581.0	UMR	F,M,S,H,C	UMR 111	Dst. 3 discharges - IA side	Discharge impact zone	42.511754	-90.637655	R	IA	6	12
IA0001767	Non-major	580.0		EGS		Dubuque EGS	Coal Powered Electricity Generation	42.502462	-90.65601	R	IA	6	12
		579.8	UMR	F,M,S,H,C	UMR 112	Dst. Dubuque EGS	EGS impact zone	42.496798	-90.649908	R	IA	6	12
IL0025186	Non-major	579.2		WWTP		East Dubuque WWTP	Municipal WWTP	42.491667	-90.65	L	IL	6	12
		579.0	UMR	F,M,S,H,C	UMR 113	Dst. East Dubuque WWTP	WWTP impact zone	42.487269	-90.655989	L	IL	6	12
IA0044458	Major	578.0		WWTP		Dubuque WWTP	Municipal WWTP	42.470083	-90.6529	R	IA	6	12
952.1126808		577.0	EPA	F,M,S,H,C	UMR 114	GRE Site - dst. Dubuque WWTP	WWTP impact recovery zone	42.46562	-90.633442	R	IA	6	12
IL0003930	Non-major	573.0		Industry		Rentech Energy Midwest Corporation	Nitrogenous Fertilizer Manufacturing	42.44	-90.561667	L	IL	6	12
		572.8	UMR	F,M,S,H,C	UMR 115	Dst. Rentech Energy	Discharge impact zone	42.43744	-90.562436	L	IL	6	12
		571.8	UMR	F,M,S,H,C	UMR 115.1	Side channel survey site	Side channel lateral strata assessment	42.420454	-90.564859	R	IA	6	12

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
941.0914922		570.0	EPA	F,M,S,H,C	UMR 116	GRE Site - dst. Dubuque discharges	Discharge impact zone	42.410472	-90.536655	R	IA	6	12
939.6129238		569.0	EPA	F,M,S,H,C	UMR 117	GRE Site - dst. E. Dubuque discharges	Discharge impact zone	42.40498	-90.52095	L	IL	6	12
937.0888673		568.0	EPA	F,M,S,H,C	UMR 118	GRE Site - far-field survey site	Discharge impact recovery zone	42.39209	-90.49593	R	IA	6	12
		567.1	UMR	F,M,S,H,C	UMR 117.1	Side channel survey site	Side channel lateral strata assessment	42.388996	-90.483204	L	IL	6	12
M563.9T		563.9	LTRMP	C	UMR 119	Fixed Sta.	Fixed station provides chemical data	42.353195	-90.444787	R	IA	6	12
		563.9	UMR	F,M,S,H	UMR 119	Far-field survey site at fixed stattion	Far-field survey site; recovery assessment	42.353195	-90.444787	R	IA	6	12
		560.7	UMR	F,M,S,H,C	UMR 119.1	Side channel survey site	Side channel lateral strata assessment	42.317655	-90.42871	R	IA	6	12
924.2821588		560.0	EPA	F,M,S,H,C	UMR 120	GRE Site - far-field survey site	Far-field survey site	42.303447	-90.421007	L	IL	6	12
IA0029009	Non-major	557.0		WWTP		Bellevue City of STP	Municipal WWTP	42.266521	-90.426014	R	IA	6	12
		556.8	UMR	F,M,S,H,C	UMR 121	Dst. Bellevue WWTP; ust. L&D 12	WWTP impact zone; impounded effect	42.26255	-90.423191	R	IA	6	12
556.7	**L&D**	**556.7**		**Dam**		**Lock and Dam 12**	**Dam**	**42.261394**	**-90.420346**	**R&L**	**IA/IL**	**6**	**12**
M556.4A		556.4	LTRMP	C	UMR 122	Fixed Sta.	Fixed station provides chemical data	42.257112	-90.420392	R	IA	6	13
		556.4	UMR	F,M,S,H	UMR 122	Dst. L&D 12 - tailwaters	Tailwater site assessment	42.257112	-90.420392	R	IA	6	13
IA0066010	Non-major	555.8		WWTP		Bellevue State Park WWTP	Park WWTP	42.261394	-90.417164	R	IA	6	13
915.9630923		555.0	EPA	F,M,S,H,C	UMR 123	GRE Site - far-field survey site	WWTP impact zone	42.238101	-90.400304	L	IL	6	13
912.7778728		553.0	EPA	F,M,S,H,C	UMR 124	GRE Site - far-field survey site	WWTP impact recovery zone	42.21672	-90.3783	R	IA	6	13
911.1662535		552.0	EPA	F,M,S,H,C	UMR 125	GRE Site - far-field survey site	WWTP impact recovery zone	42.20959	-90.36218	L	IL	6	13
909.5722559		551.0	EPA	F,M,S,H,C	UMR 126	GRE Site - far-field survey site	WWTP impact recovery zone	42.20411	-90.34471	L	IL	6	13
548.6		548.6	UMR	F,M,S,H,C	MAQ 4	Maquoqueta R.	Within 2.0 km of mouth	42.188700	-90.308606	R	IA	6	13
M545.5B		545.5	LTRMP	C	UMR 127	Fixed Sta.	Fixed station provides chemical data	42.152065	-90.260858	L	IL	6	13
		545.5	UMR	F,M,S,H	UMR 127	Far-field survey site at fixed stattion	Far-field survey site	42.172462	-90.252968	R	IA	6	13
AL02.3M		545.2	LTRMP	C	UMR 127	Fixed Sta.	Fixed station provides chemical data	42.185961	-90.236836	R	IA	6	13
		544.2	UMR	F,M,S,H,C	UMR 127.1	Side channel survey site	Side channel lateral strata assessment	42.167581	-90.227924	L	IL	6	13
894.38663		541.0	EPA	F,M,S,H	UMR 128	GRE Site - far-field survey site	Far-field survey site	42.133934	-90.20347	R	IA	6	13
M540.2T		540.2	LTRMP	C	UMR 128	Fixed Sta.	Fixed station provides chemical data	42.126183	-90.185804	L	IL	6	13
IL0020541	Non-major	536.8		WWTP		Savanna WWTP	Municipal WWTP	42.09	-90.156667	L	IL	6	13
		536.6	UMR	F,M,S,H,C	UMR 129	Dst. Savanna WWTP	WWTP impact zone	42.20959	-90.36218	L	IL	6	13
IA0032867	Non-major	534.4		WWTP		Sabula City WWTP	Municipal WWTP	42.261394	-90.172422	R	IA	6	13
M532.3T		532.3	LTRMP	C	UMR 130	Fixed Sta.	Fixed station provides chemical data	42.029936	-90.150986	R	IA	6	13
879.8283529		532.0	EPA	F,M,S,H	UMR 130	GRE Site - far-field survey site	WWTP impact recovery	42.03119	-90.15296	L	IL	6	13
876.7291683		531.0	EPA	F,M,S,H,C	UMR 131	GRE Site - far-field survey site	Far-field survey site	42.00646	-90.1381	L	IL	6	13
IL0073890	Non-major	529.0		WWTP		Thompson WWTP	Municipal WWTP	41.968056	-90.121111	L	IL	6	13
		528.5	UMR	F,M,S,H,C	UMR 132	Dst. Thompson WWTP	WWTP impact zone	41.978295	-90.147606	L	IL	6	13
M525.5L		525.5	LTRMP	C	UMR 133	Fixed Sta.	Fixed station provides chemical data	41.938581	-90.161096	R	IA	6	13
		525.5	UMR	F,M,S,H	UMR 133	Far-field survey site at fixed stattion	Far-field survey site	41.938581	-90.161096	R	IA	6	13
865.337488		523.0	EPA	F,M,S,H,C	UMR 134	GRE Site - ust. L&D 13	Far-field survey site; impounded effect	41.910235	-90.161521	L	IL	6	13
522.6	**L&D**	**522.6**		**Dam**		**Lock and Dam 13**	**Dam**	**41.898455**	**-90.157216**	**R&L**	**IA/IL**	**6**	**13**
M12		522.5	IL EPA	C	UMR 135	Fixed Sta.	Fixed station provides chemical data	41.89726	-90.154963	L	IL	7	14
		522.5	UMR	F,M,S,H	UMR 135	Dst. L&D 13 - tailwaters	Tailwater site assessment	41.89726	-90.154963	L	IL	7	14
IL0028860	Non-major	519.5		WWTP		Fulton WWTP	Municipal WWTP	41.856667	-90.168333	L	IL	7	14
		518.1	UMR	F,M,S,H,C	UMR 135.1	Side channel survey site	Side channel lateral strata assessment	41.840273	-90.174289	L	IL	7	14
857.0219742		518.0	EPA	F,M,S,H,C	UMR 136	GRE Site - dst. Fulton WWTP	WWTP impact zone	41.842033	-90.18192	L	IL	7	14
		517.0	UMR	F,M,S,H,C	UMR 137	Ust. ADM discharges	Ust. ADM discharges	41.823039	-90.182001	R	IA	7	14
IA0080543	Non-major	516.2		EGS		ADM Clinton Cogeneration EGS	Coal Powered Electricity Generation	41.822749	-90.204819	R	IA	7	14
IA0082279	Non-major	516.0		Industry		ADM Polymers	Plastic Materials and Resins	41.822749	-90.204819	R	IA	7	14
IA0003620	Non-major	515.8		Industry		ADM Corn Processing	Wet Corn Milling	41.822749	-90.204819	R	IA	7	14
IA0000914	Non-major	515.5		Industry		Darling International Inc.	Animal and Marine Fats and Oils	41.815411	-90.217421	R	IA	7	14
IA0000183	Non-major	515.5		Industry		Sethness Products Inc.,	Cane Sugar Refining	41.815411	-90.217421	R	IA	7	14
		515.3	UMR	F,M,S,H,C	UMR 138	Dst. ADM + 2 discharges	Dst. ADM discharges impact zone	41.80214	-90.191242	R	IA	7	14
		515.0	UMR	F,M,S,H,C	UMR 139	Far-field survey site - opposite bank	Cross channel site from ADM	41.800477	-90.196351	L	IL	7	14
IA0068101	Non-major	513.8		Industry		Vertex Chemical Corporation	Industrial Inorganic Chemicals	41.80932	-90.229674	R	IA	7	14
IA0001759	Non-major	513.7		EGS		M L Kapp EGS	Electric Power Generation	41.806884	-90.231668	R	IA	7	14
IA0035947	Major	513.5		WWTP		Clinton WWTP	Municipal WWTP	41.80796	-90.238472	R	IA	7	14
		513.3	UMR	F,M,S,H,C	UMR 140	Dst. Cinton WWTP & 3 discharges	WWTP & EGS impact zone	41.791543	-90.227028	R	IA	7	14
		513.3	UMR	F,M,S,H,C	UMR 139.1	Side channel survey site	Side channel lateral strata assessment	41.799015	-90.234628	R	IA	7	14
		511.5	UMR	F,M,S,H,C	UMR 141	Dst. Clinton discharges	WWTP & EGS impact recovery zone	41.776926	-90.25518	R	IA	7	14
IA0021261	Non-major	510.8		WWTP		Comanche WWTP	Municipal WWTP	41.776447	-90.273634	R	IA	7	14
		510.6	UMR	F,M,S,H,C	UMR 142	Dst. Comanche WWTP	WWTP impact zone	41.770136	-90.269864	R	IA	7	14
IL0003140	Major	509.0		Industry		3M - Cordova	Plastic Materials and Resins	41.754444	-90.288333	L	IL	7	14

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
		509.0	UMR	F,M,S,H,C	UMR 142.1	Side channel survey site	Side channel lateral strata assessment	41.761196	-90.296686	R	IA	7	14
		508.8	UMR	F,M,S,H,C	UMR 143	Dst. 3M cordova	Discharge impact zone	41.754706	-90.29633	L	IL	7	14
M508.1F		508.1	LTRMP	C	UMR 144	Fixed Sta.	Fixed station provides chemical data	41.747029	-90.306112	R	IA	7	14
		508.1	UMR	F,M,S,H	UMR 144	Dst. Clinton discharges	Discharge impact zone	41.747029	-90.306112	R	IA	7	14
838.708485		507.0	EPA	F,M,S,H,C	UMR 145	GRE Site - far-field survey site	Discharge impact recovery zone	41.734173	-90.315718	R	IA	7	14
506.8		506.8	UMR	F,M,S,H,C	WAP 5	Wapsipinicon R.	Within 2.0 km of mouth	41.729680	-90.319859	R	IA	7	14
		506.7	UMR	F,M,S,H,C	UMR 146	Dst. Wapsipinicon R.	Wapsicon R. influence	41.7286	-90.316878	R	IA	7	14
IL0005037	Major	506.7		EGS		Quad Cities Nuclear EGS	Nuclear energy plant	41.726389	-90.310278	L	IL	7	14
		506.5	UMR	F,M,S,H,C	UMR 147	Dst. Quad Cities EGS	EGS impact zone	41.725797	-90.317431	L	IL	7	14
		504.5	UMR	F,M,S,H,C	UMR 147.1	Side channel survey site	Side channel lateral strata assessment	41.701888	-90.327457	R	IA	7	14
IA0033227	Non-major	503.0		WWTP		Princeton WWTP	Municipal WWTP	41.680819	-90.338545	R	IA	7	14
IL0025356	Non-major	502.2		WWTP		Cordova WWTP	Municipal WWTP	41.67	-90.33	L	IL	7	14
		502.0	UMR	F,M,S,H,C	UMR 148	Dst. Princeton, Cordova WWTPs	WWTPs impact zone	41.668719	-90.338247	L	IL	7	14
		502.0	UMR	F,M,S,H,C	UMR 149	Far-field survey site - opposite bank	Cross channel site from WWTPs	41.668719	-90.338247	R	IA	7	14
IL0023507	Non-major	499.2		WWTP		Port Bryon WWTP	Municipal WWTP	41.626694	-90.33	L	IL	7	14
		499.0	UMR	F,M,S,H,C	UMR 150	Dst. Port Byron WWTP	WWTP impact zone	41.6252	-90.339712	L	IL	7	14
IA0078824	Non-major	497.0		Stormwater		LeClaire MS4	Stormwater outfall	41.599426	-90.342435	R	IA	7	14
820.345146		496.0	EPA	F,M,S,H,C	UMR 151	GRE Site - dst. LeClaire MS4	Stormwater discharge impact zone	41.584256	-90.353349	R	IA	7	14
IA0022012	Non-major	495.4		WWTP		LeClaire WWTP	Municipal WWTP	41.582914	-90.366497	R	IA	7	14
		495.0	UMR	F,M,S,H,C	UMR 152	Dst. LeClaire WWTP	WWTP impact zone	41.578145	-90.37367	R	IA	7	14
		493.6	UMR	F,M,S,H,C	UMR 153	Ust. L&D 14; far-field survey site	Impact recovery zone; impounded effects	41.57556	-90.396605	R	IA	7	14
493.4	**L&D**	**493.4**		**Dam**		**Lock and Dam 14**	**Dam**	**41.572502**	**-90.398445**	**R&L**	**IA/IL**	**7**	**14**
		493.2	UMR	F,M,S,H,C	UMR 154	Dst. L&D 14 - tailwaters	Tailwater site assessment	41.57378959	-90.40194977	R	IA	7	15
IA0073695	Non-major	491.5		Industry		Americold Bettendorf	Refrigerated Warehouse and Storage	41.555147	-90.431175	R	IA	7	15
		491.0	UMR	F,M,S,H,C	UMR 154.1	Side channel survey site	Side channel lateral strata assessment	41.544115	-90.421816	L	IL	7	15
IL0028550	Major	490.2		WWTP		East Moline WWTP	Municipal WWTP	41.533611	-90.426667	L	IL	7	15
		490.1	UMR	F,M,S,H,C	UMR 155	Dst. E. Moline WWTP	WWTP impact zone	41.540558	-90.440977	L	IL	7	15
490	PWS	490.0		PWS Intake		E. Moline Water Department	Public Water System	41.530845	-90.438319	L	IL	7	15
IA0003611	Major	489.8		EGS		MidAmerican Energy Co. - Rivers EGS	Coal Powered Electricity Generation	41.53862	-90.452267	R	IA	7	15
		489.6	UMR	F,M,S,H,C	UMR 156	Dst. MidAmerican EGS	EGS impact zone	41.534537	-90.44688	R	IA	7	15
808.7692493		489.0	EPA	F,M,S,H,C	UMR 157	GRE Site - dst. E. Moline	E. Moline impact zone	41.52503	-90.45766	L	IL	7	15
IA0001198	Non-major	487.2		Industry		Amoco Oil - Bettendorf Terminal	Petroleum Bulk Stations and Storage	41.521805	-90.48515	R	IA	7	15
		486.5	UMR	F,M,S,H,C	UMR 158	Ust. Moline PWS intake	Discharge impact recovery; PWS issues	41.518868	-90.500461	L	IL	7	15
486	PWS	486.0		PWS Intake		Moline Water Department	Public Water System	41.512538	-90.514844	L	IL	7	15
IL0003000	Non-major	485.0		Industry		John Deere Seeding and Cylinder	Farm Equipment Manufacturing Plant	41.51	-90.521667	L	IL	7	15
		484.5	UMR	F,M,S,H,C	UMR 159	Ust. Iowa-American Water PWS intake	Discharge impact zone	41.524429	-90.538009	R	IA	7	15
IL0029947	Major	484.2		WWTP		North Slope WWTP	Municipal WWTP	41.510556	-90.538056	L	IL	7	15
		484.0	UMR	F,M,S,H,C	UMR 160	Dst. N. Slope WWTP	WWTP impact zone	41.524429	-90.547515	L	IL	7	15
484	PWS	484.0		PWS		Iowa-American Water - Davenport	Public Water System	41.528249	-90.54285	R	IA	7	15
		483.7	UMR	F,M,S,H,C	UMR 160.1	Side channel survey site	Side channel lateral strata assessment	41.510879	-90.551702	L	IL	7	15
		483.5	UMR	F,M,S,H,C	UMR 161	Ust. Rock Island Water PWS intake	WWTP impact recovery; PWS issues	41.522645	-90.556464	L	IL	7	15
483	PWS	483.0		PWS Intake		Rock Island Water Department	Public Water System	41.518938	-90.56474	L	IL	7	15
483	PWS	483.0		PWS Intake		Rock Island Arsenal	Public Water System	41.51852	-90.566017	L	IL	7	15
		483.0	UMR	F,M,S,H,C	UMR 162	Dst. Bettendorf - opposite bank	Bettendorf impact zone	41.518145	-90.564374	R	IA	7	15
M-02		482.9	IL EPA	C	UMR 163	Fixed Sta.	Fixed station provides chemical data	41.517289	-90.566039	L	IL	7	15
		482.9	UMR	F,M,S,H	UMR 163	Ust. L&D 15 at fixed sta.	Far-field survey site; impounded effect	41.517289	-90.566039	L	IL	7	15
482.9	**L&D**	**482.9**		**Dam**		**Lock and Dam 15**	**Dam**	**41.518853**	**-90.568815**	**R&L**	**IA/IL**	**7**	**15**
		482.7	UMR	F,M,S,H,C	UMR 164	Dst. L&D 15 - tailwaters	Tailwater site assessment	41.515617	-90.569389	L	IL	7	16
IL0030783	Major	480.4		WWTP		Rock Island Main WWTP	Municipal WWTP	41.499444	-90.597222	L	IL	7	16
		480.2	UMR	F,M,S,H,C	UMR 165	Dst. Rock Island WWTP	WWTP impact zone	41.496018	-90.604962	L	IL	7	16
IA0043052	Major	479.1		WWTP		Davenport WWTP	Municipal WWTP	41.49168	-90.6286	R	IA	7	16
479.0		479.0	UMR	F,M,S,H,C	ROR 6	Rock R.	Within 2.0 km of mouth	41.482699	-90.616231	L	IL	7	16
		478.9	UMR	F,M,S,H,C	UMR 166	Dst. Davenport WWTP	WWTP impact zone	41.483681	-90.622289	R	IA	7	16
		477.5	UMR	F,M,S,H,C	UMR 167	Dst. Davenport area	Davenport impact zone	41.472081	-90.644051	R	IA	7	16
788.9375414		477.0	EPA	F,M,S,H,C	UMR 168	GRE Site - dst. Rock R.	Rock R. influences	41.461887	-90.653534	L	IL	7	16
IA0075604	Non-major	475.8		Freight		Blackhawk Fleet LLC	Water Transportation Services	41.46275	-90.679519	R	IA	7	16
IA008292	Non-major	475.6		Petroleum		Flint Hill Resources LLC Pine Bend	Petroleum Bulk Stations and Storage	41.463886	-90.667572	R	IA	7	16
IA0001180	Non-major	475.5		Petroleum		Texpar Energy LLC	Petroleum Bulk Stations and Storage	41.463287	-90.677757	R	IA	7	16
IA0063525	Non-major	475.3		Industry		LaFarge North America LLC	Cement Quarry	41.460993	-90.683482	R	IA	7	16

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
		475.1	UMR	F,M,S,H,C	UMR 169	Dst. Bulk storage, fleeting, quarry	Discharges impact zone	41.459815	-90.68386	R	IA	7	16
		474.4	UMR	F,M,S,H,C	UMR 169.1	Side channel survey site	Side channel lateral strata assessment	41.448419	-90.696678	L	IL	7	16
IL0021202	Non-major	473.7		WWTP		Andalusia WWTP	Municipal WWTP	41.446667	-90.708333	L	IL	7	16
		473.5	UMR	F,M,S,H,C	UMR 170	Dst. Andalusia WWTP	WWTP impact zone	41.453095	-90.713222	L	IL	7	16
IA0020800	Non-major	473.0		WWTP		Buffalo City WWTP	Municipal WWTP	41.45703	-90.725038	R	IA	7	16
IA0078760	Non-major	473.0		Stormwater		Buffalo City MS4	Stormwater outfall	41.45703	-90.725038	R	IA	7	16
		472.8	UMR	F,M,S,H,C	UMR 171	Dst. Buffalo City	Discharges & Stormwater impact zone	41.4509138	-90.72631068	R	IA	7	16
IA0067059	Non-major	472.0		WWTP		Camp Abe Lincoln	RV Parks and Campsites	41.453767	-90.742766	R	IA	7	16
776.119938		469.0	EPA	F,M,S,H,C	UMR 172	GRE Site - far-field survey site	Discharge impacts recovery zone	41.454167	-90.802622	R	IA	7	16
		468.0	UMR	F,M,S,H,C	UMR 173	Far-field survey site - opposite bank	Far-field survey - cross channel site	41.455164	-90.816908	L	IL	7	16
IA0001562	Non-major	467.6		EGS		Central IA Power Coop EGS	Coal Powered Electricity Generation	41.457144	-90.825016	R	IA	7	16
		467.4	UMR	F,M,S,H,C	UMR 174	Dst. Central IA Power Coop EGS	EGS impact zone	41.455257	-90.828342	R	IA	7	16
IA0077453	Non-major	466.4		WWTP		Riverview Subdivision WWTP	Municipal WWTP	41.457941	-90.852966	R	IA	7	16
		465.8	UMR	F,M,S,H,C	UMR 174.1	Side channel survey site	Side channel lateral strata assessment	41.436003	-90.854643	L	IL	7	16
		465.2	UMR	F,M,S,H,C	UMR 174.2	Side channel survey site	Side channel lateral strata assessment	41.43906	-90.968676	R	IA	7	16
		457.5	UMR	F,M,S,H,C	UMR 175	Ust. L&D 16	Far-field survey site; impounded effects	41.426952	-91.003952	L	IL	7	16
457.2	**L&D**	**457.2**		**Dam**		**Lock and Dam 16**	**Dam**	**41.246550**	**-91.015202**	**R&L**	**IA/IL**	**7**	**16**
		457.0	UMR	F,M,S,H,C	UMR 176	Dst. L&D 16 - tailwaters	Tailwater site assessment	41.424511	-91.013001	L	IL	7	17
753.5571871		455.0	EPA	F,M,S,H,C	UMR 177	GRE Site - ust. Discharges	Far-field survey site; ust. Discharges	41.414259	-91.049446	R	IA	7	17
		454.0	UMR	F,M,S,H,C	UMR 177.1	Side channel survey site	Side channel lateral strata assessment	41.405251	-91.047945	L	IL	7	17
IA0003441	Major	453.7		Industry		Grain Processing Corp.	Grain Milling	41.397204	-91.059281	R	IA	7	17
		453.5	UMR	F,M,S,H,C	UMR 178	Dst. Grain Processing Corp.	Discharge impact zone	41.39859693	-91.05541918	R	IA	7	17
IA0001082	Major	453.0		EGS		Muscatine Power & Water EGS	Coal Powered Electricity Generation	41.389954	-91.056083	R	IA	7	17
IL0079120	Non-major	452.0		Industry		Natural Gas Pipeline Co. of America	Natural Gas Transmission	41.379167	-91.046111	L	IL	7	17
		451.8		F,M,S,H,C	UMR 179	Dst. Natural Gas Pipeline Co,	Discharges impact zone	41.375821	-91.060042	L	IL	7	17
		450.6		F,M,S,H,C	UMR 180	Dst. Muscatine area	Muscatine impact zone	41.360146	-91.068813	R	IA	7	17
		450.3	UMR	F,M,S,H,C	UMR 180.1	Side channel survey site	Side channel lateral strata assessment	41.354251	-91.058832	L	IL	7	17
IA0000205	Major	449.9		Industry		Monsanto Co.	Pesticides and Agricultural Chemicals	41.350845	-91.07238	R	IA	7	17
		449.7		F,M,S,H,C	UMR 181	Dst. Monsanto Co.	Monsanto impact zone	41.347232	-91.070666	R	IA	7	17
		448.7	UMR	F,M,S,H,C	UMR 181.1	Side channel survey site	Side channel lateral strata assessment	41.308218	-91.084045	R	IA	7	17
IA0063282	Major	448.0		EGS		MidAmerican Energy Co. - Louisa EGS	Coal Powered Electricity Generation	41.316941	-91.082505	R	IA	7	17
740.5091843		447.0	EPA	F,M,S,H,C	UMR 182	GRE Site - far-field survey site	EGS impact; Monsanto impact recovery	41.307314	-91.073084	L	IL	7	17
		445.1	UMR	F,M,S,H,C	UMR 182.1	Side channel survey site	Side channel lateral strata assessment	41.284342	-91.085382	L	IL	7	17
734.5842904		443.0	EPA	F,M,S,H,C	UMR 183	GRE Site - far-field survey site	EGS impact & recovery zone	41.2633	-91.10531	R	IA	7	17
		441.8	UMR	F,M,S,H,C	UMR 183.1	Side channel survey site	Side channel lateral strata assessment	41.243466	-91.096079	L	IL	7	17
		438.3	UMR	F,M,S,H,C	UMR 185.1	Side channel survey site	Side channel lateral strata assessment	41.195714	-91.081371	R	IA	7	18
726.7055686		438.0	EPA	F,M,S,H,C	UMR 184	GRE Site - far-field survey site	Far-field survey site	41.19874	-91.06553	R	IA	7	17
725.5075544		438.0	EPA	F,M,S,H,C	UMR 185	GRE Site - ust. L&D 17	Far-field survey site; impounded effect	41.20779	-91.07296	L	IL	7	17
437.2	**L&D**	**437.2**		**Dam**		**Lock and Dam 17**	**Dam**	**41.188582**	**-91.063995**	**R&L**	**IA/IL**	**7**	**17**
L-04		437.0	IL EPA	C	UMR 186	Fixed Sta.	Fixed station provides chemical data	41.190804	-91.056129	L	IL	8	18
		437.0	UMR	F,M,S,H	UMR 186	Dst. L&D 17 - tailwaters	Tailwater site assessment	41.190804	-91.056129	L	IL	8	18
723.0617719		436.0	EPA	F,M,S,H,C	UMR 187	GRE Site	Far-field survey site	41.179397	-91.05109	R	IA	8	18
434.0		434.0	UMR	F,M,S,H,C	IAR 7	Iowa R.	Within 2.0 km of mouth	41.603306	-91.024748	R	IA	8	18
IL0074926	Non-major	432.0		WWTP		New Boston WWTP	Municipal WWTP	41.161667	-90.991667	L	IL	8	18
716.0855373		432.0	EPA	F,M,S,H,C	UMR 188	GRE Site - dst. New Boston WWTP	WWTP impact zone	41.153338	-90.98746	L	IL	8	18
		431.0	USFWS	C	UMR 189	Fixed Sta.	Fixed station provides chemical data	41.142331	-90.982646	L	IL	8	18
		431.0	UMR	F,M,S,H	UMR 189	Far-field survey site -fixed sta.	WWTP impact recovery zone	41.142331	-90.982646	L	IL	8	18
		427.5	UMR	F,M,S,H,C	UMR 189.1	Side channel survey site	Side channel lateral strata assessment	41.092951	-90.964091	R	IL	8	18
704.0928421		425.0	EPA	F,M,S,H,C	UMR 190	GRE Site	Far-field survey site	41.05765	-90.9512	R	IA	8	18
699.9245648		423.0	EPA	F,M,S,H,C	UMR 191	GRE Site	Far-field survey site	41.03492	-90.94905	L	IL	8	18
697.7211501		422.0	EPA	F,M,S,H,C	UMR 192	GRE Site	Far-field survey site	41.01539	-90.95708	L	IL	8	18
		420.2	UMR	F,M,S,H,C	UMR 192.1	Side channel survey site	Side channel lateral strata assessment	41.001887	-90.961895	R	IA	8	18
690.8859709		417.0	EPA	F,M,S,H,C	UMR 193	GRE Site	Far-field survey site	40.957488	-90.950891	R	IA	8	18
		411.2	UMR	F,M,S,H,C	UMR 194	Ust. L&D 18	Far-field survey site; impounded effect	40.891081	-91.015861	R	IA	8	18
410.4	**L&D**	**410.4**		**Dam**		**Lock and Dam 18**	**Dam**	**40.884315**	**-91.027170**	**R&L**	**IA/IL**	**8**	**18**
		410.2	UMR	F,M,S,H,C	UMR 195	Dst. L&D 18 - tailwaters	Tailwater site assessment	40.879084	-91.027562	L	IL	8	19
674.0660322		407.0	EPA	F,M,S,H,C	UMR 196	GRE Site - far-field survey site	Far-field survey site	40.855654	-91.078513	L	IL	8	19
IA0000787	Non-major	405.0		Industry		CNH America LLC	Construction Machinery	41.827687	-91.100076	R	IA	8	19
405	PWS	405.0		PWS Intake		Burlington Municipal Water Works	Public Water System	40.82043	-91.097192	R	IA	8	19

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
IA2909001	Major	404.5		WWTP		Burlington WWTP	Municipal WWTP	40.79909	-91.10008	R	IA	8	19
		404.3	UMR	F,M,S,H,C	UMR 197	Dst. Burlington WWTP	WWTP impact zone	40.814359	-91.095834	R	IA	8	19
		401.0	UMR	F,M,S,H,C	UMR 197.1	Side channel survey site	Side channel lateral strata assessment	40.766054	-91.071709	L	IL	8	19
		398.0	UMR	F,M,S,H,C	UMR 198	Far-field survey site	Far-field survey site	40.726835	-91.116857	R	IA	8	19
646.4384505		391.0	EPA	F,M,S,H,C	UMR 199	GRE Site - far-field survey site	Far-field survey site	40.648337	-91.169797	R	IA	8	19
IL0028312	Non-major	389.8		WWTP		Dallas WWTP	Municipal WWTP	40.633333	-91.181667	L	IL	8	19
		389.6	UMR	F,M,S,H,C	UMR 200	Dst. Dalls WWTP	WWTP impact zone	40.641582	-91.191707	L	IL	8	19
637.4165421		385.0	EPA	F,M,S,H,C	UMR 201	GRE Site - far-field survey site	Far-field survey site	40.632588	-91.269687	L	IL	8	19
384	PWS	384.0		PWS Intake		Fort Madison Municipal Water Works	Public Water System	40.62735	-91.313757	R	IA	8	19
IA0022219	Major	382.0		WWTP		Ft. Madison WWTP	Municipal WWTP	40.62148	-91.334878	R	IA	8	19
IA0077143	Non-major	381.5		WWTP		The Kensington	Residential Care	40.628335	-91.311207	R	IA	8	19
630.4462812		381.0	EPA	F,M,S,H,C	UMR 202	GRE Site - dst. Ft. Madison	Discharges impact zone	40.605963	-91.341995	R	IA	8	19
IA0003387	Non-major	379.0		Industry		Chevron Chemical Co.	Nitrogen Fertilizers	40.622997	-91.33328	R	IA	8	19
		378.8	UMR	F,M,S,H,C	UMR 203	Dst. Chevron	Chevron impact zone	40.585578	-91.370101	R	IA	8	19
IL0062391	Non-major	376.4		WWTP		Nauvoo WWTP	Municipal WWTP	40.551667	-91.401667	L	IL	8	19
IA0081001	Non-major	376.4		WWTP		Fort Madison WTP	Municipal WWTP	40.551794	-91.427701	R	IA	8	19
		376.2	UMR	F,M,S,H,C	UMR 204	Dst. Nauvoo WWTP	WWTP impact zone	40.556924	-91.400514	L	IL	8	19
376	PWS	376.0		PWS Intake		Nauvoo Water Dept.	Public Water System	40.549059	-91.40233	L	IL	8	19
IL0060453	Non-major	373.0		WWTP		Nauvoo-Colusa High School	Elementary and Secondary Schools	40.529276	-91.372167	L	IL	8	19
614.4068792		372.0	EPA	F,M,S,H,C	UMR 205	GRE Site - dst. Nauvoo area	Nauvoo impact zone	40.504261	-91.365591	L	IL	8	19
IA0063045	Non-major	371.0		Industry		Hendricks River Logistics	Marine Cargo Handling	40.49646	-91.373495	R	IA	8	19
		370.0	UMR	F,M,S,H,C	UMR 206	Dst. Nauvoo area	Nauvoo impact recovery zone	40.478336	-91.367221	L	IL	8	19
IA0065391	Non-major	368.7		WWTP		Sandusky Mobile Home Village	Package Plant	40.468718	-91.381469	R	IA	8	19
IL0043117	Non-major	368.6		WWTP		Camp Eastman	Recreation and Sports Camp	40.46	-91.361667	L	IL	8	19
606.9428344		367.0	EPA	F,M,S,H,C	UMR 207	GRE Site - dst. Ft. Madison area	Far-field survey site	40.440179	-91.380573	R	IA	8	19
365	PWS	365.0		PWS Intake		Keokuk Municipal Water Works	Public Water System	40.403025	-91.374301	R	IA	8	19
K-22		364.6	IL EPA	C	UMR 208	Fixed Sta.	Fixed station provides chemical data	40.400511	-91.373362	L	IL	8	19
		364.6	UMR	F,M,S,H	UMR 208	Ust. L&D 19 at fixed sta.	Far-field survey site; impounded effect	40.400511	-91.373362	L	IL	8	19
364.5	**L&D**	**364.5**		**Dam**		**Lock and Dam 19**	**Dam**	**40.390982**	**91.372644**	**R&L**	**IA/IL**	**8**	**19**
		364.3	UMR	F,M,S,H,C	UMR 209	Dst. L&D 19 - tailwaters	Tailwater site assessment	40.396415	-91.374518	R	IA	8	20
IL0024911	Non-major	364.2		CSO		Hamilton City CSOs	CSO outfall	40.463333	-91.355	L	IL	8	20
IL0047651	Non-major	364.0		WWTP		Hamilton City WWTP	Municipal WWTP	40.396694	-91.358306	L	IL	8	20
364	PWS	364.0		PWS Intake		Hamilton Water Department	Public Water System	40.390493	-91.366847	L	IL	8	20
IA0033600	Non-major	364.0		EGS		Ameren UE Keokuk EGS	Electric Power Generation	40.392535	-91.376597	R	IA	8	20
		363.9	UMR	F,M,S,H,C	UMR 211	Dst. Ameren EGS	EGS impact zone	40.391089	-91.377279	R	IA	8	20
		363.8	UMR	F,M,S,H,C	UMR 210	Dst. Hamilton WWTP, CSOs	WWTP impact zone	40.389843	-91.378501	L	IL	8	20
IA0042609	Major	362.9		WWTP		Keokuk WWTP	Municipal WWTP	40.386065	-91.385001	R	IA	8	20
		362.8	UMR	F,M,S,H,C	UMR 212	Dst. Keokuk WWTP	WWTP impact zone	40.38436896	-91.39528099	R	IA	8	20
IA0000256	Major	362.8		Industry		Roquette America, Inc.	Wet Corn Milling	40.3879	-91.397	R	IA	8	20
361.3		361.3	UMR	F,M,S,H,C	DMR 8	Des Moines R.	Within 2.0 km of mouth	40.380669	-91.421992	R	IA	9	20
		360.5	UMR	F,M,S,H,C	UMR 213	Dst. Des Moines R.	Des Moines R. influence	40.369492	-91.431309	R	IA	9	20
360	PWS	360.0		PWS Intake		Warsaw Water Department	Public Water System	40.365866	-91.436123	L	IL	9	20
		355.0	UMR	F,M,S,H,C	UMR 214	Far-field survey site	Far-field survey site	40.304372	-91.483072	L	IL	9	20
		352.1	UMR	F,M,S,H,C	UMR 214.1	Side channel survey site	Side channel lateral strata assessment	40.265635	-91.480973	L	IL	9	20
576.3913912		349.0	EPA	F,M,S,H,C	UMR 215	GRE Site - far-field survey site	Far-field survey site	40.21992	-91.49775	R	IA	9	20
569.7228395		345.0	EPA	F,M,S,H,C	UMR 216	GRE Site - far-field survey site	Far-field survey site	40.16893	-91.51139	R	IA	9	20
567.7029297		344.0	EPA	F,M,S,H,C	UMR 217	GRE Site - far-field survey site	Far-field survey site	40.149156	-91.510705	L	IL	9	20
		342.5	UMR	F,M,S,H,C	UMR 218	Ust. L&D 20	WWTP impact zone; impounded effect	40.400511	-91.373362	R	IA	9	20
IL0030503	Major	342.3		WWTP		Quincy WWTP	Municipal WWTP	39.901389	-91.432222	L	IL	9	20
342.2	**L&D**	**342.2**		**Dam**		**Lock and Dam 20**	**Dam**	**40.144077**	**-91.510848**	**R&L**	**MO/IL**	**9**	**20**
		342.0	UMR	F,M,S,H,C	UMR 220	Dst. L&D 20 - tailwaters	Tailwater site assessment	40.126685	-91.510511	R	MO	9	21
		341.5	UMR	F,M,S,H,C	UMR 220.1	Side channel survey site	Side channel lateral strata assessment	40.123811	-91.495764	L	IL	9	21
MO0056278	Non-major	341.2		WWTP		Canton WWTP	Municipal WWTP	40.114917	-91.513806	R	MO	9	21
		341.0	UMR	F,M,S,H,C	UMR 221	Dst. Canton WWTP	WWTP impact zone	40.112529	-91.507665	R	MO	9	21
MO0087513	Non-major	338.7		WWTP		River Valley Country Club	Membership Sports and Recreation Club	40.079639	-91.507028	R	MO	9	21
MO0041203	Non-major	335.5		WWTP		Lagrange WWTP	Municipal WWTP	40.035806	-91.499417	R	MO	9	21
		335.3	UMR	F,M,S,H,C	UMR 222	Dst. Lagrange WWTP	WWTP impact zone	40.032783	-91.494392	R	MO	9	21
		335.0	UMR	F,M,S,H,C	UMR 223	Far-field survey site - opposite bank	Cross channel site from WWTP impacts	40.028896	-91.492069	L	IL	9	21
		333.0	UMR	F,M,S,H,C	UMR 223.1	Side channel survey site	Side channel lateral strata assessment	40.0072	-91.458374	L	IL	9	21

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
		327.5	UMR	F,M,S,H,C	UMR 224	Ust. Quincy PWS intake	Far-field survey site; PWS issues	39.938189	-91.423432	L	IL	9	21
327	PWS	327.0		PWS Intake		Quincy Water Department	Public Water System	39.933523	-91.416054	L	IL	9	21
MO0124770	Non-major	326.4		Industry		BNSF West Quincy Yard	Railroad Yard	39.928218	-91.425018	R	MO	9	21
IL0003590	Non-major	325.5		Industry		ADM Quincy	Soybean Processing	39.908333	-91.415	L	IL	9	21
K-17		325.0	IL EPA	C	UMR 225	Fixed Sta.	Fixed station provides chemical data	39.904155	-91.427792	L	IL	9	21
		325.0	UMR	F,M,S,H	UMR 225	Ust. L&D 21; dst. ADM	ADM impact zone; impounded effects	39.904155	-91.427792	L	IL	9	21
325.0	**L&D**	**325.0**		**Dam**		**Lock and Dam 21**	**Dam**	**39.905701**	**-91.431148**	**R&L**	**MO/IL**	**9**	**21**
		324.8	UMR	F,M,S,H,C	UMR 226	Dst. L&D 21 - tailwaters	Tailwater site assessment	39.902343	-91.430404	R	MO	10	22
IL0030503	Major	324.7		WWTP		Quincy WWTP	Municipal WWTP	39.901389	-91.432222	L	IL	10	22
		324.5	UMR	F,M,S,H,C	UMR 227	Dst. Quicy WWTP	WWTP impact zone	39.899736	-91.434397	L	IL	10	22
533.2985804		323.0	EPA	F,M,S,H,C	UMR 228	GRE Site - far-field survey site	WWTP impact recovery zone	39.880779	-91.452899	R	MO	10	22
531.7476314		322.0	EPA	F,M,S,H,C	UMR 229	GRE Site - far-field survey site	Far-field survey site	39.869688	-91.445661	R	MO	10	22
MO0001821	Non-major	321.0		Industry		CF Industries Inc. Palmyra Terminal	Fertilizers - Mixing Only	39.8445559	-91.442556	R	MO	10	22
		320.8	UMR	F,M,S,H,C	UMR 230	Dst. CF Industries	CF impact zone	39.851617	-91.439802	R	MO	10	22
		320.0	UMR	F,M,S,H,C	UMR 231	Far-field survey site - opposite bank	Cross channel site from CF impacts	39.840063	-91.43471	L	IL	10	22
MO0001716	Major	319.7		Industry		BASF Hannibal Plant	Pesticides and Agricultural Chemicals	39.835028	-91.42875	R	MO	10	22
		319.5	UMR	F,M,S,H,C	UMR 232	Dst. BASF	BASF impact zone	39.835832	-91.427116	R	MO	10	22
		319.0	UMR	F,M,S,H,C	UMR 232.1	Side channel survey site	Side channel lateral strata assessment	39.840813	-91.414136	L	IL	10	22
521.0474517		317.0	EPA	F,M,S,H,C	UMR 233	GRE Site - far-field survey site	BASF impact recovery zone	39.812627	-91.380759	L	IL	10	22
		312.0	UMR	F,M,S,H,C	UMR 234	Far-field survey site	Far-field survey site	39.752704	-91.367538	L	IL	10	22
		311.5	UMR	F,M,S,H,C	UMR 234.1	Side channel survey site	Side channel lateral strata assessment	39.743883	-91.359275	L	IL	10	22
		309.5	UMR	F,M,S,H,C	UMR 235	Ust. Hannibal PWS intake	Far-field survey site; PWS issues	39.719238	-91.359628	R	MO	10	22
309	PWS	309.0		PWS Intake		Hannibal Water Department	Public Water System	39.708374	-91.358482	R	MO	10	22
MO0085391	Non-major	308.8		WWTP		Hannibal WWTP	Municipal WWTP	39.703167	-91.359	R	MO	10	22
		308.6	UMR	F,M,S,H,C	UMR 236	12	WWTP impact zone	39.710252	-91.347533	R	MO	10	22
		306.0	UMR	F,M,S,H,C	UMR 237	Far-field survey site - opposite bank	Cross channel site from WWTP impacts	39.68422	-91.311864	L	IL	10	22
MO0111686	Non-major	305.7		Industry		Continental Cement Company	Cement Manufacturing	39.6794439	-91.315694	R	MO	10	22
		305.5	UMR	F,M,S,H,C	UMR 238	Dst. Continental Cement	Discharge impact zone	39.679743	-91.304462	R	MO	10	22
		301.5	UMR	F,M,S,H,C	UMR 239	Ust. L&D 22	Far-field survey site; impounded effect	39.63972	-91.252161	L	IL	10	22
301.2	**L&D**	**301.2**		**Dam**		**Lock and Dam 22**	**Dam**	**39.638829**	**-91.244599**	**R&L**	**MO/IL**	**10**	**22**
		301.0	UMR	F,M,S,H,C	UMR 240	Dst. L&D 22 - tailwaters	Tailwater site assessment	39.633855	-91.247085	R	MO	10	24
0		297.8	UMR	F,M,S,H,C	UMR 240.1	Side channel survey site	Side channel lateral strata assessment	39.601394	-91.202352	R	MO	10	24
485.293704		295.0	EPA	F,M,S,H,C	UMR 241	GRE Site - far-field survey site	Far-field survey site	39.581204	-91.171524	L	IL	10	24
479.8061027		292.0	EPA	F,M,S,H,C	UMR 242	GRE Site - far-field survey site	Far-field survey site	39.55095	-91.13418	L	IL	10	24
0		287.5	UMR	F,M,S,H,C	UMR 242.1	Side channel survey site	Side channel lateral strata assessment	39.517761	-91.067427	L	IL	10	24
469.2110782		286.0	EPA	F,M,S,H,C	UMR 243	GRE Site - far-field survey site	Far-field survey site	39.491053	-91.063694	L	IL	10	24
		283.5	UMR	F,M,S,H,C	UMR 2448	Ust. Louisiana PWS intake	Far-field survey site; PWS issues	39.458529	-91.05006	R	MO	10	24
283	PWS	283.0		PWS Intake		Louisiana Water Department	Public Water System	39.448496	-91.042308	R	MO	10	24
MO0001597	Non-major	282.2		Water Treat.		Louisiana WTP	City WTP	39.44525	-91.041611	R	MO	10	24
MO0023124	Non-major	282.2		WWTP		Louisiana WWTP	Municipal WWTP	39.4454999	-91.04275	R	MO	10	24
MO0127132	Non-major	281.8		Industry		SSS Inc.	Construction Sand & Limestone Mining	39.4362779	-91.030361	R	MO	10	24
		281.6	UMR	F,M,S,H,C	UMR 245	Ust. Discharges	Discharges impact zone	39.437626	-91.025564	R	MO	10	24
MO0105783	Major	281.0		Industry		Dyno Nobel Inc., Nitrogen Division	Nitrogenous Fertilizer Manufacturing	39.4304169	-91.022556	R	MO	10	24
MO0000311	Major	281.0		Industry		MO Chemical Works	Industrial Organic Chemicals	39.4319439	-91.018611	R	MO	10	24
460.5804938		280.0	EPA	F,M,S,H,C	UMR 246	GRE Site - dst. Dyno & MO Chemical	MO Chemical impact zone	39.4317	-91.009177	R	MO	10	24
		280.0	EPA	F,M,S,H,C	UMR 247	Far-field survey site - opposite bank	Cross channel site from MO Chemical	39.42725037	-91.00059427	L	IL	10	24
0		276.6	UMR	F,M,S,H,C	UMR 247.1	Side channel survey site	Side channel lateral strata assessment	39.406334	-90.945136	L	IL	10	24
MO0000159	Non-major	275.5		Industry		Holcim (US) Inc.	Cement Manufacturing	39.3789719	-90.941194	R	MO	10	24
K-21		273.5	IL EPA	C	UMR 248	Fixed Sta.	Fixed station provides chemical data	39.374498	-90.906937	L	IL	10	24
		273.5	UMR	F,M,S,H,C	UMR 248	Ust. L&D 24	Discharge impact/recovery; impounded	39.374498	-90.906937	L	IL	10	24
273.4	**L&D**	**273.4**		**Dam**		**Lock and Dam 24**	**Dam**	**39.376091**	**-90.904587**	**R&L**	**MO/IL**	**10**	**24**
		273.2	UMR	F,M,S,H,C	UMR 249	Dst. L&D 24 - tailwaters	Tailwater site assessment	39.371727	-90.902665	R	MO	10	25
MO0039632	Non-major	272.0		WWTP		Clarksville WWTP	Municipal WWTP	39.3575279	-90.892028	R	MO	10	25
		271.8	UMR	F,M,S,H,C	UMR 250	Dst. Clarksville WWTP	WWTP impact zone	39.360837	-90.881372	R	MO	10	25
0		268.0	UMR	F,M,S,H,C	UMR 250.1	Side channel survey site	Side channel lateral strata assessment	39.335815	-90.818018	L	IL	10	25
		265.0	UMR	F,M,S,H,C	UMR 251	Far-field survey site	Far-field survey site	39.30593	-90.779346	L	IL	10	25
0		260.5	UMR	F,M,S,H,C	UMR 251.1	Side channel survey site	Side channel lateral strata assessment	39.256311	-90.730082	L	IL	10	25
425.652777		259.0	EPA	F,M,S,H,C	UMR 252	GRE Site - far-field survey site	Far-field survey site	39.239557	-90.732666	L	IL	10	25
422.9132583		258.0	EPA	F,M,S,H,C	UMR 253	GRE Site - far-field survey site	Far-field survey site	39.21989	-90.72061	L	IL	10	25

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
0		253.6	UMR	F,M,S,H,C	UMR 253.1	Side channel survey site	Side channel lateral strata assessment	39.160244	-90.722252	R	MO	10	25
411.5128515		252.0	EPA	F,M,S,H,C	UMR 254	GRE Site - far-field survey site	Far-field survey site	39.13656	-90.6989	L	IL	10	25
402.0074678		246.0	EPA	F,M,S,H,C	UMR 255	GRE Site - far-field survey site	Far-field survey site	39.07301	-90.70692	L	IL	10	25
0		245.4	UMR	F,M,S,H,C	UMR 255.1	Side channel survey site	Side channel lateral strata assessment	39.055443	-90.701774	L	IL	11	26
399.75649		244.0	EPA	F,M,S,H,C	UMR 256	GRE Site - far-field survey site	Far-field survey site	39.04284	-90.70895	R	MO	10	25
397.5047781		243.0	EPA	F,M,S,H,C	UMR 257	GRE Site - far-field survey site	Far-field survey site	39.030371	-90.700679	R	MO	10	25
394.0599593		242.0	EPA	F,M,S,H,C	UMR 258	GRE Site - far-field survey site	Far-field survey site	39.01562	-90.69183	L	IL	10	25
MO0029955	Non-major	241.7		WWTP		US Army Corps of Engineers	Federal Government WWTP	39.003667	-90.715861	R	MO	10	25
241.6	**L&D**	**241.6**		**Dam**		**Lock and Dam 25**	**Dam**	**39.005963**	**-90.684260**	**R&L**	**MO/IL**	**10**	**25**
M241.4K		241.4	LTRMP	C	UMR 259	Fixed Sta.	Fixed station provides chemical data	39.002532	-90.688692	L	IL	11	26
		241.4	UMR	F,M,S,H	UMR 259	Dst. L&D 25 - tailwaters	Tailwater site assessment	39.002532	-90.688692	L	IL	11	26
389.3681748		239.0	EPA	F,M,S,H,C	UMR 260	GRE Site - far-field survey site	Far-field survey site	38.97139	-90.676616	R	MO	11	26
M237.2G		237.2	LTRMP	C	UMR 261	Fixed Sta.	Fixed station provides chemical data	38.945424	-90.668975	R	MO	11	26
		237.2	UMR	F,M,S,H	UMR 261	Far-field survey site at fixed station	Far-field survey site	38.945424	-90.668975	R	MO	11	26
237.0		237.0	UMR	F,M,S,H,C	CUR 10	Cuirve R.	Within 2.0 km of mouth	38.934319	-90.687014	R	MO	11	26
M235.5D		235.5	LTRMP	C	UMR 262	Fixed Sta.	Fixed station provides chemical data	38.922068	-90.659803	R	MO	11	26
		235.5	UMR	F,M,S,H	UMR 262	Far-field survey site at fixed stattion	Far-field survey site	38.922068	-90.659803	R	MO	11	26
		234.5	UMR	F,M,S,H,C	UMR 262.1	Far field survey site	Far-field survey site added to main channel	38.911625	-90.64658	L	IL	11	26
380.3530467		234.0	EPA	F,M,S,H,C	UMR 263	GRE Site - far-field survey site	Far-field survey site	38.897643	-90.648024	L	IL	11	26
		231.0	UMR	F,M,S,H,C	UMR 263.1	Side channel survey site	Side channel lateral strata assessment	38.878969	-90.604803	L	IL	11	26
MO0058343	Major	226.0		WWTP		Mississippi WWTP	Regional WWTP	38.8763329	-90.519278	R	MO	11	26
		225.8	UMR	F,M,S,H,C	UMR 264	Dst. Mississippi WWTP	WWTP impact zone	38.889806	-90.526286	R	MO	11	26
MO0101303	Non-major	225.4		WWTP		Yacht Club of St. Louis	Amusement and Recreation Services	38.8887499	-90.503333	R	MO	11	26
		224.4	UMR	F,M,S,H,C	UMR 264.1	Side channel survey site	Side channel lateral strata assessment	38.902459	-90.502111	R	MO	11	26
MO0111627	Non-major	221.3		WWTP		Duck Club Marina	Amusement and Recreation Services	38.9351109	-90.473583	R	MO	11	26
353.837297		219.0	EPA	F,M,S,H,C	UMR 265	GRE Site - far-field survey site	Discharges impact & recovery zone	38.957146	-90.451876	R	MO	11	26
IL0029025	Non-major	218.2		WWTP		Grafton WWTP	Municipal WWTP	38.968333	-90.426667	L	IL	11	26
		218.0	UMR	F,M,S,H,C	UMR 265	Dst. Grafton WWTP; ust. Illinois R.	WWTP impact zone	38.962104	-90.427522	L	IL	11	26
217.5		217.5	UMR	F,M,S,H,C	ILR 11	Illinois R.	Within 2.0 km of mouth	38.965780	-90.417384	L	IL	11	26
IL0067971	Non-major	217.0		WWTP		Raging Rivers Waterpark	Amusement Park	38.970833	-90.408333	L	IL	11	26
		216.8	UMR	F,M,S,H,C	UMR 266	Dst. Illinois R.	Illinois R. influence	38.963839	-90.406312	L	IL	11	26
IL0045462	Non-major	214.0		WWTP		Principia College WWTP	School WWTP	38.95	-90.356667	L	IL	11	26
		213.6	UMR	F,M,S,H,C	UMR 266.1	Side channel survey site	Side channel lateral strata assessment	38.93679	-90.356354	R	MO	11	26
MO0107328	Non-major	212.5		WWTP		Portage des Sioux WWTP	Municipal WWTP	38.928028	-90.344583	R	MO	11	26
		212.3	UMR	F,M,S,H,C	UMR 267	Dst. Portage des Sioux WWTP	WWTP impact zone	38.933716	-90.333503	R	MO	11	26
IL0044971	Non-major	210.2		WWTP		Lockhaven Country Club	Membership Sports and Amusement Club	38.935	-90.298333	L	IL	11	26
210	PWS	210.0		PWS Intake		Ameren UE - Sioux Plant	Public Water System	38.920557	-90.042308	R	MO	11	26
338.8082374		210.0	EPA	F,M,S,H,C	UMR 268	GRE Site - Ust. Ameren UE PWS intake	Far-field survey site; PWS issues	38.923585	-90.292877	R	MO	11	26
MO0000353	Major	209.7		EG		Ameren MO Sioux Energy Center	Coal Powered Electricity Generation	38.9094169	-90.292972	R	MO	11	26
		208.0	UMR	F,M,S,H,C	UMR 268.1	Side channel survey site	Side channel lateral strata assessment	38.908482	-90.266611	R	MO	11	26
IL0036421	Major	207.8		WWTP		Godfrey WWTP	Municipal WWTP	38.930833	-90.226944	L	IL	11	26
333.9659256		207.0	EPA	F,M,S,H,C	UMR 269	GRE Site - dst. Godfrey WWTP	WWTP & EGS impact zone	38.918316	-90.250841	L	IL	11	26
M206.1T		206.1	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	38.912849	-90.229479	L	IL	11	26
M206.0S		206.0	LTRMP	C	UMR 270	Fixed Sta.	Fixed station provides chemical data	38.908016	-90.221152	L	IL	11	26
		205.5	UMR	F,M,S,H	UMR 270	Ust. IL American PWS intake	Far-field survey site: PWS issue	38.908016	-90.221152	L	IL	11	26
IL0000299	Non-major	205.0		Water Treat.		IL American Water Co. - Alton Plant	Water Supply	38.898889	-90.203056	L	IL	11	26
204	PWS	204.0		PWS Intake		Illinois-American Water, Alton	Public Water System	38.889892	-90.190486	L	IL	11	26
M203.5R		203.5	LTRMP	C	UMR 271	Fixed Sta.	Fixed station provides chemical data	38.890723	-90.194418	L	IL	11	26
		203.5	UMR	F,M,S,H	UMR 271	Far-field survey site at fixed station	Far-field survey site	38.890723	-90.194418	L	IL	11	26
M202.6T		202.6	LTRMP	C		Fixed Sta.	Not included in polllution survey	38.88241	-90.18653	L	IL	11	26
M202.6V		202.6	LTRMP	C		Fixed Sta.	Not included in polllution survey	38.881512	-90.181621	L	IL	11	26
M202.6X		202.6	LTRMP	C		Fixed Sta.	Not included in polllution survey	38.881411	-90.177453	L	IL	11	26
M202.2N		202.2	LTRMP	C		Fixed Sta.	Not included in polllution survey	38.870467	-90.189502	L	IL	11	26
M201.7Q		201.7	LTRMP	C		Fixed Sta.	Not included in polllution survey	38.867423	-90.176485	L	IL	11	26
IL0000612	Major	201.4		Industry		Alton Steel Inc.	Industrial discharge	38.883889	-90.154722	L	IL	11	26
		201.2	UMR	F,M,S,H,C	UMR 272	Dst. Alton Steel; ust. L&D 26	Discharge impact zone; impounded effect	38.872864	-90.159237	L	IL	11	26
J-98		200.8	IL EPA	C		Ust. L&D 26	Fixed station provides chemical data	38.869112	-90.154343	L	IL	11	26
200.7	**L&D**	**200.7**		**Dam**		**Mel Price Lock & Dam (L&D 26)**	**Dam**	**38.869288**	**-90.153004**	**R&L**	**MO/IL**	**11**	**26**
		200.5	UMR	F,M,S,H,C	UMR 273	Dst. L&D 26 - tailwaters	Tailwater site assessment	38.867129	-90.148547	L	IL	11	27

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
200	PWS	200.0		PWS Intake		Olin Corp. - East Alton Plant	Public Water System	38.862518	-90.13647	L	IL	11	27
IL0051357	Non-major	199.3		Water Treat.		East Alton WTP	Water Supply	38.8775	-90.125833	L	IL	11	27
IL0070173	Non-major	199.3		Industry		Koch Nitrogen - Wood River Terminal	Special Warehousing and Storage	38.873333	-90.12	L	IL	11	27
IL0031852	Major	198.0		WWTP		Wood River WWTP	Municipal WWTP	38.851667	-90.100556	L	IL	11	27
IL0000035	Non-major	197.8		Industry		BP Products - Wood River	Petroleum Bulk Storage and Terminals	38.841667	-90.108333	L	IL	11	27
IL0076465	Non-major	197.5		Industry		Buckeye Terminals LLC - Hartford Termin	Petroleum Bulk Storage and Terminals	38.831699	-90.087097	L	IL	11	27
IL0001244	Non-major	197.5		Industry		Premier Refining Group Inc.	Petroleum Bulk Storage and Terminals	38.8315	-90.082	L	IL	11	27
IL0021423	Non-major	197.5		WWTP		Hartford CSO	Municipal WWTP	38.831667	-90.106667	L	IL	11	27
		197.3	UMR	F,M,S,H,C	UMR 274	Dst. Hartford CSO + 6 discharges	WWTP & discharges impact zone	38.838453	-90.107098	L	IL	11	27
M196.9Q		196.9	LTRMP	C	UMR 275	Fixed Sta.	Fixed station provides chemical data	38.832714	-90.108506	L	IL	11	27
		196.9	UMR	F,M,S,H	UMR 275	Dst. discharges - at fixed sta.	Dst. discharges impact recovery zone	38.832714	-90.108506	L	IL	11	27
IL0079669	Non-major	196.7		Industry		Marathon Pipeline LLC	Marine Cargo Handling	38.826667	-90.108056	L	IL	11	27
IL0071803	Non-major	195.1		Industry		Conoco Inc. - Wood River Terminal Tank	Petroleum Bulk Storage and Terminals	38.813889	-90.091667	L	IL	11	27
195.0		195.0	UMR	F,M,S,H,C	MOR 11	Missouri R.	Within 2.0 km of mouth	38.814675	-90.121717	R	MO	12	27
		194.3	UMR	F,M,S,H,C	UMR 276	Dst. Missouri R.	Missouri R. influence	38.796914	-90.119098	R	MO	12	27
312.6339243		194.0	EPA	F,M,S,H,C	UMR 277	GRE Site - far field survey site	Far-field survey site; PWS issues	38.791341	-90.13251	L	IL	12	27
192	PWS	192.0		PWS Intake		Illinois-American Water, Granite City	Public Water System	38.778496	-90.147173	L	IL	12	27
IL0075523	Non-major	191.4		WWTP		Chain of Rocks Recycling and Disposal	Refuse Systems	38.76214	-90.129514	L	IL	12	27
MO0000604	Non-major	191.2		Water Treat.		Chain of Rocks Water Treatment Plant	Water Supply	38.755556	-90.188806	R	MO	12	27
		190.5	UMR	F,M,S,H,C	UMR 278	Ust. St. Louis PWS intake	Far-field survey site; PWS issues	38.764151	-90.179548	R	MO	12	27
190	PWS	190.0		PWS Intake		City of St. Louis Water Department	Public Water System	38.662768	-90.185411	R	MO	12	27
		188.5	UMR	F,M,S,H,C	UMR 279	Far field survey site - opposite bank	Far-field survey site	38.747547	-90.189578	R	MO	12	27
		187.0	UMR	F,M,S,H,C	UMR 280.1	Side channel survey site	Side channel lateral strata assessment	38.719058	-90.190721	L	IL	11	27
		186.5	UMR	F,M,S,H,C	UMR 280	Ust. L&D 27	Far-field survey site; impounded effect	38.727368	-90.205959	L	IL	12	27
186.2	**L&D**	**186.2**				**Lock and Dam 27**	**Dam**	**38.703002**	**-90.181296**	**R&L**	**MO/IL**	**12**	**27**
		186.0	UMR	F,M,H,C	UMR 281	Dst. L&D 27 - tailwaters	Tailwater site assessment	38.71143	-90.20929	L	IL	12	OR
MO0115568	Non-major	185.0		Industry		Norfolk Southern Railway Co. - Luther Ya	Railroad Yard	38.6914719	-90.211444	R	MO	12	OR
MO0136786	Non-major	185.0		WWTP		St. Louis Disposal Systems	Refuse Systems	38.6905901	-90.2163663	R	MO	12	OR
IL0078794	Non-major	183.8		EGS		Center Point Energy EGS	Coal Powered Electricity Generation	38.676111	-90.178889	L	IL	12	OR
MO0025178	Major	183.8		WWTP		MSD - Bissell Point WWTP	Municipal WWTP	38.6763059	-90.191028	R	MO	12	OR
		183.6	UMR	F,M,H,C	UMR 282	Dst. Center Point Energy EGS	Discharges impact zone	38.676409	-90.185565	L	IL	12	OR
		183.5	UMR	F,M,H,C	UMR 283	Dst. MSD - Bissell Point WWTP	WWTP impact zone	38.675212	-90.184973	R	MO	12	OR
IL0071765	Non-major	183.5		Water Treat.		IDOT District 8 Venice Pump Station	Water Supply	38.669444	-90.18	L	IL	12	OR
IL0000175	Non-major	182.5		EGS		Ameren UE - Venice EGS	Coal Powered Electricity Generation	38.666667	-90.166667	L	IL	12	OR
MO0111805	Non-major	181.7		Industry		The Kiesel Co. - Kiesel Marine	Petroleum Bulk Storage and Terminals	38.65789	-90.18562	R	MO	12	OR
MO0113328	Non-major	181.7		WWTP		Saint Louis Terminals Co.	Municipal WWTP	38.651112	-90.183861	R	MO	12	OR
MO0000345	Non-major	181.5		EGS		Tractebel Power Inc.	Combination Utilities	38.636391	-90.181084	R	MO	12	OR
		181.3	UMR	F,M,H,C	UMR 284	Dst. 5 discharges; ust. PWS intake	Discharges impact zone	38.59162694	-90.19932337	R	MO	12	OR
181	PWS	181.0		PWS Intake		Illinois-American Water, East St.Louis	Public Water System	38.661737	-90.179252	L	IL	12	OR
MO0134741	Non-major	179.2		Industry		American River Transportation Co.	Marine Cargo Handling	38.621406	-90.191635	R	MO	12	OR
IL0033472	Non-major	178.8		WWTP		E. St. Louis CSOs	Municipal WWTP	39.588333	-90.805	L	IL	12	OR
		178.6	UMR	F,M,H,C	UMR 285	Dst. E. St. Louis CSOs	CSOs impact zone	38.571493	-90.228387	L	IL	12	OR
IL0065145	Non-major	177.4		WWTP		Sauget - ABRTF	Municipal WWTP	38.591944	-90.183889	L	IL	12	OR
		177.2	UMR	F,M,H,C	UMR 284	Dst. Sauget - ABRTF	WWTP impact zone	38.59162694	-90.19932337	L	IL	12	OR
IL0071552	Non-major	177.2		WWTP		Veolia ES Technical Solutions	Refuse Systems	38.586111	-90.186111	L	IL	12	OR
MO0121169	Non-major	175.9		Industry		JD Streett and Co.	Petroleum Bulk Storage and Terminals	38.5819169	-90.218444	R	MO	12	OR
		175.0	UMR	F,M,H,C	UMR 285	Far field survey site - opposite bank	Cross channel site from discharges	38.571493	-90.228387	R	MO	12	OR
MO0001601	Non-major	172.5		Industry		Louisiana Dock Co. LLC	Marine Cargo Handling	38.5389719	-90.2565	R	MO	12	OR
MO0025151	Major	171.3		WWTP		MSD - Lemay WWTP	Municipal WWTP	38.5236939	-90.267083	R	MO	12	OR
		171.3	UMR	F,M,H,C	UMR 286	Dst. MSD - Lemay WWTP	WWTP impact zone	38.52525323	-90.26279029	R	MO	12	OR
MO0117307	Non-major	171.3		Industry		Rockwood Pigments Inc.	Inorganic Pigments	38.529873	-90.272431	R	MO	12	OR
MO0119733	Non-major	168.6		Industry		JB Marine	Marine Gasoline Service	38.4859719	-90.279806	R	MO	12	OR
262.2880643		163.0	EPA	F,M,H,C	UMR 287	GRE Site - far field survey site	Discharges impact recovery zone	38.409493	-90.317478	L	IL	12	OR
J-36		162.2	IL EPA	C	UMR 288	Fixed Sta.	Fixed station provides chemical data	38.40575	-90.323521	L	IL	12	OR
		162.2	UMR	F,M,H,C	UMR 288	Far field survey site - at fixed sta.	Discharges impact recovery zone	38.40575	-90.323521	L	IL	12	OR
MO0000361	Major	161.1		EGS		Ameren MO - Mermec EGS	Coal Powered Electricity Generation	38.4010829	-90.332611	R	MO	12	OR
		160.9	UMR	F,M,H,C	UMR 289	Dst. Mermec EGS	EGS impact zone	38.392801	-90.33909	R	MO	12	OR
MO0106461	Non-major	159.0		WWTP		Kimmswick WWTP	Municipal WWTP	38.3686939	-90.359778	R	MO	12	OR
MO0056162	Major	158.7		WWTP		Glaize Creek SD WWTP	Municipal WWTP	38.334194	-90.37525	R	MO	12	OR

Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
		158.5	UMR	F,M,H,C	UMR 290	Dst. Glaize Creek SD WWTP	WWTPs impact zone	38.360334	-90.356964	R	MO	12	OR
249.1555691		155.0	EPA	F,M,H,C	UMR 291	GRE Site - far field survey site	WWTPs impact recovery zone	38.305035	-90.371933	R	MO	12	OR
MO0046736	Non-major	153.5		WWTP		Teamsters Local 688	RV Parks and Campsites	38.2874999	-90.380583	R	MO	12	OR
		152.0	UMR	F,M,H,C	UMR 292	Far field survey site - opposite bank	Cross channel site from discharges	38.267876	-90.370617	L	IL	12	OR
MO0000281	Major	151.6		Industry		Doe Run Herculaneum Smelting	Smelting/Refining-Nonferrous Metal	38.2618609	-90.37275	R	MO	12	OR
MO0027111	Non-major	151.5		WWTP		Herculaneum WWTP	Municipal WWTP	38.254556	-90.374306	R	MO	12	OR
		151.4	UMR	F,M,H,C	UMR 293	Dst. Herculaneum Smelting & WWTP	WWTP impact zone	38.259271	-90.369406	R	MO	12	OR
237.5886657		147.0	EPA	F,M,H,C	UMR 294	GRE Site	Far-field survey site	38.206456	-90.347067	R	MO	12	OR
MO0000035	Non-major	145.6		Industry		River Cement Co. - Selma	Cement Manufacturing	38.1787779	-90.336944	R	MO	12	OR
MO0000817	Major	144.5		Industry		Laroche Industries Crystal City Nitrogen	Nitrogenous Fertilizer Manufacturing	38.163611	-90.321111	R	MO	12	OR
		144.3	UMR	F,M,H,C	UMR 295	Dst. Crystal City Nitrogen	Discharges impact zone	38.176506	-90.305784	R	MO	12	OR
MO0000043	Major	143.0		EGS		Ameren MO Rush Island EGS	Coal Powered Electricity Generation	38.1330279	-90.262889	R	MO	12	OR
MO0133787	Major	142.9		Industry		Holcim (US) Inc. STE Genevieve Plant	Cement Manufacturing	38.104558	-90.299456	R	MO	12	OR
		142.7	UMR	F,M,H,C	UMR 296	Dst. STE Genevieve Plant	EGS impact zone	38.16564	-90.281735	R	MO	12	OR
		142.0	UMR	F,M,H,C	UMR 297	Far field survey site - opposite bank	Cross channel site from EGS	38.156619	-90.274162	L	IL	12	OR
		140.5	UMR	F,M,H,C	UMR 298	Ust. Ameren PWS intake	Discharge impact recovery; PWS issues	38.135703	-90.259966	R	MO	12	OR
140	PWS	140.0		PWS Intake		Ameren UE - Rush Island	Public Water System	38.139018	-90.265103	R	MO	12	OR
		138.0	UMR	F,M,H,C	UMR 298.1	Side channel survey site	Side channel lateral strata assessment	38.11224	-90.229871	L	IL	12	OR
		133.0	UMR	F,M,H,C	UMR 299	Far field survey site	Far-field survey site	38.066935	-90.158626	R	MO	12	OR
205.776969		128.0	EPA	F,M,H,C	UMR 300	GRE Site - far field survey site	Far-field survey site	38.020952	-90.096254	L	IL	12	OR
MO0124044	Major	127.2		Industry		Chemical Lime Co.	Lime Manufacturing	38.015333	-90.091167	R	MO	12	OR
MO0135399	Non-major	127.0		Quarry		Tower Rock Stone Company	Crushed and Broken Limestone	38.00975	-90.095222	R	MO	12	OR
		126.8	UMR	F,M,H,C	UMR 301	Dst. 2 discharges	Discharges impact zone	38.013711	-90.081019	R	MO	12	OR
IL0079545	Non-major	125.5		Industry		Kaskaskia Regional Port District	Marine Cargo Handling	38.013056	-90.058056	L	IL	12	OR
MO0052159	Non-major	122.5		WWTP		Ste Genevieve WWTP	Municipal WWTP	37.9792779	-90.038222	R	MO	12	OR
		121.8	UMR	F,M,H,C	UMR 301.1	Side channel survey site	Side channel lateral strata assessment	37.983348	-90.002502	L	IL	12	OR
195.3387224		121.0	EPA	F,M,H,C	UMR 302	GRE Site - dst. St.Genevieve	WWTP impact zone	37.966671	-90.004191	R	MO	12	OR
MO0129186	Non-major	120.5		Industry		Bigfield Terminal	Inland Water Freight Transportation	37.95925	-89.987472	R	MO	12	OR
117.5		117.5	UMR	F,M,H,C	KAS 12	Kaskaskia R.	Within 2.0 km of mouth	37.974899	-89.957538	L	IL	13	OR
I-05		111.0	IL EPA	C		Fixed Sta.	Fixed station provides chemical data	37.910296	-89.854057	L	IL	13	OR
		111.0	UMR	F,M,H,C	UMR 303	Far field survey site - at fixed sta.	Far-field survey site	37.910467	-89.853909	L	IL	13	OR
110	PWS	110.0		PWS Intake		Chester Water Department	Public Water System	37.905587	-89.836664	L	IL	13	OR
IL0072931	Major	107.0		WWTP		Chester WWTP	Municipal WWTP	37.8875	-89.788333	L	IL	13	OR
		106.8	UMR	F,M,H,C	UMR 304	Dst. Chester WWTP	WWTP impact zone	37.877316	-89.789925	L	IL	13	OR
IL0060674	Non-major	103.0		WWTP		Kinder Morgan Bulk Terminals	Port and Harbor Operations	37.806667	-89.671667	L	IL	13	OR
164.802578		102.0	EPA	F,M,H,C	UMR 305	GRE Site - far field survey site	WWTP impact recovery zone	37.83782	-89.73183	L	IL	13	OR
		101.5	UMR	F,M,H,C	UMR 305.1	Side channel survey site	Side channel lateral strata assessment	37.838193	-89.714	L	IL	13	OR
159.7768012		99.0	EPA	F,M,H,C	UMR 306	GRE Site - far field survey site	Far-field survey site	37.809497	-89.687188	L	IL	13	OR
		96.0	UMR	F,M,H,C	UMR 306.1	Side channel survey site	Side channel lateral strata assessment	37.775554	-89.67485	R	MO	13	OR
145.5385305		90.0	EPA	F,M,H,C	UMR 307	GRE Site - far field survey site	Far-field survey site	37.71939	-89.60206	L	IL	13	OR
142.3904753		88.0	EPA	F,M,H,C	UMR 308	GRE Site - far field survey site	Far-field survey site	37.70864	-89.56935	R	MO	13	OR
IL0000124	Major	81.9		EGS		Ameren Grand Tower EGS	Coal Powered Electricity Generation	37.658056	-89.511667	L	IL	13	OR
		81.7	UMR	F,M,H,C	UMR 309	Dst. Grand Tower EGS	EGS impact zone	37.655623	-89.517724	L	IL	13	OR
129.1270914		79.0	EPA	F,M,H,C	UMR 310	GRE Site	EGS impact recovery zone	37.622635	-89.507813	L	IL	13	OR
M078.0B		78.0	LTRMP	C	UMR 311	Fixed Sta.	Fixed station provides chemical data	37.603884	-89.510106	L	IL	13	OR
126.3379521		78.0	EPA	F,M,H	UMR 311	GRE Site - at fixed sta.	Far-field survey site	37.599945	-89.517707	L	IL	13	OR
BM00.7S		75.7	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	37.576483	-89.509419	L	IL	13	OR
75.7		75.7	UMR	F,M,H,C	BMR 13	Big Muddy R.	Within 2.0 km of mouth	37.573311	-89.517462	L	IL	13	OR
M070.2A		70.2	LTRMP	C	UMR 312	Fixed Sta.	Fixed station provides chemical data	37.499705	-89.493898	L	IL	13	OR
113.6069051		70.0	EPA	F,M,H	UMR 312	GRE Site - at fixed sta.	Far-field survey site	37.492583	-89.492248	R	MO	13	OR
MO0044121	Major	69.8		Industry		Proctor & Gamble Paper Products	Paper Mill	37.479028	-89.508611	R	MO	13	OR
		69.6	UMR	F,M,H,C	UMR 313	Dst. P&G	P&G impact zone	37.490857	-89.491522	R	MO	13	OR
M066.4C		66.4	LTRMP	C	UMR 314	Fixed Sta.	Fixed station provides chemical data	37.455013	-89.456299	R	MO	13	OR
		66.4	UMR	F,M,S,H	UMR 314	Far field survey site - at fixed sta.	P&G impact recovery zone	37.455013	-89.456299	R	MO	13	OR
M066.3B		66.3	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	37.45526	-89.45799	R	MO	13	OR
M066.3A		66.3	LTRMP	C		Fixed Sta.	Fixed station provides chemical data	37.45526	-89.45799	R	MO	13	OR
M059.5I		59.5	LTRMP	C	UMR 315	Fixed Sta.	Fixed station provides chemical data	37.361094	-89.426173	L	IL	13	OR
		59.5	UMR	F,M,H	UMR 315	Far field survey site - at fixed sta.	Far-field survey site	37.361094	-89.426173	L	IL	13	OR
96.79198974		59.0	EPA	F,M,H	UMR 316	GRE Site - far field survey site	Far-field survey site	37.360633	-89.427183	R	MO	13	OR

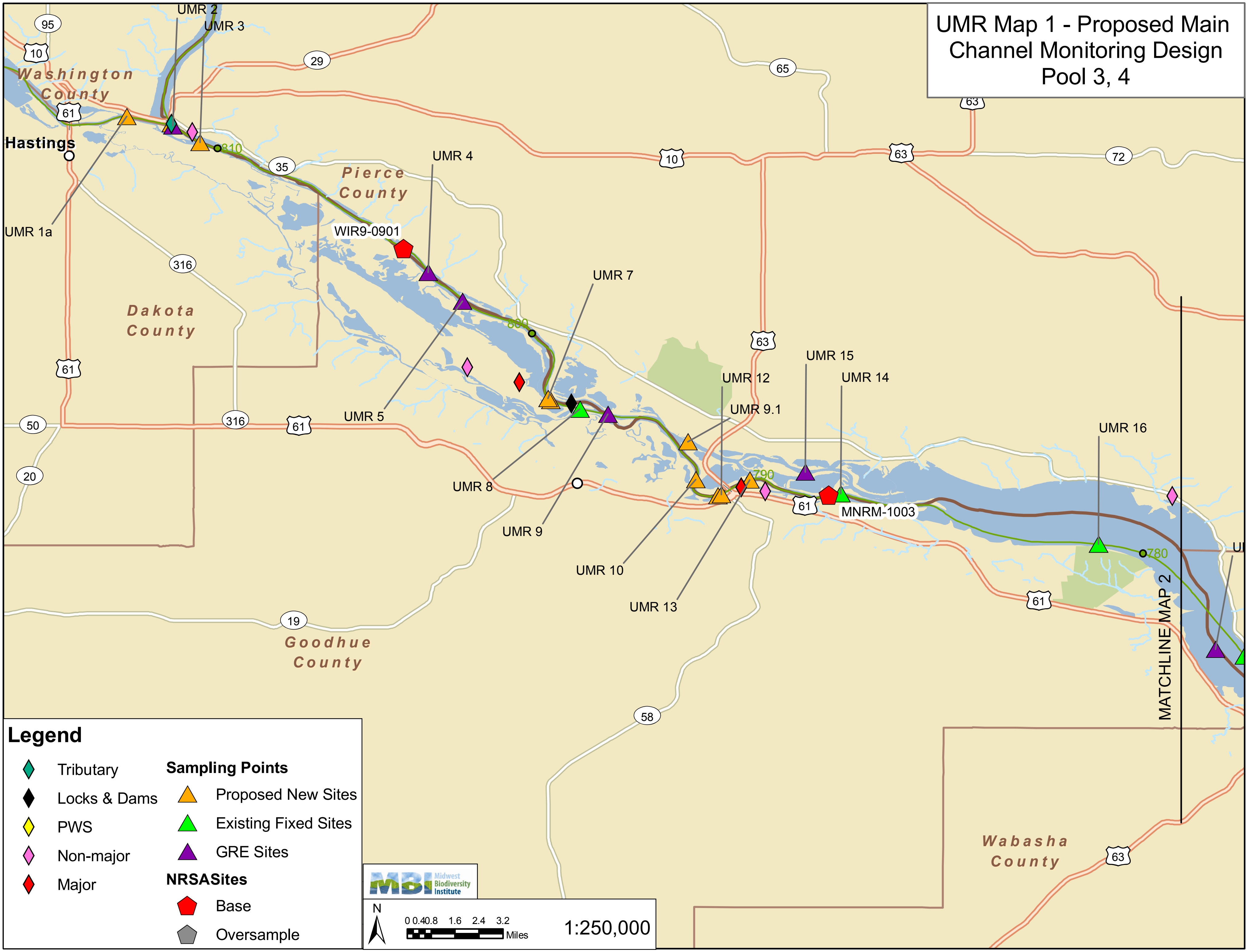
Appendix Table C-1. Upper Mississippi River master pollution survey design (Site Type: F = fish; M = macroinvertebrates, S = submersed aquatic plants; H = habitat; C = water/sediment chemistry).

Existing Site ID	Permit	River Mile	Program	Site Type	UMR Site ID	Description	Sampling Site Description/Role in Pollution Survey Design	Latitude	Longitude	River RorL	State	CWA Reach	Pool
M056.0I		56.0	LTRMP	C	UMR 317	Fixed Sta.	Fixed station provides chemical data	37.339099	-89.469439	R	MO	13	OR
		56.0	UMR	F,M,H	UMR 317	Far field survey site - at fixed sta.	Far-field survey site	37.339099	-89.469439	R	MO	13	OR
54	PWS	54.0		PWS Intake		Alliance Water Resources	Public Water System	37.325	-89.497431	R	MO	13	OR
MO0050580	Major	50.1		WWTP		Cape Girardeau WWTP	Municipal WWTP	37.2769719	-89.527306	R	MO	13	OR
MO0102474	Non-major	50.0		WWTP		Biokyowa	Medicinal and Botanical Mfg.	37.271889	-89.528694	R	MO	13	OR
		49.7	UMR	F,M,H,C	UMR 317.1	Far-field survey site	Far-field survey site added to main channel	37.265104	-89.52548	R	MO	13	OR
		49.2	UMR	F,M,H,C	UMR 317.2	Side channel survey site	Side channel lateral strata assessment	37.268717	-89.505604	L	IL	13	OR
MO0000809	Major	49.0		Industry		Buzzi Unicem USA	Cement Mfg.	37.2546669	-89.5361939	R	MO	13	OR
MO0120421	Non-major	48.5		Industry		SE MO Regional Airport	Marine Cargo Handling	37.24675	-89.506	R	MO	13	OR
MO0120642	Non-major	48.0		Industry		MO Fibre Corporation	Wood Products	37.246083	-89.4918059	R	MO	13	OR
73.25783172		45.0	EPA	F,M,H,C	UMR 318	GRE Site - dst. discharges	Discharges impact zone	37.238302	-89.45921	R	MO	13	OR
MO0119300	Non-major	44.4		Industry		Cape Girardeau Terminal	Pipeline Petroleum Products	37.2278609	-89.4807499	R	MO	13	OR
I-84		44.0	IL EPA	C	UMR 319	Fixed Sta.	Fixed station provides chemical data	37.221322	-89.465996	L	IL	13	OR
		44.0	UMR	F,M,H	UMR 319	Far field survey site - at fixed sta.	Far-field survey site	37.221322	-89.465996	L	IL	13	OR
65.13189523		40.0	EPA	F,M,H,C	UMR 320	GRE Site - far field survey site	Far-field survey site	37.17176	-89.44502	R	MO	13	OR
60.20629452		37.0	EPA	F,M,H,C	UMR 321	GRE Site - far field survey site	Far-field survey site	37.132533	-89.420472	L	IL	13	OR
44.65579938		28.0	EPA	F,M,H,C	UMR 322	GRE Site - far field survey site	Far-field survey site	37.02626	-89.34697	R	MO	13	OR
37.64915815		24.0	EPA	F,M,H,C	UMR 323	GRE Site - far field survey site	Far-field survey site	36.989064	-89.284561	L	IL	13	OR
34.24119514		22.0	EPA	F,M,H,C	UMR 324	GRE Site - far field survey site	Far-field survey site	37.00889	-89.26047	L	IL	13	OR
24.8270824		16.0	EPA	F,M,H,C	UMR 325	GRE Site - far field survey site	Far-field survey site	37.070589	-89.306975	L	IL	13	OR
10.59859992		7.0	EPA	F,M,H,C	UMR 326	GRE Site - far field survey site	Far-field survey site	37.019633	-89.204166	R	MO	13	OR
		3.5	UMR	F,M,H,C	UMR 326.1	Side channel survey site	Side channel lateral strata assessment	36.985937	-89.176145	L	IL	13	OR
		1.0	UMR	F,M,H,C	UMR 327	Far field survey site - ust. Ohio R.	Far-field survey site	36.981078	-89.142927	R	MO	13	OR

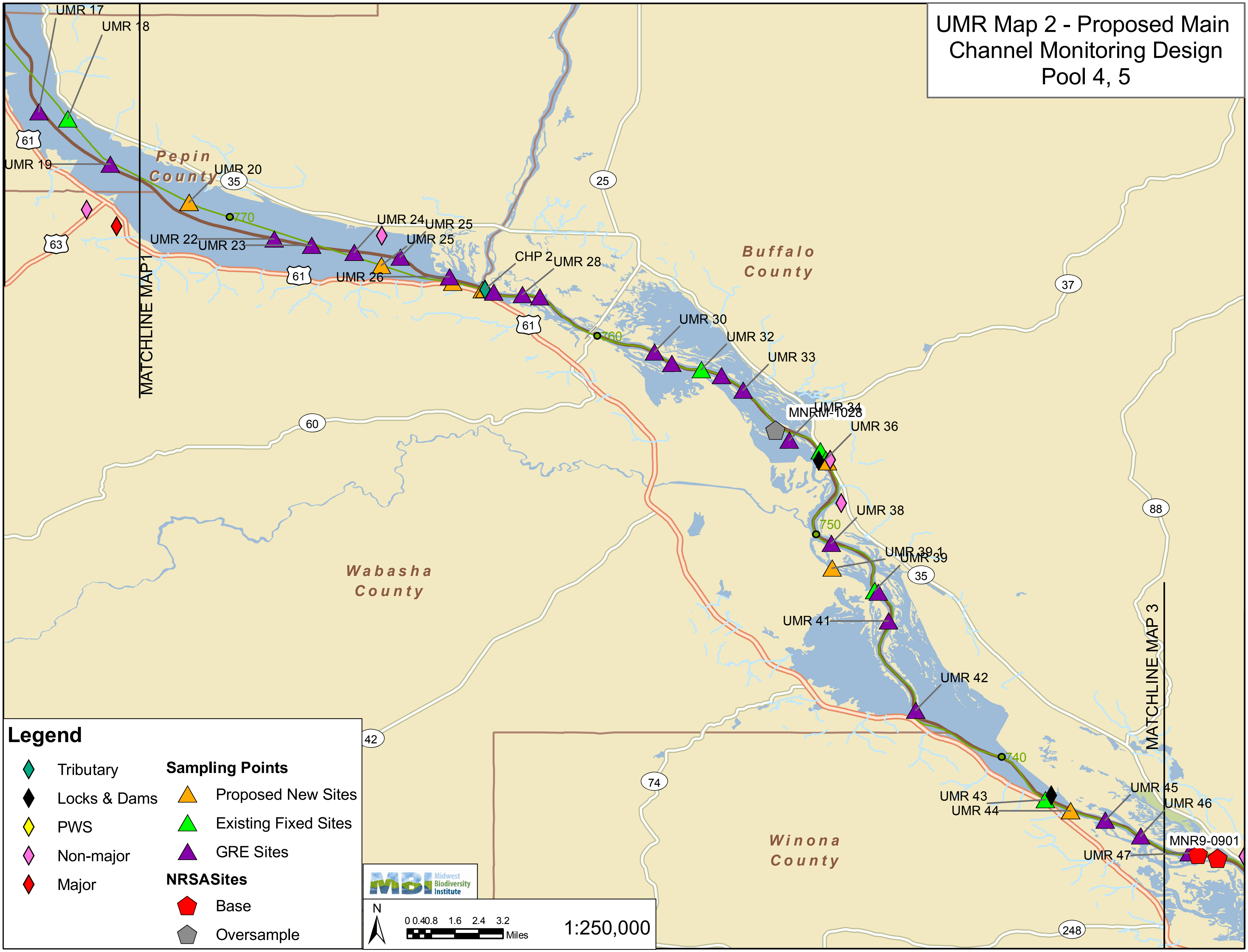
FOOTNOTES:
a - Each intensive pollution survey site is assigned an alpha numeric code in order from upstream to downstream by river mile. Side channel sites are assigned 0.1 to preceding UMR code. An additional 10% of intensive pollution survey sites are held in contingency for detailed study planning (N ≈ 35-40) and will result in additonal sites.
[b] - Major tributaries are assigned a tributary site with 2 km of the mouth and each is assigned a unique alpha-numric site code.
[c] - The 2004-6 GRE sites are included to demonstrate how the Probabilistic C design could be blended with the intensive pollution survey design.
[d] - Most of the existing fixed stations are incorporated into the intensive pollution survey design and will provide chemical/physical data - sampling frequency will be increased during the summer-fall index period.

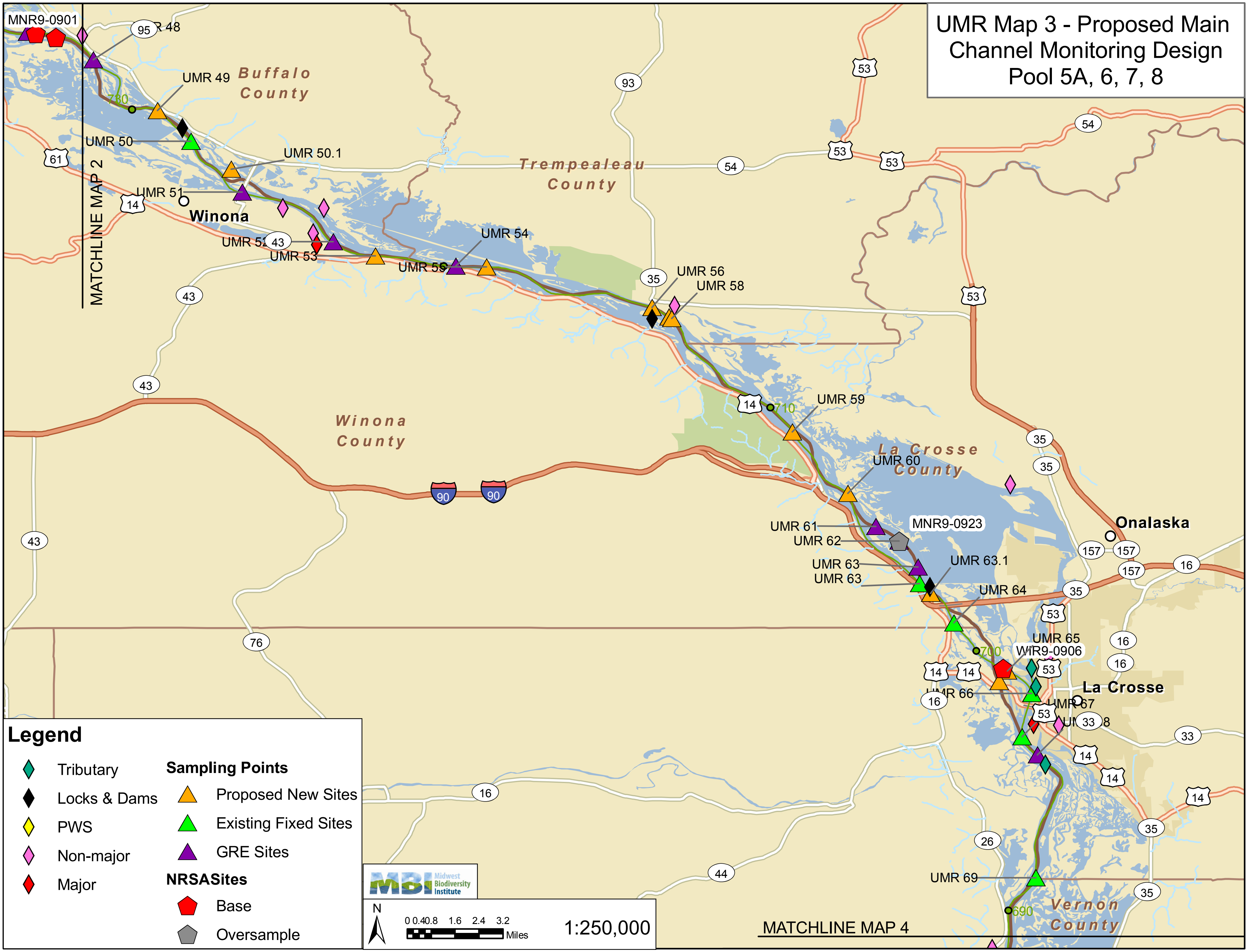
UMR Reference Sites: (N = 30)
St. Croix R. - 6 sites in lower 30 miles
Chippewa R. - 6 sites in lower 30 miles
Wisconsin R. - 6 sites in lower 30 miles
Rock R. - 3 sites in lower 20 miles
Iowa R. - 5 sites in lower 25 miles
Kaskaskia R. - 4 sites in lower 20 miles
All core & supplememntal chemical, physical, and biological indicators are to be collected at reference sites.

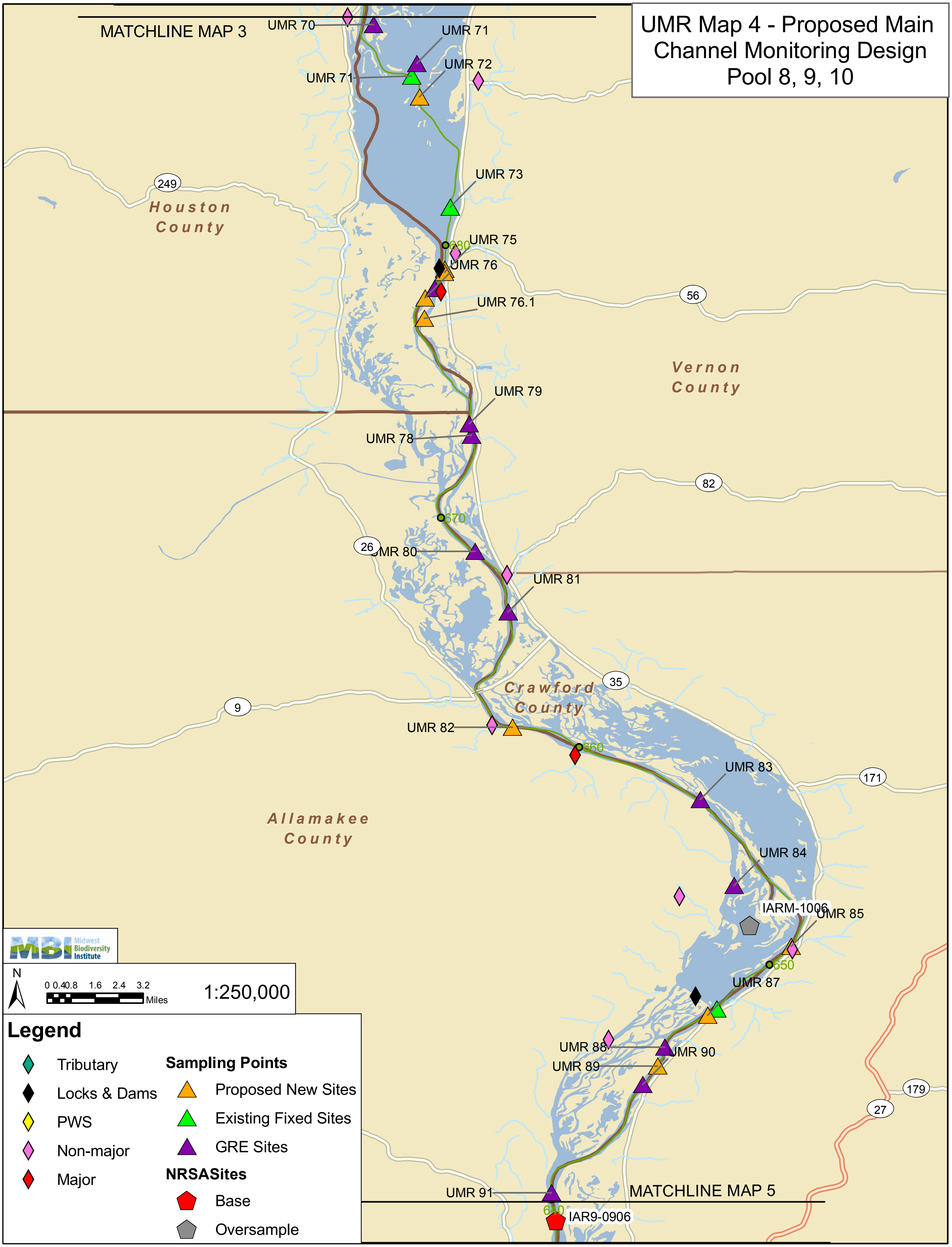
Upper Mississippi River Master Intensive Pollution Survey design maps showing sites and stressors listed in Appendix Table C-1 (1:250000 scale).

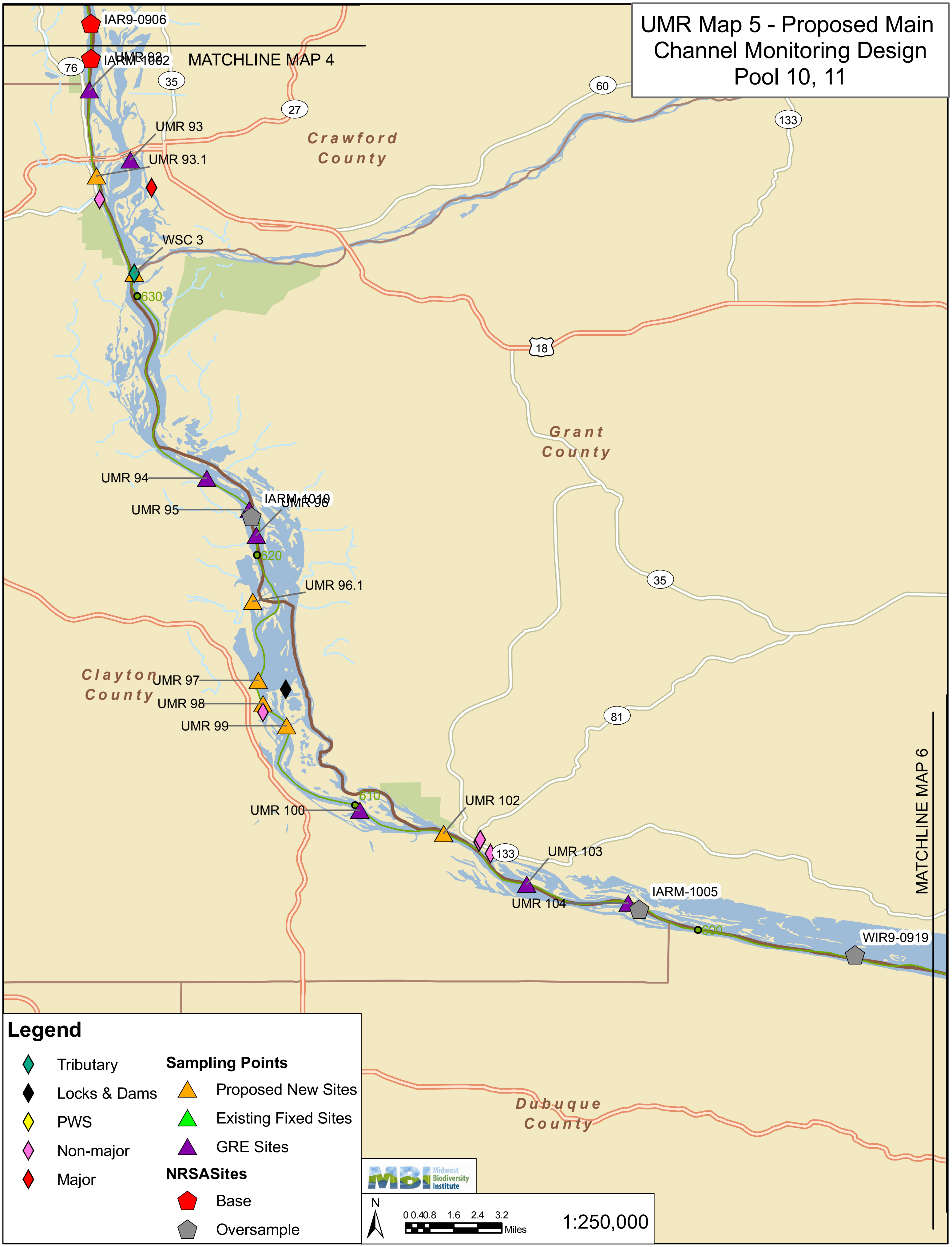


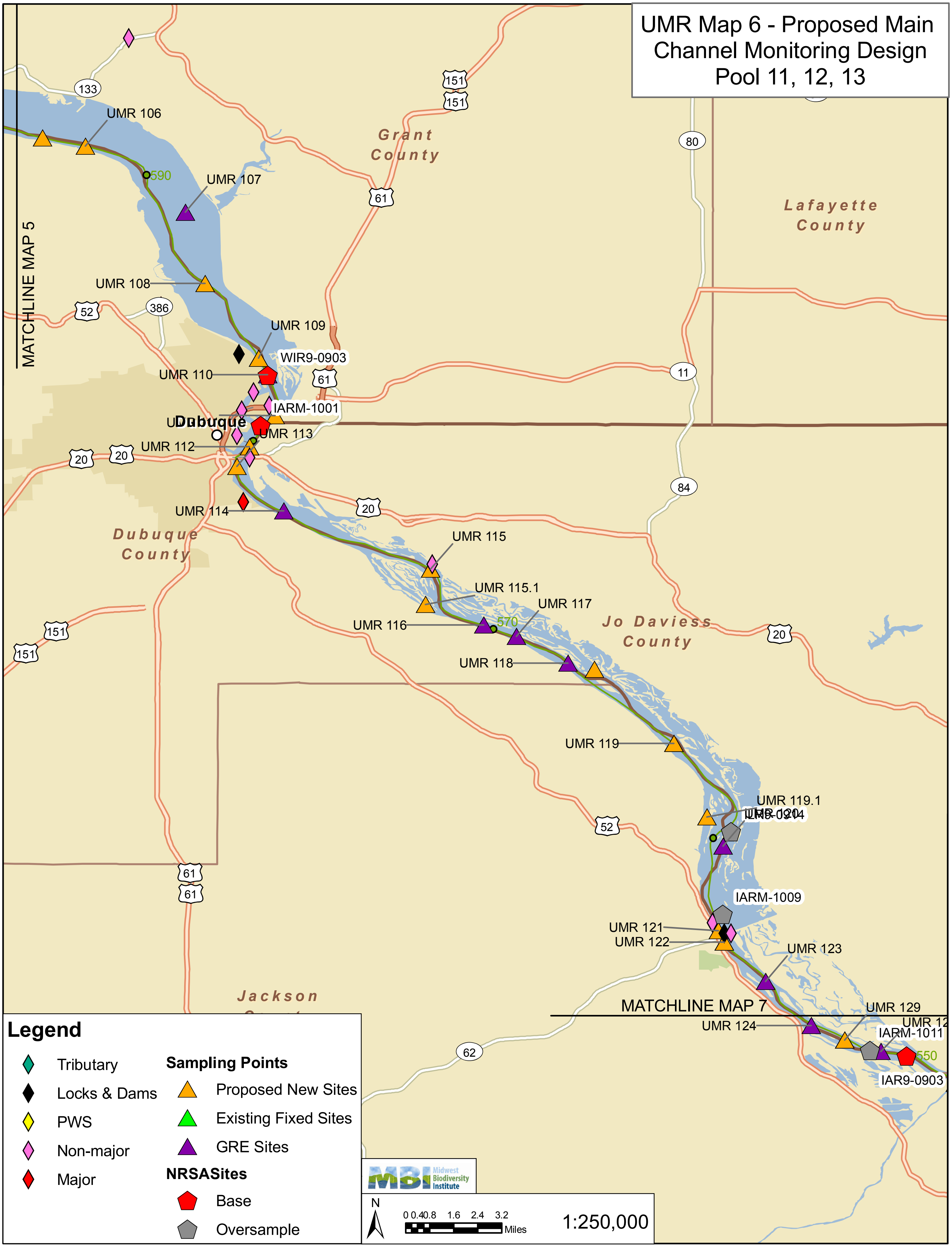
UMR Map 1 - Proposed Main Channel Monitoring Design
Pool 3, 4
Washington County
Pierce County
Dakota County
Goodhue County
Wabasha County
Hastings
UMR 1a
UMR 2
UMR 3
UMR 4
UMR 5
UMR 7
UMR 8
UMR 9
UMR 9.1
UMR 10
UMR 12
UMR 13
UMR 14
UMR 15
UMR 16
WIR9-0901
MNRM-1003
810
800
790
780
MATCHLINE MAP 2
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2
Miles
1:250,000

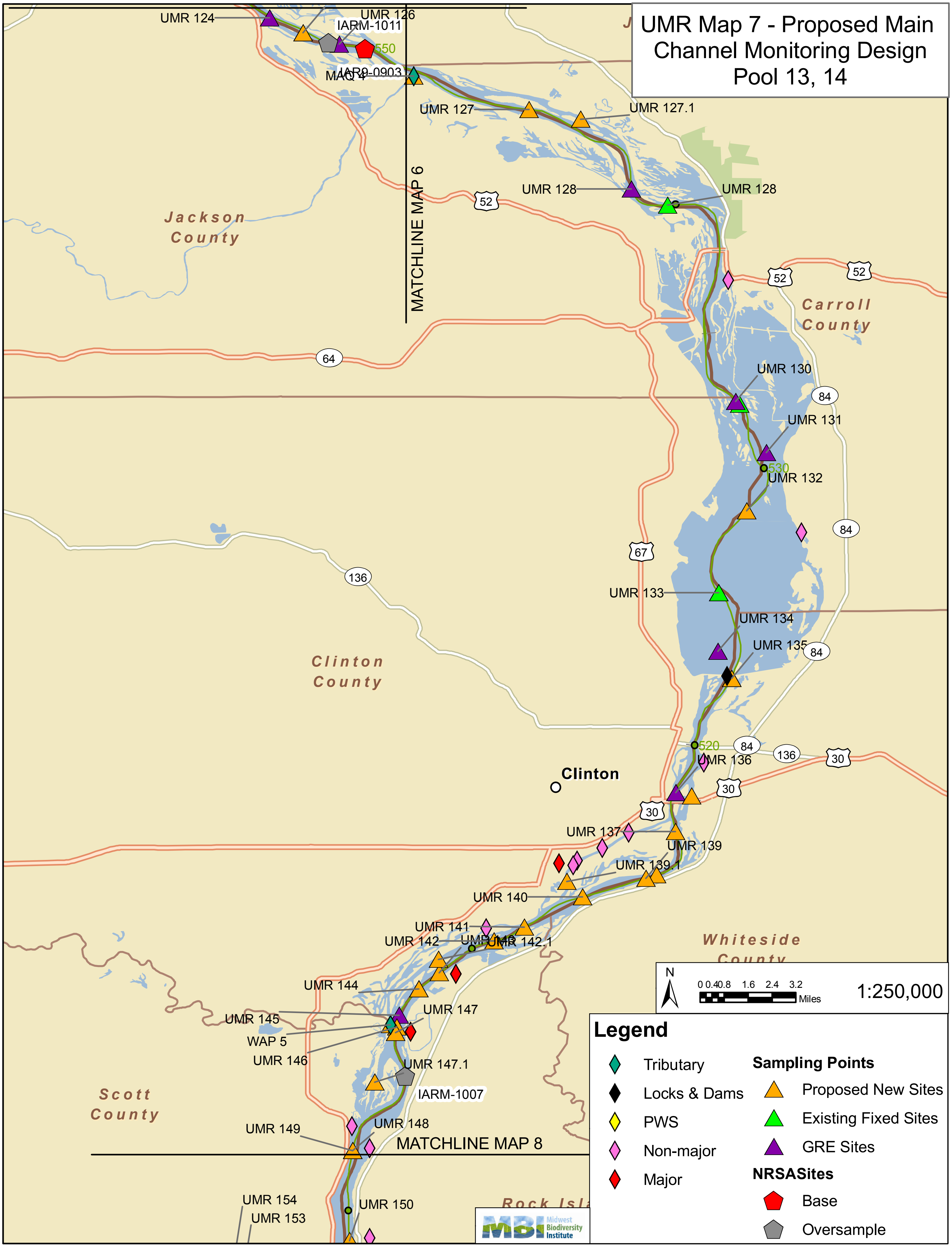

UMR Map 2 - Proposed Main Channel Monitoring Design Pool 4, 5
UMR 17
UMR 18
UMR 19
UMR 20
UMR 22
UMR 23
UMR 24
UMR 25
UMR 25
UMR 26
CHP 2
UMR 28
UMR 30
UMR 32
UMR 33
UMR 34
MNRM-1028
UMR 36
UMR 38
UMR 39.1
UMR 39
UMR 41
UMR 42
UMR 43
UMR 44
UMR 45
UMR 46
UMR 47
MNR9-0901
Pepin County
Buffalo County
Wabasha County
Winona County
MATCHLINE MAP1
MATCHLINE MAP 3
770
760
750
740
61
63
35
25
37
60
88
42
74
248
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2 Miles
1:250,000


UMR Map 3 - Proposed Main Channel Monitoring Design
Pool 5A, 6, 7, 8
MATCHLINE MAP 2
MATCHLINE MAP 4
Buffalo County
Trempealeau County
Winona County
La Crosse County
Vernon County
Winona
Onalaska
La Crosse
MNR9-0901
MNR9-0923
WIR9-0906
UMR 49
UMR 50
UMR 50.1
UMR 51
UMR 53
UMR 54
UMR 56
UMR 58
UMR 59
UMR 60
UMR 61
UMR 62
UMR 63
UMR 63
UMR 63.1
UMR 64
UMR 65
UMR 66
UMR 67
UMR 69
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2
Miles
1:250,000

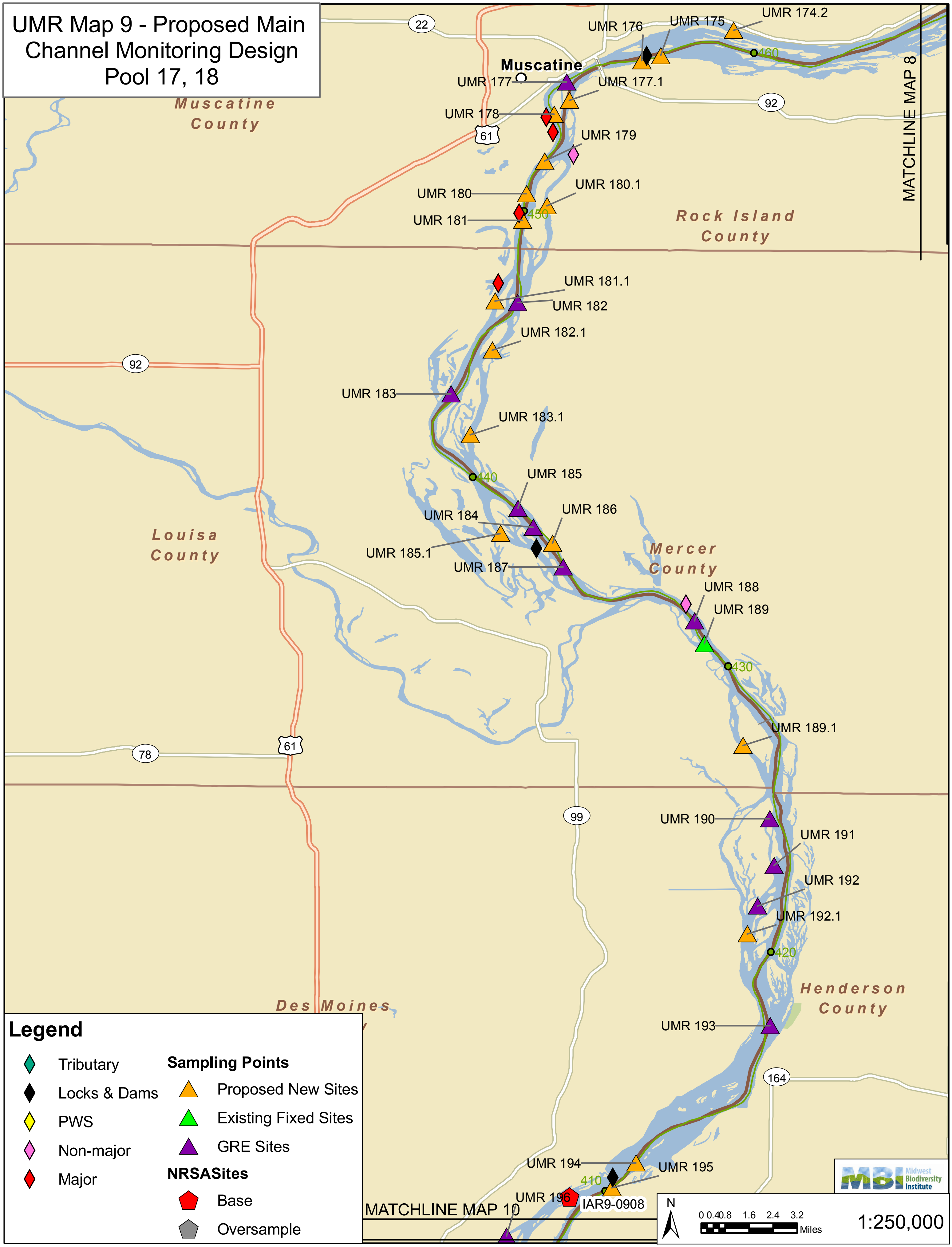

UMR Map 4 - Proposed Main Channel Monitoring Design Pool 8, 9, 10
MATCHLINE MAP 3
UMR 70
UMR 71
UMR 71
UMR 72
UMR 73
UMR 75
UMR 76
UMR 76.1
UMR 79
UMR 78
UMR 80
UMR 81
UMR 82
UMR 83
UMR 84
IARM-1006
UMR 85
UMR 87
UMR 88
UMR 89
UMR 90
UMR 91
IAR9-0906
MATCHLINE MAP 5
Houston County
Vernon County
Crawford County
Allamakee County
249
56
82
26
35
9
171
179
27
680
670
660
650
640
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2 Miles
1:250,000
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample

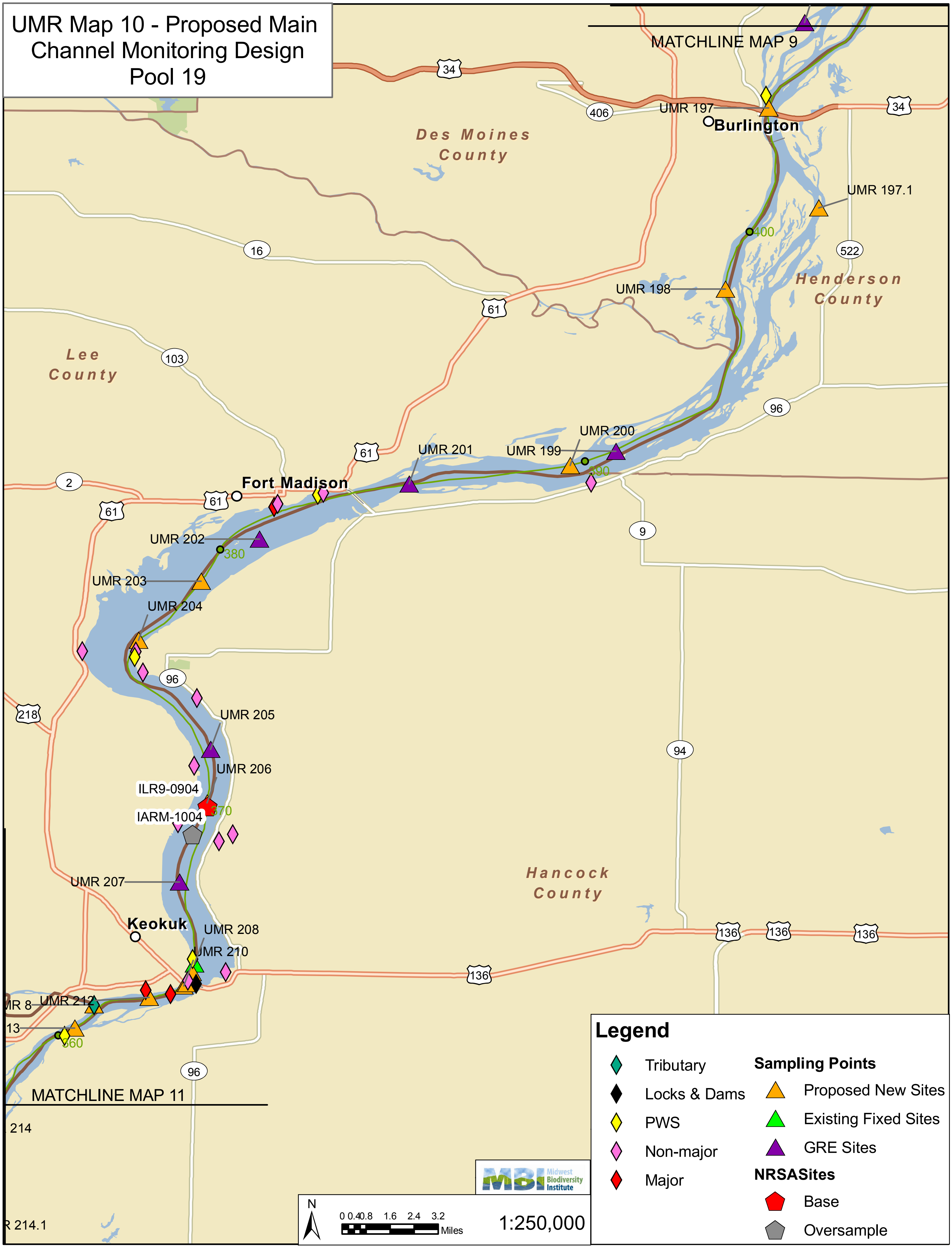

UMR Map 5 - Proposed Main Channel Monitoring Design
Pool 10, 11
MATCHLINE MAP 4
MATCHLINE MAP 6
IAR9-0906
IARM-1002
UMR 92
UMR 93
UMR 93.1
WSC 3
630
Crawford County
Grant County
Clayton County
Dubuque County
UMR 94
UMR 95
IARM-1010
UMR 96
620
UMR 96.1
UMR 97
UMR 98
UMR 99
UMR 100
610
UMR 102
UMR 103
UMR 104
IARM-1005
600
WIR9-0919
76
35
27
60
133
18
81
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2
Miles
1:250,000


UMR Map 6 - Proposed Main Channel Monitoring Design
Pool 11, 12, 13
MATCHLINE MAP 5
MATCHLINE MAP 7
Grant County
Lafayette County
Dubuque County
Jo Daviess County
Jackson
Dubuque
UMR 106
UMR 107
UMR 108
UMR 109
WIR9-0903
UMR 110
IARM-1001
UMR 112
UMR 113
UMR 114
UMR 115
UMR 115.1
UMR 116
UMR 117
UMR 118
UMR 119
UMR 119.1
IARM-1009
UMR 121
UMR 122
UMR 123
UMR 124
UMR 129
IARM-1011
IAR9-0903
590
570
550
133
151
80
61
52
386
11
20
84
62
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2
Miles
1:250,000

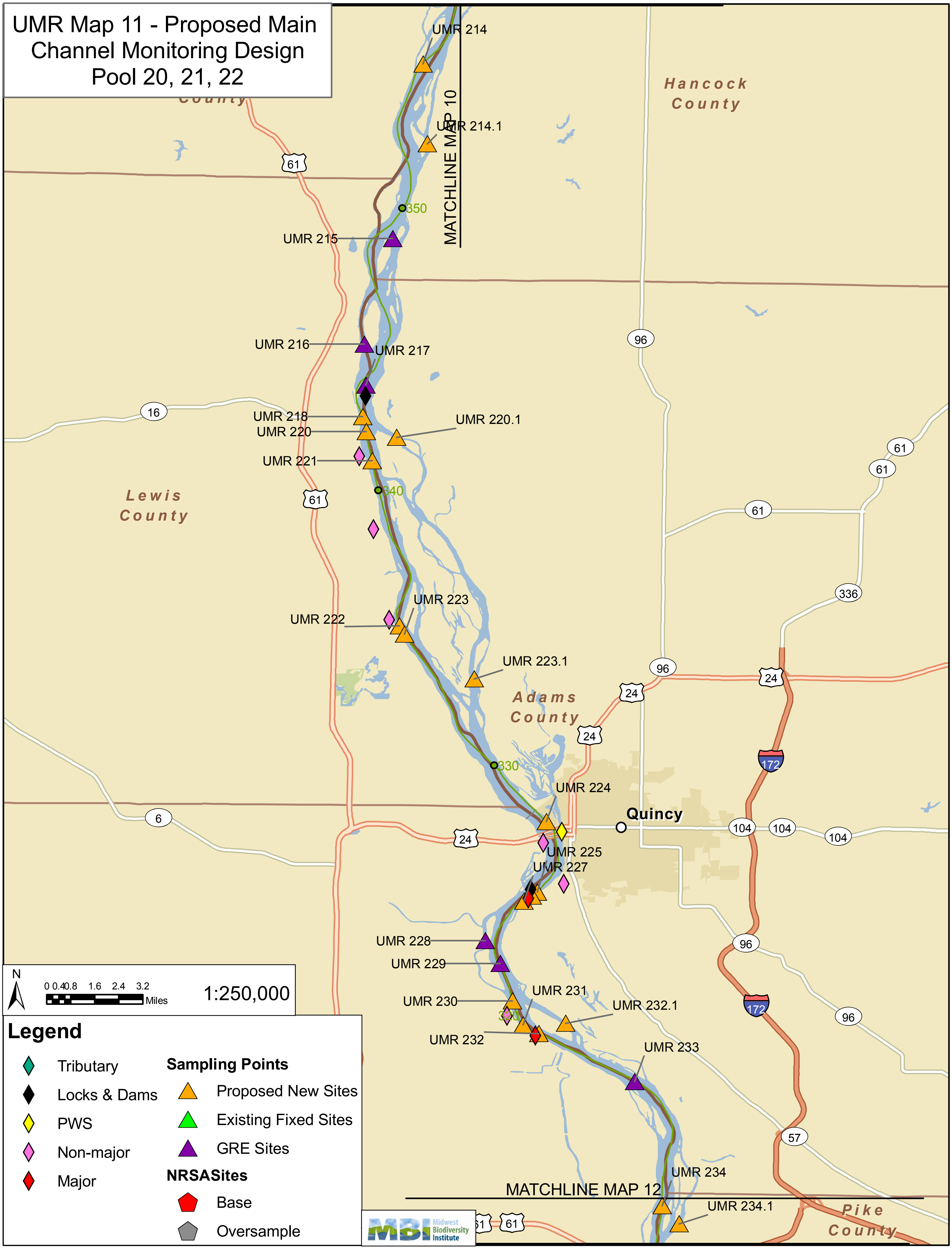

UMR Map 7 - Proposed Main Channel Monitoring Design
Pool 13, 14
UMR 124
UMR 126
IARM-1011
550
IAR9-0903
MAQ 4
UMR 127
UMR 127.1
MATCHLINE MAP 6
UMR 128
UMR 128
52
Jackson County
Carroll County
64
UMR 130
84
UMR 131
530
UMR 132
84
67
136
Clinton County
UMR 133
UMR 134
UMR 135
84
520
84
136
30
UMR 136
Clinton
30
30
UMR 137
UMR 139
UMR 139.1
UMR 140
UMR 141
UMR 142
UMR 143
UMR 142.1
Whiteside County
UMR 144
UMR 145
UMR 147
WAP 5
UMR 146
UMR 147.1
IARM-1007
Scott County
UMR 149
UMR 148
MATCHLINE MAP 8
UMR 154
UMR 153
UMR 150
Rock Isla
N
0 0.4 0.8 1.6 2.4 3.2 Miles
1:250,000
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute

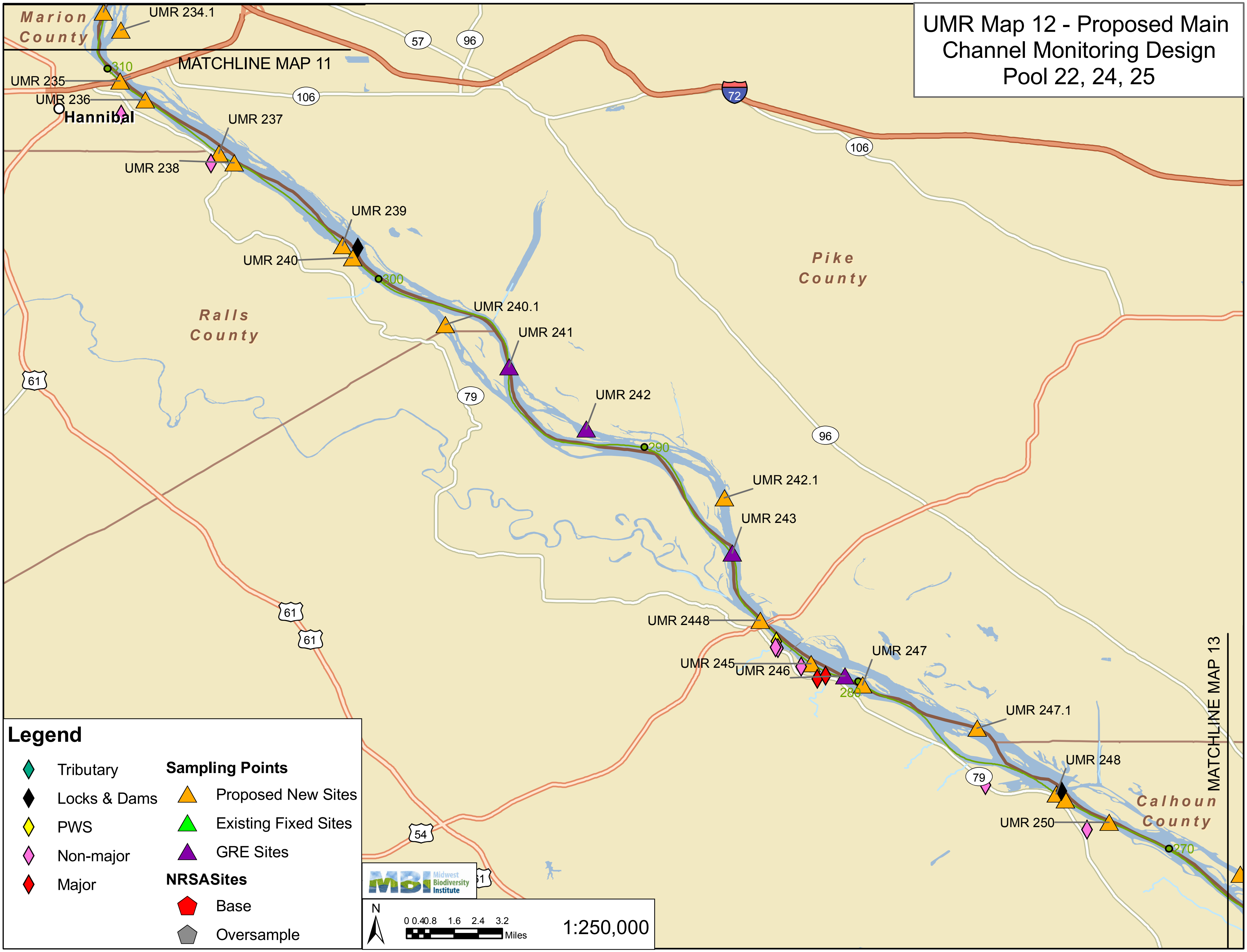

UMR Map 8 - Proposed Main Channel Monitoring Design Pool 14, 15, 16
MATCHLINE M
MATCHLINE MAP 9
Muscatine County
Scott County
Rock Island County
Henry County
Mercer County
Bettendorf
East Moline
UMR 150
UMR 151
UMR 152
UMR 153
UMR 154
UMR 154.1
UMR 155
UMR 156
UMR 157
UMR 158
UMR 159
UMR 160
UMR 160.1
UMR 161
UMR 162
UMR 163
UMR 164
UMR 165
UMR 166
UMR 167
UMR 168
UMR 169
UMR 169.1
UMR 170
UMR 171
UMR 172
UMR 173
UMR 174
UMR 174.1
ROR 6
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
N
0 0.40.8 1.6 2.4 3.2 Miles
1:250,000


UMR Map 9 - Proposed Main Channel Monitoring Design
Pool 17, 18
Muscatine
Muscatine County
Rock Island County
Louisa County
Mercer County
Henderson County
Des Moines
MATCHLINE MAP 8
MATCHLINE MAP 10
UMR 174.2
UMR 175
UMR 176
UMR 177
UMR 177.1
UMR 178
UMR 179
UMR 180
UMR 180.1
UMR 181
UMR 181.1
UMR 182
UMR 182.1
UMR 183
UMR 183.1
UMR 184
UMR 185
UMR 185.1
UMR 186
UMR 187
UMR 188
UMR 189
UMR 189.1
UMR 190
UMR 191
UMR 192
UMR 192.1
UMR 193
UMR 194
UMR 195
UMR 196
IAR9-0908
460
450
440
430
420
410
22
92
61
78
99
164
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
N
0 0.40.8 1.6 2.4 3.2
Miles
1:250,000
Midwest Biodiversity Institute

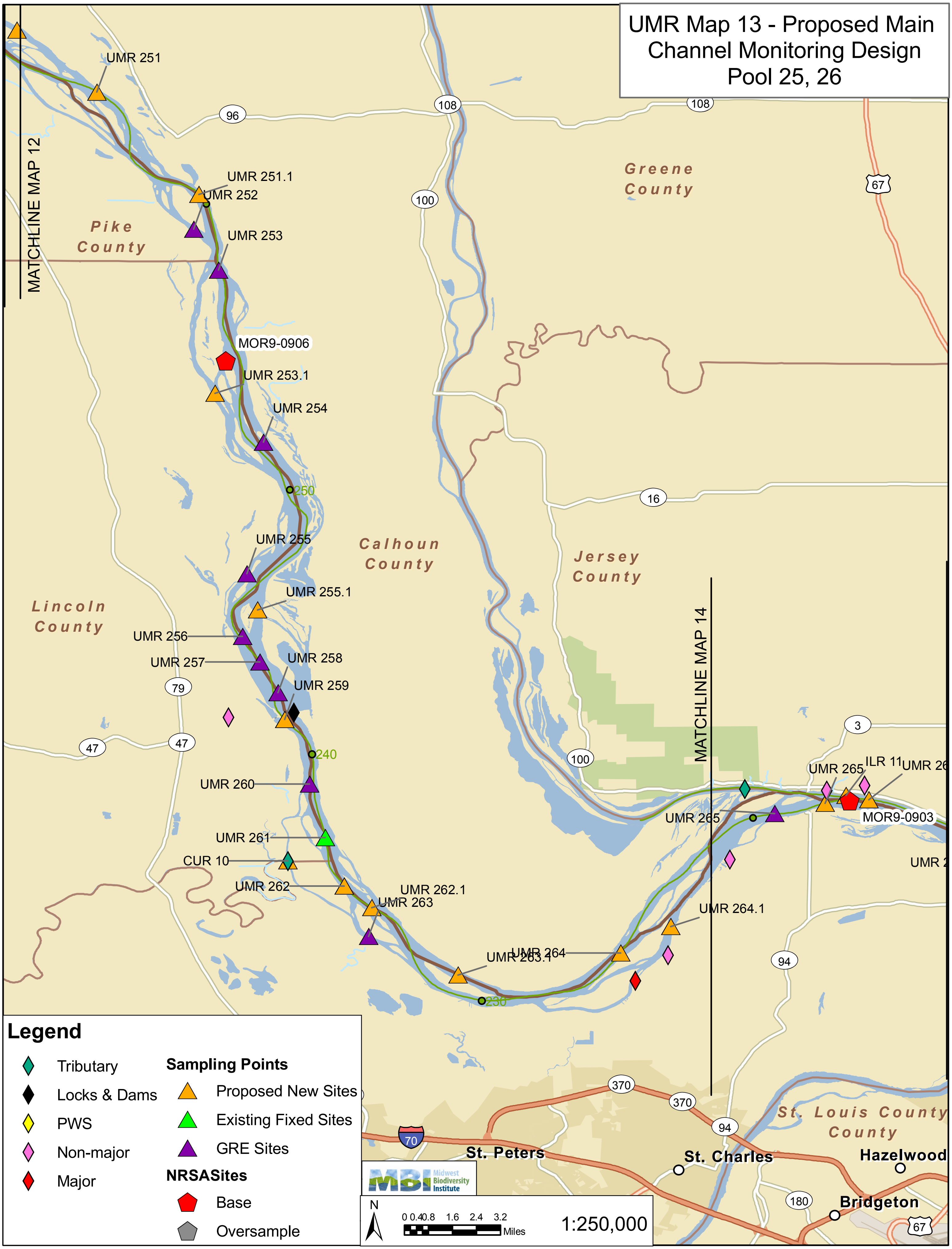


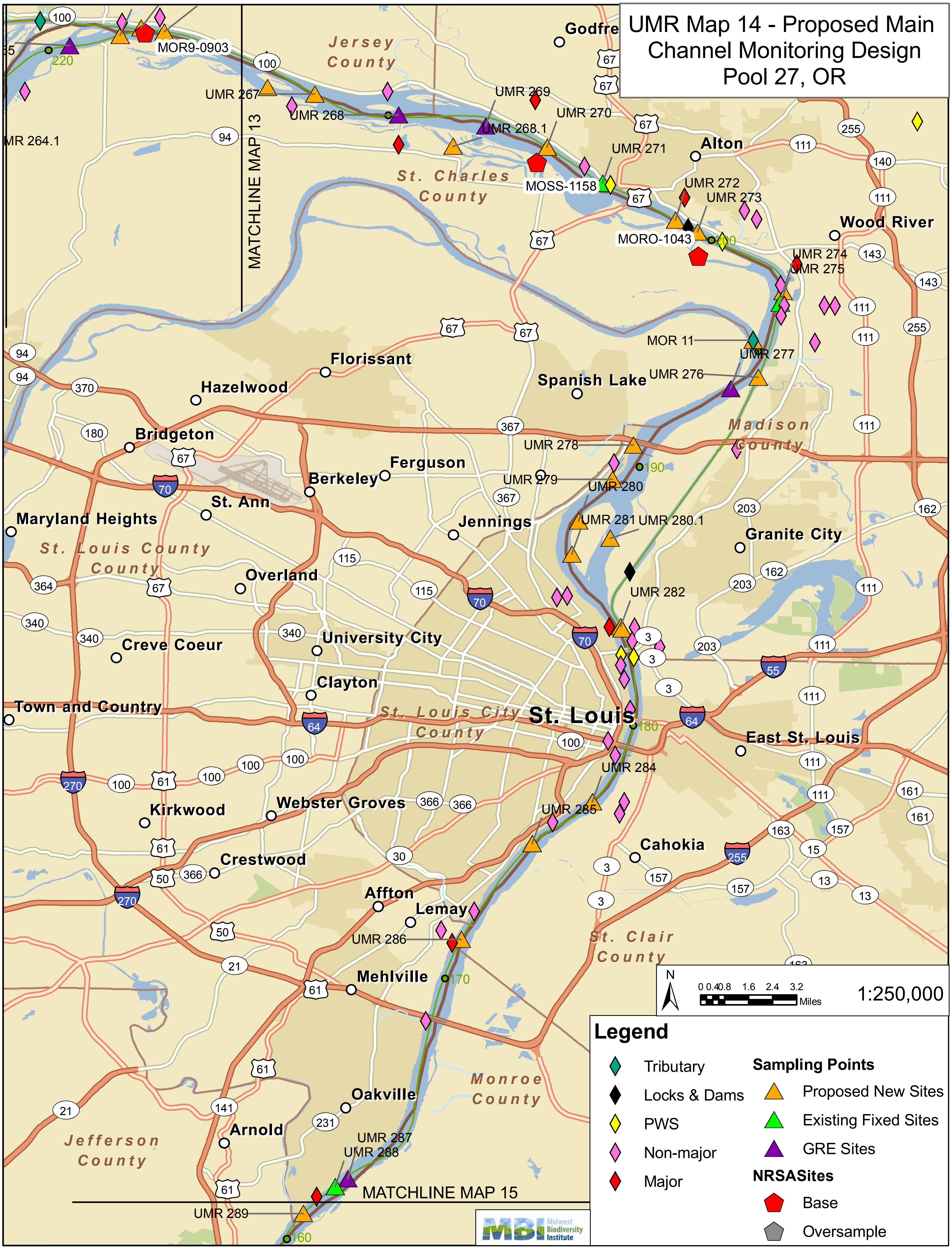
UMR Map 10 - Proposed Main Channel Monitoring Design Pool 19
MATCHLINE MAP 9
Des Moines County
Lee County
Henderson County
Hancock County
Burlington
Fort Madison
Keokuk
UMR 197
UMR 197.1
UMR 198
UMR 199
UMR 200
UMR 201
UMR 202
UMR 203
UMR 204
UMR 205
UMR 206
ILR9-0904
IARM-1004
UMR 207
UMR 208
UMR 210
UMR 212
MATCHLINE MAP 11
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2 Miles
1:250,000

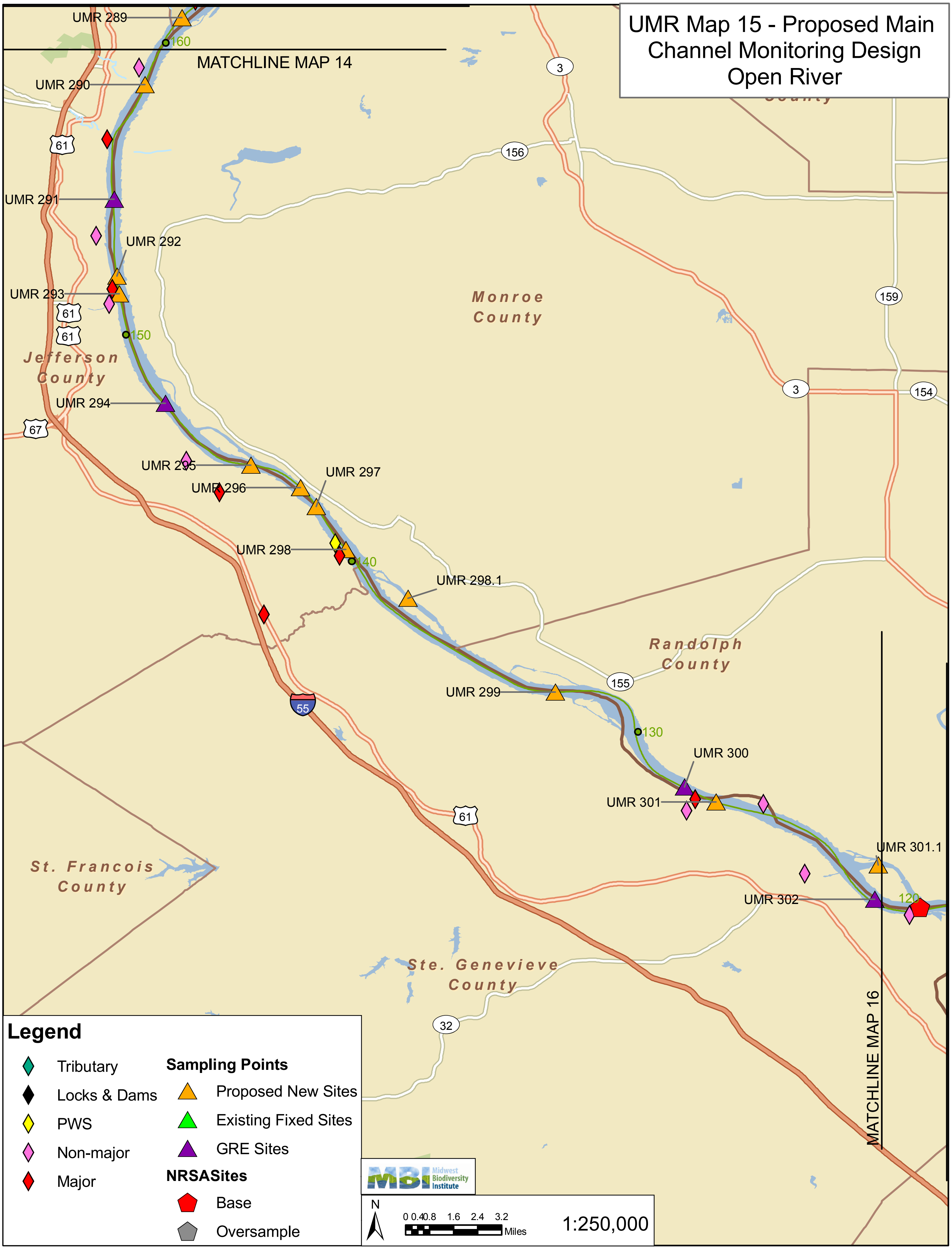

UMR Map 11 - Proposed Main Channel Monitoring Design
Pool 20, 21, 22
Hancock County
Lewis County
Adams County
Pike County
Quincy
MATCHLINE MAP 10
MATCHLINE MAP 12
UMR 214
UMR 214.1
UMR 215
UMR 216
UMR 217
UMR 218
UMR 220
UMR 220.1
UMR 221
UMR 222
UMR 223
UMR 223.1
UMR 224
UMR 225
UMR 227
UMR 228
UMR 229
UMR 230
UMR 231
UMR 232
UMR 232.1
UMR 233
UMR 234
UMR 234.1
350
340
330
N
0 0.4 0.8 1.6 2.4 3.2 Miles
1:250,000
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute

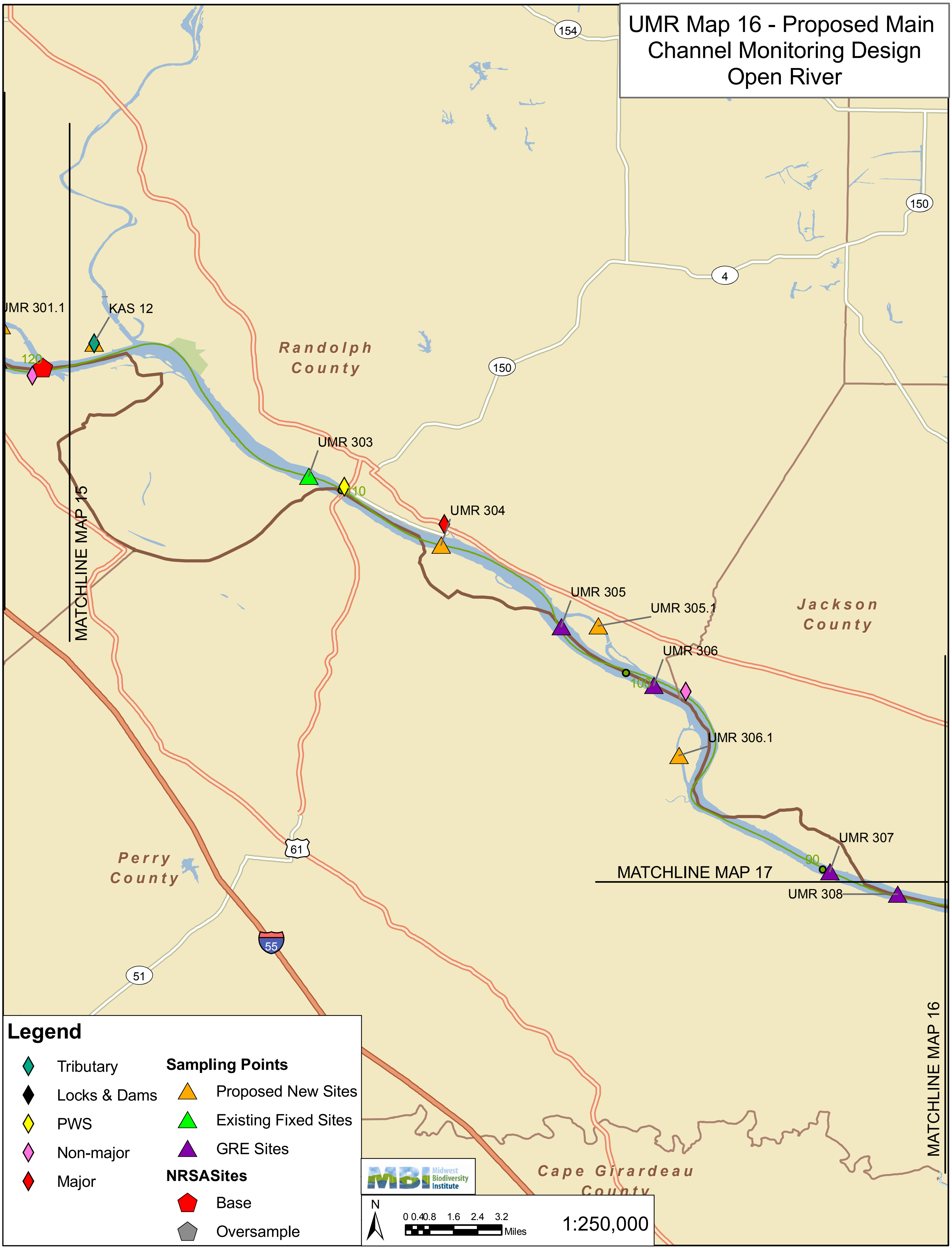


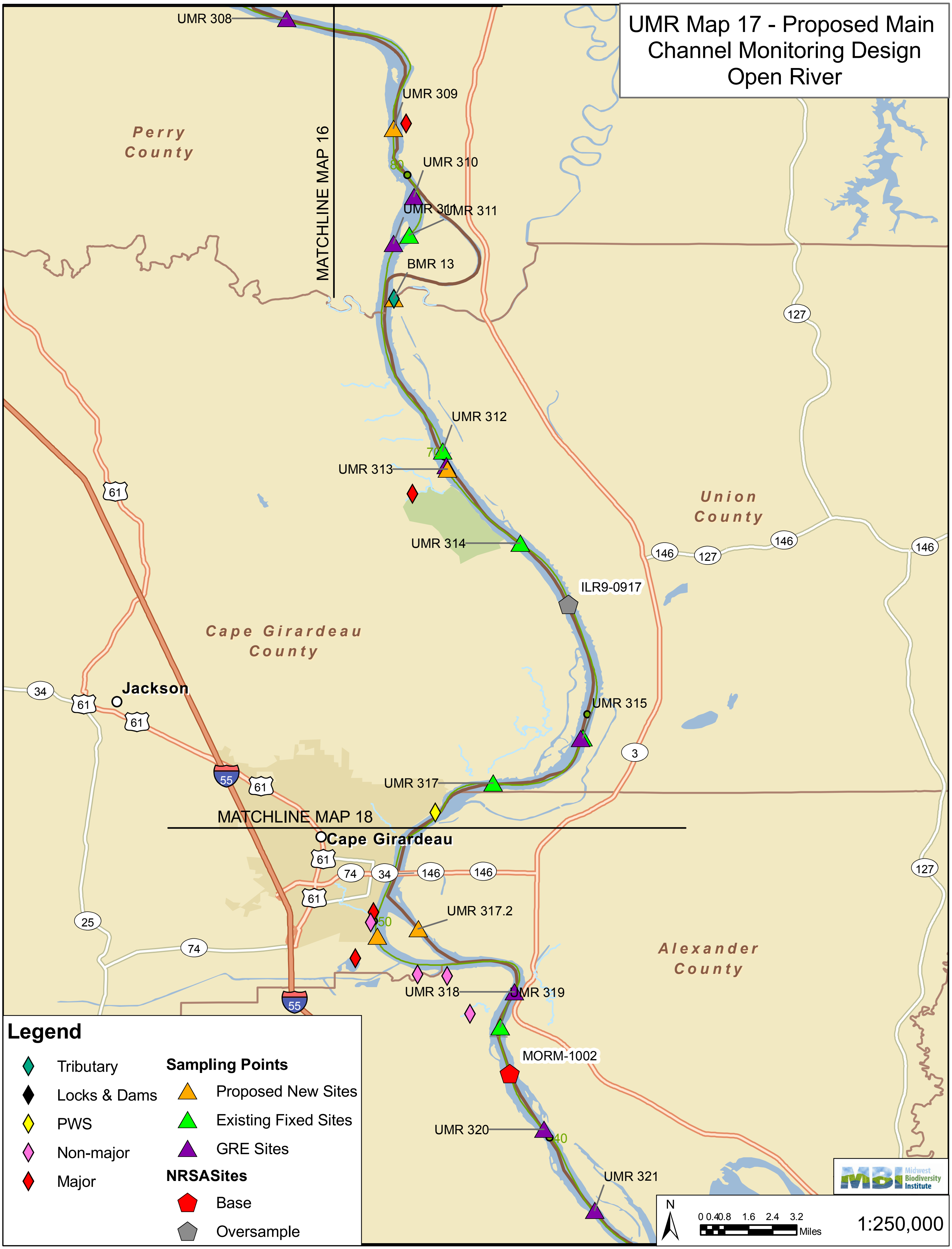
UMR Map 12 - Proposed Main Channel Monitoring Design Pool 22, 24, 25
MATCHLINE MAP 11
MATCHLINE MAP 13
Marion County
Ralls County
Pike County
Calhoun County
Hannibal
UMR 234.1
UMR 235
UMR 236
UMR 237
UMR 238
UMR 239
UMR 240
UMR 240.1
UMR 241
UMR 242
UMR 242.1
UMR 243
UMR 2448
UMR 245
UMR 246
UMR 247
UMR 247.1
UMR 248
UMR 250
310
300
290
280
270
57
96
106
72
61
79
54
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
MBI Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2
Miles
1:250,000


UMR Map 13 - Proposed Main Channel Monitoring Design
Pool 25, 26
MATCHLINE MAP 12
MATCHLINE MAP 14
Pike County
Greene County
Calhoun County
Jersey County
Lincoln County
St. Louis County
UMR 251
UMR 251.1
UMR 252
UMR 253
MOR9-0906
UMR 253.1
UMR 254
250
UMR 255
UMR 255.1
UMR 256
UMR 257
UMR 258
UMR 259
240
UMR 260
UMR 261
CUR 10
UMR 262
UMR 262.1
UMR 263
UMR 263.1
UMR 264
230
UMR 264.1
UMR 265
ILR 11
MOR9-0903
96
108
100
67
16
79
47
3
94
370
70
180
St. Peters
St. Charles
Hazelwood
Bridgeton
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2
Miles
1:250,000

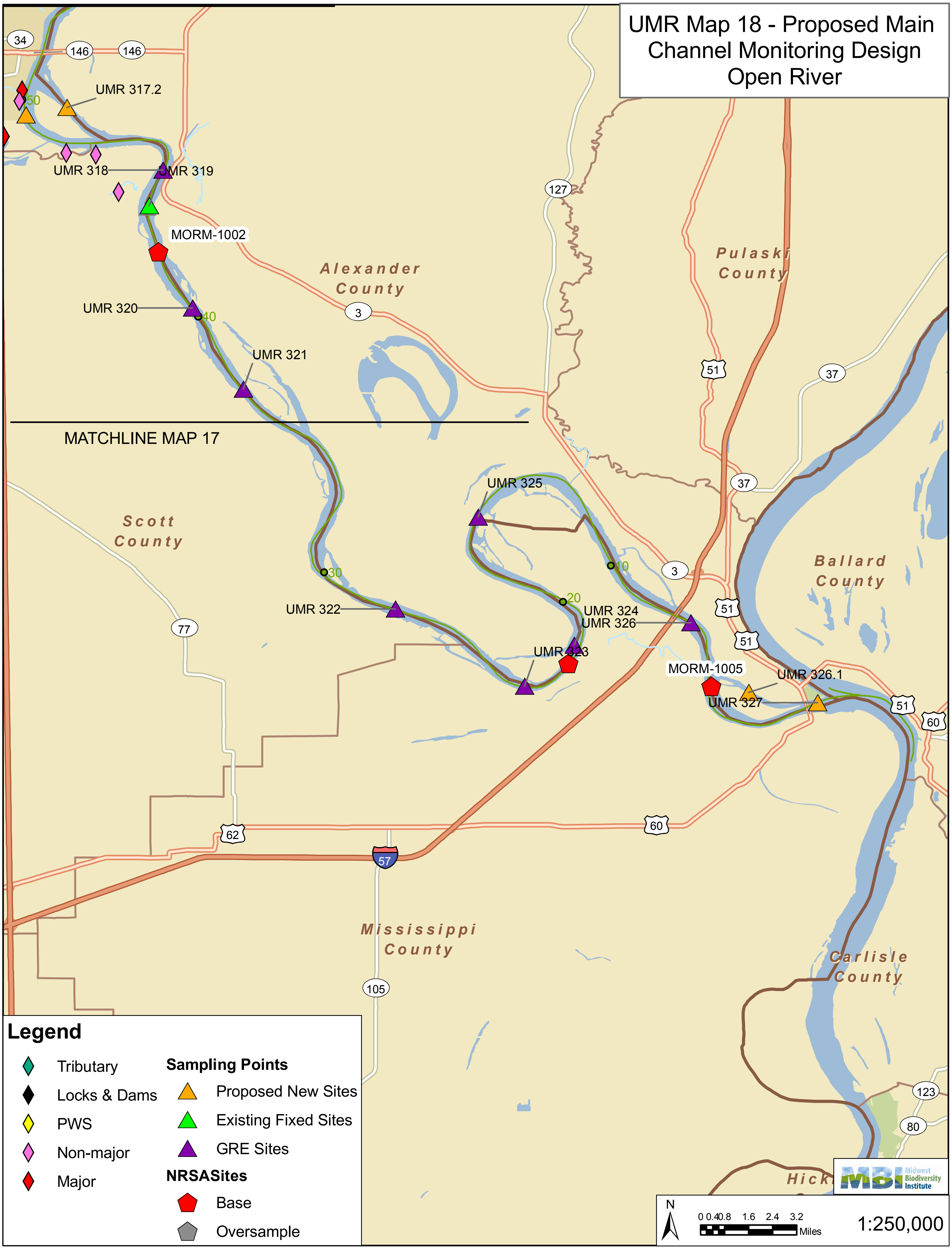

UMR Map 14 - Proposed Main Channel Monitoring Design
Pool 27, OR
MATCHLINE MAP 13
MATCHLINE MAP 15
Jersey County
St. Charles County
St. Louis County
St. Louis City County
Madison County
St. Clair County
Monroe County
Jefferson County
Godfrey
Alton
Wood River
Florissant
Hazelwood
Spanish Lake
Bridgeton
Ferguson
Berkeley
St. Ann
Maryland Heights
Jennings
Granite City
Overland
University City
Creve Coeur
Clayton
Town and Country
St. Louis
East St. Louis
Kirkwood
Webster Groves
Crestwood
Cahokia
Affton
Lemay
Mehlville
Oakville
Arnold
MOR9-0903
UMR 264.1
UMR 267
UMR 268
UMR 269
UMR 268.1
UMR 270
UMR 271
MOSS-1158
UMR 272
UMR 273
MORO-1043
UMR 274
UMR 275
MOR 11
UMR 277
UMR 276
UMR 278
UMR 279
UMR 280
UMR 281
UMR 280.1
UMR 282
UMR 284
UMR 285
UMR 286
UMR 287
UMR 288
UMR 289
220
200
190
180
170
160
1:250,000
0 0.4 0.8 1.6 2.4 3.2
Miles
N
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute


UMR Map 15 - Proposed Main Channel Monitoring Design Open River
MATCHLINE MAP 14
MATCHLINE MAP 16
UMR 289
UMR 290
UMR 291
UMR 292
UMR 293
UMR 294
UMR 295
UMR 296
UMR 297
UMR 298
UMR 298.1
UMR 299
UMR 300
UMR 301
UMR 301.1
UMR 302
160
150
140
130
120
Monroe County
Jefferson County
Randolph County
St. Francois County
Ste. Genevieve County
3
156
159
154
61
67
55
155
32
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2 Miles
1:250,000


UMR Map 16 - Proposed Main Channel Monitoring Design Open River
154
150
4
150
UMR 301.1
KAS 12
120
Randolph County
UMR 303
110
UMR 304
UMR 305
UMR 305.1
Jackson County
UMR 306
100
UMR 306.1
UMR 307
90
MATCHLINE MAP 17
UMR 308
MATCHLINE MAP 15
MATCHLINE MAP 16
61
Perry County
55
51
Cape Girardeau County
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
Midwest Biodiversity Institute
N
0 0.4 0.8 1.6 2.4 3.2
Miles
1:250,000



UMR Map 17 - Proposed Main Channel Monitoring Design Open River
UMR 308
UMR 309
UMR 310
UMR 311
UMR 311
BMR 13
MATCHLINE MAP 16
Perry County
UMR 312
UMR 313
UMR 314
ILR9-0917
Union County
Cape Girardeau County
Jackson
UMR 315
UMR 317
MATCHLINE MAP 18
Cape Girardeau
UMR 317.2
Alexander County
UMR 318
UMR 319
MORM-1002
UMR 320
UMR 321
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
N
0 0.4 0.8 1.6 2.4 3.2
Miles
1:250,000


UMR Map 18 - Proposed Main Channel Monitoring Design Open River
UMR 317.2
UMR 318
UMR 319
MORM-1002
UMR 320
UMR 321
MATCHLINE MAP 17
UMR 322
UMR 323
UMR 324
UMR 325
UMR 326
MORM-1005
UMR 326.1
UMR 327
Alexander County
Pulaski County
Scott County
Ballard County
Mississippi County
Carlisle County
Legend
Tributary
Locks & Dams
PWS
Non-major
Major
Sampling Points
Proposed New Sites
Existing Fixed Sites
GRE Sites
NRSASites
Base
Oversample
N
0 0.4 0.8 1.6 2.4 3.2
Miles
1:250,000

Appendix Table D-1. Itemized costs for each of the UMR main channel design options.

Design Option Summary	Annual Cost	Years to Complete	Approx. Number of Sites	Total UMR	Cost/Site
Probabilistic A	$614,710.00	1	50	$614,710.00	$12,294.20
Probabilistic B	$827,580.00	2	120	$1,655,160.00	$13,793.00
Probabilistic C	$1,054,840.00	2	170	$2,109,680.00	$12,409.88
Probabilistic D1	$1,206,120.00	4	390	$4,824,480.00	$12,370.46
Probabilistic D2	$1,256,120.00	2	195	$2,512,240.00	$12,883.28
Nonrandom Longitudinal Survey (baseline)	$1,256,120.00	2	180	$2,512,240.00	$13,956.89
Nonrandom Longitudinal Survey (follow-up)	$790,580.00	2	60	$1,581,160.00	$13,176.33
Nonrandom Longitudinal Survey (TOTAL)	NA	4	300	$4,093,400.00	$13,644.67
Intensive Pollution Survey	$1,181,120.00	4	400	$4,724,480.00	$11,551.30
Index Sites (n ≈30)	$372,365.00	1	30	$372,365.00	$12,412.17

Appendix Table D-1. Itemized costs for each of the UMR main channel design options.

Probabilistic A

Full Time FTEs	Unit Cost	Est. Project Units	Cost Estimate	Budget Subtotal	%
Project Manager	$60.00	620	$37,200.00		
Fish Crew leader	$25.00	1020	$25,500.00		
Macroinvertebrate Taxonomist	$25.00	1020	$25,500.00		
SAV Botanist	$25.00	1020	$25,500.00		
Chemical Crew Leader	$20.00	760	$15,200.00		
Direct Labor Costs			$128,900.00		
Task 1 Labor Fee (OM 1.4 applied)			**$180,460.00**		
Full Time Subtotal				**$180,460.00**	**29%**
Field Technician FTEs					
Field Technician x 2	$15.00	2000	$30,000.00		
Field Technician x 1	$15.00	1000	$15,000.00		
Field Technician x 2	$15.00	2000	$30,000.00		
Direct Labor Costs			$75,000.00		
Task 2 Labor Fee (OM 1.4 applied)			**$105,000.00**		
Technician Subtotal				**$130,000.00**	**21%**
Fixed Field Costs					
Equipment Use (Vehicle, sampling gear)	$500.00	30	$15,000.00		
Vehicle Mileage	$0.55	15000	$8,250.00		
Lodging/Food/Misc.	$960.00	50	$48,000.00		
Supplies	$25,000.00	1	$25,000.00		
RDC Subtotal			**$96,250.00**		
Fixed Costs Subtotal				**$96,250.00**	**16%**
Chemical Lab Costs					
Chemical Sample Analysis (Water Column Grabs)	$600.00	60	$36,000.00		
Chemical Sample Analysis (Sediment)	$500.00	60	$30,000.00		
Chemical Sample Analysis (Fish Tissue)	$1,500.00	60	$90,000.00		
RDC Subtotal				**$156,000.00**	**25%**
Data Management & Reporting					
Database Manager	$60.00	500	$30,000.00		
Task 5 Labor Fee (OM 1.4 applied)			**$42,000.00**		
Database Support	$10,000.00	1	$10,000.00		
Data Management & Reporting Subtotal				**$52,000.00**	**8%**
Annual Total Cost				**$614,710.00**	**100%**
Personnel Costs				**$352,460.00**	
ODC Costs				**$106,250.00**	
Laboratory Analystical Costs				**$156,000.00**	

Appendix Table D-1. Itemized costs for each of the UMR main channel design options.

Probabilistic B

Full Time FTEs	Unit Cost	Est. Project Units	Cost Estimate	Budget Subtotal	%
Project Manager	$60.00	625	$37,500.00		
Fish Crew leader	$25.00	1040	$26,000.00		
Macroinvertebrate Taxonomist	$25.00	1040	$26,000.00		
SAV Botanist	$25.00	1040	$26,000.00		
Chemical Crew Leader	$20.00	780	$15,600.00		
Direct Labor Costs			$131,100.00		
Task 1 Labor Fee (OM 1.4 applied)			**$183,540.00**		
Full Time Subtotal				**$183,540.00**	**22%**
Field Technician FTEs					
Field Technician x 2	$15.00	2500	$37,500.00		
Field Technician x 1	$15.00	1250	$18,750.00		
Field Technician x 2	$15.00	2080	$31,200.00		
Direct Labor Costs			$87,450.00		
Task 2 Labor Fee (OM 1.4 applied)			**$122,430.00**		
Technician Subtotal				**$147,430.00**	**18%**
Fixed Field Costs					
Equipment Use (Vehicle, sampling gear)	$500.00	60	$30,000.00		
Vehicle Mileage	$0.55	15000	$8,250.00		
Lodging/Food/Misc.	$960.00	100	$96,000.00		
Supplies	$25,000.00	1	$25,000.00		
RDC Subtotal			**$159,250.00**		
Fixed Costs Subtotal				**$159,250.00**	**19%**
Chemical Lab Costs					
Chemical Sample Analysis (Water Column Grabs)	$600.00	180	$108,000.00		
Chemical Sample Analysis (Sediment)	$500.00	66	$33,000.00		
Chemical Sample Analysis (Fish Tissue)	$1,500.00	66	$99,000.00		
RDC Subtotal				**$240,000.00**	**29%**
Data Management & Reporting					
Database Manager	$60.00	1040	$62,400.00		
Task 5 Labor Fee (OM 1.4 applied)			**$87,360.00**		
Database Support	$10,000.00	1	$10,000.00		
Data Management & Reporting Subtotal				**$97,360.00**	**12%**
Annual Total Cost				**$827,580.00**	**100%**
Personnel Costs				**$418,330.00**	
ODC Costs				**$169,250.00**	
Laboratory Analystical Costs				**$240,000.00**	

Appendix Table D-1. Itemized costs for each of the UMR main channel design options.

Probabilistic C

Full Time FTEs	**Unit Cost**	**Est. Project Units**	**Cost Estimate**	**Budget Subtotal**	
Project Manager	$60.00	1060	$63,600.00		
Fish Crew leader	$25.00	1760	$44,000.00		
Macroinvertebrate Taxonomist	$25.00	1760	$44,000.00		
SAV Botanist	$25.00	1760	$44,000.00		
Chemical Crew Leader	$20.00	1320	$26,400.00		
Direct Labor Costs			$222,000.00		
Task 1 Labor Fee (OM 1.4 applied)			**$310,800.00**		
Full Time Subtotal				**$310,800.00**	**29%**
Field Technician FTEs					
Field Technician x 2	$15.00	2500	$37,500.00		
Field Technician x 1	$15.00	1250	$18,750.00		
Field Technician x 2	$15.00	2080	$31,200.00		
Direct Labor Costs			$87,450.00		
Task 2 Labor Fee (OM 1.4 applied)			**$122,430.00**		
Technician Subtotal				**$147,430.00**	**14%**
Fixed Field Costs					
Equipment Use (Vehicle, sampling gear)	$500.00	60	$30,000.00		
Vehicle Mileage	$0.55	15000	$8,250.00		
Lodging/Food/Misc.	$960.00	100	$96,000.00		
Supplies	$25,000.00	1	$25,000.00		
RDC Subtotal			**$159,250.00**		
Fixed Costs Subtotal				**$159,250.00**	**15%**
Chemical Lab Costs					
Chemical Sample Analysis (Water Column Grabs)	$600.00	300	$180,000.00		
Chemical Sample Analysis (Sediment)	$500.00	80	$40,000.00		
Chemical Sample Analysis (Fish Tissue)	$1,500.00	80	$120,000.00		
RDC Subtotal				**$340,000.00**	**32%**
Data Management & Reporting					
Database Manager	$60.00	1040	$62,400.00		
Task 5 Labor Fee (OM 1.4 applied)			**$87,360.00**		
Database Support	$10,000.00	1	$10,000.00		
Data Management & Reporting Subtotal				**$97,360.00**	**9%**
Annual Total Cost				**$1,054,840.00**	**100%**
Personnel Costs				**$545,590.00**	
ODC Costs				**$169,250.00**	
Laboratory Analystical Costs				**$340,000.00**	

Appendix Table D-1. Itemized costs for each of the UMR main channel design options.

	Probabilistic D1					Probabilistic D2				
Full Time FTEs	**Unit Cost**	**Est. Project Units**	**Cost Estimate**	**Budget Subtotal**		**Unit Cost**	**Est. Project Units**	**Cost Estimate**	**Budget Subtotal**	**%**
Project Manager	$60.00	1250	$75,000.00			$60.00	1250	$75,000.00		
Fish Crew leader	$25.00	2080	$52,000.00			$25.00	2080	$52,000.00		
Macroinvertebrate Taxonomist	$25.00	2080	$52,000.00			$25.00	2080	$52,000.00		
SAV Botanist	$25.00	2080	$52,000.00			$25.00	2080	$52,000.00		
Chemical Crew Leader	$20.00	1560	$31,200.00			$20.00	1560	$31,200.00		
Direct Labor Costs			$262,200.00					$262,200.00		
Task 1 Labor Fee (OM 1.4 applied)			**$367,080.00**					**$367,080.00**		
Full Time Subtotal				**$367,080.00**	**30%**				**$367,080.00**	**29%**
Field Technician FTEs										
Field Technician x 2	$15.00	2500	$37,500.00			$15.00	2500	$37,500.00		
Field Technician x 1	$15.00	1250	$18,750.00			$15.00	1250	$18,750.00		
Field Technician x 2	$15.00	2080	$31,200.00			$15.00	2080	$31,200.00		
Direct Labor Costs			$87,450.00					$87,450.00		
Task 2 Labor Fee (OM 1.4 applied)			**$122,430.00**					**$122,430.00**		
Technician Subtotal				**$147,430.00**	**12%**				**$147,430.00**	**12%**
Fixed Field Costs										
Equipment Use (Vehicle, sampling gear)	$500.00	60	$30,000.00			$500.00	60	$30,000.00		
Vehicle Mileage	$0.55	15000	$8,250.00			$0.55	15000	$8,250.00		
Lodging/Food/Misc.	$960.00	100	$96,000.00			$960.00	100	$96,000.00		
Supplies	$25,000.00	1	$25,000.00			$25,000.00	1	$25,000.00		
RDC Subtotal			**$159,250.00**					**$159,250.00**		
Fixed Costs Subtotal				**$159,250.00**	**13%**				**$159,250.00**	**13%**
Chemical Lab Costs										
Chemical Sample Analysis (Water Column Grabs)	$600.00	600	$360,000.00			$600.00	600	$360,000.00		
Chemical Sample Analysis (Sediment)	$500.00	60	$30,000.00			$500.00	100	$50,000.00		
Chemical Sample Analysis (Fish Tissue)	$1,500.00	30	$45,000.00			$1,500.00	50	$75,000.00		
RDC Subtotal				**$435,000.00**	**36%**				**$485,000.00**	**39%**
Data Management & Reporting										
Database Manager	$60.00	1040	$62,400.00			$60.00	1040	$62,400.00		
Task 5 Labor Fee (OM 1.4 applied)			**$87,360.00**					**$87,360.00**		
Database Support	$10,000.00	1	$10,000.00			$10,000.00	1	$10,000.00		
Data Management & Reporting Subtotal				**$97,360.00**	**8%**				**$97,360.00**	**8%**
Annual Total Cost				**$1,206,120.00**	**100%**				**$1,256,120.00**	**100%**
Personnel Costs				**$601,870.00**					**$601,870.00**	
ODC Costs				**$169,250.00**					**$169,250.00**	
Laboratory Analystical Costs				**$435,000.00**					**$485,000.00**	

Appendix Table D-1. Itemized costs for each of the UMR main channel design options.

	Nonrandom Longitudinal Survey (baseline)					Nonrandom Longitudinal Survey (follow up)				
Full Time FTEs	**Unit Cost**	**Est. Project Units**	**Cost Estimate**	**Budget Subtotal**	**%**	**Unit Cost**	**Est. Project Units**	**Cost Estimate**	**Budget Subtotal**	**%**
Project Manager	$60.00	1250	$75,000.00			$60.00	625	$37,500.00		
Fish Crew leader	$25.00	2080	$52,000.00			$25.00	1040	$26,000.00		
Macroinvertebrate Taxonomist	$25.00	2080	$52,000.00			$25.00	1040	$26,000.00		
SAV Botanist	$25.00	2080	$52,000.00			$25.00	1040	$26,000.00		
Chemical Crew Leader	$20.00	1560	$31,200.00			$20.00	780	$15,600.00		
Direct Labor Costs			$262,200.00					$131,100.00		
Task 1 Labor Fee (OM 1.4 applied)			**$367,080.00**					**$183,540.00**		
Full Time Subtotal				**$367,080.00**	**29%**				**$183,540.00**	**23%**
Field Technician FTEs										
Field Technician x 2	$15.00	2500	$37,500.00			$15.00	2500	$37,500.00		
Field Technician x 1	$15.00	1250	$18,750.00			$15.00	1250	$18,750.00		
Field Technician x 2	$15.00	2080	$31,200.00			$15.00	2080	$31,200.00		
Direct Labor Costs			$87,450.00					$87,450.00		
Task 2 Labor Fee (OM 1.4 applied)			**$122,430.00**					**$122,430.00**		
Technician Subtotal				**$147,430.00**	**12%**				**$147,430.00**	**19%**
Fixed Field Costs										
Equipment Use (Vehicle, sampling gear)	$500.00	60	$30,000.00			$500.00	60	$30,000.00		
Vehicle Mileage	$0.55	15000	$8,250.00			$0.55	15000	$8,250.00		
Lodging/Food/Misc.	$960.00	100	$96,000.00			$960.00	100	$96,000.00		
Supplies	$25,000.00	1	$25,000.00			$25,000.00	1	**$25,000.00**		
RDC Subtotal			**$159,250.00**					**$134,250.00**		
Fixed Costs Subtotal				**$159,250.00**	**13%**				**$134,250.00**	**17%**
Chemical Lab Costs										
Chemical Sample Analysis (Water Column Grabs)	$600.00	600	$360,000.00			$600.00	180	$108,000.00		
Chemical Sample Analysis (Sediment)	$500.00	100	$50,000.00			$500.00	60	$30,000.00		
Chemical Sample Analysis (Fish Tissue)	$1,500.00	50	$75,000.00			$1,500.00	60	$90,000.00		
RDC Subtotal				**$485,000.00**	**39%**				**$228,000.00**	**29%**
Data Management & Reporting										
Database Manager	$60.00	1040	$62,400.00			$60.00	1040	$62,400.00		
Task 5 Labor Fee (OM 1.4 applied)			**$87,360.00**					**$87,360.00**		
Database Support	$10,000.00	1	$10,000.00			$10,000.00	1	$10,000.00		
Data Management & Reporting Subtotal				**$97,360.00**	**8%**				**$97,360.00**	**12%**
Annual Total Cost				**$1,256,120.00**	**100%**				**$790,580.00**	**100%**
Personnel Costs				**$601,870.00**					**$418,330.00**	
ODC Costs				**$169,250.00**					**$144,250.00**	
Laboratory Analystical Costs				**$485,000.00**					**$228,000.00**	

Appendix Table D-1. Itemized costs for each of the UMR main channel design options.

Intensive Pollution Survey

Full Time FTEs	**Unit Cost**	**Est. Project Units**	**Cost Estimate**	**Budget Subtotal**	**%**
Project Manager	$60.00	1250	$75,000.00		
Fish Crew leader	$25.00	2080	$52,000.00		
Macroinvertebrate Taxonomist	$25.00	2080	$52,000.00		
SAV Botanist	$25.00	2080	$52,000.00		
Chemical Crew Leader	$20.00	1560	$31,200.00		
Direct Labor Costs			$262,200.00		
Task 1 Labor Fee (OM 1.4 applied)			**$367,080.00**		
Full Time Subtotal				**$367,080.00**	**31%**
Field Technician FTEs					
Field Technician x 2	$15.00	2500	$37,500.00		
Field Technician x 1	$15.00	1250	$18,750.00		
Field Technician x 2	$15.00	2080	$31,200.00		
Direct Labor Costs			$87,450.00		
Task 2 Labor Fee (OM 1.4 applied)			**$122,430.00**		
Technician Subtotal				**$122,430.00**	**10%**
Fixed Field Costs					
Equipment Use (Vehicle, sampling gear)	$500.00	60	$30,000.00		
Vehicle Mileage	$0.55	15000	$8,250.00		
Lodging/Food/Misc.	$960.00	100	$96,000.00		
Supplies	$25,000.00	1	$25,000.00		
RDC Subtotal			**$159,250.00**		
Fixed Costs Subtotal				**$159,250.00**	**13%**
Chemical Lab Costs					
Chemical Sample Analysis (Water Column Grabs)	$600.00	600	$360,000.00		
Chemical Sample Analysis (Sediment)	$500.00	60	$30,000.00		
Chemical Sample Analysis (Fish Tissue)	$1,500.00	30	$45,000.00		
RDC Subtotal				**$435,000.00**	**37%**
Data Management & Reporting					
Database Manager	$60.00	1040	$62,400.00		
Task 5 Labor Fee (OM 1.4 applied)			**$87,360.00**		
Database Support	$10,000.00	1	$10,000.00		
Data Management & Reporting Subtotal				**$97,360.00**	**8%**
Annual Total Cost				**$1,181,120.00**	**100%**
Personnel Costs				**$576,870.00**	
ODC Costs				**$169,250.00**	
Laboratory Analystical Costs				**$435,000.00**	

Appendix Table D-1 Itemized costs for each of the UMR main channel design options.

			Index Sites		
Full Time FTEs	**Unit Cost**	**Est. Project Units**	**Cost Estimate**	**Budget Subtotal**	**%**
Project Manager	$60.00	365	$21,900.00		
Fish Crew leader	$25.00	300	$7,500.00		
Macroinvertebrate Taxonomist	$25.00	300	$7,500.00		
SAV Botanist	$25.00	300	$7,500.00		
Chemical Crew Leader	$20.00	220	$4,400.00		
Direct Labor Costs			$48,800.00		
Task 1 Labor Fee (OM 1.4 applied)			**$68,320.00**		
Full Time Subtotal				**$68,320.00**	**18%**
Field Technician FTEs					
Field Technician x 2	$15.00	725	$10,875.00		
Field Technician x 1	$15.00	290	$4,350.00		
Field Technician x 2	$15.00	580	$8,700.00		
Direct Labor Costs			$23,925.00		
Task 2 Labor Fee (OM 1.4 applied)			**$33,495.00**		
Technician Subtotal				**$40,995.00**	**11%**
Fixed Field Costs					
Equipment Use (Vehicle, sampling gear)	$500.00	18	$9,000.00		
Vehicle Mileage	$0.55	5000	$2,750.00		
Lodging/Food/Misc.	$960.00	30	$28,800.00		
Supplies	$25,000.00	0.3	$7,500.00		
RDC Subtotal			**$48,050.00**		
Fixed Costs Subtotal				**$48,050.00**	**13%**
Chemical Lab Costs					
Chemical Sample Analysis (Water Column Grabs)	$600.00	180	$108,000.00		
Chemical Sample Analysis (Sediment)	$500.00	30	$15,000.00		
Chemical Sample Analysis (Fish Tissue)	$1,500.00	30	$45,000.00		
RDC Subtotal				**$168,000.00**	**45%**
Data Management & Reporting					
Database Manager	$60.00	500	$30,000.00		
Task 5 Labor Fee (OM 1.4 applied)			**$42,000.00**		
Database Support	$10,000.00	0.5	$5,000.00		
Data Management & Reporting Subtotal				**$47,000.00**	**13%**
Annual Total Cost				**$372,365.00**	**100%**
Personnel Costs				**$151,315.00**	
ODC Costs				**$53,050.00**	
Laboratory Analystical Costs				**$168,000.00**	