INDICATORS IMPLEMENTATION TASK FORCE
Final Report

2000

Indicators
Implementation
Task Force

Report to
the International
Joint Commission

INDICATORS IMPLEMENTATION TASK FORCE

FINAL REPORT

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EXECUTIVE SUMMARY

The Great Lakes Water Quality Agreement of 1978 (Agreement) and its 1987 Protocol, commit the Parties "to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem." Under the Agreement, the International Joint Commission (IJC or the Commission) is charged with monitoring the progress made by the Parties toward this commitment.

In 1993, the IJC established an Indicators for Evaluation Task Force (IETF) to develop a framework within which to evaluate the Parties' progress under the Agreement and assist the IJC in developing advice. The IJC emphasized state-of-the-lake reporting and the consideration of integrative indicators of ecosystem integrity. The IETF 1996 Report, "Indicators to Evaluate Progress Under the Great Lakes Water Quality Agreement," proposed a framework for the Parties to use to provide information upon which progress in meeting the commitments of the Agreement can be assessed. The framework identified nine Desired Outcomes, in part derived from Annex 2, "Impairment of Beneficial Uses," against which to gauge progress.

To assist in implementing[1] the use of indicators, the Commission formed an Indicators Implementation Task Force (IITF) with the following terms of reference.

1. Provide advice on the approach being developed by the Commission to obtain the required data and information to address the nine Desired Outcomes.

2. Provide a linkage between the Desired Outcomes and the development of priorities for the next cycle and the strategic plan of the Commission.

3. Investigate the feasibility of implementing indicators to monitor the Parties' progress under the Agreement.

4. Prepare a final report to the Commission.

This report outlines the work of the IITF between 1997 and 1999. It presents recommendations to the IJC for further action and support for developing indicators to describe the state of the Great Lakes and to measure progress under the Agreement.

1 "Implementation" in this report means "searching for the information necessary and sufficient for measurements and indicators selected to support and define the nine Desired Outcomes, supporting indicator selection and proposing strategies to move the process forward."

DESIRED OUTCOMES AND INDICATORS

The task force examined in detail the Desired Outcomes and indicators proposed by the IETF and considered how these could be implemented.

Indicators for "Fishability," "Swimmability" and "Drinkability"

The IITF recommends that:

- **the IJC, in its Tenth Biennial Report, advise the Parties to operationalize these three Desired Outcomes along with the associated indicators and measurements to report progress under the Agreement, starting in the year 2000.**

Initially, using selected high-use Great Lakes beaches (for Swimmability), water treatment plant data from selected major municipalities in the basin (for Drinkability) and Areas of Concern in lakes Erie and Ontario (for Fishability), the Parties should begin reporting progress in 2000.

In order to avoid misinterpretation of the intent of the "Fishability" Desired Outcome, the IITF recommends that:

- **the "Fishability" Desired Outcome be retitled, "Fish Safe for Human Consumption."**

Other Desired Outcomes

For the "Physical Environment Integrity" Desired Outcome, the IITF recommends that three specific indicators, modified from the IETF proposed indicators, be implemented. These are as follows.

- **Quantity and quality of Great Lakes wetlands.** Wetlands are among the most studied habitat types of the Great Lakes basin. Although a significant amount of information about both Canadian and American wetlands is available, a consistent binational inventory of Great Lakes wetlands is required. There appears to be more information about the quantity of remaining wetlands than about the quality of those wetlands and more emphasis has been placed on coastal wetlands.

- **Quality and quantity of stream base flow in the Great Lakes basin.** Implementing the indicator for stream base flow would address commitments under Annex 16 of the GLWQA.

- **Number and extent of engineered land/water interfaces in the Great Lakes basin.** This indicator addresses two separate issues dealing with anthropogenic manipulation of shorelines and land/water interfaces, leading to changes in the dynamics of natural water flow. The first issue encompasses "true" land/water interfaces such as wharfs, sheet piles, groynes and other engineered shoreline interfaces.

  The second issue deals with the increase in the extent of horizontal impervious/hardened surfaces resulting from increasing urban density (e.g. roofs, airports, parking lots, roads, sidewalks, etc.) This spread of engineered interfaces has led to more artificial landscapes in which hardened surfaces lead to: enhanced runoff due to decreased water absorption into the ground, less groundwater recharge, reduced stream base flow, increased soil erosion, wider and straighter stream channels, and increased water temperatures and salinity, in turn leading to altered aquatic habitat.

All three of these indicators are supported by available monitoring data, and integrate other potential indicators.

For the "Biological Community Integrity and Diversity" Desired Outcome, the IITF recommends that:

- **recognizing the inextricable relationships between living systems and their environs, the Commission should combine the now separated Desired Outcomes of: (a) Biological Community Integrity/Diversity; and (b) Physical Environment Integrity.**

The IITF also recommends that the Commission:

- **encourage the Parties to further the development of the network termed *Biodiversity Investment Areas*, to designate sites as soon as practicable, and to establish monitoring and surveillance programs at these sites to further the understanding of integrity and diversity in the Great Lakes basin. Such monitoring programs should specify the type and the scale of each ecosystem compartment being evaluated.**

Additionally, the IITF recommends that:

- **the IETF Desired Outcome, "Absence of Excess Phosphorus," be changed in response to recent advances in scientific understanding of phosphorus dynamics in large freshwater lakes. The recommended new Desired Outcome is "Return to a Nutrient-Balanced State" and the associated indicators and measurements are:**
  - **hypolimnetic oxygen levels;**
  - **extent of temporal/spatial coverage of undesirable/ harmful algal blooms; and**
  - **amount of nearshore submerged vegetation.**

Both the IJC's Health Professionals Task Force and SOLEC are actively researching the IETF "Healthy Human Populations" Desired Outcome and its associated indicators and measurements.

The IITF therefore recommends that:

- **the IJC continue to be engaged with this important work. It has been the experience of the IITF that the best means of developing and implementing indicators is to engage experts from a broad range of Great Lakes agencies, jurisdictions and disciplines to achieve a consensus. This approach is now being taken by both SOLEC and the Health Professionals Task Force.**

Data and Information Management

Measuring progress in restoring and maintaining "the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem" requires information. Such information must come from careful interpretation of high quality data collected by well-planned monitoring and surveillance programs. The application of any suite of indicators is futile without sustained management of data and resultant intelligence.

In the Great Lakes basin, Canada and the United States, with their state and provincial partners, have amassed much data over the last 27 years – enough data to support the use of indicators to evaluate progress. However, more effort is needed to improve data collection, analysis and reporting because of non-uniform quality and many gaps in existing data sets.

Overall, the task force found that improved data quality assurance/quality control, the further development of the meta database (started by the IITF) and the need to have universal GIS-based reporting of data must be addressed. These efforts would also meet the commitments under Annex 11 to have an integrated approach to basin-wide surveillance and monitoring. Many data sets developed from monitoring the same problem are so diverse as to be incompatible for across-basin comparisons (e.g. contaminants in sport fish – "Fishability").

The Integrated Atmospheric Deposition Network (IADN), established by Environment Canada and the United States

Environmental Protection Agency to monitor the deposition of airborne toxic substances into the Great Lakes, represents an excellent model of how the two countries can work together to produce consistent and comparable monitoring data to support environmental indicators. For example, as part of IADN, the U.S. and Canada have agreed on a common list of chemicals to monitor; data quality objectives; monitoring and analytical techniques; and data storage and reporting protocols.

New partnerships will be necessary for efficient data collection, analysis and reporting. For example, data about some drinking water parameters are collected and stored at the local level, often on a plant-by-plant basis with no reporting requirements to another level of government. Non-traditional networking will therefore need encouragement and support in the development of new partnerships. Assistance in this regard has been offered by the American Water Works Associations' Great Lakes Work Group. Analyses and reporting requirements will need more specific definition to enable the use of these data. Additionally, issues of cost recovery for data and data confidentiality agreements must be addressed

Finally, whatever is reported publically by either Party or the IJC must use indicators that are understandable by technical and regulatory specialists, as well as citizens-at-large. Selecting indicators should result from a balance between those indicators that best measure ecosystem integrity and those to which the public can relate (Can I drink the water, eat the fish and swim safely?). Communication of progress using these indicators and others, as they are further refined, is a key element of indicator implementation and will require careful consideration by the Commission and the Parties.

Recommendations

- **The IJC should advise the Parties that new and focused efforts are needed to correct existing problems with data collection, analyses and reporting. Further, the Parties should explicitly address non-uniform sampling protocols, data quality gaps and quality assurance/quality control inconsistencies in present surveillance and monitoring programs. As well, the IJC should urge the Parties to continue development of a joint meta database and propose that the Parties accelerate data manipulation and portrayal using Geographic Information System (GIS) technology.**

- **The IJC should express concern to the Parties about accessibility of data due to third party confidentiality agreements and cost-recovery policies which contradict the spirit of the Agreement (Article VII).**

- **The IJC should commend the Parties for starting the development of new partnerships through non-traditional networking associated with the joint IJC/Parties' work on "Fishability," "Swimmability" and "Drinkability."**

Long-Term Involvement by the IJC

Recommendations

- **The IJC, in order to meet its commitments specified in Article VII of the GLWQA, commit resources to support the on-going work in the basin on the application, use, implementation and reporting of indicators over the next decade.**

This recommendation is important based on the following information.

- The Parties, through the SOLEC process, are starting a staged implementation of a suite of 80 indicators. They are primarily responsible for implementing the indicators and reporting on progress. SOLEC 2000 will focus on human health issues and will report on the Desired Outcomes "Fishability," "Swimmability" and "Drinkability".

- The Parties will need to modify and, in some cases, initiate new surveillance and monitoring programs to meet the information required to apply the 80 indicators. This Parties' activity should speak to commitments under Annex 11 of the Agreement.

- The Parties must arrange new and very different partnerships (e.g. with local governments and agencies) to implement focussed, coordinated surveillance and monitoring required by the application of the proposed suite of 80 indicators; and

- The Parties need to modify existing information management, storage and portrayal systems (e.g. the use of GIS) to make the application of any indicator effective and understandable by governments and citizens alike.

- **The IJC continue involvement in the process of developing and applying indicators to measure progress under the Agreement.**

This can be achieved by the following.

- Make the indicators implementation process an ongoing IJC priority assigned jointly to the Great Lakes Water Quality Board (WQB) and the Great Lakes Science Advisory Board (SAB).

- Assign a staff member to maintain expertise in the process of indicator development who would:

  - support the WQB and the SAB in meeting their commitments associated with the assigned priority;

  - report to the WQB and the SAB on progress by the Parties to reach consensus on a common set of indicators, on how the Parties are implementing a binational and integrated monitoring program, and where and how the IJC can collaborate with and assess these processes;

  - liaise with the Council of Great Lakes Research Managers, the International Air Quality Advisory Board and Health Professionals Task Force as they might work on indicators; and

  - follow the SOLEC 2000 and 2002 processes and serve on the steering committee as an IJC representative.

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ACKNOWLEDGEMENTS

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1.0 INTRODUCTION

1.1 Background

The Great Lakes Water Quality Agreement (Agreement) of 1978 and its 1987 Protocol, commit the Canadian and U.S. governments "to restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem." Under the Agreement, the International Joint Commission (IJC or the Commission) is charged with monitoring the progress made by the Parties toward this commitment.

In 1993, the IJC established an Indicators for Evaluation Task Force (IETF) to develop a framework within which to evaluate Parties' progress under the Agreement and assist the IJC in developing advice. The IJC directed the IETF to emphasize state-of-the-lake reporting and consider integrative indicators of ecosystem integrity. The IETF reported to the IJC in April 1996 (IETF Report - Indicators to Evaluate Progress under the Great Lakes Water Quality Agreement). The IETF Report proposed a framework for the Parties to use to provide information upon which progress in meeting the commitments of the Agreement can be assessed. The framework identified nine Desired Outcomes, in part derived from Annex 2, "Impairment of Beneficial Uses," against which to gauge progress (Table 1). The Parties, through SOLEC '94, '96 and '98, in reporting on the environmental status of the lakes, used some of the recommendations in the IETF Report.

To assist in implementing these indicators, the Commission established an Indicators Implementation Task Force (IITF) with membership from Agreement Boards and IJC staff with the following terms of reference.

1. Provide advice on the approach being developed by the Commission to obtain the required data and information to address the nine Desired Outcomes.
2. Provide a linkage between the Desired Outcomes and the development of priorities for the next cycle and the strategic plan of the Commission.
3. Investigate the feasibility of implementing indicators to monitor the Parties' progress under the Agreement.
4. Prepare a final report to the Commission.

1.2 Definitions

In this report, the following definition is used for an indicator.

> *"An indicator provides a clue to a matter of larger significance or makes perceptible a trend or phenomenon that is not immediately detectable. An indicator is a sign or symptom that makes something known with a reasonable degree of certainty. An indicator reveals, gives evidence, and its significance extends beyond what is actually measured to a larger phenomenon of interest."* (IETF 1996).

The U.S. Intergovernmental Task Force on Monitoring Water Quality (ITFM) defined an environmental indicator as a:

> *"measurable feature which singly or in combination provides managerially and scientifically useful evidence of environmental and ecosystem quality, or reliable evidence of trends in quality."* (ITFM as cited in IETF 1996).

Table 1
Desired Outcomes for the Great Lakes Basin Ecosystem (IETF 1996)

1.	Fishability	There shall be no restrictions on the human consumption of fish in the waters of the Great Lakes basin ecosystem as a result of anthropogenic (human) inputs of persistent toxic substances.
2.	Swimmability	No public bathing beaches closed as a result of human activities or, conversely, all beaches are open and available for public swimming.
3.	Drinkability	Treated drinking water is safe for human consumption; human activities do not result in application of consumption restrictions.
4.	Healthy Human Populations	Human populations in the Great Lakes basin are healthy and free from acute illness associated with locally high levels of contaminants or chronic illness associated with long-term exposure to low levels of contaminants.
5.	Economic Viability	A regional economy that is viable, sustainable and provides adequate sustenance and dignity for the human population of the basin.
6.	Biological Community Integrity and Diversity	Maintenance of the ability of biological communities to function normally in the absence of severe environment stress (ecosystem health) and to cope with changes in environmental conditions which impose stress, i.e. to be able to maintain their processes of self-organization on an ongoing basis (ecological integrity). Maintenance of the diversity of biological communities, species and genetic variation within species.
7.	Virtual Elimination of Inputs of Persistent Toxic Substances	Virtual elimination of inputs of persistent toxic substances to the Great Lakes system.
8.	Absence of Excess Phosphorus	Absence of excess phosphorus entering the water as a result of human activity.
9.	Physical Environment Integrity	Land development and use compatible with maintaining aquatic habitat of a quantity and quality necessary and sufficient to sustain an endemic assemblage of fish and wildlife populations.

The IETF Report also proposed a Framework to Evaluate Agreement Progress (Figure 1).

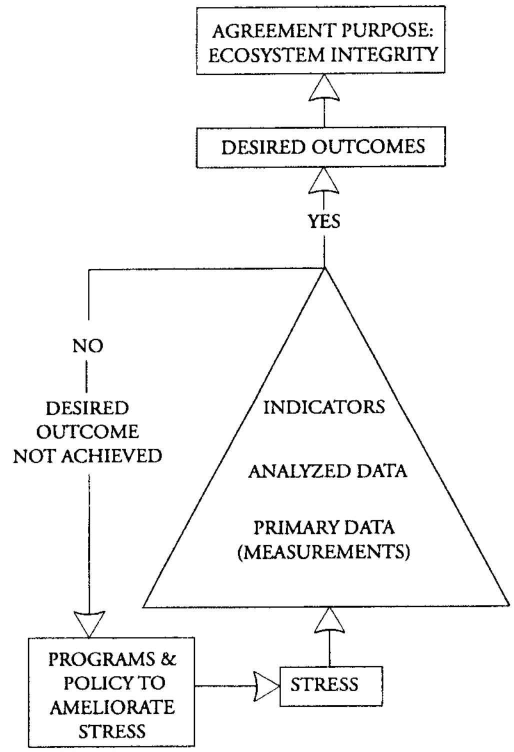

Figure 1
Framework to Evaluate Agreement Progress

1.3 Guiding Principles

IITF suggests the following guidelines for the selection of indicators.

1. Indicators must be definable in the same manner by all parties. They should be standardized, using accepted terminology easily understood by the public.

This definition is particularly useful when the "measurable feature" is associated with an explicit goal or desired outcome. Environmental indicators encompass a broad suite of measures, including tools for assessment of chemical, physical and biological conditions and processes at several scales.

The word "indicator" has been generally missing in ecological literature until only very recently. Harris and Scheberle (1995) reviewed 12 recent college ecology text books and found only one that presented a broad discussion of the term as it is being used today. Other sciences, including the social sciences, have more commonly used indicator concepts and terminology.

2. Indicators must include metrics that are measurable, using accepted scientific techniques consistent and reasonable with the practices currently being carried out by those in natural resources fields.

3. Indicators must be selected with the assumption that there are hundreds of potential indicators that would be equally plausible. The selection of specific indicators represents a best attempt to select those that will adequately measure environmental health and the progress of programs toward this goal.

2.0 TASK FORCE ACTIVITIES

2.1 Research of Great Lakes Databases

2.1.1 Scope

The IITF initiated a "Pilot Study" in 1997 to:

1. find information to support the IETF framework (i.e. to collect information about the kind of data that are currently being collected in the Great Lakes basin ecosystem (the basin) which could be used to support the proposed indicators/measurements), and

2. assess the feasibility of implementing indicators and measurements for evaluating the Parties' progress toward achieving the nine Desired Outcomes for the basin.

The Pilot Study progressed through several phases and incorporated the work of various researchers. Over time, its methodology and scope were modified to reflect the lessons learned by the researchers who were attempting to identify data collection activities in the basin. In particular, the researchers were looking for information that could be used to support the IETF indicators and measurements. While the Pilot Study originally focused on locating information for lakes Superior and Erie, these boundaries were subsequently expanded to include the activities of agencies in Ontario, Wisconsin, Minnesota, Michigan, Illinois, Indiana and Ohio.

2.1.2 Methodology

2.1.2.1 The Criteria

The IITF identified 17 criteria for the assessment of both the data and data support systems for indicators and Desired Outcomes. The criteria was derived from the "Criteria for Scientific Completeness" identified by the Indicators for Evaluation Task Force (IETF 1996, p.11). The assessment covers three levels in the framework illustrated in Figure 1. These levels are primary data (measurements), analyzed data and indicators. Within this framework, the criteria are meant to:

- assess the format, quality, availability and relevance of primary and analyzed data;

- assess the contribution by the data to support the associated indicator(s); and

- assess the indicator's feasibility and suitability for assessing progress toward achieving the Desired Outcome.

The criteria are multi-functional (Table 2). Criteria questions are guides for gathering information about individual datasets. The criteria are also instrumental in comparing the relative merits and suitability of datasets for supporting an indicator. Finally, the criteria can be used to form a picture of how adequately each indicator or Desired Outcome is supported by data, and to reveal which indicators support more than one Desired Outcome.

In acknowledgement of this multi-functionality, the 17 criteria were categorized to clarify their application to the Pilot Study at each of the three levels: primary data, analyzed data and indicators. The five criteria categories were temporal coverage, geographic coverage, acquisition, scientific and utility questions.

Table 2
Revised Criteria

BASIC QUESTIONS

Name of Database
Responsible Agency
Indicator(s) and and Desired Outcome(s) of Relevance
Contact Name and Number

Temporal Coverage
- Over what time are data collected?
- At what frequency are measurements made?
- Is monitoring projected to continue?
- Can historical trends in the data be tracked?

Geographic Coverage
- Over what area are data collected?
- Are data collected for Lake Erie and Lake Superior?
- Where are the specific sites of data collection?
- Which jurisdiction and/or agency is collecting the data?

Acquisition
- What are the costs associated with acquiring the data?
- What are the estimated costs of making data compatible, if they are not?
- Are the data in electronic form?
- Is the data format suitable for GIS application?
- If data are already in GIS format, what software is used?
- Where are the data located?
- Are the data available without restrictions on their use?
- If applicable, are the critical eleven toxins covered?

SECOND ROUND QUESTIONS

Scientific Criteria
- Are the data scientifically valid?
- Can reference or target values be identified or established?
- What is the quality of the data; can confidence be placed in them?
- Are data measurements sensitive, i.e. without an all or none response or extreme natural variability?
- Are the data measurements integrative, i.e. possessing the capacity to combine diverse information?

Utility Criteria
- Are measurements taken and data processed quickly enough to initiate effective action?
- Can the data provide an early warning, an indication of change before serious harm has occurred?
- Are data applicable to more than one indicator or Desired Outcome?
- How easily can data be adapted to this exercise when they were originally collected for other purposes?
- Are data adequate to assess progress?

INDICATOR QUESTIONS

- Is the indicator sensitive, i.e. without an all or none response or extreme natural variability?
- Is the indicator integrative, i.e. possessing the capacity to combine diverse data and information?
- Is the indicator timely, i.e. providing data and information quickly enough to initiate effective action?
- Is the indicator anticipatory, i.e. capable of providing an early warning, an indication of change before serious harm has occurred?

2.1.2.2 The Matrix

A matrix was constructed to describe minimally each data set:
- title
- years of coverage
- geographical extent
- brief description
- format (electronic, paper, etc.)
- costs to acquire or use the data
- contact personnel

The basis of the matrix was a SOLEC 1996 survey (Leger and Greenwood,1996) to identify nearshore databases and information holdings for the Great Lakes in Canada and the United States. The original SOLEC '96 matrix was augmented by datasets suggested by the IITF.

2.1.2.3 Complexity

Research was done on eight of the nine IETF Desired Outcomes; the exception was *Economic Viability.* There is a vast amount of data, research and academic study to support the use of indicators to measure environmental health. A number of factors made the review difficult and complex. Among these were:

1. jurisdictional complexity of the basin. Many different government and non-governmental agencies are involved in on going data collection activities;
2. range of issues needing quantification for each Desired Outcome;
3. wording of the IETF indicators. The wording of many of the indicators (e.g. "quantity and quality of habitat") was not clear enough to facilitate data collection efforts;
4. evolution of the proposed indicators/measurements. New indicators/measurements are constantly being proposed;
5. number of diverse datasets pertaining to a single topic;
6. difficulty of locating the responsible database managers in each jurisdiction. Some large agencies are not always aware of the data that they are collecting and compiling;
7. inconsistent Internet formats, terminology and structure made this method of data collection time consuming and difficult;
8. *incompatible sampling protocols.* In many cases, data about the same subject were not compatible due to differences in sampling protocols; and
9. lack of a comprehensive surveillance and monitoring framework.

2.1.2.4 Catalogue of Great Lakes Databases

The catalogue is a compilation of the most recent information available for particular databases (Morrison 1999). No attempt was made to standardize the format or fully verify this information. The catalogue must be therefore considered a draft document.

At a minimum, each entry includes a brief description of the contents of the database and the database contact information. The catalogue is currently in paper form, organized alphabetically by database name, and contains 581 records. In addition, the spreadsheets containing the information compiled by Leger and Greenwood (1996) for the 1997 "Information and Information Management" SOLEC Background Paper have been included in their entirety. SOLEC 2000 will continue to amend and incorporate this catalogue.

2.1.3 Findings

A number of federal, state, provincial and local government agencies and other organizations provided information and data. Major sources are listed in Table 3.

The IITF identified databases and other sources of information that could be used to support the proposed indicators program and task force findings. The task force encountered difficulties related to incompatible sampling protocols and different reporting formats used by agencies in the basin. Additionally, access to data often was restricted due to confidentiality agreements with providers or were only available on a cost-recovery

Table 3
Key Agencies, Organizations and Partnerships

U.S. Federal	Canadian Federal	NGOs
Environmental Protection Agency	Environment Canada	The Nature Conservancy
U.S. Fish and Wildlife Service	Health Canada	The Audubon Society
U.S. Army Corps of Engineers		Ducks Unlimited
National Resource and Conservation Service		The National Wildlife Federation
Sea Grant Programs		The Natural Resources Defense Council

basis (e.g. Stats Can). Further, a lack of uniform data quality and gaps in sampling and analysis complicate progress. Surveillance and monitoring activities differ across the basin and are not guided by clearly defined strategies.

There are temporal and spatial gaps in the data supporting indicators and measurements. For example, data for the 11 critical persistent toxic substances are uneven and site specific. Gaps also are present in data documentation, or metadata.

To solve this problem, for example, for Desired Outcome "Biological Community Integrity and Diversity," selecting indicators and accompanying measurements would be facilitated by clearly defining their scope and developing and reaching consensus on definitions for the terms *Integrity* and *Diversity*.

General Findings from the Study of Other Indicator Initiatives (see Appendix "A")

Several international agencies stated that, in order to implement successful indicators strategies, the following suggestions should be followed:

- unprecedented collaboration must become the norm to allow for real improvement;
- an internationally supported framework must be developed to provide a "common language" and to facilitate interagency communication;
- indicators are needed which are "necessary and sufficient" for local needs;
- indicators must be tied to specific goals and objectives. Targets add an easily interpreted element to this process which clearly demonstrate progress toward goals;
- this work must be continually monitored and updated as new issues emerge;
- managing databases in an efficient and standard manner is absolutely critical;
- frameworks need to be geared to policymakers and the public at large; and
- indicators must be placed within a proper context or risk misinterpretation.

2.2 Workshop on Indicators of Integrity and Diversity of the Great Lakes Basin Ecosystem, 1998

According to Angermeier and Karr (1994), the terms *biological integrity* and *biological diversity* are widely used by the media, citizens, policymakers and some biologists without adequate attention to the concepts they embody. For the IITF, which is tackling the even larger concepts of *ecosystem integrity* and *ecosystem diversity*, this lack of attention must be addressed. Both ecosystem integrity and ecosystem diversity are strictly scale-dependent concepts. In this workshop, which used an ecological rationality, focus was on integrity and diversity at the scale of the entirety of the Great Lakes ecosystem as defined by various criteria for observation. There is an urgent need to entify the Great Lakes ecosystem by these explicit criteria, and by others, so as to allow the defining of ecosystem integrity and *ecosystem diversity* within each of those logical types of description. Defining integrity and diversity for the Great Lakes ecosystem is a step that must be taken before headway toward those ideals may be measured using indicators. Progress on the development of indicators to describe the Desired Outcomes *Physical Environment Integrity* and *Biological Community Integrity and Diversity* requires a better understanding of the various types of ecosystems, as that understanding will give a particular meaning to the terms *ecosystem integrity* and *ecosystem diversity*.

Aided by six preliminary presentations and a commentary by IJC Commissioner Susan Bayh, the workshop participants proposed many potential indicators of integrity and diversity. However, as with previous attempts to devise environmental indicators, the group noted that the data for the indicators ranged in state of consolidation, from a high level to no decision on even the parameters for determining what information needs to be collected. The participants concluded that the following questions should be used to scrutinize the utility of each prospective indicator.

- Is the indicator measurable? If so, what is the measurement and its unit?
- Does the indicator characterize the Great Lakes basin ecosystem in its entirety?
- If the indicator is a surrogate for direct measurement, is there a body of knowledge that supports its relationship to integrity or diversity? Participants observed that most of the listed indicators were surrogate measures of diversity as opposed to direct measures of diversity.

2.3 1998 Great Lakes-St. Lawrence Mayors' Conference

At this conference, the IJC emphasized the need for coordination among the IITF and SOLEC initiatives. The IJC needs information to indicate progress toward the general goals outlined in the Agreement and the IETF framework provides a useful tool to organize this information. Since an increasing amount of the information base for this framework is being, or has been, shifted to the municipal/local government levels, there is an even greater need for coordination and for formation of non-traditional partnerships to collectively measure progress under the Agreement.

2.4 State-of-the-Lake Ecosystem Conference, 1998. IITF Breakout Session on Implementing Indicators

During this session, the IITF focused discussion on the potential indicators: *PCBs in Lake Trout*, which supports both the Fishability and Virtual Elimination of PTS Desired Outcomes, and *Boil-Water Orders*, which supports the Drinkability Desired Outcome. These two indicators were used because they represent, respectively, indicators for which data are primarily collected at the provincial/state and federal levels of government, and indicators for which the data are collected locally.

Participants were asked to identify the tasks involved in developing an indicator in the Great Lakes basin. Participants were asked not to debate the merits of the two indicators but, instead, were to treat them as though they had been adopted by the IJC and were to be implemented.

General observations from the SOLEC '98 session.

1. An indicator must be responsive to public needs.
2. The Desired Outcomes should be better communicated to the public.
3. The matter of scale is important. The loss of specific information in basin-wide reporting is significant as many issues are highly relevant to local populations. The public makes decisions (i.e. Can I drink the water? Eat the fish?) that are based on information about local conditions.
4. Tension exists between the "top-down" and "bottom-up" approaches to selecting indicators (i.e. basin versus local).
5. Agencies have ownership of the data they collect. However, lateral and vertical information transfer needs to be encouraged.
6. The IJC indicators must be compatible with those of SOLEC.
7. Panels of experts should be assembled to further progress on measurement and interpretation of proposed indicators.

Participants recommend that SOLEC be used as a forum to develop further approaches to developing indicators, since implementation will be the responsibility of the Parties.

2.5 Technical Review of the June and October 1998 and May 1999 SOLEC Draft Reports

The IITF review of the above documents contributed to the modification of the SOLEC indicators database, allowing it to be sorted by the IETF proposed Desired Outcomes and by the annexes of the Agreement. In addition, the IITF sent its progress report to SOLEC including its Catalogue of Great Lakes Databases. SOLEC provided both personnel and money to support and further the work of the IJC. The compatibility of the two indicator efforts is highlighted by the potential for the development of common measurements that could then be used to support indicator efforts of both SOLEC and the IJC.

The SOLEC organizers have used IITF documents as a major source for the compilation of the SOLEC indicators for Great Lakes basin ecosystem health. As well, the IITF Catalogue of Great Lakes Databases has become a unique resource and a valuable addition to the databases which support SOLEC indicators.

2.6 The International Association for Great Lakes Research Conferences, 1998 and 1999

At the 1998 conference in Hamilton, Ontario, the IITF presented a paper entitled *Pilot Study Experiences for Implementing Indicators of Ecosystem Integrity in the Great Lakes Basin.*

In 1999, the IITF presentation Indicators to Evaluate Progress under the Great Lakes Water Quality Agreement focused on the challenges associated with achieving consensus on a suite of indicators, measurements and reporting formats by highlighting three Desired Outcomes: *Swimmability, Fishability* and *Drinkability* and the relationship of IITF to the SOLEC process. The need for more co-ordinated data gathering activities in the Great Lakes basin was underlined, and focused workshops co-sponsored by SOLEC was discussed as a means of working toward indicators implementation.

2.7 Great Lakes Commission Online GIS Workshop, 1998

Members of the IITF participated in this conference because of its relevance to implementing indicators in the Great Lakes and to potentially co-sponsoring a Geographical Information Systems (GIS) Congress related to use of GIS in managing, analyzing and visualizing indicators databases.

The workshop assembled GIS experts to provide guidance to the Great Lakes Commission in initiating a new project entitled Great Lakes GIS Online. The project's goal is to develop a spatial data library for the Great Lakes and to provide timely access to this information by providing the information over the Internet via the Great Lakes Information Network. If successful, this project could provide a vehicle by which the Parties can share their data with the Great Lakes community and the world.

Working sessions covered topics including: consistent coverages and data production; data access, data sharing and data limitations; visualizing Great Lakes ecosystems; and collaborative initiatives. The need for planning and coordination among all participating organizations has to occur prior to collecting data and building the database and analysis system. This process is consistent with the recommendations of the task force in this area. Other messages include: 1) good quality assurance/quality control for data and good metadata are essential; 2) always define the questions and the audience before beginning; and 3) involve and receive buy-in from policy makers at beginning of the project.

2.8 Drinkability Workshop, August 24-25, 1999

This workshop, co-sponsored by U.S. EPA, Environment Canada and the International Joint Commission, gathered together two dozen experts on drinking water standards, treatment and delivery. The workshop hosted presentations from municipal, state, federal and provincial agencies who are responsible for drinking water quality in the Great Lakes basin.

The workshop heard about the evolution of the U.S. Safe Drinking Water Act, from its inception in 1974 to the latest amendments of 1996. The evolution was long and somewhat difficult, and more work is still needed. There is no similar federal legislation in Canada. Instead, there are national drinking water guidelines developed co-operatively with provincial governments. For Ontario, the Ministry of Environment uses the Ontario Water Resources Act (MOEE 1994) to regulate drinking water quality.

Monitoring programs for drinking water in the Great Lakes basin are not comparable. Differences occur because of different legal mandates; different parameters are more important to some jurisdictions than are others; sampling protocols vary widely; and much of the data and information are only available at each treatment plant, rather than in a binational data base. As well, most data collected at each treatment plant are measures of quality of raw water and relatively less information is collected for finished water quality.

Most problems associated with drinking water quality, especially boil water orders, are the result of deteriorating or damaged distribution infrastructures and not the result of inadequate treatment in a plant.

Improperly situated raw water intakes are also of concern.

Responsibility for the quality of finished drinking water varies across the basin amongst federal, provincial, state, county and municipal governments.

The local water treatment representatives at the workshop proposed that the IJC and the Parties emphasize the need for more attention to the quality of the raw water, and the issue of its treatability.

Assistance in the continuing IJC/SOLEC efforts to refine raw water quality indicators and measurements has been offered by the American Water Works Association Great Lakes Work Group.

2.9 1999 Great Lakes Water Quality Forum Session on Indicators

The session at the 1999 Great Lakes Water Quality Forum, "Moving Ahead with Indicators: Benefits, Challenges and Future Directions," provided an update on the progress of indicator selection by the task force. At the same time, the session explored what factors lead to the successful use of indicators in other places. Officials from local, state, national and regional governments and organizations detailed their experiences regarding the development of indicators and the subsequent incorporation of indicators into public programs.

The recommendations from these officials was remarkably similar and are summarized in Table 4. Most notably, lessons about the use of indicators in other situations suggest that it is unlikely that the "perfect" indicator or suite of indicators will be chosen in the initial selection process. Thus, it is more important to gain consensus about the usefulness of indicators than it is to search for the best indicator. A second key

Table 4
Summary Points About the Successful Use of Indicators

Development of indicators

- *Understand that the development of indicators is a "work in progress."* It is very unlikely that all of the indicators chosen will ultimately be the best ones to use. One presenter commented that about two-thirds of the indicators chosen needed some revision (and, in some cases, needed to be eliminated).
- *Recognize the importance of getting started.* Scientists and policy makers could look forever for the perfect suite of indicators. Setting a deadline to have indicator selections made will help move the process along.
- *Base indicator selection on what citizens can understand.* It's a balance between what indicators are the best measures of ecosystem integrity and the ones to which the public can relate. Indicators need to be understandable in order to be communicated.
- *Involve people in the process of indicator selection.* Ask them what their visions are for the ecosystem you are evaluating. Base indicator selection on what the public desires for the future state of the system.

Once indicators are selected

- *Set short term targets and long term goals.* Indicators mean nothing without goals in mind. If goals are too long-term, however, it's hard to generate enthusiasm for the indicator process. Therefore, a series of short-term achievable targets should be a priority for any indicator process.
- *Be honest in communicating progress (or the lack thereof).* If conditions have gotten worse, say so. On the other hand, look for opportunities to report positive change. When conditions improve, be sure to communicate that as well.
- *Communicate with the public in ways that are easy to understand.* Many presenters have an annual report with simple communication regarding indicator progress. All presenters had public forums to communicate progress.
- *Indicators require a long-term commitment by government.* Don't underestimate the need for resources and for the people who collect the data used to report indicator progress to support the program.
- *Use partnerships whenever and wherever possible.* Look for ways to work with professional organizations, other governments, private entities and citizens to make the program operate more efficiently and effectively.

observation is that indicators are meaningless without long and short-term goals attached to them. Short-term goals include measurable, quantifiable targets that are easy to communicate and to understand. Finally, indicators and goals must be communicated to the public in meaningful ways.

2.10 "Swimmability" Workshop, October 1999

The joint IITF/SOLEC Swimmability workshop was held in conjunction with the U.S. EPA East Coast Regional Beach Conference on October 19-20, 1999. Approximately 225 delegates participated in presentations and discussions concerning the use of indicator organisms for beach closings, rapid analytical methods, trends in recreational water quality exceedences and related issues.

With over 750 public beaches, the Great Lakes are an important resource for recreation, including activities such as swimming and sail boarding that involve body contact with the water. Apart from the risks of accidental injuries, the major human health concern for recreational waters is microbial contamination by bacteria, viruses and parasites. Gastrointestinal disorders and skin, eye, ear, nose and throat infections have been associated with microbial contamination of recreational waters.

The primary tool to evaluate beach water quality is the measurement of fecal indicator organisms. When levels in beach water exceed established guidelines, public beaches are posted with signs warning bathers. The two indicator organisms most commonly used to measure bacterial levels in fresh water beaches are fecal coliforms and *Escherichia coli (E. coli)*. Although there are many jurisdictions that currently use fecal coliform measurements, the trend in Canada and the United States is to adopt *E. coli* as the micro-organism of choice for monitoring freshwater beach quality. Ontario has been using *E. coli* since 1992 and in the United States, the "Action Plan for Beaches and Recreational Waters" (U.S. EPA 1999) will require the states to adopt *E. coli* measurements into their state water quality standards by 2003. Consequently, *E. coli* data will become more readily available over time as the technology for measuring this organism improves and as more jurisdictions adopt it for assessing beach water quality.

Beach postings can be useful in tracking beach water quality. However, beaches may be posted for reasons other than microbial contamination, for example, algae, chemicals or physical hazards. In some cases, presumptive closings may occur until confirmatory tests are completed. In other instances, beaches are permanently posted in areas where it is not possible, for economic reasons or otherwise, to post beaches with temporary signs when impairments occur.

Notable observations included:

- The goals of the U.S. Clean Water Act are fishable and swimmable waters. The cause of recreational water impairment is most often human and animal fecal matter. Worldwide, millions die every month from diarrhea and gastroenteritis caused by ingesting water or food tainted with feces. It was noted that chlorinating sewage treatment plant effluent will often kill indicator bacteria but not viruses and some pathogens (i.e. cryptosporidium cysts).

- A single Canada Goose produces a pound of feces/day; therefore, large resident flocks can be the cause of regularly closing beaches. Because geese often consume cattle manure, which may contain *cryptosporidium* cysts, the parasite is often included in their feces (Olson, et al. 1999).

- Caffeine is a potential inorganic indicator of human fecal contamination. Mass spectophotometry is used to analyze for caffeine. The analysis is quick, routine and inexpensive. A combination of chemical (caffeine) and biological (E. coli) indicators should give reliable results.

- California has introduced three beach warning levels – Advisories, Postings and Closings, but there is no consistent system for beach designation nationwide. Monitoring is often conducted on a county by county or municipal basis. As beach water monitoring increases, the number of exceedences also will increase, as was noted in California due to new state-mandated standards.

- The deep tunnel project in Milwaukee, as well as storm water, retention ponds and tanks in Toronto and Hamilton have resulted in many more beaches open for more days during the swimming season.

- New York City never closes beaches on hot days because the crime rate escalates; officials would rather risk an outbreak of gastrointestinal discomfort than more crime.

- In the Cleveland Metro area, recreational water sampling is done between 6-9 a.m. at a depth of 18 inches. A significant correlation exists between turbidity, increased wave height, antecedent rainfall, and high waste water treatment plant flows with incidents of high *E. coli* concentration in recreational water. Beach closing forecasts are therefore often published on the weather forecast page in local newspapers.

- Very susceptible toddlers play in water depths of 6 to 12 inches in the "swash" zone, where turbid water and re-suspended pathogens are more common. Recreational water monitoring samples are ordinarily taken in one to three feet of water.

- Monitoring, using traditional sampling and 48-hour testing protocols, is always too late. Most jurisdictions, therefore, use a long term history of testing to determine problem beaches and then key on those. Many jurisdictions begin monitoring before the season starts to designate potential problem areas.

- Bacteria counts are often higher in the early morning on beaches because later in the day they are killed by UV in sunlight. Usually there are more beach closures in August and September than in June and July.

- *E. coli* counts are often 6 - 10 times higher in one foot deep sand on a beach (due to the incubation effect and protection from UV radiation) than in the adjacent water; sand castle building, therefore, is risky.

- Currently there are 580 designated bathing beaches on the U.S. side of Great Lakes of which about two thirds are monitored.

- The beach postings data (Figure 2 and Table 5) for Lake Ontario beaches in the Toronto region are an example of how such data can help assess trends in beach water quality (Gauthier 1999). The length of the swimming seasons from 1994 to 1999 ranged between 87 and 98 days. Although *E. coli* measurements were not taken every day of the swimming season, postings at these beaches were usually related to bacterial levels exceeding guidelines either from direct measurements of *E. coli* or from levels expected to exceed guidelines based on historical patterns and experience following weather events such as wind and precipitation. Beach closings, expressed either as the number of days posted or the percentage of the swimming days posted, varied greatly between beaches and from year to year at any given beach.

In conclusion, these data suggest that a useful indicator of "swimmability" on the Great Lakes might include two components. First, a statistic showing the number of beach water quality exceedences, normalized for monitoring effort. This would prevent changes in monitoring frequency from artificially influencing the condition indicator. Second, a statistic should be derived showing the number of "beach-user" days which were lost relative to the total number available. Similar statistics are generated in the National Park Service to show park utilization and recreation rates. For the 1999 data shown on Table 5, the average Toronto Lake Ontario beach was closed 41% of the 92-day swimming season last summer. Assuming 500,000 beach user days, this closure rate represents a loss of over 200,000 user days.

2.11 "Fishability" Teleconference, November 1999

The IITF and SOLEC co-chairs organized a teleconference on November 1, 1999 to discuss the feasibility of implementing the proposed indicator for the desired outcome "Fishability" as related to human consumption of fish. Representatives of all Great Lakes management agencies involved in issuing advisories in Canada and the U.S. participated. The following are some of the main points that emerged.

- We could look at some kind of summary on advisories, a comparison between five to 10 years ago and now, but if you look at the difference between 10 years ago and now, you are going to find more advisories rather than fewer.

- We could, for example, report on how many walleye in Lake Erie had unrestricted consumption, how many had some kind of restriction, how many were totally banned, and report every two years. Will this provide any sort of trend toward the desired outcome of zero advisories?

- However, the consensus on the call was that fish advisories alone will not be a good indicator; contaminant trend data are equally important.

Therefore, participants recommended the following two-tiered approach:

1. state information as number of restrictions partial restrictions or unrestricted; compare a couple of years of information and also look at trend data; use lake trout and walleye and whatever forage fish for which there are data; do this for lakes Ontario and Erie; and

2. use indicator chemicals such as PCBs and DDT, and at least one or two metals, including mercury, reporting on selected areas of a lake.

The indicator would consist of two parts: summarized advisories, and data for each species for each compound and for each geographic area.

- All the data will not be available or analyzed for SOLEC 2000, but likely will be for SOLEC 2002.

- SOLEC agreed to continue with the development of this indicator by hosting a workshop in mid- 2000.

Table 5
Six Year Summary of TORONTO BEACH POSTINGS, 1994 - 1999
(Adapted from Gauthier 1999)

Beach	Days Posted (percentage)					
	1994	1995	1996	1997	1998	1999
Etobicoke**						
Amos Waites Park						82 (89%)
Col. Samuel Smith East						57 (62%)
Col. Samuel Smith West						36 (39%)
Humber Bay Park East						7 (8%)
Marie Curtis Park East						54 (57%)
Marie Curtis Park West						55 (60%)
Scarborough**						
Bluffer's Park Beach						88 (96%)
Rouge Beach						87 (95%)
Western						
Boulevard Club	60 (69%)	64 (67%)	57 (66%)	25 (26%)	50 (51%)	26 (28%)
Sunnyside	64 (74%)	79 (85%)	57 (66%)	39 (41%)	68 (69%)	31 (34%)
Windermere	70 (80%)	79 (85%)	64 (74%)	46 (48%)	82 (82%)	80 (97%)
Eastern						
Balmy Beach	32 (37%)	24 (26%)	8 (9%)	2 (2%)	6 (6%)	6 (7%)
Beaches Park	0*	9 (10%)	4 (5%)	0	6 (6%)	14 (15%)
Kew Beach	0*	14 (15%)	4 (5%)	0	6 (6%)	14 (15%)
Woodbine Beach	0*	8 (9%)	4 (5%)	0	0 (0%)	16 (17%)
Islands						
Centre Island	45 (52%)	62 (68%)	38 (44%)	46 (48%)	61 (62%)	53 (58%)
Cherry Beach	0 (0%)	14 (15%)	6 (7%)	13 (14%)	6 (6%)	0 (0%)
Hanlan's Point	22 (25%)	13 (14%)	21 (24%)	14 (15%)	11 (11%)	6 (7%)
Ward's Island	0 (0%)	16 (17%)	25 (29%)	16 (17%)	13 (13%)	0 (0%)
Total Number of Potential Swimming Days	87	93	87	96	98	92

*48-hour Rainfall Rule in effect, i.e. beaches not officially posted but considered polluted and unfit for swimming for 48 hours after rainfall. In 1995, the 48- hour Rainfall Rule was discontinued following the installation of the Retention Tanks in the Eastern Beaches.

**Data not available.

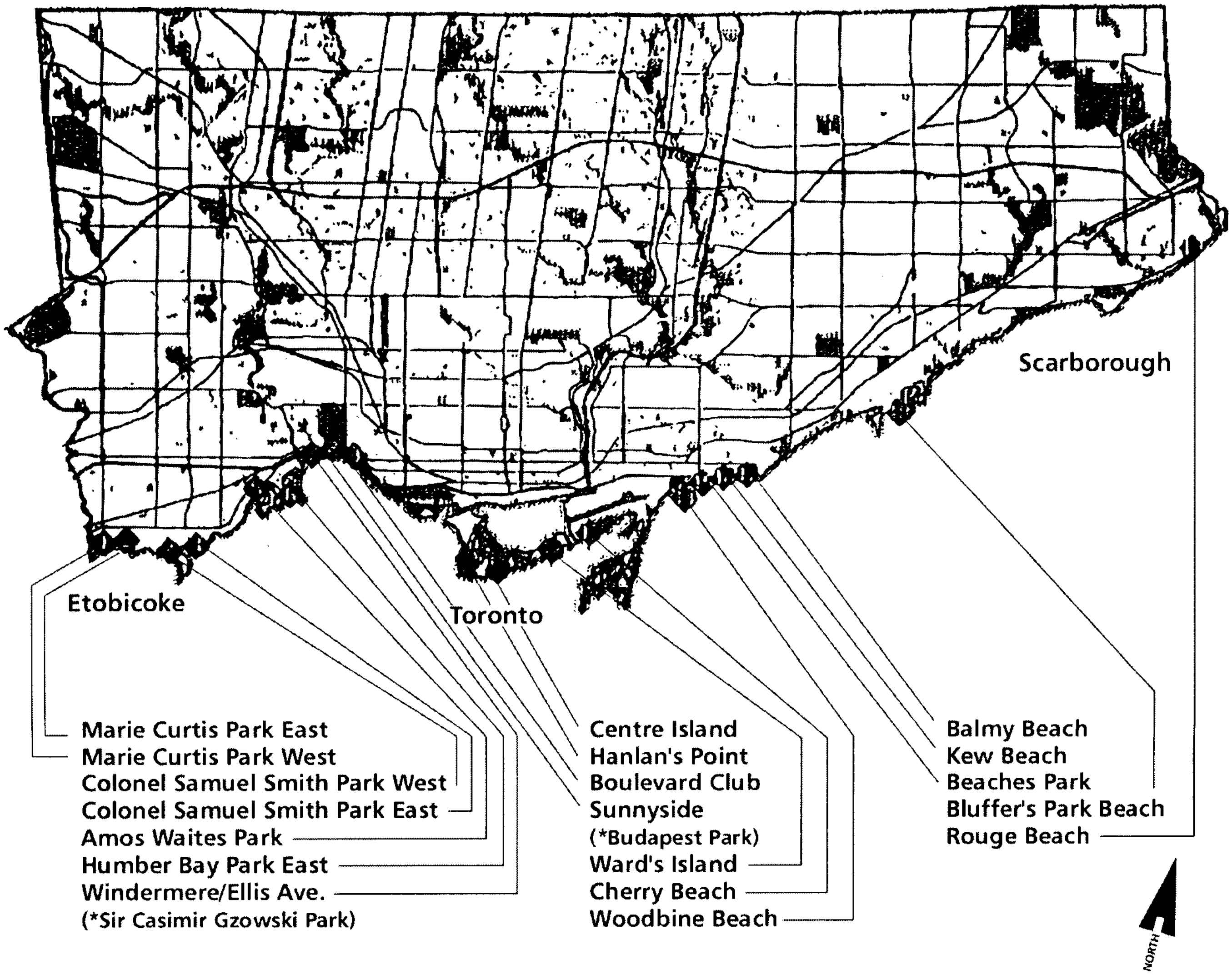

Figure 2
Toronto Lake Ontario Beaches

3.0 RELATIONSHIP WITH SOLEC

The IITF review of the SOLEC indicator suite and IJC participation in the 1998 conference helped the SOLEC steering committee focus greater attention on the Agreement. SOLEC has now cross-referenced its indicators with the 14 impairments of beneficial uses from Annex 2 of the Agreement; the IJC Desired Outcomes; all of the other Agreement Annexes; pressure, state and human activity; Great Lakes Fishery Commission (GLFC) fish community objectives; environmental compartments, such as air, land and water; and with issues, such as nutrients, toxic chemicals and non-native species. In addition, SOLEC has modified a pair of indicators that address concerns raised by the IITF review of earlier SOLEC documents. These new indicators are for the Desired Outcomes *Fishability* and *Drinkability*. SOLEC also has referenced or drafted an ecosystem objective/Desired Outcome for the majority of the proposed indicators. The results demonstrate a clear connection between the IJC work and that of SOLEC, tying them both to the purpose of the Agreement.

SOLEC '98 and The State-of-the-Great Lakes (1999) Report represent a transition between reporting on the ad hoc indicators from 1994 and 1996, and reporting on a proposed suite of 80 indicators. Some indicators will require agencies to collect additional data. Other indicators and measurements will require the collection analysis and synthesis of data from non-traditional sources, such as municipalities, private sector or volunteer organizations. There will be a period of phasing in the indicators, but the Parties expect to report on all of the 80 indicators within the next 10 years.

Another major thrust by the Parties has been the development of the Biodiversity Investment Area (BIA) concept, first proposed (Reid and Holland, 1996) at SOLEC '96 and subsequently included in the 1997 State of the Great Lakes Report (Canada and the U.S., 1997). The idea of highlighting areas of significant natural biodiversity and habitat value for conservation was well received in 1996, but SOLEC participants demanded more. The development of the BIA concept is at different stages, with the terrestrial being the most highly developed, and the aquatic ecosystem BIA the least developed.

The SOLEC process has picked up on discussions started at the three Desired Outcome(s) workshops organized by the Parties and the IJC (IITF), concerning Swimmability, Drinkability and Fishability. Human Health will be a focus for SOLEC 2000, reporting on these three workshops and expecting a report from the IJC Health Professionals Task Force, which is organizing a workshop for Autumn 2000 in Quebec City on indicators for human health. As well, other indicators, e.g. non-native species and endocrine disruptors will be featured in subsequent SOLEC plans.

SOLEC also is seeking ways to organize cooperative workshops on issues and appropriate indicators. These workshops would be during the "off-years" of SOLEC. SOLEC is interested in working with the IJC, GLFC, and the Great Lakes Commission. These proposed workshops are the results of the successes generated by the three IITF/SOLEC workshops on Fishability, Drinkability and Swimmability. Also, SOLEC is starting discussions on the development of "Integrating Indicators" that would be indices of the overall health of the basin.

4.0 DESIRED OUTCOMES AND INDICATORS

The task force examined in detail the Desired Outcomes and indicators proposed by the IETF and considered how these could be implemented. As well, the IITF compared the IETF proposed suite of indicators with the SOLEC suite (Canada and U.S.A., 1999) as follows.

4.1 Swimmability

IJC Desired Outcome:
No public bathing beaches closed as a result of human activities or, conversely, all beaches are open and available for public swimming (IETF 1996).

IITF Recommended Indicator:
Recreational Water Quality Guideline Exceedences and Beach Closings.

Measurements:
1) Trends in the frequency of E. coli exceedences of recreational water quality guidelines over a swimming season for a selected "market basket" of high-use Great Lakes beaches*.
2) (supplementary) Trends in number of beaches posted/closed because water posed a human health risk over a predetermined swimming season.

SOLEC Ecosystem Objective:
Waters should be safe for recreational use. Waters used for recreational activities involving body contact should be substantially free from pathogens, including bacteria, parasites and viruses that may harm human health.

Related SOLEC Indicator:
Fecal Pollution Levels of Nearshore Recreational Waters (ID: 4081).

Measurements:
1) Counts of fecal coliform and/or E. coli in recreational waters.
2) Frequency of beach closings at specific locations.

Local governments are responsible for beach postings and closings. Such decisions have significant repercussions on a community as the result of lost revenue from tourism and recreational activities, negative public perception regarding the quality of water, and direct costs of closing the beach. Beaches are closed for a number of reasons, not all of which are quantifiable. Professional judgement plays a significant role in decisions made about the swimmability of local water bodies. For example, beaches may be routinely closed after a period of heavy rainfall or high winds in anticipation of water quality problems. Thus, in order to answer the question "Can I swim in the water?" it is necessary to incorporate a level of flexibility into the indicator definition.

The 1992 Ontario Beach Management Protocol recommends beach postings where there is

*Note: For jurisdictions which currently do not use *E. coli*, fecal coliforms could be used as an interim measure.

evidence "that the beach water poses a risk to the health of bathers." The evidence of potential danger may be based on bacteriological analysis, historical and epidemiological data, or the physical quality of the water. Reasons for beach postings may include:

- unacceptable results from bacteriological tests;
- outbreak of infectious disease in the community;
- presence of hazardous or infectious material, (such as medical waste);
- high water temperatures;
- pH outside the range 6.5-8.5;
- water clarity reductions; and
- any visible blue-green algae.

In the U.S.A., beach monitoring documents are issued by EPA, the National Resources Defense Council and by each state. In both countries, monitoring is the responsibility of local agencies. In May 1999, EPA announced the results of its 1998 survey of 1,400 beaches nation-wide based on a survey of 300 mostly local or regional agencies. Results of the 1999 survey will be on the EPA Beach Watch web site www.epa.gov/glnpo

In the opinion of the IITF, the recommended indicators and the related SOLEC indicators and measurements are now compatible.

Several questions need further consideration.

- Does the definition of "beaches" include all recreational beaches in the Great Lakes basin including inland lakes, regardless of water body size?
- Due to the variabiity among beaches in factors such as length of the swimming season, beach size and number of bathers, should we consider normalizing the data to account for these factors?
- Should beach posting, as opposed to beach closing, data also be tracked?

4.2 Fishability or Fish Safe for Human Consumption

IJC Desired Outcome:
There shall be no restrictions on the human consumption of fish in the waters of the Great Lakes basin ecosystem as a result of anthropogenic (human) inputs of persistent toxic substances (IETF 1996).

IITF Recommended Indicator:
Chemical Contaminants in Fish and Fish Consumption Advisories.

Measurements:
1) Trends in chemical contaminants (PCB, DDT and mercury) in selected species of fish (walleye, lake trout, coho salmon, smelt, alewife).
2) Trends in the number of added, altered, or lifted advisories, by Great Lake, and by Great Lake sub-basin.

SOLEC Ecoystem Objective:
Fish should be safe to eat

SOLEC advocates, as an endpoint, the elimination of fish consumption advisories in the Great Lakes.

Related SOLEC indicators:
1) Contaminants in Recreational Fish (ID:113).
2) Chemical Contaminants in Fish Tissue (ID:4083).

The term Fishability is misleading. It mistakenly implies that the ability to catch Great Lakes fish is under consideration. Therefore, the Desired Outcome should be renamed "Fish Safe for Human Consumption."

Fish consumption advisories are issued by all Great Lakes state and provincial governments. In addition, U.S. EPA has recommended "Fish Consumption Advisories" as an indicator for its own work. The U.S. EPA supports a comprehensive database that contains information about both Canadian and American fish consumption advisories.

Certain issues confound the development of this indicator.

- Criteria to define fish advisories and sampling protocols to collect data to support them vary among jurisdictions. Until a common set of protocols and criteria are implemented basin-wide, there will be inequities in comparing progress among lakes or sub-basins.
- A limited number of chemicals are routinely measured (e.g. PCBs, dioxin, DDT, mercury). This limited analysis may miss other harmful compounds. For example, PAHs and the potent liver toxin Microcystin which is a serious problem in Lake Erie.
- A limited number of fish species are routinely monitored for contaminants.
- A limited number of samples per fish species are routinely monitored for contaminants.
- Human populations are exposed to different levels of risk from eating Great Lakes fish (i.e. women of child-bearing age and children are more susceptible to health threats

caused by eating contaminated Great Lakes fish, as are high consumers of Great Lakes fish).
- The communication of fish consumption advisory information to the public (particularly non-anglophones and low-income populations) is inadequate.
- Over the course of a year, fish consumption advisories are added, altered and withdrawn making them difficult to count in a given jurisdiction.

The IJC indicator is very compatible with those proposed by the Parties in the State-of-the-Great Lakes Report (Canada and the U.S., 1999) and would be confirmed by other SOLEC indicators for long term trend data for contaminants in otter, snapping turtles, herring gull eggs and bald eagles.

As a test of the applicability and feasibility of the indicators and measurements for this Desired Outcome, the Parties are proposing to collect information for these indicators on lakes Erie and Ontario, keying on selected Areas of Concern.

4.3 Drinkability

IJC Desired Outcome:
Treated drinking water is safe for human consumption; human activities do not result in application of consumption restrictions (IETF 1996).

IITF Recommended Indicator:
Drinking Water Quality

Measurements:
1) Trends in raw (intake) water, organic, inorganic and microbial quality.
2)Trends in the number of exceedences of established drinking water standards.

SPECIFIC PARAMETERS

Suspended matter:
Nephelometric Turbidity (NTU)
(deviation from local baseline)

Organic matter:
Total Organic Carbon (TOC) or Dissolved Organic Carbon (DOC) (<2.0 mg/L)

Taste and odour:
100% inoffensive versus offensive

Pathogens:
Escherischia coli (show improvement)

Chemical contaminants:
- atrazine (target is non detectable; trend shows improvement)
- NO3/NO2 (1/2 maximum consumption level; trend shows improvement)

SOLEC Ecosystem Objective:
Treated drinking water supplies should be safe to drink.

Related SOLEC Indicator:
Drinking Water Quality (ID:4175) features trends in chemical and microbial contaminant levels in raw, treated and distributed water.

There are a number of issues yet to be addressed.

Current Monitoring Programs: The limitations of current drinking water databases, in both Canada and the U.S., need to be examined. Privatization of water treatment may further exacerbate difficulties in both monitoring and reporting. The Ontario Drinking Water Information System contains water quality data collected through the Drinking Water Surveillance Program (DWSP) and the Water Inspections Program. DWSP monitors water quality 2-6 times per year based on source water type. THMs are monitored quarterly. DWSP monitors at least as frequently as the operating authorities of the water supply systems are required under the Ontario Drinking Water Objectives (MOEE 1994). There is no organized water quality monitoring program for private (often groundwater) supplies. The U.S. Federal Safe Drinking Water Information System (SDWIS/FED) is not currently a fully reliable source of information. In 1998, the U.S. EPA acknowledged that "it had serious data problems after finding that 16% of violations in 1996 were missing from the database."

Raw versus Finished Water Quality: Drinking water quality is a function of: raw water quality; the capability of the treatment plant to clean the water; and, the state of the water distribution infrastructure. If any of these parameters is substandard, drinking water problems usually result.

Raw water quality is directly linked to water quality at the tap. Even well-managed water treatment plants can release chemical and/or microbial contaminants into the distribution system. Poorly maintained and aging distribution systems contaminate drinking water supplies due to the introduction of untreated water from outside the conduit. Thus, indicators are needed that reflect these various stages of drinking water treatment and delivery. Public concern about drinking water quality is high, and a significant proportion of the population has responded by installing point-of-use devices and by using bottled water.

Sources of Raw Water: Groundwater versus Surface Water: Approximately one-half of the Great Lakes basin population uses groundwater for its potable water supply. There are also many water supply systems within the Great Lakes watershed that use surface water supplies that are tributary to the lakes themselves. Private groundwater systems are not monitored as closely as large water utilities that take water from surface or groundwater. Many rural households drink groundwater with little or no treatment.

Raw Water Turbidity: Throughout North America, water treatment plants keep records of the turbidity of their raw water. Turbidity is measured in nephelometric turbidity units (NTUs) which relate to how light is scattered in water. This parameter is sampled frequently each day or continuously, with in-line turbidity meters, to meet U.S. and Canadian drinking water requirements (under the Safe Drinking Water Act, commonly known as the "Surface Water Treatment Rule" in the U.S.). It is intrinsically related to every water treatment plant daily operating procedures. The information is plant-specific, but may also be found, albeit for more limited sampling periods, in the Ontario DWSP database.

Several studies show a strong correlation between turbidity levels and significant cost increases for treatment, as well as chemical (pesticides and nutrients), disinfection by-products (THMs) and microbiological contamination of finished drinking water. Waterborne disease outbreaks are often found to be associated with increased raw water turbidity (e.g. Milwaukee 1993). The Thunder Bay Post (MacDonald 1998) reported that it would cost the city approximately $1.5 million to install chlorine dioxide treatment to combat its problems with *Giardia* and *Cryptosporidium*. The estimated cost of installing microfiltration was $56 million with a five-month installation waiting period.

While treated (or finished) water turbidity is information that must be reported to the U.S. EPA by each body with primacy for all of their water treatment plants, they are not required to report information about raw water turbidity. Therefore, this information is found either at the plant level or in the plant monthly reports to the agency with primacy.

As a result of the "Drinkability" workshop, the IITF recommends that a "market basket" of suitable/selected municipalities be designated to provide informaton on drinking water quality measurements. We propose that the following communities be used for this purpose:

- Milwaukee (Lake Michigan)
- Windsor (Detroit River)
- Thunder Bay (Lake Superior)
- Duluth (Lake Superior)
- Toronto (Lake Ontario)
- Rochester (Lake Ontario)
- Toledo (Lake Erie)
- Erie, PA (Lake Erie)
- Waterloo (Groundwater)
- Sarnia/Port Huron (Lake Huron)
- Detroit (Lake St. Clair/Lake Huron)

Therefore, the IITF recommends that:

- **the IJC, in its Tenth Biennial Report, advise the Parties to operationalize these three Desired Outcomes, along with the associated indicators and measurements to report progress under the Agreement by the year 2000.**

4.4 Healthy Human Populations

At SOLEC '98, a core group reported on a proposed suite of indicators applicable to describe human health. The State-of-the-Great Lakes Report (Canada and the U.S., 1999) lists several indicators related to human health, many of which overlap with the IITF recommended indicators and measurements for the Desired Outcomes, Swimmability, Fishability and Drinkability. Others in the list address human disease incidence, air quality and radionuclides. As well, the IJC Health Professionals Task Force is organizing a workshop in Quebec City in 2000 to continue this work. To maintain the continuity and the impetus of these activities, SOLEC 2000 will highlight a report from the Quebec City workshop to further discussion.

4.5 Economic Viability

This Desired Outcome was not researched by the IITF as agreed by the IJC in October 1998. However, significant work is underway in national and binational arenas, e.g. the GPI (GPI Atlantic 1998a) is being tested by StatsCan as a measure of economic and environmental activities in Nova Scotia (see Appendix A).

4.6 Other Desired Outcomes

The following IJC Desired Outcomes have not been completely reviewed by the IITF. However, some initial thoughts and proposals are listed for consideration by the IJC and SOLEC as indicator development and implementation proceed.

4.6.1 Biological Community Integrity and Diversity

The first step toward effective biological monitoring and assessment is to realize that the goal is to measure and evaluate the consequences of human actions on biological systems (e.g., on ecosystems be they landscapes, process-function ecosystems, communities, organisms, or populations of organisms). As is recognized in the definition of "Great Lakes Basin Ecosystem" in Article I of the Great Lakes Water Quality Agreement, humans are included in such systems; and the community integrity and diversity highlighted in this Desired Outcome is intended to include consideration of all these various ecosystem types as well as their integral connection with the Desired Outcome of Physical Environment Integrity.

"Freshwater links the land and the oceans via groundwaters and riverine flow and is especially important in the cycling of elements such as nitrogen and phosphorus. Freshwater habitats respond to climate change and cultural impacts from a wide range of human activities. The most obvious responses to such perturbations are in surface waters, but changes that occur in subsurface habitats -- where most of the world's freshwater resides -- are of major significance. These "unseen" habitats harbor biota that are central to fundamental ecological processes at local and global scales" (Palmer et al. 1997).

Degradation of freshwater sediments will limit the availability and quality of surface water, disrupt global biogeochemical cycles, destroy habitats for many unique species, and alter our climate and the flux of gases globally. Because the biota associated with sediments mediate biogeochemical transformations that ensure proper vitality or functioning of freshwater ecosystems, protecting these biota is essential. Approximately 175,000 species of organisms associated with freshwater sediments have already been described; and, yet, still new species continue to be discovered. Their diversity and distributions range greatly along gradients of depth, dissolved oxygen, latitude, and altitude in wetlands, lakes, rivers and groundwaters. Deep, isolated habitats contain unique, endemic species especially among those organisms with limited dispersal ability (Palmer et al. 1997).

"Certain species or certain functional groups (species with similar ecological roles) of freshwater sediment biota play pivotal roles in ecological processes that are central to healthy freshwater ecosystems. The ability for freshwater ecosystems to persist in a healthy state, despite species loss, is low in freshwater habitats that are dominated by functional groups that typically have only a few species and in freshwater habitats with few species due to extreme conditions. The latter includes anoxic waters and groundwaters with very low water flow. Examples of species-poor functional groups in freshwater sediments include benthic invertebrates that tear apart decaying leaves and other organic matter while feeding (the shredders) and sediment fauna that stir up and displace sediment while they move or feed (the bioturbators). . . . Ecosystem functioning refers to ecological processes such as the breakdown of organic material and the recycling of nutrients. Healthy freshwater sediments are those in which ecological processes continue unimpeded to ensure that water is clean and plentiful and that organic matter is not lost or accumulating in excess. The benthic fauna play a key role in these processes. ... The most important ecological processes in freshwater sediments are decomposition of organic matter, the uptake and transfer of materials, and the production by green plants and certain bacteria" (Palmer et al. 1997).

The projected mean future extinction rate for freshwater fauna is about five times greater than the rate for terrestrial fauna and three times the rate for coastal marine mammals. About 40 of some 1,060 North American freshwater fish have become extinct in this century and the modern regional rate of extinction is equivalent to one extinction every 2,600 species-years — 1,000 times higher than the background rate (Ricciardi and Rasmussen, 1999). Considering the Desired Outcome of biological community integrity and diversity, these are alarming trends that warrant further monitoring as decision support for ecomanagement policy changes such as a move to adaptive management (Holling 1978; Holling 1992; Holling and Meffe, 1996; Walters 1997; Gunderson 1999; Johnson and Williams, 1999; Lee 1999). These extinctions are linked to extensive habitat deterioration caused by such human activities as stream fragmentation and flow regulation by dams, channelization and dredging projects, sediment loading and organic pollution from land use activities, toxic contaminants from municipal and industrial sources, and by interactions with increasing numbers of exotic species introduced by humans (Benke 1990; Allan and Flecker, 1993; Dynesius and Nilsson, 1994; Arthington and Welcomme, 1995; Robitaille et al. 1995; Neves et al. 1997; Richter et al. 1997; and Ricciardi et al 1998).

As Karr and Chu (1997) have noted, "Retaining the biological elements of freshwater systems (populations, species, genes), as well as the processes (mutation, selection, fish migration, biogeochemical cycles) sustaining these elements, is crucial to retaining the goods and services fresh waters provide. ... Waters and fish travel over vast distances in space and time. The integrity of water resources thus depends on processes spanning many spatial and temporal scales... Protecting the elements and processes society values therefore demands a broad, all-encompassing view -- one not yet encouraged by conventional management strategies and terminology. In particular, the word *pollution* must take on broader connotations. In conventional usage and agency jargon, pollution refers to chemical contamination. A more appropriate, yet little-used, definition that more accurately represents what is at stake as water resources decline is the definition given by the 1987 reauthorization of the [U.S.A.'s] Clean Water Act: pollution is any "manmade or man-induced alteration of the physical, chemical, biological, or radiological integrity of water." Under this definition, humans degrade or "pollute" by many actions, from irrigation withdrawals to overharvesting, not only by releasing chemical contaminants. ... Human activities degrade water resources by altering one or more of five principal groups of attributes -- water quality, habitat structure, flow regime, energy source, and biological interactions -- often through undetected yet potentially devastating effects on water resources ... (Karr 1991; 1995b). ... [T]he science of biological monitoring is still way ahead of the regulatory and policy framework used to manage water resources. The problem lies not in the letter or spirit of our laws but in a pervasive reluctance to shift from a narrow pollution-control mentality to a broader regard for the biological condition of our waters. ... Large rivers, lakes, reservoirs, and coastal and estuarine environments contain a diversity of habitats. No single sampling method is appropriate to every one of those habitats... Multimetric indexes can reflect changes in resident biological assemblages caused by single point sources in one river or stream as well as differences over a wide geographic area. ... Until all states see protecting biological condition as a central responsibility of water resource management, until they see biological monitoring as essential to track attainment of that goal and biological criteria as enforceable standards mandated by the Clean Water Act, life in the nation's waters will continue to decline."

Allen and Hoekstra (1990; 1992) have made clear that it is essential to resist the temptation to base ecological understanding on a belief that ecological systems are an ultimate reality beyond observation. The observer uses a filter to engage the world; the filter chosen by the observer is as much a matter of human decision as is the definition of structures such as ecosystems. The notion of *ecosystem integrity* is rooted in certain ecological concepts, combined with certain sets of human values. The relevant normative goal of human-environmental relationships is to seek and to maintain the integrity of a combined natural/cultural ecosystem which is an expression of both ecological understanding and an ethic that guides the search for proper relationships (Article I(g) and Article II, Great Lakes Water Quality Agreement 1978). No conventional political ideology within the Canadian and American parts of the Great Lakes basin now has an ethical and conceptual base that relates clearly to an emerging vision of "ecological integrity." We know of no way to sketch the concept of ecosystem integrity in a linear, closed way; in fact, to do so would be contradictory to its meaning. There is room for choice in the kinds of ecosystems with integrity that humans might prefer (Regier 1993). In human-dominated ecosystems, it is really a matter of, "What kind of garden do we want? What kind of garden can we get?" (Clark 1986).

"Studying functional diversity is limited by our lack of knowledge of the organisms present, but overcoming this shortcoming is at least now possible for many organisms and improving for microbial groups where methodological problems persist. Molecular methods may be unable to provide answers to some basic questions in microbial ecology, as their main strength is in comparing naturally occuring microbial diversity to well-characterized pure cultures. ... Our ability to assess functional biodiversity is improving rapidly. Many taxonomy problems are now being overcome with molecular and biochemical techniques. Unequivocal taxonomy is important because improved taxonomic capability will facilitate descriptive field work...to test hypotheses on biodiversity patterns. ... In short, rapidly advancing technologies offer a tremendous array of tools to tackle many exciting questions on how biodiversity and ecosystem services are related" (Snelgrove et al. 1997).

As the IETF reported, there are several indicators (and measurements) that have potential for use with this Desired Outcome, for example, quantity and quality of particular habitat types (e.g. wetlands); toxic contaminant levels in selected fish species and in selected fish-eating birds; cumulative number and abundance of exotic species introduced; and multimetric biological indexes such as the lack of intolerant taxa among fish or invertebrates. As Karr and Chu observed (1997), "Most multimetric biological indexes for use in aquatic systems comprise 8 to 12 metrics, each selected because it reflects an aspect of the condition of a biological system. These metrics are not independent because they are calculated from a single collection of organisms, just as multiple personal health tests are done on a single individual. But even if metrics are statistically correlated, they are not necessarily biologically redundant. Rather, just as a fever plus a high white-blood-cell count reinforces a diagnosis of bacterial infection, multiple metrics all contribute to a diagnosis of ecological degradation (ecological disease)."

In pursuing this Desired Outcome, of course, we are interested in a combination of biological community integrity and diversity which is more than community health which, in turn, is more than the absence of disease. The relative abundance of organisms at various levels in the system's trophic organization reflects the condition of the food web, including energy flow and nutrient dynamics; if we know what to expect from minimally-disturbed sites in a region, we can then more readily distinguish the deviations caused by human activities from that expectation.

Through the SOLEC process the Parties are developing a system [a network of sites called *Biodiversity Investment Areas* (BIAs)] to protect the diversity and supporting physical and chemical characteristics of the Great Lakes ecosystem. BIAs are sites of minimal disturbance around the Great Lakes - sites rich with diverse biotic communities where ecosystems can be studied and monitored free from most disturbances, and where a reservoir of living material is available to start regeneration and rehabilitation of degraded areas, some of which include humans. BIAs have potential for developing monitoring and surveillance systems that can begin to measure physical, chemical and biological integrity and diversity in the Great Lakes basin.

Measurements of the quantity and quality of particular habitat types such as wetlands comprise an obvious link of this Desired Outcome with the Desired Outcome of Physical Environment Integrity.

A number of databases that contain relevant information about this topic have been identified. However, the sampling techniques, the monitoring frequencies, and the geographic coverage vary significantly among these databases. Additionally, SOLEC '98 has considered several indicators with potential to apply to this Desired Outcome.

The Commission and the Parties have committed to using an ecosystem approach that fosters integrity of the Great Lakes ecosystem. That commitment can only be realized though two strategies which the IITF recommends be adopted and pursued by the Commission.

Biological systems do not exist apart from their physical, chemical and biological environs. All ecosystems are integrated sets of living system/environment relationships. Ecosystem integrity is not meaningfully measured by looking only at the living system part of the living system/environment partnership.

Therefore, the IITF recommends that:

- **recognizing the inextricable relationships between living systems and their environs, the Commission should combine the now separated Desired Outcomes of:**
  (a) Biological Community Integrity/Diversity; and
  (b) Physical Environment Integrity.

The IITF further recommends that the Commission:

- **encourage the Parties to further the development of the system termed the *Biodiversity Investment Areas* to designate the sites as soon as practicable and to establish monitoring and surveillance programs at these sites to further the understanding of integrity and diversity in the Great Lakes basin. Such monitoring programs should specify the type and the scale of each ecosystem compartment being evaluated.**

4.6.2 Virtual Elimination of Inputs of Persistent Toxic Substances

There are many indicators nominated by the IETF (1996) and SOLEC, which apply to this Desired Outcome.

There is a major question yet to be addressed, i.e. "what are the specific chemicals to be considered?" Should a focus be on the persistent toxic substances groups listed in Annex 1 of the Agreement, or should the list be reduced, or expanded?

4.6.3 Absence of Excess Phosphorus

> Desired Outcome:
> Absence of excess phosphorus entering the water as a result of human activity.

Significant scientific studies have changed the understanding of phosphorus dynamics in large freshwater lakes. **The IITF recommends that this Desired Outcome be changed to "Return to a Nutrient-Balanced State" and the following indicators and measurements be used.**

- **Hypolimnetic oxygen levels;**
- **Extent of temporal/spatial coverage of undersirable/ harmful algal blooms; and**
- **Amount of nearshore submerged vegetation.**

Of these, undesirable/harmful algal blooms are a particular problem in the Great Lakes. The Rondeau Bay, Ontario area, appears to have *"persistent annual problems (July-September) with excessive Cladophera growth and fouling."* The Lake Erie LaMP (1998) recently reported the following about *Microcystis*:

> *"Between 1995-1998 Microcystis bloom appeared during the late summer and fall, in the western and central basins. Microcystis is a blue-green algae which can be described as a "thick slick of grass-green paint."*

The presence of *Cladophera* and blue-green algae are also associated with a degradation of the aesthetics of the Great Lakes. In addition, *Microcystin* is a potent liver toxin (Lake Erie LaMP 1998).

Some water quality databases, such as EC's STAR database, do contain information about algae. The STAR database uses a scale from 0-4 to rank floating alga samples. This ranking scale, and the amount of data on this subject that are contained in the database, needs to be examined further.

According to Dolan (1998, pers. comm.), current information about undesirable algal blooms in the Great Lakes is, for the most part, study-specific. Although detailed information does exist for certain areas of the Lakes, much more information is in the form of anecdotal reports from people on the Lakes. Some field stations have information about the presence/absence of algal blooms. Unless these phenomena are within the research mandate of the station, it may not have more specific information about them (i.e. temporal/spatial data).

Information about harmful algal growths could be collected by aerial or satellite surveillance of the Lakes. The ground-truthing and updating of this record would require a substantial investment of time and money (Dolan 1998, pers. comm.).

4.6.4 Physical Environment Integrity

Desired Outcome:
Land development and use compatible with maintaining aquatic habitat of a quantity and quality necessary and sufficient to sustain an endemic assemblage of fish and wildlife populations.

There are five indicators proposed by the IETF for this Desired Outcome. Additionally, SOLEC has nominated several indicators which would serve this Desired Outcome.

The IITF recommends that the following three specific indicators modified from the IETF list be implemented. These are nominated because of their relevance, because there are many supporting data and because they integrate many other potential indicators and their measurements.

a. Quantity and Quality of Wetlands

Wetlands are among the most studied habitat types of the Great Lakes basin. Although a significant amount of information about both Canadian and American wetlands is available, a consistent binational inventory of Great Lakes wetlands is required. There appears to be more information about the *quantity* of remaining wetlands than about the *quality* of those wetlands and more emphasis has been placed on "coastal" wetlands.

Recent compilations of information related to Great Lakes wetlands include:

- SOLEC '98 discussion paper by Chow-Fraser and Albert (1998) entitled "Coastal Wetland Ecosystems";
- Environment Canada (1995) "A Catalogue of Wetland Databases and Inventories for the Canadian Great Lakes Basin"; and
- Nature Conservancy of Canada (1998) on-line "Catalogue of Great Lakes Wetlands Information Resources."

In addition, non-governmental organizations, in particular Ducks Unlimited, have done much to promote and protect wetland habitats. There is much information and data available from this and similar sources.

b. Quality and Quantity of Stream Base Flow

Surface water is usually hydraulically connected to groundwater, but the interactions are difficult to observe and measure and commonly have been ignored in water management decisions and policies. Most groundwater contamination caused by leaking petroleum storage tanks and hazardous waste disposal sites, attributed to agricultural fertilizers and pesticides, and to sewage pathogens and deicing compounds, is located in shallow aquifers that are directly connected to surface water. Therefore, groundwater can be a major and potentially long-term contributor to contamination of surface water. In some cases, surface water quality standards and criteria are unlikely to be met without reducing contaminant loads from groundwater discharges.

The amount of water that groundwater contributes to streams can be estimated by analyzing stream flow hydrographs to determine the groundwater component, which is termed "base flow" (Troyak 1996). Withdrawing water from shallow aquifers near surface water bodies can diminish the available supply by capturing some of the groundwater flow that otherwise would have discharged to surface water. The quantity of groundwater withdrawn is approximately equal to the reduction in stream flow that is potentially available to downstream users. In landscapes that are relatively flat, drainage of land is a common practice preceding agricultural and urban development. Drainage is often accomplished by burying tile drains beneath the land surface, which can change the areal distribution of groundwater recharge and discharge. These changes ultimately affect stream base flow.

The USGS has water quality and stream flow datasets for 679 locations in the U.S. from 1962 to 1995, and for 618 stations from 1973 to 1995. In the Great Lakes Region, water quality and stream flow data are organized in separate station and parameter files. This data is readily available and can be easily accessed. Environment Canada also has such data. The web site where this information can be found is: http://wwwrvares.er.usgs.gov/wqn96/ .

The daily stream flow values for 54 U.S. streams for the 30-year period, 1962-1991, were used by the USGS for base flow analysis. An average of 52 percent of the stream flow was found to be contributed by groundwater. Base flow ranged from 14 percent to 90 percent, with a median of 55 percent. The Sturgeon River basin in Michigan, which is underlain by highly permeable sand and gravel, has approximately 90 percent of its average annual flow contributed by groundwater. Other USGS data estimate that the groundwater contribution to total tributary flow averages 45 percent in the Lake Erie basin and averages 62 percent in the Lake Huron basin.

c. Number and Extent of Engineered Land/Water Interfaces

This indicator addresses two separate issues dealing with anthropocentric manipulation of shorelines and land/water interfaces, leading to changes in the dynamics of natural water flow.

The first issue encompasses "true" land/water interfaces such as wharfs, sheet piles, groynes and other engineered shoreline interfaces. A better understanding of the extent of these structures could lead to improved shoreline habitat protection.

The second issue deals with the increase in the extents of impervious/hardened surfaces resulting from increasing urban density (e.g. roofs, airports, parking lots, roads, sidewalks, etc.) This spread of engineered interfaces has led to more artificial landscapes in which hardened surfaces lead to: enhanced runoff due to decreased water absorption into the ground, less groundwater recharge, reduced stream base flow, increased soil erosion, wider and straighter stream channels, and increased water temperatures and salinity, in turn leading to altered aquatic habitats (Reisman 1999b). All of these impacts are attributable to *"serious hydrological disruption"* in which there is a reduction in *"the natural infiltration of rainfall and a great increase in the amount and rate of stormwater runoff"* (Reisman 1999b).

5.0 DISCUSSION AND RECOMMENDATIONS

5.1 Data and Information Management

The process of measuring progress in restoring and maintaining "the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem" requires information. Such information must come from careful interpretation of high quality data collected by well-planned monitoring and surveillance programs. The application of any suite of indicators is futile without sustained management of data and resultant intelligence.

In the Great Lakes basin, Canada and the United States, with their state and provincial partners, have amassed much data over the last 27 years – enough data to support the use of indicators to evaluate progress. However, more effort is needed to improve data collection and analysis and reporting because of non-uniform quality and many gaps in existing data sets.

Overall, questions related to quality assurance/quality control, the further development of the meta database (started by the IITF), and the need to have universal GIS-based reporting of data, must be addressed. These efforts would also meet the commitments under Annex 11 to have an integrated approach to basin-wide surveillance and monitoring. Many data sets developed from monitoring the same problem are so diverse as to be incompatible for across-basin comparisons (e.g. contaminants in sport fish – "Fishability").

The U.S. Safe Drinking Water Information System (SDWIS) database continues to evolve from its initial start-up problems toward becoming a reliable repository of national water monitoring data. It is an example of "getting started" and how a public forum corrects and refines an initial effort.

The Integrated Atmospheric Deposition Network (IADN) established by Environment Canada and the United States Environmental Protection Agency to monitor the deposition of airborne toxic substances into the Great Lakes, represents an excellent model of how the two countries can work together to produce consistent and comparable monitoring data to support environmental indicators. For example, as part of IADN, the U.S. and Canada have agreed on a common list of chemicals to monitor; data quality objectives; monitoring and analytical techniques; and data storage and reporting protocols.

New partnerships will be necessary for efficient data collection, analysis and reporting. For example, data about some drinking water parameters are collected and stored at the local level, often on a plant-by-plant basis and often with no reporting requirements to another level of government. Non-traditional networking will therefore need encouragement and support in the development of new partnerships. Additionally, analyses and reporting requirements will need more specific definition to enable the use of these data.

Finally, whatever is reported publically by either Party or the IJC must use indicators that are understood by technical and regulatory specialists as well as citizens-at-large. Selecting indicators should result from a balance between those indicators which best measure ecosystem integrity and those to which the public can relate (Can I drink the water, eat the fish and swim safely?) Communication of progress using these indicators and others, as they are further refined, is a key element of indicator implementation and will require careful consideration by the Commission and the Parties.

It is recommended that:

- **the IJC advise the Parties that new and focussed efforts are needed to correct existing problems with data collection, analyses and reporting. Further, the Parties should explicitly address non-uniform sampling protocols, data quality, gaps and quality assurance/quality control inconsistencies in present surveillance and monitoring programs. As well, the IJC should urge the Parties to continue development of a joint meta database and propose that the Parties accelerate data manipulation and portrayal using Geographic Information System (GIS) technology.**

- **At the same time, the IJC should commend the Parties for starting the development of new partnerships through non-traditional networking associated with the joint IJC/ Parties' work on "Fishability," "Swimmability" and "Drinkability."**

5.2 Indicators for "Fishability," "Swimmability" and "Drinkability"

- **As outlined in Section 4 herein, the IITF specifically recommends that the Commission in its Tenth Biennial Report advise the Parties to operationalize indicators related to the three Desired Outcomes, "Fishability," "Swimmability" and "Drinkability."**

- **Initially using selected high-use Great Lakes beaches (for Swimmability), water treatment plant data from selected major municipalities in the basin (for Drinkability) and from Areas of Concern in lakes Erie and Ontario (for Fishability) the Parties should begin reporting progress in 2000.**

- **In order to avoid misinterpretation of the intent of the "Fishability" Desired Outcome, the IITF recommends that this Desired Outcome be re-titled, "Fish Safe for Human Consumption."**

5.3 Other Desired Outcomes

Although it wasn't possible within time and resource constraints to thoroughly investigate all of the IETF Desired Outcomes and their associated indicators/measurements, the IITF did review relevant indicator development work by other regional and international agencies. These summaries are included as Appendix "A" herein.

- **For the "Physical Environment Integrity" Desired Outcome, the IITF recommends that three specific indicators, modified somewhat from the IETF proposed indicators, be implemented. These are discussed in Section 4.6 herein and include:**

a) **quantity and quality of Great Lakes wetlands;**
b) **quality and quantity of stream base flow in the Great Lakes basin; and**
c) **number and extent of engineered land/water interfaces in the Great Lakes basin.**

All are supported by available monitoring data, integrate other potential indicators and address Great Lakes Water Quality Agreement Annexes.

- **The IITF further recommends that the IETF Desired Outcome, "Absence of Excess Phosphorus," be changed in response to recent advances in scientific understanding of phosphorus dynamics in large freshwater lakes. The recommended new Desired Outcome (as discussed in Section 4.6) is "Return to a Nutrient-Balanced State" and the associated indicators and measurements are:**

  - **hypolimnetic oxygen levels**
  - **extent of temporal/spatial coverage of undesirable/ harmful algal blooms**
  - **amount of nearshore submerged vegetation**

Both the IJC's Health Professionals Task Force and SOLEC are actively researching the IETF "Healthy Human Populations" Desired Outcome and its' associated indicators and measurements.

The IITF recommends that:

- **the IJC continue to be engaged with this important work. It has been the IITF's experience that the best means of developing and implementing indicators is to engage experts from a broad range of Great Lakes agencies, jurisdictions and disciplines to achieve consensus. This approach is now being taken by both SOLEC and the Health Professionals Task Force.**

5.4 Long-Term Involvement by the IJC

It is recommended that:

- **The IJC, in order to meet its commitments specified in Article VII of the GLWQA, commit resources to support the on-going work in the basin on the application, use, implementation and reporting of indicators over the next decade.**

This recommendation is important based on the following information.

- The Parties, through the SOLEC process, are starting a staged implementation of a suite of 80 indicators. They are primarily responsible for implementing the indicators and reporting on progress. SOLEC 2000 will focus on human health issues and will report on the Desired Outcomes "Fishability," "Swimmability" and "Drinkability".

- The Parties will need to modify and, in some cases, initiate new surveillance and monitoring programs to meet the information required to apply the 80 indicators. This Parties' activity should speak to commitments under Annex 11 of the Agreement.

- The Parties must arrange new and very different partnerships (e.g. with local governments and agencies) to implement focussed, coordinated surveillance and monitoring required by the application of the proposed suite of 80 indicators; and

- The Parties need to modify existing information management, storage and portrayal systems (e.g. the use of GIS) to make the application of any indicator effective and understandable by governments and citizens alike.

- **The IJC continue involvement in the process of developing and applying indicators to measure progress under the Agreement.**

This can be achieved by the following.

- **Make the indicators implementation process an ongoing IJC priority assigned jointly to the Great Lakes Water Quality Board (WQB) and the Great Lakes Science Advisory Board (SAB).**

- **Assign a staff member to maintain expertise in the process of indicator development who would:**

  - **support the WQB and the SAB in meeting their commitments associated with the assigned priority;**

  - **report to the WQB and the SAB on progress by the Parties to reach consensus on a common set of indicators, on how the Parties are implementing a binational and integrated monitoring program, and where and how the IJC can collaborate with and assess these processes;**

  - **liaise with the Council of Great Lakes Research Managers, the International Air Quality Advisory Board and Health Professionals Task Force as they might work on indicators; and**

  - **follow the SOLEC 2000 and 2002 processes and serve on the steering committee as an IJC representative.**

APPENDIX "A"

OTHER INITIATIVES USING INDICATORS

The development of indicators is difficult and highly complex — a consensus supported by the IITF and others working on similar projects, such as the European Union (EU), Environment Canada (EC) and U.S. Environmental Protection Agency (EPA). Many monitoring programs fail because operational issues, such as data management and information transfer are not adequately addressed. As well, some concepts, such as ecosystem management, are constantly being redefined. Regular monitoring and long-term funding are essential. Updating the indicators and accompanying measurements is also essential as new issues emerge.

Many governmental jurisdictions are faced with similar environmental issues, many of which cross political boundaries. Collaboration through strategic partnerships should become the norm. As the IJC has stated, multi-jurisdictional agencies are playing an increasingly critical role in the coordination of efforts within the Great Lakes basin.

To advance inter-agency communication and cooperation, there is a need for an acceptable indicator framework to guide local decision makers, and to provide a common language, based on clear terminology and concepts. It is important for the IJC to be aware of how other multinational agencies are implementing indicators to ensure compatibility. As well, detailed and location-specific indicators are also needed to reflect unique regional conditions and the needs of local decision makers.

OECD

In 1993, the Organization for Economic Cooperation and Development (OECD 1993), an agency of the European Union, developed a core set of indicators for environmental performance reviews. Their work is set within a pressure-state-response framework that serves to structure and classify types of indicators, similar to the approach taken by State-of-the-Lakes Ecosystem Conference (SOLEC). In this model, *pressure* refers to stresses from human activities on the environment, *state* reflects the present conditions in an ecosystem and *response* deals with society's efforts to tackle environmental problems caused by pressures so that a feedback mechanism is enacted.

This core set of indicators is meant to form a common link to all OECD member nations and allow for cross-country comparisons. These are generally supplemented by more detailed, country-specific indicators that reflect the unique conditions of each region and the needs of decision-makers.

NAFTA and the CEC

The tri-lateral North American Free Trade Agreement (NAFTA), signed by Canada, the United States and Mexico in 1994, was supplemented by the North American Agreement on Environmental Cooperation (NAAEC), entered into that same year. The Commission for Environmental

Cooperation (CEC) was subsequently created to administer this side accord. The CEC primarily achieves its mandate through information exchange, consulting services, and by fostering the development of new strategies for dealing with issues affecting the continent.

Two primary components of multinational environmental cooperation were identified (CEC, 1997):

a. Respect for each nation's sovereignty in establishing priorities, policies and legal frameworks that suit the needs of each country.

b. The importance of coordinated efforts in resolving shared environmental problems.

Each country maintains its own environmental regulatory framework while agreeing to collaborate tri-laterally in support of achieving sustainable development for all three nations.

The CEC designed a framework to assess the effects of NAFTA on the North American environment (CEC 1999). This framework will:

- develop an understanding of the connections between trade and the environment;
- assist in anticipating important environmental impacts in the context of trade liberalization; and
- develop policy tools to better mitigate negative impacts and maximize positive ones.

As with many of the other initiatives reviewed in this report, the CEC recognizes the importance of assessing pressures on the environment (e.g. pollution). The CEC also refers to "environmental supports," such as waste management practices, which mitigate pressures and which may be created through government policies.

GPI

The Genuine Progress Index was developed in 1995 by StatsCan as an holistic measure of progress integrating social, economic and environmental variables (GPI Atlantic 1998a). In 1997, Nova Scotia was chosen by Statistics Canada for a pilot project in which they adapted the original concept to reflect local conditions and to emphasize policy applications and relevance. This work demonstrates an acknowledgment that the traditional measure of progress, based upon the Gross Domestic Product, is inadequate to address the importance of sustainable development. It is widely accepted that "new indicators of progress are urgently needed to guide our society: ones that include the presently unpriced value of natural and societal capital in addition to the value of conventionally measured economic production . . . the GPI is an important step in this direction" (GPI Atlantic 1998a).

The Nova Scotia GPI is based upon social, economic and environmental indicators selected to reflect community well being and prosperity and to determine progress toward sustainability. The index will be developed by integrating the trends over the last 25 years with existing market statistics to construct an overall index of sustainable development for the province. The GPI is expected to be released in 2000 (GPI Atlantic 1998b).

The State of Ohio 1998 State of the Lake Report: Lake Erie Quality Index (OLEC 1998)

The Ohio Lake Erie Commission evaluated 28 aspects of the status of Lake Erie using 10 indicators and 28 metrics (measurements). The framework used existing databases and looked for short and long term trends. The three main objectives were to:

1. determine what is essential to know about Lake Erie;
2. design and implement effective measuring systems for these essential factors; and
3. establish goals and scoring systems that will allow for critical evaluation of progress.

Unlike most of the similar initiatives, this report and its indicators were intended for the public and, therefore, designed using straightforward terms and easily understood references. Three "themes" or areas of focus were used to set the context for the report, shown in Table 6.

Scores for individual metrics were weighted according to importance, then tallied to produce a descriptive rating for the overall indicators.

For example, to assess the rating for water quality, the following five metrics were used: toxic contamination, contaminated sediments, bacterial pollution, drinking water, and water clarity.

These metrics were averaged to get the overall rating of "Good" for the indicator water quality. The Ohio Lake Erie Commission views this endeavor as a starting point of monitoring and restoration efforts. Metrics and indicators must be constantly reviewed and updated if information is to be kept relevant for the Ohio public.

Hamilton-Wentworth Region; Vision 2020 Sustainable Community Initiative

The Regional Municipality of Hamilton-Wentworth, Ontario (1999) sustainability indicator development program won the 1998 outstanding planning award for excellence in municipal planning from the Ontario Professional Planners Institute. The 10 year process has used 29 indicators tied to sustainability goals set to measure progress. The indicators are linked to the remedial action plan for Hamilton Harbour (Table 7).

The initiative began because of concerns about air quality, water quality and economic restructuring in the Region. From 1990 to 1993, thousands of citizens helped set goals about what the community could look like in the year 2020. Then from 1993 to 1997, an attempt was made to apply strategies necessary to achieve the goals. Behavioural change from individual citizens was expected, as was multi-sectorial participation.

Since the program began, the Region has doubled the amount of natural areas, all new municipal transit buses are to be powered by natural gas, and $60 million has been spent on combined sewer overflow tanks that make the water cleaner so people can swim at the beaches in Hamilton Harbour.

The Vision 2020 initiative incorporates both short term targets and long term goals. Both are important to success. Indicators mean nothing without goals in mind. If goals are too long

Table 6
Framework for the Lake Erie Quality Index (OLEC 1998)

Theme		*Indicators*
1. Environment	1.	Water quality
	2.	Pollution sources
	3.	Habitat
	4.	Biological
2. Recreational Resources	5.	Coastal recreation
	6.	Fishing
	7.	Boating
	8.	Beaches
3. Derived Economy	9.	Tourism
	10.	Shipping

Table 7
Some Hamilton-Wentworth Vision 2020 Sustainability Indicators

Suspended Solids Discharged into Hamilton Harbour	Number of "All Beaches Open" days during Swimming Season
Volume of Waste sent to Landfill Site	Number of Good or Very Good Air Quality Days per Year
Crime Rates	Number of Complaints about Air Quality per Year
Livelihood - Economic Indicators	Annual Use of Hazardous Waste Depot
Stewardship of Environmentally Significant Areas	Annual Transit Ridership per Capita
Water Resources	Low Birth Weight Babies as % of Total Births
Amount of Road Salt used on Regional Roads	Annual Approval for Rezoning from Rural to Urban Land Uses
Energy Use	

term it's hard to generate enthusiasm for the indicator process.

During the program, a large amount of energy and time is spent on communication activities and indicators are reported at an annual event that celebrates success and measures progress.

The program directors have found that it's important to be honest in communicating progress (or the lack thereof). If conditions have become worse, say so. On the other hand, look for opportunities to report positive change. Be sure to communicate with the public in ways that are easy to understand.

Realize that indicators require a long-term commitment by government and stakeholders. Don't underestimate the need for resources and for the people who collect the data used to report indicator progress to support the program.

It's also important to use partnerships whenever and wherever possible. Look for ways to work with professional organizations, other governments, private entities and citizens to make the program operate more efficiently and effectively.

Kid Friendly Cities (ZPG 1999)

The mission of the seventh edition of the Children's Environmental Index (1999) was to compile and present the best available data on the social, economic, educational and physical environment in our cities where our children live, grow, learn and play.

Indicators have been developed and measured to allow a more comprehensive look at the quality of children's lives. To reach that goal, federal, state and local data collectors must collaborate with communities.

The report is intended not only for federal, state and local officials, but also for parents, teachers and activists who would like to explore community sustainability issues using quantifiable measures of well-being. The report card is seen as a useful tool for anyone who wants to foster and maintain a quality community.

The selection of indicators was based on methodological considerations, such as data availability, timeliness, quality and consistency, and all data sources used are the most recently available as of February 1999. Unpublished data from special tabulations by the National Center for Health Statistics, the Bureau of Labor Statistics, the Federal Bureau of Investigation and the Environmental Protection Agency also was requested.

The report provides data on the status of children under age 18 who live in large and smaller cities.

Some of the ranked indicators include population change, teen births, low birth weight, unemployment rate, children in poverty, bad air days and public transportation use.

Results from Great Lakes cities show that Detroit, MI was near the bottom of the list, ranked 23rd out of 25, major U.S. cities, followed by Cleveland, OH, ranked 19th, and Chicago, IL, ranked 18th.

Among a group of smaller municipalities in the Great Lakes basin, Milwaukee, WI was ranked 95 out of 112, Rochester, NY ranked 91st, Buffalo, NY ranked 87th, Erie, PA 63rd, Toledo, OH ranked 45th and Green Bay, WI was near the top of the list ranked 6th out of 112.

Results of Review of Other Initiatives

In reviewing the process and progress of each of these indicator initiatives, the IITF notes that they reinforce its own findings and where appropriate have been incorporated into the IITF work.

- Collaboration must become the norm to allow for real improvement.
- An internationally supported framework is needed to provide a common language and to promote inter-agency communication.
- Indicators must be necessary and sufficient to portray a state of the system.
- Indicators must be tied to specific goals and objectives.
- Indicators must be continually monitored and updated as new issues emerge.
- Managing databases in an efficient and standard manner is critical.
- Frameworks need to be geared to policymakers and the public at large.
- Indicators must be placed within a proper context, otherwise misinterpretation may occur.
- Understand that the development of indicators is a "work in progress." It is very unlikely that all of the indicators chosen will ultimately be the best ones to use.
- Recognize the importance of getting started. Setting a deadline to have indicator selections made will help move the process along.
- Base indicator selection on what citizens can understand. Indicators need to be understandable in order to be communicated.
- Involve people in the process of indicator selection. Ask them what their visions are for the ecosystem you are evaluating.

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