Canada / U.S.
Lake Ontario – St. Lawrence River Framework Data Project

Milestone 1: LOSLR Framework Strategy Plan

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Prepared for the Federal Geographic Data Committee and the GeoConnections Secretariat in partial fulfillment of the requirements of the 2002 NSDI Cooperative Agreements Program Category 4 Canadian/U.S. Spatial Data Infrastructure Project.

Document Purpose

In addition to this project addressing the immediate needs of the IJC LOSLR Study and the LOSLR Framework community, other framework projects and similar studies could benefit from the LOSLR Framework development experiences. This document serves as a foundation upon which to develop thorough documentation of the LOSLR Framework Data Project to sustain the LOSLR Framework and contribute to a "best practices" knowledge base associated with development of a U.S./Canadian bi-national Spatial Data Infrastructure. Future reports coming out of this study should build upon the issues discussed in this report, contributing additional detail or considerations to any topic area associated with the framework.

In conjunction with the Milestone tasks and project workplan documents (both documents have been internally distributed among the LOSLR Framework Data Project participants), this document is intended to clarify key components of the LOSLR Framework Data Project and the respective roles and responsibilities of the project's participants. This document also represents an initial attempt to provide potential participants and any interested parties with a greater understanding of the LOSLR Framework and all of its related components. The LOSLR Framework Strategy Plan will clarify, for the entire Framework community, the common vision of the LOSLR Framework.

Background

The International Lake Ontario - St. Lawrence River Study Board was formed in December 2000 by the International Joint Commission (IJC) to assess and evaluate the Commission's Order of Approval used to regulate outflows from Lake Ontario through the St. Lawrence River. The current Order of Approval requires that the St. Lawrence Seaway Power Project be operated to meet certain conditions and criteria to protect the interests in both countries, including shoreline communities, commercial navigation, and hydropower production. The Study is also evaluating the impacts of changing water levels on environmental factors, shore erosion, flood damages, recreational boating, and tourism. The Study Team is a bi-national group of experts from government, academia, native communities, and interest groups representing the geographical, scientific, and community concerns of the Lake Ontario - St. Lawrence River system. The IJC also appointed a volunteer bi-national Public Interest Advisory Group (PIAG) to ensure effective communication between the public and the International Lake Ontario-St. Lawrence River Study team for the duration of the Study. After completion of the 5-year Study, the Board will, based upon the results of the Study and consultations with the public, deliver recommendations to the IJC for possible amendments or additions to the present criteria and the recommended regulation plan to give effect to these criteria.

The Information Management, formerly Common Data Needs, Technical Working Group (IMTWG) of the International Joint Commission's Lake Ontario – St. Lawrence River Study (LOSLR "Study") was charged with the development and implementation of an Information Management Strategy (IMS) for the Study. In response, the IMTWG assembled an IMS Team consisting of GIS, IM, and IT professionals either participating in the Study, or associated with agencies or organizations in the Study region. With assistance from a contractor, Pangaea

Information Technologies, the IMS team conducted a comprehensive Needs Assessment and two workshops to aid in the formulation of that Strategy.[1]

During the second workshop, the group discussed the opportunity to acquire additional resources for implementing the IMS for the Study through a Category 4 grant from the 2002 National Spatial Data Infrastructure (NSDI) Cooperative Agreements Program (CAP). Prior to the workshop, discussions with FGDC and GeoConnections provided some guidance for responding to the RFP. A breakout group at the workshop identified a preliminary set of public and private partners.

Following the breakout session, it was decided that the Category 4 CAP grant should be applied for with the IJC serving as the lead organization for the proposed project, and Roger Gauthier and Wendy Leger as POCs, serving in their capacity as Information Management TWG Co-chairs. Other public sector partners included the U.S. Army Corps of Engineers, Environment Canada, Ontario Ministry of Natural Resources (OMNR), and may include other provincial and state agencies. Pangaea Information Technologies and Great Lakes Commission (GLC) would constitute the principle U.S. partners. Christian J. Stewart Consulting (CJSC) and Baird & Associates (Baird) would constitute the principle Canadian partners.[2] The grant was awarded in May 2003. The project will last roughly one year and will run through March 2003.

2002 CAP Grant Proposal Summary

A multi-sector partnership proposes developing a framework for geospatial data essential for research, management, and business operations in the Great Lakes region. As a starting point, the "Lake Ontario – St. Lawrence River Framework Data Project" will integrate, afford discovery of, and begin to provide for the long-term storage, maintenance, and flexible accessibility of a number of "framework data" layers. These include shoreline, political units, transportation features, watersheds, hydrography, conservation management areas, orthoimagery, and elevation (hypsographic and topometric) data. The project is designed to provide a scalable system with respect to new participants, data types, geographies, and data uses, and to augment the growing knowledge base by documenting all procedures, policies, and lessons learned, and making these widely available.[3]

What is the Framework?

Framework data and the organizational strategies and policies which support its development and subsistence are important components of the Spatial Data Infrastructure (SDI) initiatives being implemented at national and global levels. The SDI refers to "the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data."[4] The framework, as opposed to "framework data," is a collaborative effort to create a

[1] Information Management Strategy for the International Joint Commission Lake Ontario – St. Lawrence River (IMS Report), May 2002, p.1
[2] Taken from the IMS Report p. 24-25
[3] Taken from: IMS Report p. 118
[4] GSDI Cookbook, Version 1.1, 15 May 2001, p. 8, http://www.gsdi.org/pubs/cookbook/cookbook0515.pdf

common source of basic geographic data. The framework data represents "data you can trust" -- the best available data for an area, certified, standardized, and described according to a common standard. It provides a foundation on which organizations can build by adding their own detail and compiling other data sets.[5] The framework also represents a growing community available for data sharing and provides an environment for exchanging the experiences and lessons learned by all of its participants.

The framework's key aspects are:

- specific layers of digital geographic data with content specifications
- procedures, technology, and guidelines that provide for integration, sharing, and use of these data; and
- institutional relationships and business practices that encourage the maintenance and use of data.

Additional guidance for development of the LOSLR Framework comes out of the Global Spatial Data Infrastructure (GSDI) Cookbook.

> Organizations build national and regional framework efforts by coordinating their data collection and development activities based on intersecting interests within a community. The bounds of this community, however, given the diversity of types of organizations and individuals involved, needs to be non-exclusive and open to innovative contributions, exchanges, and partnerships. The framework should be developed by the entire community, with organizations from all areas playing roles. For some, the framework will supply the data they need to build applications. Others will contribute data, and some may provide services to maintain and distribute data. Some organizations will play several roles in framework development, operation, and use. The framework will take many years to develop fully, but useful components are being developed continuously.[6]

Other resources that should be utilized throughout the LOSLR Framework Project and later stages of developing the LOSLR Framework include, but are not limited to, the following:

> **"Framework Introduction and Guide"** - An FGDC commissioned guide developed primarily for practitioners in public sector agencies at all levels of governments that produce, use or enable use of digital geospatial data. The guide explains the framework concept, outlines the benefits of participating in a framework, shows tangible progress in advancing the framework initiative, and systematically inventories current practices and the consensus of opinion on each element of the framework. Available at http://www.fgdc.gov/framework/frameworkintroguide/.
>
> **"Development of a National Geospatial Data Framework"** - This April 1995 report is the first description of the framework concept as it relates to the US National Spatial Data Infrastructure (NSDI). Available at http://www.fgdc.gov/framework/framdev.html.

[5] http://www.fgdc.gov/framework/overview.html
[6] GSDI Cookbook, Version 1.1, 15 May 2001, p. 20, http://www.gsdi.org/pubs/cookbook/cookbook0515.pdf

"Framework Data – Bringing it together" - The main webpage for GeoConnection's framework effort which links to "terms of reference", "overview", "activities", and other information relevant to the framework component of the Canadian Geospatial Data Infrastructure (CGDI). Available at http://www.geoconnections.org/english/framework/.

"CGDI Framework Data Definition" - Prepared by the GeoConnections Framework Data Node, this document outlines a working definition for framework data as it relates the Canadian Geospatial Data Infrastructure (CGDI). Available at http://cgdi.gc.ca/english/rfp/announcements/moreinfo/RFP_SD_definition.pdf.

Other Geospatial Data and Information Initiatives

Many public sector projects and initiatives have been launched in support of the principles of establishing and maintaining an integrated and widely available SDI. To maximize the usefulness of the LOSLR Framework, the LOSLR Framework Data Project should establish a complete understanding of local, regional and national geospatial data and information initiatives which support the principles of the Framework. This knowledge will enable LOSLR Framework participants to engage and leverage the resources available through these programs. Establishing a relationship with other government led initiatives and defining the LOSLR framework within the larger SDI context will minimize overlap and help to promote the synergy that the coordination of these programs would create.

Outlined below is a list of government led geospatial data and information initiatives and a brief description of each. This list is not comprehensive and should be updated as more contacts are made in the development of the LOSLR Framework. The descriptions offered below are general and should be expanded in the future, particularly in respect to how the program in question relates to other programs and the LOSLR Framework.

Geospatial Information One-Stop Service:
The Geospatial Information One-Stop Project will support "one-stop" access – citizens will only have to go to one location – to the Federal Government's geospatial data assets. The project will accelerate the development and implementation of the National Spatial Data Infrastructure (NSDI) and includes state, local and tribal governments along with the private sector and academia as participants. By making current and accurate place-specific information readily accessible locally, nationally, and globally, the One-Stop project and NSDI will support a variety of efforts, ranging from economic development, environmental quality and stability, and social progress.[7]

The National Map:
The National Map is a USGS sponsored program that will provide public domain, core geographic data about the United States and its territories that other agencies can extend, enhance, and reference as they concentrate on maintaining other data that are unique to their needs. The National Map will be a foundation of information to which the private sector can contribute core feature content and to which proprietary datasets can be linked to provide access to higher resolution data, additional (non-base) features, and enriched attribute information. The National

[7] http://www.fgdc.gov/geo-one-stop/docs/factsheet.pdf

Map will promote cost effectiveness by minimizing the need to find, develop, integrate, and maintain geographic base data each time they are needed.

Federal Geographic Data Committee:
The Federal Geographic Data Committee is a 19 member interagency committee composed of representatives from the Executive Office of the President, Cabinet-level and independent agencies. The FGDC is developing the National Spatial Data Infrastructure (NSDI) in cooperation with organizations from state, local and tribal governments, the academic community, and the private sector. The NSDI encompasses policies, standards, and procedures for organizations to cooperatively produce and share geographic data.[8]

Geospatial Data Clearinghouse:
The Geospatial Data Clearinghouse, sponsored by the FGDC, is a decentralized system of servers located on the Internet which contain field-level descriptions of available digital spatial data. This descriptive information, known as metadata, is collected in a standard format to facilitate query and consistent presentation across multiple participating sites. Clearinghouse uses readily available Web technology for the client side and uses the ANSI standard Z39.50 for the query, search, and presentation of search results to the Web client. The Clearinghouse provides access to digital spatial data through metadata. The Clearinghouse functions as a detailed catalog service with support for links to spatial data and browse graphics. Clearinghouse sites are encouraged to provide hypertext linkages within their metadata entries that enable users to directly download the digital data set in one or more formats.[9]

GeoConnections:
GeoConnections (http://www.geoconnections.org) is a Canadian national initiative to provide geospatial information over the Internet. GeoConncetions partners include federal, provincial and territorial governments and private-sector organizations who participate in program decision making and delivery by contributing technology and expertise. Of the seven programs encompassed by GeoConnections in support of the CGDI, five of these are notable in their relation to the LOSLR Framework. These programs include:[10]

> **Access:** Creating an interconnected national network for sharing data requires the collaboration of all participants — federal agencies, provincial and territorial governments, private-sector firms and academia. By coordinating the efforts of these participants, the Access program is helping build the infrastructure, technology, tools and protocols to deliver geospatial information over the Internet.
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> **Framework Data:** This program is intended to establish a consistent foundation to simplify data integration. Consistency is required to properly integrate and analyze data about road networks, census divisions, provincial/territorial boundaries, and rivers and streams, for example.
>
> **GeoInnovations:** The GeoInnovations industry partnership program brings together expertise and technology to spur the development of new applications, tools and services

[8] http://www.fgdc.gov
[9] http://www.fgdc.gov/clearinghouse/background.html
[10] General descriptions of GeoConnections and the programs listed under the GeoConnections initiative are from http://www.connect.gc.ca/en/692-e.htm

for the CGDI. By investing with the private sector in commercially attractive projects, GeoInnovations is helping fuel the Canadian geomatics industry.

GeoPartners: GeoPartners is a federal-provincial/territorial partnership designed to streamline information flows and facilitate data sharing. Administered by the GeoConnections Secretariat, the program involves coordinating studies, holding cross-country consultations on program development, maintaining the GeoConnections web site, and ensuring that the parts of the broader program work together harmoniously.

National Atlas of Canada: The objective of this program is to provide students and other members of the public with access to national information about Canada's physical, environmental, economic, social and cultural issues. It will act as a portal to the CGDI, providing on-line geo-info about themes such as climate change, industrial development and population growth. (http://atlas.gc.ca)

Canadian Earth Observation Network (CEONet):
CEONet (http://ceonet.cgdi.gc.ca) is a clearinghouse for geospatial products and services from suppliers worldwide. It offers an advertising service that allows organizations to advertise their geomatics and Earth observation products and services at no charge, a yellow pages directory, and a distributed search service that enables consumers to execute a single query across hundreds of distributed databases connected to CEONet from across Canada and the world.

GeoGratis:
GeoGratis (http://geogratis.cgdi.gc.ca) assembles and distributes geospatial data sets from a wide range of sources and makes them available on-line for free. These data sets include legacy and framework map layers and satellite imagery, and are compatible with geographic information systems, image analysis and desktop graphic applications. Distributing geospatial data in this way stimulates research and development and promotes a more diversified user base.

Comparison of NSDI, CGDI and LOSLR Framework Data

The GSDI Cookbook identifies a number of data layers that may be considered to be common-use and of national or trans-national importance as framework data. Candidate national framework categories listed in the GSDI Cookbook include:[11]

- cadastral information
- geodetic control
- geographic feature names
- orthoimagery
- elevation
- transportation
- hypsography
- governmental units

[11] GSDI Cookbook, Version 1.1, 15 May 2001, p. 23, http://www.gsdi.org/pubs/cookbook/cookbook0515.pdf

The framework data layers specified by the U.S. and Canadian national SDI initiatives and the common base data layers identified by the LOSLR Study IMTWG are listed in Table 1.1 below. The "Lake Ontario - St. Lawrence River Framework Data Project" will integrate, afford discovery of, and begin to provide for the long-term storage, maintenance, and flexible accessibility to a number of "framework data" layers. These include shoreline, political units, transportation features, watersheds, hydrography, conservation management areas, orthoimagery, and elevation (hypsographic and topometric) data.

U.S. NSDI Framework Data Layers	**Canadian CGDI Framework Data Layers**	**LOSLR Study IMTWG Common Base Data Layers**
Geodetic Control / High Accuracy Reference Network (HARN)	Geodetic Reference System / Canadian Data Alignment Layer (CDAL)	
Orthoimagery	Imagery (type is scale dependent)	
Elevation	Hypsography (DEM)	Elevation
Transportation	Roads & Railroads	Transportation
Hydrography	Hydrography	Tributaries
Governmental Units	Administrative Boundaries (International, Provincial, Municipal)	Political Units
Cadastral Information	Crown Subdivisions	
	Watersheds	Watershed Boundaries
	Parks	Conservation Mgt. Boundaries
		Shoreline
	Ecological Units	
	Toponymy	

Define the "LOSLR Framework Data Project"

The one-year LOSLR Framework Data Project is a component of a longer-term LOSLR Framework. Due to its direct support of LOSLR Study needs, it is likely that the LOSLR Framework will receive some support for the next 3-4 years. Initiated as a result of being awarded the 2002 Category 4 CAP Grant, the "Lake Ontario - St. Lawrence River Framework Data Project" has begun the development of a LOSLR Framework. This process and the resulting organizational relationships and data products will contribute to the national SDI initiatives of the U.S. and Canada and support the information management needs of the IJC Lake Ontario – St. Lawrence River Study. The institutional relationships, knowledge, and technical infrastructure resulting from the development of the LOSLR Framework will support the integration, discovery, and flexible access to the framework layers identified above, and will begin to provide for their long-term storage and maintenance. Non-framework data being generated and utilized by the Study may also be provided for through the LOSLR Framework infrastructure, as it will contribute to the public information holdings for the Lake Ontario and St. Lawrence region.

The LOSLR Framework Data Project, as outlined in the CAP proposal, separates the work being performed for the project into six milestones, each having multiple associated tasks and deadlines.

Milestone 1: Orientation and Framework Strategy Development

A major component of this milestone will be to collect and organize information that will guide development of the strategic and operational approach for the overall project. In addition, we will research and synthesize information essential for selecting specific databases for framework layers (for both present and near future), developing a bi-national schema and data dictionary, and generating guidelines for data integration.

Milestone 2: Implement LOSLR Framework Data Integration Guideline

Milestone 2 represents the application/implementation of the Framework Data Integration Guidelines developed under Milestone 1. This will require the actual physical integration of US and Canadian baseline data layers from the LOSLR work to the extent that is recommended during the Framework development phase. All data layers will be vertically integrated, and we anticipate that a subset of layers (e.g., roads, hydrology, and watersheds) will be horizontally integrated. When appropriate, the attribute information associated with all data layers will be made relatable though the development of crosswalk tables. After this integration is complete, team members will prepare a report describing the overall data quality of all framework data layers, as well as technical documentation that describes the data after conversion is complete. The main deliverable produced under this milestone will be the integrated framework data itself and metadata reflecting processing of the parent data sets.

Milestone 3: LOSLR Framework Metadata and Data Discovery

The data integration performed in Milestone 2 need to benefit the LOSLR Study Participants and the general Public. The greatest benefit of integrating all geospatial LOSLR data under a common framework and developing a spatial data infrastructure will enhance data discovery and availability to the wider user community. A critical step in this process is to create and publish a consistent set of standards-compliant metadata describing the key characteristics of all LOSLR framework data.

A Metadata Workshop will be held to coordinate the metadata efforts of the LOLSR Framework Data Project and the Technical Working Groups (TWG) of the LOSLR Study. With the assistance of a metadata trainer, the workshop will focus on developing a standard operating procedure for the creation and review of FGDC standard-compliant metadata. The support structure for the Study's metadata efforts will be further defined and presented to the TWG Metadata Liaisons attending the workshop.

After this workshop, FGDC-compliant metadata in the recommended format will be developed for each of the framework data layers for the LOSLR. After a review and QA/QC process, these metadata files will be loaded onto a metadata clearinghouse node. Mechanisms will be put in place at that time to ensure that as changes are made locally to any of the framework data layers, these changes are reflected in the metadata held on the clearinghouse node.

Milestone 4: LOSLR Framework Data Storage, Maintenance, Access, and Distribution

It is our understanding that the IJC, at present, does not desire to be in a data ownership or stewardship role in the long-term (i.e., after completion of the Study). Thus, partnerships with agencies and organizations that can provide for long-term data ownership and

stewardship should be utilized. Organizations possessing the necessary interest or motivation to ensure the long-term storage, maintenance, and accessibility of data (e.g., state or federal agencies) should be identified as potential data owners. Data stewards should be identified (by the data owner) as entities with the necessary technical and operational capabilities to conduct and document data maintenance activities. In most but not necessarily all cases, the data steward would belong to the organization that is the data owner. In many cases, the data host will not be the data owner (and thus, not necessarily the appointed steward).

While the transfer of *ownership* will occur at the completion of a particular phase of the Study after which the necessary evaluation of the data has been completed, transfer of data *stewardship* should occur as soon as possible after the creation of the data. Experiences crucial for a thorough understanding of a dataset and its successful maintenance in the long-term occur within the beginning stages of that dataset's life cycle. In the interest of establishing quality stewardship for data, transfer of stewardship responsibilities should occur as soon as possible in the life of a dataset. The transitional phase for data stewardship will require that Study Participants have access to data without compromising their ability to conduct their business activities (i.e., analyses).

For many datasets, the IJC will need to provide for data storage and accessibility through the life of the Study. As long as Study needs are provided for, and it is economical to do so, it makes sense to identify data hosts that could serve in a longer term capacity. A preliminary survey of organizations to function as potential data hosts has led us to a distributed, regional approach to data storage and access for Study Participants and the public. At present, dividing the datasets by the geo-political regions of the Study (i.e., Ontario, Quebec, and New York State) appears to have the greatest potential in matching data and information content to those agencies/organizations with the mission and operational capabilities to function as long-term data storage locations. While not yet formalized or committed to, Land Information Ontario (OMNR), Environment Canada-Ste. Foy, and a yet to be determined organization on the U.S. side (perhaps GLC-GLIN, or a New York state agency or organization) will constitute the regional data hosts. Details concerning the system designs for implementing data access and maintenance would be left largely to the discretion of the individual host organization. Stewardship and publishing specifications will require considerably more coordination.

Milestone 5: LOSLR Framework Data Public Outreach

In order to fully leverage the integrated datasets, and inform the wider user community and general public of its existence, we intend to carry out a concentrated public outreach strategy. This strategy will be highlighted by the development of a LOSLR Framework Project web mapping service (WMS) with the LOSLR Framework Data available for viewing in a wide variety of combinations and scales. This LOSLR Framework Data Project website will provide an excellent opportunity for public outreach, and we hope that the site eventually becomes a logical "jumping-off" point where the public can learn more about various processes of the Lake Ontario system, and its current and anticipated future states. The WMS will be developed using an open-source, OGC-compliant server application. Links from the IJC and other central stores of information about the Lake

Ontario region will be made to publicize the existence of the site to the greatest extent possible.

Aside from this outreach to the general public, we will also attempt to publicize our efforts within the academic and government research communities. This will be accomplished through the presentation of our results at an international conference. This will not only spread awareness of the LOSLR Framework Data and the efforts carried out under the CAP program, but also serve to alert the research and academic communities to the availability of an important set of data for the LOSLR region.

Milestone 6: LOSLR Framework Data Project Conclusion

In this final phase of the proposed work, we intend to hold a summary workshop, designed to focus on advancing the geospatial user community's ability to apply methods and strategies like those developed for this work in creating the LOSLR Framework Data. We intend to focus on strategies and lessons learned through this process that will help other similar efforts establish permanent, long-term archives of geospatial data. The critical deliverables from this milestone will include a comprehensive project report containing formal recommendations for future framework development, and describing our experiences with this process.

LOLSR Framework Data Project Participants

During the initial evaluation of the Category 4 CAP opportunity, a number of willing partners for a CAP project were identified. Through the development of that proposal and the subsequent kick-of meeting held in July, the list of LOSLR Framework Data Project participants has been formalized. The participating organizations and their respective involvement in the project are listed below.

International Joint Commission	• Co-chairs of the IMTWG (formerly CDNTWG) serves as the POCs for the US and Canadian Project Members
US Army Corps of Engineers	• Technical and Policy Research • Develop Metadata Support and SOP • Develop Public Outreach Strategy • Develop and Present LOSLR Framework Data Project Presentation at Conference • Write and Review Final Reports
Environment Canada	• Technical and Policy Research • Data Dictionary • Develop Metadata Support and SOP • Develop and Implement Framework Data Storage, Maintenance and Distribution Strategy • Develop Public Outreach Strategy • Design and Implement Framework Data Web Mapping Service • Develop and Present LOSLR Framework Data Project Presentation at Conference • Write and Review Final Reports

Ontario Ministry of Natural Resources - Land Information Ontario	• Technical and Policy Research • Develop and Implement Framework Data Storage, Maintenance and Distribution Strategy • Design and Implement Framework Data Web Mapping Service
Great Lakes Commission	• Technical and Policy Research • Develop Metadata Support and SOP • Publish Metadata on the Clearinghouse • Develop and Implement Framework Data Storage, Maintenance and Distribution Strategy • Design and Implement Framework Data Web Mapping Service
Pangaea Information Technologies	• LOSLR Framework Data Project Principle Agent • Technical and Policy Research • Report Writing and Review • Conduct and Report on Data Integration Procedures • Develop Metadata Support and SOP • Develop and Implement Framework Data Storage, Maintenance and Distribution Strategy • Document System Architecture, Policies and Procedures • Design and Implement Framework Data Web Mapping Service • Develop LOSLR Framework Data Project Presentation
W. F. Baird & Associates	• Write Data Integration Guidelines • Conduct and Report on Post-Integration Data Quality • Develop Public Outreach Strategy • Design and Implement Framework Data Web Mapping Service
Christian J. Stewart Consulting	• Develop Metadata Support and SOP • Develop Public Outreach Strategy • Design and Implement Framework Data Project Website • Design Framework Data Web Mapping Service • Develop Public Outreach Documentation

A successful development and implementation of the LOSLR Framework will require that full advantage be taken of the diverse knowledge, experience, and contacts of the framework participants. The shared insight and wisdom of the framework participants will ensure that we make the best use of our combined knowledge and resources. While we need to focus on the success of this 8-month Project, we also need to consider the LOSLR Framework as a scalable project: a spatial data infrastructure that will serve user needs beyond 31 March 2003 (official CAP project completion date) or even the LOSLR Study completion (2006).

Identifying LOSLR Framework Users

The LOSLR Framework Project serves the LOSLR community in providing a single location for access to "best available" geospatial data. Developed with scalability and extensibility in mind, the LOSLR Framework will be a valuable resource in the Great Lakes region in providing the organizational and technical infrastructure, experiences and lessons learned upon which to develop integrated and full-featured information systems to share and distribute "best-available" data. Future IJC studies will benefit from the experiences and infrastructure (organizational and

technical) developed in the LOSLR Framework Data Project. Acceptance of standards, procedures and methodologies identified through this project will serve the IJC in the long-term to ensure a greater degree of information integration and interoperability in future studies. Being scalable with respect to both areal extent and included themes (i.e., layers), the LOSLR Framework will be a valuable resource for other Great Lakes studies in the future.

Areal Extent of the LOSLR Framework

The Information Management TWG had selected at the beginning of the data collection and development effort a 5 km buffer distance from the shoreline or the 77-meter contour, whichever is farther inland, to define the areal extent of the common base layers. With the Study's common base data serving as the data source for the LOSLR Framework Data Project, the areal extent of the Study's common base layers will define the areal extent of the LOSLR Framework Data Project. As the LOSLR Framework Data Project develops the LOSLR Framework, it may be necessary to consider a redefinition of the areal extent of the framework so as to meet the needs of a broader user community. To support the scalability and extensibility of the LOSLR Framework, the areal extent of its data sets should be defined by meaningful geographic features or characteristics. It is possible that defining the areal extent of the LOSLR Framework to watershed features affecting the system would better serve the long-term needs of the LOSLR Framework. Related to the areal extent of the LOSLR Framework but more clearly defined in the data source definition is the decision of whether it is appropriate for a particular data source to be processed using a "clip" or "select" function for the defined areal extent of the Framework. Source data should be maintained to accommodate future modifications to the framework definition of the areal extent of framework data in the future.

Defining Framework Data and Evaluating Framework Data Sources

As mentioned above, the common base layers already identified by the Information Management TWG for use in the LOSLR Study will serve as data sources for the LOSLR Framework Data Project. Because these data have already been identified as "best available" data for the Study's areal extent, much of the initial evaluation of data sources has already been undertaken during Study activities. The LOSLR Framework will require data to be updated, appended to, or in some cases entirely replaced as new data becomes "best available." By developing the LOSLR Framework in such a way as to make it flexible and sustainable, each data layer included in the LOSLR Framework needs to have a set of evaluation criteria developed for it, which would allow for newly available or discovered data to be compared with existing framework data as the LOSLR Framework evolves. Data review committees should also be established for each of the Framework's thematic layers with the defined purpose of period evaluation of data which would be considered "best available." By continually monitoring the existence of prospective framework data and participants, the LOSLR Framework can maintain its currency.

A list of evaluation criteria and/or considerations to be made with respect to prospective framework data should include:

- Scale / Resolution

- Currency
- Redistribution policies, related to licensing, security and/or liability concerns
- Cost associated with data acquisition and/or maintenance
- User needs, cognizant of the changing needs of the LOSLR Framework community
- "Seamlessness", or the associated effort required to support data integration
- Adherence to relevant data standards (i.e., SDSFIE, NCITS, ISO)
- Presence of other open and accessible data provision that is useful to the LOSLR Framework community (i.e., do comparable or better data sets exist that are both discoverable and accessible via WMS/WFS connections and for download?)
- Impact that a change of framework data would have on current data users

While providing a value scale and weighting for every criteria would make the evaluation of prospective framework data procedural and clean, this approach may not be feasible. However, to the greatest extent possible, the LOSLR Framework Data Project should provide a clear illustration of the framework data evaluation process.

Accommodating the change and growth of the LOSLR Framework data is an important component of the framework development process. Similarly, accommodating future extensions of the LOSLR Framework to include additional thematic layers (e.g., toponomy, orthoimagery, shipping channels) is necessary to ensure that the LOSLR Framework is able to address the needs of the framework community as it evolves. The LOSLR Framework development process should consider the evaluation criteria to determine whether inclusion of a particular thematic layer to framework data status is appropriate. The development process should provide insight into the criteria and/or criteria weightings which will contribute to selecting the "best available" data to represent any additional framework data layer.

Data Integration Issues

Detailed methodology for integrating the regional datasets selected for each framework thematic layer will be developed and presented in the Data Integration Guidelines. The Data Integration Guidelines will establish the procedures for data integration by outlining the considerations that will need to be made for specific layers and datasets. Ensuring vertical, horizontal and attribute integration will require a thorough evaluation of the quality and potential for seamlessness of selected framework datasets. Determining the procedure by which detailed evaluation and edits will be performed must accommodate the organizational structure and institutional relationships associated with framework datasets. In an ideal scenario and to the greatest extent possible, data owners and possible data stewards should play a significant role in developing the LOSLR Framework Data Integration Guidelines. For example, should a transportation feature originating in the LIO database be the source of discontinuity along the international or provincial border, a procedure should be put in place to notify LIO of this specific feature, allowing the data steward of that particular dataset to perform the necessary edits. Integration of some datasets will not require the amount of communication and division of responsibility outlined in the example above. The Data Integration Guidelines will determine the level of procedural complexity required in

conducting the initial LOSLR Framework data integration and outline the process of developing those procedures so to accommodate changes in the LOSLR Framework over time. While most active in the original data integration phase of the project, these procedures will form the basis for establishing feature updating mechanisms within the LOSLR Framework.

Data Discovery Issues

Data discovery and its associated mechanisms and functions provide the means by which information about the existence of data can be obtained. Current data discovery mechanisms require that some form of metadata, data or information about data, be compiled for data and/or processes and typically be made available in some organized fashion. As part of the SDI, the LOSLR Framework is required to document the framework data and related processes, making this information searchable through the clearinghouse network.

Although the value of geospatial data is recognized by both government and society, the effective use of geospatial data is inhibited by poor knowledge of the existence of data, poorly documented information about the data sets, and data inconsistencies.[12] Metadata protects an organization's (or community's) investment in data. Well documented data can mitigate the effect of organizational changes, facilitate data re-use, update and/or reproduction, and demonstrate proof of data quality and reliability. Producing publicly available documentation about data inputs, outputs and processes so to allow for the "reproducibility" of the data and analysis promotes government accountability and supports the basic foundation of open governance through the transparency of regulatory and policy decision-making procedures. Through consistent use of terminology, descriptive elements and predictable structure, a metadata standard, such as FGDC-1998 CSDGM, enables the broad-based discovery and evaluation of data. As framework data represents "best available" data, the metadata associated with framework data should also represent a high level of quality. Good quality metadata demonstrates the quality of data stewardship and can serve as a basis upon which to build trust in data quality.[13]

The LOSLR Framework Data Project has accepted the IJC LOSLR Study's policy, which acknowledges the importance of quality metadata, thus adopting the FGDC 1998 CSDGM as the metadata standard to which data products must adhere. Additionally, the LOSLR Framework Data Project is committed to making data discoverable in both English and French, per the LOSLR Study requirement. After metadata has been reviewed, found to be compliant with FGDC 1998 content standards and translated, the final metadata records will be made globally discoverable by loading them onto a registered node of the SDI metadata clearinghouse network.

Data Access Issues

Providing access to "best available" framework data is a requirement of the LOSLR Framework Data Project. As part of the evaluation criteria used in selecting a dataset or data layer to be added

[12] GSDI Cookbook, Version 1.1, 15 May 2001, p. 26, http://www.gsdi.org/pubs/cookbook/cookbook0515.pdf
[13] The content of this paragraph is a summary of points presented at http://www.sdvc.uwyo.edu/metadata/why.html#benefit

to the LOSLR Framework, the ability and willingness of data owners to allow free and open access to data must be clearly defined and understood. Data access policies currently held by LOSLR Framework Data Project participants need to be clearly documented, and the implications of data access policies on the framework's ability to effectively serve the framework data community must be understood. Specific data access policies will need to be reviewed as they relate to cost recovery principles and/or subscription requirements. Providing for the appropriate level of data access (e.g., data viewing, data distribution, feature query, feature extraction, etc.) will require the coordinated understanding of institutional policies and the appropriateness of various levels of data access for each dataset included in the Framework.

Data Storage (Regionally Distributed RDBMS)

Developing and maintaining long term, flexible and powerful computing systems for the storage of data developed by the Study is critical if the Study TWGs are to complete their efforts in a timely and cost effective manner. Moreover, coordinating the storage and access of data within the Study will have a direct impact on particpants' ability to minimize data redundancy, ensure consistency between datasets, and complete more integrated analyses. Outside the Study itself, a robust data storage and maintenance system will play a key role in providing a long term, sustainable system for dissemination of data to the public and other interested parties.

In order for the Study goals to be achieved in a timely fashion, the regional RDBMS developed for data storage and maintenance must leverage existing technical and institutional resources to the greatest extent possible. For this and a number of other reasons, the LOSLR Information Management Strategy (IMS) recommends a regionally-distributed system of relational databases (RDBMS). This type of system most effectively addresses the need for regional partners to ensure the longevity of data associated with the Study. This will allow data owners to maintain close proximity to their data stores, both geographically and organizationally. This data management model is considered to be progressive, and is endorsed and promoted by the public sector (e.g., FGDC, GeoConnections), private sector (e.g., CubeWerx, Inc.), and NGOs (e.g., OpenGIS Consortium).

The regionally distributed system described in the LOSLR IMS[14] is envisioned as consisting of three nodes, each having data holdings consistent with their geographic location. Given this geographic criterion alone, then, the ideal locations for the distributed RDBMS system would be: New York, Ontario and Quebec. However, there are a number of other important factors that must be evaluated in conjunction with this primary need. For example, while data owners will always have the ultimate decision regarding where their datasets are stored, it is important to note that limited resources will likely necessitate some compromises given the Study timeframe. In what follows, an evaluation of candidate locations and existing infrastructure is presented.

The LOSLR IM Strategy describes a number of existing systems that are either planned, or already in place that may offer a wide range of benefits for use by the Study. Each location has one or more candidates for the location of distributed RDBMS nodes for the Study. Geographically, these locations are:

[14] See Section 7.2.1.5 (p. 45-47) of the IMS Report

New York

The New York State GIS Clearinghouse (http://www.nysgis.state.ny.us). This system for data discovery and distribution includes a detailed, comprehensive metadata repository for geographic data within the State of New York. In many instances, GIS data layers are available for download from this site via FTP from a web browser client. Data contributors and owners involved with the system include numerous local, federal and state agencies, as well as businesses in both the public and private sectors. The system has been particularly effective at uniting the efforts of many parties involved in GIS throughout the State, and has an active and well established active user community.

The Great Lakes Commission (http://www.glin.net/gis). The GLC presently coordinates the Great Lakes Information Network Data Access Clearinghouse, which indexes and makes available FGDC-compliant data layers developed at the GLC. Work is presently underway to expand this tool into a centralized "GLIN Data Directory" whereby the GLC would warehouse and make available data from both its own projects as well as significant data sets from other agencies. These plans would dovetail well with data from the Study, in that the mechanisms for data discovery and access being developed at this warehouse are very similar to those proposed in the IM Strategy.

Ontario

Land Information Ontario (http://www.lio.mnr.gov.on.ca). The LIO system was developed by the Government of Ontario in an effort to "orchestrate the collection and management of land information in the Province of Ontario." LIO includes a well developed database environment that presently stores numerous spatial and non-spatial data layers, and features a number of data discovery mechanisms ranging from fielded searches to Z39.50 access through wider ranging data discover systems. LIO is the coordinating entity for Ontario's participation in GeoConnections, and the system is an important part of the Canadian Geospatial Data Infrastructure (CGDI).

Quebec

Environment Canada Quebec Region (Ste-Foy)(http://lavoieverte.qc.ec.gc.ca/envcan/indexe.html). ECQR has played an integral role in the Study to date, and continues to be at the forefront of data development, analysis, storage and maintenance through their participation in several Study TWGs. The Hydrologie Section has built a complex Oracle database system inside their firewall that presently houses a large volume of data generated by the Study. The institutional knowledge gained through the development and maintenance of this system would be invaluable to the Study as the regional RDBMS is built out.

In order to make an informed decision about the suitability of each location to meet the Study's IM needs, fifteen formal evaluation criteria have been established and applied to each of the four candidate locations:

(1) Geographic proximity to data holdings

As described above, in ideal circumstances, the physical location of any data stores to be used as a part of this infrastructure will remain close to the actual owners of regional datasets to be included.

In fact, in an ideal situation, the system owners would be the same as the owners of the data, thus facilitating sustained access to a high level of expertise and experience that would be invaluable as others begin to utilize the dataset(s) in the future.

(2) Willingness and ability to play an active role in the distributed RDBMS
Some of the candidate organizations currently play important roles in the Study itself, and it is expected that their contributions to the data distribution and maintenance system will be critical to the overall success of the Study in making both framework and non-framework data available to the TWGs and the general public. The type of organizational support required should be present at all vertical levels of the organization, from GIS technicians up through high-level decision makers.

(3) Participation in national / international geospatial data discovery and access systems
In order to facilitate simple, integrated discovery of framework data layers by the public and other interested parties, the candidate sites should be well integrated with existing national and/or international geospatial data discovery and access systems. At a minimum, this would include the capability of searching Study geodata archives via applications using the Z39.50 standard (or future http-based) protocol, as well as node participation in the NDSI or CGDI.

(4) Adherence to standards and open access
The software running on the distributed RDBMS (e.g.: middleware, WMS, database) should adhere to specifications set forth by the Open GIS Consortium (OGC). This will ensure that the long-term accessibility of data and applications made available as a part of the framework remain accessible via current and future GIS technologies. OGC is an international industry consortium of more than 220 companies, government agencies and universities participating in a consensus process to develop publicly available geoprocessing specifications.

(5) Data storage in RDBMS systems
Progressive, state-of-the-art storage and distribution systems for geospatial data utilize sophisticated database technologies at the core of their information infrastructure. These databases provide a fast, robust, scalable and reliable system in which data can be stored, queried and accessed in a secure fashion. Moreover, these technologies allow users to quickly access only the portions of data that meet certain specified spatial or non-spatial criteria. The best alternatives for the distributed RDBMS will include sites that utilize popular, open databases as the storage mechanism for all geospatial data in their archive. This is as opposed to storing geospatial data on "flat" file systems, made available as entire datasets via FTP or through other mechanisms.

(6) Web mapping capabilities and software
While full-fledged Web Mapping Services for all framework data are evaluated and described in more detail in a subsequent section of this document, this is an important factor to consider for the purposes of data storage, distribution and maintenance as well. In order for the Study to effectively and easily be able to offer web mapping and web feature services, the data distribution architecture and selected sites would ideally provide WMS (and potentially, WFS) capabilities locally. This would avoid the need to establish a complex system with disparate sites for storage and graphical browsing of the data, respectively.

(7) Institutional participation in Study

In order for the data distribution system to remain stable and in place throughout the course of the Study and beyond, it is important that the sites chosen to comprise the distributed RDBMS be committed to supporting the Study goals and requirements. All else equal, organizations that currently participate in the Study are considered to be more desirable than those who presently do not play an active role.

(8) Institutional participation with FGDC, GeoConnections, etc.

To ensure long term sustainability of the site and the Study framework data, it is critical that the sites chosen for storage are active participants within major national and international geodata organizations. In the United States, partnership with the Federal Geographic Data Committee (FGDC) and/or registration as an NSDI node is considered to be a great benefit. In Canada, participation in the GeoConnections organization and/or registration with the CGDI would be highly beneficial to the framework data distribution system being developed for the Study.

(9) Ease of entering into the partnership

Partnership agreements between the Study and sites chosen for the data distribution system will vary depending on the nature of the hosting site's relationship to the IJC and other organizations. In the cases of some candidates, relationships among these entities are long standing and well developed. In these instances, it is likely that entering into a partnership for the purposes of data storage and distribution will be more straightforward than it may be to forge a new relationship with a previously unfamiliar organization.

(10) Suitability of existing system for Framework needs

All of the sites currently being considered as nodes for the framework distributed RDBMS have some type of data storage, maintenance and distribution system in place. These range from very mature, production-class systems that serve data to hundreds or thousands of users, to smaller pilot systems that are being developed at present to meet internal organizational needs. To the greatest extent possible, it is desirable to leverage existing resources when developing the distributed RDBMS to reduce the funds and effort that would be required to bring relatively nascent geodata storage and distribution sites into the system.

(11) Flexibility in conformity to Study needs

While it is considered important to leverage existing infrastructure to the benefit of the Study's needs, it is equally important to ensure that the selected sites for this system will be flexible in terms of their ability to accommodate the specific needs of the study as outlined in the IM Strategy. For instance, some large existing systems may utilize hardware or software technologies that are not compatible with those chosen as most appropriate for the Study needs, while some smaller entities may have the ability to develop a system that is completely conformant to the Study recommendations.

(12) Bandwidth availability / networking constraints

Many government organizations can only offer limited access to their internal computing resources due to network security protocols. Firewalls, routers and other hardware or software solutions often restrict access to data stores. Moreover, some agencies are limited in terms of the available bandwidth for query and retrieval of large geospatial data layers. The best sites for the

distributed RDBMS will feature ample bandwidth to the public Internet that can be made available for the purposes of the Study for dissemination of its framework data.

(13) Security and availability of system

One important feature of any production-class data distribution system is its ability to provide a high level of security (both physical and digital) and availability (e.g., measured by the percentage of time throughout the year that the system can be accessed over the Internet). While the Study requirements for the system do not include "24 x 7" availability or complex security, it is important that the system be highly available (desired level 95% or better) and secure enough to ensure that any sensitive datasets that are only available for limited distribution are not disseminated to unauthorized persons.

(14) Institutional stability

While the immediate goal of the Study is to ensure that framework geospatial data layers are made readily available for distribution within the Study and to the public, the system should be designed to support the distribution of all Study data into the foreseeable future. For this reason, a consideration of the stability and predicted longevity of the organizations and/or computing systems that will comprise the distributed RDBMS is important.

(15) Scalability of system

Framework data itself represents a relatively small fraction of all data developed and used by Study participants. In the near future, non-framework data will also be incorporated into the data storage and distribution system. The nodes participating in the distributed RDBMS, then, must feature scalable storage and computing resources to accommodate an expanding data volume, and increasing bandwidth to public networks as data becomes more frequently downloaded by those within and external to the Study itself.

In Table 1 below, each site is rated with respect to the fifteen criteria presented above. In evaluating each option in light of these criteria, we are making the assumption that costs shown in Table 2 will be made available for the Study. In the event that only partial funding is available for the proposed options, we will then need to determine what tradeoffs must be made to build the best possible system given any funding constraints in place.

Table 1: Evaluation of candidate sites

	Evaluation Criteria	NY		ON	QC
		NYSGIS	*GLC*	*LIO*	*EC*
1	Geographic proximity	★	▲	★	★
2	Active role in system	●	★	★	★
3	Participation in national / international geodata systems	★	★	★	★
4	Adherence to OpenGIS standards and open access	★	★	★	★
5	Data storage in RDBMS systems	▲[15]	★	★	★
6	Web mapping capabilities and software	■[16]	★	★	★
7	Institutional participation in Study	●	★	★	★
8	Institutional participation with FGDC, GeoConnections	★	■	★	▲
9	Ease of entering into the partnership	▲	★	★	★
10	Suitability of existing system for framework needs	▲	■	★	■
11	Flexibility in conformity to Study needs	▲	★	▲	★
12	Bandwidth availability / network constraints	★	★	★	▲
13	Security and availability of system	★	★	★	■
14	Institutional stability	★	★	★	★
15	Scalability of system	★	★	★	■

● = poor ▲ = fair ■ = good ★ = excellent

Based on the recommendations made in the IM Strategy plan, and subsequently, the evaluation of four candidate sites to serve as the three nodes of a regionally distributed RDBMS system for Study data storage, maintenance and distribution, the following recommendations are made:

[15] Metadata only, geodata not presently stored in RDBMS
[16] All sites utilize ESRI ArcIMS with the exception of the NYSGIS site that uses MapInfo MapXtreme

Table 2: Costs (USD) for Implementation & Maintenance of Recommended System

Description (all costs in USD)	FY2002	FY2003	FY2004	FY2005	*Study Total*	After Study
Great Lakes Commission						
New Windows / Intel server for spatial and metadata hosting. Physically located at GLIN	$25,000	$0	$0	$0	*$25,000*	*$0*
Oracle 9i unlimited standard license	$15,000	$0	$0	$0	*$15,000*	*$0*
Software Maintenance	$0	$7,000	$7,000	$7,000	*$21,000*	*$7,000*
Maintenance and Hosting *OPTION 1*: Yearly 24x7 computer maintenance, access and hosting costs at GLIN	n/a [1]	$18,500	$20,000	$21,500	*$62,500* [1]	*$23,000*
OPTION 2: M-F, 8-5 computer maintenance, access and hosting costs at GLC	$2,500	$11,000	$12,000	$13,000	*$38,500*	*$14,000*
GLC TOTALS (Option 1)	**$42,500** [17]	**$25,500**	**$27,000**	**$28,500**	***$123,500*** [1]	***$30,000***
GLC TOTALS (Option 2)	**$42,500**	**$18,000**	**$19,000**	**$20,000**	***$99,500***	***$21,000***
Land Information Ontario						
Yearly partnership / subscription costs	$0	$35,000	$35,000	$35,000	*$105,000*	*$35,000*
LIO TOTALS	**$0**	**$35,000**	**$35,000**	**$35,000**	***$105,000***	***$35,000***
Environment Canada St. Foy						
New Windows / Intel server to serve as mirror for internal site. Placed outside firewall at ECQR.	$10,000	$15,000	$0	$0	*$25,000*	*$0*
Oracle 9i unlimited standard license	$10,000	$5,000	$0	$0	*$15,000*	*$0*
Software Maintenance	$0	$7,000	$7,000	$7,000	*$21,000*	*$7,000*
Bandwidth Recovery Costs	$500	$2,000	$2,000	$2,000	*$6,500*	*$2,000*
Maintenance and Hosting *OPTION 1*: Yearly 24x7 computer maintenance, access and hosting costs	n/a [1]	$18,500	$20,000	$21,500	*$62,500* [1]	*$23,000*
OPTION 2: M-F, 8-5 computer maintenance, access and hosting costs	$2,500	$11,000	$12,000	$13,000	*$38,500*	*$14,000*
ECQR TOTALS (Option 1)	**$23,000** [1]	**$47,500**	**$29,000**	**$30,500**	***$130,000*** [1]	***$30,000***
ECQR TOTALS (Option 2)	**$23,000**	**$40,000**	**$21,000**	**$22,000**	***$106,000***	***$24,000***
TOTAL REQUEST (Option 1)	***$65,500*** [1]	***$108,000***	***$91,000***	***$94,000***	***$358,500*** [1]	
TOTAL REQUEST (Option 2)	***$65,500***	***$93,000***	***$75,000***	***$77,000***	***$310,500***	

[17] Note that this amount includes $2,500 for M-F, 8-5 support and maintenance as per Option 2. Option 1 (24x7 computer support) is not recommended for the first partial year of system operation. Maintenance for M-F 8-5 support is recommended for both Options 1 and 2 for the first year of operation.

Sites to be included in the system

New York State: Great Lakes Commission. The New York State GIS Clearinghouse offers a number of compelling advantages as a location for one node of the proposed system. From a geographic standpoint, this site most clearly meets our requirement of close proximity to the data holdings. Additionally, the Clearinghouse is a mature, well-known system for data distribution in New York State, and features an active user community that would offer a great deal of data and expertise that may benefit the Study considerably. The node is already registered as an NSDI spatial data discovery site, and is searchable via Z39.50 and other open access methods.

While the New York State GIS is a strong candidate for the location of this data center, the Great Lakes Commission offers a number of important advantages that make it a more desirable location for the long term benefit of the Study. Most importantly, this site is recommended because of the active participation from an institutional standpoint in the LOSLR study by the staff of the GLC. While the GLC computing infrastructure presently available to support the Study's needs is not as mature as the NYSGIS Clearinghouse, mapping and data serving tools are present. The Study is in a position to direct the enhancements that take place, which will allow for a great deal of flexibility in creating a node that is highly capable of meeting the specific needs of the Study now and in the future. The GLC's ability to offer the option of co-hosting the system at the same physical location as the Great Lakes Information Network (GLIN), a secure, robust 24x7 facility for data hosting, may be an important added benefit to the overall system. Moreover, establishing the proposed GLC node for the purposes of the LOSLR will enable the GLC to provide these services more broadly as other similar studies are initiated throughout the Great Lakes watershed. In this way, the GLC node may serve as the most comprehensive, single source of geospatial data for the Great Lakes watershed in the future. With all of its advantages in providing a data storage solution for the LOSLR Framework data, the GLC alone will not be able to provide the local ownership and stewardship of New York area framework data. To ensure the maintenance and currency of the New York area framework data, the GLC will need to enlist the involvement of organizations with local interest in the New York area framework data to perform the necessary ownership and stewardship roles.

Ontario: Land Information Ontario. As illustrated in the table above, the LIO site is an excellent location for meeting the Study's needs for storage and dissemination of data in the Ontario region. The site is rated as "excellent" in nearly every category evaluated, and is already a mature, important source of geodata in the CGDI. Institutional partnership among OMNR, GeoConnections and the IJC is highly robust, and staff involved in the LIO system are active participants in the LOSLR Study. The site provides mechanisms for Z39.50 discovery, data download from relational database storage systems and Web Mapping Services for a wide range of data at the present time, and no specific additional hardware or software would be required to establish this node. Use of the systems, relationships, and procedures already developed and maintained by the LIO will require an annual subscription fee of $50,000 (CDN).

Quebec: Environment Canada Quebec Region, Ste. Foy. While the computing infrastructure currently in place at ECQR is not able to meet the specific needs of the Study for data storage, maintenance and distribution, locating a node at this site would provide a number of significant benefits. The site is already the host location for a vast archive of Study datasets, and the institutional knowledge gained in the development and current storage of these datasets will be

invaluable as the distributed system is implemented. Much of the work required for database and system design has already been completed at this site, and funding is only required to support the creation of a mirror site for serving of this data outside the ECQR firewall to facilitate access via the Internet.

Recommended software for data storage, distribution and access

All three proposed sites for the system utilize ESRI software for internal, and in some cases external, storage and distribution of geospatial data. Because of the institutional knowledge and expertise in using these applications, as well as the fact that all software proposed for the distributed RDBMS meets OGC compliancy standards, it is recommended that Oracle / ArcSDE and ArcIMS be utilized for the system. ArcSDE is recommended as the geospatial middleware to serve spatial data from Oracle databases at each of the proposed locations. The LIO site is already utilizing this combination of software for hosting data in their system, and Oracle is in use at ECQR for the storage of a large volume of Study data. These applications are well known in the GIS community for providing powerful, open access tools for the storage and distribution of spatial data. The Study will benefit from the knowledge and expertise of IMTWG members and Framework Project participants related to designing, implementing, and maintaining this type of system.

Other alternatives, particularly those for providing WMS capabilities at the proposed sites would offer a number of benefits to the Study. The open source MapServer product is OGC compliant web mapping software that can be acquired for no cost via Internet download. While this product would meet the needs of the study for WMS, it is important to consider that no staff at the proposed system locations currently have any experience in using this software or in developing production-quality systems for use on the Internet. As open source, cascading WMS applications become better developed and available, the Study may consider migrating the platform towards MapServer technology, especially when considering yearly licensing and support fees associated with other software packages.

On the other hand, all three sites presently pay for, use, and have expertise with ArcIMS to provide WMS capabilities to varying extents. ArcIMS supports all open standards required by the Study (Z39.50, OGC WMS, etc.), and will provide a capable, robust platform that will allow for the dissemination of mapping products to Study participants and the general public. Additionally, this system can provide an excellent basis for the development of powerful applications that may benefit the Study in the short or long-term.

Data Maintenance

To ensure the LOSLR Framework maintains the "best available" data, routine maintenance procedures must be developed by the data stewards, under the direction of the data owners. Maintenance procedures will be unique to each data layer included in the Framework. Data maintenance should be included in the evaluation process conducted as part of the selection process. In as much detail as possible, the data maintenance rules and procedures need to be defined prior to the data's inclusion in the Framework.

The LOSLR Framework needs to be continually aware of new or improved data as it becomes available for public use. The data which makes up the LOSLR Framework after its inaugural year will likely not be the same of "best available" data five years later. A continual effort to improve the Framework through the inclusion of new data and new participants will contribute to the sustainability of the Framework. For this reason, the LOSLR Framework must accommodate future needs for data updates and wholesale replacement.

Extended Data Access through Web Services

Providing access to data visualization and presentation tools over the Internet is a level of data accessibility that allows for very limited and controlled access to data. The data is presented in a way that can be utilized and understood by a variety of potential users. Software solutions for providing web visualization and presentation capabilities vary in from and function, however basic standards for web mapping services have been developed to ensure interoperability both between different vendor-based solutions and different components of an integrated web-base mapping application. By applying standards-based technology to the LOSLR Framework development and design, the system will remain flexible in its ability to support interoperability with various other web mapping components within and outside of the Framework community. As the technology improves and the simple visualization of data through web mapping services gives way to a higher level of data access in feature and coverage services, system standards and specifications will ensure that future increases to the functionality of the system can evolve rather need to be continually reinvented.

Developing the Business Model for Framework Sustainability

Before we can effectively evaluate the appropriateness of business models to support the sustainability of the framework project, it is necessary to define the scope of services being offered by the LOSLR Framework. At the most basic level, the LOSLR Framework serves the "best available" geospatial data layers. Through implementation of a regionally distributed system and the application of standards and specifications, data access can be supported at many different levels, thereby supporting a variety of possible services. The web mapping services being developed by the LOSLR Framework project provides web-based data viewing, useful to potential data user requiring a preview of the data layers for evaluation and other persons interested in basic data visualization. Compliance with standards for storing, accessing and transmitting data in the LOSLR Framework system support the potential for future development of applications utilizing the framework data to address specific analyses and concerns. The scalability and extensibility of the LOSLR Framework project requires that any analysis of business models consider flexibility in supporting an expansion of the services both in areal and thematic, extent and functional capacity.

As part of the business model analysis and design process, a list of alternative business models should be considered. Business models currently being utilized by similar initiatives should be referred to and the organizations involved in those initiatives be contacted as part of the research phase of the business model analysis process. Private partnerships currently maintained by USGS, GeoConnections and other public sector agencies should be reviewed and considered for their

appropriateness in being applied to the unique services being offered by the LOSLR Framework. The principle participants in the LOSLR Framework should be ultimately responsible for the development of the business model supporting the sustainability of the LOSLR Framework. Only by developing a business model coordinated among the existing and future principal participants and consistent with their individual business plans will the long-term sustainability of a LOSLR Framework be achieved. Institutional involvement and dedication to the Framework will need to be well defined and supported at the highest level of authority as possible. In particular, the roles of the IJC and the GLC will need to be clearly defined in the context of sustaining the LOSLR Framework. As both of these organizations have a vested interest in the framework data and community, their involvement in and commitment to the LOSLR Framework will be crucial.

LOSLR Framework Public Outreach

Public outreach was identified at the beginning of the LOSLR Framework development process as a critical factor in ensuring the success of the framework. Just as the IJC LOSLR Study benefits the efforts being made by the LOSLR Framework, the Framework will benefit from the well developed public outreach and involvement efforts being sustained by the Study. Incorporating the LOSLR Framework into the Study's communication efforts will be mutually beneficial to both concerns. At the very beginning of the LOSLR Framework process, a brochure should be designed and distributed that informs the Study participants and the public of the LOSLR Framework, its purpose and vision, and how it will contribute to a more comprehensive understanding of the Lake Ontario and St. Lawrence system.

The LOSLR Framework Data Project should identify each segment of the Framework community and develop for these individual audiences a profile upon which to base the development of public outreach products. Study participants, the scientific and research communities, and the interested public comprise the three main user groups of LOSLR Framework, each benefiting from varied levels of a system's functionality and sophistication. An important component of the LOSLR Framework public outreach effort will be the education of policymakers, the general public, students, and data users on the significance of the LOSLR Framework and how it can be utilize in improving their understanding of the Lake Ontario and St. Lawrence system. By means of developing a project website, designing and distributing brochures and engaging the mass media, communicating the work being done by the Study and Framework community will improve the effective use and relative success of the LOSLR Framework.

Glossary of Terms

Attribute:
1. Characteristic of the feature that is being mapped. [18]
2. A characteristic of a geographic feature described by numbers, characters, images and CAD drawings, typically stored in tabular format and linked to the feature by a user-assigned identifier (e.g., the attributes of a well might include depth and gallons per minute). [19]

Attributed/Attribution:
1. Assignment of a trait, quality or property to a geographical feature within a relational data model, equivalent to the column in a relational table.[20]

CAP Grant:
1. The FGDC Cooperative Agreements Program (CAP) Grant program, begun in 1994, has worked to provide "seed money" to communities willing to advance the National Spatial Data Infrastructure through the establishment of Clearinghouses, metadata, and data standards consistent with the NSDI goals. Category 4 of the CAP Grant (a source of fund for this project) specifies a Canadian/US framework collaborative project in which the FGDC and GeoConnections provide funding assistance to U.S. and Canadian organizations who are collaborating to share, create and maintain data over a common geography.

Catalogs (Metadata):
1. A collection of entries, each of which describes and points to a feature collection. Catalogs include indexed listings of feature collections, their contents, their coverages, and other metadata. Catalogs register the existence, location, and description of feature collections held by an Information Community. Catalogs provide the capability to add and delete entries. At a minimum Catalog will include the name for the feature collection and the locational handle that specifies where this data may be found. The means by which an Information Community advertises its holdings to members of the Information Community and to the rest of the world. Each catalog is unique to its Information Community. [21]

Clearinghouses:
1. A distributed network of data producers, managers, and users linked electronically, such as over the Internet. Through the Clearinghouse, users can use a single interface to search and access metadata and/or data for the themes they seek. The Clearinghouse includes the sites across the country where the metadata and data are stored, usually at the site of the producer or intermediary.[22]
2. An information clearinghouse is a collection of data servers or “nodes”, which can be searched through a single interface based on data descriptions or metadata referenced in the system. A clearinghouse allows for data discovery within its network of data servers.

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[18] http://fwie.fw.vt.edu/tws-gis/glossary.htm
[19] http://www.esri.com/library/glossary/a_d.html
[20] http://www.geo.ed.ac.uk/agidexe/term?460
[21] http://www.opengis.org/techno/guide/guide980615/AppendA.htm
[22] http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html

Coverages:

1. Refers to a layer of spatial data within a GIS. In remote sensing, this term is often used to describe the extent of the earth's surface represented on an image.[23]
2. Geographic data set that represents a specific type of feature (e.g., vegetation coverage). Often simply called a layer. ARC/INFO also has a data format that is referred to as a coverage. [24]
3. A set of thematically associated data considered as a unit. A coverage usually represents a single theme such as soils, streams, roads, or land use. [25]

Data Discovery:

1. The data discovery mechanism is the means by which data can be located for a given search. Data discovery requires some degree of metadata be collected and made searchable. The range of detail provided in the process can vary from names of data sets to extensive metadata. For geo-spatial data discovery, applications have been developed which utilize the ANSI Z39.50 Information Search and Retrieval protocol in performing data discovery searches on FGDC standard metadata. Data discovery mechanism results are typically provided by displaying the metadata. Contained in most metadata is information related to data ownership, stewardship and distribution. The data discovery mechanism can through data distribution component of the metadata direct users from the data discovery portal to a data access and/or distribution point. Because data discovery only provides information contained in metadata, it can be considered separate from most liability and security concerns associated with data access and distribution.

Data Distribution:

1. Data Distribution is the mechanism by which data is transfered via the access point from the data store to the data user. Data need not be transferred in its file form. Access to information or data if done over the Internet could entail making the data viewable from a web browser. In an off-line system, information could be in digital or hardcopy formats. Production costs increase for an off line option. The cost difference between digital and print media for distribution is dependant on the volume and format of information being distributed.

Data Feature:

1. Any visible object of nature or of man-made culture shown on a map[26]
2. A digital representation of a real world entity or an abstraction of the real world. It has a spatial domain, a temporal domain, or a spatial/temporal domain as one of its attributes. Examples of features include almost anything that can be placed in time and space, including desks, buildings, cities, trees, forest stands, ecosystems, delivery vehicles, snow removal routes, oil wells, oil pipelines, oil spill, and so on. Features are usually managed in groups as feature collections. [27]
3. A defined entity and its object representation. A real world feature is used in framework discussions to emphasize the goal that framework data should be based on the original

[23] http://www.geo.ed.ac.uk/agidexe/term?546
[24] http://fwie.fw.vt.edu/tws-gis/glossary.htm
[25] http://www.esri.com/library/glossary/a_d.html
[26] http://atlas.gc.ca/site/english/index.html
[27] http://www.opengis.org/techno/guide/guide980615/AppendA.htm

encoding of an observation, or be removed from an observation by the fewest possible generations or interpretations. [28]

Data Maintenance:

1. From the day-to-day updating of data sets to any error correction or format manipulation, data maintenance refers to the technical needs to ensure a dataset's currency and quality. Data maintenance responsibilities are provided to the data steward under the authority of the data owner. Data maintenance is often associated with a defined schedule of tasks to ensure consistency application of maintenance procedures.

Data Owner:

1. A data owner holds responsibility for data security, use, and maintenance. The data owner has the authority to define data access and distribution. For the purpose of the LOSL Study, data ownership is held by the IJC for the duration of the Study. After the life of the Study, the longevity of the data comes into questions as the IJC has not assumed maintenance responsibility after the Study. While archived, the data would still exist, however providing for access and distribution would not be actively managed. Because many of the data generated by the study is valuable to potential data users during and beyond the Study, alternatives for implementing and information management system for the Study address these concerns.

Data Series:

1. A collection of related data sets.

Data Stewards:

1. The data steward, sometimes referred to as a data custodian, is the person or agency responsible for the day-to-day maintenance a particular dataset. Given the authority by the data owner, a data steward is familiar with issues and concerns specific to a dataset. A data steward provides efficiency and continuity in the data maintenance process. While not required of a data steward, most likely he or she is part of the agency or organization that is the data owner.

Database Management System (DBMS):

1. A set of computer programs for organizing the information in a database. A DBMS supports the structuring of the database in a standard format and provides tools for data input, verification, storage, retrieval, query, and manipulation. [29]
2. A DBMS is software that supports processes germane to organizing, cataloging, locating, storing, retrieving, and maintaining data (i.e., information) in a data base. [30]
3. A set of computer programs for organizing the information in a database. Typically, a DBMS contains routines for data input, verification, storage, retrieval, and combination.[31]
4. DBMS sometimes refers to the software that contains and organizes the data, and sometimes refers to an organizational plan for the use of information within a single project, or within one unit or the whole of an organization. [32]

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[28] http://www.fgdc.gov/framework/frameworkintroguide/append_a.html
[29] http://www.esri.com/library/glossary/a_d.html
[30] http://edcwww.cr.usgs.gov/glis/hyper/glossary/index
[31] http://www.geog.ubc.ca/courses/klink/gis.notes/glossary.html

Data Set:

1. A collection of related data.

Decision Support System (DSS):

1. An interactive computer-based system that can help decision makers utilize data and models to solve unstructured or semi-structured problems.[33]

Digital Earth Reference Model (DERM):

1. The concept of the DERM is a multi-resolution, 3-D representation of planet, into which we can embed vast quantities of georeferenced data; integration of information is the key point. Lead agency is currently NASA. DERM architecture closely based on OpenGIS reference model: interoperability among clients, data servers, map servers, catalogs, metadata, service registries.[34]

Framework Data:

1. The framework forms the data backbone of the NSDI. It has three aspects: data, procedures and technology for building and using the data, and institutional relationships and business practices that support the environment. The framework is designed to facilitate production and use of geographic data, to reduce operating costs, and to improve service and decision making.[35]

Gateway:

1. An information "gateway" provides the most general level of information about data and the organization which provides access to that data. The gateway directs users to other sites from which data discovery and access can be conducted, or sites at which data can simply be accessed.

Gazetteer:

1. A work of geographic reference that supplies place name and location information. When a place name is known, a gazetteer can provide the co-ordinates of the place. Most atlases contain gazetteers. Well known digital gazetteers are the USGS Geographic Names Information System (GNIS) and the gazetteer in the Digital Chart of the World (DCW).[36]
2. A list of geographical place or feature names in alphabetical order, usually accompanied by geographic or grid coordinates and basic information about the feature, such as population or classification[37]
3. A work of geographic reference that supplies place name and location information. When a place name is known, a gazetteer can provide the coordinates of the place. Most atlases contain gazetteers. Well-known digital gazetteers are the USGS Geographic Names Information System (GNIS) and the gazetteer in the Digital Chart of the World (DCW). In ArcInfo the

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[32] http://www.opengis.org/techno/guide/guide980615/AppendA.htm
[33] Malczewski, J. (1999) GIS and Multicriteria Decision Analysis. *John Wiley & Sons, Inc.*
[34] http://www.fgdc.gov/fgdc/coorwg/1999/cwgjul99.html
[35] http://www.fgdc.gov/framework/faqframe.html
[36] http://www.geo.ed.ac.uk/agidexe/term?31
[37] http://atlas.gc.ca/site/english/index.html

gazetteer spatial index is done as a grid of alpha and numeric references which is converted into a polygon coverage. Places (points or polygons) are then overlaid with this grid, then sorted alphabetically. This produces a list of place names sorted both alphabetically and by reference grid number. [38]

Geospatial Data:

1. Information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the Earth. This information may be derived from, among other things, remote sensing, mapping, and surveying technologies. Statistical data may be included in this definition at the discretion of the collecting agency. [39]
2. Information that identifies the geographic location and characteristics of natural or constructed features and boundaries on the earth. The information may be derived from - among other things - remote sensing, mapping, and surveying technologies. [40]
3. Data, usually stored as coordinates, that describe the location, shape, and spatial relationships of geographic features[41]
4. Information that identifies the geographical location and characteristics of natural or man-made features and boundaries of the Earth. Geodata represent abstractions of real-world entities, such as roads, buildings, vehicles, lakes, forests and countries. [42]

Geographic Markup Language (GML):

1. The Geographic Markup Language (GML) is an XML encoding for the transport and storage of geographic information, including both the spatial and non-spatial properties of geographic features. Specified XML Schema, mechanisms, and conventions defining GML provide an open, vendor-neutral framework for the definition of geospatial application schemas and objects.

Imagery:

1. A graphical 2-dimensional representation of an object, or the Earth's surface. An image can be produced by an optical device, such as a photographic camera, or an electronic device, such as a scanner. Remotely sensed images taken from a satellite are digital representations of the Earth's surface.[43]
2. Picture or graphical representation. In remote sensing and GIS as a term that describes digital representations of earth features. [44]
3. A graphic representation or description of a scene, typically produced by an optical or electronic device. Common examples include remotely sensed data (e.g., satellite data), scanned data, and photographs. An image is stored as a raster data set of binary or integer values that represent the intensity of reflected light, heat, or other range of values on the electromagnetic spectrum. [45]

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[38] http://www.esri.com/library/glossary/a_d.html
[39] http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html
[40] http://www.fgdc.gov/framework/frameworkintroguide/append_a.html
[41] http://atlas.gc.ca/site/english/index.html
[42] http://www.opengis.org/techno/guide/guide980615/AppendA.htm
[43] http://atlas.gc.ca/site/english/index.html
[44] http://fwie.fw.vt.edu/tws-gis/glossary.htm
[45] http://www.esri.com/library/glossary/a_d.html

Land Information Ontario (LIO):

1. The Government of Ontario has established Land Information Ontario (LIO) to orchestrate the collection and management of land information (e.g. property boundaries, zoning, population, topographic, roads and other information) in the Province of Ontario.

Metadata:

1. Information about data, such as content, source, vintage, accuracy, condition, projection, responsible party, contact phone number, method of collection, and other characteristics or descriptions. [46]
2. Graphical or textual information about the content, quality, condition, origins, and characteristics of data. [47]
3. Data about the content, quality, condition, and other characteristics of data. [48]

Metadata Content

1. Quality and completeness of metadata has strong implications on data discovery processes, making the Study's commitment to metadata crucial should a data discovery mechanism require it. For information and data such as reports, surveys or other documentation, metadata can consist of citation, abstract and keywords.

Metadata Standards

1. Metadata standards have been developed to promote a consistent application of metadata documentation practices. Standards for metadata have been developed by the FGDC and ISO. The Information Management TWG has identified the FGDC metadata standards as being most appropriate for the study's geospatial data.

Network:

1. An interconnected set of arcs representing possible paths for the movement of resources from one location to another. [49]
2. Two or more interconnected computer systems for implementation of specific functions. OR A set of interconnected lines (arcs, chains, strings) defining the boundaries of polygons. [50]

NRVIS (Natural Resources and Values Information System):

1. An Ontario Ministry of Natural Resources Geographical Information System (GIS) that provides the ability to work with geographical data along with the corresponding attribute information. This geographic information and database management system houses a variety of data on natural values (such as topography, forest cover, wetlands, and fish and wildlife habitats) and the impacts of human activities (including mine sites, pits, quarries, roads and timer harvest areas. NRVIS allows users to work with resource issues and programs in a number of spatial and tabular formats.[51]

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[46] http://www.whitehouse.gov/omb/circulars/a016/a016_rev.html
[47] http://www.opengis.org/techno/guide/guide980615/AppendA.htm
[48] http://www.fgdc.gov/framework/frameworkintroguide/append_a.html
[49] http://www.esri.com/library/glossary/a_d.html
[50] http://www.geog.ubc.ca/courses/klink/gis.notes/glossary.html
[51] http://tdr.tug-libraries.on.ca/GIS_SITE/NRVIS/

Open GIS Consortium (OGC):

1. OGC is an international industry consortium of over 220 companies, government agencies and universities participating in a consensus process to develop publicly available geoprocessing specifications. OpenGIS Specifications support interoperable solutions that "geo-enable" the Web and mainstream IT, and empower technology developers to make complex spatial information and services accessible and useful with all kinds of applications. Visit the OGC website at www.opengis.org.

Orthophotography/Orthoimagery:

1. A modified copy of a perspective photograph or image of the earth's surface with distortions due to tilt and relief removed.[52]
2. An oblique aerial photograph that has been rectified (corrected) to remove the displacement of points caused by camera tilt and terrain relief. [53]
3. An aerial photograph or satellite image from which displacements caused by terrain relief and sensor tilt have been removed. The result combines the image characteristics of a photograph with the geometric qualities of a map. [54]
4. Orthorectified images produced using photogrammetric techniques to orthorectify scans of aerial photos and paper maps. [55]

Powerhouse:

1. A geographic information powerhouse is an information warehouse that offers geospatial data services such as web mapping and other decision support tools. Typically the powerhouse is accessible via an Internet-based interface and is connected with one or more warehouses or warehouse functions.

Servers:

1. A computer or device on a network that manages network resources. For example, a file server is a computer and storage device dedicated to storing files. Any user on the network can store files on the server. A print server is a computer that manages one or more printers, and a network server is a computer that manages network traffic. A database server is a computer system that processes database queries. Servers are often dedicated, meaning that they perform no other tasks besides their server tasks. On multiprocessing operating systems, however, a single computer can execute several programs at once. A server in this case could refer to the program that is managing resources rather than the entire computer.[56]

Spatial (Geospatial) Data Infrastructure:

1. The Spatial Data Infrastructure supports ready access to geographic information. This is achieved through the coordinated actions of organizations that promote awareness and implementation of complimentary policies, common standards and effective mechanisms for the development and availability of interoperable digital geographic data and technologies to support decision making at all scales for multiple purposes. These actions encompass the policies, organizational remits, data, technologies, standards, delivery mechanisms, and

[52] http://www.geo.ed.ac.uk/agidexe/term?770
[53] http://atlas.gc.ca/site/english/index.html
[54] http://www.fgdc.gov/framework/frameworkintroguide/append_a.html
[55] http://www.opengis.org/techno/guide/guide980615/AppendA.htm
[56] http://www.webopedia.com/TERM/s/server.html

financial and human resources necessary to ensure that those working at the global, national, regional and local scale are not impeded in meeting their objectives.

Spatial Middleware:

1. Middleware generally refers to software which connects two or more separate applications. Spatial middleware refers more specifically to software which connects separate applications involving the creation, update, maintenance, storage, access and/or distribution of geospatial data and/or services.

Temporal Data:

1. A collection of facts, concepts or instructions indexed by time. Time can either be represented as discrete steps, or less commonly, as a continuous variable.

Warehouse:

1. An information warehouse is a repository for information and data. As a repository, an information warehouse contains everything necessary to provide access to data and information. Implemented through a file server and/or database server, the information warehouse is the data store in a client/server environment.

Web Feature Services:

1. The web feature service (WFS) is a developing technology which uses the web services development approach to support more robust functionality in a web-based GIS. The WFS would allow for greater flexibility in developing web-based custom processes with GIS data. As burgeoning technology WFS considerations should be made in terms of future information management and system development.

Web Mapping Services:

1. A web mapping service (WMS) produces maps as images in an Internet-enabled environment. As a web service, the WMS is a modular application where functions deployed by the WMS can be utilized by other applications and services in the web environment. A strong proponent of web mapping service technology and implementation is the Open GIS Consortium (OGC), whose mission is one of interoperability and openness in geographic information functions and services.

Web Services:

1. The term Web services describes a standardized way of integrating Web-based applications using the XML, SOAP, WSDL and UDDI open standards over an Internet protocol backbone. XML is used to tag the data, SOAP is used to transfer the data, WSDL is used for describing the services available and UDDI is used for listing what services are available. Used primarily as a means for businesses to communicate with each other and with clients, Web services allow organizations to communicate data without intimate knowledge of each other's IT systems behind the firewall. Unlike traditional client/server models, such as a Web server/Web page system, Web services do not provide the user with a GUI. Web services instead share business logic, data and processes through a programmatic interface across a network. The applications interface, not the users. Developers can then add the Web service to a GUI (such as a Web page or an executable program) to offer specific functionality to users. Web services allow different applications from different sources to communicate with each

other without time-consuming custom coding, and because all communication is in XML, Web services are not tied to any one operating system or programming language. For example, Java can talk with Perl, Windows applications can talk with UNIX applications. Web services do not require the use of browsers or HTML. Web services are sometimes called application services. [57]

[57] http://www.webopedia.com/TERM/W/Web_services.html