Appendix J:

Information Resources, Modeling and Data Exchange

Measurement Converter Table

U.S. to Metric

Length
feet x 0.305 = meters
miles x 1.6 = kilometers

Volume
cubic feet x 0.03 = cubic meters
gallons x 3.8 = liters

Area
square miles x 2.6 = square kilometers

Mass
pounds x 0.45 = kilograms

Metric to U.S.

Length
meter x 3.28 = feet
kilometers x 0.6 = miles

Volume
cubic meters x 35.3 = cubic feet
liters x 0.26 = gallons

Area
square kilometers x 0.4 = square miles

Mass
kilograms x 2.2 = pounds

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APPENDIX J:

Information Resources, Modeling and Data Exchange

Introduction

Management of Great Lakes water resources requires that decisions be made based upon scientifically defensible information and processes. Increasingly, decisions require improved understandings of fundamental physical, biological, economic and social processes. With advancements in data collection, transmission, storage, analysis and retrieval occurring continuously, the decision support framework requires reliable information analysis and management tools. The Water Resources Management Decision Support System (WRDMSS) report identified key improvements needed for the management of water resources, including:

- increased knowledge of the linkages among watershed components (e.g. uplands, rivers, wetlands, habitat, land use and groundwater);
- increased understanding of the processes among components at differing spatial and temporal scales;
- increased availability of compatible data and information that provide useful indicators of watershed conditions;
- increased availability of advanced watershed simulation and forecasting models; and,
- increased understanding of the roles of risk and uncertainty in the decisionmaking process.

A wealth of data and information has been developed and gathered over time, but it is often difficult to **discover**, **access** and **exchange** these datasets. Problems include the diversity of data and information sources, inconsistencies in or lack of metadata, lack of compatibility of data structures and limited accessibility. Metadata are descriptive information, associated with digital data holdings, which describe the content, quality and other pertinent characteristics of the data, including its accuracy and currency. Although large amount of environmental data and information are increasingly available, they are often distributed across inaccessible servers, repositories and websites, stored in different data formats organized according to differing data structures.

To reduce information inconsistencies, distributed information systems have been more often developed to provide access to scattered sources of environmental data. Distributed information systems seek to address these difficulties by employing standard metadata as a common communication language to facilitate the **discovery** of information, improve **access** to this information and expedite **exchange** between data sources and users. The focus of this appendix is to identify ways to integrate each information component in a coordinated and effective manner to meet the decision support requirements of the region.

Current Data Repositories and Clearinghouses

Throughout this report, key data providers and information holdings for the Great Lakes - St. Lawrence River basin have been identified. Data have become increasingly available in digital forms and "georeferenced" for input to sophisticated computer models and analysis tools. These improvements are reflected in a variety of national and international initiatives and policy efforts such as the National Spatial Data Infrastructure (NSDI), Federal Geographic Data Committee (FGDC), National States Geographic Information Council (NSGIC) and a number of other government programs to increase public accountability, access and awareness of information resources. However, many efforts in data collection remain fragmented and un-coordinated between federal, state, provincial and local agencies, academic institutions and non-governmental organizations such as The Nature Conservancy and Ducks Unlimited. The flood of digital geospatial data have brought about a new set of problems including challenge of how to deal with data of varying completeness, scale, quality and reliability (Tulloch and Robinson, 2000).

There is a growing need for agencies to coordinate and share data more frequently. Under the mandate of the NSDI, the intent is to optimize cost-savings by documenting information holdings and facilitating data exchange. The NSDI focuses on four main activities which include creating and maintaining a comprehensive digital data clearinghouse, developing and promoting data standards, promoting interagency partnerships and promoting standard "framework" data. Framework data are digital map themes that are used by many often-differing applications, but are nevertheless, critical to each, such as transportation features, political divisions, coordinate references, habitat types and imagery.

NSDI Clearinghouse

The development of the NSDI Clearinghouse among U.S. federal agencies was motivated by a desire to minimize duplication of effort in the collection of expensive digital geospatial data and foster cooperative digital data collection activities. The geospatial data clearinghouse allows individual agencies, consortia, or geographically-defined communities to promote their available geospatial data and to help users discover these resources via the Internet. Each agencies, consortia, or geographically-defined communities can establish a node to catalogue their own data holdings to be searched through the Clearinghouse. The Clearinghouse is a decentralized system of servers using the Internet that contain catalogues of metadata. Essentially, the Clearinghouse allows any user to query distributed collections of geospatial information through their metadata descriptions.

The fundamental goal of the NSDI Clearinghouse is to provide access to digital spatial data through metadata. To discover spatial data in the Clearinghouse, users utilize the standard web client with the Z39.50 protocol that provides the ability to search and retrieve specific datasets across various clearinghouse platforms. Z39.50 is more properly known as North American standard ANSI/NISO Z39.50-1995, Information Retrieval (Z39.50): Application Service Definition and Protocol Specification, or as the matching international standard ISO 10163-1995. The Z39.50 protocol includes client and server software that establish a connection, pass a formatted query, return query results, and present identified documents to the client in one of several formats. The Z39.50 protocol was initially developed by the library community to discover bibliographic records using a standard set of attributes, that would allow any Z39.50 client to present information from different yet similarly-structured servers.

This distributed cataloguing environment includes pointers to data sources, instructions for ordering data, graphics that depict conditions of datasets such as completeness, time of collection/creation and other detailed use information. All of this information is provided through the metadata entries. This metadata acts in three roles: 1) documenting the location of the information, 2) documenting the content and structures of the information and 3) providing the end-user with detailed information on its appropriate use. Z39.50 maintenance agencies have the ability to register specific sets of attributes, operators, and rules of implementation as Application Profiles. Once adopted, these profiles are available to the implementer community for incorporation into existing client and server software.

By promoting the availability, quality and requirements for digital data through a searchable on-line system, the NSDI Clearinghouse assists in coordination of data collection and research activities. Current registered Clearinghouse server nodes which catalogue geospatial information about the Great Lakes - St. Lawrence River basin is listed below:

U.S. Federal Agencies

- Bureau of Transportation Statistics – US DOT
- National Atlas of the United States
- National Biological Information Infrastructure Metadata Clearinghouse
- National Gap Analysis Program Metadata Node
- National Park Service
- National Wetlands Inventory
- Natural Resources Conservation Service
- National Oceanic Atmospheric Administration
  - Cooperative Data (COOP) Node
  - Environmental Satellite, Data and Information Services
  - Coastal Services Center (CSC)
  - National Climatic Data Center Node
  - Snow and Ice Data (NSIDC) Node
- U.S. Army Corps of Engineers
- U.S. Census Bureau
- U.S. Environmental Protection Agency - Environmental Information Management System (EIMS)
- U.S. Fish and Wildlife Service
- U.S. Geological Survey (USGS)
  - National Aerial Photography Program
  - National Elevation Dataset
  - Digital Elevation Model
  - Digital Orthophoto Quadrangles
  - Landsat Imagery
  - Water Resources Spatial Information

Relevant Canadian Agencies

- Ecological Monitoring and Assessment Network Data Set Library
- National Atlas of Canada
- National Topographic Data Base

State/Local Agencies

- Chicago Regional Clearinghouse Cooperative
- Illinois Natural Resources Geospatial Data Clearinghouse
- IndianaMap Data Clearinghouse
- Michigan GIS
- Minnesota: Department of Natural Resources
- Minnesota: Department of Transportation
- Minnesota: Land Management Information Center
- Minnesota: MetroGIS
- Ohio Geographically Referenced Information Program (OGRIP) Metadata Server
- Pennsylvania Spatial Data Access
- Wisconsin Land Information Clearinghouse

Non-Profits/Academia

- Cornell University Geospatial Information Repository
- Great Lakes Information Network Data Directory

Private Sector

- Geography Network (ESRI)

Finding 55: Little of the biohydrological data available for support of the Great Lakes Charter Annex decisionmaking process is self documented, particularly with respect to its legacy, inherent uncertainty and appropriateness for use.

In response to this finding, the following tasks have been determined:

Task 55: The USACE, in conjunction with the USGS and in cooperation with other U.S. federal agencies, state entities and Canadian interests, needs to ensure that all federal biohydrological data for the Great Lakes – St. Lawrence River is served on registered NSDI clearinghouse nodes.

Metadata Standards

Executive Order 12906, "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure," was signed on April 11, 1994, by President Clinton. The FGDC develops geospatial data standards for implementing the NSDI, in consultation and cooperation with state, local and tribal governments, the private sector and academic community, and, to the extent feasible, the international community. The goal of FGDC standards is to facilitate sharing spatial data by establishing common characteristics. There are many data standards under development and endorsed by the FGDC, including:

- Content Standard for Digital Geospatial Metadata (CSDGM);
- Content Standard for Digital Orthoimagery;
- Content Standard for Remote Sensing Swath Data;
- Spatial Data Transfer Standard (SDTS);
- Cadastral Data Content Standard;
- Vegetation Classification Standard;
- Soils Geographic Data Standard;
- Geospatial Positioning Accuracy Standard; and,
- Classification of Wetlands and Deep Water Habitats;

Finding 56: Metadata standards are not comprehensively employed throughout the region, particularly for hydrologic, meteorologic, ecological, and water quality data.

In response to this finding, the following tasks have been determined:

Task 56: The USGS, in conjunction with other U.S. federal agencies, state entities and Canadian interests, needs to develop metadata standards to handle all hydrologic, meteorologic, ecological and water quality data needed for Great Lakes – St. Lawrence River water resource decision support.

Each of these initiatives promotes metadata as a foundation to enable an inquirer to ascertain that existence of data, its appropriateness for use and a reference for access. Production of metadata benefits the data-producing organization as well. As personnel change within an organization, undocumented data are usually lost, or have marginal value. New personnel may have little understanding of the content and applicable use of data and may not trust results generated from these data.

Lack of knowledge about other organizations' data can lead to duplication of effort. It may seem burdensome to add the cost of generating metadata to the cost of data collection or creation, but in the long run the value of the data is dependent on its documentation. Creating correct metadata is like library cataloguing, except the creator needs to know more of the scientific background of the information to properly document them.

Finding 57: Decision support tools rely upon metadata to provide measures of reliability and appropriateness of use. Comprehensive and complete metadata for all U.S. federal biohydrological data, when posted and maintained on a NSDI registered clearinghouse node, would substantially improve water resources decisionmaking.

In response to this finding, the following tasks have been determined:

Task 57: The USACE, in conjunction with the USGS, needs to ensure that all U.S. federal biohydrological data that is collected and stored for the Great Lakes –St. Lawrence River to have metadata created and posted on a NSDI registered clearinghouse node.

Web Mapping Services

The purpose of geospatial standards is to facilitate data sharing and increase interoperability among automated geospatial information systems. A new evolving tool of importance to water resource decisionmaking is web mapping services. These services allow Internet users to discover, evaluate and access geospatial data stored on multiple cooperating data servers and generate custom maps on demand. These services are increasingly based on public domain software tools, which minimize costs and maximize cooperation.

A workshop was conducted involving multiple U.S. and Canadian federal, state, provincial and academic representatives to promote a formal Great Lakes – St. Lawrence River Regional Data Exchange Agreement. The goal of this initiative is to develop relationships between agencies to facilitate interoperable decision support systems which will fully exploit the potential of new web-based information services.

Relevant U.S. Federal Programs

Federal Geographic Data Committee

The Federal Geographic Data Committee (FGDC) was organized in 1990 under the Office of Management and Budget to promote the coordinated use, sharing and dissemination of geospatial data on a national basis. It is an interagency committee composed of representatives from the Executive Office of the President and Cabinet-level and independent agencies. The FGDC is tasked by Executive Order 12906 to develop procedures and assist in the implementation of a distributed discovery mechanism for digital geospatial data. Under the Executive Order, the FGDC was tasked with creating a metadata standard to meet these objectives. The Content Standard for Digital Geospatial Metadata serves as a uniform summary description of a data set, which allow for standardized documentation electronically accessible to the Clearinghouse network for data exchange between federal-state and state-state agencies.

Organizations currently participating in the NSDI include:

- GeoData Alliance
- The National States Geographic Information Council
- The National Association of Counties
- The Open GIS Consortium
- The University Consortium for Geographic Information Science
- The National League of Cities
- Cooperating State Councils
- International City/County Management Association (ICMA)
- Intertribal GIS Council

Cooperation among federal, state, local, private and academic sectors should be based on shared responsibilities, shared commitment, shared benefits and shared control aimed at improving the geospatial data delivery system. Contributions of value include: establishing forums for communication, facilitating access to data, building framework and thematic data sets, developing educational and training programs and fostering partnerships for data production and sharing.

In addition in building partnerships, the FDGC coordinates the development of framework data. Framework data is a set of core data sets that are commonly used. Table J-1 below lists seven key geospatial framework themes and the federal agencies which are responsible for their establishment and maintenance (Tulloch and Robinson, 2000).

Table J-1: U.S. National Framework Data Themes

Framework Theme	**Key Federal Agency**
Geodetic Control	National Geodetic Survey (NGS), National Oceanic and Atmospheric Agency (NOAA)
Orthoimagery	National Mapping Division (NMD) - U.S. Geologic Survey (USGS)
Elevation (dry)	National Mapping Division (NMD) - U.S. Geologic Survey (USGS)
Elevation (wet) or Bathymetry	Coast Survey, NOAA
Transportation	Bureau of Transportation Statistics
Hydrography	National Mapping Division (NMD) - U.S. Geologic Survey (USGS)
Government Units	U.S. Bureau of Census

Based on results from the 2003 FGDC Annual Report, most member agencies have spatial data holdings compliant with standards and publish their data and metadata on the NSDI Clearinghouse (FGDC, 2003). Due to lack of resources to produce compliant metadata, these issues also affect agencies' abilities to register their servers as clearinghouse nodes. Hence, funding is needed for agencies to coordinate data collection and standards development.

United States Department of Agriculture

The Geospatial Data Gateway or Geo-Data Gateway of the USDA provides consistent access to natural resource data collected and developed by the department. As part of the reorganization efforts begun under the Reorganization Act of 1994, the Geospatial Data Gateway is designed to offer high quality "one-stop" service to customers to all service center agencies—the Farm Services Agency (FSA), the Natural Resources Conservation Service (NRCS) and Rural Development (RD). The centralized data portal has direct impacts on four business areas: (1) Farm and Community Programs, (2) Eligibility/Compliance, (3) Conservation and (4) Resource Inventory and Assessment. The concept of the Geospatial Data Gateway will improve service center operations and program delivery.

Currently individuals or organizations who want to acquire USDA soils and climatic data can access data through the NRCS National Cartography and Geospatial Center (NCGC) clearinghouse node (http://fgdc.ftw.nrcs.usda.gov/NRCSgateway.html). For users who need to acquire information on plants and vegetation, these data can be accessed from the National PLANT database (http://plants.usda.gov/).

The Geospatial Data Gateway facilitates access, browsing, retrieval and use of GIS data, integrated data themes are stored or linked to a data warehouse or geospatial data servers. As part of the data warehouse, tools are provided to improve access. Data contained in these warehouses may originate from agency collected information such as soils, be purchased for use by USDA customers as is the case for orthoimagery, or be linked to some data partner such as USGS. Some components of the data warehouse include metadata catalogs, security, metrics on content and use, quality control, data cleansing and database optimization.

United States Department of the Interior

USGS

As the primary Federal science agency for water-resource information, the USGS has been developing highly successful cost-sharing partnership with water-resource agencies at the state, local and tribal levels through the Cooperative Program. The Coop Program can assist efforts by addressing issues that includes determining the effects of land use practices on surface and ground water quality; evaluating effectiveness of non-point source pollution management practices; improving strategies to identify and protect drinking water sources; and increasing the availability of water-quality information, including real-time data, for rivers and coastal waters.

Under the Cooperative Program, USGS is required to enhance its hydrologic-data networks; improved accessibility and presentation of available information, such as an increase in the availability of real-time data for surface water and ground water and presenting regional summaries of current conditions and coordination of program activities with those of other agencies involving in monitoring activities. The USGS is also developing more comprehensive water-use data and analysis of water-use information for participating agencies to quantify the stress on existing supplies and to better model possible demand management options to traditional supply approaches.

The Cooperative Program and other federal agencies will still play a major role to ensure readily available data and information to be accessible. The National Streamflow Information Program (NSIP) collects streamflow data needed by federal, state and local agencies for planning and operating water-resources projects and regulatory programs. The NSIP plan is designed to improve monitoring streamflow, by equipping streamgages with precipitation, temperature and water-quality sensors. About 4,200 stations, which total 60 percent of the USGS network, are equipped with automated Data Collection Platforms (DCPs) that use satellite radio transmitters to broadcast stream-stage data 24 hours a day directly to major cooperators, such as the National Weather Service (NWS), the U.S. Army Corps of Engineers and the Bureau of Reclamation. These and other federal, state and local agencies use the river-stage data to forecast river conditions, to issue flood warnings and river-conditions statements and to plan reservoir releases or water withdrawals.

As part of the USGS program of disseminating water data to the public, the USGS maintains the National Water Information System (NWIS), a distributed network of computers and fileservers for the storage and retrieval of water data collected through its activities at approximately 1.5 million sites around the country. Many types of data are stored in this NWIS network, including: site information, time-series (flow, stage, precipitation and chemical), peak flow, ground water, water quality. This information are being provided through the NWIS website, referred as NWISWeb.

The goal of NWISWeb is to provide both internal and external users of USGS water information with an easy to use, geographically-seamless interface to the large volume of USGS water data maintained on 48 separate NWIS databases nationwide. Data is updated from the NWIS sites on a regularly scheduled basis; real-time data is transmitted to NWISWeb several times a day. NWISWeb provides several output options: real-time streamflow, water-levels and water quality graphs, data tables and site maps; tabular output in html and ASCII tab delimited files; lists of selected sites as summaries with reselection for details.

The USGS maintains the Cooperative Topographic Mapping (CTM) program works with partners in other federal agencies and with partners from state, county and local governments; and the private sector to ensure that accurate, current and complete USGS quadrangle maps are kept up to date.

The USGS also manages the U.S. Land Remote Sensing (LRS) Program is the largest archive of remotely sensed land data in the world. Working with NASA, NOAA, commercial satellite companies, state and local governments and international programs, the USGS under the LRS Program collects, maintains and distributes millions of images acquired from satellite and aircraft sensors. From such images scientists and land managers, both public and private, derive information about natural resources, hazards and long-term changes to the landscape. Through advancements in data archive and processing technology and through the operation and maintenance of satellites such as Landsat 5 and 7, the LRS Program provides continuous access to worldwide land images that can be used in mankind's effort to sustain the ever-changing Earth.

Federal Emergency Management Agency
The Federal Emergency Management Agency (FEMA) developed a plan in 1997 to modernize the FEMA flood mapping program. The plan outlined the steps necessary to update FEMA's flood maps for the nation to digital format and streamline FEMA's operations in raising public awareness of the importance of the maps and responding to requests to revise them. Since that time, the plan has continually evolved as new products, processes and technical specifications have been developed and implemented within present funding levels.

Relevant Canadian Federal Programs

The Canadian Geospatial Data Infrastructure (CGDI) promotes the sharing and expanded use of geographically related data by providing an appropriate technical, institutional foundation nation-wide. Implementation of the CGDI provides an environment for users to find, access, integrate and analyze geospatial data from diverse sources, including provincial, territorial, federal and private entities. The CGDI initiative has been supported since 1996 by the Inter-Agency Committee on Geomatics (IACG) and the Canadian Council on Geomatics (CCOG). Natural Resources Canada has been initiating the national partnership under GeoConnections, which guides and implements the CGDI.

GeoConnections is advanced by the Program Advisory Network. The Program Advisory Network consists of 12 committees or "nodes" whose open, national membership enables it to leverage expertise and contributions from stakeholders. The goal of GeoConnections is to provide easy, consistent and harmonized access to geographic information and services and to build the geographic information component of the Internet that enables partnerships between federal, provincial and territorial governments, private interests and academia. Key Canadian framework data themes and stewardship agencies are outlined in the table below.

Table J-2: Canadian National Framework Data Themes

Framework Theme	Key Federal Agency
Geodetic Reference System	Natural Resources Canada (NRCan) – Geodetic Service Division
Imagery	Natural Resources Canada (NRCan), Provincial Geomatics Centres
Data Alignment Layers	Natural Resources Canada (NRCan) – Mapping Service Branch
Roads	Natural Resources Canada (NRCan) – Mapping Service Branch, Provincial Ministries
Hypsography	Natural Resources Canada (NRCan) – Mapping Service Branch
Hydrography (land and marine)	Natural Resources Canada (NRCan) – Mapping Service Branch, Department of Fisheries and Oceans, Provincial Geomatic Centres
Administrative Boundaries	Natural Resources Canada (NRCan), Statistics Canada, Elections Canada, Provincial Geomatics Centres

State/Provincial Agencies

The NSGIC is an organization of states committed to efficient and effective government through the prudent adoption of geospatial information technologies. Members of NSGIC include delegations of senior state GIS managers from across the United States. Other members include representatives from federal agencies, local government, the private sector, academia and professional organizations.

NSGIC provides a unified state voice on geographic information and technology issues, advocates state interests and supports its membership in their individual initiatives. The Council actively promotes prudent geographic information integration and systems development. NSGIC reviews legislative and agency actions, promotes positive legislative actions and provides advice to public and private decision-makers. NSGIC members are involved in the application of geospatial technologies in their member states. The state GIS coordinators exert influence on the geospatial spending habits of the constituencies in their states.

Illinois

Illinois' statewide GIS coordination is the Illinois Geographic Information Council (ILGIC). The legislation establishes the Council to be coordinated through the Illinois DNR and specifies its membership, leadership and advisory group. In addition, ILGIC's duties and powers include evaluating proposals and making recommendations to the Governor, as well as, providing funding to state agencies regions, local and academic sectors in the state. The DNR is the lead agency for geographic information development and manages statewide initiatives including GIS database dissemination and statewide database development. The DNR also serves as a comprehensive a repository through its Clearinghouse to state bureaus, centers and offices.

Indiana

The Indiana GIS Initiative (INGISI) and the Indiana Government GIS Task Force coordinate state GIS initiatives. The INGISI is statewide in scope and its objective is to coordinate statewide geographic information through dissemination of data and data products, education and outreach, building partnerships and adoption of standards. The INGISI is also working to increase networking and communication opportunities for the Indiana geographic information user community. The GIS Task Force is a collaborative effort of state agencies to foster the efficient use of state GIS resources and provide geographic data in usable forms to the citizens of Indiana. Primary access to Indiana GIS data is through the INGISI.

Michigan

The Michigan Geographic Framework (MGF) program is designed to solve the data and communication problem of the state by creating and maintaining a single "official" state base map for state business needs. The Michigan Geographic Framework Network (MGFN) is a extension of the MGF program. The Michigan Center for Geographic Information (MCGI) goals are to ensure: 1) an "up-to-date" and seamless statewide digital map base supports ongoing state GIS needs; 2) users play an active role in its ongoing development and promotion and 3) users of this data are empowered to more effectively apply the information to critical business needs. The MGFN strives to align the geographic data standards and update mechanisms with existing state/federal/local business processes.

Minnesota

Minnesota's Governor's Council on Geographic Information (GCGI) is the principal organization charged with identifying statewide geographic information technology initiatives. The GCGI has several responsibilities, including advising the executive and legislative branches of state government, representing state interests to the federal government, developing and promoting statewide policies and standards, researching technical issues, making policy recommendations and publishing critical material. It also fosters communication with users and producers, promotes effective uses of geographic information technologies, collaborates with similar groups, promotes effective data development and works to improve access to spatial information. The Land Management Information Center supports the GCGI by bringing in geospatial technologies into state government and by supplying users with pertinent information.

The Land Management Information Center (LMIC) offers services and products that promote the effective use of geographic data and geographic information technology to benefit its constituency. The LMIC provides coordination, data and technological services to state, local and federal governments, professional associations, nonprofit organizations and the private sector. This resource is generally referred to as the Minnesota Geographic Data Clearinghouse.

New York

The New York State (NYS) GIS Coordination Program serves as the leading geographic information coordination group and provides leadership, direction and coordination; establishes "preferred" standards; and develops policy recommendations for the program. The program facilitates statewide forum for recognizing, analyzing and developing solutions to problems affecting GIS and spatial information development. Through the NYS Technology Policy 97-6, state agencies are directed to "share GIS data in a consistent and appropriate manner" with others "at little or no cost." State agencies were directed to follow standards for data production, submit metadata to the NYS GIS Clearinghouse and make data available to public agencies.

The Data Sharing Cooperative was primarily developed to encourage public agencies in New York to share in the creation, use and maintenance of GIS data sets at the least possible cost. Two key features of the Data Sharing Cooperative are: (1) Data creators (primary custodians) retain ownership of their GIS data sets, but agree to share it with other Cooperative members for free or, at most, for the cost of copying it; and (2) Users of the GIS data (secondary custodians) pass updates, corrections and revisions back to the creators of the data set, resulting in improved data quality. Key benefits of the Data Sharing Cooperative are included in Table J-3.

Table J-3: Key benefits of NY Data Sharing Cooperative

Broad Participation • Potential for more participants than Federal Model • Gain access to some of the "best" data (bypass problem of public domain release) • Combine aspects of Federal Model with marketplace mechanisms • Scalable to multiple levels; local or regional cooperatives with links to statewide cooperative Shared Maintenance • No new effort mandated • Channel ongoing efforts, data maintenance that would happen anyway • Lower total cost & effort of data maintenance • Improved data quality • Primary Custodians maintain control of datasets, decide how to incorporate improved data Simplified Sharing • Within the Cooperative, all members use same agreement, sign it only once • No "up front" data contribution needed to join, simply agree to terms of Data Sharing Agreement (license) • Low or no cost data transfers, especially if performed over the Internet or NYT	Connection to Amended FOIL Legislation • Enable licensing of GIS records • Primary/secondary custodians • Basic access rights unchanged • Avoids reliance on copyright Fees • Not a revenue-generating business model • Cost of duplication (or less) within the Cooperative • Option to charge commercial users up to "fair market value" • Encourage partnerships w/private sector for joint benefits • Levels the playing field for better bargaining power by data owners Empowered Custodians • Retain ownership and maintenance autonomy of datasets; decide how best to maintain • Sole source for obtaining a particular dataset; eliminates confusion, ambiguity, & orphaned datasets • Option to put data into public domain • Ability to negotiate outside of Cooperative for value-added improvements • Decision on whether to charge fees to commercial users rests with Primary Custodians

The Coordination Program established a State Clearinghouse, developed an intergovernmental data sharing framework and addressed legal and coordination issues, standards and training. Over 200 government entities and not-for-profits (including 65 state agencies) participate in the NYS GIS Cooperative and GIS use and data sharing has expanded significantly in recent years.

Ohio

The State of Ohio initiated a program, through the Executive Order 2000-05T in 2000, to coordinate geospatial technologies efforts in the state and local government and private sector known as the Ohio Geographically Referenced Information Program (OGRIP). The program's vision is to "encourage the creation of digital geographic data of value to multiple users and foster the ability to easily determine what geographic data exist, as well as the ability to easily access and use these data." Within OGRIP, representation includes private utilities, municipalities and universities as well as representatives from state agencies and a number of local government participants. Ohio has created a GIS Support Center in the Department of Administration Services to provide GIS assistance to state agencies in Ohio.

Pennsylvania

Pennsylvania Geospatial Information Council (PAGIC) was established in 1999, between Commonwealth agencies and participating partners consisting of state-wide associations and nonprofit organizations. PAGIC's primary purpose is to cooperatively facilitate the sharing of common geospatial data; develop and recommend management approaches to data development and sharing; develop partnerships with public and private sector organizations. The Pennsylvania Spatial Data Access system (PASDA) is Pennsylvania's official geospatial information clearinghouse and is a node on NSDI. The PASDA clearinghouse provides for the widespread sharing of geospatial data, eliminates the creation of redundant data sets and serves as a resource for locating data throughout the Commonwealth through its data storage, interactive mapping, WebGIS applications and metadata and documentation efforts.

Wisconsin

The Wisconsin Land Information Board (WLIB) leading responsibility is the administration of the Wisconsin Land Information Program (WLIP). The WLIB's primary duties include: guide development of and approve county-wide plans for land records modernization, approve state agency data integration plans, serve as the state clearinghouse for land information and land information systems, administer a grants-in-aid program for local government and provide technical assistance to state and local government. Other agencies that support the program include the County Land Information Officers Network and the Wisconsin Initiative for Statewide Cooperation for Land Cover Analysis and Data (WISCLAND) Steering Committee. A key component of the program is that the county land information offices serve as focal points for information coordination within their jurisdictions, and also with other units of local government and the private sector located in an individual county. Its Land Information Clearinghouse provides a node for data access.

Ontario

In Canada, the development, maintenance and distribution of geospatial data is largely a provincial and municipal issue. While the federal government does have activities pertinent to cadastral data, these are generally quite limited, highly specific to federal lands and generally not closely linked with provincial data.

The Ontario Geospatial Data Exchange (OGDE) draws its members from all levels of government with a mandate in Ontario (federal, provincial and municipal). Membership is also available to First Nations and aboriginal communities as well as broader public sector entities such as conservation authorities, school boards and post-secondary educational institutions. Through OGDE, the Province of Ontario has established the Land Information Ontario (LIO) to orchestrate the collection and management of land information. Participant members are required to compile standardized metadata which describes their data sets in the Ontario Land Information Directory (OLID). This process makes the data discoverable on the Internet. While members may elect to retain the responsibility of distributing their own data, a central data warehouse facility, designated as the Ontario Land Information Warehouse (OLIW), has been established to facilitate access by members. The goal LIO is to establish standards in managing land information and to coordinate Ontario's participation and its development of land information infrastructure as part of GeoConnections and the CGDI.

Finding 58: Biohydrological data collected by various U.S. federal agencies need to be universally shared between themselves and with collaborating state and provincial entities.

In response to this finding, the following tasks have been determined:

Task 58: The USACE needs to lead U.S. federal interagency coordination for promoting regional data exchange agreements covering all required Great Lakes – St. Lawrence River biohydrological data.

Inventory of Modeling Tools

The descriptive model inventory which follows describes modeling tools that have been identified with prospective relevance to ecological impact assessment of water withdrawals in the Great Lakes - St. Lawrence basin. The compilation of this information addresses the need for an understanding of the state of the science of existing quantitative tools that may be used in a water resources management decision support system.

Review sheets were prepared for 38 models that fall into at least one of five categories. While the models included in the descriptive model inventory are considered to be the most relevant for assessment of the ecological effects of water withdrawals and are generally accepted by the modeling community, other models may also be relevant. No geomorphic models for nearshore zones were included in the inventory, but some models that focus on hydrodynamic and sediment transport processes have been developed for some Great Lakes rivers and should be reviewed to assess their applicability to water withdrawals.

Hydrodynamic/Hydraulic Models

Hydrodynamic/hydraulic models provide a description of circulation, mixing and density stratification processes that can affect the water quality and transport of pollutants within a water body. These models use water body geometry, boundary conditions, inflows, withdrawals and meteorological data to simulate water levels, flow velocities, salinities, temperatures and velocity field. Information on physical properties of water body, such as depth, slope of bed, precipitation and temperature, provide input parameters for these models. Physical processes simulated by hydrodynamic models include tidal, wind and buoyancy or density forcing and turbulent momentum and mass transport. The spatial dimensions of these models vary from one-dimensional longitudinal, two-dimensional in the longitudinal and vertical, two-dimensional in the horizontal (vertically-averaged), to fully three-dimensional. Hydrodynamic models use numerical solutions to fundamental governing equations for the conservation of momentum and/or mass to predict water movements.

A hydraulic model can be used to simulate variations in the composition and distribution of habitats during different flow regimes, which is helpful information for development of habitat and bioenergetic models for fish. Table J-4 below provides of list of relevant hydrodynamic/hydraulic models and indicates the models that are described in detailed review sheets in the models inventory report.

Table J-4: Hydrodynamic/Hydraulic Models

Model	**Description**	**Steady State/ Dynamic**	**Dimension**	**Supporting Agency/ Developer**
CE-QUAL-RIV1*	Hydrodynamic & Water Quality Model for Streams	Dynamic	1-D	USACE
CE-QUAL-W2*	2D Laterally-averaged Water Quality Model	Dynamic	2-D vertical	USACE
CH3D-WES*	Curvilinear Hydrodynamics in Three Dimensions - Waterways Experiment Station	Dynamic	3-D	USACE
CORMIX	A mixing-zone model	Steady State	3-D	USEPA
DYNHYD5	Link-Node Tidal Hydrodynamic Model	Dynamic	1-D	USEPA/CEAM
ECOMSED	Hydrodynamic and Sediment Transport Model	Dynamic	3-D	HydroQual, Inc.
EFDC*: Environmental Fluid Dynamics Code	Hydrodynamics and transport model	Dynamic	1-D to 3-D	Tetra-Tech/Virginia Institute of Marine Sciences
HEC-2/HEC-RAS*	River Analysis System	Steady State	1-D (HEC-2)	USACE/ HEC
HEM1D/HEM2D/ HEM3D	Hydrodynamic Eutrophication Model	Dynamic	1-D to 3-D	Virginia Institute of Marine Science
HSCTM-2D	Hydrodynamic and Sediment and Contaminant Transport Model	Dynamic	2-D lateral	USEPA/CEAM
MIKE-11/ MIKE-21/ MIKE-3*	Generalized Modeling Package-1D/ 2D/3D - Hydrodynamics	Dynamic	1-, 2- and 3-D	Danish Hydraulic Institute
POM	Princeton Ocean Model	Dynamic	3-D	Princeton University
RIVMOD-H	River Hydrodynamic Model	Dynamic	1-D	USEPA/CEAM
RMA-2V*	Hydrodynamic analysis model	Dynamic	2-D lateral	WES

Table J-4: Hydrodynamic/Hydraulic Models

Model	Description	Steady State/ Dynamic	Dimension	Supporting Agency/ Developer
UNET	1-D Unsteady Flow through a Full Network of Open Channels	Dynamic	1-D	USACE

Hydrologic/Watershed Models

Hydrologic/watershed models are useful for assessing hydrology for managing the water resources of watersheds. This category includes models that simulate the generation and movement of water and water-borne pollutants from the point of origin to discharge into receiving waters. These models can be used to quantify total watershed contributions of flow, sediment, nutrients and other constituents of interest. The hydrologic/watershed models can be applied to evaluate surface and subsurface pollutant transport to receiving water bodies with subsequent simulation of instream transport and transformations, watershed hydrology and water quality of both conventional and toxic pollutants.

Generally, these models require data such as rainfall, records of evapotranspiration, temperature, humidity and solar intensity. The watershed loading models evaluate the effects of land uses and practices, land cover and soil properties on pollutant loadings to water bodies. Available hydrologic/watershed models vary from simple methods to detailed loading models depending on their capabilities. Simple methods have very limited predictive capabilities and generally provide rough estimates since they are typically derived from empirical relationships. Detailed models are generally complex models with greater spatial and temporal resolutions, and they use storm events or continuous simulation to predict flow and pollutant concentrations for a range of flow conditions. They include physical processes of infiltration, runoff, pollutant affects, and groundwater and surface water interactions. Applications for these models vary depending on data availability and modeling needs. Table J-5 provides a list of relevant hydrologic/watershed models and indicates the models that are described in detailed review sheets in the models inventory report.

Table J-5: Hydrologic/Watershed Models

Model	Description	Supporting Agency/ Developer
AGNPS	Agricultural Nonpoint Source Pollution Model	USDA
ALIS*	Aquatic Landscape Inventory System (ALIS) and associated database	OMNR
ANSWERS	Event based agricultural area runoff/erosion model	University of Georgia
ATLSS*	Across trophic level system simulation for the freshwater wetlands of the everglades and big Cypress swamp	Coordinated through USGS
BASINS*	Better Assessment Science Integrating point and Nonpoint Sources (NPSM – Dynamic, QUAL2E – Steady state)	USEPA/CEAM
CREAMS/ GLEAMS	Field scale runoff/erosion model	USDA
ELM*	Everglades Landscape Model	SFMD (H. Carl Fitz)

Table J-5: Hydrologic/Watershed Models

Model	Description	Supporting Agency/ Developer
GAWSER	Object-Oriented Guelph All-Weather Storm Event Runoff Model	John A. Hinckley, Jr. (USCOE)
GWLF	Generalized Watershed Loading Functions	EPA/CEAM
HSPF*: Hydrological Simulation Program – FORTRAN	Capable of simulating mixed-land-use watersheds (urban and rural) (1-D, Dynamic)	USEPA/CEAM
LBRM *	GLERL Large Basin Runoff Model	GLERL/NOAA
OFAT*	Ontario Flow Assessment Techniques (OFAT) Version 1.0	OMNR
SLAMM	Source Loading and Management Model	University of Alabama
SPARROW*	Spatially Referenced Regression On Watershed attributes	USGS
SWAT*	Soil and Water Assessment Tool	USDA
SWMM	Storm Water Management Model	USEPA/CEAM
WAM*	Watershed Assessment Model	SWET
WARMF*	Watershed Analysis Risk Management Framework	Systech Engineering, Inc. under the sponsorship of EPRI
WATFLOOD	The WATFLOOD Hydrologic Model	Nick Kouwen (Univ. of Waterloo, Ontario, Canada)

Surface Water Quality Models

Surface water quality models address problems associated with variables that can result in fish kills, taste and odor problems, human health impacts and other ecosystem disturbances. This category includes models of dissolved oxygen, nutrient-eutrophication, sediment transport and fate and transport of contaminants. Surface water quality models are used to analyze water quality related problems and to synthesize the principal components: inputs, reactions and physical transport and outputs. The analysis of pollutants in surface waters describes load-response relationships, cause-effect mechanisms and, in some cases, the impact of pollutants on biota in the system. These models focus on the objective of protecting plants, animals, humans, wildlife, aquatic life and the environment from the negative effects pollutants and toxic substances.

Some water quality models simulate the effect of pollution discharges from various sources to air, water and land. The external inputs include point and non-point sources. This category includes eutrophication models, which predict the production, transformation and decay of phytoplankton biomass in response to changes in nutrients, temperature and light. Table J-6 provides of list of relevant surface water quality models and indicates the models that are described in detailed review sheets in the models inventory report.

Table J-6:   Surface Water Quality Models

Model	Description	Steady State/ Dynamic	Dimension	Supporting Agency/Developer
AQUATOX*	Ecosystem Model	Dynamic	2-D	USEPA
CE-QUAL-ICM*	3-D Time variable integrated compartment eutrophication model	Dynamic	3-D	USACE
CE-QUAL-RIV1*	Hydrodynamic and water quality model for streams	Dynamic	1-D	USACE
CE-QUAL-W2*	2-D laterally averaged hydrodynamic and water quality model	Dynamic	1-D, 2-D	USACE
ECOFATE*	Ecosystem model	Dynamic	2-D	Simon Fraser University, Canada (Frank P. Gobas)
EUTROMOD*	Receiving water model	Steady-state	1-D	NALMS
GBTOX/GBOCS*	Green Bay Toxics Model	Dynamic	3-D	USEPA
HUDTOX	Contaminant Fate and Transport Model	Dynamic	3-D	USEPA
MIKE11-WQ MIKE21-WQ MIKE3WQ*	Generalized Modeling Package-1D(/2D/3D) Water Quality Module	Dynamic	1-D to 3-D	Danish Hydraulic Institute
QUAL2E*	Steady-state, 1-D stream water quality model	Steady-State	1-D	USEPA/CEAM
QWASI	Quantitative Water Air Sediment Interaction Model			Trent University, Canada (Donald Mackay)
RATECON*	Rate Constant Model for Chemical Dynamics	Dynamic	1-D	Trent University, Canada (Donald Mackay)
SAGEM*	Saginaw Bay Ecosystem Model	Dynamic	3-D	USEPA
SMPTOX4*	Simplified Method Program – Variable-Complexity Stream Toxics Model	Steady-state	1-D	USEPA/CEAM
WAQ-DELFTS3D	3-D time variable water quality model	Dynamic	3-D	WL Delft Hydraulics
WARMF*	Watershed Analysis Risk Management Framework			Systech Engineering, Inc. (w/ EPRI)
WASP5*	Water Quality Analysis Simulation Program	Dynamic	1-D to 3-D	USEPA
WASTOX	Water Quality Analysis Simulation of TOXics	Dynamic	1-D to 3-D	USEPA/CEAM

Groundwater Models

Groundwater models address issues related to water supply, sub-surface containment transport, remediation and mine dewatering. These models can be used to track pollutants in the saturated and unsaturated zones and evaluate the transport of pollutants due to migration and interactions of groundwater and surface water. Groundwater withdrawals can result in lower river and stream water levels. The hydrology of the watershed can be impacted by precipitation, runoff, groundwater, surface storage and river water levels. In fact, the watershed hydrology indirectly includes the groundwater components in assessing the impact of water quantity on watersheds.

Groundwater models generally require a large amount of information and a complete description of the flow system, as well as specialized expertise. Table J-7 provides of list of relevant groundwater models and indicates the models that are described in a detailed review sheet in the models inventory report.

Table J-7: Groundwater Models

Model	Description	Source
AQTESOLV	Aquifer Test Design and Analysis Computer Software	HydroSOLVE Inc.
Bioplume III	Transport of Dissolved Hydrocarbons under the influence of oxygen-limited biodegradation.	Scientific Software Group
Bioscreen	Simulates remediation through natural attenuation of dissolved hydrocarbons	USEPA
Chemflo	Simulates Water and Chemical Movement in Unsaturated Soils	Scientific Software Group
FLONET/TRANS	FLONET Computes potentials, streamlines and ground-water velocities in a vertical section through a confined or unconfined aquifer. FLOTRANS computes heads, velocities and contaminant concentrations in a vertical section through a confined or unconfined aquifer. It has advective-dispersive solute transport capability	IGWMC Colorado School of Mines
GEOPACK	Geostatistical Software for Conducting Analysis of the Spatial Variability of One or More Random Functions	Scientific Software Group
GMS*	Sophisticated Groundwater Modeling Environment for MODFLOW, MODPATH, MT3D, RT3D, FEMWATER, SEAM3D, SEEP2D, PEST, UTCHEM and UCODE (1-D to 3-D)	Scientific Software Group
HSSM-DOS	Hydrocarbon Spill Screening Model (HSSM)	USEPA/CEAM
MODFLOW/ Visual_MODFLOW*	Three-Dimensional Finite-Difference Ground-Water Flow Model	USGS/ Scientific Software Group/ Waterloo Hydrogeologic, Inc.
MOFAT	Multiplephase Flow and Multi-component Transport Model (Dynamic, 2-D)	USEPA
MT3D99	A Modular 3D Solute Transport Model	Scientific Software Group
RETC	Analyzes Soil Water Retention and Hydraulic Conductivity Functions of Unsaturated Soils	Scientific Software Group

Table J-7: Groundwater Models

Model	Description	Source
RITZ	Regulatory and Investigative Treatment Zone Model	Scientific Software Group
VLEACH	One-Dimensional Finite-Difference Vadose Zone Leaching Model	Scientific Software Group/USEPA
WhAEM	Wellhead Analytic Element Model (WhAEM2000)	USEPA/CEAM
WHPA	Wellhead Protection Area Model (Steady-state, 2-D)	Scientific Software Group
WinTran	Groundwater Flow and Finite-Element Contaminant Transport Model	Scientific Software Group

Ecological Effects Models

This category includes a wide variety of models and techniques for the ecological assessment of the aquatic system. It includes habitat and species classification, index systems and toxicological and ecological models that simulate the effect of stressors on habitats. These types of models can examine or predict the status of a habitat, biological population, or biological community. Water withdrawals can cause changes in the features of the system such as depth, velocity, temperature, oxygen, surface area and vegetation and this information can be used to evaluate the effect on aquatic ecosystems. Ecosystem models that respond to these hydraulic and hydrologic changes will be most valuable for application to a water resources decision support system. Table J-8 provides of list of relevant ecological effects models and indicates the models that are described in a detailed review sheet in the models inventory report.

Table J-8: Ecological Effects Models

Model	Description	Supporting Agency/Developer
ATLSS*	Across trophic level system simulation for the freshwater wetlands of the everglades and big Cypress swamp	Coordinated through USGS
ECOFATE *	Model to investigate whether existing or planned chemical emissions can be expected to pose an ecological or human health risk,	Simon Fraser University (Frank P. Gobas)
ELM*	Everglades Landscape Model	SFWMD (H. Carl Fitz)
EXAMS II*	A fate and exposure model for assessing toxics in receiving waters	USEPA/CEAM
FGETS*: Food and gill exchange of toxic substances	Fish bioaccumulation simulation modeling for laboratory and field condition	USEPA/CEAM
HEP/HS*: Habitat Evaluation Procedures/Habitat Suitability Indices	Species based-evaluation method that determines the quality and quantity of available habitat and measures the impact of land or water use changes on that habitat	USEPA/CEAM
HES*: Habitat Evaluation System	Community-based evaluation technique to assess the impacts of development projects for aquatic and terrestrial habitat evaluations	USEPA/CEAM
HGM: Hydrogeomorphic	Used for determining the integrity of physical, chemical and biological functions of wetlands as	USEPA/CEAM

Table J-8: Ecological Effects Models

Model	**Description**	**Supporting Agency/Developer**
Assessment	they compare to reference conditions	
IFIM*: Instream Flow Incremental Methodology	Collection of analytical procedures and computer models used to assess riverine habitats	USEPA/CEAM
PHABSIM: Software that combines Fish-habitat preference models and discharge-habitat models	Describes the weighted Usable Area (a measure of habitat) under a variety of channel configurations and flow management conditions	
TSLIB: Time-Series library	Creates habitat time series and habitat-duration curves using habitat discharge relationships produced by PHABSIM	
MNSTREM: Minnesota Stream Temperature Model	Simulates dynamic stream temperatures averaged over one to six hours	USEPA/CEAM
PVA*: Population Viability Analyses	Population dynamics modeling for aquatic and terrestrial populations	USEPA/CEAM
RBPs: Rapid Bioassessment Protocols	Techniques to characterize the biological integrity of streams and rivers	USEPA/CEAM
SAGEM*	Saginaw Bay Ecosystem Model	USEPA
SNTEMP*: Stream Network TEMPerature Model	Models that simulate mean daily water temperature for a stream segment for a single time period	USEPA/CEAM
SSTEMP: Stream Segment for a Single Time Period	Models that simulate mean daily water temperature for a stream network with multiple tributaries for multiple time periods	
WET II: Wetland Evaluation Technique, version 2.0	A community-based habitat evaluation approach that can provide a broad overview of potential project impacts on wetland habitat functions	USEPA/CEAM

Ecological effects models that address the impacts of water withdrawals include a wide range of evaluation and assessment techniques that affect the ecosystem structure and function. Changes in water quantity, water quality and sediment dynamics driven by water withdrawals can affect many components and interactions in an aquatic ecosystem, including species habitat, production and diversity of flora, predator-prey relationships and food web structure.

Because of the inherent connection between species and habitat, the effects models are best suited when used in combination with each other and with other categories of models. Several environmental impact assessment modeling frameworks have been developed to assess the effects of different flow conditions on aquatic ecosystems. For example, the Instream Flow Incremental Methodology (IFIM) is a habitat-based impact assessment and water management tool used to manage stream fishery habitat. These steady flow frameworks would need to be modified to include the potential effects of changes in flow conditions on habitat and aquatic biota.

Finding 59: Physical process models, ecological impact models and predictive tools need to be linked as seamlessly as possible to expedite the assessment of ecological impacts of water withdrawals.

In response to this finding, the following tasks have been determined:

Task 59: The USACE, in cooperation with other U.S. federal agencies, state entities, Canadian interests, and regional academic institutions needs to develop procedures for maintaining and promoting linkages between computer models needed to support implementation of the Great Lakes Charter Annex.

Implementation Strategies – Information Resources, Modeling and Data Exchange

Tasks for improving information exchange between agencies within the base of Great Lakes - St. Lawrence River basin are presented in this section. These tasks are defined within a comprehensive framework of enhancing the U.S. federal role in creating and maintaining an information base to support science-based decisions on water withdrawals and diversions from the Great Lakes - St. Lawrence River basin. Each task is defined at different options of implementation under the USACE plan formulation approach. This approach, in a broad sense, is being used to develop systematic alternative plans that Congress could consider for supporting the states' Great Lakes Charter Annex decisionmaking process.

Five implementation options are presented, each as a separate integrated approach. This, however, is not an exclusive list and does not represent an "all or nothing" approach. Individual elements from one option could be pulled out and funded separately, making an important contribution to Great Lakes - St. Lawrence River basin information base. Even modest increases in funding over the "Without Plan" option can enhance decisionmaking. Water resources managers should examine each particular integrated plan option as well as individual recommendations to discern where important progress can be made.

Described below are five implementation alternatives considered:

- **Without Plan Strategy** – Describes the status of the recommended activity as it currently exists. Without change, this current status may actually decline, representing negative impacts. If negative impacts are expected, they are highlighted wherever possible.

- **Minimum Investment Strategy –** Describes the least costly measures needed to insure minimum functionality of the decision support system. Not all system components of an implementation plan are included in this option.

- **Selective Implementation Strategy –** Describes an integrated system comprised of prioritized components. Few components are fully funded, but no essential components are excluded.

- **Enhanced Implementation Strategy –** Describes an integrated system that includes all essential components at funding levels which enhance information accuracies and decision support system functionalities.

- **Full Implementation Strategy –** Describes an integrated system that fully implements the recommended activity. Technical staff and financial resources are not restricted. Information accuracies and completeness approaches state-of-the science.

Due to the interdependent nature of many issues described in the appendices, some findings may be repeated in total or in part elsewhere in another appendix. The interdependence of findings is noted explicitly in the appendices wherever appropriate.

A dollar value has been estimated for the four potential alternatives that require additional investment over a 10-year implementation schedule. Monetary value is based on the best available information through extensive research and review by project collaborators and is presented in 2004 U.S. dollars. Further information is provided in Appendix K – Cost Estimation, including an analysis of the uncertainty associated with these estimates.

Comparisons of costs at various implementation levels provide a useful measure of investment versus return. It is important to remember that the primary objective of all investments is to reduce uncertainties associated with decisionmaking. Since the hydrology, climatology, geology and biology of the Great Lakes – St. Lawrence River system is highly complex, reductions in uncertainty are sought for each task outlined for the integrated and comprehensive information system.

The definition of the individual tasks outlined in this report has sought to eliminate "double-counting" as much as possible. Costs for the various tasks also explicitly address any interdependencies that occur under a particular implementation alternative. Cost estimates for each task under each implementation alternative also reflect anticipated economies of scale.

Risk and Uncertainty

Risk and uncertainty are inherent aspects of all facets of an integrated information system for water management of the Great Lakes – St. Lawrence River system. Risk can be viewed relative to human and aquatic health, to real property, to the ability to attain profit from a commercial venture, or to relative benefits that can be attained at given investment levels.

The integrated information system described within this report, once improved above current conditions, has a very low likelihood of adverse risk to human health, life or personal property. It is simply a monitoring, modeling and predictive system that does not include significant physical structures or construction. The converse does apply however; continued financial stressors on the monitoring system can cause atrophy of monitoring abilities which could, in turn, mask physical, chemical and biologic change to natural streamflow throughout the system.

Risk is also factored in throughout this report related to the prospective reward or benefit attained at increasing levels of investment. Each task in the integrated information system is evaluated in terms of cost effectiveness, whenever practical. This discussion is addressed in detail in the Main Report, although each appendix includes detailed information on the risk/return for each task under each implementation alternative.

Uncertainty is pervasive throughout the design, implementation and operation of any integrated water management system. At the current level of investment in groundwater, surface water and open lake monitoring and modeling, cumulative withdrawals from headwater systems can not be detected, measured or adequately estimated. Hence, the uncertainty of cumulative hydrologic effects is extremely large under the Without Plan and Minimum Investment alternatives. Even under the Full Implementation alternative, uncertainty will continue to exist, albeit at a much lower level. Current limitations affecting information exchange across jurisdictional boundaries further exacerbates uncertainties in decisionmaking.

The analytical functions of the integrated information system will generally have reduced uncertainties as funding increases from one implementation alternative to the next. In addition, these uncertainties can be computed with greater confidence as more investment is made in the monitoring frame and computer modeling. The legal defensibility of permitting water withdrawal improves as uncertainty is reduced, in part or in total.

Integrated Information System Tasks

Tasks 55-58 described in this appendix present an integrated approach towards enhancing information exchange between jurisdictions within the Great Lakes – St. Lawrence River system, and enhancing model integration. It is important to see that these tasks are important "building blocks" for the integrated information system, as important in some respects as improved monitoring. Improvements under any specific task will provide incremental benefit, but the sum of the parts provides the greatest opportunity for reducing uncertainties under each implementation alternative. These tasks are repeated below.

Task 55: The USACE, in conjunction with the USGS and in cooperation with other U.S. federal agencies, state entities and Canadian interests, needs to ensure that all federal biohydrological data for the Great Lakes – St. Lawrence River is served on registered NSDI clearinghouse nodes.

Task 56: The USGS, in conjunction with other U.S. federal agencies, state entities and Canadian interests, needs to develop metadata standards to handle all hydrologic, meteorologic, ecological and water quality data needed for Great Lakes – St. Lawrence River water resource decision support.

Task 57: The USACE, in conjunction with the USGS, needs to ensure that all U.S. federal biohydrological data that is collected and stored for the Great Lakes –St. Lawrence River to have metadata created and posted on a NSDI registered clearinghouse node.

Task 58**:** The USACE needs to lead U.S. federal interagency coordination for promoting regional data exchange agreements covering all required Great Lakes – St. Lawrence River biohydrological data.

Implementation Mechanisms and Costs
The proposed approaches/mechanisms for implementing the tasks and associated costs are provided below for each of the five implementation alternatives considered. The U.S. federal agency which has the assigned mission responsibility for implementing these activities is identified, whenever clear. If potential overlap occurs between U.S. federal agencies in mission responsibilities, one is proposed over the other based on perceived technical or administrative competencies to complete the necessary work within budget and schedule.

Task 55: The USACE, in conjunction with the USGS and in cooperation with other U.S. federal agencies, state entities and Canadian interests, needs to ensure that all federal biohydrological data for the Great Lakes – St. Lawrence River is served on registered NSDI clearinghouse nodes.

Without Plan Strategy (55) – Biohydrological data will remain fragmented across the different federal agencies. Institutional agency "fiefdoms" will persist, compromising science-based water resources management decisions across the basin.

Minimum Investment Strategy (55) – Provide funding to the USACE to work in partnership with the Great Lakes Commission to insure integration of existing biohydrological data across the Great Lakes – St. Lawrence River system and posting of associated metadata to registered NSDI clearinghouse nodes. The estimated cost for this effort is $600 K over the next 3-years.

Selective Implementation Strategy (55) – Provide funding to the USACE to work in partnership with the Great Lakes Commission to insure integration of existing biohydrological data across the Great Lakes – St. Lawrence River system and posting of associated metadata to registered NSDI clearinghouse nodes. The estimated cost for this effort is $600 K over the next 3-years.

Enhanced Implementation (55) **–** Provide funding to the USACE to work in partnership with the Great Lakes Commission to insure integration of existing biohydrological data across the Great Lakes – St. Lawrence River system and posting of associated metadata to registered NSDI clearinghouse nodes. The estimated cost for this effort is $600 K over the next 3-years.

Full Implementation Strategy 55) – Provide funding to the USACE to work in partnership with the Great Lakes Commission to insure integration of existing biohydrological data across the Great Lakes – St. Lawrence River system and posting of associated metadata to registered NSDI clearinghouse nodes. The estimated cost for this effort is $600 K over the next 3-years.

Task 56: The USGS, in conjunction with other U.S. federal agencies, state entities and Canadian interests, needs to develop metadata standards to handle all hydrologic, meteorologic, ecological and water quality data needed for Great Lakes – St. Lawrence River water resource decision support.

Without Plan Strategy (56) – Inconsistent, incomplete, non-uniform and unreliable information will continue to be the norm. Current FGDC endorsed standards do not cover all of the datasets required to make informed management decisions in the Great Lakes - St. Lawrence River system.

Minimum Investment Strategy (56) – Increase funding for the USGS to support the FGDC to expand metadata standards development program emphasizing hydrologic and meteorologic data models and definition of their accuracies and consistencies for model input at a cost of $500 K over 2- years.

Selective Implementation Strategy (56) – Increase funding for the USGS to support the FGDC to expand metadata standards development program emphasizing hydrologic and meteorologic data models and definition of their accuracies and consistencies for model input at a cost of $2 M over 5 years.

Enhanced Implementation Strategy (56) – Increase funding for the USGS to support the FGDC to expand metadata standards development program emphasizing hydrologic, meteorologic and biologic data models and definition of their accuracies and consistencies for model input at a cost of $4 M over 5 years.

Full Implementation Strategy (56) – Increase funding for the USGS to support the FGDC to expand metadata standards development program emphasizing hydrologic, meteorologic and biologic data models and all other relevant model inputs and outputs and definition of their accuracies and consistencies for model input at a cost of $6 M over 5 years.

Task 57: The USACE, in conjunction with the USGS, needs to ensure that all U.S. federal biohydrological data that is collected and stored for the Great Lakes –St. Lawrence River to have metadata created and posted on a NSDI registered clearinghouse node.

Without Plan Strategy (57) – Under Executive Order 12906, each federal agency is directed to document all geospatial data it collects, produces and distributes. Minimal funding has been set aside for metadata development for historic data. Implementation of the Executive Order has been spotty at best over the region. Inconsistent, incomplete, non-uniform and unreliable information will continue to be the norm.

Minimum Investment Strategy (57) – Provide funding to the USACE to work in partnership with the other U.S. federal agencies to become compliant with all of the provisions of Executive Order 12906. The estimated cost for this effort is $600 K over a ten-year period.

Selective Implementation Strategy (57) – Provide funding to the USACE to work in partnership with the other U.S. federal agencies to become compliant with all of the provisions of Executive Order 12906. The estimated cost for this effort is $600 K over a ten-year period.

Enhanced Implementation Strategy (57) – Provide funding to the USACE to work in partnership with the other U.S. federal agencies to become compliant with all of the provisions of Executive Order 12906. The estimated cost for this effort is $600 K over a ten-year period.

Full Implementation Strategy (57) – Provide funding to the USACE to work in partnership with the other U.S. federal agencies to become compliant with all of the provisions of Executive Order 12906. The estimated cost for this effort is $600 K over a ten-year period.

Task 58: The USACE needs to lead U.S. federal interagency coordination for promoting regional data exchange agreements covering all required Great Lakes – St. Lawrence River biohydrological data.

Without Plan Strategy (58) – Current information base is sporadic and incomplete. This situation is not likely to change without additional investment.

Minimum Investment Strategy (58) – Provide funding to the USACE to coordinate with federal, state and provincial agencies in the U.S. and Canada to develop a data exchange agreement and implement the necessary data exchange mechanisms for sharing and accessing data. The estimated cost for this program is $1 M over ten years, with commensurate funding per annum thereafter.

Selective Implementation Strategy (58) – Provide funding to the USACE coordinate with federal, regional, state and provincial agencies in the U.S. and Canada to develop a data exchange agreement and implement the necessary data exchange mechanisms for sharing and accessing data. This will require pass-through funding to the Great Lakes states to build requisite infrastructure. The estimated cost for this program is $5 M over ten years, with commensurate funding per annum thereafter.

Enhanced Implementation Strategy (58) – Provide funding to the USACE coordinate with federal, regional, state and provincial agencies in the U.S. and Canada to develop a data exchange agreement and implement the necessary data exchange mechanisms for sharing and accessing data. This will require pass-through funding to the Great Lakes states to build requisite infrastructure. The estimated cost for this program is $5 M over ten years, with commensurate funding per annum thereafter.

Full Implementation Strategy (58) – Provide funding to the USACE coordinate with federal, regional, state and provincial agencies in the U.S. and Canada to develop a data exchange agreement and implement the necessary data exchange mechanisms for sharing and accessing data. This will require pass-through funding to the Great Lakes states to build requisite infrastructure. The estimated cost for this program is $5 M over ten years, with commensurate funding per annum thereafter.

Task 59: The USACE, in cooperation with other U.S. federal agencies, state entities, Canadian interests, and regional academic institutions needs to develop procedures for maintaining and promoting linkages between computer models needed to support implementation of the Great Lakes Charter Annex.

Without Plan Strategy (59) **–** Projecting likely impacts of potential water withdrawals will continue to be compromised due to inconsistencies between model inputs and outputs. Limited model integration will proceed out of necessity, but not in a systemic approach. Holistic analysis will continue to be difficult and not be cost effective.

Minimum Investment Strategy (59) **–** Develop a prototype integrated and holistic model that can illustrate all the cause-effect relationships that exist between potential water withdrawals and biological impacts and apply it for one high priority Great Lakes watershed at a cost of $1.5 M over two years.

Selective Implementation Strategy (59) **–** Develop a prototype integrated and holistic model that can illustrate all the cause-effect relationships that exist between potential water withdrawals and biological impacts and apply it for one high priority Great Lakes watershed at a cost of $1.5 M over two years.

Enhanced Implementation Strategy (59) **–** Develop and implement a prototype integrated and holistic model framework. Models would be developed and applied to individual watersheds or subwatersheds based upon priority need. The cost of this effort is estimated at $3 million over the next five-years.

Full Implementation Strategy (59) **–** Develop and implement an integrated and holistic model framework for each U.S. Great Lakes – St. Lawrence watershed. The cost of this effort is estimated at $5 million over the next five-years.

Total Costs Over 10 Years

Without Plan Strategy (TOTAL) **–** $0 M

Minimum Investment Strategy (TOTAL) **–** $4.2 M

Selective Implementation (TOTAL) **–** $9.7 M

Enhanced Implementation Strategy (TOTAL) **–** $13.2 M

Full Implementation Strategy (TOTAL) **–** $17.2 M

References

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