Great Lakes Watershed Ecological Sustainability Strategy (GLWESS): Watershed Characterization and Selection of Candidate Pilot Watersheds

Prepared for:

Great Lakes Protection Fund
and the
GLWESS Project Advisory Panel (PAP)

in collaboration with

The Nature Conservancy
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EXECUTIVE SUMMARY

Presented in this report is a description of the methodology and outcome of the watershed characterization (physical and readiness) for the Great Lakes Basin. Because of relative data availability in terms of spatial resolution and access, the various characterization metrics were determined at different levels of watershed scale: physical characterization in the U.S. was done at the HUC-10 level; physical characterization in Canada was done at the quarternary level; readiness characterization in the U.S. was done at HUC-8 level; and readiness characterization in Canada was done at the Tertiary level. Physical characterization assessment included "hydrologic impact" and "human impact" metrics. Readiness characterization included "watershed plans", "watershed capacity", watershed funding", and "watershed activity level" metrics. The characterization analysis and scoring and ranking approach is presented below.

One of the important outcomes from our watershed characterization task is the selection of pilot watersheds for Phase II of our planned development of the Great Lakes Watershed Ecological Sustainability Strategy (GLWESS). In this report, we present our candidates for pilot programs within three categories, as described below. For each category, we have identified a series of candidate watersheds and present them in order of decreasing priority:

- <u>Category A</u>: a watershed with high runoff potential and high impact primarily due to agricultural activity and with "high" readiness for action.
  - Paw Paw River (MI, Lake Michigan) – tributary to St. Joseph River near mouth;
  - Lye Creek or Riley Creek HUC-10 (OH, Lake Erie) – in Blanchard River sub-basin in Maumee River watershed;
  - Crockery Creek (MI, Lake Michigan) - tributary to Grand River near mouth; and
  - East Twin River (WI, Lake Michigan) – southeast of Green Bay, small direct tributaries to Lake Michigan

- <u>Category B</u>: a watershed with high runoff potential and high impact primarily due to urban activity and with "high" readiness for action.
  - East River (WI) – a HUC-10 watershed that is entirely within the city of Green Bay, WI and flows into the Lower Fox River near its mouth;
  - One of the lower urban sub-basins of the Huron River (MI) watershed, which flows into Lake Erie through the southeast Michigan urban complex (we would plan to work with Laura Rubin, Director of the Huron River Watershed Council on this project);

- The Cuyahoga River watershed, which flows into Lake Erie through Cleveland, OH; and

- A sub-basin of the Clinton River (MI) watershed, which also has a significant amount of urban land use and a very active watershed protection group.

- Category C: one with watershed problems but with a relatively "low" readiness for action.
  - A sub-basin of the St. Marys River near Sault St. Marie, MI;
  - The Bad-Montreal watershed (WI), which drains into Lake Superior; and\
  - The Oswego River (NY), which has a moderate level of readiness based on our criteria, but is a Great Lakes AOC and has low head dams (we would plan to work with Kristy LaManche, Program Coordinator, Finger Lakes - Lake Ontario Watershed Protection Alliance (FL-LOWPA) on this system).

These nominations are for review by the Project Advisory Panel and by our funding agency, the Great Lakes Protection Fund, and will be finalized subsequent to our September 17, 2010 PAP meeting.

1. INTRODUCTION

The characterization of watersheds in the Great Lakes Basin is a key task in Phase I of the GLWESS project. This effort involved assessing and categorizing watersheds based on two main components: 1) physical attributes of the system, and 2) "readiness" attributes with respect to planning and implementing watershed restoration activities. The ultimate objective of the characterization is to develop a set of metrics that can be used to classify individual subwatersheds in the Great Lakes basin with respect to both physical and "readiness" attributes.

The classification of subwatersheds in the Great Lakes basin with respect to their physical and "readiness" attributes will support the selection of pilot watersheds for test application of the GLWESS. An additional output of this task will be the development of a Great Lakes watershed data base that can be used for other programs and assessments that can benefit from the raw data that has been compiled to compute the classification metrics described below. This document describes the methodology and results for the physical and "readiness" components of the watershed characterization, as well as recommendations for candidate watersheds for pilot projects to be included in Phase II of our GLWESS development project.

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2. WATERSHED PHYSICAL CHARACTERIZATION

The classification of subwatersheds in the Great Lakes basin with respect to their physical and "readiness" attributes will support the selection of pilot watersheds for test application of the GLWESS. An additional output of this effort is the development of a Great Lakes watershed database that can be used for other programs and assessments that can benefit from the raw data that has been compiled to compute the classification metrics described below. This chapter describes the methodology and results for the watershed physical characterization. The "readiness" component of the overall Great Lakes watershed characterization is presented in Chapter 3.

2.1 GENERAL APPROACH TO PHYSICAL CHARACTERIZATION

The GLWESS physical characterization of Great Lakes watersheds was conducted at the HUC-10 and quaternary levels for U.S. and Canadian watersheds, respectively (including approximately 1,200 subwatershed units). The average surface area of subwatersheds at these levels is roughly 400 km2, which is about 10 times finer than the average area of 3,300 km2 for subwatersheds at the HUC-8/tertiary level. Operating at the HUC-10/quaternary scale insures that key features of subwatershed systems will not be "averaged out", which would be a likely consequence if physical datasets were aggregated to the HUC-8/tertiary level.

For the physical component of the watershed characterization, each subwatershed was classified based on the following two categories:

1. Hydrologic Condition; and
2. Human Impact Condition

The "Hydrologic Condition" category addresses the present-day runoff potential of the system, necessarily including both the influence of natural drivers (e.g., surficial geology, land slope) and human drivers (e.g. land use/cover alterations). In contrast, the "Human Impact Condition" is intended to focus specifically on assessing the level of stress introduced by human settlement and development. It is recognized that there will be considerable overlap in the "hydrologic" and "human impact" categories for many subwatersheds, given that the hydrologic condition is often strongly influenced by non-natural factors in concert with natural drivers. However, there is value in evaluating these categories separately because 1) the relative contributions of the runoff and baseflow components of streamflow affect ecological condition, and 2) a non-flow dependent assessment of human impact provides important context for evaluating the relative importance of natural and non-natural factors in driving the hydrology and the ecological condition of the system.

The prescribed approach provides a means for classifying Great Lakes subwatersheds along two major gradients. These gradients (i.e., "Hydrologic Condition" and "Human Impact Condition") then serve as the basis for developing a physical characterization matrix once all subwatersheds have been classified. This matrix, which is shown conceptually in Figure 2-1, will be produced for the complete set of U.S. (HUC-10) subwatersheds and Canadian (quaternary) subwatersheds within the Great Lakes Basin, although it could also be used to summarize the classification results by state, lake basin, or major watershed unit (e.g., HUC-6, HUC-8). As illustrated in Figure 2-1, subwatersheds that fall within the upper left corner of the matrix are characterized by relatively low runoff potential and relatively low human impacts. In contrast, subwatersheds that fall within the lower right corner of the matrix are characterized by relatively high runoff potential and a relatively high level of human impact.

		Human Impact Condition		
		Low Impact	Moderate Impact	High Impact
Hydrologic Condition	Low Runoff (high baseflow)	*# of watersheds*	*# of watersheds*	*# of watersheds*
	Moderate Runoff (moderate baseflow)	*# of watersheds*	*# of watersheds*	*# of watersheds*
	High Runoff (low baseflow)	*# of watersheds*	*# of watersheds*	*# of watersheds*

Figure 2-1. Conceptual Summary Matrix for Great Lakes Physical Characterization

2.2 SELECTION OF METRICS

The classification of subwatersheds as illustrated in Figure 2-1 requires a supporting quantitative evaluation of key physical metrics within each subwatershed. A suite of possible metrics that could be used to represent the "Hydrologic Condition" and "Human Impact Condition" gradients were initially defined and then evaluated. Final metrics for both gradients were selected based on the following criteria:

1. Representativeness of the metric for the 'condition gradient' with respect to the primary objective of the physical characterization (i.e., selection of pilot watersheds);

2. Overlap or redundancy of the metric with respect to other potential metrics; and

3. Availability of accessible data to support quantification of the metric.

The following sections describe the candidate metrics identified for each condition gradient, identify which metrics were ultimately selected for the analysis, and provide the rationale for those selections.

2.2.1 Hydrologic Condition

The following metrics were initially proposed and evaluated in the context of classifying subwatersheds for the "Hydrologic Condition" gradient:

- Runoff Curve Number: the Runoff Curve Number has been extensively researched and developed, and it provides a useful empirical technique for integrating the impacts of land use, soil infiltration properties (i.e., hydrologic soil type), and land surface slope (USDA-NRCS 1986; Neitsch et al. 2005).

- Flashiness Index: the Richards-Baker flashiness index ("R-B Index") provides a simple, yet effective technique for evaluating the relative stability of streamflow conditions (Baker et al., 1994). When evaluated in the context of watershed drainage area, the R-B Index can be used to efficiently rate the relative stability and prevalence of runoff and baseflow contributions across a wide range of subwatersheds that have associated gaged streamflow datasets.

- Baseflow Contribution: the relative contribution of baseflow and runoff to total streamflow can be assessed using any number of hydrograph separation/partitioning techniques, including the PART algorithm developed by the USGS.

- Extent of Unnatural Impoundments: large man-made impoundments often have profound effects on the hydrologic condition of a subwatershed that may not be fully captured, or may even be masked, by the other metrics described above.

Final Metric Selection

After evaluating the suite of candidate metrics described above, the Runoff Curve Number metric was selected as a single representative metric for the "Hydrologic Condition" gradient. Although it is empirical in nature, the Runoff Curve Number provides an effective approach for integrating information concerning land use/cover, soil drainage characteristics, and land slope to provide an overall indicator for runoff potential. For U.S. subwatersheds, complete datasets are available to support the Runoff Curve Number calculation. For Canadian watersheds, land use/cover and soil drainage data are available, but land slope is not readily available. However, it was determined that the land use/cover and soil drainage estimates were sufficient to provide reasonable estimates of Runoff Curve Numbers for Canadian quaternary watersheds.

The metrics for streamflow "flashiness" and baseflow contributions are appealing because they are based on specific, detailed observations for a watershed system. However, there are important disadvantages of these metrics with respect to the objectives of the watershed physical characterization. First, streamflow data are not available for every HUC-10/quaternary watershed within the Great Lakes basin. Second, streamflow metrics by their nature integrate the physical and hydrologic attributes of the entire catchment area upstream of the gaging location. The integrative nature of these metrics is often an import benefit when evaluating ecological condition. However, the GLWESS approach includes a strong focus on restoration projects that occur within the catchment area, so characterizing the local catchment characteristics is a high priority. These attributes of streamflow mean that considerable time and effort would be required to compile and analyze existing data for the purpose of supporting the physical characterization.

The metric for extent (i.e., surface area) of unnatural impoundments was originally developed because it provides potentially useful information concerning how the receiving water body within a watershed has been modified with manmade structures. However, this information is not readily available, and therefore considerable effort would be required to compile surface area data for unnatural impoundments. Therefore, this metric was also eliminated from consideration.

2.2.2 Human Impact Condition

The following metrics were initially proposed and evaluated in the context of classifying subwatersheds for the "Human Impact Condition" gradient:

- Impervious Cover: the impervious surfaces (pavement, roofs, etc.) that typically dominate urban landscapes can have a significant impact on water quantity and quality characteristics in local and regional watersheds.

- Agricultural Land Use: the quantity of land surface area developed and used for agricultural purposes is a metric of equal importance to the impervious cover metric, as it provides a strong indicator for the extent of non-urban human impacts on a subwatershed.

- Consumptive Water Use: consumptive water usage rates provide an indication of the extent of direct human impact on water quantity and storage within a subwatershed.

- Point Source Discharges: the relative contributions of point source discharges to water bodies within a subwatershed provide an indication of water quality impacts.

- Impaired Waters: the U.S. EPA provides 303(d) listings for impaired streams within the U.S. portion of the Great Lakes Basin. These data can be used to summarize the extent to which specific water quality concerns have been identified within the receiving water bodies for a given subwatershed.

- Man-Made Structures: the number of dams per unit area can provide an indicator for the extent to which human activities have modified water bodies within a subwatershed system.

Final Metric Selection

The potential metrics for "Human Impact Condition" represent a variety of unique and important characteristics with respect to the effect of human development on watershed. In addition, supporting data are readily available to calculate these metrics for the entire U.S. portion of the Great Lakes Basin. Therefore, it was determined that all six metrics be retained for use in classifying the "Human Impact Condition" for U.S. watersheds. The following adjustments were made to the human impact metrics for Canadian subwatersheds due to limited data availability:

- A Canadian dataset equivalent to the 303(d) spatial data available for the U.S. was not identified. Therefore, it was not possible to quantify the "impaired waters" metric for Canadian watersheds.

- Spatial data for point source discharges is considered to be extremely sensitive data in the province of Ontario, and therefore it was not possible to obtain this information. Therefore, the "point sources discharge" metric was excluded from the human impact analysis for Canadian watersheds.

Given the data limitations described above, the weighting scheme for the "Human Impact Condition" metrics was modified for Canadian watersheds to reflect the use of four metrics instead of six.

2.3 METHODOLOGY FOR CLASSIFICATION

The methodology for the physical characterization of Great Lakes watersheds included the following steps:

1. Acquiring and processing the datasets to support each metric for "Hydrologic Condition" and "Human Impact Condition";

2. Generating a distribution of results for each metric across the full set of HUC-10 and quaternary watersheds; and

3. Scoring each watershed for both "Hydrologic Condition" and "Human Impact Condition" on a distribution-based scale.

2.3.1 Data Acquisition & Processing

-The Curve Runoff Number (USDA-NRCS, 1986) to support the "Hydrologic Condition" classification was derived from the following datasets:

- Land Use/Cover: For the U.S. subwatersheds, the 2001 National Land Cover Dataset was processed at a 30-meter resolution to provide the total areas for 16 individual land use/cover types (http://www.epa.gov/mrlc/nlcd-2001.html). These data were initially processed at the HUC-12 watershed resolution. For the Canadian portion of the Great Lakes Basin, the Ontario Land Cover dataset was processed at a 25-meter resolution to provide total areas by quaternary watershed for 28 individual land use/cover types.

- Soils Drainage: Data for soils drainage in U.S. subwatersheds were compiled from the state-level STATSGO soils database. The STATSGO hydrologic soil group (i.e., A, B, C, or D) data were used to estimate the drainage properties for each HUC-12 subwatershed. For the Canadian portion of the Basin, the "Soil Landscapes of Canada - Version 3.1.1" was obtained from Agriculture and Agri-Food Canada and processed for soil drainage characteristics.

- Land Slope: A 10-meter digital elevation model (DEM) of the U.S. portion of the Great Lakes Basin was derived from the National Elevation Dataset (NED). These data were used to compute the mean percent slope for each HUC-12 subwatershed. As discussed above, it was not possible to obtain a high-resolution DEM for the Canadian portion of the Basin.

Once all land use/cover, soils drainage, and land slope data had been compiled, these data were incorporated into the NRCS equations for Runoff Curve Number to calculate a single Curve Number (CN) for each HUC-12 subwatershed (see Neitsch et al. 2005). This calculation was performed at the HUC-12 level in order to avoid averaging out important details related to varying combinations of land use/cover, soils, and slope characteristics. As a final step, Curve Numbers calculated at the HUC-12 scale were used to calculate an overall, area-weighted Runoff Curve Number for each HUC-10 subwatershed unit. For Canadian watersheds, Runoff Curve Numbers were directly calculated for each quaternary subwatershed unit.

The acquisition and processing of supporting datasets for the six "Human Impact Condition" metrics is summarized below:

- Imperviousness: The 2001 National Land Cover Dataset (NLCD) was used to estimate percent impervious cover for all U.S. subwatersheds (HUC-10 level). A percentage of impervious area was assigned to each NLCD type consistent with the approach used by Ebert and Wade (2004), as shown in Table 2-1.

Table 2-1. Percent Impervious Area by NLCD Type (for U.S. subwatersheds)

NLCD Type	Impervious Cover
Developed, Open Space	10%
Developed – Low Intensity	40%
Developed – Medium Intensity	50%
Developed – High Intensity	75%
Other types	0%

The Ontario Land Use dataset provides only type of "developed" land use. For simplicity, it was assumed that 50% of this land area consists of impervious surfaces.

- Agricultural Land Use/Cover: The 2001 NLCD data were also used to estimate percent cover of agricultural areas for all U.S. subwatersheds. This was accomplished simply by summing the fraction of land area for the two agricultural land use/cover types included in the NLCD: "Pasture/Hay" and "Cultivated Crops". An analogous approach was used for Canadian quaternary watersheds: the Ontario Land Cover dataset was used to estimate agricultural land cover by summing the percentages of area assigned to the "Pasture and Abandoned Fields" and "Cropland" classes.

- Consumptive Water Use: Water usage information was compiled at the HUC-8 watershed level from USGS data available for 1995 (http://water.usgs.gov/watuse/) (Solley et al. 1995). This dataset provides a summary of overall water use, as well as water withdrawals and consumptive use estimates by individual sector (agricultural, municipal, etc.). For Canada, consumptive use estimates were obtained for tertiary watersheds from Michael Shantz of Environment Canada based on a water use and supply study (Environment Canada, 2007). Because water use data are only available at the relatively coarse HUC-8 and tertiary levels, the consumptive usage estimates were assigned to all HUC-10/quaternary units contained within each HUC-8/tertiary unit.

- Point Source Discharges: Effluent discharge data for U.S.-based point source discharges were obtained from the National Pollutant Discharge Elimination System (NPDES) via two online databases: Enforcement & Compliance History Online (ECHO) and Permit Compliance System (PCS). Spatial location information for NPDES facilities was reviewed for accuracy. Based on this review, it was determined that the most accurate summaries of NPDES discharge data could be developed by summing only discharges greater than or equal to 1 MGD. The design flow rates for facilities meeting this criterion were summed by HUC-10 watershed to support this metric. (Note that electrical utilities were excluded from the analysis because these facilities have very large associated discharges (and associated withdrawals), and the water quality impacts for these utilities are generally limited to water temperature.) As noted above, it was not possible to obtain point source discharge information for the province of Ontario; therefore, the "point source discharges" metric was excluded from the analysis for Canadian watersheds.

- Impaired Waters: Spatial datasets for 303(d) listings for impaired streams within the U.S. portion of the Great Lakes basin were obtained from the EPA's "Watershed Assessment, Tracking & Environmental Results" (WATERS) website and processed to obtain an estimate of the impaired stream length per unit area for each subwatershed. As noted above, it was not possible to obtain analogous information for impaired water bodies for the province of Ontario; therefore, the "impaired waters" metric was excluded from the analysis for Canadian watersheds.

- Man-Made Structures: Spatial information concerning dam structures was obtained for the U.S. portion of the Great Lakes Basin from USEPA's Better Assessment Science Integrating Point & Non-Point Sources (BASINS) database (USEPA, 2001). The original intent in developing this metric was to make use of dam height data to quantify the cumulative height of structures per unit subwatershed area. However, it was determined that the data for dam height were not complete or accurate enough to support this assessment. Therefore, this metric was calculated simply as the total number of structures per unit area within each HUC-10 subwatershed. An inventory of dam structures located in Canadian watersheds was obtained from The Nature Conservancy, and an analogous analysis was conducted to summarize the number of dams per unit area within each quaternary watershed.

A more detailed summary of the data sources used to support the watershed physical characterization metrics is provided in Appendix A.

2.3.2 Scoring

After the supporting data were processed to provide a suite of metric results for each HUC-10 and quaternary watershed, the distribution of results for a given metric were used to develop a score for that metric on a country-specific basis. A scale of 1 to 5 was used to score watersheds based on the following percentile ranges for each distribution:

- Score = 1 (very low): 0 to 20th percentile;
- Score = 2 (low): 20th to 40th percentile;
- Score = 3 (moderate): 40th to 60th percentile;
- Score = 4 (high): 60th to 80th percentile; and
- Score = 5 (very high): 80th to 100th percentile.

Because the Runoff Curve Number represents the only metric used to classify subwatersheds for the "Hydrologic Condition", the score for this metric was taken as the overall "Hydrologic Condition" score. For the "Human Impact Condition", it was necessary to integrate the results from six (for U.S.) or four (for Canada) individual metrics. This was accomplished by assigning each of the six metrics a weight relative to the total score (Table 2-2). The weights were developed based on best professional judgment regarding the importance and representativeness of each metric.

Table 2-2. Weighting of Metrics for Human Impact Scoring

Human Impact Metric	Units	Weight (U.S.)	Weight (Canada)
Imperviousness	mean % cover	25%	31.25%
Agricultural Land Cover/Use	mean % cover	25%	31.25%
Consumptive Water Use	flow (MGD) per unit area (km^2)	25%	31.25%
Point Source Discharges	flow (MGD) flow per unit area (km^2)	10%	n/a
Impaired Waters	cumulative length (m) per unit area (km^2)	10%	n/a
Manmade Structures	number of structures per unit area (km^2)	5%	6.25%

The weights in Table 2-2 were applied to the scores (1 to 5 scale) for the individual metrics to develop an overall score for the "Human Impact Condition". As a final steps, the distribution of these metric-weighted scores was then used to determine a final "Human Impact Condition" score for each HUC-10 and quaternary watershed based on the 1-5 scale presented above.

2.4 CLASSIFICATION RESULTS

Final scores were compiled for each HUC-10 and quaternary subwatershed for the "Hydrologic Condition" and "Human Impact Condition". The spatial distribution of scores (1 to 5 scale) for "Hydrologic Condition" and "Human Impact Condition" are provided as maps in Figure 2-2 and Figure 2-3, respectively. Additional maps illustrating the spatial distribution of results for the six human impact metrics are provided in Appendix B. Tabulated scoring results for all metrics for all subwatersheds are available in the spreadsheet file provided as Appendix C.

The scoring results for "Hydrologic Condition" (Figure 2-2) indicate that subwatersheds located in the Lake Erie, Lake Ontario, and southern Lake Huron basins have the highest runoff potential. This includes highly developed urban centers, such as Detroit and Cleveland, but also intensively farmed lands characterized by poorly draining soils. For example, the Maumee and Saginaw River basins, as well as southern Ontario represent agricultural regions characterized by very high runoff potential. In the Superior and Michigan basins, the subwatersheds with high runoff potential generally coincide with highly urbanized areas, including Chicago, Milwaukee, Green Bay, and Duluth. Subwatersheds in the Lake Superior basin and the northern Lake Michigan and Lake Huron basins generally have the lowest runoff potential, largely owing to the lack of urban and agricultural development and generally sandy, well-draining soils.

As discussed previously, the scoring results for "Human Impact Condition" (Figure 2-3) integrate the results for six individual metrics. As would be expected based on intuition, the overall scores suggest that the highest human impact occurs in the southern half of the Great Lakes basin. In particular, the highest human impact scores are found in southern Ontario and the Lake Erie basin (e.g., Maumee River and Sandusky River sub basins), as well as urban centers such as Detroit, Cleveland, Chicago, Milwaukee, Green Bay, Toronto, Sault Ste. Marie, Sudbury, and Duluth. The lowest human impact scores are generally found in the Lake Superior and northern Lake Michigan and Lake Huron basins.

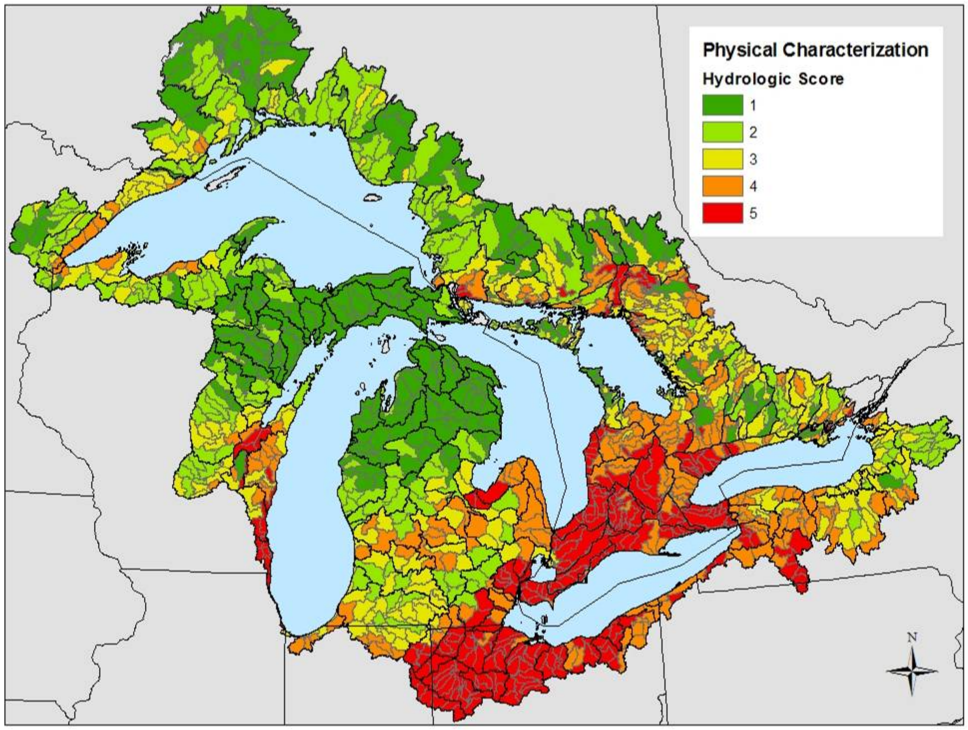

Figure 2-2. Classification Results for "Hydrologic Condition" Gradient

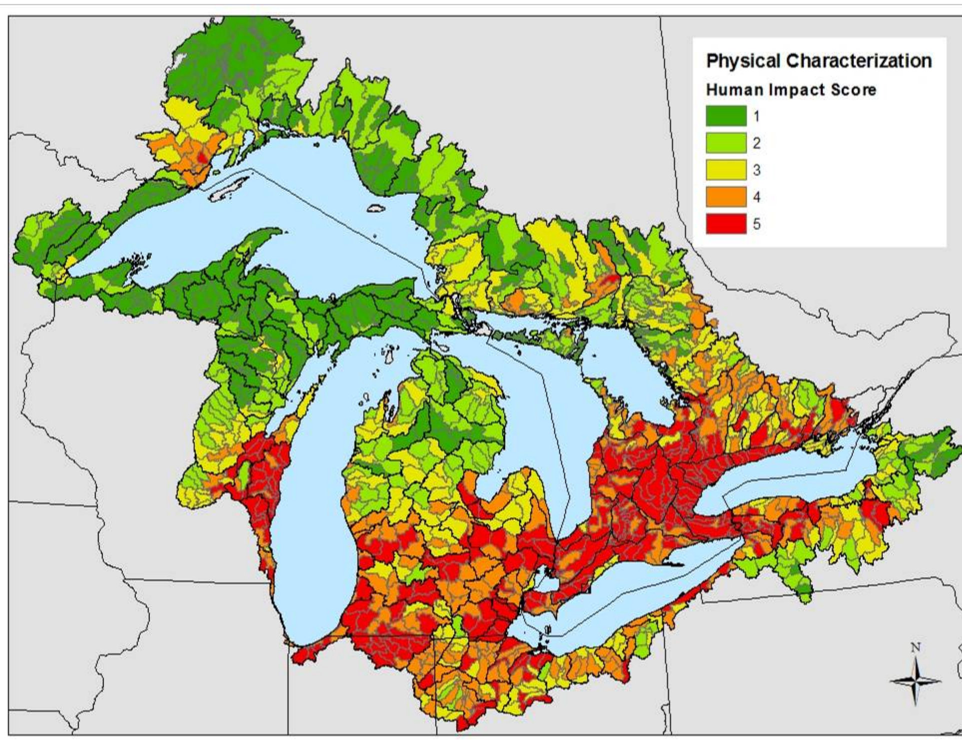

Figure 2-3. Classification Results for "Human Impact Condition" Gradient

As illustrated conceptually in Figure 2-1, the results of the physical classification for the "Hydrologic Condition" and "Human Impact Condition" gradients can be summarized in the form of the matrices provided in Table 2-3 and Table 2-4 for the U.S. subwatersheds and Canadian subwatersheds, respectively. This matrix provides insight into what combinations of hydrologic and human impact scores occur most frequently and least frequently across U.S. subwatersheds at the HUC-10 scale. Therefore, this matrix and the underlying results can be used as a tool for an informed selection of subwatersheds for pilot watershed restoration projects.

Table 2-3. Physical Characterization Summary Matrix for U.S. Subwatersheds

		Human Impact Condition				
		1	2	3	4	5
Hydrologic Condition	1	60	51	13	0	0
	2	40	35	21	20	6
	3	18	17	34	23	30
	4	6	13	21	41	42
	5	2	8	29	51	32

Table 2-4. Physical Characterization Summary Matrix for Canadian Subwatersheds

		Human Impact Condition				
		1	2	3	4	5
Hydrologic Condition	1	55	23	30	6	1
	2	58	20	19	13	4
	3	20	23	42	20	9
	4	13	9	22	35	35
	5	4	6	6	33	65

3. WATERSHED READINESS CHARACTERIZATION

The intent of the readiness characterization is to identify social differences in watersheds in their capacity, interest, and will to pursue watershed improvements. It is anticipated that these differences will presage the variability in communities' responses to the GLWESS approach, which will make readiness important to consider in selecting pilot watersheds. For the purposes of this project the watershed readiness is being defined as a function of governmental and non-governmental capacity within a watershed, demonstrable evidence of watershed management planning and implementation, and public and private funding allocated to watershed improvement practices. It is also recognized that these watershed readiness attributes will vary over time within a watershed so, when possible, we will look for trends and consistency.

3.1 METHODOLOGY FOR CLASSIFICATION

The watershed readiness characterization was conducted at the HUC 8 level for U.S. watersheds and at the Tertiary Watershed level for Canadian watersheds. Unfortunately much of the data needed for readiness assessment do not correspond exactly to these boundaries. Instead, data was often available only for smaller watershed units. Since this varied across the Basin, though, it was not feasible to analyze the watersheds at a more detailed level. The five steps outlined for the readiness characterization culminate in the development of a "readiness index". The approaches associated with each of these individual steps are described in the following sub-sections.

3.1.1 Step 1: Watershed Management Plan

The presence or absence of a watershed management plan is a central element in potential readiness, because it indicates that at least some thinking has taken place on the issues and remedies needed within a watershed. It also indicates that there is at least some level of interest and will in the community to consider actions needed for watershed health, although this can span a wide range in the capacity to actually implement actions. Development of some type of watershed management plan is a prerequisite for any credible process of watershed improvement. Lack of at least a simple plan truly indicates a lack of any readiness to move ahead comprehensively with watershed strategies. Therefore, the absence of any type of comprehensive plan will be considered a disqualification for further consideration in 'readiness' of a watershed for GLWESS. In the northern parts of the basin, this approach may eliminate many watersheds which lack watershed management plans. In the southern part of the basin more plans have been developed, and the remaining steps of the readiness assessment will differentiate among them.

Watershed management plans vary in their complexity, completeness, and usefulness for implementation. Some plans such as 'nine element' plans meeting U.S. EPA specifications under Section 319 qualify a watershed to apply for funding for implementing the plan. Some jurisdictions have less intensive planning regimes that are commonly used, such as Michigan's "Clean Michigan Initiative" (CMI) planning method, which qualifies a watershed for some state funding but not EPA 319 grants. As noted above, some watersheds have plans completed for the full HUC 8 or Tertiary extent, while in other cases plans have only been done for a smaller component of these watersheds. Because of these variations, it is useful to differentiate among the geographic extent and complexity of watershed plans that have been done.

In the portion of the Great Lakes watershed within the U.S., all HUC 8 units were searched for the existence of any type of watershed management plan. For this step and for some subsequent data points, a variety of national and state on-line data sources were searched for indications of watershed planning. For U.S. watersheds these included:

- Surf Your Watershed http://cfpub.epa.gov/surf/locate/index.cfm
- Great Lakes Wiki http://www.greatlakeswiki.org/index.php/Main_Page
- MDEQ – Approved Watershed Plans https://mail.google.com/a/mail.gvsu.edu/?ui=2&view=bsp&ver=ohhl4rw8mbn4
- NYS Dept. of Environmental Conservation – Watersheds, Lakes, & Rivers http://www.dec.ny.gov/lands/26561.html
- Indiana Department of Environmental Planning – Watershed Planning http://www.in.gov/idem/4342.htm
- Bureau of Watershed Management – WDNR http://dnr.wi.gov/org/water/wm/
- State Endorsed Watershed Action Plans – Ohio ftp://ftp.dnr.state.oh.us/Soil_&_Water_Conservation/WatershedActionPlans/EndorsedPlans/
- Western Lake Erie Basin Partnership http://www.wleb.org/watersheds/watersheds.html
- Watershed Management – IL http://www.epa.state.il.us/water/watershed/index.html
- Pennsylvania DEP – Watershed Management http://www.portal.state.pa.us/portal/server.pt/community/watershed_management/10593
- Minnesota Natural Resources – Watersheds http://www.state.mn.us/portal/mn/jsp/hybrid.do?ct=899193537&ct2=899193537&ct1=523943088&hometopic=11&id=-8722&agency=NorthStar

In Canada, the website of Conservation Ontario (http://www.conservation-ontario.on.ca/) was searched as well as the sites of the various Conservation Authorities (C.A.), which frequently coincide with Tertiary Watershed boundaries, to determine whether completed watershed management plans exist for each C.A.

3.1.2 Step 2: Capacity

For all watersheds with management plans, the extent of watershed management capacity was evaluated based on the existence of watershed management organizations, or any type of group or coalition tasked with carrying out the strategies developed in the watershed management plan. In the U.S., this included the activities of Conservation Districts. The EPA Surf Your Watershed and Conservation Ontario websites were primary tools for this search.

3.1.3 Step 3: Level of Capacity

Watersheds with any amount of capacity were further categorized by level of capacity, using several factors that are described below.

- Funding: Where possible, it was determined whether there have been significant grants or other funding for carrying out watershed strategies, or if there is evidence of pursuit of such funding. This was determined through (1) evidence from the websites listed above under Step 1; (2) websites for individual watershed organizations identified in Step 2; (3) awards under the recent Great Lakes Restoration Initiative; and (4) a survey of staff from The Nature Conservancy and Nature Conservancy of Canada responsible for working with freshwater strategies. The survey asked staff to evaluate the funding they were aware of for each HUC 8 or Tertiary watershed in their state or province.
- Watershed Plan Implementation Activity: We sought to document evidence of a current commitment of organizations to implement strategies in the various watersheds. We sought evidence of any efforts towards organizing effective activities to improve conditions (e.g. volunteer monitoring or stream clean-ups) on any level within the watershed. Activity was assessed using the tools noted above under "Funding", including the survey.

- Proportion of Watershed in Protected Areas: The proportion of the watershed within some type of protected status has proven to be a useful indicator of capacity and potential for success in other Great Lakes assessments. For the United States, data for protected areas originated from the U.S. Geological Survey[1]. For Ontario, various data layers from were combined together from Nature Conservancy of Canada's database. For each HUC 8 or Tertiary watershed, we calculated the percentage area in GAP status categories 1-4 and 4a. These are defined as follows:
  Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.

  Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including - suppression of natural disturbance.

  Status 3: An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging, OHV recreation) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area.

  Status 4: There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout or management intent is unknown.

  Status 4a: Long-term Conservation Easement (6 - 14 years) with management intent to conserve biodiversity.

  For Ontario, specific types of land protection status were available, correlated to GAP 1 and 2 categories, according to the crosswalk shown in Table 3-1.

[1] US Geo-logical Survey, National Biological Information Infrastructure, Gap Analysis Program (GAP). May 2010. Protected Areas Database of the United States (PAD-US) Version 1.1**.** http://gapanalysis.nbii.gov/portal/server.pt/community/maps_and_data/1850/

Table 3-1. Crosswalk for GAP Categories and Canadian Protected Area Types

Canadian Protected Area Type	GAP Category
National Park	1
Provincial Park	1
Provincial Conservation Reserve	1
Conservation Authority Property	2
ANSI (Life Science or Earth Science)	2
NCC owned property	2
Provincially Significant Wetlands	2

3.1.4 Step 4: Financial Demographics

For watersheds with any amount of capacity, we sought to examine financial data to differentiate among them. There are sometimes significant differences in pursuit of watershed management strategies that relate to demographic indicators, with higher-income areas tending to have more resources and political will to pursue watershed goals than less advantaged areas. To examine this element, we chose to examine median income for each watershed, but with somewhat different data sources for the two nations. The U.S. analysis was conducted using census tract level data from the 2000 U.S. census. The Canadian analysis was done with 2006 census data at the census division level, which is much larger than the U.S. census tract in terms of area and population.

3.1.5 Step 5: Readiness Index

The various analyses above were combined to generate a single index to consider readiness, using the following scoring system, where up to 25 points were possible.

- Watershed Management Plan:
    - 5 points – 319 watershed management plan or equivalent available for full watershed
    - 4 points – 319 watershed management plan or equivalent available for part of watershed
    - 3 points – less rigorous type of watershed management plan available for full watershed
    - 1 point – less rigorous type of watershed management plan available for part of watershed
- Capacity:
    - 1 point – any watershed management organizations in place and active in the watershed.

- 0 points – no watershed management organizations identified in the watershed.

- Funding:
    - 5 points – High (Significant funding secured or highly probable for an extended period)
    - 3 points – Medium (Short-term funding secured or highly probable, for one year)
    - 1 point – Low (Minimal or no funding and/or no clear funding sources)

- Activity Level:
    - 5 points – High
    - 3 points – Medium
    - 1 point – Low

- Protected Areas:
    - 5 points – 33-92% in GAP 1-4a
    - 4 points – 12-33% in GAP 1-4a
    - 3 points – 6-12% in GAP 1-4a
    - 2 points – 2.5-6% in GAP 1-4a
    - 1 point – 0-2.5% in GAP 1-4a

- Median Income:

	U.S.	Ontario
4 points -	$50,456 - 62,093	$60,547 - 70,888
3 points -	$41,243 - 50,455	$53,270 - 60,546
2 points -	$35,011 - 41,242	$48,865 - 53,269
1 points -	$1 – 35,010	$1 - 48,864

(Note: US figures in US dollars, Ontario figures in Canadian dollars.)

3.2 CLASSIFICATION RESULTS

The methodology and associated steps described in Section 3.1 were applied to acquire, process, and develop scores for the individual readiness metrics and the overall "readiness index". The following sub-sections summarize the results obtained for the various metrics and the overall readiness index. The complete set of results are provided in tabular form as part of Appendix C.

3.2.1 Step 1: Watershed Management Plan

The majority of watersheds have some type of management plan in place, although those in the northern part of the Great Lakes Basin are the most likely to lack a plan (Figure 3-1).

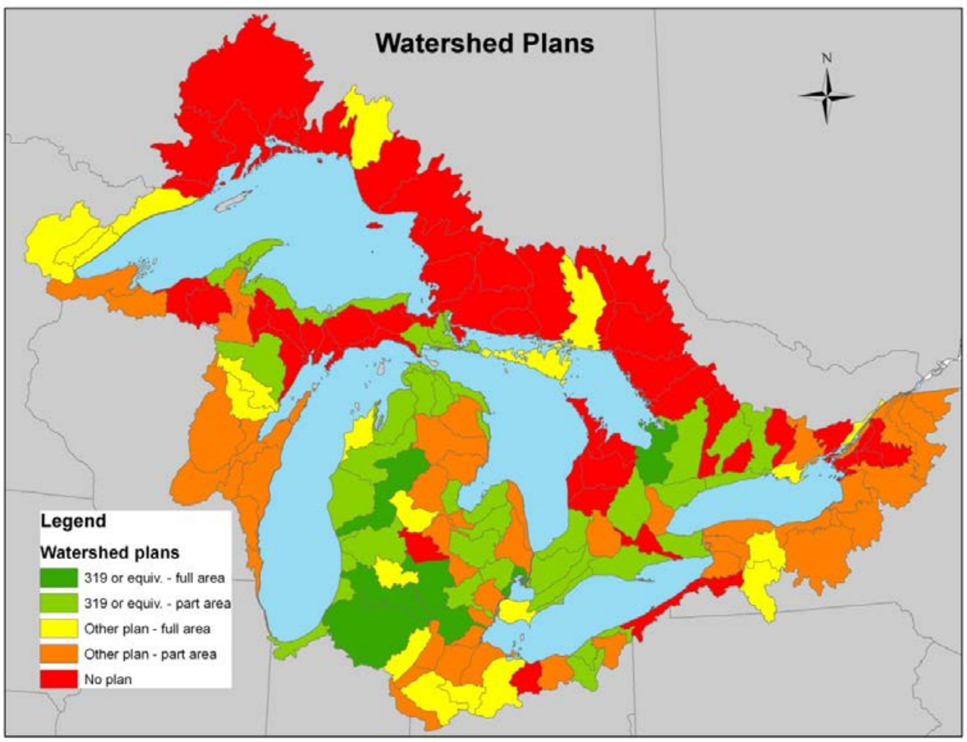

Figure 3-1. Presence of Watershed Management Plans by HUC 8/Tertiary Watershed

3.2.2 Step 2: Capacity

The vast majority of watersheds in the Great Lakes Basin have some watershed management groups in place and active, providing a level of capacity for watershed management implementation (Figure 3-2).

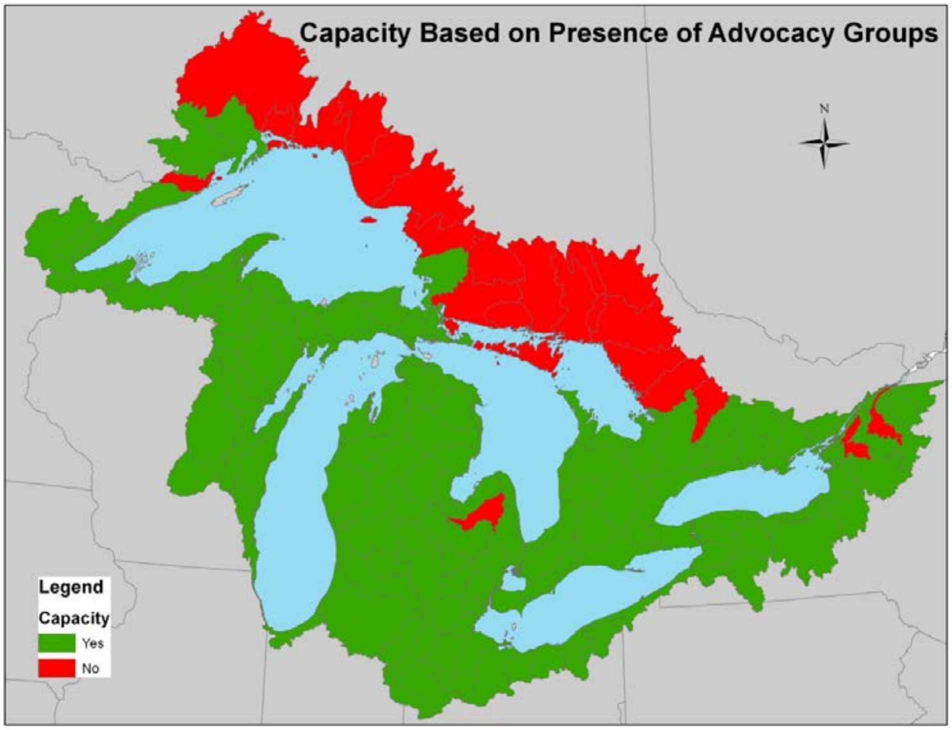

Figure 3-2. Capacity Based on Presence of Watershed Management Organizations by HUC 8/Tertiary Watersheds

3.2.3 Step 3: Level of Capacity

Watersheds with any amount of capacity were further categorized by level of capacity, based on the factors described in Section 3.1. The metric results for funding, level of activity, and proportion of watersheds in protected areas are summarized in the following sub-sections.

3.2.3.a Funding

Funding for implementation of watershed management plans varies significantly across the Basin (Figure 3-3). While many northern watersheds lack funding, especially those in Canada, there are some lacking funding in the southern part of the Basin as well.

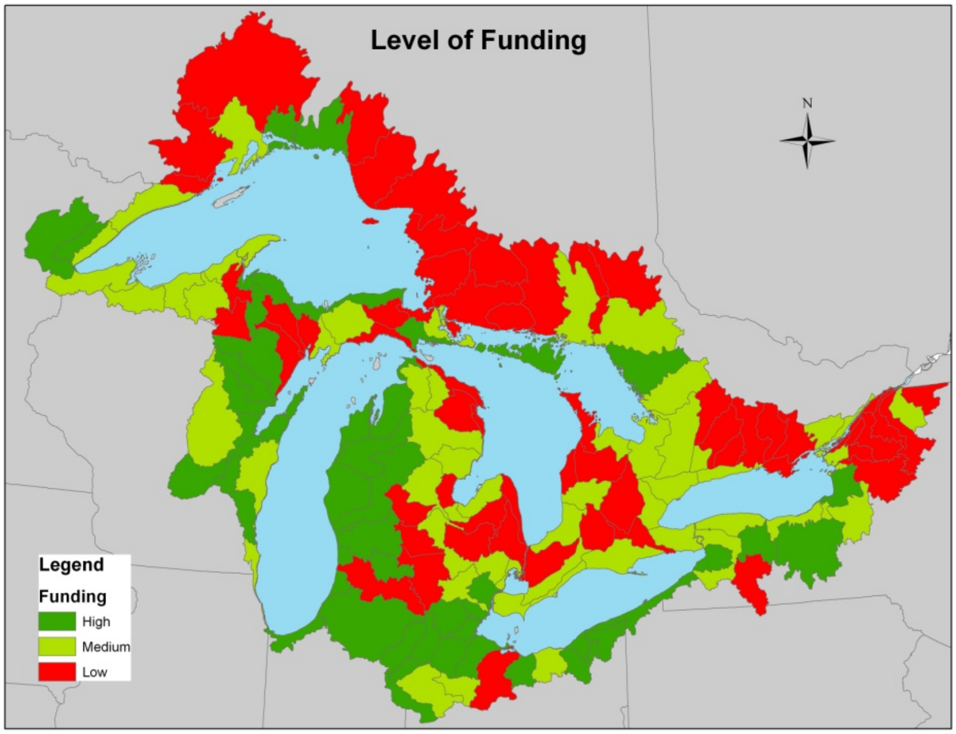

Figure 3-3. Level of Funding by HUC 8/Tertiary Watershed

3.2.3.b Level of Activity

The level of watershed plan implementation activity also varies widely across the Great Lakes Basin, with pockets of high and low activity scattered throughout the region (Figure 3-4). It should be noted that there are a few watersheds for which it was not possible to find sufficient data for scoring.

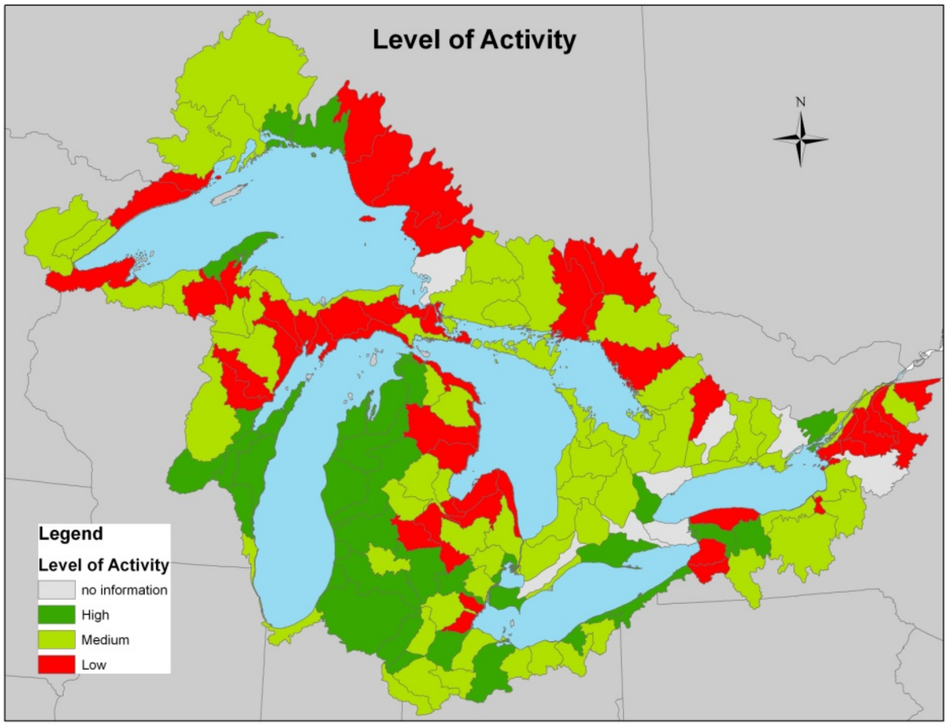

Figure 3-4. Level of Activity by HUC 8/Tertiary Watershed

3.2.3.c Proportion of Watershed in Protected Areas

The proportion of watersheds in a protected status, and thus more readily available for management strategy implementation, varies in a predictable way with the least protected areas in the southern part of the Basin (Figure 3-5). However, the Canadian watersheds show less of a north-south gradation among proportion of protected lands, with significant variation among the northernmost tertiary watersheds.

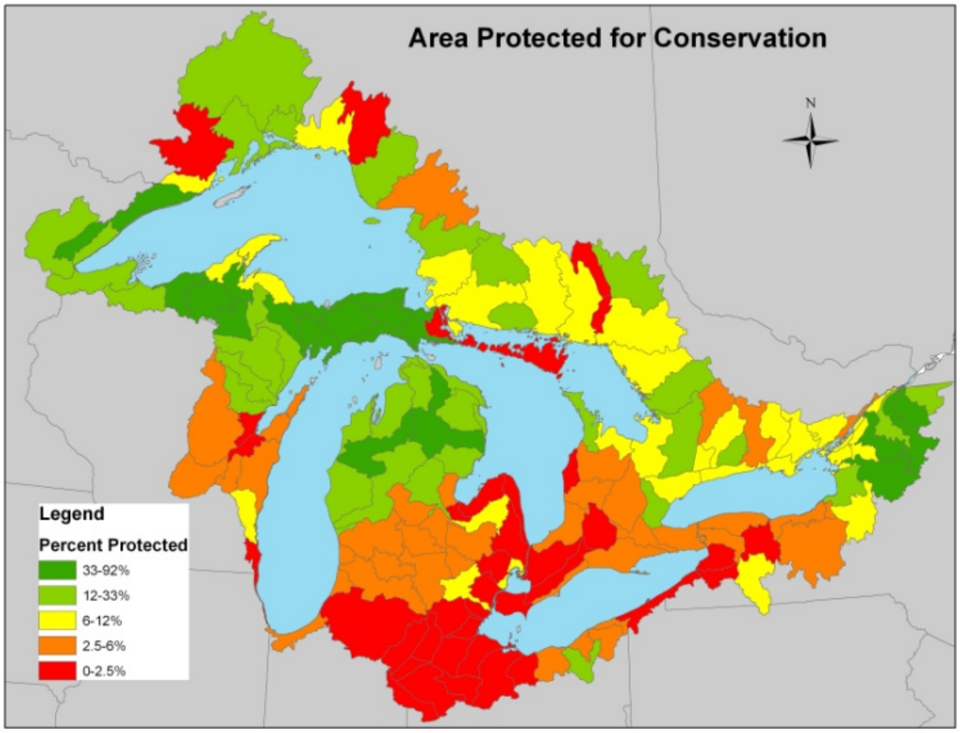

Figure 3-5. Proportion in Protected Status by HUC 8/Tertiary Watersheds

3.2.4 Step 4: Financial Demographics

Median household income for the Great Lakes Basin is predictably highest in the vicinity of larger urban areas, with concentrations of lower income households in the more rural, but non-agricultural, parts of the Basin (Figure 3-6).

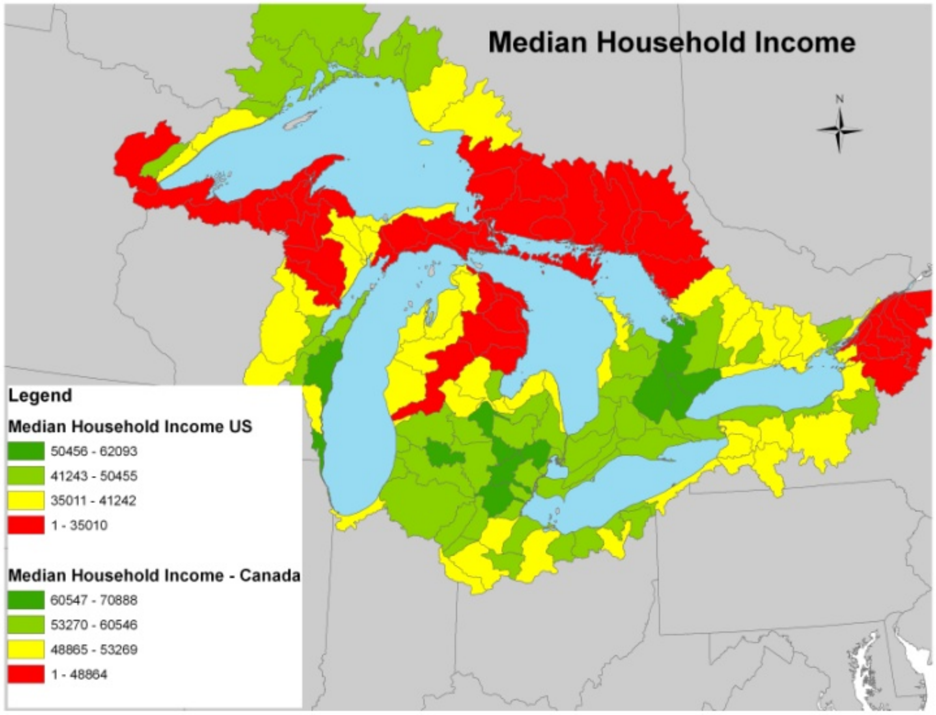

Figure 3-6. Financial Comparison of HUC 8/Tertiary Watersheds

3.2.5 Step 5: Readiness Index

The "Readiness Index" provides a combined view of the various factors (Figure 3-7). While imperfect, it does give a sense of the probable, relative ease of introducing the WESS concept into a given watershed. While each of the five Great Lake Basins has all (or nearly all) of the five levels of readiness, there are substantial differences as well. Lake Michigan appears to have a particularly high proportion of strongly engaged, 'more ready' watersheds, while Lake Huron may have the highest proportion of 'less ready' watersheds.

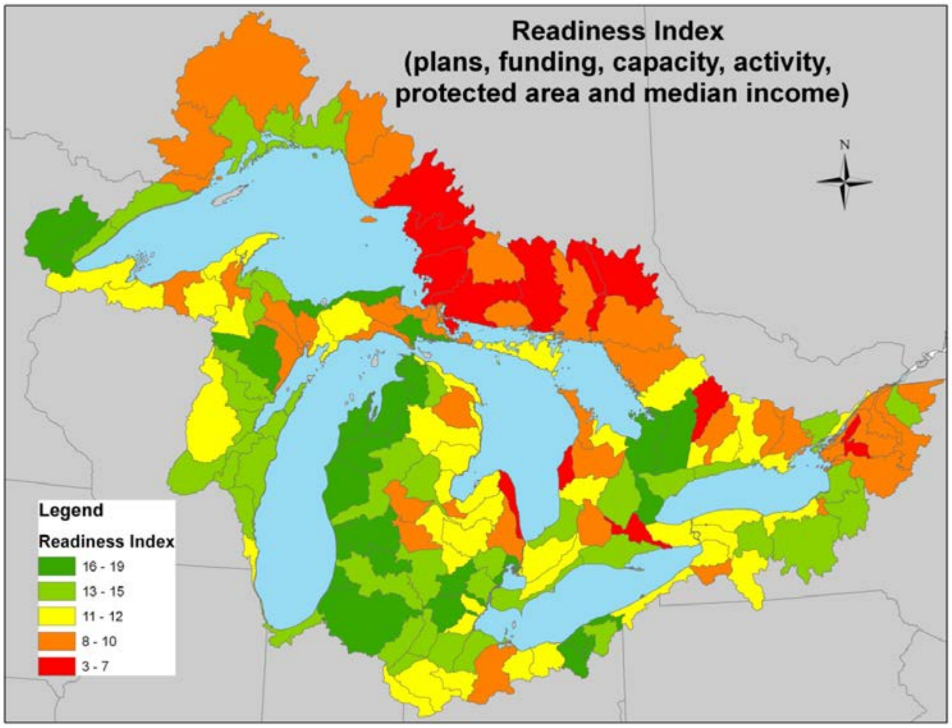

Figure 3-7. Combined Index of Readiness by HUC 8/Tertiary Watershed

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4. CANDIDATE WATERSHEDS FOR RESTORATION PILOT PROJECTS

One of the primary purposes of conducting the watershed characterization analysis for the Great Lakes was to inform the selection of pilot watersheds for demonstration of the feasibility and utility of the GLWESS. The previous chapters indicate that there is a wide range of hydrologic condition, human impact condition, and readiness among Great Lakes watershed. Our pilot program should attempt to encounter as wide a range of watershed characteristics as possible within the available time and resources for conducting the pilot program. We also want the pilot program to test as many watershed restoration action categories as possible among the nine categories that we have already identified. These categories are:

1. Agricultural land practice changes: Agriculture is the largest consumptive water user on a global basis (2030 Water Resources Group, 2009). Better irrigation, nutrient and pesticide management, and vegetative and tillage practices offer opportunities to improve receiving water quality and restore natural hydrologic regimes in highly agricultural watersheds.
2. Stormwater management: Runoff from impervious areas is a significant source of water pollution and can disrupt the hydrologic regime of a watershed by rapidly transporting water “downstream” before it can be stored, infiltrated, or evapotranspirated. Potential actions include restoration of pervious landscape features, such as floodplains and wetlands, and structural actions including green roofs.
3. Land use/land cover alterations: Protecting or restoring natural vegetation through land conservation or reforestation or other measures can protect or create a more natural hydrologic regime and minimize soil erosion.
4. Hydraulic/hydrologic waterbody alterations: Riparian wetland restoration may increase infiltration, improve the timing and distribution of flows, and reduce pollutant loads. Dam removal or re-operation may improve the timing of flows, improve sediment transport, and/or restore the natural temperature regime.
5. Conservation in water systems, including leak repair: Installation of water efficient fixtures and other conservation measures, as well as water savings through leak repair, may improve flows or raise water tables.
6. Wastewater treatment: Construction or improvement to existing wastewater treatment plants and treatment wetlands reduce pollutant concentrations and loads.
7. Biologic management: Measures to manage invasive species that affect water quantity or quality may qualify as restoration actions. Management measures may reduce flooding, increase water yield, and in some cases reduce sedimentation or increase dissolved --oxygen concentrations.

8. Water reuse: Beneficial reuse of water for agriculture or other purposes may improve flow regimes due to decreased withdrawal rates, and reuse may also reduce pollutant loads.
9. Rainwater harvesting and aquifer recharge: Capturing rainwater for recharge increases water table elevations and may reduce stormwater runoff.

The first four categories are probably most applicable to Great Lakes watersheds. With that in mind, it makes sense to identify three categories of Great Lakes watersheds that would best test the GLWESS in terms of likely watershed restoration actions and watershed readiness. Therefore, we are seeking to identify three pilot watersheds, one in each of the following three categories:

- Category A: one with high runoff potential and high impact primarily due to agricultural activity and with “high” readiness for action.
- Category B: one with high runoff potential and high impact primarily due to urban activity and with “high” readiness for action.
- Category C: one with watershed problems but with a relatively “low” readiness for action.

In selecting a pilot watershed in Category C, we are aiming to test the feasibility of developing and applying the GLWESS in a watershed that is less prepared to undertake it. This will demonstrate to potential users in the watershed that they do not have to already be advanced in their thinking in order to benefit from the GLWESS process.

Below are described the prioritized candidates for each of these three categories and the rationale for the recommendations. We did not offer any Canadian watersheds as pilot candidates, largely because of the difficulty of getting raw physical data from Canada. It is also likely that we might be seen as intruding on the more advanced watershed planning that has been conducted by most Canadian Watershed Conservation Authorities.

4.1 CATEGORY A: AGRICULTURAL FOCUS, “HIGH” READINESS

There are many watersheds in the Great Lakes basin whose water quality and quantity are impacted by non-point source problems associated with agricultural land uses. That makes this category a very important one to include in our pilot program. It is also important to have success with this pilot program in demonstrating the value and feasibility of watershed restoration actions in Categories 1 and 3 above. Hence, selecting a watershed that has a high degree of social readiness for dealing with known agricultural problems drove our candidate selections in this category.

Our highest priority candidate in this category was the Paw Paw River watershed, which drains into the St. Joseph River in southwestern Michigan. The Paw Paw not only has known agricultural problems, but The Nature Conservancy has already been working with a number of watershed programs there to begin to develop initiatives for addressing those problems. Therefore, this watershed has a high degree of readiness and has already compiled a significant data base to support development of a physical watershed model to inform the GLWESS process.

Our second priority agricultural watershed is one of two HUC-10 basins (Lye Creek or Riley Creek) within the Blanchard River watershed (OH), which is itself a sub-basin within the Maumee watershed. The Maumee River inputs the largest load of suspended sediments and phosphorus to the Great Lakes of any single tributary in the basin. Once again, this is an area with very high agricultural land use and one with a very high degree of social readiness. LimnoTech has just completed developing and applying a watershed model to the Blanchard watershed. Also, in conducting that work we have developed a strong relationship with the NRCS office for that area. We have also developed a relationship with the Blanchard River Watershed Partnership (http://www.blanchardriver.org/), which is a multi-stakeholder group that seeks to address problems and concerns that affect the health of the Blanchard River Watershed.

We have identified two other potential watersheds that meet our criteria for this category. They are: the Crockery Creek basin, which is a tributary to the Grand River in Michigan near its mouth; and the East Twin River (WI), which is a direct tributary to Lake Michigan southeast of Green Bay.

4.2 CATEGORY B: URBAN FOCUS, "HIGH" READINESS

Category B watersheds have been selected to have a preponderance of urban land use problems, which will serve as a test for stormwater management and green infrastructure watershed restoration actions. Another filter in this category is that there is a reasonably high degree of social readiness within the basin.

We have identified four candidates for our pilot in this category, presented here in order of decreasing priority:

- East River (WI) – a HUC-10 watershed that is entirely within the city of Green Bay, WI and flows into the Lower Fox River near its mouth;
- One of the lower urban sub-basins of the Huron River (MI) watershed, which flows into Lake Erie through the southeast Michigan urban complex (we would plan to work with Laura Rubin, Director of the Huron River Watershed Council on this project);
- The Cuyahoga River watershed, which flows into Lake Erie through Cleveland, OH; and
- A sub-basin of the Clinton River (MI) watershed, which also has a significant amount of urban land use and a very active watershed protection group.

4.3 CATEGORY C: "LOW" READINESS

Category C includes a list of three watersheds that have human impact problems that require attention but appear on the basis of our analysis to have a relatively "low" level of social readiness. This category is intended to demonstrate that the GLWESS can work even in watersheds that have not progressed very far along the path of watershed restoration.

We have identified three potential pilot watershed candidates for this category, presented here in order of decreasing priority:

- A sub-basin of the St. Marys River near Sault St. Marie, MI;
- The Bad-Montreal watershed (WI), which drains into Lake Superior; and\
- The Oswego River (NY), which has a moderate level of readiness based on our criteria, but is a Great Lakes AOC and has low head dams (we would plan to work with Kristy LaManche, Program Coordinator, Finger Lakes - Lake Ontario Watershed Protection Alliance (FL-LOWPA) on this system).

5. REFERENCES

Baker, D.B., Richards, R.P., Loftus, T.T., and J.W. Kramer. 2004. "A New Flashiness Index: Characteristics and Applications to Midwestern Rivers and Streams." Journal of the American Water Resources Association, 40:2, 503-522.

Ebert, D.W. and T.G. Wade. 2004. "Analytical Tools Interface for Landscape Assessments (ATTILA) User Guide: Version 2004." Office of Research and Development, U.S. Environmental Protection Agency. Las Vegas, NV, 23 p.

Environment Canada. 2007. "Water Use and Supply Project for the Great Lakes Basin – Summary Report." Internal draft report. April, 2007.

Neitsch, S.L., J.G. Arnold, J.R. Kiniry, and J.R. Williams. 2005. "Soil and Water Assessment Tool Theoretical Documentation: Version 2005." January.

Solley, W.B., Pierce, R.R., and H.A. Perlman. "Estimated Use of Water in the United States in 1995." U.S. Geological Survey Circular 1200. URL: http://water.usgs.gov/watuse/pdf1995/html/.

USDA-NRCS. 1986. "Urban Hydrology for Small Watersheds – Technical Release 55 (TR-55)." 2nd Edition.

USEPA. 2001. "Better Assessment Science Integrating point and Non-point Sources (BASINS) – Version 3.0 User's Manual." USEPA Office of Water. June 2001. URL: http://www.epa.gov/waterscience/basins/b3docs/usermanual.pdf.

USGS. 2005a. "Calculation of Streamflow Statistics for Ontario and the Great Lakes States." Open File Report 2005-1295.

USGS. 2005b. "Base Flow in the Great Lakes Basin." Open File Report 2005-5217.

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APPENDIX A

Summary of Data Sources for Physical Characterization

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Table A-1. Physical Datasets to Support GLWESS Watershed Characterization

Data Category	Specific Datasets of Interest	Country	Source(s)	Format/ Resolution	Comments
Watershed Delineation	HUC-8 boundaries	U.S.	USGS (via NRCS Geospatial Data Gateway)	Polygon shapefile	
	HUC-10/-12 boundaries	U.S.			
	Tertiary watersheds	Canada	Water Survey of Canada (WSC) (via GeoGratis website)	Polygon shapefile	
	Quaternary watersheds	Canada	OMNR – Land Information Ontario (LIO) via Great Lakes GIS	Polygon shapefile	
Land Use/Cover	National Land Cover Dataset (NLCD) – 2001 version	U.S.	USGS (via NRCS Geospatial Data Gateway)	Grid (~30-meter)	
	NHDPlus (2006)	U.S.	NHDPlus website	Overlay of NLCD-2001 dataset on NHDPlus grid	
	National Agricultural Statistics Service (NASS) Cropland Data Layer	U.S.	NASS (via NRCS Geospatial Data Gateway)	Grid (56-meter)	
	Ontario Land Cover Dataset	Canada	OMNR – Land Information Ontario (LIO) via The Nature Conservancy	Grid (25-meter	
Topography (DEM)	National Elevation Dataset (NED)	U.S.	USGS (via NRCS Geospatial Data Gateway)	Grid (~30-meter)	
	Digital Elevation Model - Version 2.0.0	Canada	OMNR – Land Information Ontario (LIO)	10-20 meter	**Not obtained for this project**
Soils	State Soil Geographic Database (STATSGO2)	U.S.	USDA NRCS (via NRCS Geospatial Data Gateway)	n/a	
	Soil Landscapes of Canada - Version 3.1.1	Canada	Agriculture and Agri-Food Canada	Polygon shapefile	
Hydrology	USGS National Water Information System (NWIS)	U.S.	USGS (http://waterdata.usgs.gov/nwis)	n/a	
	Water Survey Canada Hydrometric Network	Canada	Water Survey Canada	n/a	
Climate	"Large Basin Runoff Model" – daily meteorological inputs	U.S. / Canada	Great Lakes Environmental Research Laboratory (GLERL)	Daily precip, air temperature averaged for HUC-8 level watersheds	

Data Category	Specific Datasets of Interest	Country	Source(s)	Format/ Resolution	Comments
-Water Usage	USGS – Water Use in the United States	U.S.	USGS (http://water.usgs.gov/watuse/)	County or watershed (HUC-8) level	
	Water Use & Consumptive Use for Great Lakes Basin	Canada	Environment Canada (per "Water Use & Supply" project)	Tertiary watershed polygon attributes	
Water Quality	NPDES permitted discharge	U.S.	U.S. EPA: *"Enforcement & Compliance History Online"* (ECHO): PCS and ICIS-NPDES databases	Discharger-specific permit information via websites	
	Impaired Waters – 303(d) Listings		U.S. EPA – WATERS Program http://www.epa.gov/waters/data/downloads.html	Polyline/polygon shapefile	
	Permitted discharger information for Ontario	Canada	(unknown)	(unknown)	**Not obtained for this project**

APPENDIX B

Human Impact Metric Maps for Great Lakes Basin

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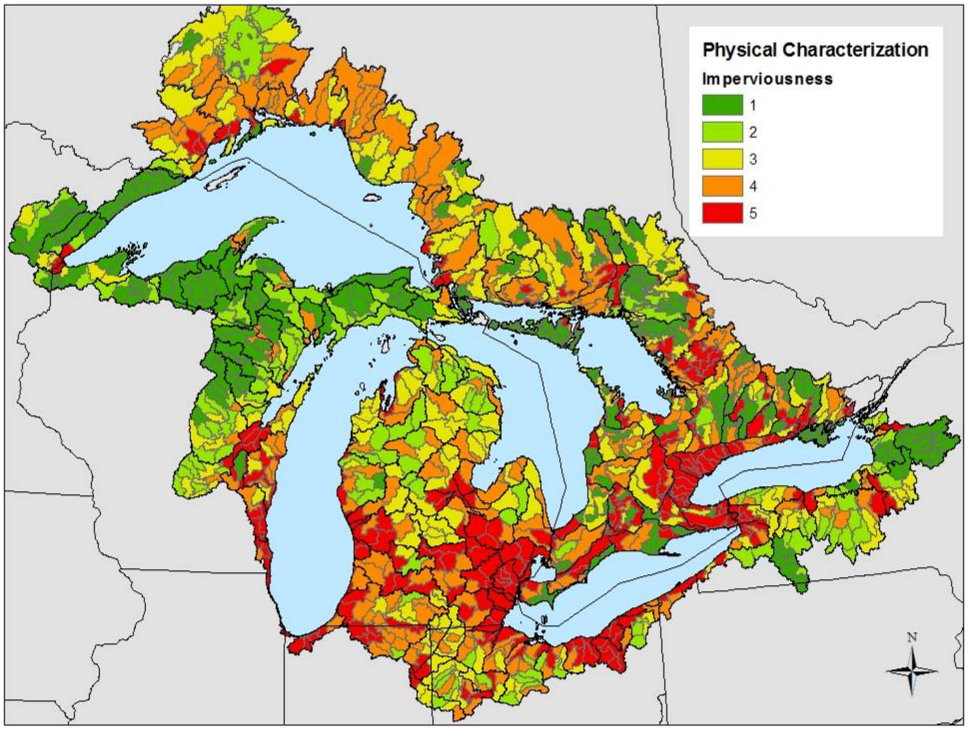

Figure B-1. Scoring Results f-or "Imperviousness" Metric

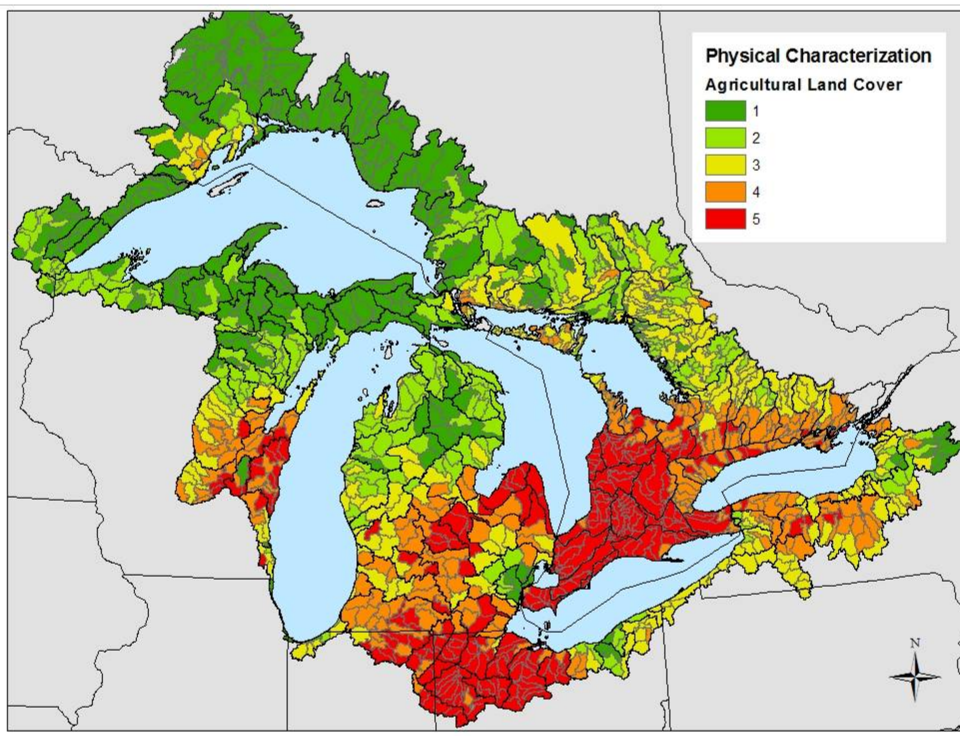

Figure B-2. Scoring Results for "Ag-ricultural Land Use/Cover" Metric

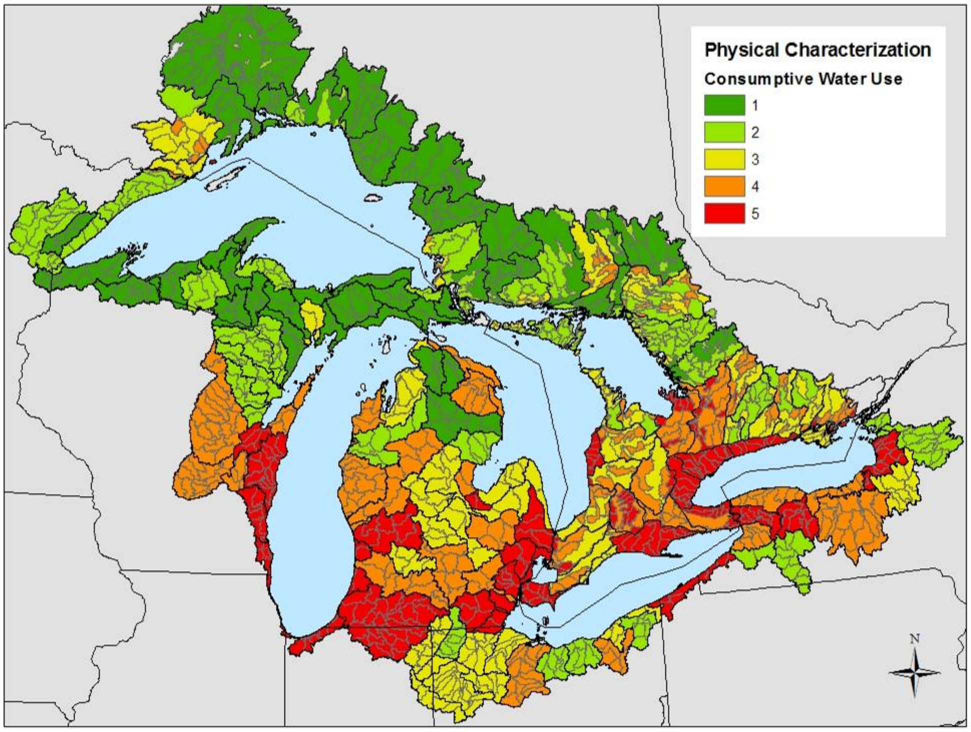

Figure B-3. Scoring Results for "Consumptive Water Use" Metric

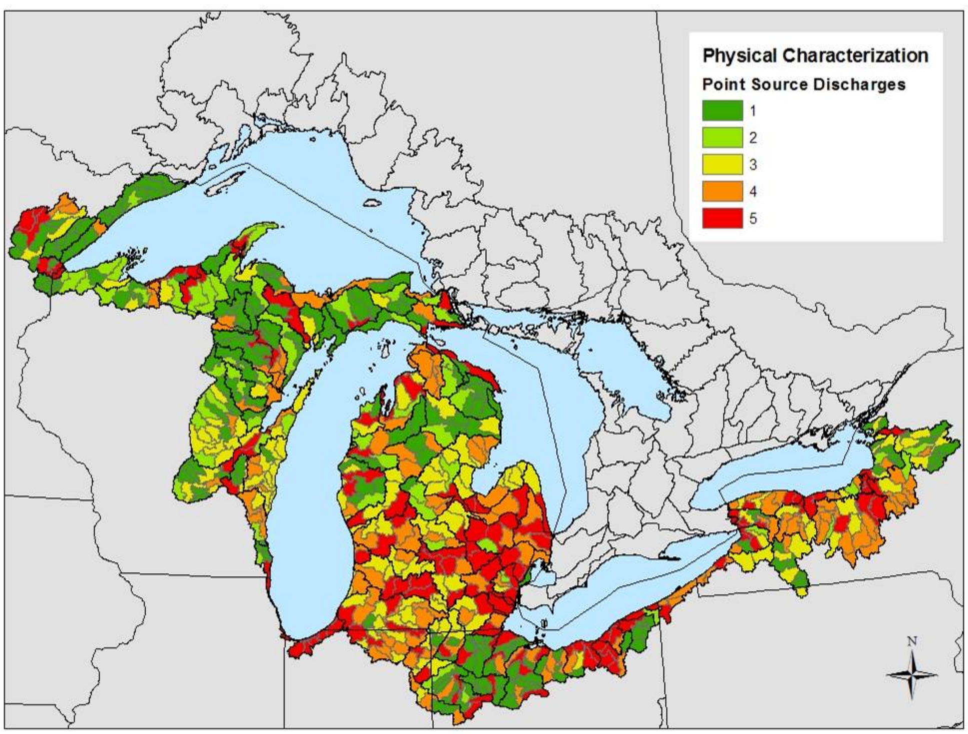

Figure B-4. Scoring Results for "Point Source Discharges" Metric

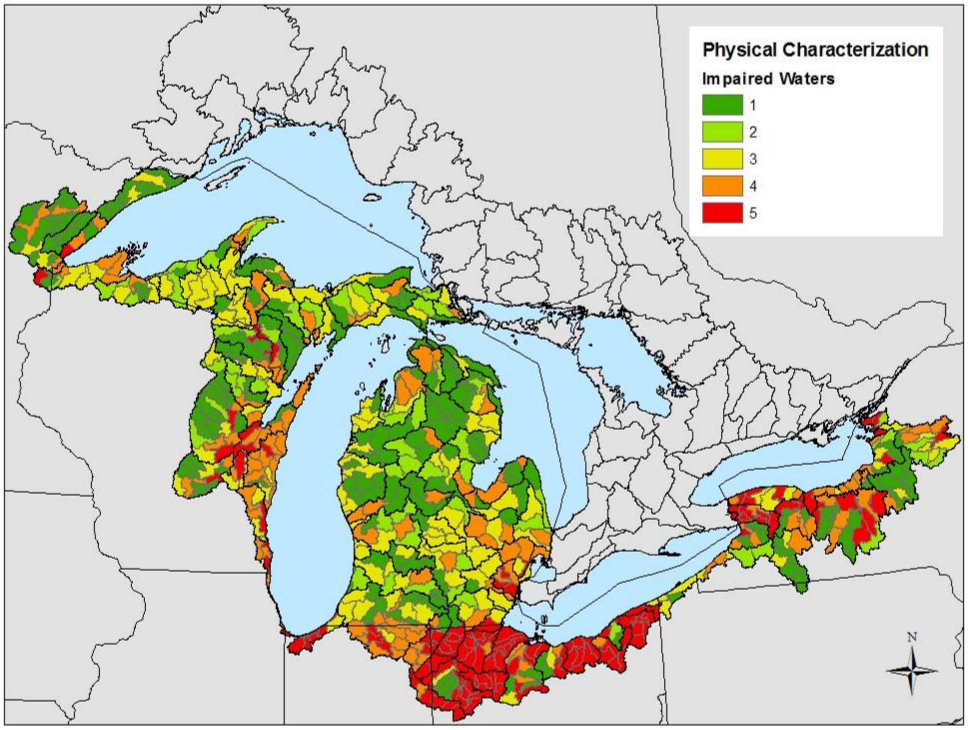

Figure B-5. Scoring Results for "Impaired Waters" Metric

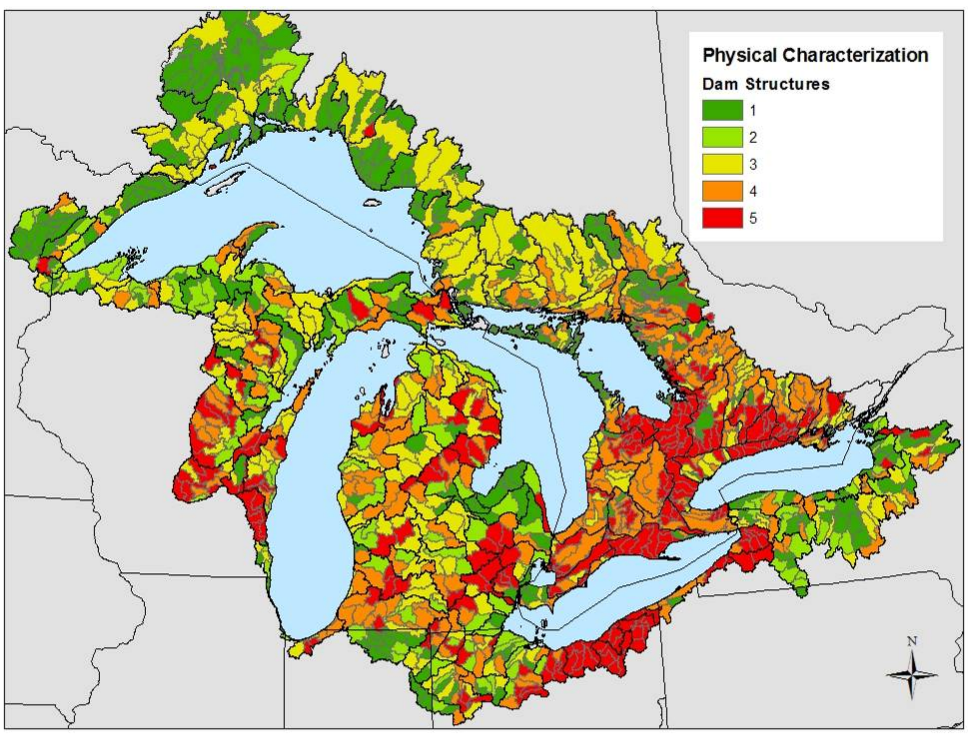

Figure B-6. Scoring Results for -"Manmade Structures" Metric

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APPENDIX C

Great Lakes Basin Physical and Readiness Watershed Characterization Tabulated Results

(Note: Appendix C is provided as a Microsoft Excel spreadsheet that provides a detailed summary of the metric scores for each individual subwatershed area.)

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