earth-water Concepts inc.

groundwater research, surveys, modeling, remediation
water resource development, protection, management

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Company profile and Statement of qualifications

table of contents . . .

your experienced partners in water resources . . .

earth-water Concepts inc. is a science-based company dedicated to the task of protecting the quality of our rivers, lakes, streams, and aquifers. **earth-water Concepts inc.** is a small water resources consulting firm that specializes in surface and subsurface hydrologic systems analysis; independent research for the environmental protection and development of sustainable water supplies for private, commercial and government clients.

Water is one of the earth's most precious resources and around the world, municipalities, industrial users, and individuals are becoming aware of the increased demand on existing water sources and the difficulty of obtaining new supply. Industrial and domestic growth, additional demand for water, and protecting nature often face competing interests and physical limits that must be taken into account by developers and regulators.

The service we provide is to work with our clients so they can understand these constraints on water resources while we help find new sources and ways to protect the quality and quantity of new and existing supply. We help engineers and others achieve maximum results for their clients, and we contract our expertise directly to the private and public sectors.

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Who we are . . . . . .

earth-water Concepts inc. is a Canadian company that operates from Halifax, Nova Scotia. We offer our services to all of Atlantic Canada and beyond, and have completed projects in Prince Edward Island, New Brunswick, Labrador, Ontario, Alberta, and the Northwest Territories.

Our service is science-based; analysis for planning, design, construction and management that can help enhance your project and avoid undesirable impact. We use our experience to examine and develop innovative and alternative water resource management approaches that meet your specific needs.

Our philosophy is to focus on close partnerships with clients to obtain a clear understanding of their objectives, and to utilize a pro-active project management approach and our knowledge and expertise to achieve those objectives, while protecting public health in balance with the environment.

While larger companies often segregate activities by department and seniority, earth-water Concepts inc. is a small specialist firm that involves the same senior professional at every stage of each project from design to background research, site work and data collection, to analysis, reporting and client liaison. In other words, the Principals proposing the work are the ones doing the work. The result is higher quality scientific output and a more productive partnership with the client. Thus, our clients can be assured that they will receive the level of expertise and caliber of work they expect when hiring a professional service.

Since the early 1990s, earth-water Concepts inc. has been applying geology, hydrology, hydrogeology, and other natural sciences to help

industry, land developers, and government prepare or update their water resource management plans and implement special studies and improvement projects. We use our experience as scientists to pinpoint the key issues important to our clients and deliver practical, cost-effective solutions, striving in the process to make their job easier and add value to their businesses.

Expertise . . . . . .

Relevant analysis of surface and subsurface hydrologic systems requires a firm appreciation of the integrated client-project, natural, and regulatory elements. Achieving this demands having a clear grasp of the project and quality assurance requirements for collecting field data; expertise to understand the statistical properties of the data that describe the quality, flow and quantity of the water resource at the scale of interest; and the ability to communicate those characteristics so clients can make sound, well informed decisions. But extraordinary client service goes beyond training and expertise. We're flexible and work with the client to provide real, practical solutions.

Range of services . . . . . .

Our general areas of expertise and range of services offered include:

- source of supply investigations, development, water resource planning,
- well field siting, design, optimization and permitting and protection,
- demand, supply and capability analysis, drought planning
- geothermal heat source and potable water source interaction assessments
- surface, groundwater hydrology
- groundwater exploration
- watershed, groundwater modeling
- general geology, hydrogeology,
- water quality monitoring, geochemistry.

service and expertise . . .

Our staff . . . . . .

Our goal is to bring modern skills and new tools to our clients. Our staff includes one of Nova Scotia's leading hydrogeologists, and over 700 assignments have given us the type of expertise and insight needed to resolve many facets of your water resource development and management needs. Since its inception, earth-water Concepts inc. has established a reputation for completing assignments cost-effectively and on-time, while exceeding high client and scientific standards for quality control. Plus our clients benefit from the experience and hands-on involvement of the Company's senior staff.

earth-water Concepts inc. delivers credible, objective, and accurate technical analysis. Our success in solving problems is based on creativity, technical skill and the ability to listen to our clients.

Some of our clients . . . . . .

Regulatory agencies
Public Works Canada
Parks Canada
NS Dept of Natural Resources
Supply and Services NS
NS Dept of Transport

Municipalities
Municipality of the District of Chester
Municipality of Pictou County
Town of Mahone Bay
Mun. of the District of Annapolis

Investor owned water utilities
Canadian Springs Water Ltd.
Spa Springs Water Co. Ltd.

Engineering contractors
Beasy Nicoll Engineering
KVM Engineering Consulting Ltd.
CBCL
Strait Engineering Ltd.
Acres International

Industrial, institutional, legal
Frito-Lay Canada Ltd.
Patterson Law
Reardon Constr. & Dev. Ltd.
Keltic Petrochemicals Inc.
Zurich Canada
McInnes Cooper & Robertson Law
The Co-Operators Insurance Co.
Halifax Insurance Co.
General Accident Assurance Co.

Isaacs Harbour River watershed and water supply study

Keltic Petrochemicals Inc. • September 2000 – February 2010

earth-water Concepts inc. was hired to conduct a regional study on Nova Scotia's Eastern Shore for a 76,800 m^3/d water supply for a petrochemical plant, LNG receiving terminal, and 200 MW power plant. The study involved four watersheds of 900, 7745, 8340 and 32460 ha. Each discharges via well-formed drainage systems into the Atlantic Ocean. The larger watershed flows to the east and is underlain by well-drained soil and permeable sandstone. The others watersheds are located topographically below the larger one, all drain to the south, and all have thin glacial tills over impermeable meta-sediments. These form the basement bedrock complex beneath the larger watershed, and faults in the meta-sediments, along which there have been many kilometers of lateral displacement, are believed to extend also under the larger watershed.

The 7745 ha. Isaacs Harbour River watershed and the 900 ha. Goldbrook sub-watershed were chosen as primary and backup water source candidates based on their proximity to the plant site. **earth-water Concepts inc.** performed a comprehensive investigation that:

- included installation of rain gauges at coastal and inland locations where there was no precipitation data, large-scale GIS precipitation modeling, and installation of four stream gauges to record continuous stream flows,
- characterized water balances and capacity for the subject watersheds, defined reservoir requirements and criteria for dam design and water taking,
- quantified river discharge surplus that resulted from groundwater sub-flow from the northern watershed via the regional basement complex fault system,
- formed the basis for doing range of variability determinations for ecological stream flow maintenance and for withdrawal permitting.

Chester water supply options

Municipality of the District of Chester • August 2007 – ongoing

The village of Chester, Nova Scotia, is a coastal community of about 2,000 people that has a central sewage collection and treatment system, but where individual water wells service residents and businesses. Many of these water supplies consist of shallow dug wells that have a history of going dry during the summer months. Due to changes in groundwater recharge possible because of climate change, and to the possibility of groundwater draining through the materials used to fill the sewer-line trenches, there is concern that the number, severity and duration of wells going dry could increase.

Groundwater work done by earth-water Concepts inc. earlier in the area suggested that wells drilled into the local meta-sedimentary bedrock could meet water demand, but that high iron concentrations in groundwater are likely to require costly treatment. However, a nearby lake in a relatively pristine watershed could also serve as a water source. **earth-water Concepts inc.** was hired to perform a study that:

- monitors groundwater levels in a number of selected drilled and dug wells situated within the village,
- defines the effects that the sewer collection-system trenches may have on groundwater through 3-D mapping and groundwater level modeling,
- characterizes the nearby watershed capacity and water quality through a comprehensive water sampling program and installation of lake level and stream gauging stations,
- systematically evaluates the groundwater and surface water supply characteristics and options for the Village of Chester.

sample projects . . .

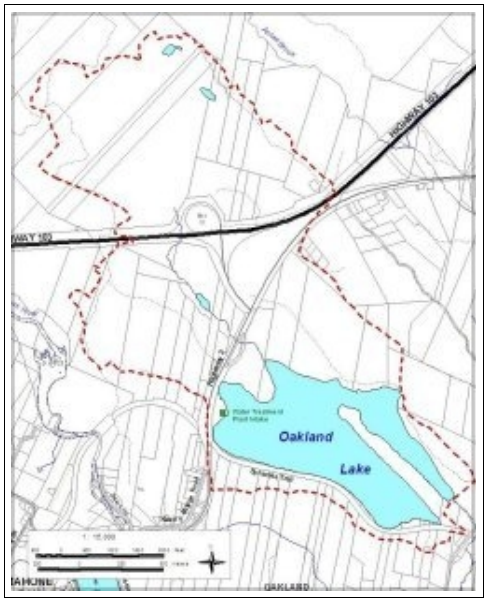
Town of Mahone Bay water supply

Town of Mahone Bay • July 2006 – June 2008

The Town of Mahone Bay, located on Nova Scotia's south shore, has been using Oakland Lake as water supply for many generations without difficulties. The Town is now completing a source water protection plan, and in the process of registering the source with the province to ensure its protection, the Town was asked to apply for a withdrawal approval for the surface water supply.

Water taking is metered at the lake and after treatment, but very few nearby watersheds are gauged, and there is no data on natural flows in the Oakland Lake watershed. The Town of Mahone Bay hired earth-water Concepts inc. to help obtain the permit, requiring comprehensive investigations that:

- collected precipitation, stream flow, lake storage, and water taking data to obtain water balances for the local watershed, and to simulate long-term source flows using data from a nearby gauged watershed,
- evaluated local watershed yield under current and projected future conditions,
- mapped lake bathymetry and defined lake water residence times,
- evaluated land use and risks of contamination in upper parts of the watershed and at the lake,
- evaluated the adequacy of lake storage and reservoir requirements for present and future use,
- systematically evaluated water supply options and long-term operating requirements.



Private hydro project

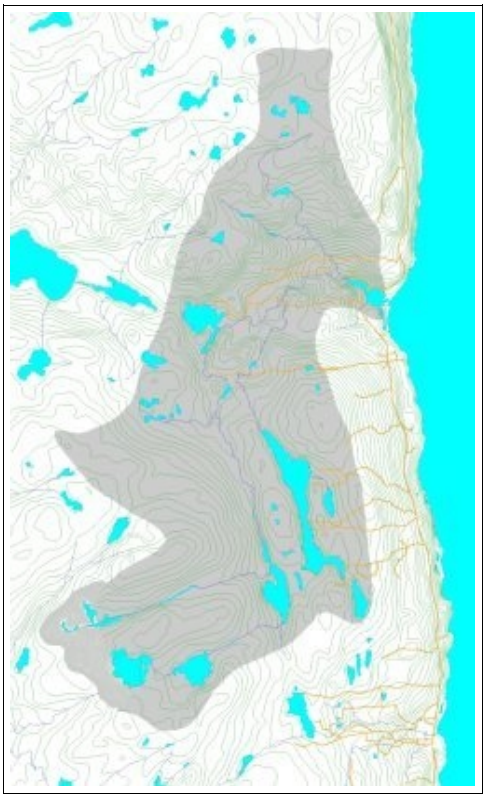
Confidential client • September 2006 – March 2008

earth-water Concepts inc. was hired to conduct a regional surface water investigation in north-eastern Nova Scotia to assess and develop local water resources in support of a proposed hydro-electric project.

The small power generation project was intended to produce power for sale onto the main grid, while also being used to carry out research on new water turbine technologies.

There were no gauged watersheds nearby, so desk-top studies were done initially to assess general watershed characteristics, then stream gauges were installed at key locations within selected local watersheds to evaluate:

- total annual availability of water in the gauged watersheds,
- seasonal and longer-term variability of supply and flows,
- reservoir storage requirements to help reduce seasonal variability in flows so water resources could be better used for power generation,
- terrain and slope analysis to identify the best locations for water taking and transfer to meet power generating needs,
- water taking and reservoir management criteria for small scale power generation purposes, and
- water taking schedules needed to maintain ecological systems at the reservoir, at the water taking location, and downstream of the power generating/testing facility.



Shubenacadie private well water supplies

Confidential clients • June 2007 – April 2008

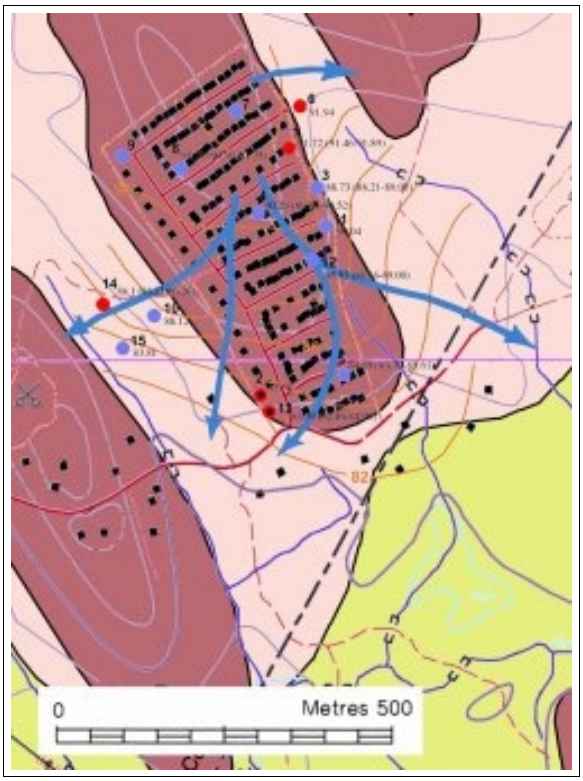
The Municipality of the District of East Hants is developing a groundwater supply in a shallow, confined, unconsolidated Cretaceous sand and gravel channel and delta aquifer complex to replace the surface source that currently serves the village of Shubenacadie, in Nova Scoia. Aquifer recharge, which is thought to be occurring a long distance from the proposed well field, is poorly understood, and additional groundwater withdrawals by the municipality will be significant. This has a number of local dairy farm owners concerned that limited aquifer resources, which in Nova Scotia are allocated generally on a first come first serve basis, may not be correctly appropriated to ensure continued water supply to meet their existing and future water needs.

To ensure the recognition and a fair allocation of the water resources that are already in use, local farm owners hired earth-water Concepts inc. to obtain groundwater withdrawal permits for a number of existing well water supply sources. This required a number of pumping tests and studies to assess and document:

- overall local aquifer capabilities and short and long-term capacities for existing individual wells,
- current and future groundwater farm supply requirements,
- mutual influences and interference that pumping at any of the farm wells may have on others nearby,
- production sustainability relative to the current understanding of aquifer recharge,
- fair allocation of water resources and prescription of appropriate pumping rates for permit applications.

Valley Gate well water Supply

Valley Gate Mobile Home Park Ltd. • April 2004 – January 2010



The Valley Gate Mobile Home Park, located within metamorphosed greywacke and slates of the Cambrian-Ordovician age Meguma Group in central Nova Scotia, services about 200 homes from a private groundwater source.

earth-water Concepts inc. was hired by property management in response to requests by the province for the mobile home park to obtain a groundwater withdrawal approval.

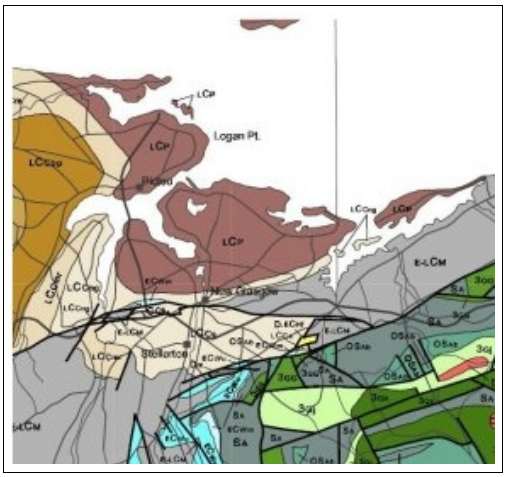
A detailed study was carried out that included water quality reviews, pumping tests on existing wells, and reviews of historic and current water demands to evaluate the ability of the original water supply system to sustain both existing and long-term growth at the park. It was found that the existing supply could not sustainably meet either the existing or projected long-term demand, and water quality from the existing system was less than adequate. So a groundwater exploration program was launched that involved extensive geological field mapping, followed by successful drilling for new supply, pumping tests, client training in the management of the new water supply, and documentation for permitting of a supply that was able to meet the site's long-term demand and water quality needs. Staff personnel were trained in the management, operation and protection of the new, 15 well field water supply.

sample projects . . .

Pictou County Community water supply

Municipality of the County of Pictou • May 2002 – September 2004

The Municipality of Pictou County hired earth-water Concepts inc. to conduct a regional groundwater study involving several watersheds on the northern mainland of Nova Scotia. The aim to of the study was to investigate the capacity of Carboniferous sandstone and conglomerate deposits within the Cumberland and Mabou Groups to meet some of the municipal and commercial water supply needs in the east and west New Glasgow areas. The study was also designed to evaluate the potential for various land uses to affect water quality, to quantify those risks, and undertake preliminary exploration and pumping test work to verify the results of the assessment. **earth-water Concepts inc**. carried out a comprehensive investigation that:

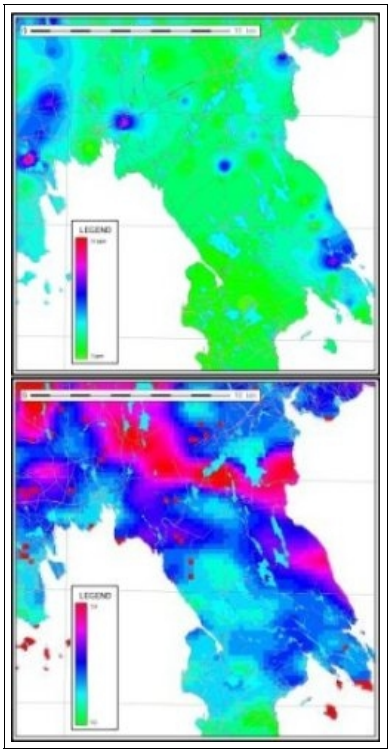


- characterized municipal and commercial water demands to reflect increased development as new water would become available,
- defined water availability via watershed/groundwater recharge,
- evaluated each of several geologic units for their potential to serve as possible commercial aquifers,
- evaluated yields for candidate aquifers under current/future uses,
- described the local and regional effects of groundwater withdrawal,
- identified and inventoried known and possible contamination sources and evaluated their risks to various candidate aquifers,
- defined optimum aquifer protection prospects and drilling targets,
- involved the local community with greatest potential for groundwater exploration for early inclusion in water resource protection planning,
- defined the physical, hydrologic and hydrochemical characteristics of selected aquifers through detailed drilling and pump testing programs.

Mill Cove Groundwater Supply

Municipality of the District of Chester • April 2004 – ongoing

The Municipality of the District of Chester hired earth-water Concepts inc. to conduct a groundwater study of the Aspotogan Peninsula, Nova Scotia. The purpose of the study was to assess an existing water supply well and to evaluate options to improve upon it to meet new quality standards, to investigate the local groundwater resource potential to replace or augment the existing supply, to do preliminary groundwater exploration to confirm assessment results, and evaluate the ability of a new potential supply to sustain future growth at Mill Cove.



The peninsula has a thin soil veneer that is underlain by granite. Residential well yields average less than 2 US gpm. Mill Cove, a former military base now being considered for residential development, obtained water from a nearby lake that, due to high treatment costs, was replaced with groundwater from a single, high-production well that had been located by luck based solely on proximity to the water facility. **earth-water Concepts inc.** performed a groundwater investigation that included:

- reviews of all available water quality results from the former base water supply sources and from a number of nearby residential wells,
- a review of all available regional residential well production data,
- terrain and lineament analysis from air photos, digital elevation models, and multiple shaded relief surfaces,
- review and assimilation of all available stream & soil geochemistry data, and relevant airborne geophysical surveys, with well data,
- drilling and pumping test evaluations on a number of exploration wells that were constructed to successfully exceed the existing supply well production capability.

Pictou Landing water supply protection

Public Works Canada, Indian Affairs • March 1992 – April 1993

Pictou Landing is a Mi'kmaq First Nation Community of approximately 400 people located adjacent to the Boat Harbour tidal estuary on Nova Scotia's north shore. Several years ago, a dam was built across the estuary's outlet to create a stabilization lagoon for the treatment of effluent from a nearby paper mill. This created a significant number of environmental issues both on-land and with the well water supply at Pictou Landing.

As part of the site planning and community compensation process following the decision to decommission the lagoon, the Federal Department of Indian Affairs hired earth-water Concepts inc. staff to assess the level of impact that the lagoon may have had on land and groundwater at Pictou Landing, and the effects that returning saltwater to the estuary after decommissioning the lagoon might have on the community's well water supply. A comprehensive investigation was carried out that included:

- detailed soil geochemical surveys of the community and along the north shore of the lagoon,
- quality testing of the well water supply over an extended period of time,
- laboratory testing of soil and water samples for numerous inorganic and organic parameters, with analysis down to part per quadrillion levels,
- pumping tests of the community wells to characterize the local aquifer,
- determination of solute migration times though the aquifer both from the lagoon to the south, and from the ocean to the north,
- design of groundwater monitoring system using nested monitoring wells to further characterize the local physical and chemical hydrogeology,
- design of an expanded water supply to reduce point-drawdown stresses at existing wells and to serve as backup supply wells in case of lagoon water or sea water breakthrough.

Debert Industrial Park water supply protection

NS Dept. of Supply and Services • November 1994 – March 1995

The Debert Air Industrial Park is located on the former lands of Canadian Forces Station Camp Debert in central Nova Scotia. The industrial park obtains its water from a number of open bedrock wells drilled into the semi-confined to unconfined Triassic age Wolfville Formation. Individual wells at the industrial park have long-term yields that reported to range from 100 US gpm to over 1,000 US gpm.

While twinning the section of the Trans-Canada highway that passes immediately to the south of the Debert industrial park, a large volume of grubbing materials were buried in one of the construction borrow pits, causing a drop in the local and adjacent subsurface redox conditions and, as a result, causing the quality of the water from one of the park's major production wells to become degraded.

The Nova Scotia Department of Public Works and Supply and Services hired earth-water Concepts inc. staff to investigate the possible cause and nature of the water quality decline, to assess whether other wells in the industrial park might also become affected, and to recommend best locations for new wells to replace the one that had become affected..

The investigation included an intensive search of old military water system maintenance records; hydrogeologic mapping to identify possible locations for new water supply wells; computer groundwater modeling; and delineation of solute flow paths for 0.25, 0.5, 1, 2, 3, 6 and 10 year time-of- travel capture zones. This was done for the affected well to confirm the cause of the water quality problem experienced, for all other existing wells, and for several possible drilling locations for a replacement well – done as a means of defining the best places within the industrial park to drill for replacement water supply.

Canadian Springs water supply upgrade

Canadian Springs Water Ltd. • April 1995 – ongoing

The Sparkling Spring Water Ltd. bottling company, which is now operating under the name Canadian Springs Water, hired earth-water Concepts inc. staff to upgrade their well water supply. Their Atlantic Canadian bottling plant is located at Valley, central Nova Scotia. Water production at the plant site is from the Triassic age Wolfville Formation sandstone, from which commercial wells are able to produce between 50 US gpm and 200 US gpm.

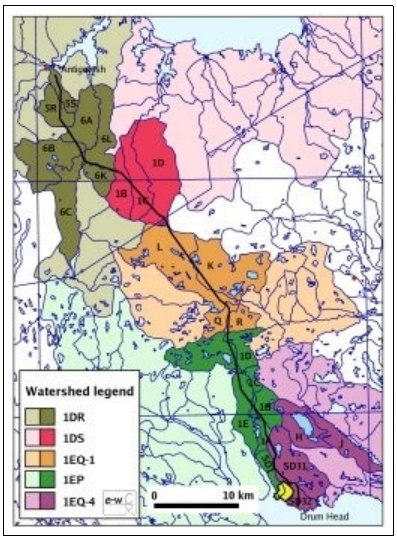
Sparkling Spring Water was growing its market and needed to increase both the amount of supply for the plant, and the level of supply protection. **earth-water Concepts inc.** performed a comprehensive groundwater investigation that included:

- hydrogeologic mapping to select the best locations within client-owned lands at which to drill additional supply wells,
- field surveys to inventory possible contamination sources within the likely zones of influence for the proposed new wells,
- aquifer vulnerability determinations using DRASTIC,
- preliminary groundwater modeling to determine solute migration paths and times of travel as a means of confirming well locations and assessing the viability of protecting any of the proposed new water supply wells,
- drilling for new water supply, pumping tests, hydrogeological analysis, follow-up groundwater modeling to reflect conditions at the new wells,
- delineating solute migration paths and defining 1, 2, 5 and 10 year time-of-travel capture zones for the newly drilled and existing water supply wells,
- defining best management practices for the new and existing water sources and for the surrounding land use.

Keltic Petrochemicals Inc. environmental assessment

Keltic Petrochemicals Inc. • September 2000 – January 2008

Keltic Petrochemicals Inc. hired earth-water Concepts inc. as part of a science team to conduct the surface hydrology, geology and hydrogeology components of environmental impact assessments for a proposed petrochemical plant, a co-generation electrical power plant, and an LNG receiving terminal located at the community of Goldboro, plus 58 km of new 100-series-type highway proposed to extend from the petrochemical plant site across Nova Scotia to the Trans-Canada highway near the Town of Antigonish.



The plant site is at a former gold mine, with extensive underground and surface workings and complex bedrock geology. The proposed highway route traversed the entire geologic cross-section of Nova Scotia and included 38 stream crossings in 21 separate watersheds. Working with team terrestrial biologists, earth-water Concepts inc. undertook a comprehensive investigation that included:

- in-depth reviews of old mine reports to locate former mine workings and tailings deposits,
- mapping of the site geology, extensive collection of soil, stream water and sediment samples to assess past mining legacies and create a new baseline,
- installation and hydraulic testing of several piezometre nests on and off site,
- a detailed residential well survey and well water quality sampling at all wells located near the proposed plant site,
- assessment of potential surface water-groundwater interactions and affects to ecosystems resulting from proposed land form and land use changes,
- assessment of groundwater related to global climate change and long-term viability of the proposed industrial site shorelines from possible tsunami,
- survey of hundreds of residential water wells within 1 km of the proposed highway, assessment of acid generating rock along the proposed highway,
- physical hydrologic assessment of all proposed stream-road crossings.