The sources, use and future demand of Great Lakes water at a sub-basin level and the potential implications of climate change.

Project Plan

1. Introduction:

In order to meet the needs of water demand while maintaining the sustainability of aquatic ecosystems, a sustainable framework for water allocation in the Great Lakes basin is essential. One of the key pieces of information on which to base public policy decisions concerning the use and management of surface and groundwater resources in the Great Lakes region is baseline water supply (source and abundance) and water use/demand information. The recent drought of 1998 through Spring 2000, with the lowest water supplies in the Great Lakes Basin in over thirty years, has served as a reminder that water is a limited resource which must not be taken for granted. The additional threat of climate change augments the need to understand the diversities and sensitivities of our water resource system so it can be managed wisely. Baseline information is needed now.

This need for baseline data is also emphasized in the recent International Joint Commission report on the "Protection of the Waters of the Great Lakes" in which one of the recommendations made is for federal, state, and provincial governments to move quickly to remedy water use data deficiencies. To this end, the Great Lakes Commission out of Ann Arbor, MI have developed a proposal to lead a large scale collaborative effort that will yield an inventory of the sources and use of Great Lakes water, and the ecological consequences of such use. Environment Canada and the province through the Ontario Ministry of Natural Resources are partners in this initiative and this project represents a significant contribution to that effort. In addition, the Ontario provincial government has initiated the development of a Water Management Framework to guide, integrate and coordinate provincial actions across provincial ministries. A major component of this Water Management Framework includes the development of a Strategic Water Policy. Efforts will be made through this project to coordinate with that initiative.

2. Objective:

The purpose of this project is to gain baseline information on water supply, use and demand at a sub-basin level and to make projections for the future including the potential impacts of climate change. The goal is to improve our understanding of the diversity of water resource conditions across the Great Lakes basin and the sensitivities of the system to potential climate change and variability.

3. Project Summary:

Water supply will be calculated based on hydrologic factors including precipitation, evaporation, stream discharge and base flow index on a sub-basin level within a study area which covers the Great Lakes Basin, Ottawa River Basin and upper St. Lawrence River Basin (see figure 1).

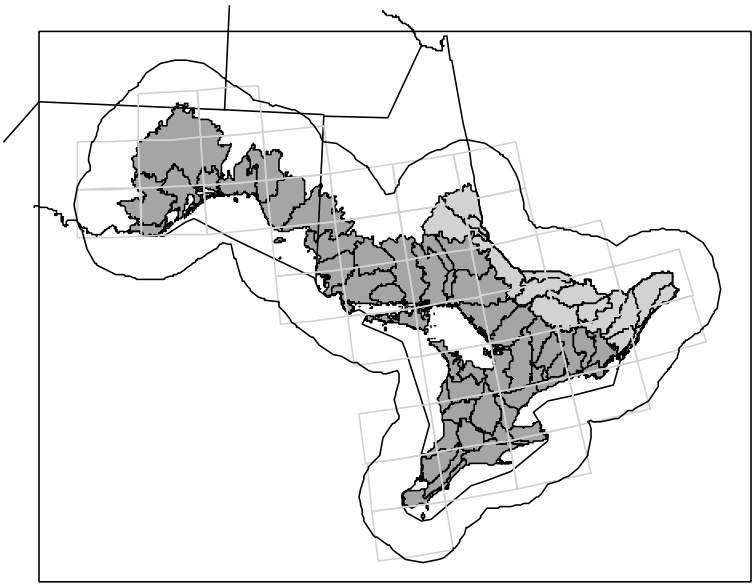

Figure 1: Study Area covering the Great Lakes, Ottawa and upper St. Lawrence River Watersheds

According to data compiled by the Great Lakes Commission, agricultural, public and industrial uses account for the bulk of consumption. Although it is known that we are presently impacting both ground and surface water conditions, there is relatively little knowledge of the stress that current water use applies on our water supply system, or of the potential stress that additional demand may apply. This project will estimate current water use and projected demand in the watersheds of Ontario beginning with the Lake Erie watershed. Based on historic water use and socio-economic trends and observations the latest possible water use data as it relates to withdrawals, instream uses, inter-basin diversions and consumptive use will be examined. Sectors will include agricultural, public supply and industrial/commercial/institutional sectors, in addition to the dominant non-consumptive use in Ontario - such as hydroelectric power generation.

Consideration will be given to the current uses of water and the priorities of uses set out in the 1909 Boundary Waters Treaty Articles VIII. A characterization of the ecosystem requirements for water will be assessed based on the information gathered.

4. Study Structure:

The project will be managed by a Study Team made up of representatives from Environment Canada, the Ontario Ministries of Natural Resources and Environment and Conservation Ontario. The Study Team will guide the study and provide overall leadership and direction in the design and conduct of all project tasks. The project will also have an Advisory Committee made up of numerous agencies and major stakeholders. This group will not be directly involved in the project, but will be kept apprised of it's progress and will be called upon from time to time for guidance and review. There will also be a number of technical working groups to address specific tasks of the project. The working groups will report directly to the Study Team as shown in Figure 3.

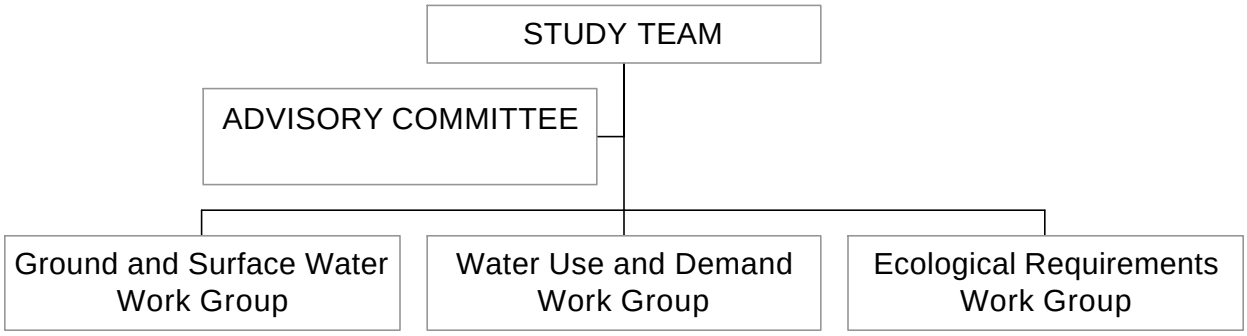

Figure 3: Study Structure

5. Project Tasks:

5.1. Data Acquisition

Data will be acquired from various sources. Most of it is available through federal and provincial agencies. Available databases that will be used for the project include:

Water Use
MUD - Municipal (Water) Use Database (1991, '96 and '98) (Environment Canada)
Industrial Water use Surveys Database (Statistics Canada and Environment Canada)
Provincial Water Taking Permits (Ontario Ministry of the Environment)
1996 Agricultural Census Data (Statistics Canada)
Drinking water database (Ministry of Environment)
Census data (Statistics Canada)
Municipal boundaries (Ontario Ministry of Municipal Affairs)

Water Supply
Sub-watershed delineation (Ontario Ministry of Natural Resources)
Precipitation and temperature data (Environment Canada)
HYDAT - Surface water data for Ontario (Environment Canada)
Water well construction records (Ontario Ministry of the Environment)
Observation well data (Environment Canada/Ontario Ministry of the Environment)
Base Flow Indices (Environment Canada)
Quaternary geology (Ontario Geological Survey, MNDM)
Bedrock geology (Ontario Geological Survey, MNDM)
Municipal discharge database (Ministry of the Environment)
Flow regulation structure (Ontario Ministry of Natural Resources)
Municipal/other surface water withdrawals (Ontario Ministry of the Environment)
Climate change scenarios (e.g. CCCma, Hadley) (Environment Canada)
Large basin runoff model (Environment Canada)
Digital Elevation Model (Ontario Ministry of Natural Resources)

5.2. Data Preparation

Once the databases have been acquired, they must be prepared for analysis. This includes extracting and reformatting of required data; working through the databases to determine continuity and inconsistencies; importing any required databases into a GIS; and linking various databases in a relational database (RDMS). Substantial expertise in the assembly and interpretation of spatial and relational databases has been developed during surface and ground water studies in the Great Lakes Basin (Southam et. al, 1997).

5.3. Water Source and Abundance Calculations

The principal sources of data for determining water source and abundance are: stream flow data collected by the Water Survey of Canada of Environment Canada (HYDAT); water well construction records collected by the Environmental Monitoring and Reporting Branch of the Ontario Ministry of the Environment; observation well data developed by Environment Canada in collaboration with the Ontario Ministry of the Environment; and digital maps of Quaternary geology developed by the Ontario Geological Survey of the Ontario Ministry of Northern Development and Mines at 1:50,000 scale, where available, and 1:1,000,000 scale for all other areas. Climate data from the Meteorological Service of Canada will be used to indicate the timing of precipitation events and temperature variations and may also be used to estimate the accumulation and dissipation of snow pack. Data will be compiled on a monthly time-scale.

For this portion of the study, a heavy reliance will be placed on results coming from a concurrent Climate Change Action Fund study to determine Groundwater and Climate Interaction in Southern Ontario headed by Andrew Piggott, Doug Brown and Brian Mills, of Environment Canada. (Piggott et al., 2000). For this study, stream flow data is directly linked to the distribution of sub-watersheds and will be divided into surface runoff and groundwater discharge components using methods of base flow separation implemented within a GIS and relational database management setting. Observation well data provide direct measurements of groundwater levels and variations within local and regional aquifers than, in turn, reflect changes in the volume of groundwater in storage. Water well construction records indicate patterns of water resource development and use, naturally occurring groundwater quantity and quality limitations, and the composition of unconsolidated sediments and bedrock, all on a spatial basis. These records will be partitioned by sub-watershed and by quaternary and bedrock geological units using GIS technologies. A relation between base flow index (BFI) and quaternary geology has been developed (Piggott et al., 1999) using principle component analysis allowing BFI to be applied to unguaged and/or flow regulated sub-watersheds. In this way, the methodology can be applied across the study region.

5.4 Water Use Estimations

The primary sources of data for estimating water is the municipal water use database (MUD) from Environment Canada. In addition, data will be extracted from the industrial water use survey from Environment Canada and agricultural census data from Statistics Canada and from the provincial Permit to Take Water database.

Municipal/Domestic Water Use:

This will be calculated using the MUD database and filling in the gaps using provincial wastewater discharge data and trend analysis. The MUD database quantifies the water actually used in each municipality. Data includes municipal population, populations served, average daily flows, water user classes, water source (groundwater or surface water or combined), and a field summarizing quantity or quality problems by year. (Lacelle, 1998). The MUD database will be linked to a municipal GIS coverage and water use estimations will be presented on both a municipal and sub-watershed basis. Estimations will be made when portions of a municipality boundary cross watershed boundaries. For municipalities not included in MUD, water consumption will be extrapolated based on the linear regression of normalized water consumption to population served and with information gathered from the provincial wastewater discharge database. Estimates will be presented across the study region by water use category and by groundwater and surface water.

Townships, reserves, small villages, and portions of towns and cities not serviced by municipal supplies will be assumed to draw their water from private groundwater wells. Water use for domestic private wells will be estimated by an average rate such as 159L/day/person used by Southam et.al., 1997.

Industrial Water Use: The primary source of data for the industrial water use is the industrial water use survey (Tate and Scharf, 1996). This database includes the number of industries by sector for each municipality and includes intake, and discharge and the source of the water (e.g. municipal source, self-service groundwater or self-service surface water). However, the survey does not include all industries. Total industries by sector for each municipality will be accessed through Statistics Canada. Water use data will then be extrapolated from the Industrial Water Use Survey data to the remaining industries to get estimates of industrial water use by census subdivision and by sub-watershed.

A secondary source of data for industrial water use will be the Permit to Take Water (PTTW) data, which will be used to enhance the estimates available through the industrial water use survey. The MOE requires water taking permits for withdrawals greater than 50,000L/day for water uses such as industrial, commercial, municipal, public, recreational, irrigation, and aquaculture. The permits provide the maximum allowed withdrawals and the source of water (groundwater or surface water). These permits only specify how much is permitted to be pumped and not how much is actually pumped. Nevertheless the permits provide valuable information on groundwater use that is not available elsewhere.

Agricultural Water Use: The primary source of data for agricultural water use will be the 1996 agricultural census data from Statistics Canada. Coefficients created by Ecologistics (1993) and adjusted by Kreutzwiser and deLoe (1996) will be applied to the 1996 Agricultural census data to estimate water use for all categories of livestock and crops. Agricultural water use will be calculated by census subdivision by sub-watershed. Data will be broken down according to withdrawals, and consumptive uses.

As a secondary source of data, the PTTW data will be used primarily to assign the breakdown between surface water and groundwater sources of agricultural water use.

Hydropower: Hydro-power is considered an in-stream use. The amount of power generated depends on head, flow, continuity and efficiency. Flow is the amount of water that falls through the turbines, which converts potential energy to electrical power. Therefore, the amount of water flowing directly impacts the amount of power generated. Data will be gathered from Ontario Power Generation (OPG).

Inter-Basin Diversions: Sources that come from one basin and are discharged to another, or sources that come from groundwater and are discharged to surface water alter the natural flow of water and have an impact of water availability on a sub-basin level. Information will be reported based on the data above on the amount of water affected by inter-basin diversions.

5.6 Future Demand:

Ideally, estimates on future demand will be calculated based on municipal development plans, past trends in development, potential changes as a result of climate change (e.g. changes to crop types). Existing demand projection models will be assessed and a suitable methodology selected based on available information time and resources. Future demand calculations will be used in conjunction with climate change scenarios in an attempt to determine the sensitivity of the existing water supply to population growth and climate change.

5.6 Characterization of Ecosystem Requirements

Based on the information gathered in this study and through data and literature on minimum ecological requirements for sustaining adequate water quantity and quality for natural aquatic and biotic ecosystems, a characterization of the existing minimum ecosystem requirements will be made. This will be based on a set of indicators and will help to identify natural constraints on water supply that will be evaluated as a sensitivity analysis.

5.7 Climate Change Scenarios:

Climate change can not only effect the source and abundance of water supply, but also the demand for water. Climate change scenarios are a method of testing sensitivities, vulnerabilities and opportunities with respect to the issue of climate change. Using the outputs of a range of climate scenarios provides an indication of sensitivities of a particular region or economic sector to climate. These scenarios are not precise forecasts of the future, but provide a range of possible futures. Results from two climate change models will be used. The Canadian Centre for Climate Modelling and Analysis (CCma) and the Hadley Centre Coupled Model (HadCM2). Scenarios will be generated for possible futures (e.g. 2020, 2050, 2090). The output of these models with respect to precipitation and temperature will be input to the groundwater supply model to give estimates of future water supply. These scenarios will also be run with various future demand scenarios. Results should provide a good indication of areas sensitive or vulnerable to climate change.

6. Schedule:

Year 1:	(Nov 1/00 - Oct. 31/01)	Data acquisition and theme assembly
Year 2-3:	(Nov 1/01 - Mar. 31/04)	Basin-focused studies
Year 3-4½:	(Apr. 1/04- Mar. 31/05)	Climate change scenarios and final report

7. Deliverables:

- Estimations of the existing water supply (source and abundance) by sub-basin and on a monthly scale.
- Current water use and projected demand for select watersheds in the agricultural, public supply, industrial/commercial/institutional and hydroelectric power generation sectors.
- Projections of monthly water supply and water use on a sub-basin level considering future demand and climate change.
- Ecological sensitivities and limiting factors of water supply to climate change will be identified on a sub-basin level.

References

Ecologistics Limited, 1993. *A Review of Water Use and Water Use Efficiency in Ontario Agriculture - Final Report.* Water Efficiency Ontario, Agricultural Working Group, Ontario Ministry of Agriculture and Food, Guelph, Ontario. 82 pp.

Kreutzwiser, R. and Rob de Loe. 1999. *Agricultural and Rural Water Use in Ontario: A report to the Agricultural Adaptation Council under the National Soil and Water Conservation Program.* Rural Water Management Group. Guelph, Ontario: Department of Geography

Lacelle, D., 1998. *1996 Municipal (Water) Use Database (MUD).* Environment Canada.

Piggott, Andrew, Chuck Southam, Syed Moin, and Doug Brown, 1999. *Determining Base Flow Indicators in West-Central Ontario* (unpublished manuscript)

Piggott, Andrew, Doug Brown and Brian Mills, 1999. *Groundwater and Climate Interaction in Southern Ontario*. A Proposal Submitted to the Climate Change Action Fund.

Southam, C.F., Mills, B.N., Moulton, R.J., and Brown, D.W., 1997. *Adapting to the impacts of climate change and variability in the Grand River basin: Surface water supply and demand issues.* Environment Canada, Great Lakes - St. Lawrence Basin Project on Adapting to the Impacts of Climate Change and Variability, Burlington, Ontario.

Tate Donald M. and David N. Scharf, 1992. *Water Use in Canadian Industry, 1991.* Social Science Series No. 24

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