Impaired Waters Research Symposium
February 11-12, 2008
Final Report

Photo by Don Breneman, U of M Extension

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Introduction

Despite decades of progress in cleaning up water pollution, hundreds of Minnesota's lakes, rivers and streams still cannot meet basic human needs or sustain healthy aquatic communities. These "impaired" waters do not meet water-quality standards and pose risks to people, aquatic life, and recreation. Problems associated with impaired waters are not limited to Minnesota. Citizens and governments are wrestling with this issue across the United States. It is, however, especially important to Minnesotans because of the abundance of our water resources. Minnesota is headwaters to three major water basins and is well known as the "land of 10,000 lakes." According to polling on environmental issues, our water resources define the essence of the state for many Minnesotans. Since passage of the Clean Water Legacy Act in 2006, Minnesota has used the impaired waters program as a vehicle for highlighting the need for protection and restoration of our most sensitive natural resources and the potential exists to implement protection and restoration strategies in future years.

The University of Minnesota Water Resources Center and Department of Bioproducts and Biosystems Engineering hosted an Impaired Waters research symposium on February 11 and 12, 2008. Other sponsors who provided funding were the Minnesota Board of Water and Soil Resources (BWSR), the Minnesota Environmental Quality Board (EQB), the Minnesota Department of Agriculture (DOA), the Minnesota Department of Natural Resources (DNR) and the Minnesota Pollution Control Agency (PCA). The forum was developed with the assistance of a steering team. The steering team members are listed in Appendix A.

The purpose of the symposium was to bring together researchers, state decision makers, practitioners and citizen representatives to understand the current state of research in managing Minnesota's surface water and identifying gaps in information and knowledge that could be bridged through additional research. For purposes of managing the discussion, the program for the two-day symposium consisted of a combination of presentation and break-out sessions on the following topic areas: Assessment and Standards, Total Maximum Daily Load, Implementation (restoration and protection), and Effectiveness Monitoring. This symposium clearly identified additional research in all aspects of surface water management as laid out in the Clean Water Legacy Act. The symposium topic was narrowly focused on impaired waters, so issues such as ground water, water availability, and drinking water issues were not discussed. The full two-day program schedule can be found in Appendix B.

This report synthesizes the key concepts and ideas that resulted from discussions during the symposium. The ideas generated during the discussion have not been prioritized, but rather are presented under discrete research themes. This is not a consensus document. Further work is required to identify the most critical research areas, to consider ideas within the framework of the Clean Water Legacy Act and to determine which items are or have been researched to some extent but the results have not yet been adequately communicated. The full set of the unedited comments generated throughout the two days is given in Appendix C. While the goal of this process was to identify key research needs, many policy issues were discussed as well. Those issues are included in the comments given in Appendix C but are not incorporated directly into the research needs identified in this report.

The research needs are relatively broad in their scope and are not focused on specific research projects. The steering team recommends that these broad needs be further developed into specific projects that are prioritized and incorporated into a research plan. A potential roadmap to achieve these goals is given in the Future Activities section. Some comments from the break-out sessions were related to specific research projects

Strategies

In addition to identifying research needs, approaches and strategies for addressing these needs surfaced during the symposium. A summary of broad approaches and strategies is provided below.

Interdisciplinary approach. Solutions to the most important water-resource problems require an integration of knowledge across disciplines. The time is ripe for interdisciplinary impaired waters research. Currently, research programs effectively expand the boundaries of knowledge in the individual disciplines related to the physical, chemical, biological, social and cultural aspects of water resources. To address the questions identified in this report successfully, researchers from different disciplines need to work together to find a pathway that incorporates their expertise into an interdisciplinary solution. Ownership in this pathway results in a greater commitment to the interdisciplinary goals. Interdisciplinary research can initially be expensive, though, and sufficient resources are required to support a diverse group of investigators. Over a long period, interdisciplinary research can be less expensive as resources are focused on addressing the most important issues.

Ecosystem/land use approach. The current approach for setting statewide standards, which drives surface water management, does not always lead to effective protection and restoration of state waters. An approach based on geographic boundaries and ecosystems is potentially more useful in defining standards and strategies for managing our waters. Examples of this approach are ago-ecoregions, ecoregions, and watersheds/sub-watersheds. While this approach necessitates additional research and a change in current operations on the part of state agencies, feedback from participants suggests that it provides a more effective vehicle for addressing the detection and restoration of impaired waters. .

Sentinel watersheds approach. One approach that was identified throughout the symposium was the use of sentinel watersheds. Watersheds provide the hydrologic units within which we can relate land use and the vegetative and physical characteristics to water flow and water quality; and therefore, they integrate physical, chemical, and biological data over space and time. By selecting small to medium sized watersheds for intensive monitoring, they can be the harbinger for determining regional hydrologic and water quality conditions and impairment that have resulted from human activities. There was widespread agreement among participants that a systematic monitoring program is needed to improve the understanding of watershed response and the impact of the implementation of best management practices. This support was most often expressed in comments for the establishment of a system of sentinel watersheds. However, the participants appear to have different definitions for a sentinel watershed. Some define it as demonstration watershed, some as a watershed representative of particular conditions, and still others had alternative definitions. The sentinel watershed approach is worthy of serious consideration, where a common definition needs first to be established and communicated. The SLICE program, organized and coordinated by the Department of Natural Resources, is an application of the sentinel watershed approach. Since the symposium, the Minnesota Pollution Control Agency has also been exploring with partners the use of a more comprehensive watershed approach.

Engagement strategy. Unlike the point source problems of the past, the problems of today and the future are largely from nonpoint sources of pollutants, like eroding soil, nutrients from farmland and urban areas, road salt, and coliform from septic systems and farm animals. Most of Minnesota's water quality impairments (except for mercury) are from these diffuse sources of pollutants. Removing these impairments therefore means changing peoples behaviors, through some combination of direct regulation, financial incentives or disincentives, social marketing, education, or other means. Many participants noted the need for greater citizen involvement in the TMDL process. A comprehensive strategy to engage citizens in the process as well as in changing personal practices is needed to accomplish the goal of removing water quality impairments.

Strategy for sharing databases. Large databases have been and are currently being collected by different agencies and organizations. A strategy is needed for merging and sharing information in these databases. Issues related to different methods for collecting and storing data need to be resolved as well as establishing adequate quality assurance procedures. Merged databases should include physical, biological, chemical, economic, demographic, and behavioral information related to water resources. Web-based programs are powerful tools for sharing this information. In addition, Geographic Information Systems provide a useful vehicle for summarizing the different layers of spatial data and combining information for analyses

Strategy for identifying existing research. One issue that was evident throughout the symposium was that existing water research is not readily accessible to end users or other researchers. Some of the identified research needs are actually being investigated by faculty or staff at academic and non-academic institutions. One suggestion is the development of a searchable database that resides on a university website. The Clean Water Council is currently exploring this opportunity. The first task of such a project would be to develop an inventory of existing research.

Research Themes and Needs

Introduction

Seventeen research needs have been identified from information gathered from the symposium. These needs are loosely organized around five general research themes. Organizational themes are given below.

(1) Assess the Status of Waters: Research needs for this theme are centered on the monitoring and assessment tools for determining the status of our waters. They are primarily focused on chemical, biological and physical measures and methods and are aimed at determining the levels of water pollutants.

(2) Compare Status of Waters to Standards: Research needs here are focused on the appropriateness of the standards. They address issues related to the determination of beneficial uses, consideration of natural background characterization and variability and the selection of indicators of water resources (lake, stream, and wetland) health.

(3) Restore and Protect: Research needs for this theme are needed to improve the effectiveness of the implementation plans as part of Total Maximum Daily Load studies or other watershed plans. They include studies on the selection of best management practices, the cost and benefits of implementation, and human factors influencing adoption of practices.

(4) Evaluate Programs: Research needs here are focused on developing methodology to evaluate the success of implementation plans to restore and protect waters. Research is needed to define measures of success for the natural sciences as well as to assess the costs and benefits of implementation programs.

(5) Engage and Communicate to Stakeholders. Research needs for this theme are centered on the engagement of stakeholders and citizens, of which an important component is determining the appropriate communication vehicle for a given audience. Additional research is needed to develop better methods, tools, and strategies for effective citizen engagement.

Assess the Status of Waters

The following are the seventeen research needs as synthesized from the symposium.

1. Develop and expand data and databases. The foundation of natural and social science is based on sound experimental and observational data. Reliable and accessible databases are therefore needed in virtually all of the research related to water resources. For example, the successful use of assessment tools is dependent on the type and quality of the data that describe the watershed characteristics. In addition, new types of data, such as DNA-fingerprinting for indicator bacteria, elemental and isotopic fingerprinting for sediment and water source, need to be developed and integrated into monitoring plans and databases. Research is needed for efficient organization of massive databases. Bioinformatics concepts, developed using techniques from applied mathematics, informatics, statistics, computer science, and artificial intelligence, have had only limited number of applications in natural sciences. Development and expansion of data and databases are closely related to the design of an effective monitoring network.

2. **Design and implement an effective monitoring system for measuring the physical, chemical, and biological responses of watersheds.** Measuring progress toward restoration of impaired waters is fundamentally tied to a cost-effective monitoring system. Data collected from the monitoring systems provide the backbone for assessing water quality and for evaluating the effectiveness of implementation plans. Monitoring systems are also important in the calibration and evaluation of models and other assessment tools. A well-designed monitoring network needs to capture long-term trends as well as the short-term impact resulting from the use of best management practices. In developing monitoring systems, inclusion of sentinel watersheds, lakes, and streams can be important components of a state-wide monitoring system. Research is needed to select properly the location, frequency and prioritization of sampling. This work can be built on well-established statistical techniques. Additional research is needed to explore the possible use of cheaper surrogates of indicators of water quality.

3. **Develop, improve and evaluate the accuracy of assessment tools.** Models and other assessment tools are of critical importance in the selection of best management practices (BMPs) as part of implementation plans for addressing impaired waters. Improvements and/or the development of additional tools for selecting BMPs are needed to meet the goals of the state. Assessment tools for selecting BMPs for stormwater and for agricultural drainage are especially important for Minnesota. Additional research is needed to develop simulations that apply to a wide range of spatial and temporal scales with clearly specified modeling uncertainties. More research is needed to incorporate biological indicators and community responses as part of the assessment tools and to link them to hydrologic and conventional water quality indicator responses to stressors. There is also a need for research that determines the accuracy of different indicators for identifying the causes and effects of stressors and quantifying the recovery following restoration activities.

Compare Status of Waters to Standards

4. **Evaluate the existing designated uses (beneficial uses), water quality criteria and water quality standards.** Research is needed in the selection of appropriate standards. Old standards that are no longer relevant should not be used, and new standards need to be developed in response to emerging contaminants. Some standards may need to be adjusted for individual waters, for an ecoregion, a river basin or even for statewide use. Determining a site specific standard is allowed with adequate research and justification. Addition work is also needed for defining non-degradation standards. The interconnections between various pollutants need to be more fully understood. There continues to be research needs in integrating chemistry and biology, and investigations are needed in considerations of the physical (e.g. flow, hydrologic modification, temperature, habitat, etc.) interactions with biology and chemistry, and how to incorporate the physical aspects into water quality standards. Emerging contaminants may require new designated uses and standards, to protect the environment. Currently, issues such as pharmaceuticals, personal care products,

mercury and pesticides are being researched. Similarly, the impacts of climate change and other watershed changes could place into question the viability of current standards.

5. **Define natural background for purposes of setting standards, evaluating watersheds for impairments and protection**. Natural background remains an area of contention, even after it was defined by the Clean Water Legacy Act. The interpretation and application of the term needs further exploration and research to determine its use in TMDL studies and water and watershed management. The Clean Water Legacy Act defines natural background as "characteristics of the water body resulting from the multiplicity of factors in nature, including climate, geology and ecosystem dynamics, which affect the physical, chemical, or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence." Application of natural background is a policy decision that needs to be informed by additional research. One of the key areas of research in considering TMDL goals is adoption of appropriate water quality standards and designated use, the use of natural background and the recognition that certain human activities have resulted in essentially irreversible changes in the landscape (e.g. agricultural and urban land uses) and state water resources (e.g. dams). Research into historic conditions and documenting changes over time will help with this task as well as for setting realistic goals. The contributions of legacy loads and past land use change should be considered and estimated, with appropriate measures of uncertainty.

6. **Develop and evaluate improved indicators of stream and lake health.** The health or ecological condition of water bodies is determined by the complex interactions among physical, chemical and biological processes occurring within the context of the watershed's geology, climate, and societal land uses. Bioindicators are useful integrators of these processes. Geomorphologic indices also allow for the integration of physical and biological processes. Different combinations of factors are possible resulting in many potential indicators of water-body health. Additional work is needed in the development and selection of the best indicators for the impaired water program. From a management perspective, indicators need to be adopted into water quality standards and tied to practices identified in implementation plans.

Restore and Protect

7. **Develop, improve and evaluate best management practices.** Managers of Minnesota's water resources need to make wise decisions in the selection of best management practices to restore impaired waters. Current knowledge of the performance of BMPs is typically based on relatively small databases over very limited time scales. Additional research is needed to assess their efficacy under the range of Minnesota conditions and at watershed scales. Little information is known on the effectiveness of new practices such as two-stage ditch designs, pervious pavement, rain gardens and a host of other practices flooding the marketplace. Prudent management decisions require that practices be prioritized based on their effectiveness, installation cost and long-term operation and maintenance. The overall monitoring plan should be designed to cover the costs of evaluating and communicating the effectiveness of BMPs to a variety of relevant audiences.

8. **Determine the costs and benefits of various prevention and restoration techniques** The Clean Water Legacy Act requires a cost-benefit analysis be included in the TMDL study. Costs are often difficult to predict, especially at the beginning of the process, and benefits are often challenging to quantify. Differences in cost-benefit ratios between protection/prevention and restoration need to be examined and understood for the prudent use of limited resources. A more accurate accounting of the costs and benefits for installation of various practices should be completed and made widely available. The economic analysis is inadequate if it only includes costs and benefits for installation and neglects the maintenance and monitoring costs and benefits. The maintenance costs can be substantial. Those practices with high maintenance costs are less likely to be successful because of the financial realities of making this long term investment. Full cost accounting will help better define the actual costs and benefits of restoration and prevention on a local and statewide scale, and will also help decision makers and citizens determine which practices will move them toward restoration or prevention more quickly and at lower total cost. The information must also be reviewed on a regular basis and modifications communicated efficiently and rapidly.

9. **Identify the factors that cause humans to change their behavior.** Although considerable work has been done in this area, additional research is needed to understand human behavior in relationship to environmental systems. As an example, specific research is needed to identify those land owners who are resistant to change and to understand their behaviors. Environmental science also needs research into methods for grouping individuals. Simplistic grouping methods, such as farmers, business owners, and cities dwellers, often fail to capture the diversity of people within groups. Individuals choose to act based on a number of factors. Research is needed to understand the range of possible reasons for certain inappropriate behaviors and to tie these reasons to specific individuals and entities at the local level.

10. **Predict and incorporate changes in landscape and watersheds characteristics.** Watershed characteristics are dynamic. Changes in climate, demographics and major economic forces, such as ethanol production, can have major impacts on water quality. These changes need to be considered in the prioritizing efforts in the impaired waters program and in the development of implementation plans. Uncertainties in projected changes contribute to the overall uncertainty in the more locally focused TMDL process. Research is needed in forecasting these large scale changes and incorporating the results into the impaired waters program.

11. **Synthesize and integrate impaired waters within broader societal and natural resources context.** The Impaired Waters program is tied to specific sections of the federal Clean Water Act and associated Minnesota rules and statutes, and as such, the goals are focused on improving water quality and aquatic habitat. Although important, water quality is only one component of multi-faceted goals for the natural resources of the State. Protection is also needed for our land and air resources as well as the cultural and social well being of communities. Success will only be achieved if the Clean Water Legacy policies and research are considered in the context of broader societal issues and policies. Research is therefore needed to include the interaction with energy policy, economics and changes in the natural system such as climate change. The research effort includes work in both natural and social sciences.

Evaluate Programs

12. **Develop strategy and measure of success for implementation programs.** Continued support of the impaired waters program requires that the resources invested in improving water quality are successful. Research is needed in the selection of criteria used to define success. Criteria need to consider physical, chemical, biological and socioeconomic changes in the watershed. Definitions are needed for both short-term and long-term impacts. Development of sensitive bioindicators is one possible research activity. Natural variability and trends in weather variables represent a significant hurdle in obtaining robust measures of success. Over the short-terms, non-traditional statistical techniques, such as wavelets, re-sampling methods, and artificial neural networks, are potentially useful in addressing variability issues but will need to be verified using data generated from new and existing long-term monitoring projects.

13. **Evaluate the costs and the benefits of the impaired waters program for improving and protecting surface waters.** Addressing both restoration and prevention of degradation of Minnesota's waters includes much more than the costs of installation and maintenance of practices by individuals or entities. The designated uses and accompanying water quality standards lay the foundation for the entire program. There is a cost for having inappropriate standards and for errors in the subsequent process to meet those standards. Costs include those for study, research, education, public engagement, and "fixing" the impairments and protecting other waters at risk. Incorrect standards or designated uses that society does not embrace result in unnecessary financial costs. On the other hand, degradation of waters because of standards that are not protective enough of the designated use also costs society in the long term as waters become degraded and public and environmental health suffer. This can result in decreased recreational opportunities, decline of species diversity and lack of waters for human consumption and economic uses (industry, agriculture, etc.), and even increased public health risks. There are also transaction costs for monitoring and enforcement as well as any administration costs involved in setting up new standards or regulations. More research is needed to estimate the many non-market benefits we receive from improved water quality. Research is needed on the costs and benefits for the entire system, and various components, so that better decisions can be made regarding this process and citizens will support the system.

Engage and Communicate to Stakeholders

14. **Develop better methods and tools for engaging citizens in surface water management.** The challenge to the science and regulatory community has been and continues to be the timing of citizen engagement. Key questions are what motivates individuals to engage, how to improve public awareness of water resource issues and how to improve public understanding of the true costs of restoration efforts. History shows that one tool or one approach will not work across the diversity of citizens and interests, and multiple tools and approaches matched with specific interests will likely be necessary. Research is needed in the selection of optimal methods and tools for a given community with a particular water problem.

15. **Assess education needs for each audience and develop tools to meet these needs.** In order for various audiences to engage in the management of surface waters, they must understand the issue, their role, why they are critical in the process, what they can do and how they can add value. Key issues for further research include the identification of who needs what information and the best delivery mechanisms for target audiences. In some cases, the best deliverer of information may not be knowledgeable scientists but professional educators, or perhaps educators and scientists in collaboration. Finally, mass persuasion has not been effective, so more research is needed on targeted approaches that are dependent on specific situations, locales and even individuals.

16. **Identify and develop communication tools for stakeholders, citizens and other audiences**. Historically, water specialists and scientists working in water resources are the same people who communicate with the public. While the information may be accurate, the delivery is often too technical. Research is needed on the proper terminology for specific audiences, on methods for creating effective feedback loops, and on techniques for setting realistic expectations. Identifying the proper level of technical delivery for a given audience is critical in presenting a clear message that is not buried among all the other issues. Research is needed to develop methods to assist in the selection of the appropriate level of technical content for different audiences.

17. **Develop a communication strategy that ensures research, new practices and successes are shared between agencies, watersheds and with citizens**. Research and new methods in water management are continually being developed. This knowledge has little impact on water quality if these new practices are not shared among managers and citizens. Additional research is needed for effective communication between researchers and those who can benefit from the research. It is often difficult to communicate results published in peer-reviewed journals to other audiences. The communication strategy is needed to ensure that information is not "lost" and is easily accessible to meet the diversity of audiences. In addition, this strategy needs to provide a feedback to the researchers from the end-users. This feedback is important in planning and conducting additional studies to meet the needs of the impaired waters program.

Future Activities

The purpose of the symposium was limited to identifying research needs. Of practical importance is a research plan that provides a framework for addressing these needs. The completion of a research plan was beyond the scope of symposium. This report can be viewed as Phase I of a more comprehensive planning process. A proposed strategy for the comprehensive plan developed by the steering committee is shown below. In order to meet the needs of state agencies, the Clean Water Council and other entities, the next proposed step is to develop a prioritized list of specific research project (Phase II). Because the Clean Water Legacy will impact a wide range of interests, an inclusive process is needed to develop this list. Proposed Phases III and IV are necessary to conduct the research and update the plan based on the results of the research.

Phase	Activity	Time frame for completion
I	Inventory of Research Needs	1 year (6/30/08 completion)
II	Prioritization of research projects	6 months
III	Prioritized research plan developed	1 year
IV	Plan Used, tracked and adjusted every 1-2 years	5 – 10 years

Appendices

Appendix A

2008 Impaired Waters Symposium Planning Committee

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Appendix B
Impaired Waters Symposium Program
February 11 and 12, 2008

Day 1

8:30 a.m. – 8:40 a.m.	**Welcome** Faye Sleeper *Water Resources Center, University of Minnesota*
8:45 a.m. – 9:30 a.m.	**Keynote** Deborah Swackhamer *Institute on the Environment, University of Minnesota*
9:30 a.m. – 10:00 a.m.	**Agency Perspectives** *Minnesota Board of Water and Soil Resources* *Minnesota Department of Agriculture* *Minnesota Department of Natural Resources* *Minnesota Environmental Quality Board* *Minnesota Pollution Control Agency*
10:00 a.m. – 10:15 a.m.	**BREAK**
10:15 a.m. – 10:45 a.m.	**Session 1: Standards and Monitoring Assessment** Presenter: Shannon Lotthammer *Minnesota Pollution Control Agency*
10:45 a.m. – 11:45 a.m.	**Breakout Session 1**
11:45 a.m. – 12:45 p.m.	**LUNCH**
12:45 p.m. – 1:30 p.m.	**Reports from Breakout Session 1**
1:30 p.m. – 2:00 p.m.	**Session 2: Total Maximum Daily Load Studies** Presenter: Gaylen Reetz *Minnesota Pollution Control Agency*
2:00 p.m. – 2:15 p.m.	**BREAK**
2:15 p.m. – 3:15 p.m.	**Breakout Session 2**
3:15 p.m. – 4:00 p.m.	**Reports from Breakout Session 2**

Impaired Waters Symposium Program
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Day 2

8:00 a.m. – 8:05 a.m.	**Welcome** Abel Ponce de León *College of Food, Agricultural, and Natural Resource Sciences, University of Minnesota*
8:05 a.m. – 8:45 a.m.	**Keynote** Pete Nowak *Institute for Environmental Studies, University of Wisconsin*
8:45 a.m. – 9:15 a.m.	**Session 3: Implementation, Point Source and Nonpoint Source** Presenter: Steve Woods *Minnesota Board of Water and Soil Resources*
9:15 a.m. – 9: 30 a.m.	**BREAK**
9: 30 a.m. – 10:30 a.m.	**Breakout Session 3**
10:30 a.m. – 11:15 a.m.	**Reports from Breakout Session 3**
11:15 a.m. – 11:45 a.m.	**Session 4: Effectiveness Measures** Presenter: Lucinda Johnson *Natural Resources Research Institute, University of Minnesota Duluth*
11:45 a.m. – 12:45 p.m.	**LUNCH**
12:45 p.m. – 1:45 p.m.	**Breakout Session 4**
1:45 p.m. – 2:30 p.m.	**Reports from Breakout Session 4**
2:30 p.m. – 3:00 p.m.	**Wrap Up and Next Steps** Scott Lanyon *Bell Museum, University of Minnesota*

Appendix C
Resources

1. Minnesota's Clean Water Legacy Act:
https://www.revisor.leg.state.mn.us/bin/getpub.php?type=s&num=114D

2. Clean Water Council: http://www.pca.state.mn.us/water/cleanwatercouncil/index.html

3. Board of Water and Soil Resources Clean Water Legacy Information:
http://www.bwsr.state.mn.us/CWL/index.html

4. Minnesota Pollution Control Agency Impaired Waters information:
http://www.pca.state.mn.us/water/tmdl/index.html

5. Minnesota Department of Agriculture Water Protection information:
http://www.mda.state.mn.us/protecting/waterprotection/default.htm

6. Minnesota Department of Natural Resources Water information:
http://www.dnr.state.mn.us/water/index.html

7. U. S. Environmental Protection Agency Impaired Waters/TMDL page:
http://www.epa.gov/owow/tmdl/

8. University of Minnesota Water Resources Center: http://wrc.umn.edu/

9. University of Minnesota, Institute on the Environment's Environmental Searchable Research Database: http://www.environment.umn.edu/research/projects.php

Appendix D
Individual comments

SESSION I: STANDARDS AND MONITORING

1. Monitoring

a. design

- How to assess the large number of water resources
  - Existing monitoring system is not practical
  - Monitoring strategy for all water resources in State to be efficient and effective
- Achievable monitoring, through statistics scale, and monitoring location
- Time of monitoring, redefine "open water season", climate change, gaps
- Monitoring sites in right places?
- Design of monitoring network?
  - One network to meet to assessment, diagnosis, effectives rather than separate
- Integrated monitoring with models
  - Real time results for assessment
  - Readily available data network

Scale/Network Design (spatial and temporal):

- Where to install
- What scale (Reach by Reach vs. watershed)
- How much data and when
- How to collect? (to match policy requirements)
- 1 network to achieve assessment diagnosis, effectiveness
- Cost/Benefit analysis-acceptable uncertainty
- Integrating existing dataset (USGS, EPA, PCA, etc.)
- WATERS Network- watershed monitoring-national
- Comprehensive Evaluation. - Holistic approach
  - Look at levels of as many parameters simultaneously as possible (nutrients, sediment, etc) along with habitat, flow, etc.) Integrity, physical, biological, chemical look at whole system.
- Set monitoring parameters-clear definitions
  - How often, how much, required for which issues.
  - If you do x, do we need what complementary parameters for assessment goals
  - Complete detailed situational monitoring protocols
  - QUAL2 scenario data requirement standard matrix
  - Design of monitoring system so decision makers understand the process and conclusions
- Lake assessment remote sensing for certain for which impairment
- to assess or reduce ground truth monitoring requirements
- Strategies to minimize total monitoring costs
  - Comparison of technologies to data conclusively
  - Cost to data volume quality
- When to monitor given temporal variation?
- Establish long term monitoring programs comprehensive

- Are we set up with temporal and spatial AB monitoring design setup to define load allocation and BMP effectiveness
- Spring monitoring
- Interaction/communication – modelers and monitor
- Lack of specific monitoring goals
  - Spatially and temporally
- More focused approach
- Comprehensive monitoring
  - Biological/chemical/physical
- Identify sites for comprehensive monitoring
  - Scale issues and time scales
  - Size
- Research into consistent basin approach
  - Thresholds
- Consistent approach for watershed assessment
  - Very broad to very specific
  - Biological/physical/chemical/hydrology
- Protocols for linking data
  - Upstream – downstream
  - Different levels: Simple to detailed
- Research on design and sampling and how it affects data
- Make use of statistical techniques in design
- What are we monitoring? Source/discharge?
- Finding new ways to use volunteer monitoring
- Monitor for specific results
- Trend analysis to focus monitoring and pre-impairment fixes How to use emerging technologies (LIDAR and satellite imaging)
- Spatial and temporal integration and distribution of monitoring
- Protocols for stormwater monitoring: We need protocols for large (such as the Mississippi) river monitoring that are cost-effective. Depth-integrated sampling is excellent but not cost-effective for frequent monitoring.

b. methods

- Monitoring assessment protocols
- What info can we get from monitoring devices/technology?
- Critical review, development of monitoring methods
  - Quality control paradigms for evaluation of rapid monitoring
- Revisiting how parameters are measured and consequences of methods
- Models to tie continuous and spotty sample data into PARA
- How do we best get technology deployed
  - Who needs what monitoring handbook
- Value of TSS vs. turbidity vs. G.S. methods
- Approach to determine best field and lab methods based on explicit criteria
  - TSS suspended sediment
  - GS techniques
- To achieve integrated data uniformity that translates among agencies

- To bring in value of surrogates for understanding the system; integration of suites of parameters
    - Understanding the meaning of turbidity results by specific methods in context of specific systems/TMDL
- Identify full range of pollutants monitor for full site instead of piece meal.
- Instrumentation equipment
- Statewide high resolution DEM (LIDAR)
- Methods other than monitoring
    - More to performance assessment than monitoring
- Research on different assessment methods (data models)
    - Variability
    - Begin to standardize
    - Database
- Synthesizing monitoring protocols and methodology (esp. biological)
- Research to bring lake remote sensing data up to the level where it (virtually) alone can be used to determine impairment – this would greatly expand out "% assessed" figure for lakes
- I believe we either already have or are very close to being able to use remote sensing to properly assess lakes and determine if they are meeting clarity/P standards
- Research into what level of QA/QC is necessary to utilize citizen-collected data
- How can the citizen-collected data be n=most useful for assessment
- What type of data collected how, where, how often/ let's develop clear need and ways for citizens to help out by producing useful and useable data (instead of make work or work that they find fun but without clear purpose). How does citizen monitoring compare with remote sensing?

c. costs

- How do we fund long-term monitoring programs?
- Connecting funded projects w/public policy makers

d. collection

- Data collection
- Assessment of emerging pollutants
    - Before and after presence of impacts
    - Effectiveness monitoring
- Watershed delineation storage method to share data
    - Quality of delineating
- TMDL assessment – did anything change?
- How much data do we need?
    - Extrapolation and repeat visits
        - How much? Can't get info on every reach
        - New data vs. using data we already have (apply same data to multiple questions)
- Whose data?
    - Where come from?
    - What is quality

    - Needs to be believable
- Integration of time series data into stream water quality assessment. Continuous data segue into modeling. Data for dual purpose assessment- modeling, diagnosis restore.
- Discharge permit monitoring information electronic and available to all
- Establish a database (point source)
- Method of making data and models available to all
- Accuracy of past data (and future)
- Common baseline dataset for matching chemical/biological/physical
    - Make broadly available
- How usable is data (accuracy)?
- Is point source data the ‘gold standard’?
- Data need: critical need for network of atmospheric deposition of wet and dry TP, and dry TN and DIN (NO3-N, NH4-N, NO2-N, NOx). We currently only have decent wet-dep for N. What happens if agricultural fertilization increases or it gets drier and more dust blown into the air over time? We have >5000 nutrient deficient lakes.
- Research to develop effective methods of delivering/disseminating complex data and common sense interpretation of it to the public, teachers and decision-makers.

e. biological monitoring

- Habitat- how to assess
    - What variables to use
    - What is healthy
    - Should there be a standard
- Assessing Biol. Communities after a disturbance (natural or other) – what is right time frame for assessment?
- Step up biological monitoring
    - Set up milestone sites or seminal systems
    - Unify assessment
    - Protocol issues
        - Increase frequency and coverage of biological monitoring data collection
- Improve tools (Biological Monitoring)

f. climate change

- Loads vs. concentration monitoring with spotty data regarding flow interpretation
- Monitoring strategies to identify climate change impacts as they occur
- Time scale, mining of old data to look back more clearly at trends so far.
    - Untapped lake site records
    - How system, landscapes, responded to past changes
    - Where are the restoration endpoints?
    - What do current best monitoring practices really measure? Examine biased systematic Auto sampler with shifting depth for sampling from stratified, variable composition waters
- Variability with climate change
    - Better defined

2. Designated Uses and Natural Background

a. Designated Uses

- Classify water resources to minimize natural and regional variability
- Beneficial uses of water resource. health, biotic Integrity aesthetics
- Use – aquatic life standard is applied to all waters across state
- Can we simplify the groups to more manageable – to be able to use simple proxy indices
- Connecting standards to refined designated use (use-clues system)
- Connect standards to ecological conditions
  - Baseline data needed for assessment of waters
  - What level of monitoring and other tools needed to define ecology health
  - Multiple stressors/interaction
- Criteria development- needs to be updated
  - Slow progress at EPA
  - Bio accumulative criteria- key links in food chain
  - Chemical interactions
- Time limits- How often/long can you violate a standard and still maintain designated use? (especially for aquatic life)
- What endpoints?
  - Acute/ chronic tax and behavioral
  - How extrapolate to larger population?
- What do we most value?
  - Human health or biota? (broadly and fundamentally)
- Ecological compositions in changing contexts
- Stream classification refinement for standard relevance. Temperature, turbidity
- Irreversible benchmarks and background
  - Altered natural states due to reservoir, dam, ditch
- Research to support initial use classification and water quality standards
- What endpoint are we measuring?
- Establishment and quantification of natural background levels for various landscapes and scales
  - Regional variance, flexibility
  - Consideration of history
- New approach for defining non-degradation

b. Natural Background

- Natural background, site specific standards and irreversible changes
  - Linking of the three
- Standards achievable in some places
  - Define natural background-“legacy” loading
- Gaps in scientific knowledge that need to be filled to inform policy decisions
- Socioeconomic/legal context for policies-research on these impacts
  - Cost/benefits analysis of clean water
- What is Natural background”? Define target levels.
  - Historical? Pre-Columbian or other?
  - Current conditions?
  - Expectations based on process modeling.

- What is relevance of natural background conditions?
- Sediment fingerprinting- what is natural background
- Establish monitoring sites to determine what the "natural background" levels for various landscapes are
- Natural background definition should be based on Clean Water Legacy Act
- Further definition of natural background to improve understanding of standards
    - Designated uses
- Definition of historic water quality (compared to today's standards for comparison

3. Appropriate Water Quality Standards (biological, physical, chemical)

- Deicing chemicals and impacts on lakes and rivers
    - Monitoring, standards etc.
    - Year round and statewide
- Interpretation of water quality data in terms of landscapes (soil, precipitation etc) not using a single turbidity standard across all "landscapes"
- Example standards, existing site, within a geography
- Reference site in a sentinel watershed
- Better approach for standards in a landscape position (what is achievable)
- Indicators (mechanistic)
- Expanded use of probabilistic methods for standards and goal setting

a. Interconnection

- Interconnection of groundwater and surface water
- Connecting biological measurements/improvements to regional chemical, physical data
- Links between hydrology, sediment, and biological impairment drivers
- Interactions between pollutants and impacts
- Bio, physical criteria to match chem. Standards
    - Develop better biological criteria
    - Put chemical violation into biological use context
- Turbidity-link to biology
    - How to better use data
- Flow alteration and hydro cycling
    - Urban forestry, Agriculture (surface and tile drainage)
    - What is intensity of flow alteration (how much drainage)
    - Given flow alteration; what are appropriate biological/chemical Endpoints?
    - Contribution to pollutant loading
- Ground water
    - Recharge rates
    - Interactions with flow alteration
    - Implications for wildlife, pollutant loads
- Importance of water as a pollutant
- Hydrology to Index of Biotic Integrity correlations, multi-trophic species comparison, ecological endpoint target
- Drinking water standard for trout stream appropriateness (designated use to numeric standards review
    - Nitrate N to index of biotic integrity relationship

        - Physical: channel morphology, temperature
        - Biological: Index of Biotic integrity
        - Habitat: QHI imbeddedness
    - Relation of biotic impacts to human health
    - Social connections revisited
    - Cause and response relationships between nutrient and stream health
    - Link biological endpoints to water quality in shallow lakes
        - Internal loading mech. (biological, physical, human)
    - Integrated, ecologically-based water quality standards (20 Needs #18)
        - Systems approach

b. Costs

- Economic issues
- Standards fit resources?
- Standard refinement- ecoregion
    - Unchangeable changes? (ditch vs. stream)
    - Acceptable changes to landscape-social economic
- Should we consider cost when we set standards?
    - Cost to meet standard
    - Cost to society
    - Cost monitoring
    - Necessary controls
    - Balance against benefits.
- Research on economics of meting/achieving standards
- Research as to whether standards are achievable. This is a huge issue to answer if you want to get local decision-makers to get involved or invest in implementation
- Research needs with respect to the economics of WQ standards. How much point sources investment, how much non-point source investment
- Assessment of a pollutant trading market potential – supply and demand
- Cost-effective development of water quality standards for highly urbanized lakes
    - Community perceptions (uses, costs, priorities)
    - Appropriate designated uses
- Economic studies on meeting standards
    - Feasibility
    - Cost/benefit

c. new standards

- Emerging contaminants
- Storm-drain systems and difference from natural systems. How to set standard for resource ______ in a pipe
- Interaction between storm sewers and end water resource
- Hydrology standard or impairment, normalization and management. Description of hydrology
- Development of biological standards/endpoints
    - Classifications for water bodies
- Tiered Aquatic Life Use for wetlands and lakes

- Standards for funding – priorities etc. recreation, human health
- Surface and groundwater interactions
    - Groundwater watersheds
- Standards-based on toxicity, not behavioral-how to regulate and define?
- Model for standard development?
- Criteria development
    - Toxic=behavioral
- Proper bio endpoint?
    - Human, wildlife, etc.
- Mixture effects?
    - Chemical by chemical vs. mixes
- Developing indicators for physical parameters
    - Indicators for hydrology and habitat
- Sort relative impacts of hydrology, habitat, water quality
    - Standards for hydrology and hydraulics
- Suitability of fixed numeric standards for naturally variable NPS
- E.Coli standards
- New standards for multiple pollutants with synergistic effects or that show interactivity w/ in water
- Consider ground water- part of hydrologic budget
- Assessing ground water for its own sake (not just stream recharge) (infiltration in park. lots becoming sources of contamination (example)
- Development of physical standards, especially for stream stability
    - Maintaining form and function and sediment balances
    - Natural vs. impacted
- Impacts of non-native species on water quality, standards for control
- Bacteria standards for open waters (lakes)
    - Beach closing, etc.
    - Types of bacteria (DNA fingerprinting) and source animals
- Develop streambed metrics related to bed mobility and biotic response for defined aquatic life uses.
- Spatial and seasonal and temporal variation issues
- Research to develop tiered aquatic life standards

d. existing standards needing revision

- Shallow lakes – total phosphorus standard will not reach desired result
- Phosphorus and ecological health
- TSS and turbidity links as turbidity is not a good measure
- Drivers other than phosphorous of ecological integrity
- How climate change will affect standards
- Greater confidence for beneficial uses of wastewater, reuse
- Define changes to hydrology
    - When, what acceptable
- Turbidity:
    - Defined protocols, methods
    - Link to biology

- Temporal scale
- Link to nat. background

- Bacteria
  - What is harmful?
  - Better defined protocols
  - Temporal scale
- TSS- How volatile suspended solids affects TSS
  - Relative to nutrients, stream discharge and land altercation
- Turbidity standard- Need to understand contribution of component parts.
- Transition from Turbidity standard to more comprehensive approach.
- More specific/nuanced standard turbidity dependent on site specific classifications
- Fecal Coliform: In the Blue Earth River basin almost every reach is impaired for fecal coliform. Most reaches well exceed the standard and may be hard to attain standard. So, standard is somewhat diluted and hard to target what reaches are the priority. May need to do more intensive monitoring of water borne pathogens, look at multiple impairments/biota, to effectively target watershed.
- Max /min sensitivity of aquatic life and how varies with disturbance.
- How stringently should a standard be met (enforced?)
- What is overall water quality goal and how does it relate to specific numeric standard of different pollutants?
- Uncertainty/ variability in parameters
- Uncertainty/ variability in parameters
- What are the physical standards
- Critique of older standards in newer contexts, turbidity, and pathogen
- Turbidity Suspended sediment relationship
- Comprehensive assessment of appropriateness of water quality standards.
  - Proper measurement and application of standards
- Bacteria indicators for lakes optimal choices
  - Spatial, seasonal, diurnal variation
  - More nimble standards
  - What gives best assessment
- Coordination with standards of neighboring states
- TP 40 update needed for over 40 years
  - Frequency duration curves, application of new total phosphorus 40 into models
- Example Turbidity- Reevaluate specific standards are they being appropriately applied across the state.
- Consider thermal pollution and indicator species
- Ecoregions for streams need update
- Validate current standards
  - Is it achievable? Costs/benefits
  - Improve if unacceptable
- Validate current standards
  - Is it achievable? Costs/benefits
  - Improve if unacceptable
- TP-40 update now
- Appropriateness of standards based on watersheds-scaling for standards setting

- Need to take a step back and look at existing WQ standards – are they the right ones? Are they good ones? Are they measured properly? Are they consistently applied in-state and with other states? Examples: Turbidity-TSS-TDS, bacteria in lakes (missing completely), E. coli or some other bacterial indicator
- More appropriate biota standards for streams
    - Pre-settlement conditions
- Lake aquatic life assessment methods and standards
    - Deep vs. shallow, urban vs. undeveloped
    - Management endpoint conflicts
- Assessment of biological appropriateness of turbidity std.
    - Lake std. base on use
    - No equiv. stream std. for use
    - Regional, wet vs. dry conditions
- Develop data and metrics to quantify stream bed mobility
    - Assess bio response
    - Changes over time

e. landscape/sentinel approach to standards

- Example standards, existing site, within a geography
- Reference site in a sentinel watershed
- Better approach for standards in a landscape position (shat is achievable)
- What is the role of landscape modification on hydrology
- Research into ecoregion vs. landscape
    - Misclassification is a problem
    - Research into a ‘set back’ for establishment of description
    - ID critical portions of landscape
    - Sentinel watersheds
    - Research into longer broad differences
- Dynamics of landscapes; time, space
    - Having policy reflect dynamism
- Reach by Reach vs. watershed (scaling again)
    - What data needed to make management shift
- Geographically dependent standards
    - On watershed Basis?
    - Ecoregion approach.
- Geographically dependent standards
    - Sentinel watershed; long-term data; systemic approach; along gradient of disturbance; feasible scale; nested watersheds
    - Uncertainty
- Identify and monitor “sentinel” watersheds
    - 10 year commitment
    - Variety of scales
    - Systems approach
- ID and develop “sentinel’ watersheds
- Develop ecological-based – integrated WQS
- Significance natural var.

    - Understand across ecoregions
    - Broaden criteria from physical and chemical to include biologic ecosystem conditions
- How to make ecologic descriptors economic, socially relevant:
    - Charismatic surrogates?
- Public communications
- Impervious, land use, watershed yield standards
    - Relationship stationary
    - Drainage, connectivity
    - Connection between watershed and TMDL impacts
- Standards robust in face of climate change
- Establish sentinel watersheds
- Statewide land-cover data:
    - Baseline data for research use
        - Watershed data (Hi-res DEM)
        - Land use
    - Consistent and comprehensive statewide
- Link baseline data to develop simple methods (tiered assessment)
    - Does it benefit all practitioners?
    - How to use baseline to communicate issues and problems to a variety of audiences
- Monitoring for specific results
- Multi-metric indices for large lake and river systems
- Climate change effects on monitoring (scheduling, dry/wet, etc.)
    - Attainability of standards
- Appropriateness of standards based on watersheds-scaling for standards setting
- Research to define "natural" variability.
- Update ecoregion mean/ranges for reference streams and effects of scale

4. Local Involvement/Public Involvement

- Educate public, integrate with research
- Need assessments to be "cheaper and easier
    - Use citizens, improve technology
- Citizen monitoring- giving useful info?
    - Use as assessment tool?
- Public perception
    - Benchmark of perception for water quality (4 resources). (value of standards and improvements)
    - Outreach education
- Between large entities w/in state (cities-ag-development)
- Helping community and legislators to understand the importance of impaired water work
- Communicating priorities to citizens, meaning to standards
    - assessing norms and values of public
- More local involvement at assessment stage (before listing)
    - Both agencies and citizens
    - Local early-warning indicators

    - Stakeholder involvement before TMDL

5. Better Science

- Biological monitoring as a measure of emerging contaminants
- Variability in biological assessments
- Ecoregion research
    - Research into independent applicability
- Better understanding of biological performance
- Better terrain model (resolution scale) – LIDAR
- How much data is enough? – good science
- What point is research too much?
- Use new tech-finer details-i.e. watershed model
    - Paleolimnology-tie in history to define natural background
- Nested research-define spatial and temporal scales-link them (i.e. CHASM in England)
- Technology robustness-how do new tech's work
- Where is greatest uncertainty in linking water quality Parameters to valued outcomes?
- Biota effects on water quality; i.e., carp
- Do we have models for water quality?
- Better understand variability, trends
- How drainage effects hydrograph in climate change
- Understanding history of geomorphology in diff. landscapes
    - Predictive tool for hydrologic improvements or changes
    - Do we have unrealistic goals?
- Develop improved comprehensive framework research activities to focus efforts and additional resources simple diagram (perhaps systems dynamics model)
- Modeling and assessment
    - What is biology telling us?
- Toxins from blue green algae, rapid assessment methods
- Discharge of sulfate (Iron mines and ethanol). Mercury methalation

6. Listing issues/impairment

- What is impact of impairment
    - Why should people care
    - Link to social perception
- Diagnostic issues- What are the causes of impairment?
- Better link between hydrology and managing stream flow connection to impairment
- Better link between Imp. Causes for better mandated responses.
- Timing question
    - Proceed w/ biological monitoring. time listing. with development with causal links and mgmt response to do implementation TMDLs
- Delineation of causes (in higher level)
- Take integrated approach not to rush to list/ piecemeal.
- At what point do we know enough to make a decision.
- Focus monitoring on models used integrated monitoring-listing approach (feedback system)
    - Integrate metrics

- Data required to list Number of observations, time persistence, etc.), watershed based?
    - Balance between breadth and depth of data collection
- Research focus on poorly understood systems rather than river-by-river study
    - Understand ecoregion or river type system before listing/TMDL study

SESSION II: TMDL
1. Social/Cultural
a. understanding

- Human behaviors that contribute to impairment
- Social aspects of BMPs, cost and benefits
    - future climates
- Understand TMDLs in resource protection
    - Strengths and limitations
    - Community education
- Realistic expectations
- Relate scale of TMDL study and to motivation of stakeholder.
- Define scale
    - Governance
    - Monitoring
    - Stakeholder motivation
- Research need:
    - What types of info do stake holders need to make decisions
    - Create models that produce that type of info
- Involving stakeholders in the modeling and in the TMDL
    - Do consultants involve stakeholders in this?
    - Research on how to do that
    - What are belief systems of stakeholders
    - How to communicate ax diff. beliefs/backgrounds/stakeholders perspectives
- What resources, measures, bring stakeholders to the table to plan TMDL and stay engaged
- Credit for no load allocation to system, to engage public daily business choices, what incentives would effect citizen choice-affect restoration
- Stakeholders need comparative future options to address
    - Uncertainty
    - Climate change
    - Resistant and social systems
    - Adaptive capacity
- How will you negotiate TMDL decision-making
- Decision points: What key information/knowledge do decision-makers need to compare options, multiple criteria analysis?
- Social indicators of behavior change
- To sell implementation-connect practices to benefit
    - Why should landowners do it?
- Different protocols for different parameters

b. education

- Education and sharing practices
- Study effectiveness of education of research
- Future-people disengaged from resource
- Need for sociologist (rural)
- Research targeted toward private lands
  - Info and education on land use
  - Behavior change

c. communication

- Communication!
  - Get research to everyone-scientists to policymakers to stakeholders
  - Localized approaches
- Research serving broad needs for many different studies
- Re-name "TMDL" to involve community more fully?
- Not necessarily a research need, however, a need nonetheless: better knowledge from PCA to resource managers as to what data (precisely) was used to list a reach, what analyses were performed and what were comments in professional judgment team meeting with regards to that listing.
- How do you create public discourse with justice-fairness in TMDL stages
- Voice and influence for decision-makers, both distributive justice and procedural justice
- How can you create feedback (monitoring data and other) that informs behavior for all actors at multiple scales?
- Understandable colloquial terminology equivalents for jargon short hand
- Lag time for expected results –communicating this to society

d. acceptance

- What normative behavior beliefs exist that create incentive or disincentive for change?
- Study acceptance in relation to involvement
- Cultural shifts that are available and necessary and acceptable
- How to define problem and build consensus
  - Esp. for WL reduction
  - Knowledge needed by public
- Acceptability of rehab strategies to diff. stakeholders
- Community buy in what roles in TMDL do local stakeholders trust most in decision process
- Research on social acceptance of BMP strategies
  - Watershed
  - In water body processes for example safety vs. water quality (salt)
- Timeframe for future TMDL work
  - Commitment to long-term

e. Stakeholder participation

- How can a 25 person volunteer group involved in TMDL affect quality of implementation
- How can community groups be more effective in TMDL practice
- Engaging stakeholders

- What stakeholder process is effective?
    - Deal with multiple impairments (process repeats)
    - Manage expectations-set achievable goals
- Collaborative strategies for WLA +LA reductions
- Define citizen goals for watershed-how to incorporate TMDL w/these
    - What is stakeholder motivator?
    - Economic?
    - Philanthropic?
- Intuitive (simple) tools useable by practitioners
    - Translate model-graph
- Stakeholders
    - Collaborative strategies for W (illegible)
    - Successful engagement strategies
    - Link to broader goals
- Causes of stakeholder drop out in decision making process. Barriers to feeling valued as a participant. Things that keep people engaged long term
- Effective motivation of citizens, cities
    - What motivates engagement in TMDL process and implementation activities
- Systems for upfront stakeholder involvement
    - Local knowledge of system
    - Potential for implementation options
    - Social science study, economics, culture, politics, organization
    - Dev. of local capacity for sustainable implementation

2. Scale

- Develop an organizing 'scale' that could be used fro TMDL (for streams) – consider multiple parameters at a time
- Appropriate models- understood by stakeholders
- Strategic choice of TMCL scale for optimal restoration progress
- Do TMDL goals add up across scales
    - Aggregation of TMDLs between scales
- Spatial time scale of data collection, calibration
- Variability across different sites
    - Variable source

a. Watershed/reach

- Delivery of soluble phosphorous in agricultural settings, watershed scale – forms of phosphorous
- How to put multiple reach characteristics together in a TMDL
- Develop biophysical models to link watersheds to locals
- How to move from single impairment to watershed model
- If goal is space change
    - Small assessment areas needed, less precision
    - Create key piece of info relevant to all stakeholders
- Monitoring info at nested spatial scales- field, drainage system, minor watershed., major watershed; use to calibrate and validate model results.

    - Capture different processes at different scales
- Drainage systems at different scales
    - Public drainage system
    - Planning for storage within these systems (relative to economy, ethanol)
- Connection of watershed to reach impairment
- Scale issues connecting impacts to reaches at varied separation.
- Research needs:
    - Scale issues: how much does it take to have an effect on a certain scale (field—watershed)
        - As scales rise, is there a point where practices produce diminishing returns?
        - Cumulative positive effects as scales rise or do improvements cap at some point?
        - Need to understand effects of combining field BMPs with wetland restoration
        - Cumulative effects
        - Take a watershed scaled approach to see cumulative effects.
        - Don't forget thermal impairment
- Research on larger watershed factors for reach listings

b. basin/watershed

- Are ecoregions comparable, context of land use on TMDL
- Effectiveness of how loads are allocated in larger scale TMDLs
- Larger or complex watersheds will need more information/data (than that needed for use assessment) for development of the TMDL study
-

3. Models

a. Issues - Validity

- Adequate sampling (always verify impairment) to prove impairment (ties into scale/network design)
- Define scale of impairment-
    - Effectiveness of watershed approach-how big and still involve stakeholders
- Effectiveness of various levels of government
    - Scale of governance
- How to keep people involved before and after
    - Institutionalized process
- Review what model form needed to assess impairing
- Ice covered lakes into Australian lake models used
- Functional based mechanisms or targets as TMDL goals
- Skepticism re. value and validity of modeling
- Convincing mode output
- Field verification and demonstration of model ability of predict a tangible result
- Evaluation of contextual model validity
- Empirical vs. model, no substitute for mode forecast
- Review of model mis-application in allocation of sources, actually field verification still needed
- Certainty, relative, of models and implications to policy
- Determine proper parameters for water quality models

- Models can’t always predict
    - Physically bases approaches
- Better models,(using physically based models) so we can test and examine land use changes
    - New model development for new scenarios
    - Need refinement ex. evaporation runoff coefficient
    - Hydrologic inputs for empirical models
    - Make sure basic building blocks are up to date
    - Should depict:
        - BMPs
        - Land use changes directly
        - groundwater/surface interactions
        - Cultural practices
        - Non-structural BMPs
        - Changes in public education
        - Vegetation changes/crops
        - Hydrologic system changes
        - Climate changes
        - Channel morphology
        - Sediment from channel vs. watershed
    - Should be evaluating tools for TMDL
    - Studies where tools are inadequate
    - Slow down process
    - How do TMDLs interact with in-lake, in-stream processes
- Capture variability of mgmt practices (BMP implementation, tillage)
    - Assume uniform practices
    - Calibrating models better-what’s currently going on in the landscape
    - Landscape variability and landscape vulnerability
    - Determine sources of variability in BMP practices, natural vs. human
- Need simple modeling package, decision analysis
    - Load estimating component based on land use and coefficient
    - Load reduction factor based on BMPs-that can be overlaid (mix and match various BMPs until get the desired results) with GIS component
- Models need to be synergistic to recognize cumulative landscape changes (ex. multiple rain gardens)
- Improving TMDL models
    - Validating models w/data
    - Appropriateness of models (geographically)
    - Comparing results across models
- Calibration of models-verification
    - Sensitivity analysis-ranges for constants (coefficients)
- Model reliability
    - Case studies by region
- TMDL study-sets, beneficial use, standards, classifications
- Scale/ models –field size, watershed conflicts
- Geomorphic context, natural vs. changed.

- Link edge-of-field to water body-how do land processes link to soil/water quality?
    - Biophysical models-link watershed
    - SWAT – loads with receiving water
- MN version of watershed models
- Develop models to look at effect of different restoration options
- Bring that info to stakeholders
- Temporal variability of loads, distribution of loads
- Relative clear distinctions of climatic, flow, runoff and effect on water quality violations
- Rate indicators to track on new streams for monitoring of improvement or deterioration based more rigorously monitored streams. Extrapolation models
- Where do pollutants really come from, what situations, causes, spatial allocation in runoff NPS and hydrographs
    - Believable models of original source
- Errors/uncertainties from models
- 3 day intense storms, more energy in climate systems and implicating
- Changes in critical events for impairment

b. Data needs

- Incorporate new technologies i.e., nomograph
    - Similar to NRCS
    - Curve number standard approach
    - i.e., MN FARM model
- Useable tools by public Statewide LIDAR for data analysis and singling out cost benefit analysis
- How to encourage new tech adoption
    - Facilitate data exchange-access
    - Retain problem solving skills
- Basic data:
    - What does everyone need?
    - What would it cost?
    - Cheapest scale to implement better shared datasets
- Value of data in preset dollar terms, in opportunity cost of no data or old data, added value of new data to econ
- Consideration of likely data use in models when designing monitoring sampling system
- Use of test data applied to entire watersheds
- Land use related to hydrologic change
    - Sediment
- Indices development related to hydrologic change and sediment and nutrients
- Standardized storm events for future model development and calibration
- Statistical analysis of precipitation with climate change
- Standardized hydrology for future
    - Assumption and guesses for future storms and land use
- Characterization of uncertainly in LA and how it affects implementation
- Data collection
    - Evaporation
    - Evapo-transpiration, wind, precipitation

    - More meteorological stations
- Hi-res digital evaluation data to inform the small watershed models
- Standard procedure for setting up a core sediment sample
- Cumulative impacts fitting into stressor specific framework. How does water quality depend on the hydrograph- understand variability over time and ecosystem effects.
- Water pathways across different spatial scales, esp. given karst topography
- Sediment fingerprinting
- Connection of monitoring datasets to diagnosis
    - How it became impaired
    - Needs for diagnosis sufficient to inform treatment
- Use of satellite imagery for modeling

4. Allocation

- Better understanding of spatial and temporal variability and uncertainty (Margin of Safety) and more
- Natural background models
- Consistency and level of detail
    - QA/QC of information
    - Established stringent procedures b/t watersheds and TMDLs
- Standard procedure for allocating sources
- Consistency
    - Modeling
    - Development of TMDL
- What happens when it is not possible to meet water quality Standards? (E.g. Mercury in MN) (contribution of outside sources)
- Storage in watershed, travel-time distances
    - Of pollutants (like sediments)
    - Of water
- Rel. to how long it will take for changes in watershed to have effect
- Load allocation equity. Model to quantify, define develop equity
- Site specific goal setting.
- Sensitivity analysis. Leverage goals with value to end results
- How to define margin of safety
- Need link between implementation and load allocations
- Need a system to gauge the susceptibility of a lake or watershed to fish mercury accumulation i.e. it may take more loading (or less) to get to the listing and statewide mercury limits. TMDL allocations could be adjusted with this information
- Consider regulatory option 5-8-3 ways of reducing loads
- Weather nutrient controls alone can reach ecological endpoints

a. economics

- Cost benefits and public policy in TMDL effectiveness
- Economic support requirement for landowners
- Optimization of cost for waste load reduction amount and distribution of loads
- Potential costs, economic social injustice consequences of trading
- Economics of pollutant trading within a watershed-supply/demand

        - Scale issue
- Unit cost of management practices for prioritizing implementation
- Cost effectiveness
    - Point of diminishing returns
    - Maximizing amount of money used to fix the problem-less red tape

b. pollutant trading

- Point and non-point trading
- Pollutant trading

c. point-nonpoint source

- Assigning equitable allocations for cities with different situations
    - ex. small city with large industry
- Nutrient fate and transport in lake TMDLs, quantifying loads from point sources and NPS and their transformed forms in lake cycling
- Need to be able to directly relate WLA to actual number on ground (or from pipe)
- Balancing expectations
    - Point sources vs. non-point sources
- Feasibility of regulating non-point sources
- Quantifying natural background component of LA

d. future growth

- Better understand the future and variability- population, land use, economic activity
- Reserve capacity
    - What are cultural and economic consideration
    - Economic method for doling out
- 2nd tier to regulating LA
- Research needs: Time
    - Permits
    - Can research save multiple TMDLs
    - Can the data compliment each other
- Need clearing house for all data
    - All with impaired waters
    - Instate/out of state
    - Chemical/biological, etc
- How much margin of safety and how much reserve capacity
    - Depends on pollutant
    - Economic analysis related to need for growth.

5. Prioritization

- Road map for priorities on TMDL needs
- Prioritization of where to do TMDL first
    - Sentinel indicators, hot spots, more valued resources, chance of end restoration successes given social, econ, cultural factors
- Not just accounting studies of TMDL

6. Source Determination/diagnosis

- Internal loading in shallow lakes – very dynamic, will cutting leads make it change
- Wetlands – mercury, phosphorous, nitrogen, source or sink?
- Hydrologic modifications system understanding
- Pathogens – Identification of sources
- Disturbance level indicators (number of ditches)
- Number of BMPs in place, access to this data – fundamental collection for this data
- Biology as a diagnostic tool, response to stressors
- Natural form vs. man-made disturbances
    - Can we determine the cause?
- Documentation of protection areas
- Comment on Paleolimnology to give some information on natural vs. man-made
- Research into historical condition and predicting
- Source identification - modeling, model correction/ verification, source load quantification (i.e. fingerprinting)
    - Identify models' weakest links/strengths
    - Calibration of models with real data
    - Validate processes models are based on with field data
    - Field-based data specific to region
    - For sediments, nutrients, pathogens, etc.
    - Calibrate/validate models at small enough spatial scales; but rather than watersheds- allows for future work in changing ecological context.
- Better understanding of internal in-stream, in-lake processes
    - Public buy in to severe steps
    - Social impacts
    - Wetland drainage-better understanding of hydrologic impact
- Like to see hydrology as stressor/pollutant
    - Need to be able to calculate changes in loads
- Wind erosion's contribution to sediment loading
- Research into sediment composition in streams
    - Relationship to land use
- Pollutant source identification-consensus
    - How good does the science need to be for society to buy into it?
    - Delivery of pollutants
- Regional translators relating one pollutant to another
- Physical/chemical relations to biological conditions
- Better seasonal information
    - Is it applicable to year round?
- Research on linking biological impairments with stressors
- Stressor identification
- Better understanding of in-stream processes
- Record of current land use practices e.g. fertilizer application
- Case studies of BMPs and results
- Define drivers of impairment, resiliency of landscape
- Relating upstream cause to stream impairment
- Lets look at causative mechanisms of impairment not just average load

- What is impact of invasive aquatic plants or TMDL
- Impacts of onsite systems
- Hydrologic modifications and their impacts on streams-drainage ditches
- Continued funding for stormwater research
- . Better understanding of in-stream and in lake sources
    - Natural and anthropogenic causes
- Impacts of drainage on changing hydrology
    - Better understanding of all impacts
- Geochemical/isotopic methods to identify flow/transport pathways
- Training and implementation
- Research to create more site-specific standards
- Research to determine the effects of impervious surfaces on stream flows and turbidity
- Integrating stressor impacts
- Better characterize bacteria sources

7. Specific Pollutant Comments

- Deicing chemicals and research related to road slat
- Cumulative impacts, loading, sediment
- TMDL is a pollutant study with loads – pollution related to habitat, etc. Can this work for these topics as well.
- Sediment- practical research needed to apply TMDL approach to this pollutant (also applies to other pollutants)
    - How to measure concentration, relation to index of biotic integrities, aquatic life, source and sinks (reach, floodplain, basin scales.)
- Understanding of physical stream processes and best tools to measure them
- Continuum of pollutant transport
    - Source/transport sink mechanics
    - Time scales for transport, removal/implementation
    - Effectiveness of fixes
- Hydrology imports on system
    - Natural hydrologic regime?
    - Current regime?
    - Potential future regime?
    - Historical land-use change understanding
- For biological listings: life-cycle of biota to identify stressors for fixes
    - Synthesizing by system, region
    - Also macro inverts
    - Stream history as indicator
- Bacteria DNA fingerprinting, identify sources
- Cumulative impacts on biota
- Research needed on dechlorination of Minnesota waters, especially research in actual conditions. No one is doing it. Is parallel track to road salt tracking. No research on impacts of chlorides, algae, protozoa, microbes, few on fish. M. Eric Benson MSU has done one of the few studies of aqueous communities (total populations) Common process for pH, DO, BOD, chlorides, conductivity.

- Salt vulnerable area studies/risk assessment (Environment Canada – Niagara Falls), north shore, Duluth, Mississippi
- Impacts of chlorides on well water and groundwater
- Bacteria impairments- (E. coli)!
- Lack of data on pollutants effects on human health endpoints
- Sediment sources and sink
- Refinement of bioavailable P standards and implementation in lakes vs. streams
- How important are hotspots as pollutant sources? Are there significant non-linear responses? Does <5% of the watershed contribute to >80% of the pollutants
- Better stressor identification tools for impaired biota TMDLs
- Pollutants without "mass" (not a "load")
    - How incorporate into TMDL process

8. Prevention

- Prevention and reduction strategies demonstration and documentation of effectiveness.
- Prevent impairment historical studies
- How maintain water quality in areas where not yet impaired
    - Apply same models to predict when and where BMPs are needed
- Retrospective analysis
- What to change to avoid TMDL altogether?
    - Proactive vs. reactive
    - Look at impairment history-why does it happen?
- Focus on un-impaired systems
    - Avoid impairment
    - What data to collect to identify "pre-impairment"
- Citizen monitoring

SESSION III: IMPLEMENTATION

1. BMP Issues – Selection, Scale and Assessment Tools

- Continued research
    - Dividing larger basins into smaller basin studies and demonstration sites

  Research maintenance costs and mechanisms for sustaining it
- Research linking citizen involvement with TMDL implementation to test assumptions
- Long-term effectiveness of BMPs

    Guidance for BMP effectiveness for local government and public
- At watershed district level, need tools for guiding audiences (education and prevention) and BMP on small projects

  Prioritization of BMPs/TMDLs need for effectiveness, strategic use of resources
- Effectiveness of storm ponds and infiltration systems

  Performance based outcomes for BMPs
- Using tools to decipher data more that more than models

    How do you decipher data?
- Characterize sediment processes
- Variability over space and time
    - Include life cycle costs

    Effectiveness of implementation

- BMP learning community appropriate for landscape
- Potential for BMPs to solve problem?
- Strategic location of BMPs
- Risk-based approach to development of BMPs-accommodate larger storm events
  Strategic locations
- TP40 and risk analysis
  Adjust to current climate conditions
- Long term effectiveness of BMPs; how long?
  - Reconciling different perspectives about BMPs i.e. is rip rap good or bad?
  - Economic considerations over the long term
  - True costs of long-term maintenance

  Cost/benefit analysis
- Models to forecast different scenarios, used to demonstrate different possibilities to collaborators
- Ways to convince that BMPs improve operations and are effective
- Compromise between drainage and erosion mgmt.
  - Tools for management when to channelize
- Explore Wisconsin buffer initiative to incorporate targeting key sub watersheds
- Map development for prioritizing implementation and TMDL efforts with scarce funds
- Location of drain tiles and drainage ditch networks
  - Statewide or critical area inventory
- Tools for targeting practices to Environmentally Sensitive areas LIDAR 30m DEM is insufficient
- Tools across watershed bounds, to aid local implementation. groundwater, web query, for offices with no geographic information specialist
- Source identification
  - Intensive monitoring
  - Keep property ownership in mind
- Predictive modeling to identify vulnerable areas then work with those communities
  - Thresholds. using land/geomorphic characteristics
- BMPs suggested in TMDLs plans
  - Are they the most effective?
  - Is the data out there, how can it help us sell practices, ideas to those who are affecting the area?
- BMPs for winter feedlots
- Efficacy of source reduction vs. treatment through BMPs
- Recognize system wide changes where there has been cumulative changes
- Understand current resources and data
- Effectiveness of BMPs relative to landscape setting
- Focus on nick points as “triage”
- Quality benefits of BMPs to develop a credit-based system
- Research on rain garden implementation on catchment scale
- Measure and predict response times of waters to implemented measures
- Develop tools to identify sensitive areas
- Establish long-term case studies
  - Demonstration projects

- Include analysis translated for stakeholder groups

- Conceptual models for adaptive management strategies
  - How to use available data
- Assessment of appropriateness of endpoints and BMPs with stakeholder facilitation and creation
- Development of benchmarks or signs of progress
- Use of social science methods for measuring effectiveness for short term. Survey
- Economic validation of Low impact designs, buffers, that whole suite of practices invented to either protect or mitigate stormwater related problems. Need natural resource economic research for stormwater BMPs that helps us demonstrate the true costs of degradation vs. protection (and restoration). "Cheaper to protect"
- BMP effectiveness, buffers
- Effectiveness of BMPs
- BMP effectiveness?
  - Economic analysis
  - John Gulliver lit review-meta-analysis
  - Stressor vs. aquatic impairment
  - Load reductions and related aquatic biotic community health
  - Is use restored?
  - Compile information in useable form for practitioners
- BMP effectiveness assessment-meta analysis necessary
- Definition and justification for effective buffer widths
- Methods for reducing imperviousness w/development
  - Along with economic/social impacts of changes
- Effectiveness of BMPs restoration, precision conservation, scale issues, economics, etc.
- Measuring change over time
- Linking specific changes in land use to specific results
- How much change is possible to achieve through management
  - Theoretical possibility
  - Obtainable achievable in practice
  - Realistic goals: define economic cultural restraints on achievable restoration
- Need more research as effects of BMP implementation on actual pollutant loads
- Role of wetland restoration as a tool to improve water quality
  - Placement within watershed and stream system
  - Best watershed area/wetland area ratio
  - Also role as source
  - Potential seasonal variations
- Define threshold batter capacity
  - Is there an irreversible threshold?
  - Regional differences
- A study/research that needs to be done NOW and quickly: The impact of CRP land going back into production due to ethanol push. If the environmental and economic cost is high, what do we do to prevent this?

2. Better Science – Emerging contaminants, wastewater, and new restoration technique

- Research perennial crop mixes for improved water quality
- Future inputs: Climate change impacts on BMP effectiveness
  - Pop. growth impacts/changes
  - Plan for outliers
- Better understanding of newer practices for given watershed
- Emerging contaminators and how to remove them/management of and additive effects/interactions, bundling of nutrients
- Transferring lessons learned from other regions/countries or disciplines
- Waste water treatment and emerging contaminants and pesticides
  - Removal processes and potential redesigns

    Low level nutrient removal (0.1 ng/L Phosphorus)
- Level of science needed (small watersheds)
- Different indicators
- Ecological based BMPs address physical, chemical and biological needs of watershed

  What is the right mix of BMPs?
- Variable source concept

  Research on landscape and contributions
- How to implement hydrologic restoration?
  - No load allocation for water

    How to set impairment?

  Disconnect between natural resource science (driver of study) and affecting change (social science of who's willing to make changes)
- How to implement solutions to dynamic systems
- Fine scale watershed impact potential recognition tools
- Restoration of original landscape hydrology how significant improvement gained by addressing
- Coefficient for biological impact
- Develop ways to do synoptic sampling
  - How do you share that info?
- Procedure/protocol to use geographic information system data to determine vulnerable priority areas for impairments?
  - Define inappropriate behaviors
- Research to help approach those landowners that engage in inappropriate behaviors
- Tipping point (70-80%)
  - "Bad actors" depend on impairment and watershed
- Need to look at implementation in the context of hydrologic change
- Shifting baseline/expectations from climate change. BMP effects?
- Research into structure sizing related to regions
- Research into role of ecological risk in TMDL prioritization
- Technique for categorizing ecological risk
- Research into operation and maintenance costs of new technologies
- Sociological research to facilitate cooperation with landowners
- Framework for collaboration between upstream and downstream
- What is the best/most effective scale for implementation?

- Individual sub-watersheds or overall system focus? Lake Pepin or sub-watersheds?
- How balance local with quality goals and regional and national?
- How balance cost?

3. Public Policy

- Enforcement of non-point pollution BMPs and regulation at the LGU level
  How can state/local coordination help?
- Nonpoint and point source trading or contract as load allocation tool
  - Addresses equability of point/nonpoint pollution
  Build socioeconomic analysis into watershed plans
  Look into idea of sacrifice zones for maintaining pasture areas
  Control of channel erosion using pollutant trading, point/nonpoint
- Land conservation programs
  What are interest level opportunities?
  When do you have enough information to move forward?
- Lack of funding for staff-need more in order to implement
- Strategic implementation
  - Lake Pepin-too big for implementation
  - Work on small watersheds
- Holistic approach to solving water storage issues, i.e. public drainage systems
  - Future issues
  - Hydrology
  - Economics
  Biology
- How to assess and evaluate performance over time?
  Infrastructure needed
- How to implement prioritization strategy to get effective results?
  - Develop example watershed
  - Cost/benefit
  Successful farm restoration
- What info in really relevant/convincing to stakeholders? What's sustainable?
- Identifying effective policy tools for behavior change
  - Laws are one tool, but are others
  - Identify "narratives" by which stakeholders can make decisions
- What criteria to apply to establish restoration priorities
- What are appropriate criteria for id critical w/s in MN and how to apply these criteria
- Keep research on small enough scale that you can defend research
  Smaller scale needed
- Prevention –identify watersheds near tipping point, before impairment
  Prioritization is key
- Difference in values of different stakeholder for why they would /would not support implementation
  Rural vs. urban vs. recreational, etc
- What are effective ways to build local social capacity (identify strategies to accomplish the things below):

- Who are all relevant stakeholders?
    - Local leadership
    - Give stakeholders ownership, influence, power in decision making
    - How to communicate
  - Define success locally
- How to deal with 30% of MN streams that are channelized, ditches, and impairment thresholds.
- Absentee ownership engagement
- Trading impacts
- Does voluntary participation compromise TMDL effort?
- To be significantly effective in water quality improvement, equity of PS vs. NPS
    - Contributor requirements
- Avoidance of magic bullet solutions and false promises
- Triage vs. Prioritization
    - Downstream effects of sites to impaired themselves to restore
- What does it take to implement legislation
    - Feasibility analysis, policy
- Unenforced buffer. . .rules regulations on books that have no resources for follow through. Review of what implementation would cost and achieve. Would be required to make it work.
- Nature of public perception of TMDL
- How do you know if your TMDL has hope?
- Broader watershed goals and develop win-win scenarios
- Ramping up. Reaction time? Having local watershed groups and landowners take part in monitoring
- How do we change system at local level so we don't reward improper land use activity (ex. cleaning beach)
- Taking into account absentee ownership and rental arrangements
- "Glass house"
- Hot spots for first implementation for maximum effect
- Target areas to protect from implementation
- Methods for developing broad political support
    - Land-user buy-in (continuity between stakeholder and participant buy-in)
    - Technology
    - Targeting implementation
- Is there an alternative to the "bribery" concept?
- Integrate water quality and water availability
- How to target and get changes from the "inappropriate actors" in a regulatory framework
- Equitable distribution of WLA and LA without significant conflict
    - Including causal consideration
- Is more regulation and enforcement needed to achieve NPS goals?
- Integrated implementation for multiple pollutants within a single watershed
    - pilot project

4. Economic Analysis

- Economic analysis of TMDL cleanup
- Cost effectiveness of bio control techniques; need studies of:
  - Ecological functionality
  - Control of invasive species

    Other bio issues
- Economic large scale control of channel erosion
- Socioeconomic research into sustainability of BMPs
- Research and tabulate the detailed cost breakdowns of BMPs
  - Analysis of construction and benefits

    What are the temporal components?
- What are the maintenance elements of BMPs? Costs? Expectancy?
- Economic considerations
  - Subsidies-they don't work; don't apply sufficient pressure to affect change
  - Voluntary participation
  - More top-down reg. w/agriculture?

    Need research about best way to approach regulations: financially; who should bear financial burden?
- Case studies of local buy in-effectiveness cost benefit

    Look beyond MN for other example
- Translate broad benefits of BMPs to benefit to individual landowner
- Long term real costs of BMPs long term maintenance
- Financial worth of a BMP. At what point does critical BMP warrant mandatory or liability.
- Outright buy land, make easement and sell. When is this more cost effective? Tools to identify opportunities
- Prioritization and cost benefit analysis of easement trading, buy-out vs. extension BMP encouragement
- Accounting for costs necessary to convince stakeholders, and account for true costs
- Quantification of stream restorations achievable economic benefit to cities and individual landowners vs. implementation costs.
- Microeconomic considerations and incentive to induce desired behavior
- Identify costs of new technologies and funding methods

5. Human Dimension – Education, Adoption, Behavior Change, Public Engagement

- Social acceptance of BMPs urban and agriculture
- Perceived risks of BMPs
- Cumulative effects of BMPs and management practices on stormwater, ground water

    Human aspects
- Targeting specific groups, non-traditional, for outreach
- Consistent follow up monitoring
- Social science study of working projects
  - Mandatory verses voluntary participation

    Which approaches lead to success?
- How to engage landowners?

    How to encourage

- Find better system to identify most inappropriate behaviors on most vulnerable systems
- How do we get landowners and agencies to set together in a problem solving venue
- MN design team model-based centrally-travel around state and educate
- How to put together problem-solving team that operates state-wide?
  - Need to blend expertise and local trust (local people involved
- How to create effective watershed management by stakeholders?
  - What motivates people?
  - Civic science
  - How to minimize finger-pointing?
- Need to define solutions that are economic, practical and successful
- Demonstrations needed
- Need "success stories"
- Need better communication between implementer and stakeholder
  - Throughout process-documentation at every site
- Citizen acceptance of implementation practices?
  - Aesthetics
  - Maintenance-how much are people willing to do
- Field office technical guide-modify to raise effectiveness of BMP (bio-retention)
- Further develop problem-solving model
  - How do different stakeholders make decisions about alternative approaches
- Models difficult to interpret for farmers, others
  - Case studies easier to understand/more relevant to stakeholders
  - Need facilitators who can interpret model results
- How to link implementation more strongly to implementation plan (right now done by two different agencies)
  - Educate agencies about how to make process more cohesive and coherent
- Local buy-in—achieve by local ownership; involve local people in prioritization
- Map social capacity factors over natural resource factors to help establish priorities: Where is best chance/most important need for success-balance these 2 components
- Investigate social learning-investigate this as a research tool
- Threshold at which landholders will choose implementation
- Landowner engagement. Contact to active BMP conversation implementation process.
- Language diversity. How to engage communities with distinct understanding. Changing demographics and parcelization with urbanization
- How to educate public with regard to stable dynamic stream systems. Understanding of how land in changing. Streams will wander.
- Citizen engagement training to foster buy-in
- Defining critically important landowners
- Need demonstrated success stories
  - Review of case studies, what makes successes work, or ensures failure
- Opinion, leaders leverage in guiding public opinions
- People aren't seeing real costs
- Recognize and publicize tried and true examples of restoration (ex SWCDs)
- Disseminate information from researchers to practitioners (clearing house)
- Research barriers to implement urban issues
- Barriers to BMP implementation in highly developed urban areas

  - Convincing practitioner to adopt BMPs, lack of case studies
  - Lack of available land (expensive!)
  - Lack of understanding unconventional sediment sources and tools to deal with these and similar issues
- Communicating to a diverse audience
- Property rights and how they relate to water quality
- Rules of behavior between urban/rural areas
- Identify successful public info campaigns

SESSION IV: EFFECTIVENESS MONITORING

1. Social Sciences: Success definition, communication, social, economics

- Economic indicators
  - Along with biophysical
  - Behavior change monitoring
  - Are tools adequate, how can they be improved
- What do stakeholders view as success? Not just effectiveness?
- Public perception of success is important often different from agency/scientist's value system
- Need more social scientists involved in projects
- Education alone not enough to change behavior and beliefs
- Indicator of adoption
  - Many factors effect adoption in Agriculture
  - Often bundled together
  - Consultants, governments, seed companies, influence farmers
- Public perception of success short (social and scientific) and long (social and scientific) term
- Willingness to pay measures
- Public view of success may be different that TMDL standards
- Social science study on what results and timelines are expected?
  - Behaviors, BMPs water quality changes
- Regulatory verses voluntary problem solving
  - Where we get the best leverage?
- How widespread are benefits from implementation?
  - bring in statisticians to aid in monitoring design-assess uncertainty
  - Continual analysis and adjustment of approach
  - Use long term data to communicate to public
- Who is the correct entity to work at various scales?
- How can we relate changes in water to changes in voluntary behaviors?
  - Is there any way to monitor this?
- Guidance for success of TMDL
- How long do BMPs stay on landscape beyond contract?
- Assess landowner's view of effectiveness
- Definition of success- where do we want to get
  - Define goals, otherwise don't know what to monitor
- Administrative measures of effectiveness
  - numbers of BMP adopted, amt of acreage w/BMP,

- Need to use, but not alone
  - Connect to real changes in water quality (are they correlated?
- Measurements of social capacity that predict long term land use changes
- Measure changing public values in water quality
- identify intermediaries (agronomists?) who can shuttle between farmers and scientists
  - How to build one-on-one relationships with land users, practitioners, researchers
  - Investigate effectiveness of building different social networks as a way to make sure positive change continues over time.
- How to bring together all stakeholders (not done in this meeting)
- Effectiveness measures w/cumulative impacts (multiple uses)-how to discern changes in quality related to changes in different uses. Political implications
- How use citizen monitoring?
  - What types?
  - QA/QC
- Time- need to recognize amount of time to est. baseline, assess, implement TMDL, measure effectiveness
  - Plan for adequate time, money to complete all this
- Evaluate TMDL program as the primary mechanism of dealing w/ impaired waters?
  - We don't have enough into to assess
  - Program is new
  - But don't bother if not willing/unable to change to another approach
- Metrics of community awareness
- How to inform landowners of immediate improvements vs. gradual or delayed improvement
- Programmatic at what scale is effectiveness best measured
- Success must be defined by the individual, the community, as well as by broad agency goals/standards
  - What framework do people recognize as success
- Reassessment of original goals
  - Adaptive management sounds better that trial and error
  - At least 2 fish generations to determine success
- Informal communications are as important as official ones.
- Timeliness of info to public
  - Added value
  - Respond to both big and micro changes over time
  - Frequency of optimal marginal value
- What is awareness comprehension of local citizens before and after restoration effort? How effective are education efforts?
  - Implication for duration of success
- Acceptance of degradation over time
- Greatest improvement in great lakes perceived when sign for cleanup project posted
- Optimal frequency for review of standards, keep pace with technique available and landscape status
- Value of reports to public on the progress toward restoration
- Social, econ., consequences due to impairment
- Threshold risks to communities companies of caps on development

- What information do companies need to inform their decisions?
- Identify promote support new technologies key to monitoring cost and effectiveness
- Focus on enhancing our capabilities and use of tech strategically
- Measuring how people's perception of a location evolves. Acceptance of water quality over time
- Use of social science methods for measuring effectiveness for short term. Survey methods.
- Social/econ costs and benefits as an outcome
- Record decision points economic changes in history of degradation and recovery of eutrophic lake to answer shy lakes become eutrophic.
- What is expectation you are after for restoration?
- We are not going to be 100% effective because of other factors
- Through studies of failures learn what not to do and what to do better.
  - Failures cost a lot of money
- Public perceptions of lakes
  - Expectations have to be fully defined
  - "Vision becomes our enemy"
- Stakeholder group sets standard?
- Some land uses are virtually irreversible . . . that will affect to a degree the ability to restore
- We can apply change in behavior/land use and then assess that
  - Rehabilitate instead of restore?
- Create a level of acceptable behavior-sellable to the public (red ribbon, white ribbon etc.)
- For the Clean Water Council: effectiveness of projects that go through
- How can we measure behavior change?
- Effectiveness of education spending vs. BMP spending
- How does adaptive management fit into TMDL implementation
- How do we define success?
  - Endpoint or process?
- How can end users become more involved in the direction of research?
  - Pool resources to fund research they want done
- Levels of engagement of public
- Does the TMDL program achieve cleaner water, not just reductions in particular loads?
  - Does public desire match program goals/outcomes?
  - Program-wide cost benefit
- Financial (economic) value of reduction in impairment (public health, property value, use value)
  - Use attainability analysis
  - Total cost and value accounting
- Shifting baseline syndrome-declining level of "acceptance"
  - Track changing expectations
- Research into stakeholder participation and process effectiveness
- Post project monitoring: It will be important to document how the TMDL implementation project goes with monitoring and having this documented somewhere

2. Natural Sciences: Success definition, BMPs effectiveness on chemical, physical and biotic response

- Does BMPs level of effectiveness relate to level of disturbance?
- Design and effective monitoring to detect success of BMP
- Define magnitude of number of BMPs needed
- Do functioning ecosystems actually cost us less?
- Cost effective ways to assess effectiveness
  - Scale defined
- Reasonable scale = tributary
- What other types of non-water monitoring data can we collect to establish effectiveness
- Public sharing of data-locations of BMPs
- BMP database-where they are and obs.
- Continuously evaluate success at each stage of TMDL development. identify indices for each stage.
- Develop standardized protocols for all different impairment types
  - Would include natural and social indicators
- Need more refined measures to compare restoration options (BMPs vs. larger scale changes in crop rotation practices)
- Incorporate info about tile drainage system into effectiveness measures
  - What is contribution, quality of subsurface flow
- Effects of impoundment on measurements on value as BMP
- Identification of gaps to:
  - Sediment source identification
  - Source partitioned load tools
  - What you do with sediment once you got it
- Does BMP change monitoring results, can we resolve reductions success from other contributions
- Behavioral, numeric metric, accountability; ecol. Health
- Confidence of duration of effective BMP implementation
- Site assessment of watershed change coincident to implementation. Potential impact anticipation in TMDL
- Method to inoculate or trace sources tor more informative monitoring e.g. sediment
  - Both urban and rural contexts
  - Low gradient demonstration of such techniques
- Baseline standards
- Metrics of progress toward goal deadlines
- Clear definition of natural backgrounds found in nature non-human induced
- Integrative indicators for delisting that can stand the test of time to see that beneficial uses have been restored. ex. DO Biota indicators
- Distinction between stressor/local identification and achieving re-colonization of original species
- More complete measure of restoration
  - Measure of habitat for lakes
  - Holistic status you need to do this for different eco-regions
- What are effects on biota from pollutants vs. other factors like overfishing
- As we list for impaired biota, have to expand knowledge of effectiveness

    - do that now
- You can set up environmental metrics. upfront using the indicators from presentation, but then you must find out what is achievable
- Linkage between biological physical and Index of biotic integrity
    - How far do we have to go for habitat improvement?
- We have treated NPS like it is a PS problem
    - Not predictable
    - Factors like corn prices, land prices
- Can't just measure water quality have to consider land use
- Thorough survey of organisms to develop detailed indicators of ecological health with statistical correlation
    - systematic integration with volunteer monitoring and data dissemination
- Refinement of fecal coliform standard to link impairment to human health
    - Human vs. animal sources

3. Development of strategies for measuring impacts: Water quality measurements, scale

- Ecological effectiveness monitoring
    - Holistic view
- Adaptive management, need monitoring results in time to get feedback
- Sustainability of BMPs-long term effectiveness
- Need measures that speak to audience appropriate measures for stakeholders
- Demo sites and projects that are appealing visually
- Concern over monitoring needs for TMDLs by local government
    - Use intensively monitored sites with demo sites for visual
- Connecting research to implementation and providing into to public i.e. eLINK
- We can learn from long term monitoring and stakeholder analysis
    - International arena
- Short term success is critical as long term success my not appear for decades-but need to keep monitoring
    - research-how to strategically place monitoring sites
- Societal view on long vs. short term benefits
    - Need to change core values
- Identify tangible benefits and harm
    - Use many indicators, not one
    - Hydrology, connectivity, water quality, etc.
- Return to past projects to gain knowledge
- Linking the remediation to the outcome
- Economy needs to be mindful of ecosystem
- Building integrated information system
- Scale issue of effectiveness
    - Where and when do you make measurements?
    - Continuous data
    - Lag times-need better understanding-storage and travel times
- Basic definitions- trend (condition) monitoring vs. effectiveness
- Can the same statistical test be used for BMP implementation in watershed as is used pre/post clear cutting

- What are data requirements to de-list impaired water?
- What are measurements that indicate change? identify these
- Determine what measurements will be prior to TMDL implementation development (before practices are put in place)
- Uncertainty in water quality monitoring data
    - Are we detecting real changes when they occur
    - Are our techniques, equipment appropriate to detect
    - Need to quantify uncertainty/variability in water quality parameters
- Assessing effects of changing measurement methodology (i.e., of new techniques for measurement, DO, or social surveys)
- What are effective ways of interpreting and reporting success?
- Agent-based models that allow for forecasting effects of changes in user behavior along with natural resource info.
- How attribute change to specific practices?
- Remote sensing-use to look at changes especially in lakes
- Data quality- implications for litigation
- Key metrics tied to intended use
- Water quality monitoring design for effectiveness
    - Nested design for early responses
    - Time lag progress on larger scale
- Incorporate roadmap of improvement, restoration, benchmark goals
- Monitoring sufficient to recognize unexpected changes
- Process for evaluating designated uses in relation to water quality standards
- What are the metrics of effectiveness
    - Where do we measure, i.e. scale?
- Keep and track advancing meaningful case studies of successes and failures
    - Also deepening case studies
- Let's see what's achievable
    - Effectiveness vs. achievability
- Few intensive studies-above and beyond what we do now
- Types of monitoring for effectiveness need to be long term and adaptive
- Measuring BMP effectiveness
- Develop a consistent, long-term protocol for effectiveness implementation
- Continuously reconsider metrics
- How do we incorporate effectiveness monitoring up front and allocate resource to do so?
- Design structures for plug-in monitoring
    - Research into this design goal
- Balance between listing/delisting data requirements
- Monitoring considered early, integrated
- Can program be refined with a "prelist" to allow for study time?
    - Can data refined before regulatory actions commence?

4. Impacts of External Change: Mask results, climate change, disasters, population change, land use changes

- Effect of natural disasters, climate change on long-term improvements in water quality.
- Think beyond point source perspective

    - Need to monitor based on climate, precipitation. factors/events related to non-point source pollution transport
    - Sampling on a regular, pre-determined schedule, may not work to measure effectiveness of BMPs
- Impacts of pop. growth in Twin Cities
- Long term effects of climate change on lake productivity
    - Managing expectations for a shifting baseline (no going back to pre-settlement)
- If you measure eff. of some process, report should address what might happen
    - Guidance for land planners?
    - i.e. population growth

5. Better Science

- Improve TMDL framework and process
    - Learn how to improve it
    - Compare to other tools for water quality
- Research into how we view success-definition of success is maintaining water quality levels a success, reframing the question
- Paired studies of degraded/good sites quality
- Learn from past successes as template for future and need to maintain water quality levels
- Research into need indices that appeal to public to show positive results with short or long term
- What level of scientific uncertainty is acceptable in monitoring
    - Uncertainty is interpreted differently by farmer/public
- Long term research into education; what works for young people today and future
- Need analytical tools that reflect complexity and variability of systems and cumulative and interacting effects
- Need stats tools to analyze trends
    - What is impaired to what is improved
    - More solid research on criteria
- What's the right tool to use for different stakeholders?
- What water bodies are not impaired?
    - Why are they not?
- Understanding resilience and thresholds
- Are we addressing the fundamental cause of the problem?
- Transferring information between locations
- What monitoring design produces statistically valid results?
    - Research into optimization of effectiveness assessment
- Allocation of monitoring and non-monitoring metrics that would be useful
- Appropriate time scale for assessing change.
- Small enough scale on which to measure, report and discuss effectiveness
- Integrate social, economic, nat. res. factors into same model
- Metric combination for more robust assessment. Complementary crude metric that strongly improve metrics of interest
    - Site and visit and broad monitoring optimal combination
- Indicators to measure effectiveness appropriate to intended use
- Multi-scale success definitions

- How do new technologies assist understanding verses confound it
- Separate out factors of climate, land use, cultural practice changes
- What risk factors and proper indicators
    - Analogy to cholesterol
- Irreversible effects from some land use change?
    - What is reasonable socially, economically, ecologically?
- Relationship b/w building reasonable expectations and saying effects are irreversible
- Metrics to assess trend in:
    - Human behavior
    - Biophysical elements
    - System variability
    - Process of the plan
- Do we understand the system well enough to understand time scales?
- What do we do until we understand the systems fully?
    - Research into appropriate metrics
    - Understanding systems
    - How do we define success (metrics)
    - Consistent, long-term protocol for effectiveness measurement
- Development of holistic numerical tools (water quality, social, biol., etc.)
    - Greenhouse gas, public health, economics, public perceptions
    - Multiple lines of evidence
    - TMDLs not in a vacuum
    - Could be applied much earlier in process
- Does scale of improvements match scale of implementation?
- Representative watersheds or water bodies with enough detailed data to track progression of restoration or failed restoration
    - More than water quality data, including participation and landscape
    - Need for statistical determination of success/failure-refine monitoring techniques
    - Scale of monitoring to allow determination of cause/effect
    - What time scales are appropriate to judge success? How estimate for a given impairment/