1 Introduction

The process for monitoring cumulative impacts in the Gwich'in Settlement Area (GSA) emphasizes community involvement in reviewing existing information for a specific concern and providing direction regarding actions and solutions that might be taken.

The MVCIMP Working Group commissioned the Gwich'in Tribal Council (GTC) and Map Insight to conduct a preliminary study, limited to water quality monitoring within the GSA, to facilitate:

- communication within the Working Group as well as with communities
- integrated resource management and data exchange between stakeholders
- development of a framework for analysis

To achieve the objectives of the Working Group, monitoring data must be spatially referenced and mapped in a geographic information system (GIS) to visualize monitoring coverage and identify gaps in coverage. Consequently, part of this preliminary study included a georeferencing project. The Georeferencing Project was designed to leverage the map and monitoring data available through the Gwich'in Land and Water Board and the monitoring metadata compiled in the MVCIMP Metadatabase. The results of the Georeferencing Project produced by Map Insight will then be used in meetings of the Gwich'in Tribal Council team and community stakeholders.

1.1 Objectives

The objectives of the Georeferencing Project, as listed in the project proposal, include:

- identification of required data themes for water quality monitoring
- obtaining experience in data acquisition, data compilation and editing
- production of sample map products
- assessment of how the MVCIMP Metadatabase can be improved
- information on what infrastructure is available and what is needed to support the collection and analysis of data
- assist with communication of the MVCIMP to Gwich'in communities

The Gwich'in Land and Water Board (GLWB) has compiled an extensive collection of GIS data for the GSA. This was used as a foundation from which to build an initial water quality GIS data set for the GSA. The MVCIMP commissioned the Aurora

Research Institute (ARI) to create a monitoring metadatabase, which provides information about monitoring data collected in the Mackenzie Valley. The metadatabase was evaluated and searched for additional water quality data sets not included in the GLWB data.

The proposal stated that "The initial level of detail would be to map monitoring locations, with the long-term goal of including actual monitoring data". The objectives of the Georeferencing Project were not only met but actually exceeded. Through the cooperation of Environment Canada, Indian and Northern Affairs Canada, and the Gwich'in Land and Water Board, actual monitoring data was obtained, georeferenced, and included as part of the final products of this project.

1.2 Deliverables

The final products of the Georeferencing Project are:

- an electronic compilation of available data, in MapInfo format on CD-ROM
- sample map products
- a report summarizing the results of the Georeferencing Project

The data compilation and sample maps were presented to the GTC team during a meeting in Inuvik in December, 1999. This report represents the final deliverable product.

1.3 Definition of the Study Area

Although the terms of reference for the project specified the GSA as the study area, this was broadened to include a rectangular area that encompassed the Primary and Secondary Use Areas and land immediately surrounding the GSA (Figure 1). This rectangle corresponds with the extent of digital coverage of National Topographic Series data held by the GLWB.

Figure 1. Study area for the Georeferencing Project.

2 Approach to Integrating Multiple Data Sources

The MVCIMP Metadatabase was searched for information regarding monitoring databases. These entries were identified and flagged for future acquisition. A critique was made of the metadatabase design with reference to user-friendliness and future inclusion of geospatial metadata.

Base map and monitoring data was acquired from the Gwich'in Land and Water Board (GLWB) and government agencies. The majority of this data required file format translation, organization, and editing to be made useful for this project. Once these tasks were accomplished, sample maps were created.

2.1 MVCIMP Metadatabase

The MVCIMP Metadatabase contains information about monitoring activities in the Northwest Territories and Yukon Territory. The MVCIMP Metadatabase was searched for data sets that might be of value to the Georeferencing Project.

2.1.1 Water Quality Metadata

Two Access tables, the Monitoring table and the Point Data table, were searched for records related to monitoring of water quality and related parameters. This was done by first searching for records in each table where the "Environmental" field was checked, or "true", then sorting the results by the "Settlement" field and removing those records dealing with the Sahtu region exclusively. The results were then searched for content related to water quality issues. Finally, these results were examined for any indication that the studies in question had a mapping or georeferencing component.

2.1.2 Evaluation of the MVCIMP Metadatabase

The MVCIMP Metadatabase was evaluated by conducting numerous searches through the interface designed by the project team, as well as through exploration and manipulation of the "raw" Access tables themselves.

2.2 Gwich'in Land and Water Board Data

A variety of GIS data was made available by the GLWB for this project. The high volume of data required extensive review, interpretation (where metadata was not available), organization, and editing to maximize utility of the data for the Georeferencing Project.

2.2.1 Organization and Selection

The GLWB currently holds more than 2 gigabytes of digital data in numerous file and media formats. A comprehensive and consistent metadatabase for this data does not exist. While much of the GLWB GIS data had been imported into MapInfo in the past, a lack of documentation and consistent quality control necessitated reverting to original data files and formats in many cases.

For each data set, files were opened, reviewed, and translated into MapInfo when the files were deemed relevant to the Georeferencing Project. A hierarchical directory was created to organize the files by theme and facilitate user access. Files were assigned full, clear, and consistent file names. The data source was included in the file name where similar themes had been obtained from different sources.

2.2.2 Tabular Editing

The majority of GLWB GIS files have not been previously edited. For each data set that was selected for inclusion in the Georeferencing Project, individual map

files were opened, and an attempt was made to interpret field and record codes (where appropriate metadata was not available). To enhance accessibility by non-technical users, abbreviated or coded field names were changed to full names where possible, field columns were rearranged, and records were sorted.

2.2.3 Cartographic Editing

Each map theme, or layer, was graphically edited to suit an overall cartographic design. Various characteristics, such as line weight, symbol size, and polygon color were edited for consistency, clarity, and communication.

Map layers were ordered to ensure that all layers were visible and distinct.

2.3 Government Data

Some of the data used in this project was obtained directly from government sources, and then edited and translated into MapInfo format.

2.3.1 Data Acquisition

Concurrent with the GLWB data manipulation, staff in several government offices were contacted to obtain relevant data. The people contacted are:

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Fax (867) 669-2701

2.3.2 Data Editing and Translation

The main data sets obtained were the EcoAtlas CD-ROM and a water quality database. The data sets were received in Microsoft Access format. The files were opened, searched, and relevant data was extracted, formatted, and imported into MapInfo. Once the data was in MapInfo, the files were edited to improve usability and cartographic presentation in the same fashion as the files obtained from the Gwich'in Land and Water Board.

2.4 Data Acquisition and Compilation Issues

Much of the acquired data came from secondary sources and did not include metadata, which posed problems. Interpretation of the field codes was not always possible, or required additional research. The age, accuracy, and original source of the data were often unknown. Also, identifying gaps in the data sets proved challenging since it was not always clear whether the entire data set was present. The result is that the current map database is of varying quality.

The current georeferenced data represents an incomplete data set. Whenever possible, each water quality map database should be populated with data acquired from the *original* sources, with associated metadata. This would allow the project team members and end users to evaluate the quality of the data they are viewing. Unfortunately, the volume of data and the time required for acquisition and processing meant that this was beyond the scope of the current project.

Table 1 lists the major file directories created on the Georeferencing Project CD-ROM. Files and directories were organized in a thematic and hierarchical structure to enhance ease of use. The list represents data collected from the Gwich'in Land and Water Board as well as Environment Canada and Indian and Northern Affairs Canada.

Table 1. A list of directories and major map themes on the Georeferencing Project CD-ROM, showing the thematic organization of files.

DIRECTORY	FILES	MEGABYTES
Root Directory: C:\MVCIMP GIS Data	1	0.03
Annotation	20	0.08
Land Use and Administration		0.00
Land Use and Administration\DIAND Land Administration Data	28	3.36
Land Use and Administration\Gwich'in Land Use Planning	4	0.11
Land Use and Administration\Roads	0	0.00
Land Use and Administration\Roads\Dempster Highway - FSC Files	57	12.53
Land Use and Administration\Roads\Dept of Transportation	18	0.04
Land Use and Administration\RWED Land Use Database	5	0.80
Land Use and Administration\RWED Land Use Database\RWED Land Use Database Info	3	1.29
Physical Environment	0	0.00
Physical Environment\Ecology	0	0.00
Physical Environment\Ecology\Enduring Features Analysis	5	0.44
Physical Environment\Ecology\National Ecological Framework	5	0.26
Physical Environment\Ecology\National Ecological Framework\National Ecological Framework - Supporting Data	5	62.12
Physical Environment\Ecology\Protected Areas Strategy	3	0.42
Physical Environment\Ecology\Protected Areas Strategy\Summary of Landscape Unit Approach	1	0.02
Physical Environment\Ecology\Protected Areas Strategy\Summary of Landscape Unit Approach\GNWT - RWED - Landscapes_files	4	0.10
Physical Environment\Fish	9	0.48
Physical Environment\Fish\DFO Original and Supporting Data	6	1.52
Physical Environment\Fish\DFO Original and Supporting Data\DFO Raw Data	4	0.46
Physical Environment\Minerals	13	0.09
Physical Environment\Oil and Gas	0	0.00
Physical Environment\Oil and Gas\Pipelines__Dept of Transportation	4	0.00
Physical Environment\Oil and Gas\Wells__Geological Survey of Canada	4	0.02
Physical Environment\Oil and Gas\Wells__National Energy Board	9	0.40
Physical Environment\Sand and Gravel	12	0.38
Physical Environment\Sand and Gravel\Dept of Transportation	12	0.02
Physical Environment\Water	0	0.00
Physical Environment\Water\Hydrometric Data__EcoAtlas\Data	69	46.88
Physical Environment\Water\Hydrometric Data__EcoAtlas\Documents	30	0.10
Physical Environment\Water\Mackenzie River Basin	4	0.99
Physical Environment\Water\Rivers and Lakes	20	56.17
Physical Environment\Water\Stream Flow from GLWB	4	0.03
Physical Environment\Water\Water Quality	16	2.46
Physical Environment\Water\Water Stations__EnviroDAT	25	0.13
Physical Environment\Water\Watersheds	12	0.55
Physical Environment\Wildlife	0	0.00
Physical Environment\Wildlife\Peel River Game Preserve	4	0.03
Physical Environment\Wildlife\Porcupine Caribou Satellite Data	9	0.13
Political Features	22	9.35
Political Features\Boundaries from National Atlas	4	2.85
Political Features\Comparison of Areas	21	0.33
Political Features\Gwich'in Parcels	19	0.83
Political Features\Municipalities	0	0.00
Political Features\Municipalities\Community AutoCAD Files	0	0.00
Political Features\Municipalities\Community Boundaries	15	0.02
Political Features\Municipalities\Municipal Parcels	46	12.88
Political Features\Settlement Boundaries	32	0.32
Total:	563	219.02

3 Evaluation of the MVCIMP Metadatabase

The MVCIMP Metadatabase contains information about monitoring activities in the Northwest Territories and Yukon Territory. While the MVCIMP Metadatabase constitutes an impressive collection of information about numerous data sets, there is insufficient metadata that is useful for mapping the geographic coverage of monitoring information. Improvements to the design and interface of the metadatabase would increase user friendliness and efficiency.

3.1 Water Quality Metadata

Table 2 shows the results of the successive searches conducted with the "Monitoring" and "Point Data" tables. The results of these searches clearly indicate that very little georeferencing information has been entered into the MVCIMP Metadatabase. The GIS data compilation CD-ROM accompanying this report includes data from the one entry where georeferencing was indicated as having been done, the Land Information System (LIMS).

Table 2. MVCIMP Metadatabase search results.

Criteria	Monitoring Table	Point Data Table
Total number of records	178	123
"Environmental" = true	140	69
Relevant to the GSA	113	64
Related to water quality	44	10
Georeferencing indicated	1	0

3.2 Mapping Data from the MVCIMP Metadatabase

The MVCIMP Metadatabase does not include georeferencing information. Furthermore, the database does not indicate if georeferencing information is available, or if the results of the projects listed were mapped (unless the information was included incidentally). Table 3 was extracted from the MVCIMP Metadatabase, and lists organizations and monitoring programs that appear to have relevance to water quality monitoring in the GSA. Unfortunately, time constraints on the Georeferencing Project did not allow these to be pursued. It is recommended that these be "followed up" in the near future.

Table 3. Organizations and monitoring activity related to water quality in the GSA.

Organization	Title
AEB, Environment Canada	NWT reference hydrometric basin network
Department of Fisheries and Oceans, Resources, Wildlife and Economic Development	Fish and Marine Mammal Harvest - Northwest Territories
Department of Fisheries and Oceans	Big Fish River - Cache Creek charr monitoring
Department of Fisheries and Oceans	Monitoring NWT West Area fish stocks
Department of Fisheries and Oceans	Monitoring of Inuvik sewage lagoon effluent
Department of Fisheries and Oceans, GRRB	Rat River char monitoring
Department of Fisheries and Oceans, DIAND, Dene Nation	Fish quality and physiological condition
Department of the Environment, Fisheries Service	Evaluation of fish resources of the Mackenzie River valley
DIAND, originally part of AES, Contaminated sites devolved from Actions on Waste program	Contaminated Sites
EC, RWED, DFO, ITC, NTI, IJS, GTC, SDC, Deh Cho First Nations	Northern Contaminants Program
Environment Canada	Hydrometric data monitoring
Environment Canada	NWT water monitoring program
Environment Canada, Atmospheric Environment Branch	Mackenzie Delta water level and flow monitoring
Geological Survey of Canada	River characteristics and fluvial processes along lower reaches of major tributaries of the Mackenzie River-Fort Simpson to Mackenzie Delta
Gwich'in Renewable Resource Board, Department of Fisheries and Oceans	Peel River fish study
Indian and Northern Affairs Canada	NWT evaporation studies
Indian and Northern Affairs Canada, Environment Canada	AES baseline water quality monitoring program
Indian and Northern Affairs Canada, Yukon Contaminants Committee	Yukon fish monitoring program
Indian and Northern Affairs Canada, Yukon Contaminants Committee	Yukon snow monitoring study
Unknown	Arctic Monitoring and Assessment Program (AMAP)
Environmental Protection Service	Hazardous Materials Spill Database (HMSD)

3.3 MVCIMP Metadatabase Interface Design

While the MVCIMP Metadatabase contains a large amount of information, some changes are suggested here that would make the database more useful. While exploring the database, some limitations in the interface provided by ARI (as opposed to the interface for Access itself) and the database design became apparent. The following are suggestions regarding how the metadatabase might be improved upon:

Opening Screen: Once the user becomes familiar with the database, being forced to view the opening explanatory screens becomes unnecessary. Perhaps the information in these screens could be condensed into one screen.

Navigation: The provided interface requires more navigation tools, so that a user unfamiliar with Microsoft Access is not "stuck" looking at the results of a search, without knowing how to return to the main menu.

Data Access: The metadatabase is designed so that the user *must* search using the interface designed by the MVCIMP Metadatabase project team, as opposed to exploring the data contained in the Access tables. Future versions should enhance the use of both approaches.

Compound Searches: The search methods provided are too rigid. A mechanism for compound searches should be included (e.g. searching for records that pertain to the Gwich'in Settlement Area (GSA) *and* to water quality).

Search *Within*: Enabling refinement of the results of a search would be useful. For example, once all the records relating to "waterfowl" have been found, it would be useful to be able to search those results for studies by a particular organization. A library search engine would provide a useful model from which to work.

Clarify Results: It is unclear if a search for items related to the GSA will return records that only have a GSA code, or if records listed as "both" and/or "Mackenzie Valley" would also be returned.

Export: Once results are obtained, it would be beneficial to have a way of exporting the results to a (tab-delimited) text file.

Simplify Design: It is likely that no matter how well the interface is designed, there will be users who will want to look at the raw metadata. A user who is familiar with Microsoft Access should have the option of exploring the database without using the custom interface. While direct access is already possible, it is discouraged by the coded field names, complex database design, and lack of documentation.

3.4 MVCIMP Metadatabase: Geographic Information

Georeferencing information is vital to realizing the full potential of the MVCIMP Metadatabase. The current database does not include specific information about monitoring locations or whether georeferenced data exists. Ideally, a GIS-enabled version of the metadatabase would allow a user to view and explore the metadata through a map interface, as well as the existing interface.

Several fields should be added to incorporate specific geographic information:

- georeferenced monitoring locations: do the monitoring sites have coordinates?
- GIS layers: are the monitoring stations and data already mapped in a GIS file?
- file format: if yes to the previous, what file format?
- data resolution: do the data files contain coordinates for monitoring locations, polygons showing a range of monitoring activity, or actual data?

Adding these fields would facilitate mapping of monitoring coverage, either as an incorporated feature in the MVCIMP Metadatabase, or as a separate, GIS version. The Canadian Geospatial Data Infrastructure (CGDI) metadata initiative provides useful information about developing metadata standards in Canada that could be adopted by the MVCIMP Metadatabase.

4 Creation of Sample Maps

Several map layouts were designed to illustrate the functionality and flexibility of communicating with GIS map data. Three 8.5” x 11” maps were created:

- Land use and Gwich’in land rights (Figure 2)
- Watersheds and water monitoring (Figure 3)
- Ecoregions and fish surveys (Figure 4)

These maps indicate where water quality and quantity monitoring has occurred, as well as activities that might affect water quality, such as oil and gas exploration, and political and ecological boundaries that should be considered when reviewing this information. The maps are not meant to display actual monitoring data, nor do they include all the compiled data. Rather, they are sample maps that will allow the project team to communicate information at community meetings, and to illustrate options for mapping.

Figure 2. Land use and Gwich'in land rights.

Figure 3. Watersheds and water measurements.

Figure 4. Ecoregions and fish surveys.

Two 11" x 17" illustrations were created that included the map of watersheds and water monitoring stations, with samples of tabular data, graphs, and inset maps, which also illustrate GIS functionality and can be used to communicate general GIS concepts and monitoring information to non-technical stakeholders.

5 Summary and Recommendations

5.1 Benefits of Georeferencing Project

The Georeferencing Project has provided a number of benefits. Maps have been produced that can be used to communicate water quality monitoring coverage to members of the Gwich'in communities. A core collection of GIS data was compiled and could serve as the foundation for a larger information system. Major data sets and sources have been identified. Feedback has been provided to the MVCIMP Metadatabase project team regarding improvements to the database interface and enabling more georeferencing functionality. Discussions with members of the Working Group have helped identify information management issues.

5.2 Recommendations: Development of the MVCIMP Information Management System

The Georeferencing Project and the MVCIMP Metadatabase project are first steps in developing an information management system (IMS) for the MVCIMP. The following discussion identifies issues and options that have become apparent while working on the Georeferencing Project.

5.2.1 Objectives of the IMS

Bernard *et al.* (1994) discuss the need for a central registry, or information management system (IMS), that will:

- identify data sources
- reduce redundancies in research and monitoring
- streamline reporting
- provide communities with easy access to data
- serve as a repository or archive for monitoring and auditing data

The MVCIMP Metadatabase Project and the Georeferencing Project have both contributed to these objectives using different approaches. The IMS, as envi-

sioned by Bernard *et al.* (1994), appears to encompass both. The MVCIMP Metadatabase addresses the first two requirements, while a GIS could act as a repository for monitoring and auditing data. Both systems could contribute to reporting and enabling community access.

5.2.2 IMS Options

There are three possible options for the level of GIS implementation within the MVCIMP information management system: as an interface for the metadatabase; as a data repository; and as an analysis tool.

5.2.2.1 A. GIS as an interface to the MVCIMP Metadatabase

Monitoring coverage could be visually explored through a map interface, which would allow searching by topic and location. This would greatly facilitate in identifying geographic gaps in coverage. This version would provide information about where to obtain monitoring data sets, which would be held by the original data collection agencies.

5.2.2.2 B. GIS as a repository for monitoring data

The GIS would have a similar interface to the GIS-enabled metadatabase, but this version would include actual monitoring data within the system itself. Data could be stored in GIS format, or in its original format with a dynamic link to the GIS interface. This option would require a substantially larger commitment, since it would involve data acquisition, formatting, and management.

5.2.2.3 C. GIS as an analysis and modeling tool

A GIS can provide modeling and analysis tools that can be applied to monitoring data, assuming the data is stored within the system. Furthermore, modeling programs such as BASINS (developed by the United States Environmental Protection Agency) are integrated with GIS software (in this case, ArcView), extending the functionality of the GIS. This option would require a high level of commitment.

To date, the MVCIMP Metadatabase has contributed to option A, and the Georeferencing Project to option B. Ideally, future work should be more closely integrated, and fit into a comprehensive information management strategy.

The information management system will provide critical support to the environmental audit process. Bernard *et al.* (1994) state that the environmental audit

report should be designed to answer four questions for a non-technical audience:

1. What cumulative effects are occurring in the environment?
2. Where is it happening?
3. Why is it happening?
4. Is it significant (e.g. ecologically, culturally)?

Consequently, the IMS should be designed to assist in answering these questions. Questions 1 and 2 could be answered superficially with option A. However, to fully answer these questions, and to address questions 3 and 4, a more robust system is required. In order to be able to answer the question *why*, and to determine *significance*, option C is necessary.

5.2.2.4 Education and Communication

A monitoring program of this magnitude will have to manage a high volume of data generated by experts in a wide variety of disciplines. Understanding and interpreting the data will be a daunting task for scientists and lay people alike. The value of a GIS as a visualization tool, for the illustration and explanation of results and trends over a wide geographic area, cannot be emphasized enough. A GIS can provide a strong communication link between monitoring data and land claim beneficiaries. Maps are essential for communicating monitoring information to a non-technical audience.

5.2.3 Issues to be Addressed

Based on the assumption that a GIS will be used as a data repository and analysis tool within the MVCIMP IMS, some issues will have to be addressed during development of the system.

5.2.3.1 Scale

The compilation of existing monitoring data and the collection of new data must be prioritized according to area and level of detail. Bernard *et al.* (1994) specified three spatial scales: community, ecoregion, and Mackenzie Valley, as well as distinguishing between *general* and *project specific* monitoring. These must be taken into consideration when formulating a data management strategy.

5.2.3.2 Data Exchange

Development of the MVCIMP IMS will provide an opportunity to build a data exchange network between participating organizations in the Mackenzie

Valley. In order to simplify data exchange, the participants should adopt common standards for metadata, file formats, and possibly GIS software.

Effort should be made to coordinate the development of the MVCIMP information system with the Ecological Monitoring and Assessment Network (EMAN). EMAN's objectives (as stated on its website) are:

- to be an information clearinghouse and conduit
- maintain inventory of NWT monitoring programs
- act as entry point for metadatabase of NWT monitoring datasets

While the specific objectives and mandates of the MVCIMP and EMAN differ, it is clear that there is overlap between the two organizations.

5.2.3.3 Interpretation and Summary of Data

A key goal of the MVCIMP is communication with communities within the Mackenzie Valley. To this end, monitoring data must be interpreted and summarized for non-technical users. While a GIS is a useful tool for expressing information, the participation of experts is required to ensure that data is summarized and expressed correctly.

A second key goal of the MVCIMP is the incorporation of traditional knowledge. Since integration of traditional knowledge into a GIS is not necessarily straightforward, this information will also require expert interpretation to ensure it is properly represented within a GIS.

5.2.3.4 Application of Methods to the Mackenzie Valley

The methods used in the Georeferencing Project can be expanded in scope to other monitoring themes and applied to the entire Mackenzie Valley. This will encourage cooperation between Settlement Areas and further the process of tackling the issues raised in this section. Development of an IMS implementation strategy would benefit the Working Group by providing a framework for discussion.

Bernard *et al.* (1994) identified these main monitoring categories:

- air and climate
- water and sediments
- vegetation
- fisheries and aquatic ecosystems
- wildlife
- land use

These themes provide a basis from which to develop a data acquisition plan.

5.2.4 GIS Implementation Process

The Working Group should consider the application of a GIS to the MVCIMP by using a GIS implementation process approach. Typically, the implementation of a GIS within an organization goes through six stages (Figure 5).

To implement a GIS, the potential beneficiaries of the system should be consulted to determine the nature of their current workflow, and how that might be improved with a GIS. This can be done more formally as a "needs assessment" (also known as a functional requirements study), which describes who would use the system, and what types of functions and products they would like to see. This is done without consideration for specific hardware or software, which might limit or bias the generation of requirements. Once the needs have been identified, specific systems can then be evaluated with reference to the needs assessment. The result of the needs assessment and system evaluation is an implementation plan, which is a detailed, technical plan of how to proceed with system configuration, database and application development, staffing requirements and training, and budgets and timelines for making the system operational. This plan is used to work through system acquisition and start-up, to the final phase, which is an operational system.

The MVCIMP Working Group is still in the early stages of development of the monitoring program. However, working through the GIS implementation process, particularly the needs assessment, would be a valuable exercise. The needs assessment provides a framework that will assist the Working Group in focusing on specific objectives, requirements, and end products, both for the GIS and for the monitoring program itself. The implementation process could parallel the development of the monitoring program, so that the two are tightly integrated from an early stage.

5.2.5 GIS Technical Consultant

It is clear that the MVCIMP will have to deal with numerous data management issues, regardless of the level of commitment given to the GIS. The MVCIMP would greatly benefit from the addition of a GIS technical consultant to the Working Group. The consultant would participate in Working Group meetings, advise on issues related to GIS implementation and database management, and act as liaison between monitoring specialists and GIS staff in various participating organizations. Ideally, the consultant will have both technical and scientific qualifications, in order to fully contribute to the discussion of program development and how GIS can play a role.

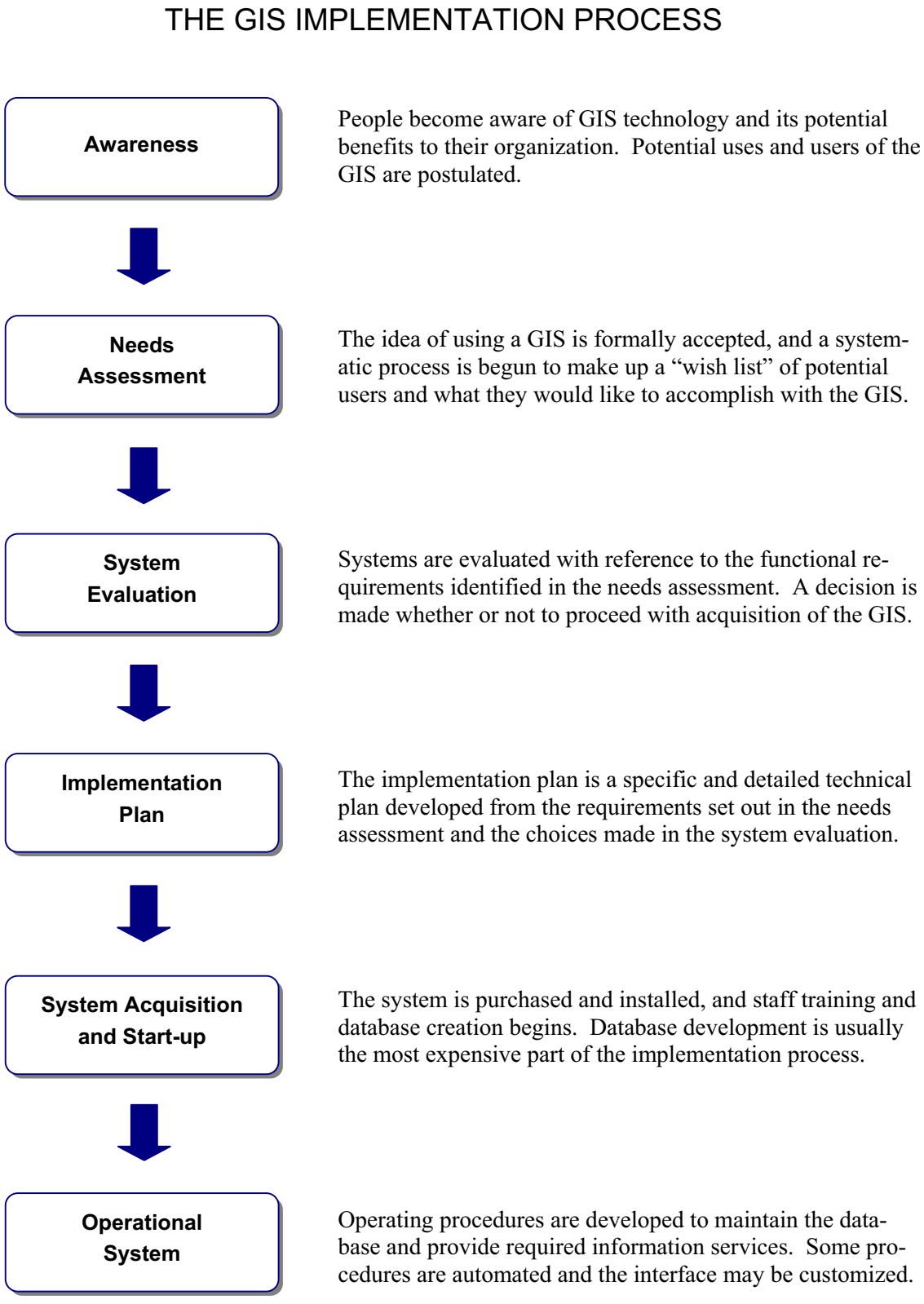

Figure 5. A general description of the implementation process.

6 References

Bernard, D.P., R.R. Everitt, and J. Green. 1994. Mackenzie Valley cumulative effects monitoring program: final report. Prepared by ESSA Technologies Ltd., Vancouver, B.C. and The Delta Environmental Management Group Ltd., Vancouver, B.C. for Indian and Northern Affairs Canada, Northern Affairs Program, Yellowknife, NWT, 87 pp.