HYDROGEOLOGICAL ASSESSMENT OF COLD BROOK, NEWFOUNDLAND AND LABRADOR

Submitted to:

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EXECUTIVE SUMMARY

AMEC Earth and Environmental, a Division of AMEC Americas Limited (AMEC), was retained by the Town of Stephenville to conduct and report on a desktop study relating to a hydrogeological assessment of Cold Brook, Newfoundland and Labrador. This report has been prepared as a desktop study and, as directed by the town of Stephenville, it follows the general outline of the Regional Municipality of Waterloo Guidelines for Hydrogeological Studies for Privately Serviced Developments (issued May 1991).

The objective of this study is to determine what impact, if any; new private developments in Cold Brook will have on the Town of Stephenville water supply. Recommendations on the limits of private development, if any, are a requirement of this study.

This report is a Stage 2 “desk top study” as defined by the Regional Municipality of Waterloo Guidelines for Hydrogeological Studies for Privately Serviced Developments (issued May 1991). The guidelines are provided in Appendix B. Any field work stated in these guidelines was not completed due to the limited timeline to final report completion. The purpose of the Regional Municipality of Waterloo Guidelines is “to define the minimum information requirements for the preparation of hydrogeological reports in support of developments on private services.”

The information was used to help establish:

- That an adequate and safe supply of potable water is available for future development;
- That the soil conditions in the area are suitable for on site sewage disposal, and;
- That the water wells and on site sewage disposal will not impair use of the groundwater resources in Cold Brook and the water supply of Stephenville.

Based on the findings of the desktop study relating to a hydrogeological assessment of Cold Brook, Newfoundland and Labrador, the following conclusions have been made:

- It is reasonable to assume that the large majority of housing developments in Cold Brook are obtaining their potable water from the overburden aquifer, as are the main production wells for the Town of Stephenville.
- If all of the water that is being recharged over the Cold Brook watershed was captured by water wells developed in the surficial aquifer there would be enough water to service approximately 167 homes, assuming four people per house and 400 litres per person per day.
- The primary impact of the existing and proposed residential developments in the Cold Brook area will be the impact of septic tank drainage on local groundwater quality in the community.
- AMEC was unable to obtain site specific percolation rate data from the Government Service Centre.
- Most of the water supply to the Stephenville well field is from the regional groundwater system of Blanche Brook, and only a small portion from the Cold Brook drainage system.

Also, there is considerable separation distance from the community of Cold Brook and the Stephenville well field, combined with observed silt and clay horizons above the well intakes. Therefore, it is unlikely that development in the community of Cold Brook will affect the quality and quantity of water within the Stephenville well field.

Based on the findings of the desktop study relating to the hydrogeological assessment Cold Brook, Newfoundland and Labrador, AMEC recommends the following further actions for the Site:

- A field hydrogeological investigation should be considered to verify the sustainability of groundwater supply under future land use scenarios.
- In order to measure percolation rates and to verify stratigraphy within the community of Cold Brook, a drilling program should be considered.
- A water quality investigation should be conducted within the community of Cold Brook, in order to determine the potential for impacts on local potable groundwater from septic tank drainage.

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1.0 INTRODUCTION

AMEC Earth and Environmental, a Division of AMEC Americas Limited (AMEC), was retained by the Town of Stephenville to conduct and report on a desktop study relating to a hydrogeological assessment Cold Brook, Newfoundland and Labrador. Maps of the study area are shown in Figures 1.1 and 1.2. This report has been prepared as a desktop study and, as directed by the town of Stephenville, it follows the general outline of the Regional Municipality of Waterloo Guidelines for Hydrogeological Studies for Privately Serviced Developments (issued May 1991).

1.1 OBJECTIVE

The objective of this study is to determine what impact, if any new, private developments in Cold Brook will have on the Town of Stephenville water supply. Recommendations on the limits of private development, if any, are a requirement of this study.

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The information was used to help establish:

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- That the water wells and on site sewage disposal will not impair use of the groundwater resources in Cold Brook and the water supply of Stephenville.

The Regional Municipality of Waterloo Guidelines for hydrogeological studies states that the “information will be provided in two stages. Stage 1 will provide preliminary information on the suitability of the site for development on private services. Details of the requirements for Stage 1 are included in the section entitled ‘Stage 1 – Preliminary Environmental Evaluation’. The Stage 1 assessment should indicate whether or not the site will likely be suitable for the proposed development and, if positive, will recommend proceeding to Stage 2, the detailed hydrogeological investigation of the Site.” AMEC has been requested to provide a desk-top Stage 2 detailed hydrogeological study. For the purposes of this study, AMEC assumes that the approval of the Stage 1 study has been met. Note that this type of hydrogeological assessment is not suitable for single-family units but is designed for multiple housing developments or subdivisions.

1.2 SCOPE OF STUDY

Based on a review of the Request for Proposal (RFP) and in consultation with the Government of Newfoundland and Labrador, Department of Environment and Conservation, Water Resources Division (the Department), the scope of work developed for the Hydrogeological Assessment of Cold Brook study included the following activities:

- Identifying aquifers and aquitards within the study area including depth, thickness, extent, continuity, and hydraulic conductivity;
- Demonstrating that the impact of contaminant loading due to septic systems is acceptable. The evaluation took into consideration the hydrogeological conditions of the site and groundwater resource evaluation; and integrating these with septic effluent disposal issues.
- Conducting a water balance appraisal including approximate annual precipitation, infiltration rate, recharge from leaching beds, water consumption and groundwater flux.
- Assessing possible contaminant contributions of groundwater to wells and the effect on groundwater quality; with emphasis on the impact, if any, on the integrity of the Stephenville water supply due to future development in Cold Brook.

This study is based on a review of reports and documents that are listed in Section 10.0 of this report. AMEC did not conduct a site visit for this study but relied entirely on available information in the literature.

1.2.1 Sources of Data

The prime source of hydrogeological data for the study area is contained in "Water Well Data for Newfoundland and Labrador 1950-2001". This is an extensive database containing information on 17,000 drilled wells in the province, pump tests, and some material on previous well simulations provided by the Groundwater Section of the Water Resources Management Division. However, regulations regarding the submission of detailed data by drilling contractors did not exist until 1983; therefore these data are commonly incomplete. Available data since 2001 were obtained from open file records at the Department.

A number of geological, environmental and geotechnical studies have been conducted by consulting engineers for government and private agencies. These reports provided background information on bedrock geology, surficial geology, hydrogeology, physiography, hydrology, water quality, and spring usage throughout the study area.

Climate normals or averages were used to summarize the average climatic conditions of the study area. They were obtained from the National Climate Data and Information Archive website (http://climate.weatheroffice.ec.gc.ca, 2008) operated and maintained by Environment Canada. At the completion of each decade, Environment Canada updates its climate normals for as many locations and as many climate characteristics as possible. The climate normals used in this study are based on climate stations with at least 15 years of data between 1971 and 2000.

Streamflow records were obtained from the National Water Data Archive provided by Environment Canada, Water Survey Branch. The data from existing gauging stations in the study area were used to assist in interpreting the groundwater contribution to stream flow and the annual rate of groundwater recharge from precipitation.

All referenced reports and other sources of data used in this study are documented in the List of References in Section 10.0 of this report.

1.3 SITE DESCRIPTION

The community of Cold Brook study area, as shown in Figure 1.1, is situated north of the town of Stephenville. The study area is situated within Zone 4 of the Town of Stephenville's designated wellhead protection area (WPA), as shown on Figure 1.2. Cold Brook is in the planning area but not within the municipal boundary of Stephenville.

The WPA of the Stephenville well field has been designed to include four protection zones; an inner Zone 1, and outer Zones 2, 3 and 4. The community of Cold Brook is situated within Zone 4 of the Town of Stephenville's WPA. Zone 4 has been designated to protect the headwater areas of Blanche Brook and lower reaches of the Cold Brook watershed areas, which are important areas for groundwater recharge for the Stephenville well field. The outer eastern boundary of this zone coincides with the main water divide of the Blanche Brook/Cold Brook drainage system, as shown in Figures 1.2 and 1.3, and includes the lower portion of the Cold Brook watershed west of Cold Brook. Zone 4 can sustain a limited forest harvesting operation provided that it does not involve the application of pesticides or other chemicals.

Based on the Town of Stephenville's Municipal Plan Review (March 13, 2001), property to the north, east and west of the study area is zoned as resource management. A small area to the south of Cold Brook is zoned as Residential Rural. The old Stephenville landfill is located approximately 3.5 km southwest and down gradient of the Site. The wellheads for the Stephenville potable groundwater supply system are located approximately 2.5 km southwest of the Site, as shown on Figure 1.2.

The Cold Brook community is situated within the Cold Brook watershed, whose eastern boundary is located just to the west, as shown on Figure 1.3. Cold Brook joins an unnamed tributary approximately 2.5 km downstream of the Cold Brook community and 0.3 km above Blanche Brook. At the confluence with this small tributary, the Cold Brook watershed is approximately 31 km^2.

Figure 1.1: Study Area Location

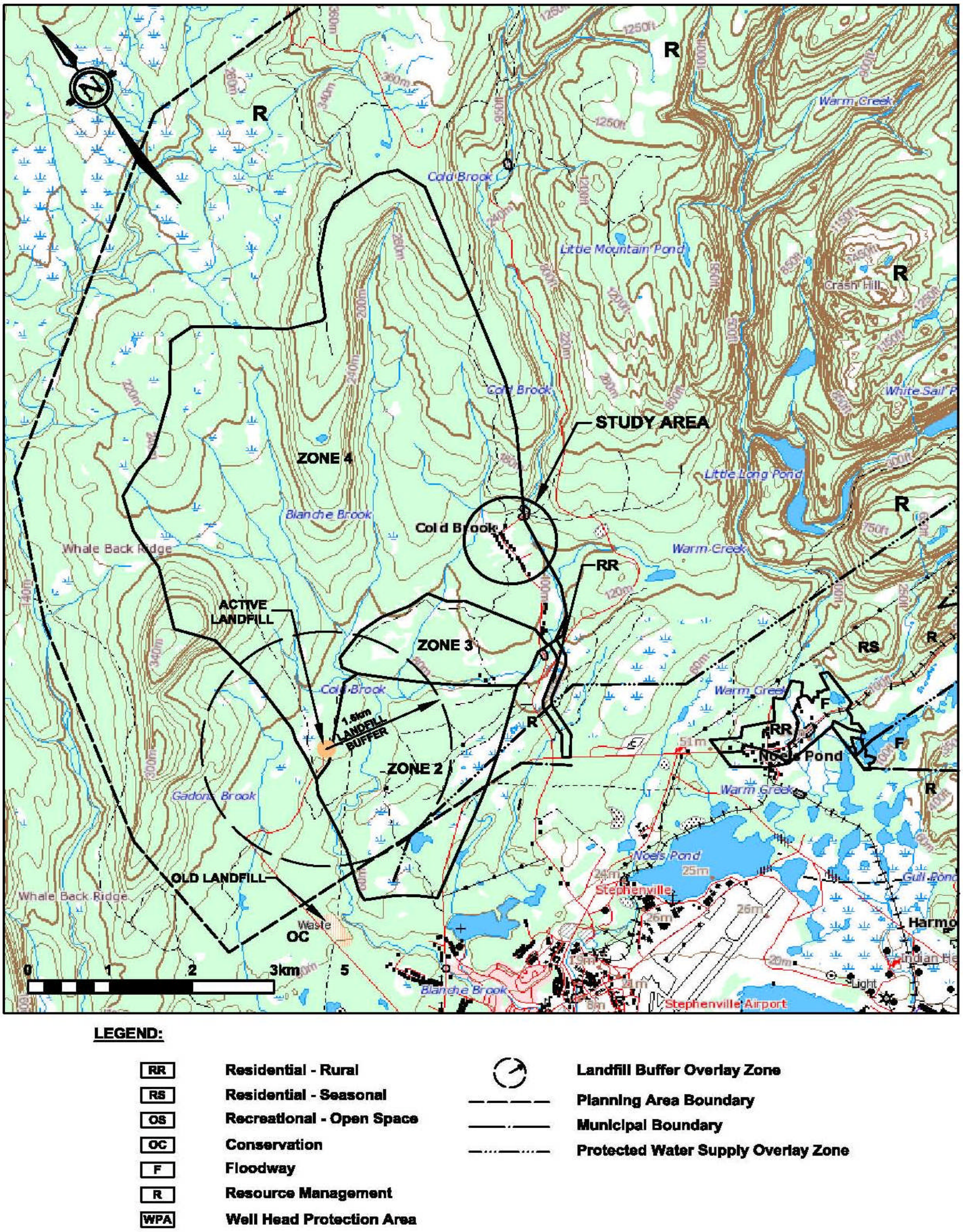


Figure 1.2: Study Area and Land Use Designation

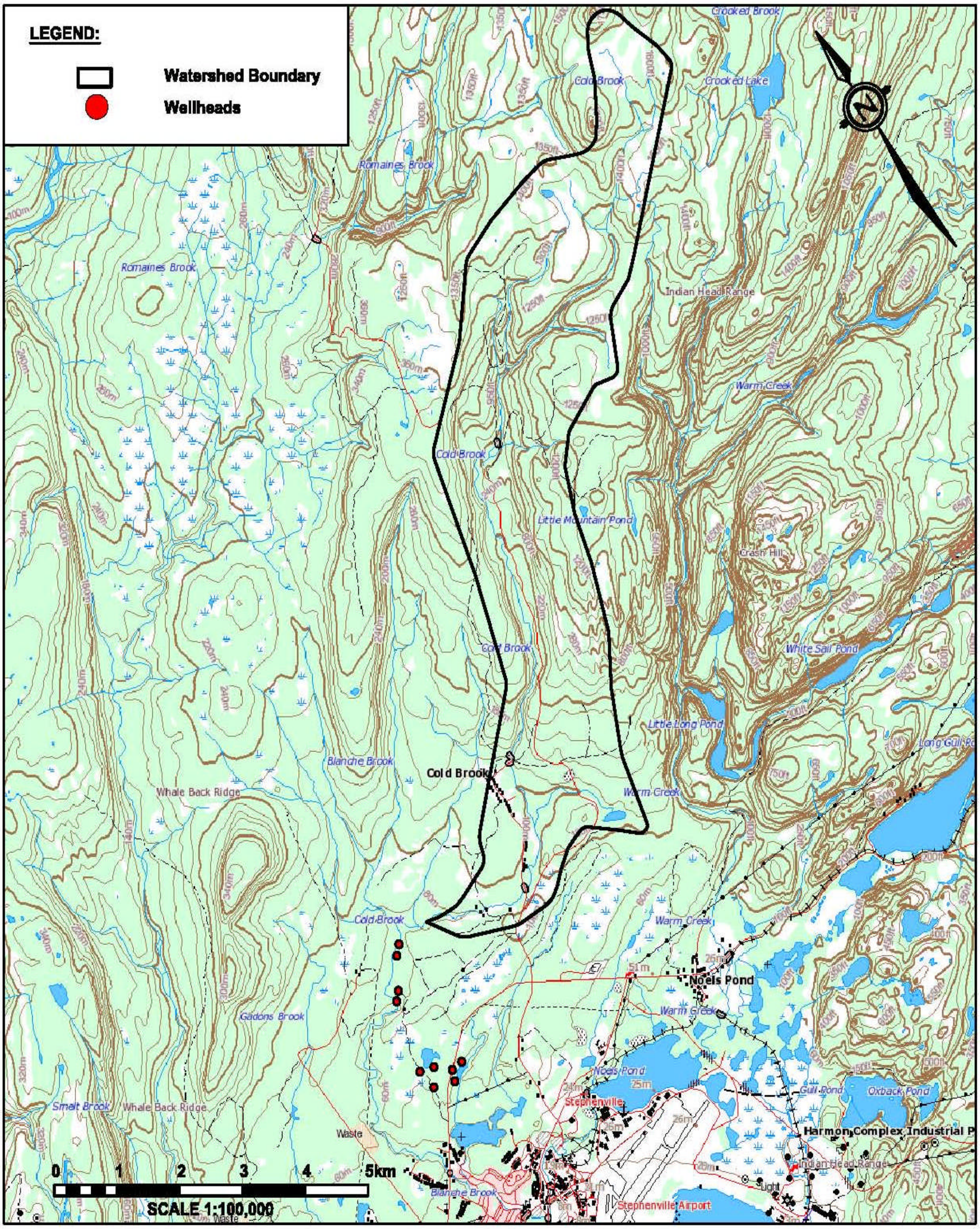


Figure 1.3: Cold Brook Watershed Boundary and Location of Stephenville Municipal Wells

1.4 CLIMATE

Data on climatic normals including temperature and precipitation were obtained from Environment Canada (Environment Canada, 2008). There is one active climate station near the study area located at the Stephenville Airport.

1.4.1 Temperature

The monthly and annual mean daily temperatures for the Stephenville Airport climate station are provided in Table 1.1. The mean annual temperature in the study area is 4.6°C. Minimum and maximum temperatures are -7.5°C and 16.2°C in February and August, respectively.

Table 1.1: Monthly Mean Daily Temperatures (°C) at Stephenville Airport

Station	Code[1]	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean Annual
Stephenville Airport	A	-6.2	-7.5	-3.6	2.3	7.4	12.0	16.1	16.2	12.2	6.9	2.3	-3.0	4.6

Notes:
1. The minimum number of years used to calculate normals are indicated by a "code" defined as:
- "A": No more than 3 consecutive or 5 total missing years between 1971 to 2000.

1.4.2 Precipitation

The monthly mean precipitation normals for Stephenville Airport climate station are provided in Table 1.2. The mean annual precipitation is 1,352 mm. Precipitation is generally greatest during the fall and early winter months and lowest in the late winter through early summer months.

Precipitation is discussed in further detail in Section 4.0.

Table 1.2: Monthly Mean Total Precipitation (mm) for the Stephenville Airport

Station	Code[1]	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Mean Annual
Stephenville Airport	A	134.5	102.1	93.7	75.6	98.1	102.3	117.4	122.8	128.0	130.2	120.7	126.7	1352.1

Notes:
1. The minimum number of years used to calculate normals are indicated by a "code" defined as:
- "A": No more than 3 consecutive or 5 total missing years between 1971 to 2000.

1.4.3 Evapotranspiration

Evaporation is broadly divided into two main categories: evaporation and evapotranspiration. Evaporation, or lake evaporation, is the water that evaporates due to solar radiation, mild to hot temperatures, and wind. Evapotranspiration is the combination of evaporation and the transpiration that occurs from trees and plants. The proportion of precipitation that is available for direct runoff or recharge is dependant on the amount of evapotranspiration.

Calculations have been made by Environment Canada for the Stephenville Airport climate station to evaluate potential and actual evapotranspiration. Potential evapotranspiration is the amount of water that would evaporate and transpire with optimum water availability, whereas actual evapotranspiration is the amount of water that evaporated and transpired, which is dependent on the seasonal availability of precipitation and soil moisture. Monthly potential and actual evapotranspiration for Stephenville Airport are shown in Table 1.3. The calculations assume 100 mm of soil moisture, which is defined as the amount of water held in place after excess gravitational water has drained.

These data illustrate the abundant seasonal availability of water, with soil moisture depletion occurring only during the period extending from July to September. In total, an average of 515 mm of precipitation is lost to evapotranspiration at the Stephenville Airport per year.

Table 1.3: Mean Monthly Evapotranspiration (mm) for Stephenville Airport

Stephenville Airport Evapotranspiration (1942-2007)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
Potential	2	2	5	19	55	87	115	107	72	40	15	3	522
Actual	2	2	5	19	55	87	114	102	71	40	15	3	515

Notes:
2. Calculations assume 100mm soil moisture

2.0 PHYSIOGRAPHY AND DRAINAGE PATTERNS

The physiography of the area is generally controlled by bedrock but has been influenced greatly by glacial action. This has given rise to varied topography and complex geological patterns. At the broadest level, the area is classified as part of the Newfoundland Highlands within the Appalachian Region as defined by Bostock (1969). The community of Cold Brook lies within the north portion of a lowland that extends south and southwest towards Stephenville and the Gulf of St. Lawrence. The community lies at an elevation of 80 m to 155 m above sea level (asl), and is situated at the base of the Long Range Mountains physiographic region, a northeast trending, forested highland and local barren plateau system occurring at elevations up to 1,600 m asl.

The upland plateau occurs to the north of the community of Cold Brook and is characterized by small lakes with local stream systems showing rapid increases in gradient. In the lowland area to the south, drainage systems show relatively low gradients over much of their lengths.

Cold Brook is generally covered with a northern boreal forest coniferous consisting primarily of black spruce, balsam fir, and alder. An area of low-lying bogs occurs at an elevation of approximately 80 m above sea level to the southeast of the community. The bogs drain south towards St. George's Bay.

The directions of groundwater flow generally mimic topography and patterns or surface water drainage, although under more subdued hydraulic gradients. Therefore, the inferred direction of shallow groundwater flow is to the east and southeast towards Cold Brook. The regional deeper groundwater flow would be south and southwest towards Stephenville and St. George's Bay.

The Stephenville well field is situated southwest of the community of Cold Brook, and hence would be within the regional groundwater flow system of Blanche Brook. The well field would not be within the local groundwater flow system beneath the community of Cold Brook, however, the most down gradient production wells would likely be within the influence of the deeper regional groundwater flow system of Cold Brook, based on the physiographical setting shown in Figure 1.3.

3.0 GEOLOGIC AND HYDROGEOLOGIC SETTING

The geologic and hydrogeologic setting of the area has been evaluated to establish potential aquifers beneath the study area and the probable yield of these aquifers.

3.1 GEOLOGY

3.1.1 Surficial Geology

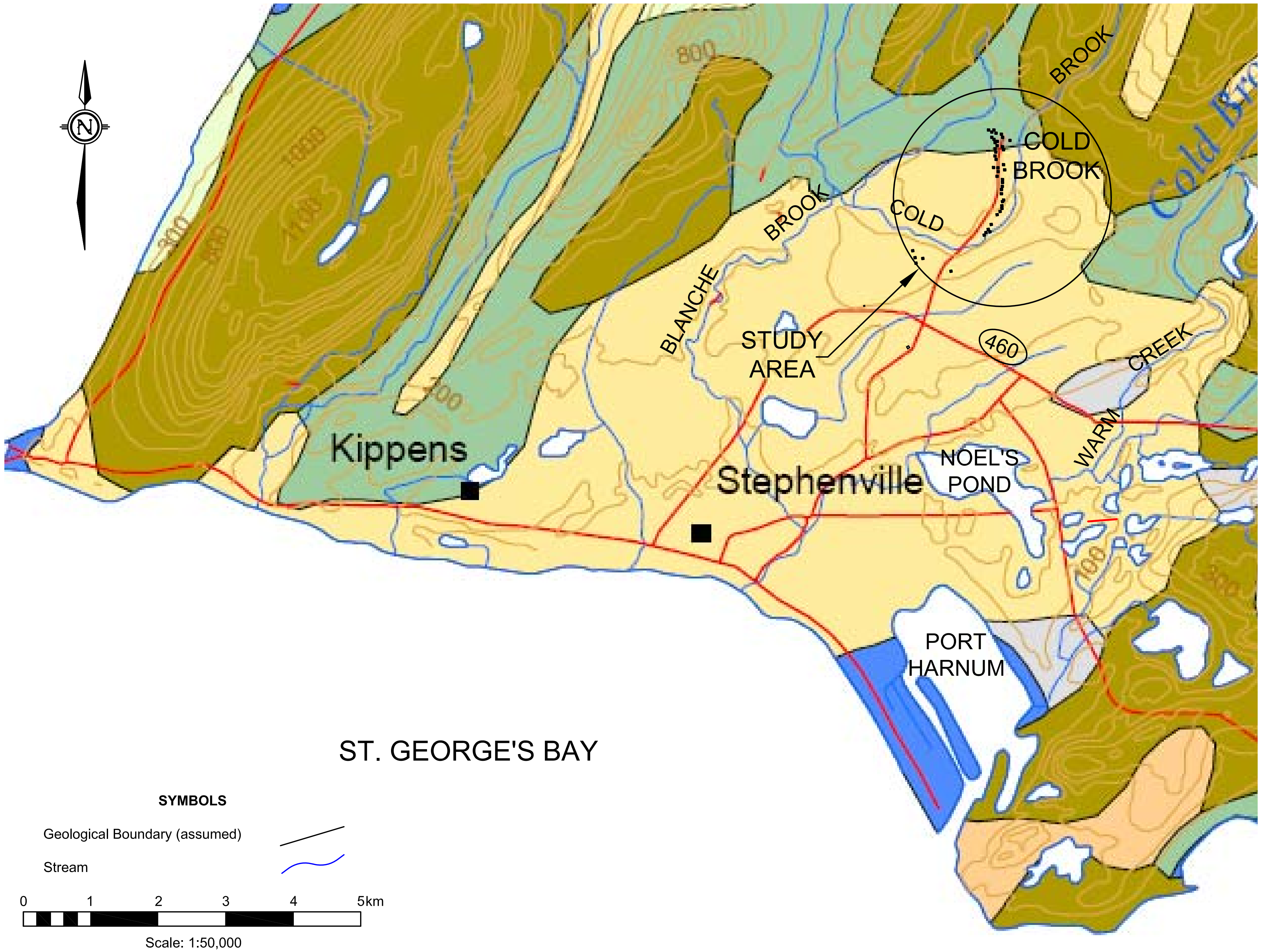
Geological reports and maps indicate that the Cold Brook area is underlain by gravel and sand deposits of glacial outwash and fluvial origin, and diamicton blanket (refer to Figure 3.1).

The glacial outwash deposits are composed of varying proportions of sand and gravel (~30% to 70% gravel, Batterson, 2003), with less than 5% silt or clay. They consist of poorly to well-sorted gravel, containing subrounded to rounded clasts up to boulder size in a medium to coarse-sand matrix (Batterson, 2003). Unit thickness can vary between 1.5 m to 50 m (Batterson et al., 2001).

The diamicton is at least 1.5 m thick and contains 20% to 90% matrix (sand size or finer), and 80% to 10% clasts (greater than sand size). The matrices are generally dominated by sand with less than 20% silt and clay with average clast sizes of 0.2 to 0.4 cm diameter (Batterson et al., 2001).

3.1.2 Bedrock Geology

The study area is underlain by a variety of clastic sedimentary rocks of the Barachois and Codroy Groups, which consist primarily of a thick succession of grey and red sandstone, with siltstone, mudstone, local conglomerate and local coal beds (refer to Figure 3.2). The original structure of the sedimentary rocks has been deformed, and extensive faulting and folding are evident within the various rock types. These rock units range in thickness from 1500 m to 2500 m (Knight, 1985).



LEGEND:

Exposed Bedrock: exposed bedrock with little or no sediment or vegetation cover; patches of till and other surficial sediment present but rare; topography and relief variable, and berock controlled

Concealed Bedrock: bedrock, mainly concealed by vegetation; patches of till, sand and gravel, and bog (commonly less than 1.5m thick) and exposed bedrock are common, but form less than 50% of the unit

Diamicton Veneer: thin (less than 1.5m) discontinuous sheet of diamicton (poorly sorted sediment containing grain sizes from clay to boulders) overlying bedrock patches of exposed bedrock and thicker sediment cover common; diamicton generally contains from 20% to 90% matrix (sand size or finer), and 80% to 10% clasts (greater than sand size); matrices generally dominated by sand with less than 20% silt and clay; maximum clast sizes from 1 to 2m diameter, but clasts mostly granules (0.2 to 0.4cmc diameter); relief and topography variable and bedrock controlled

Diamicton Blanket: similar to diamiction veneer, any deposit greater than 1.5m thick; minor irregularities of the underlying units are masked but the major topographic form is still evident

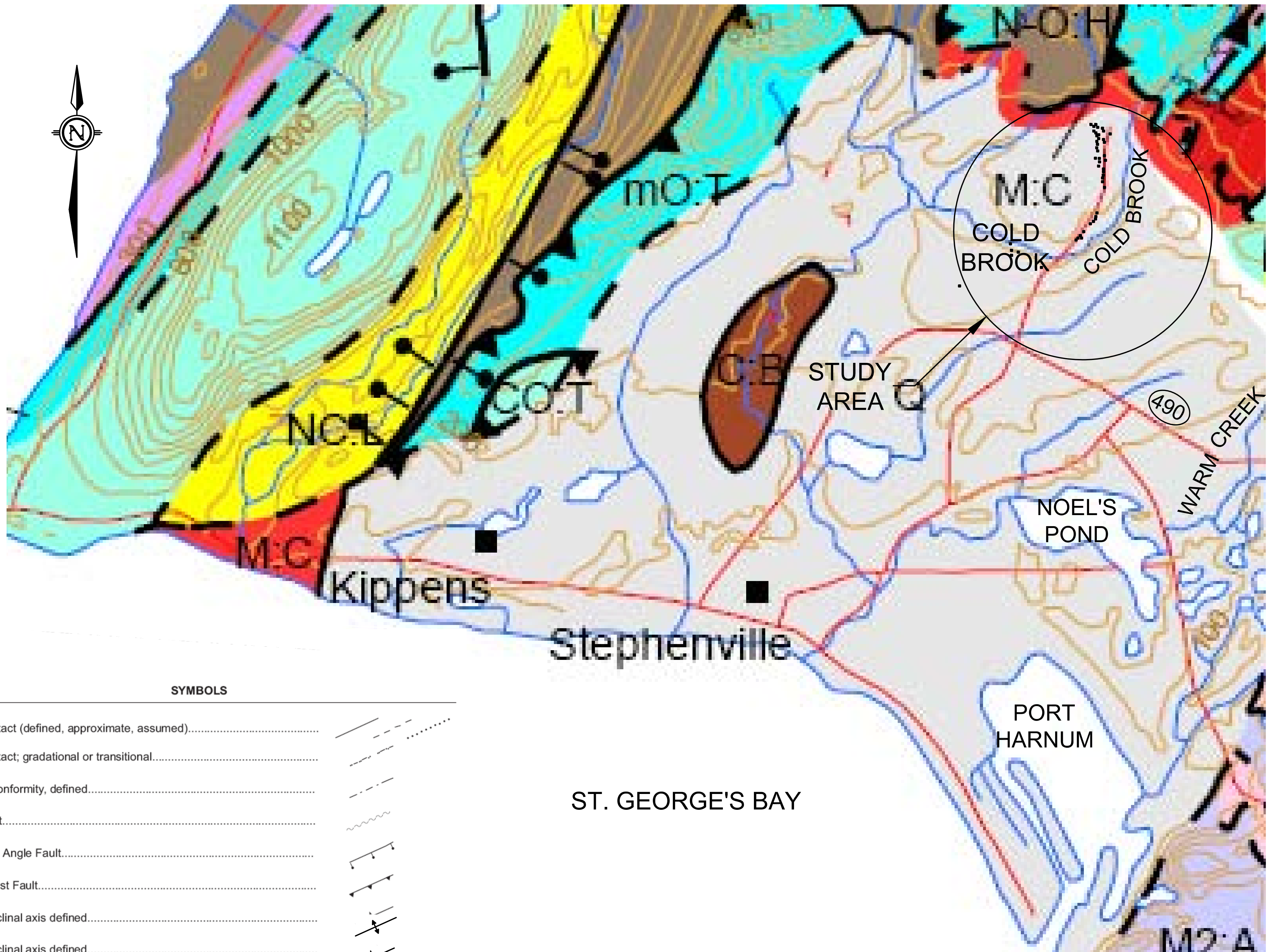
Glaciofluvial Gravel and Sand: poor to well sorted sand and gravel, 1.5 to 50m thisk, having a diverse surface topography; gravel is pebble to cobble sized, and forms 50 to 95% of the sediment; ths unit includes eskers (sinuous, elongate ridges 3 to 15m high, and up to 5km long); kames (moderated to steep sided mounds up to 15m high), and outwash plains (plains with low relief, and a channeled surface, 3 to 20m thick, and up to 10km long)

Marine clay, sand, gravel, and diamicton: this unit consists of a wide range of sediment types, deposited in a marine or glaciomarine environment; moderate to well sorted gravel and sand, up to 50m thick, found in marine terraces and raised beaches; well sorted silt and clay, up to 90m thick, are found in ice disral glaciomarine deposits with most of the sediment lying below modern sea level; all of these sediments have been raised to their present elevation by isostatic rebound, resulting in relative sea level fall since deglaciation

Bog: assumulations os degraded organic matter deposited in poorly drained low-lying areas

Reference: 1:250,000 Surficial Geology - Liverman, D.G.E. and Taylor, D.M. 1990: Surficial geology of insular Newfoundland; preliminary version: Newfoundland Department of Mines and Energy, Geological Survey Branch Map 90-08

Figure 4.1: Regional Surficial Geology



LEGEND:

Pleistocene

Surficial deposits

Q — Unconsolidated sediments (comp. various sources)

Mississippian to Pennsylvanian

Barachois Group

C:B — Arkosic and subarkosic, grey to red sandstones and pebbly sandstones, red to grey siltstones, grey to black shale and coal beds, the lithiologies are arranged in fining-upwards sewuences; locally developed conglomerates occur along fault margins of the St. George subbasin (William et al., 1985)

Mississippian

Codroy Group

M:C — Intercalated, coarse- to fine-grained red beds; evaporites including sulphate and chloride salts; limestones and dolostones, with some grey lacustrine siliciclastic rocks (Williams et al., 1985)

Middle to Late Ordovician

Goose Tickle Group

O:K — Lower dark grey to black, graptolitic shale (Black Cove Formation) overlain by American Tickle Formation of dark grey shale interbedded with green-grey sandstone, siltstone and yellow- and grey-weathering, thin bedded limestone, dolomitic limestone and dolostone, and locally shale-pebble conglomerate; shales are metamorphosed to slates and phyllites in more deformed areas; thick intervals of massive-bedded, green-grey and green sandstone and pebbly sandstone known on Pot au Port Peninsula only as the Mainland Sandstone; lenses of very thick limestone conglomerate and breccia and beds of limestone conglomerate overlain by calcernite and calcisiltite (Daniel's Habour Member); all units dismembered into melange-like deposits locally (Knight, in preparation)

Middle Ordovician

Table Head Group

mO:T — Largely comprises dark grey to light grey, thick to massive bedded, stylonodular, fossiliferous, dominantly fine grained, argillaceous and dolomitic limestone; locally grainstone; locally interbedded with fenestral limestone and dolostone near the base; minor sponge-bryozoan bioherms and large slump units and locally a conglomeratic aspect (Table Point Formation) overlain locally by fine-grained fossiliferous and graptolitic, parted, stylonodular and ribbon limestone and shale (Table Cove Formation); carbonate conglomerate and limestone and green-grey to black shale occures locally at the top on Port au Port Peninsula (Cape Cormorant Formation) (comp. Stenzel et al., 1990; comp. Knight and Cawood, 1991)

Early to Middle Ordovician

St. George Group

O:G — Off-white, light grey, grey, dark grey to black, bioturbated, stromatolitic, thrombolitic, thinly bedded and laminated, clean and dolomitic limestone as well as intraclastic, peloidal, skeletal and rarely oolitic grainstone; burrow-mottled, bioturbated, thin bedded and laminated and lesser stromatolitic, light grey to grey dolostone and dololaminite and lesser green-grey and grey shaly dolostone and shale; rare chert and dolostone pebble conglomerate and sand layers associated with disconformity surfaces; locally cut by dolostone matrix breccias below disconformities; limestones are replaced both locally and pervasively in many places by tan-grey

Middle Cambrian to Early Ordovician

Port au Port Group

CO:T — Muddy carbonate rocks, oolitic sequences, silty mudstone, and stromatolites, variably dolomitized, deposited in a subtidal to peritidal environment on a narrow, high-energy carbonate platform (comp. James et al., 1989)

Neoproterozoic to Middle Ordovician

Humber Arm Allocation (low structural slices)

N-O:H — Deep water carbonate conglomerate, grainstone, ribbon limetstone and shale (Cow Head Group), overlain by quartzo-feldspathic sandstone and shale (Lower Hear Formation); slate, quartzitic and quartzo-feldspathic sandstone and lesser conglomerate (Curling group), deep water carbonate conglomerate grainstone, ribbon limestone and shale (Nothern Head Group), overlain by quartzo-feldspathic sandstone and shale (Eagle Island Formation) (comp. Knight, in preparation)

Neoproterozoic to Middle Cambrian

Labrador Group

NC:L — Red, pink, purple and grey arkosic conglomerate, arkosic micaseous and hematitic sandstone and siltstone; white, green, red and pink quartz arenites and calcareous sandstone; olive-grey, grey, black and red shales (metamorphosed to phyllites and slates in deformed areas) locally with limestone concretion; black, grey, red and pink, intraclastic fossiliferous, oolitic, oncolitic and stylonodular, grillaceous and arenaceous, fine to grainy limestones and rarely dolostones; dark grey, mafic volcanics occur locally (comp. Knight and Cawood, 1991 ; comp. Bostock et al., 1983a)

Middle Mesoproterozoic

Elsonian anorthosite suites

M2:A — Coarse-grained, massive to well foliated, grey to bluish grey and buff anorthosite and gabbroic anorthosite, locally cut by mafic dykes, nowamphibolite; layered gabbro and anorthositic gabbro, gradational with and related to anorthosite plutons (comp. Williams, 1985a)

Late Paleoproterozoic to Early Mesoproterozoic

Long range gneiss complex

PM:L — Mainly quartzo-feldspathic gneiss, including graitic-granodioritic, quartz dioritic, and tonalitic compositions; lesser amounts of amphibolite, and dioritic and mafic gneiss; screens of pargneiss, including metacarbonate rocks, pelitic gneiss, and quartzite; metamorphosed in the anphibolite and granulite facies (comp. Owen, 1991)

SYMBOLS

Contact (defined, approximate, assumed)..

Contact; gradational or transitional...

Unconformity, defined...

Fault...

High Angle Fault..

Thrust Fault..

Anticlinal axis defined...

Synclinal axis defined..

0 1 2 3 4 5km

Reference: Colman-Sadd, S.P., and Crisby-Whittle, L.V.J. (compilers) 2005: Partial bedrock geology dataset for the Island of Newfoundland (NTS 02E, 02F, 02L, 02M, 11O, 11P, 12A, 12B, 12G, 12H, 12I, 12P and parts of 01M, 02D). Newfoundland and Labrador Department of Natural Resources, Geological Survey, Open File NFLD/2616 version 6.0.

Figure 4.2: Regional Bedrock Geology

3.2 HYDROGEOLOGY

The available water well records for the study area are summarized in tabular form in Appendix C. A total of 23 individual records of drilled domestic wells were obtained for the community of Cold Brook (Department of Environment, 1950-2001) and unpublished Department water well records. Yield and depth data recorded by the drilling companies were not always consistent, resulting in information gaps (e.g., missing well depth, well yield, and/or lithology).

The primary aquifers in the study area include the overburden unit and the carboniferous sedimentary unit. For the purpose of this report, it is assumed that the thickness of the water bearing units represents the thickness of the aquifers. Data indicates that 21 of these wells were completed in the overburden unit and only 2 wells were completed in bedrock.

Well yields are generally classified as low, moderate or high for well potential classification. A low yield well will provide between 5 L/min to 25 L/min for usage. This is suitable for a single dwelling home. A moderate yield will provide between 25 L/min and 125 L/min for usage. This is suitable for all domestic uses and some commercial uses. A high yield well will provide greater than 125 L/min for usage and can be used for domestic, industrial, commercial, or municipal needs (Acres, 1994).

3.2.1 Overburden Deposits

Materials ranging in texture from fine sand to coarse gravel are capable of being developed into a water supply well (Fetter, 1994). Material that is well sorted and free from silt and clay is best. The permeabilities of some deposits of unconsolidated sands and gravels are among the highest of any earth materials.

Deposits of gravel, sand and silt representing primarily glaciofluvial plain deposits occur extensively around the Cold Brook area. A total of 21 domestic water wells within the study area were drilled in the overburden aquifer, with records reporting units of sand and gravel, with little mention of silt, and some boulders. Well yields, as determined by short term blow tests, ranged from 9.1 L/min to 300 L/min and averaged 72 L/min. Well depths ranged from 13.1 m to 35 m and averaged 23.4 m. The available data indicates that wells drilled within the overburden deposits have a moderate potential average yield within the study area. Blow tests typically over estimate the yield characteristics.

The groundwater table was measured at depths in the range of 12 m to 35 m below grade, with an average of 23.8 m.

3.2.2 Bedrock Unit

The Carboniferous age sedimentary strata of the Barachois and Codroy Groups underlie the overburden deposits in the study area. They consist mainly of sandstone, conglomerate and shale, but also contain limestone, salt, gypsum and coal.

A total of 2 well records were drilled within the bedrock unit in the Cold Brook area. Well yields were 27 L/min to 31.8 L/min. The depths to bedrock were 20.7 m and 28.6 m below grade, with corresponding well depths of 23 m and 37.8 m respectively. The available data indicate that wells drilled within the bedrock unit in the study area have a moderate potential yield.

3.3 STEPHENVILLE WELL FIELD

Fracflow (2008) reports that 12 wells were drilled during the development of the Stephenville well field in both bedrock and overburden. The well depths ranged from 17.0 m to 45.1 m with an average well depth of 28.5 m. The static water in these 12 wells ranged from about 0.9 m above ground surface (artesian) to 7.9 m below ground surface with an average static water depth of 2.7 m below ground surface (Fracflow, 2008). The expected well yields, for greater than 24 hours of pumping, ranged from 390 L/min to 3,000 L/min with an average yield of 1,289 L/min. Although bedrock was encountered in a few of the wells, all of the operating wells have screens placed above the bedrock, and are withdrawing water from the overburden.

The well logs and geological cross-section from the Fracflow (1999) report indicate horizons of silt and clay that are continuous and should thereby act as aquitards, buffering any contaminants percolating downwards to the aquifer where the well screens are placed.

4.0 WATER BALANCE APPRAISAL

4.1 HYDROLOGICAL CYCLE

The hydrologic cycle typically starts with precipitation in the form of rainfall or snowfall. A portion of the rainfall is returned back into the atmosphere in the forms of evaporation or transpiration by the vegetation cover on the ground surface. Depending on the ground moisture conditions at the time of the precipitation event, a portion of the remaining rainfall may generate surface runoff, which feeds into the streams and causes relatively rapid rise in stream flow. The remainder of the rainfall will percolate down to the groundwater table and from there it will migrate slowly toward and feed into the receiving stream in the form of base flow. Base flow input into a stream may continue long after the surface runoff ceases.

The hydrological cycle for snowfall is similar to that for rainfall. However, snowfall generally becomes accumulated through the winter and generates runoff in the spring when the temperature rises above freezing. A much lower proportion of the snowfall will be lost to evaporation and transpiration than rainfall due to lower temperature and significantly reduced consumption by the ground vegetation cover.

Many factors govern the hydrological cycle, and proportioning of the total precipitation into various hydrological components. The most significant factors include temperature, topography, vegetation cover, soil conditions, and significant drainage features of the watershed (e.g., large lakes). Many of these factors vary seasonally and from watershed to watershed.

4.2 HYDROLOGICAL SETTING FOR COLD BROOK WATERSHED

The watershed area for Cold Brook is shown in Figure 1.3. The community of Cold Brook straddles the watershed divide between Cold Brook and a small tributary to its west. This small tributary feeds into Cold Brook approximately 2.5 km downstream of the community (0.3 km from Blanche Brook). At the confluence with this small tributary, Cold Brook has a total watershed area of approximately 31 km^2.

The Cold Brook community is located in the coastal lowland area of the St. George's Bay. To the north, the topography rises steeply, the terrain becomes mountainous and Cold Brook and the tributary become deeply incised. Satellite photos indicate that the Cold Brook watershed is generally under forest cover, and there is little development in the mountainous areas of the watershed. The Cold Brook watershed has an elongated shape that trends north - south. There is no significant storage along Cold Brook and the tributary in the forms of lakes and swamp areas. These morphological characteristics of Cold Brook and its watershed indicate the stream flow likely experiences rapid rise and fall in response to large runoff events.

4.3 CLIMATIC CONDITIONS

Environment Canada prepares climatic norms for the available meteorological stations based on 30 year records. The latest climatic norms were prepared based on meteorological records for the period from 1971 to 2000. This data is available on line (http://climate.weatheroffice.ec.gc.ca/climate_normals/index_e.html). A summary of the monthly average temperature and precipitation conditions for Stephenville are provided in Table 4.1. The snowfall amount presented in Table 4.1 is calculated as the difference between total precipitation and total rainfall.

Table 4.1 Hydrological Budget of Cold Brook

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature	-6.2	-7.5	-3.6	2.3	7.4	12	16.1	16.2	12.2	6.9	2.3	-3	4.6
Precipitation (mm)	135	102	94	76	98	102	117	123	128	130	121	127	1352
Rainfall (mm)	35	29	38	55	94	102	117	123	128	127	90	47	985
Snowfall (mm)	100	73	56	20	4	0	0	0	0	4	30	79	367
Runoff Depth (mm)	55	40	65	197	218	95	68	71	85	110	125	94	1221
Average Stream Runoff (m^3/s)	0.62	0.50	0.74	2.31	2.47	1.11	0.77	0.81	0.99	1.25	1.47	1.06	
Baseflow (mm)													200

The average monthly total precipitation for the nearby Stephenville recording station is shown in Figure 4.2. The precipitation for the study area is relatively evenly distributed throughout the year. The highest precipitation generally occurs in the fall. The lowest precipitation generally occurs in the spring. Approximately 27 percent of the total precipitation in the study area is in the form of snowfall.

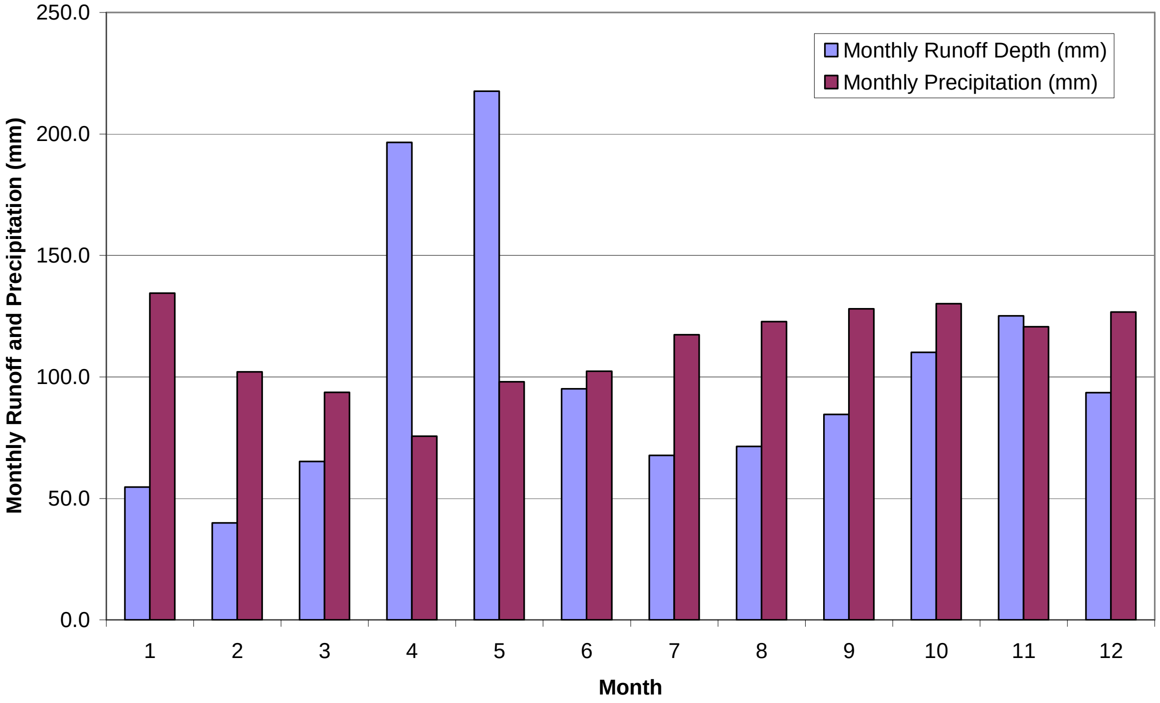


Figure 4.2: Monthly Runoff and Precipitation for the Stephenville Recording Station

Table 4.1 indicates that the average annual precipitation for the study area is approximately 1352 mm. This precipitation amount is likely representative of only the lowland area. A previous study conducted by AMEC (AMEC, 2008) indicates that the precipitation in the mountainous areas is likely much higher than in the lowland areas.

The summer in the study area is mild. Although the average temperature in the winter months is below freezing, temperatures throughout the study area do rise above freezing relatively frequently and a proportion of the precipitation in the winter is in the form of rainfall. This indicates that a portion of the precipitation in the winter months is available for feeding the stream.

4.4 SURFACE WATER AVAILABILITY

Cold Brook and its watershed are located in the Drainage Division of 2YJ as defined by Water Survey Canada (Environment Canada, 1987). There are three existing and historical hydrometric stations in the division. The hydrometric station 02YJ002 of Blanche Brook near Stephenville is considered the most representative of the Cold Brook stream. Stream flow data for this station is available from 1978-1996. The monthly and total annual runoff prorated for Cold Brook using these flow records are provided in Table 4.1. The monthly runoff depth representative of the study area is also shown in Figure 4.2.

It is seen that runoff exhibits significantly higher seasonal variation than precipitation. The highest runoff generally occurs in the spring, when snow that had accumulated through the winter months melts. The lowest runoff generally occurs in the summer when evaporation and transpiration by the ground vegetation cover are the highest. The runoff depth increases again in the fall when precipitation increases and evaporation and transpiration decrease.

The average minimum daily flow (annual minimum daily flow averaged over the record period) for Cold Brook is estimated to be 0.09 m^3/s. This provides an indication of surface water availability during very low flow period.

4.5 BASEFLOW

Water flowing into a stream can come from overland flow or from groundwater that has seeped into the stream bed. The groundwater contribution to a stream is termed baseflow. To determine the baseflow portion of the total runoff, it is necessary to analyze the daily runoff records for an average year. To determine the baseflow portion of the total runoff, the daily runoff records for a selected average year (1992) is analyzed and is shown in Figure 4.3. It is estimated that the base flow portion of the stream flow is 0.19 m^3/s, or 200 mm/year. This indicates that recharge into the aquifer is also approximately 200 mm/year. Due to the relatively even distribution and high precipitation, the groundwater table likely becomes recharged frequently, and the baseflow is relatively constant throughout the year.

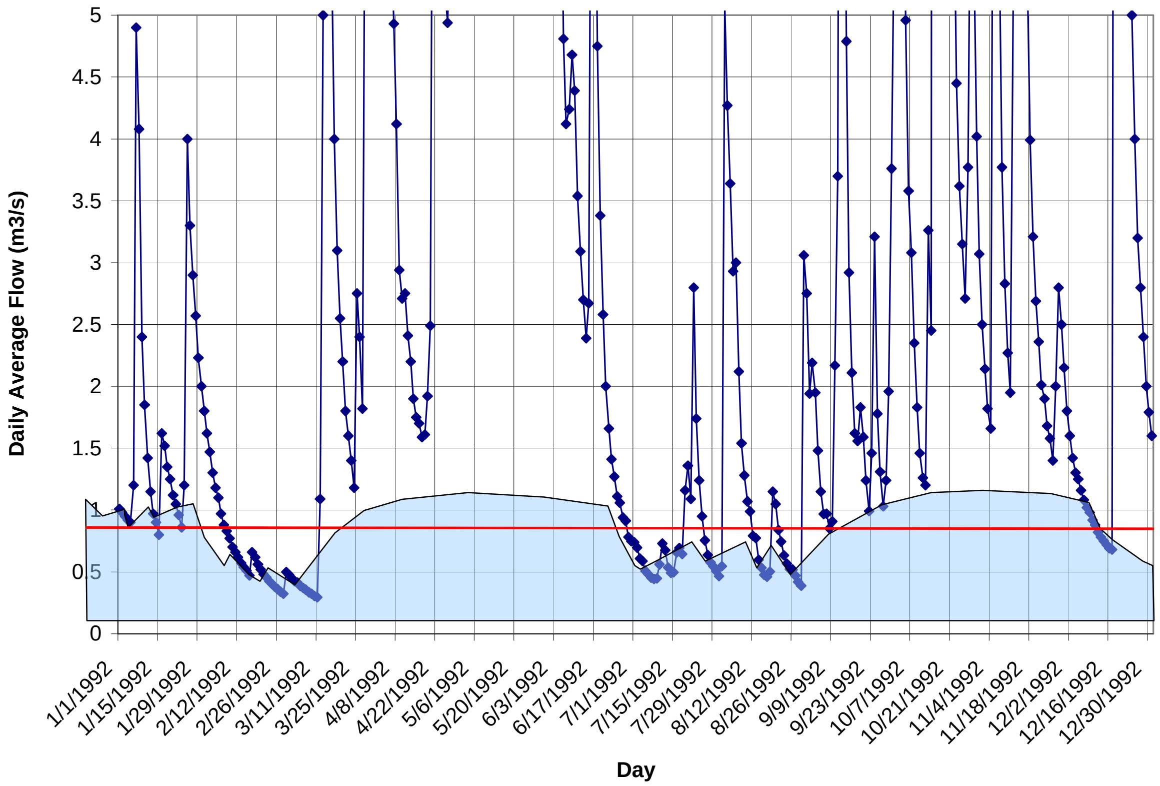


Figure 4.3: Baseflow Separation for Hydrometric Station 02YJ002

4.6 HYDROLOGICAL BUDGET

Table 4.1 summarizes the major hydrological components representative of the study area, as discussed in the previous sections. It is noted that surface runoff amounts to approximately 90 percent of the total annual precipitation. As discussed previously, the total precipitation obtained from the meteorological station in Stephenville is not representative of the mountainous regions and likely underestimates the total precipitation in the watershed.

The community of Cold Brook is approximately 1,000,000 square meters in area. If we assume an average recharge of approximately 200 mm, the annual volume of water that is being recharged over the Cold Brook watershed is approximately 200,000 cubic metres. If all of this was captured by water wells developed in the surficial aquifer, there would be enough water to service approximately 167 homes, assuming four people per house and 400 liters per person per day (Fracflow, 2008).

5.0 SEWAGE EFFLUENT FROM SEPTIC SYSTEMS

5.1 SEPTIC SYSTEMS

Contamination by sewage is a major area of concern with respect to groundwater quality within the study area. Bacterial generation from human waste in septic systems and outhouses, as well as animal waste, can be introduced into a well either through surface runoff or direct infiltration. Groundwater contamination problems that arise are commonly related to the presence of nitrogen, ammonia, phosphate, chloride and bacteria. Houses on wells and septic tank/drain fields recycle most of the water that is extracted from groundwater wells by releasing it back through the septic tank drain field.

The local households appear to take potable water from the upper groundwater column within the granular overburden. The water table appears to be at a depth of approximately 12 m to 35 m below ground surface, averaging about 24 m below grade. This water is then discharged to the septic systems in the overburden system, and allowed to percolate down to the water table.

5.2 ACCEPTABLE SOIL FOR SEPTIC DISPOSAL

Soil conditions are the most important aspect of on-site evaluation and system design. Soils acceptable for the effective absorption and treatment of sewage effluent generally will have a percolation rate of less than 30 minutes per 2.5 centimeters.

Acceptable soils are:

- Sand and Gravel: These types of soils exhibit percolation rates of less than 5 minutes per 2.5 cm.

- Loam: This type, a mixture of sand, silt, gravel and organic material, provides the most effective permeability and treatment of effluent exhibiting percolation rates of less than 15 minutes per 2.5 cm.

- Silt: This type of soil has a percolation rate that varies between 15 minutes per 2.5 cm for dry silts with a high sand content to in excess of 30 minutes per 2.5 cm for the less permeable silts.

5.3 SOILS IN THE COLD BROOK AREA

Surficial geology maps of the study area indicate that the community of Cold Brook is underlain by sands and gravels and diamictons (refer to Figure 3.1). According to the Government of Newfoundland and Labrador, Private Sewage Disposal and Water Supply Standards, this is acceptable soil in which to install on-site septic systems. However, AMEC was unable to obtain site specific percolation rate data from the Government Service Centre.

Given the separation distance of some 12 + metres from the septic tile fields and the shallowest reported groundwater table, there should be sufficient buffering capacity of the unsaturated overburden to remove pathogens before reaching the groundwater table. However, when effluent enters gravel with little of no fine material, as it appears to be the case at Cold Brook (according to well log records), it will pass through voids unfiltered so quickly that pathogens can travel hundreds of metres. This is a potential concern in the community of Cold Brook. This concern can be addressed through a groundwater sampling program, supplemented by a drilling program to verify stratigraphy and measure percolation rates.

6.0 CONCEPTUAL HYDROGEOLOGICAL MODEL

In the community of Cold Brook, the groundwater table appears to be near, at or below the corresponding nearest surface water elevations along Cold Brook to the east. The elevation of Cold Brook ranges from 85 masl just to the southeast of the community to 120 masl just to the northeast of the community. The corresponding ground elevations in the residential areas are estimated at 90 masl to 115 masl. Considering that the depths to groundwater range from 12 m to 35 m below grade within the community, the groundwater table elevation is expected to be in the order of 78 masl to 95 masl.

This would suggest that Cold Brook recharges the aquifer and that anticipated shallow groundwater flow is more southerly, corresponding to the anticipated deeper regional groundwater flow system. If this is the case, and there is no silt layer acting as an aquitard in the area, then there would be anticipated downward hydraulic gradients, and that the overburden is hydraulically connected to the underlying bedrock.

Although some of the Stephenville municipal production wells are within the regional groundwater flow system of Cold Brook, there should not be any concerns with future development in the community of Cold Brook affecting the Stephenville well field. There is considerable separation distance from the community and the well field, combined with observed silt and clay horizons above the well intakes. Most of the water supply to the well field is from the regional groundwater system of Blanche Brook, and only a small portion from the Cold Brook drainage system.

6.0 CONCLUSIONS

Based on the findings of the desktop study relating to a hydrogeological assessment of Cold Brook, Newfoundland and Labrador, the following conclusions have been made:

- It is reasonable to assume that the large majority of housing developments in Cold Brook are obtaining their potable water from the overburden aquifer, as are the main production wells for the Town of Stephenville.
- If all of the water that is being recharged over the Cold Brook watershed was captured by water wells developed in the surficial aquifer there would be enough water to service approximately 167 homes, assuming four people per house and 400 litres per person per day.
- The primary impact of the existing and proposed residential developments in the Cold Brook area will be the impact of septic tank drainage on local groundwater quality in the community.
- AMEC was unable to obtain site specific percolation rate data from the Government Service Centre.
- Most of the water supply to the Stephenville well field is from the regional groundwater system of Blanche Brook, and only a small portion from the Cold Brook drainage system. Also, there is considerable separation distance from the community of Cold Brook and the Stephenville well field, combined with observed silt and clay horizons above the well intakes. Therefore, it is unlikely that development in the community of Cold Brook will affect the quality and quantity of water within the Stephenville well field.

7.0 RECOMMENDATIONS

Based on the findings of the desktop study relating to a hydrogeological assessment Cold Brook, Newfoundland and Labrador, AMEC recommends the following further actions for the Site:

- A field hydrogeological investigation should be considered to verify the sustainability of groundwater supply under future land use scenarios.
- In order to measure percolation rates and to verify stratigraphy within the community of Cold Brook, a drilling program should be considered.
- A water quality investigation should be conducted within the community of Cold Brook, in order to determine the potential for impacts on local potable groundwater from septic tank drainage.

8.0 LIMITATIONS

This report is a desktop study only and has been prepared based on reports which were produced by others. As a result, the findings and conclusions presented in this report are based exclusively on the information that was available at the time of preparation of this report. Reports and other services of AMEC were performed by AMEC on the assumption that information furnished by the Town of Stephenville or by any person on behalf of or with instructions from the Town of Stephenville is correct, and AMEC shall not be liable for any loss, claim, damage or extra cost arising from such inaccuracy in such information. This report gives a professional opinion and, by consequence, no guarantee is attached to the conclusions or expert advice depicted in this report.

9.0 CLOSURE

We trust this meets your current needs. If you have any questions, do not hesitate to contact the undersigned to discuss.

Yours truly,
AMEC Earth and Environmental
A division of AMEC Americas Limited

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Appendix A

Regional Municipality of Waterloo Guidelines for Hydrogeological Studies for Privately Serviced Developments (issued May 1991)

REGIONAL MUNICIPALITY OF WATERLOO

GUIDELINES

FOR

HYDROGEOLOGICAL STUDIES

FOR

PRIVATELY SERVICED DEVELOPMENTS

Date of Issue: May 1991

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May 1991

REGIONAL MUNICIPALITY OF WATERLOO

GUIDELINES FOR

HYDROGEOLOGICAL STUDIES FOR

PRIVATELY SERVICED DEVELOPMENTS

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THE REGIONAL MUNICIPALITY OF WATERLOO

GUIDELINES FOR HYDROGEOLOGICAL STUDIES FOR

PRIVATELY SERVICED DEVELOPMENTS

1.0 PURPOSE OF THE GUIDELINES

1.1 The purpose of these Guidelines is to define the minimum information requirements for the preparation of hydrogeological reports in support of developments on private services.

The required information will establish:

1. that an adequate and safe supply of potable water is available for the proposed development;
2. that soil conditions on site are suitable for on site sewage disposal and,
3. that on site sewage disposal will not impair use of the groundwater resource on site or in adjacent areas

It is expected that the Guidelines will result in a faster evaluation of development proposals by ensuring that the necessary information is available at the appropriate time and that a consistent level of information is provided.

2.0 INTRODUCTION

2.1 Over the last few years the demand for rural residential development has grown substantially. These developments have proceeded with individual or communal wells for water supply and private sewage disposal systems. In many cases the geotechnical and hydrogeological assessment of the sites has been superficial, and water quality issues have been left to the purchaser to address. Assessments often do not appear to recognize that septic effluent may be recharging the water supply aquifer. Recent research into private septic disposal systems has indicated that narrow, elongated plumes are developed in granular materials and bedrock which could potentially impact local water supplies with nitrate and other contaminants. In order to address the potential public health issue, the Region has developed these guidelines to ensure that all developers address the hydrogeological and geotechnical issues relating to water supply and waste disposal as part of the approval process.

2.2 Developers will be required to submit reports which will address the issues of water supply, water treatment, if required, the impact of septic system effluent on groundwater and surface water and the design of the septic disposal system. These reports will be prepared by a qualified hydrogeologist and where necessary, a professional with experience in the design of septic systems.

2.3 In recognition of the reluctance of developers to invest heavily in hydrogeological and geotechnical investigations early in the planning approval process, the required information will be provided in two stages. Stage 1 will provide preliminary information on the suitability of the site for development on private services. Details of the requirements for Stage 1 are included in the section entitled `Stage 1 - Preliminary Environmental Evaluation'. The Stage 1 assessment will indicate whether or not the site will likely be suitable for the proposed development and if positive, will recommend proceeding to Stage 2, the detailed hydrogeological investigation of the site.

2.4 The Region's preference is to establish communal water supply systems for each new subdivision either by connecting to an existing system or by constructing a new communal system for the proposed development. Use of individual wells will be discouraged.

2.5 The recommendations and conclusions provided in the Stage 1 and Stage 2 reports must be to the satisfaction of the Regional Commissioner of Engineering and the Commissioner of Health Services on the basis of demonstrated technical feasibility.

2.6 These guidelines should be read in conjunction with the `Design Standards for Small Groundwater Supply Systems, August 1987', and `Design Standards for Septic Systems' available on request from the Region's Water and Wastewater Operations Division and Environmental Health Services Department and the MOE "Manual of Policy Procedures and Guidelines for on Site Sewage Systems".

3.0 THE PLANNING APPROVAL PROCESS

Introduction

3.1 The Planning Approval process has operated for many years under the assumption that all lands are serviceable by private sewage disposal systems designed in accordance with MOE Regulations and Regional Policies. It has also been assumed that water supplies can be made available in appropriate quantities and quality in all locations. Accordingly, private servicing considerations have normally been deferred for investigation until **after** a commitment to development has been made through Official Plans, Zoning By-law Amendments and the Draft Approval of Plans of Subdivisions.

Where water supply and private sewage servicing evaluations have subsequently revealed inherent limitations to soil and ground water conditions, the Region, Area Municipalities and development applicants have tended to engage in a "rear guard" action of attempting to mitigate these servicing problems rather than re-evaluating the development commitment itself. The tendency has been to rely on extensive modification to natural soil or the engineering of special water supply facilities to minimize such deficiencies. A full evaluation of alternative location, density or design of development has not usually occurred even where significant natural limitations for private services are found to exist. No consistent monitoring of these engineering solutions has occurred to assess their subsequent performance in servicing systems and their potential to result in groundwater and drinking water contamination. It is now evident that servicing evaluation should form a more significant consideration, earlier in the Planning Approval Process.

Principle of These Guidelines

3.2 The intent of the Guidelines is to modify the operation of the Planning Approval process to ensure that the capability of land for private servicing systems in an environmentally safe manner and on a permanent basis, be **proven** before planning commitments are made. The burden of proof will be shifted to the proponents of new development in the submission of more detailed hydrogeological studies prior to consideration of their proposals for planning approvals. No final commitment to development will generally be given until there is conclusive evidence that private servicing systems are viable in the long term without cumulative negative environmental impacts.

3.3 Policy Considerations

3.3.1 Although, as recent evidence suggests, concern should be warranted for all developments on private sewage systems with respect to ground water resources, the practical focus of this concern is on intensive developments typically associated with plans of subdivision, official plan amendments and rezonings. The implications of complex technical requirements for small scale developments are too onerous for most applicants and available staff resources. **Therefore, these Guidelines apply to residential developments of five (5) units or greater, or non- residential developments generating effluent greater than 10,000 litres per day.**

3.3.2 Notwithstanding a) above, smaller scale developments may be subject to the requirements of these guidelines if, in the opinion of the Regional Commissioner of Engineering, they pose a threat to groundwater supplies or have other significant environmental considerations.

3.3.3 For areas within Settlement Policy Area A and D of the Regional Official Policies Plan on which private serviced developments are proposed, a Stage 1 Report will not be accepted until an evaluation of full municipal servicing options has been conducted to the satisfaction of the Regional Commissioners of Planning and Development and Engineering. Such evaluation will define the methods and costs by which full services are provided and indicate the land use and density options that will facilitate the provision of full services in the long and short term.

3.4 Specific Application Type

Official Plan Amendments

3.4.1 A Stage 1 evaluation shall be required to be submitted prior to the circulation of the proposed Official Plan Amendment. Sufficient copies of the Stage 1 report will be submitted for review by Regional Departments, the Ministry of the Environment and other Agencies as appropriate. It is recommended that approval of the Stage 1 report must be obtained before the proposed Official Plan Amendment is adopted by the Area Municipal Council. Circulation of an adopted Official Plan Amendment will not occur until a Stage 1 report has been approved by the Regional Commissioner of Engineering.

3.4.2 If, in the opinion of the Regional Commissioner of Engineering a Stage 2 evaluation is appropriate before final approval of the Official Plan Amendment due to inherent limitations for private servicing or potential impact of private servicing systems on the natural environment, submission of the Stage 2 report will be required before the Official Plan Amendment is considered by Regional Council pursuant to its delegated authority under the Planning Act.

3.4.3 Where a Stage 1 evaluation has been approved by the Regional Commissioner of Engineering and the Official Plan Amendment has been approved by Regional Council, the Stage 2 report shall be required prior to the approval of an application for consent, draft approval of a plan of subdivision or third reading of an amendment to the zoning by-law.

Plans of Subdivision

3.4.4 Where a Stage 1 evaluation has not previously been conducted and the subject lands have already been designated for development by the Area Municipal Official Plan, a Stage 1 study shall be required to be submitted prior to the circulation of a Plan of Subdivision. Sufficient copies will be provided (as above) to permit review by all appropriate agencies.

3.4.5 Where a Stage 1 report has been approved by the Regional Commissioner of Engineering in the Post Circulation comments, a Stage 2 report must be completed and approved by the Regional Commissioner of Engineering and the Ministry of the Environment prior to Draft Plan Approval. The recommendations of the Stage 2 report will precisely define the conditions of Draft Plan Approval respecting the installation and monitoring of private servicing systems.

Zoning By-law Amendments and Consents

3.4.6 Where a Stage 1 evaluation has not previously been conducted and the subject lands have already been designated by an Area Municipal Official Plan, a Stage 1 study will be provided upon circulation of the proposed zoning by-law amendment or consent by the Area Municipality (as above) to permit review by all appropriate agencies.

3.4.7 Where a Stage 1 report has been approved by the Regional Commissioner of Engineering in post circulation comments, a Stage 2 report will be completed and approved by the Regional Commissioner of Engineering and the Ministry of the Environment prior to Third Reading of the Zoning By-law Amendment or the stamping of the deeds for consent to be granted.

4.0 STAGE 1 - PRELIMINARY ENVIRONMENTAL EVALUATION

Introduction

4.1 The Stage 1 investigation will involve a review of existing available geologic and hydrogeologic information, a door-to-door well survey, excavation of test pits, measurement of water levels and an estimation of the percolation time of the native soil, in order to determine the suitability of the site for development on individual wells or on a communal water system and private septic systems. A report will be prepared for review by the Regional Municipality of Waterloo and the Ministry of the Environment. The report will provide preliminary recommendations on the potential of the site for development on private services.

The information requirements at Stage 1 are as follows:

Identification Of The Site Location

4.2 Identification of the site location will include the following information:

- lot number and concession
- area municipality
- roads and/or highways bordering the site
- land use designations of the Official Plan and permitted uses in the zoning of the site and lands within 500 metres of the site
- present land use of the site and adjacent lands.

Data Review

4.3 A review of all available geologic and hydrogeologic information shall be conducted prior to conducting the preliminary field program. The data review shall include but not necessarily be limited to the following:

- topographic maps (1:10,000)
- soil and aggregate reports
- quaternary geology maps and reports
- bedrock geology maps
- hydrogeologic or septic suitability reports for adjacent subdivision developments
- Ministry of the Environment water well records
- water supply reports for existing nearby developments
- groundwater quality data

- MOE hydrogeologic files, and
- hydrogeologic maps.

The information obtained from the existing data review should include:

Site Setting

- site topography including surface relief, watercourses, ponds, ESPAs etc.;

Physiographic Region

- as described by Chapman and Putnam (1984)

Regional Geology

- overburden thickness and soil types, e.g. glaciofluvial, outwash etc., and bedrock type, e.g. unit, age, etc.

Regional Groundwater System

- overburden and bedrock aquifers, general identifiable units, general characteristics, flow direction, previous exploitation, communal well locations, permitted well locations, existing well yields, recharge and discharge areas etc.

4.4 Stage 1 Field Program

Based on the results of the review of available information, a suitable preliminary field program will be designed and implemented to undertake a preliminary determination of site specific soil and groundwater conditions. The purpose of the Stage 1 Field Program is to conduct a preliminary assessment of the feasibility of development of the site on private services.

A door-to-door inventory of water supply wells within 1.0 kilometer of the proposed development will be conducted prior to implementing the field program. The survey will be conducted to determine the condition and details of local wells, including the method of construction, water level, pump intake and well depths, water use, general water quality and suitability of the well for future monitoring, if required. The results of this survey will also determine the number of wells located 1.0 kilometer downgradient of the site, and thus the wells which could be potentially impacted by the proposed development.

An on-site investigation comprised of excavation of test pits with a backhoe, or shallow boreholes, will be conducted to determine surficial geologic and hydrogeologic conditions. One test pit is required for every two hectares (five acres) of land to be developed, and a minimum of three test pits to a minimum depth of 2 metres for each development. Additional test pits must be excavated where complex geologic conditions dictate. Where conditions indicate that the seasonal high water table is within 1.5 meters of the ground surface, a standpipe shall be installed to determine water levels and to collect groundwater samples for chemical analysis. Water levels will be monitored on completion of the installation and on at least one other occasion to determine stabilized water levels. A field survey shall also be conducted, where appropriate, to determine the direction of shallow groundwater flow.

4.5 A minimum of three representative soil samples from the proposed leaching bed, shall be analyzed in the laboratory to determine grain size distribution. An estimate of the percolation time of the native soil will be determined from the results.

4.6 Where appropriate, selected standpipes shall be fully developed prior to sampling. A minimum of three representative groundwater samples will be collected for analysis of nitrate. The chemical results will be utilized for the preliminary nitrate impact assessment to be prepared for the site. If standpipes are not installed on site, water samples shall be collected, where possible, from three nearby domestic wells.

Preliminary Nitrate Impact Assessment

4.7 A preliminary nitrate impact assessment is required in order to determine the potential for development of the site, if any, using private sewage disposal systems. Available information and on-site test results will be utilized to estimate potential recharge to the site via infiltration of precipitation and where appropriate, lateral flow. Recharge rates shall be scientifically determined, based on the nature of the soils beneath the leaching bed and downgradient areas determined during the test pit program. The results will be utilized in conjunction with the design sewage flow, to estimate available dilution, where appropriate, and ultimately the potential nitrate level at the downgradient property boundary. The results of research on plume formation should also be incorporated. Emphasis must be given to predicting where nitrate and other contaminants will travel in the long term and their ultimate impact on aquifers, wetlands, streams and lakes. Arguments for other attenuating mechanisms can also be incorporated if adequately supported by scientific research or field monitoring data. All assumptions used in the preliminary nitrate impact assessment must be stated and substantiated.

4.8 From the preliminary on site investigation and nitrate impact assessment an estimate of the number of lots which can be accommodated on the property will be determined. It should be noted that the number of lots proposed during the Preliminary Environmental Evaluation, may ultimately be revised based on the results of the more detailed Hydrogeologic Study required in Stage 2.

Stage 1 Environmental Evaluation Report Requirements

4.9 On completion of evaluation of all existing data and test results, a report will be submitted to the Regional Municipality of Waterloo's Planning Department with the application for planning approval and to other appropriate regulatory authorities for review. The primary purpose of the study is to enable a preliminary determination as to the potential suitability of the site for development on private sewage disposal systems and the availability of a potable water supply. In addition to the information requirements of paragraphs 4.2 to 4.8, the preliminary environmental evaluation will address, but not be limited to the following:

- background and predicted nitrate levels
- nitrate impact assessment
- assessment of the suitability of the site for development
- based on the preliminary hydrogeological and geotechnical assessment the proposed number of lots
- type of septic system proposed with conceptual design
- preliminary assessment of groundwater quantity and quality
- type of water supply proposed
- options for phased development based on the hydrogeological assessment of the site
- assessment of the impact of existing developments and possible future downgradient developments

4.10 The results of the Preliminary Environmental Evaluation report will be utilized by the Region to determine the potential of the site for development from the perspective of water supply and sewage disposal. If the Stage 1 study concludes the site is potentially suitable for development and regulatory authorities agree, then a detailed Hydrogeologic Study will subsequently be required to substantiate the conclusions of the preliminary assessment report. Should the Region disagree with the conclusions presented in the Stage 1 report, then the developer may request a peer review of the report by a qualified professional of the Region's choosing at the developer's cost.

5.0 STAGE 2 - DETAILED HYDROGEOLOGICAL EVALUATION

Introduction

5.1 The Stage 2 evaluation will only be undertaken if the Stage 1 report is accepted by the Region and will build on the preliminary information provided in the Stage 1 report. The Stage 2 report will be a complete stand alone document providing detailed geotechnical and hydrogeological information and analysis based on a site investigation. Preparation of the Stage 2 report will require an on site hydrogeological investigation This report will be reviewed by the Region's Planning, Engineering and Health Departments and will be the basis for providing or denying servicing approval. The Stage 2 report will include all information contained in the Stage 1 report, and the following:

Site geology, including overburden characterization and if appropriate bedrock type, unit and formation.

Identification of **aquifers and aquitards** including depth, thickness, extent, continuity, and hydraulic conductivity. The information will be presented in geologic/hydrogeologic cross-sections. The aquifer proposed for water supply must be identified.

Description of groundwater flow of shallow systems and deep systems, where appropriate including a contour plan showing flow direction, the average horizontal gradient, and determination of vertical gradients between hydrogeological units.

A **water balance appraisal** including approximate annual precipitation, infiltration rate, recharge from leaching beds, water consumption and groundwater flux.

5.2 The capability of the aquifer to supply a sufficient quantity of water in accordance with the requirements of Regional `Guidelines for Small Groundwater Supply Systems August 1987' must be demonstrated. The water quality supplied to consumers must meet the Ontario Drinking Water Objectives. Where treatment is required for removal of, for example, iron or manganese, source treatment systems will be required for communal systems.

5.3 Shallow wells will be discouraged due to their susceptibility to contamination. Where possible wells must be developed in deep confined aquifers to provide protection from surface activities. In locations where a protective aquitard does not exist, or it is limited in vertical thickness and extent, the well location must take into consideration potential sources of off-site and on-site contamination such as, septic leaching beds, farming operations, industrial operations etc., recognizing where appropriate the potential formation of plumes from these sources.

Well Capacity

5.4 Proof of existing well or new well capacity to supply the proposed development must be established by conducting a pumping test of sufficient duration (minimum of 24 hours) and analysis to demonstrate the hydraulics of the well and aquifer system.

The pumping test must satisfy both the Ministry of the Environment and Regional requirements. The degree to which vertical leakage contributes to the pumped volume must be established.

Geophysical Logs

5.5 Geophysical logs will be provided for all water supply and standby wells.

Water Quality

5.6 The quality of the water must be determined by sampling and testing the proposed water source. Parameters to be tested for must be in accordance with the Ontario Drinking Water objectives. Current or previous land use practices should be taken into consideration in defining additional parameters such as, herbicides, pesticides etc.

5.7 Irrespective of the aquifer chosen for the water supply, the water quality of the upper shallow aquifer, if applicable, must be determined.

The shallow aquifer assessment will also include the potential impact that the shallow groundwater flow will have on adjacent developments and sensitive areas such as wetlands and watercourses.

Septic System Suitability Evaluation

5.8 The evaluation must take into consideration the hydrogeological conditions of the site and groundwater resource evaluation and integrate these with septic effluent disposal issues.

5.9 The septic system study must be consistent with the minimum requirements of the MOE Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems and Regional Health Services Department Guidelines.

5.10 The septic system suitability evaluation will require soils investigations to determine soil profiles and to estimate percolation for each lot across the site. Soil profiles to a minimum depth of 2 meters are required for each surficial geologic material on the property. The percolation times can be determined by the following methods:

- Grain size analysis of representative soil samples, and/or
- In-situ Percolation tests, and/or
- Guelph permeameter tests

5.11 Any one method can be used to determine percolation times but it is recommended that more than one method be used to provide comparative results. Representative percolation times are required for all soil types on the property. Lot specific testing will be required prior to draft approval for the design of private sewage systems.

5.12 Percolation times will be used to determine the design of the septic system according to the details given by MOE's Manual of Policy, Procedures and Guidelines for Private Sewage Disposal Systems, and Regional Health Services Department guidelines. All of the limiting factors such as depth to the water table, thickness of acceptable soils, range of percolation times, and distances to wells and surface water, as set out in the MOE and Regional Guidelines must be considered in the design.

5.13 Based on the septic system design and the design sewage flow, the hydraulic loading to the groundwater must be assessed. In determining the hydraulic loading, consideration must be given to the hydraulic properties of the soil materials in which the septic systems will be placed as well as the underlying materials. The loading must be calculated on a lot-by-lot basis as well as in consideration of the development as a whole.

5.14 Using all of the information described above, provide a diagram(s) showing the typical lot plan, building and leaching bed envelopes recommended for each leaching bed design. Each leaching bed must be designed specific to the conditions on each lot.

Assessment of Potential Impact

5.15 The intent of this assessment is for the proponent to demonstrate a degree of understanding and evaluation of site conditions such that the potential impact of the proposed development can be shown. There are two main impacts which must be addressed i) those that concern effects due to exploitation of the groundwater resources and ii) those due to contamination caused by operation of septic systems.

Groundwater Resources

5.16 The proponent should address the following minimum requirements:

- determine potential long term hydraulic impact of groundwater extraction, ie what is the sustainable yield of the well and aquifer.
- address potential for well interference
- identify nearby wells and corresponding aquifer(s),
- assess long term source contributions of groundwater to wells and the effect on groundwater quality (infiltration, leakage, bedrock, surface water), and identify area over which infiltration replenishes the water supply well(s).
- provide data, calculations and interpretations to support conclusions regarding hydraulic impacts.

Septic System

5.17 Operation of a septic tank and leaching bed system introduces sewage effluent to the subsurface. It is intended that the proponent shall demonstrate that the impact of contaminant loading due to septic systems is acceptable. It is recognized through research that typical septic systems may result in long narrow contaminant plumes in permeable overburden and bedrock which contain a variety of contaminants. Therefore, the applicability of ideal dilution calculations (typically carried out for nitrate) is limited and must be used with caution.

5.18 The proponent may use such calculations to provide a subjective evaluation of the magnitude of potential impact utilizing existing MOE Reasonable Use guidelines. However, such an approach may not be appropriate for assessing impact on individual potential receptors when conditions result in long narrow contaminant plumes in groundwater.

5.19 The proponent should address the following:

- determine potential nitrate loading (or other critical contaminants) on shallow groundwater regime
- assess magnitude of potential impact on a lot by lot basis, as well as the development as a whole
- determine appropriate lot size(s) to provide adequate effluent dilution or attenuation
- identify potential receptors (such as wells, surface water, deep aquifer, future aquifer)

- assess potential impact on identified receptors (including vertical migration to deep aquifer)
- assess long term effects of contaminant loading and cumulative growth.
- identify land restrictions in the immediate vicinity of the well
- - assess the impact of plumes from leaching beds on the water supply for the development as well as off-site water sources. Where individual wells and septic leaching beds are proposed, provide location plans for wells and leaching beds taking into consideration the hydraulic gradient and plume formation.
- assess the potential for and effect of changes in the contaminant migration pathways that may occur as a result of water withdrawals from the aquifer.

6.0 MONITORING OF WATER QUALITY

6.1 Where development is being undertaken in phases, the developer will be required to demonstrate that the impact of previous phases is acceptable prior to approval of future phases. This will involve monitoring of groundwater and/or surface water quality and/or other potential receptors noted above. Wells will be required downgradient of the development for ongoing groundwater monitoring. It is recognized that several years may be required to develop plumes.

The proposed monitoring program will address:

- rationale for location of the proposed monitoring well, for example, direction of groundwater flow, contaminant sources, etc.;
- source of water supply (i.e. communal vs individual wells);
- zone(s) to be monitored (i.e. depth of well, aquifer receiving effluent, aquifer supplying water, receptors).
- chemical and other parameters to be monitored (e.g. nitrate, bacteria)

The monitoring wells will be monitored for water quality and water levels quarterly for the first year to establish baseline conditions and, semi-annually until the Region assumes responsibility for water supply to the development. Semi annual monitoring should be done during high base flow (spring) and low baseflow (late summer) conditions.

The monitoring well(s) will be constructed in general accordance with Figure 1. Where site specific conditions require modification to the typical arrangement, the developer will provide details for Regional approval.

Monitoring results will be provided to the Region's Engineering Department within 30 days of completion.

The location of all monitoring and supply wells shall be referenced by Universal Transverse Mercator (UTM) Co-ordinates and shown on a site plan. Borehole records and well logs shall be supplied for each well.

Appendix B

Water Well Records for Cold Brook and Stephenville Wellhead Area

Explanation of Column Headings

Community: The community names and their spelling are those taken from the Gazetteer of Canada - Newfoundland 1983.

Well Owner: The name of the original well owner or new owner if known.

Address: A street or road address.

Well No.: Represents an identification number for referencing each well.

Map Zone & UTM (Universal Transverse Mercator Coordinates in Metres): This location system makes use of a square grid, 1,000m X 1,000m, which is superimposed on maps ofthe National Topographic System. The vertical grid lines are called Eastings andthe horizontal lines Northings. There are three zones which cover the province.

Easting: The Easting represents the distance of a community in an easterly direction froma given north-south reference line. The Easting is the lower figure in the column.

Northing: The Northing represents the distance of a community in a northerly direction froma given east-west reference line. The Northing is the upper figure in the column.

Date: The day, month, and year in which the well was drilled.

License No.: The license number of a well drilling firm or driller. A complete list is given below.

Company	**License No.**
Martin B. Hammond Co. Ltd	1
Dynamic Drilling Co. Ltd.	2
Walton's Drilling Co. Ltd.	3
Clearwater Drilling Ltd	4
Newfoundland & Labrador Drilling Ltd.	5
P. Sullivan & Sons Co. Ltd.	6
Avalon Drilling Ltd.	7
P. O'Brien Water Well Drilling Ltd.	8
W & R Drilling Co. Ltd.	9
Aqua Well Drilling Ltd.	10
J. Goodyear & Sons Ltd.	11
Lewis A. Potter	12
West Coast Drilling Co.	14
Evangeline Well Drillers	15
D.A. Construction Ltd.	16
Northeast Well Drilling Ltd.	17
Atlantic Drilling and Blasting Co. Ltd.	18
O'Brien Drilling Services Inc.	19
Dave Sullivan's Drilling Ltd.	20

Kind of Water: The following abbreviations are used to describe the kind of water reported sampled by the driller.

Fresh	FR
Salt	SA
Sulphur	SU
Mineral	MN

Sampled?: Y or N indicates if groundwater chemical analytical data is available in a WaterWell Chemistry Database.

Water Found At: The distance below ground level at which the driller reported the occurrence(s) of water. Other water bearing zones may be listed under Final Status.

Depth: The total depth of the well in metres below ground level.

Casing Len.: The total length of casing in metres set in the well.

SWL: The static water level is the distance in metres to the water surface below ground level when the well is not being pumped and has recovered to static condition. Static water levels above ground are indicative of flowing conditions. It must be realized that drillers are not able to allow sufficient time for water levels to recover to the true static level after drilling. Therefore, for some wells the static water level given here may be greater than those actually encountered.

Test Yield: This is the drillers estimated yield in litres per minute at the time the well was drilled. The test yield is usually based on a short-term air lift test and therefore may not represent the optimum long-term yield of the well. It should, however, be close enough for domestic wells or as a guide for conducting pumping tests.

Lithology: A record of the geological formations encountered during drilling as described by the driller. Each formation is followed by a number which indicates the distanceto the bottom of the formation. Abbreviations for materials, descriptive terms, andcolours are listed on the following page.

Final Status: The purpose for which the well was drilled. The following abbreviations are used to indicate the final status of the well.

Water Supply	WS
Observation Hole	OH
Test Hole	TH
Abandoned - insufficient supply	AB - insufficient water
Abandoned - poor quality	AB - poor quality

Water Use: The following abbreviations are used to describe water use:

Domestic	DO
Stock	ST
Public Supply	PS
Commercial	CO
Industrial	IN
Irrigation	IR
Municipal	MU
Heat Pump	HP

Colour Abbreviations

BLCK	black
BLGY	blue-grey
BLUE	blue
BRWN	brown
GREN	green
GREY	grey
RED	red
WHIT	white
YLLW	yellow

Material Abbreviations

BLDR	boulders
BSLT	basalt
CGVL	coarse gravel
CHRT	chert
CLAY	clay
CONG	conglomerate
CSND	coarse sand
DLMT	dolomite
DLSN	dolostone
FGVL	fine gravel
FILL	fill
FLDS	feldspar
FLNT	flint
FSND	find sand
GNIS	gneiss
GRNT	granite
GRSN	greenstone
GRVL	gravel
GRWK	greywacke
GYPS	gypsum
HPAN	hardpan
IRFM	iron formation
LMSN	limestone
MARL	marl
MGVL	medium gravel
MRBL	marble
MSND	medium sand
MUCK	muck
OBDN	overburden
PEAT	peat
PGVL	pea gravel
PRDG	previously dug or bored
PRDR	previously drilled
QRTZ	quartz
QSND	quartzite
QTZ	quartz
ROCK	rock
SAND	sand
SHLE	shale
SHST	schist
SILT	silt
SLTS	siltstone
SLTE	slate
SNDS	sandstone
SPST	soapstone
STNS	stones
TILL	till
TPSL	topsoil
UNKW	unknown
WDFR	wood fragments

Descriptive Terms Abbreviations

CGRD	coarse-grained
CLN	clean
CLYY	clayey
CMTD	cemented
CRYS	crystalline
DKCL	dark-coloured
DNSE	dense
DRTY	dirty
DRY	dry
FCRD	factured (broken)
FGRD	fine-grained
FOSS	fossiliferous
GVLY	gravelly
HARD	hard
LIMY	limy
LOOS	loose
LTCL	light-coloured
LYRD	layered (streaked)
MGRD	medium-grained
PCKD	packed
PORS	porous
SHLY	shaly
SHRP	sharp
SLTY	silty
SNDY	sandy
SOFT	soft
STKY	sticky
STNY	stony
THIK	thick
THIN	thin
VERY	very
WBRG	water-bearing
WTHD	weathered

Conversion of Metric Units to English Units

Multiply Metric Units	by	To Obtain English Units
Centimetres	0.3937	Inches
Metres	3.2808	Feet
Litres/min.	0.2200	Imp. gal./min.

NOTES:

- a zero(0) or blank represents no information available in this database.
- many communities have amalgamated since this database was created. However, in the interest of further locating a well, the community names have not been changed. (example - Kelligrews is now part of Conception Bay South)

Domestic Wells Located in Cold Brook

Well ID	Well Number	Well Owner	Town	Address	Well Depth	Yield	Current Well Status	Depth Water Found	Zone 1 Depth	Zone 1 Yield	Water Use	Water Type	Screen Information	Lithology	Depth to Bedrock	Abandoned	Test Duration	Pump Test Rate	Casing Type	Casing Length	Casing Thickness	Casing Diameter	Grout Used	Date Drilled	Remarks
9830	8924	D.M.A.H.	COLD BROOK		29.9	68.2														12.2				5/15/1974	
9831	8925	D.M.A.H.	COLD BROOK		15.2	54.6								OBDN 015 ROCK 000						15.2				5/15/1974	
11330	16705	HALL DAVID	COLD BROOK	COLD BROOK	22.9	9.1	WS	22.9			DO	FR		RED GRVL			120			22.9				11/20/1992	
11441	17024	WOOLRIDGE, MAX	COLD BROOK	COLD BROOK	21.3	9.1	WS	18.3			DO	FR		RED GRVL 21			120							8/24/1993	
14678	19873	COLOMBE JASON	COLD BROOK		20.7	31.8			20.7	31.8	DO			BRWN GRVL 17 BRWN SAND 21 BRWN SNDS 23	20.7		90	31.8	ST	21	5	150	N	6/13/2001	
14679	19874	PINSENT ROGER	COLD BROOK		21				21	160	DO			BRWN SILT 3 GREY GRVL BLDR 23			90	160	ST	21	5	150	N	6/13/2001	
14364	19559	DOMAN PETER	COLD BROOK			90	WATER SUPPLY	26.5			DO	FR		BRWN GRVL 18 BRWN SAND SILT 26 GRVL 27			90			26.8				6/12/2000	
13733	18930	DOWNEY DAVE	COLD BROOK		20.1	37			20.1	37.8	DO			SAND GRVL BLDR 20	0		120	37.8	ST	20.1	4.6	150	N	10/25/1998	
15676	20231	BARTER, DAVE	COLD BROOK	COLD BROOK	24.3	100	DO		24.3	100	DO			GRVL BLDR BRWN SAND GRVL BRWN 24.3			90	100	S	24.3	5	150	N	8/11/2001	
15686	20232	BRAKE, WALTER	COLD BROOK	COLD BROOK	27.4	45	DO		27.4	45	DO			GRVL BLDR BRWN 10 SAND GRVL SILT BRWN 27.4			120	45	S	27.4	5	150	N	8/12/2001	
15696	20233	MACNEIL, JERRY	COLD BROOK	COLD BROOK	28.9	50	DO		28.9	50	DO			GRVL BLDR BRWN 15.3 SAND BRWN 27.4 GRVL BRWN 28.9			90	50	ST	28.9	5	150	N	8/10/2001	
15223	20217	BUTT, CRAIG	COLD BROOK	25 GILLIS DRIVE, STEPHENVILLE	28.9	20	DO		28.9	20	DO			GRVL BLDR BRWN 15.2 SILT SAND GRVL BRWN 28.9	29.5		120	20	S	28.9	5	150	N	9/14/2001	
15224	20218	WHITE, RALPH	COLD BROOK	COLD BROOK	31.3	50	DO		31.3	50	DO			SILT SAND GREY 3 BLDR GREY 6 GRVL BLDR GREY 17.6			60	50	S	31.3	5	150	N	7/27/2001	SEE RECORD FOR MORE COMPLETE LITHOLOGY.
15227	20221	WHITE, RICHARD	COLD BROOK	COLD BROOK	15.8	45	DO		15.8	45	DO			GRVL SAND BRWN 15.8			90	45	S	15.8	5	150	N	8/23/2001	
15228	20222	WHITE, BERNARD	COLD BROOK	COLD BROOK	24.3	130	DO		24.3	130	DO			GRVL BLDR BRWN 18 SAND GRVL BRWN 24.3			150	130	S	24.3	5	150	N	8/24/2001	
15229	20223	WHITE, HARVEY	COLD BROOK	COLD BROOK	31.7	50	DO		30	50	DO			UNCONSOLIDATED			180	50	S	30	188	150	N	8/21/2001	GREY CLAY GRVL FROM 24.4 TO 31.7M.
15230	20224	HIBBITTS, RUDY	COLD BROOK	COLD BROOK	37.8	27	DO		28.6	27	DO			GRVL SAND BRWN 25.6 GRVL BRWN 28.6 CONG GREY 37.8			240	27	S	28.6	188	150	N	8/23/2001	DEPTH DRILLED TO 124' (WATER), WON'T CLEAR. PLACED CASING BACK TO 94'.
15242	20225	BLANCHARD, CON & MARK	COLD BROOK	COLD BROOK	19	54	DO		19	54	DO			UNCONSOLIDATED BRWN 19.5			120	54	S	19.5	188	150	N	8/19/2001	
15602	20579	BLANCHARD, MARK	COLD BROOK	MAIN ROAD, COLD BROOK	19.5	45.5	DO		19.5	44	DO			GRVL SAND GREY BRWN 19.5			120	45.5	S		4	150	N	12/14/2002	
15615	20257	BLANCHARD, SAM	COLD BROOK	COLD BROOK	12.1	150	DO		12.1	150	DO			GRVL SAND GREY 12.1			120	150	S	12	5	150	N	9/18/2001	
15616	20258	PERRIER, PAUL	COLD BROOK	COLD BROOK	13.1	300	DO		13.1	300	DO			GRVL GREY 13.1			120	300	S	13.1	5	150	N	9/18/2002	
16324	21448	O'QUINN, RICK	COLD BROOK	Cold Brook, NL	31.7	43	DO	31.69	31.7	45.5	DO	FR		brown boulders, sand & gravel 5.2; brown sand 8.5; 31.7 grey/brown gravel		N	120	45.5	STE	31.7	5	155	N	4/14/2004	
16130	21095	WHITE, REG	COLD BROOK	COLD BROOK, NL	24.3	22.8	DO	24.3	24.3	22.75	DO	FR		12 brown gravel; 21.3 brown sand; 24.3 brown gravel		N	90	22.75	ST	24.3	5	150	N	12/20/2003	
17214	22082	BLANCHARD, KIM	COLD BROOK	Cold Brook	35	50			35	50	DO	FR		brown gravel and boulders 35			120	50	ST	35	5	150	N	7/21/2005	

Municipal Wells Located within the Stephenville Well Head Protection Area

Well ID	Well Number	Well Owner	Town	Address	Well Depth	Yield	Current Well Status	Depth Water Found	Zone 1 Depth	Zone 1 Yield	Water Use	Water Type	Screen Information	Lithology	Depth to Bedrock	Abandoned	Test Duration	Pump Test Rate	Casing Type	Casing Length	Casing Thickness	Casing Diameter	Grout Used	Date Drilled	Remarks
13837	19028	TOWN OF STEPHENVILLE	STEPHENVILLE	HANSEN HIGHWAY	24	318			23.2	318	MU		SS 40 DIA 170 FR 17.1-21.8M	SAND GRVL 4 SAND 5 SAND GRVL CLAY 24			1728	318	ST	17	6.4	200	N	2/20/1998	PTW 8
13838	19029	TOWN OF STEPHENVILLE	STEPHENVILLE	HANSEN HIGHWAY	17	1530					MU		SS 40 DIA 170MM FR 10.9-15.6M	SAND GRVL 13 SAND GRVL CLAY 16 SNDS 17	16		1872	1530	ST	10.8	6.4	200	N	1/18/1999	PTW 7
13839	19030	TOWN OF STEPHENVILLE	STEPHENVILLE	HANSEN HIGHWAY	17	1156					MU		SS 40 DIA 170MM FR 13.2-17.9M	SAND GRVL 6 SAND GRVL CLAY 13 SNDS 17	15		1752	1156	ST	13.1	6.4	200	N	1/16/1999	PTW 6
13840	19031	TOWN OF STEPHENVILLE	STEPHENVILLE	HANSEN HIGHWAY	20.7	1156					MU		SS 40 DIA 170MM FR 8.0-12.7M	BOG 4 SAND GRVL 15 SNDS 21	14.6		3456	1156	ST	8.7	6.4	200	N	12/19/1998	PTW 5
13841	19032	TOWN OF STEPHENVILLE	STEPHENVILLE	HANSEN HIGHWAY	33	227	SEALED		30	227				SAND GRVL CLAY 28 SNDS 33	29	Y	60	227	ST	23.9	6.4	200	N	12/11/1998	PTW 4 OBSERVATION WELL
13842	19033	TOWN OF STEPHENVILLE	STEPHENVILLE	HANSEN HIGHWAY	33		DRY; OBSERVATION WELL - SEALED							SAND GRVL CLAY 28 SAND GRVL 30 SNDS 33	27.3	Y			ST	27.3	6.4	200	N	12/5/1998	PTW 3
13843	19034	TOWN OF STEPHENVILLE	STEPHENVILLE	HANSEN HIGHWAY	45.1	1462	ORGINALLY DRILLED NOV/97 NOW REAMED			1462	MU		SS 60 DIA 305MM FR 25-40.2M	REAMED FR 200MM DIA TO 438MM DIA	8.8		4032	14.6	ST	10	6.4	457	Y	11/28/1998	PTW 1
13834	19025	TOWN OF STEPHENVILLE	COLD BROOK	COLD BROOK ROAD	33	1793	WELL SEALED		33	1793	MU		SS 40 DIA 170MM FR 26.6-31.4M	SAND GRVL CLAY 20 CLAY 24 SAND GRVL 33			1728	1793	ST	25.1	6.4	200	N	3/7/1999	WELL PTW 10
13835	19026	TOWN OF STEPHENVILLE	COLD BROOK	COLD BROOK ROAD	24.3	1240			21	1240	MU		SS 40 DIA 170MM FR 17.7-22.4M	SAND GRVL CLAY 17 SAND GRVL 21 SNDS 24	21		1728	1240	ST	15.9	6.4	200	N	3/21/1999	PTW 11
13836	19027	TOWN OF STEPHENVILLE	COLD BROOK	COLD BROOK ROAD	32.1	1788			32	1788	MU		SS 40 DIA 170 FR 26.3-31.1M	SAND GRVL CLAY 14 CLAY 18 SAND GRVL CLAY			1830	1788	ST	25.3	6.4	200	N	2/17/1999	PTW 9
13844	19035	TOWN OF STEPHENVILLE	COLD BROOK	COLD BROOK ROAD	26	910					MU		SS 40 DIA 170 FR 16.0-20.8	SAND GRVL CLAY 24 SNDS 26	24		1728	910	ST	15.3	6.4	200	N	3/26/1999	PTW 12