Science-Based Adaptive Management Process for Great Lakes Restoration Initiative Action Plan II

This science-based adaptive management process is used by federal agencies to prioritize restoration and protection actions to implement Great Lakes Restoration Initiative (GLRI) Action Plan II (Figure 1). The process incorporates the best available science and lessons learned from prior restoration work to:

- Identify the most critical ecosystem problems in the Great Lakes,
- Select projects that effectively address those problems,
- Assess and report on progress and effectiveness of GLRI actions, and
- Inform future restoration and protection priorities.

The adaptive management process also relies on input from state, tribal and municipal agencies, the Great Lakes Advisory Board, the scientific community, Lakewide Action and Management Plan partnerships and the general public.

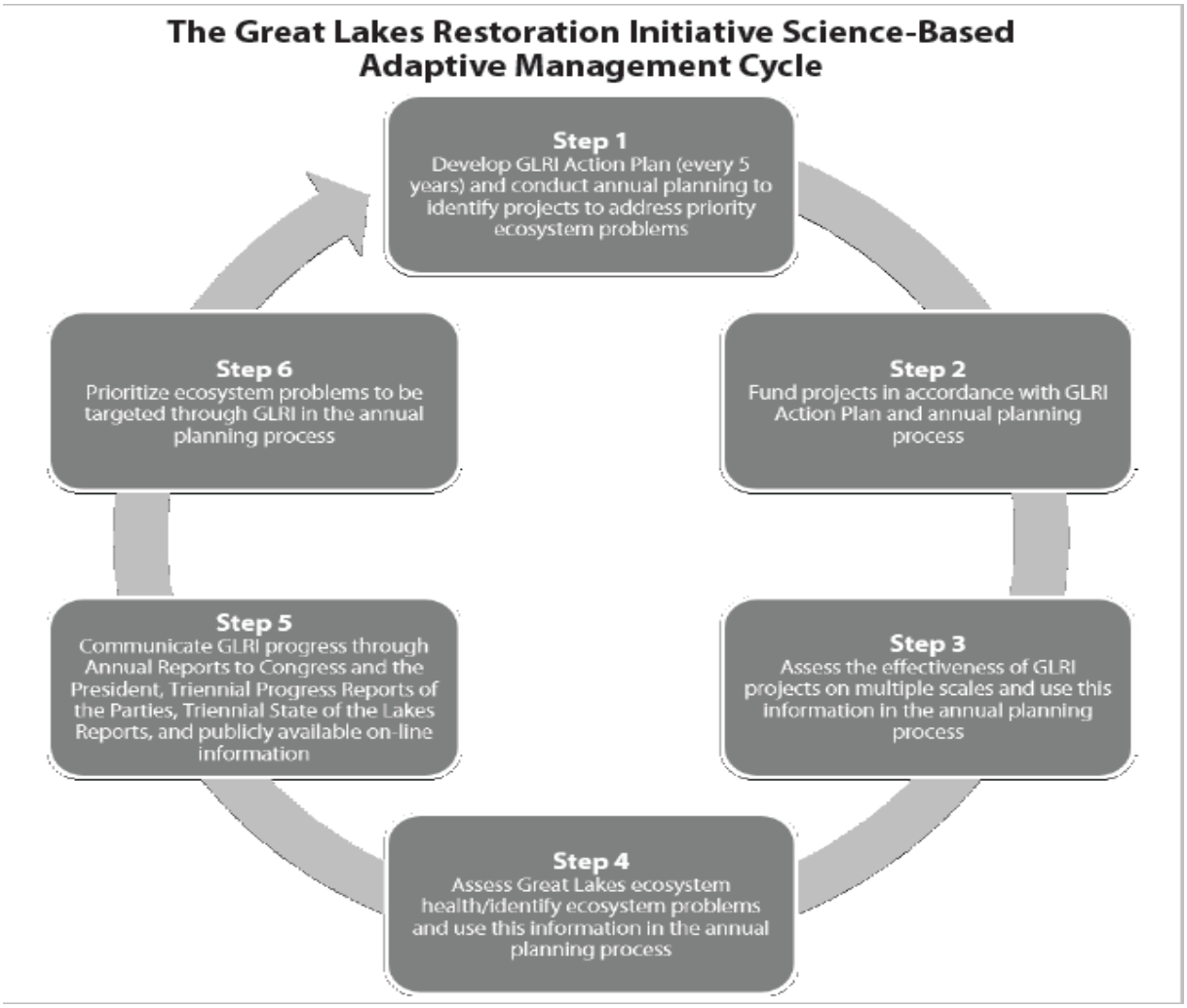


Figure 1. GLRI science-based adaptive management cycle

Adaptive management[1] is a structured management approach for addressing environmental uncertainties by testing hypotheses, linking science to decision making and adjusting project implementation, as necessary, to improve the probability of success. This approach is not unique to the GLRI -- it has been successfully practiced for years in other large ecosystems including Chesapeake Bay,[2] Puget Sound[3] and the Florida Everglades.[4] The adaptive management process includes science-based activities such as monitoring, surveillance, observation, research, and modeling and may also incorporate other bodies of knowledge, such as traditional ecological knowledge.[5]

The GLRI adaptive management process is iterative and is implemented on one- and five-year cycles:

> Every year, federal agencies identify specific projects and programs to target the highest priority problems in the Great Lakes ecosystem.
>
> Every five years, federal agencies develop a GLRI Action Plan that updates and refines objectives, commitments, measures of progress, and long-term goals.

Both of these cycles involve systematic and continual integration of careful project selection, project assessment, ecosystem monitoring and prioritization of environmental problems in order to efficiently make continued progress toward long-term goals for the Great Lakes ecosystem.

[1] GLRI's definition of adaptive management is modified from William, Szaro, and Shapiro (2009); Murray and Marmorek (2004); the *Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management* (2000); and the RECOVER (2006)

[2] Hershner, 2011

[3] Puget Sound Partnership, 2010

[4] RECOVER, 2006 & U.S. Army Corps of Engineers, ER 1105-2-100 Planning – Planning Guidance Notebook, 2000

[5] Great Lakes Water Quality Agreement 2012

Step 1: Plan

Develop the 5-Year GLRI Action Plan and conduct annual planning to identify projects to address priority ecosystem problems

Every five years, the GLRI Regional Working Group and Interagency Task Force prepare an Action Plan that establishes objectives, commitments, and measures of progress that will help achieve the long-term goals for the Great Lakes ecosystem.

Each year, the Regional Working Group engages in an annual planning process to identify priorities and programs/projects that will achieve GLRI Action Plan objectives, commitments, measures of progress and long term goals. Federal agencies propose specific programs/projects that address the priorities identified through this annual process. The GLRI Regional Working Group then reviews the proposed programs/projects and recommends a portfolio of programs/projects to the Interagency Task Force for approval.

Long-term Goals for the Great Lakes

- Fish safe to eat
- Water safe for recreation
- Safe source of drinking water
- All Areas of Concern delisted
- Harmful/nuisance algal blooms eliminated
- No new self-sustaining invasive species
- Existing invasive species controlled
- Native habitat protected and restored to sustain native species

Projects selected for the GLRI portfolio may incorporate a variety of restoration methods:

- **Proven** – *i.e.*, established and tested restoration methods that have relatively high certainty of success in localized areas.
- **Developing** – *i.e.*, existing restoration methods where the probability of success is less certain than proven methods.
- **Emerging or Innovative** – *i.e.*, new restoration methods, utilizing applied research, to address impairments where no proven methods exist.

Some environmental problems are well understood and readily addressed by well-documented restoration methods that have been proven successful over a long period of time. For example, environmental problems relating to contaminated sediments are widely understood and can be readily addressed through time-tested proven restoration methods such as dredging and capping. A broader mix of restoration methods may be needed for environmental problems that are not well understood or for which proven and well-documented restoration methods do not yet exist. For example, the restoration of wetland habitat infested with *Phragmites* is a well-documented environmental problem, but effective restoration methods to control it are still very much under development. Projects employing emerging or innovative methods with an unknown certainty of success could potentially provide a very high return for Great Lakes restoration.

The GLRI planning process incorporates the best-available science from environmental monitoring programs, applied research programs and ecosystem indicator assessments to determine ecosystem conditions and trends. The planning process also takes into account ecosystem problems that cut across multiple GLRI Action Plan focus areas; issues that are specific to targeted watersheds, habitats, or species; and gaps in scientific knowledge.

The annual planning cycle also includes a review of GLRI projects already being implemented to determine whether Action Plan commitments are being met and whether the restoration methods being employed in the implemented projects are proving to be effective. The lessons learned from this review will help guide the next annual planning cycle, including the identification of targeted watersheds, habitats and species, as well as project selection. For example, the Regional Working Group may determine that there is a need to further develop and test restoration methods for environmental problems which are not proving susceptible to restoration efforts which have already been attempted.

The ultimate goal of the planning process is to develop a portfolio of GLRI projects that will efficiently achieve significant and measurable progress to restore and protect the Great Lakes. When the portfolio is approved by the IATF and funding becomes available, federal agencies begin the process of implementing agency programs and projects.

Step 2: Fund Projects

Fund projects in accordance with the GLRI Action Plan and annual planning process

After the annual planning process is complete, funding is allocated to implement the selected portfolio of programs and projects.

Federal agencies use some GLRI funding for direct implementation of selected restoration and protection projects. This work can be performed by agency staff (*e.g.,* the National Park Service staff implement habitat restoration projects) or by federal contractors (*e.g.,* the Army Corps of Engineers retains contractors to dredge contaminated sediments in Areas of Concern).

Federal agencies also use GLRI resources to fund others to implement selected programs and projects through competitive or non-competitive grants to states, tribes and other eligible entities such as academic institutions and non-governmental organizations. For example, EPA offers funding on a competitive basis to governmental and nonprofit entities that are qualified to carry out projects included in the GLRI portfolio. EPA evaluates applications against criteria outlined in an annual grant solicitation and awards grants to applicants with the highest scores.

Step 3: Assess project effectiveness

Assess effectiveness of GLRI projects on multiple scales and use this information in the annual planning process

Individual projects and aggregations of projects, where appropriate, are assessed across programs, time, geographic scale and restoration methods to determine the effectiveness of GLRI investments.

> Assessment: Environmental monitoring is used along with other information to evaluate management effectiveness, understand resource status, and reduce uncertainty about management effects. Learning is promoted by comparing predictions generated by the models with data-based estimates of actual responses. Monitoring data can also be compared with desired outcomes, in order to evaluate the effectiveness of management and measure its success in attaining management objectives. (Williams and Brown, 2012)

<u>Individual project assessments</u>

Project implementation requires planning, design, on-the-ground and in-the-water actions and pre- and post-project assessment. Upon completion of a project, an assessment determines the effectiveness of actions taken. Project reports demonstrate whether projects were implemented as proposed and document the measurable outputs and ecosystem outcomes achieved.

GLRI Action Plan II identifies specific measures to track all actions implemented. These measures are largely programmatic outputs which are tracked in the Great Lakes Accountability System. Although important for quantifying GLRI investments, tracking outputs does not necessarily demonstrate ecosystem improvement. Therefore, the assessment process includes tracking of ecosystem outcomes for projects or aggregations of projects. For example, a habitat restoration project may supplement the tracking of number of acres with pre- and post-restoration monitoring to determine overall species diversity.

At the project level, ecosystem outcomes may be assessed at the local scale and over a relatively short-time. Although full ecosystem recovery may extend beyond the scope of a project period, it is important to document the trajectory of recovery (Figure 3).

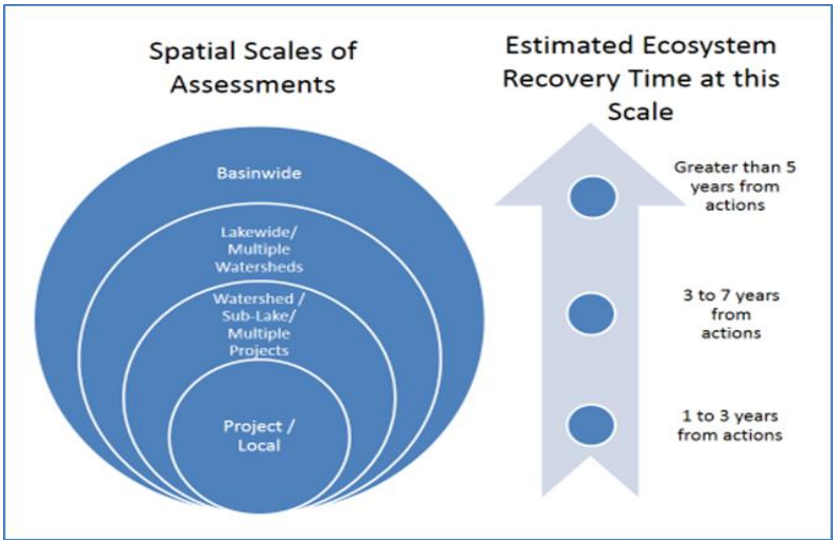


Figure 3: Spatial scales of assessments and the estimated ecosystem recovery time at this scale

The type of restoration method used in a project must be considered during project assessment (Table 1). A project employing a "proven" restoration method may require an assessment that ensures the method will continue to be effective. The assessment is based on well-established methods for predicting outcomes and monitoring effectiveness. For example, the effectiveness of a single sediment remediation project can be assessed using acres of restoration, bioaccumulation assays or biological indices.

Projects that employ a "developing" restoration method generally need more in-depth assessment than those using a proven method. This restoration method has a less certain outcome, and the ability to assess the method may not be as well established. For example, the installation of a two-stage ditch in a stream, which may be considered a developing restoration method, needs an assessment that utilizes predictive models to estimate nutrient and sediment reductions and in-stream monitoring to compare to predicted results. This dual approach will help to improve both predictive models and future implementation of two-stage ditches.

Projects using an "emerging or innovative" restoration method must incorporate method-specific assessments. New restoration methods require new assessment protocols to determine effectiveness. Routine monitoring is needed to determine long-term efficacy. For example, the control of *Phragmites* using gene silencing, an innovative restoration method, needs to evaluate the short-term and long-term effectiveness with stratification by productivity, climate, or sub-basin.

Table 1. Examples of Project Assessments across the focus areas

Focus Area	Objective	Measure of Progress	Restoration method	Assessment actions	Spatial and temporal scale
Toxics/ AOCs	Remediate, restore and delist Areas of Concern	Area of Concern Beneficial Use Impairments removed	Dredging of contaminated sediments (Proven)	Track volume of sediment remediated; Sample benthos of dredged habitat	Project-based; 1-2 years after dredging
Invasive species	Control established invasive species	Number of aquatic/ terrestrial acres	Selective toxin for controlling *quagga* mussels (Emerging)	In development; sample benthos and phytoplankton response	Lab-scale to start; but eventually basin-wide except Lake Superior
Nonpoint Source Pollution	Reduce nutrient loads from agricultural watersheds	Projected nutrient reductions from GLRI-funded projects	Reduce phosphate loading through best management practice implemented on farm (Developing)	Prediction; Edge of field; watershed; river mouth and open water sampling; harmful algal bloom assessment through water and satellite imagery.	Prediction is project-based; but larger scale assessment must integrate across projects; Beyond scope of Action Plan II; watershed to sub-lake scale
Habitat	Maintain, restore and enhance populations of native species	Number of GLRI-funded projects that promote populations of native species self-sustaining in the wild	Stocking lake trout (Developing)	Survey unmarked adult fish	Well established methods at a lake scale, over a long time frame (5+ years)

Assessments of aggregations of projects

In some cases, it may be appropriate for federal agencies and partners to assess aggregations of projects. These broad assessments may focus on:

- GLRI Action Plan commitments or measures
- Restoration methods
- Specific geographic scale (basinwide, lakewide, watershed)
- Issues such as the effects of climate change on native species
- Specific funding programs (*e.g.*, Sustain Our Great Lakes)
- Socioeconomic and public health benefits

Assessment of aggregations of projects improves understanding of cumulative impacts of restoration actions and determine whether ecological conditions are improving at the ecosystem scale. For example, the Headwaters Group Philanthropic Services[6] conducted an evaluation of the habitat restoration projects funded by Sustain Our Great Lakes[7]and provided recommendations for improving the program. This evaluation measured the overall impact of the program, identified the need for measuring collective impact of multiple habitat restoration projects and provided a series of recommendations to improve project planning and design, post-project maintenance and knowledge of effective restoration approaches.

Assessments of aggregations of projects over basinwide or lakewide geographic areas may show that ecosystem recovery will extend beyond the scope of GLRI Action Plan II (Figure 3). Ongoing federal, state, and tribal science programs may provide information in areas where clusters of GLRI restoration projects have been performed in the past or are likely to be undertaken in the future.

Assessments of aggregations of projects establish the feedback loop by which GLRI decisions are made. Large-scale assessments require resources, an accountability and information system and outside advice from independent experts.

[6] Headwaters et al, 2013

[7] Need a footnote that describes Sustain Our Great Lakes and explains relationship to GLRI

Step 4: Assess ecosystem health

Assess Great Lakes ecosystem health and identify ecosystem problems and use this information in the annual planning process

Science-based ecosystem indicators are used to assess the state of the Great Lakes, monitor ecosystem health, synthesize results, conduct scientific reviews and identify the most significant ongoing and emerging ecosystem problems.

Establish science-based ecosystem indicators

The measures in GLRI Action Plan II help federal agencies track the incremental level of effort that GLRI contributes to Great Lakes restoration. Under the Great Lakes Water Quality Agreement, the U.S. and Canada establish and maintain comprehensive, science-based ecosystem indicators to assess the state of the Great Lakes, anticipate emerging threats and measure progress. A suite of Great Lakes ecosystem indicators is selected and used to report on ecosystem health. A State of the Lakes report is released every three years. The indicators suite is periodically reviewed and updated as necessary.

Monitor ecosystem health

Federal agencies and partners establish and maintain long-term monitoring and science programs focused on the Great Lakes. These programs --including monitoring of water quality, coastal wetlands, contaminants in fish, air quality, and human health -- provide information to Great Lakes decision makers about significant environmental issues and ecosystem status and trends. Scientific information helps decision makers prioritize future actions. For example, the Great Lakes Coastal Wetlands Monitoring Program determines the status and trends of Great Lakes coastal wetlands through assessments of fish, invertebrates, birds, plant communities, and other chemical and physical variables. These assessments identify the highest quality, most degraded and most threatened coastal wetlands – which helps decision makers prioritize efforts to protect and restore these habitats. Where monitoring programs are not in place and the cost or time required to collect appropriate data is prohibitive, models can be used to describe the state of the system and improvements to it.

Ongoing science programs support decision-making at different time scales. The Cooperative Science and Monitoring Initiative (CSMI) focuses on a different Great Lake each year, on a five-year cycle. Intensive monitoring is performed on each lake to address science needs identified by the Lakewide Action and Management Plan partnerships. The information collected through CSMI results in a better understanding of impairments and potential threats, leading to the identification of appropriate management actions. CSMI supports collaborative partnerships to leverage long-term ecosystem monitoring programs and other resources to ensure that science activities are prioritized and coordinated. For example, GLRI funded the Ohio Lake Erie Commission to assess nutrient/eutrophication dynamics in western Lake Erie as part of CSMI monitoring conducted in 2014. The Lake Erie Commission project will aid in the ultimate goal of reducing harmful algal blooms in Lake Erie by: 1) improving the current understanding of the roles of external and internal nutrient loading, especially as influenced by weather forcing events; and 2) helping to prioritize nutrient and sediment reduction efforts in Lake Erie agricultural and urban watersheds.

Synthesize results

Federal agencies collect information from ongoing science programs and GLRI project results to assess progress and inform subsequent restoration and protection actions. The synthesis of information occurs on many scales. For example, scientific information from long-term monitoring

programs and short-term science projects are synthesized on a lakewide scale as part the Cooperative Science and Monitoring Initiative. Information systems can also be developed to synthesize information at other relevant geographic and temporal scales. These systems are strategic tools to assemble, analyze, and integrate monitoring and assessment information with GLRI project results. As tools, information systems help to visualize the relationship between restoration actions and ecosystem conditions.

Conduct scientific reviews

Scientific review supports the principles of adaptive management through independent evaluation of synthesized results. All GLRI science programs are implemented in accordance with federal agency policies on peer review and federal research. Periodic reviews of GLRI data by independent science panels and publication in peer-reviewed literature are an integral component of the adaptive management process.

Identify the most significant ongoing and emerging ecosystem problems

Through the monitoring, synthesis and review processes, the most significant ongoing and emerging ecosystem problems are identified by GLRI agencies and partners. Once identified, problems are prioritized as part of the adaptive management cycle and used to inform decisions about future action and further assessment.

Step 5: Communicate

Communicate GLRI progress through publicly available on-line information, annual *Reports to Congress and the President*, triennial *Progress Reports of the Parties*, and triennial *State of the Lakes Reports*

An essential step in the science-based adaptive management process occurs when federal agencies consult with state and tribal partners and seek input from the Great Lakes Advisory Board, the scientific community, Lakewide Action and Management Plan partnerships and the general public. Access to up-to-date information about GLRI activities and ecosystem health is critical to this stage of the process. The GLRI agencies report information through a variety of mechanisms, including:

Publicly available on-line information:

EPA's GLRI website (glri.us) contains project information on over 2000 GLRI projects. The information is updated semi-annually and includes:

- Project Title
- Funding Recipient
- Funding Amount
- Location of Project
- Project description

EPA's GLRI website also includes information about upcoming GLRI public engagement opportunities. Many other federal agencies also have GLRI-dedicated websites that provide further information about their specific projects and programs.

Reports to Congress and the President:

EPA produces periodic *Reports to Congress and the President* on the status of the GLRI. These reports document annual progress on the commitments and measures laid out in the GLRI Action Plan.

Triennial Reporting:

Pursuant to the *Great Lakes Water Quality Agreement*, The United States and Canada are required to jointly communicate GLRI progress, on a triennial basis, through:

- A *Progress Report of the Parties*, which documents progress toward achieving the goals of the Agreement; and

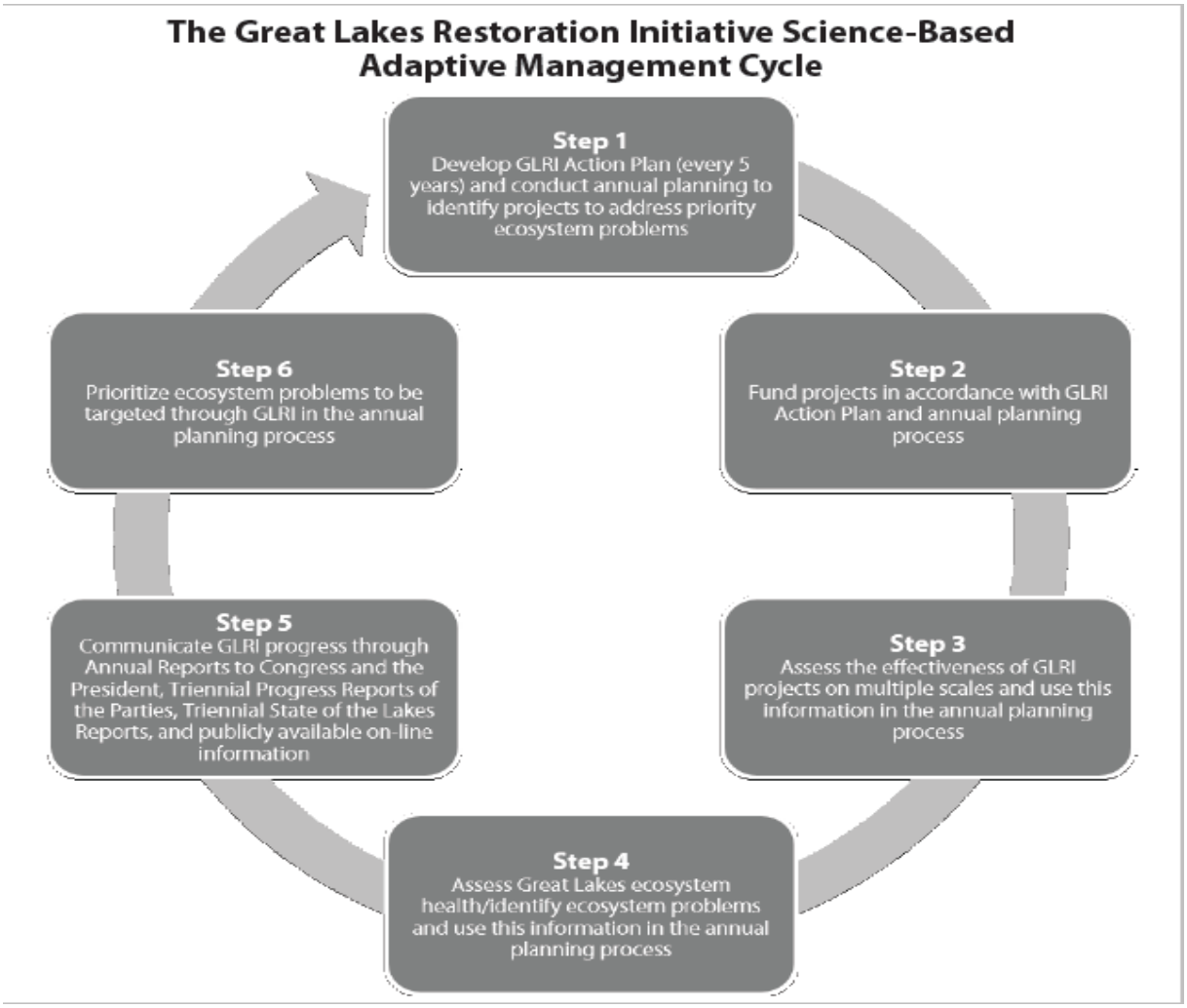
- A *State of the Lakes Report*, which describes basin-wide environmental trends and lake-specific conditions using ecosystem indicators.

Step 6: Prioritize problems

Prioritize ecosystem problems to be targeted through GLRI in the annual planning process

During the annual planning process federal agencies will review the most current information available on the overall health of the Great Lakes ecosystem (taking into account improvements brought about through the GLRI) to prioritize ecosystem problems to be targeted with GLRI projects during the coming year.

Although the GLRI has already achieved notable results, complex challenges remain and will undoubtedly persist well into the future. Moreover, new and unprecedented challenges will continually appear. For example, a changing climate will likely bring threats to the Great Lakes ecosystem that are not even envisioned today. Consequently, the ongoing implementation of the adaptive management process, with its iterative approach and its requirement of continual evaluation and re-evaluation, is essential to the success of the GLRI.



GLRI science-based adaptive management cycle

References

Hershner, C. 2011. Enabling effective adaptive management in the Chesapeake Bay Program. http://www.chesapeakebay.net/channel_files/17760/enabling_effective_adaptive_management.pdf

Murray, C. and D.R. Marmorek. 2004. Adaptive Management: A spoonful of rigour helps the uncertainty go down. In: Proceedings of the 16th Annual Society for Ecological Restoration Conference, Victoria, BC, August 24-26, 2004.

Puget Sound Partnership. 2010. Strategic Science Plan. June 2010 final review draft. Prepared by the Puget Sound Partnership Science Panel. Puget Sound Partnership. Olympia, Washington.

RECOVER. 2006. Comprehensive Everglades Restoration Plan Adaptive Management Strategy, c/o U.S. Army Corps of Engineers, Jacksonville District, Jacksonville, FL, and South Florida Water Management District, West Palm Beach, FL, http://www.evergladesplan.org/pm/recover/recover_docs/am/rec_am_stategy_brochure.pdf

Sullivan, P.J., et al, 2006. Defining and Implementing Best Available Science for Fisheries and Environmental Science, Policy, and Management. Fisheries, Vol 31, No.9, pp. 460-465.

The Government of the United States of America and the Government of Canada. 2012. Protocol Amending the Agreement Between the United States of America and Canada on Great Lakes Water Quality, 1978, as amended on October 16, 1983 and on November 18, 1987, http://www.epa.gov/greatlakes/glwqa/20120907-Canada-USA_GLWQA_FINAL.pdf

The Headwaters Group Philanthropic Services, Edward W. Consulting, and Coastal Restoration Consultants. 2013. An Evaluation of Sustain Our Great Lakes. A Report Prepared for the National Fish and Wildlife Foundation. June 2013, http://www.nfwf.org/greatlakes/Documents/sogl-eval-report.pdf

Unified Federal Policy for a Watershed Approach to Federal Land and Resource Management, Federal Register 65, no. 202, October 18, 2000, p. 62571, https://www.federalregister.gov/articles/2000/10/18/00-26566/unified-federal-policy-for-a-watershed-approach-to-federal-land-and-resource-management

U.S. Army Corps of Engineers. 2000. Engineer Regulation 1105-2-100: Planning Guidance Notebook

U.S. EPA Science Advisory Board, Review of Great Lakes Restoration Initiative Action Plan, January 24, 2012, http://yosemite.epa.gov/sab/sabproduct.nsf/fedrgstr_activites/Review%20of%20GLRI%20Action%20Plan?OpenDocument

Williams, B.K. and E.D. Brown. 2012. Adaptive Management: The U.S. Department of the Interior Applications Guide. Adaptive Management Working Group. The U.S. Department of the Interior. Washington, DC. http://www.usgs.gov/sdc/doc/DOI-Adaptive-Management-Applications-Guide-27.pdf

Williams, B. K., R. C. Szaro, and C. D. Shapiro. 2009. Adaptive Management: The U.S. Department of the Interior Technical Guide. Adaptive Management Working Group, U.S. Department of the Interior, Washington, DC. International Standard Book Number: 978-1-4133-2478-7, http://www.doi.gov/initiatives/AdaptiveManagement/