EXECUTIVE SUMMARY

In the summer of 2001, six regions of New Brunswick were selected for a pilot project to promote the testing of drinking water from private wells, and to raise awareness of the importance of water quality among rural property owners. Additional information about private wells and water quality was also gathered as part of the project.

The six communities selected, and the corresponding region number used by the Department of the Environment and Local Government, were Beresford (ELG Region 1, Bathurst); Sunny Corner (ELG Region 2, Miramichi); Memramcook (ELG Region 3, Moncton); Quispamsis (ELG Region 4, Saint John); Mazerolle Settlement (ELG Region 5, Fredericton) and St-Joseph-de-Madawaska (ELG Region 6, Edmundston).

In each region, 360 letters were sent to randomly selected households, inviting them to test their drinking water by dropping off a sample at a temporary depot, one of which was set up in each region and operated from June 11 to July 23, 2001. A variety of information material was made available at each depot. In addition, information seminars were provided in each region, one at the beginning and one near the end of the project, explaining groundwater basics, sources of well contamination, and how to avoid them. Press releases and radio advertisements were also used to inform the public of these seminars.

Participation varied from 64% in Region 3, to less than 3% in Region 6, with an average of 29% across all Regions. An average of 44% of the 633 wells initially sampled tested positive for total coliform bacteria, ranging from a high of over 60% positive in Region 3, to a low of 21% in Region 4. For E. coli bacteria, an average of 7% were positive overall, from 11% in Region 3 to less than 1% in Region 4. Unacceptable water test results were followed up by Regional Department of Health and Welfare staff.

The project gathered physical information about the wells being tested via a questionnaire, filled out by each homeowner. This revealed that many of those taking part were frequently not aware of aspects of their wells, such as wellhead location, casing depth, and thickness of overburden (soil, sand, and gravel over bedrock). The information available was examined in relation to the observed contamination rates.

Wellhead location did not appear to have a major influence on the degree of contamination found, although there was some indication that above-ground wellheads may have higher average contamination rates. Casing depth likewise was not strongly correlated to the degree of contamination.

Considering different well types, drilled wells had the lowest average contamination, and springs and surface supplies the highest, with driven and dug wells intermediate. Wells of all ages were found to be contaminated. Most wells involved in this study for which data were reported were drilled in the 1970s, but almost half of those taking part did not know the age of their wells.

More than 70% of those participating did not report data for overburden thickness. Of those reporting, there was some indication that contamination rates were lower with greater thicknesses of overburden.

A follow-up telephone survey was carried out immediately following the end of the sampling campaign. Twenty-five households were called in each region. The vast majority reported they found the information supplied to be helpful. The main reasons for taking part in the project were that it was a good opportunity to have water tested (over 25%), general concern over water quality (20%), and for peace of mind (15%). Much lower percentages indicated that their motivation was because the issue was in the news, or because others had problems (about 10% combined).

Reasons given for not participating were varied and numerous. Miscellaneous reasons were most frequent (over 45%). After that came concerns over cost (18%), and believing their water was already good (15%). About 14% of those responding said they did not want to know, and 1% indicated that it was too much bother. 11% stated they were not available to take part.

The project also determined that rural property owners are frequently confused over roles and responsibilities in terms of maintaining their wells and in particular, testing their water. A significant number of those taking part suggested it was the responsibility of government to conduct such testing.

ACKNOWLEDGMENTS

This study is the result of the efforts of many individuals. Thanks to Ron Brinsmead and Darryl Pupek, for assistance in selecting the study regions; staff of the DELG regional offices, for coordinating activities in their areas, in particular the following coordinators and summer students: Michel Poirier and Denis Lebel (Region 1), Denis Daigle and Elizabeth Walsh (Region 2), Stéphane O'Carroll and Mark Hamilton (Region 3), Deanna McCullum and Tammy Savoie (Region 4), Fred McLellan and Renee Degorie (Region 5) Gilles Martin and Melanie Beaulieu (Region 6); the staff of the DELG laboratory, especially Bill Seymour, Dave Schellenberg, and Tracy Arsenault; Reginald Albert for coordination of activities at the Department of Health and Welfare; and Regional Public Health inspection staff.

The cooperation of the communities of Beresford, Sunny Corner, Memramcook, Quispamsis, Upper Kingsclear and Saint-Joseph is appreciated, in making their community facilities available for temporary use as drop-off depots for the project. Special thanks to Shauna Ingram for entry of data and questionnaire results, and Matthew Dickson for help with data analysis and chart preparation.

Reginald Albert, Todd Arsenault, Matthew Dickson, Bernie Doucet, Shauna Ingram, Diane Kent Gillis, Stephanie MacDougall, Darryl Pupek and Paul Vanderlaan provided comments on the initial draft of this report and made many useful suggestions for improvement.

The pilot project was coordinated and managed at DELG by Bernie Doucet, Sustainable Planning Branch. Data analysis and report text by Robert Hughes, Sciences and Reporting Branch. Layout and final production: Deborah Wybou. Cover graphics: Eric Horncastle.

Feedback

Your feedback on this report or any aspects of the pilot water testing program, would be appreciated. You may send comments at any time via email to envcomm@gnb.ca, or call 457 4846, fax 457 7823.

Environmental Reporting Series

This series of reports is intended to provide information on environmental quality in New Brunswick. Reports in this series have a technical or scientific theme, and may be general in nature, or deal with specific projects.

In addition to this report, other reports in preparation deal with river water quality, trends in groundwater levels, flooding, air quality, lake acidification trends, and other special studies. For more information, please contact the Sciences and Reporting Branch of the Department of the Environment and Local Government at 506 457 4844.

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INTRODUCTION

New Brunswick has a large and scattered rural population, the vast majority of which obtains its water from domestic wells. The responsibility for maintaining these wells lies with the property owner. These wells vary considerably in age, type and standard of construction and maintenance. The well types most commonly found include dug and drilled wells. Both kinds may be of variable depth, and may have a metal liner (or casing) which helps prevent collapse and infiltration of sand and rock fragments, or surface water. Older wells may have liners of inadequate length, or no liner at all, and, depending on local water chemistry, old liners are often found to be extensively corroded and may not be performing as they should.

Government departments have little control over activities in the vicinity of private wells, which are therefore at risk of contamination from a variety of sources. The most common threats are biological or organic cross-contamination from malfunctioning or improperly maintained sewage disposal systems; grey-water infiltration areas on the same or adjacent property; petroleum contamination from leaking oil or gasoline storage tanks; spills of petroleum products, or, on farms, spills of pesticides.

The state of physical construction of domestic wells is highly variable. Many were installed before construction standards were in place, and many are seldom inspected or maintained. Very few rural homeowners have their water quality tested regularly. Lending institutions ask for a one-time bacteriological test before a loan or mortgage will be approved for the purchase of a property, but this is not a legal requirement by government. For wells drilled since September 1994, a voucher system for an initial bacteriological and inorganic water test has been in place. The property owner pays for the initial test as part of the well drilling fee. This is a requirement under legislation. Even with this arrangement, only about 50% of the vouchers are used.

About 15,000 vouchers have been issued since 1993.

As a result of all these factors:

- a relatively high percentage of private wells in rural areas, installed before standards were in place, are suspected of being constructed to an inadequate standard;
- rural property owners probably do not test their water quality often enough;
- rural property owners are probably not adequately informed about the potential risks to the safety and quality of their water supplies;
- rural property owners are not sufficiently aware of their responsibility to maintain and test their own wells.

The 2001 pilot water testing survey was designed to address these concerns by:

- raising public awareness about water testing and quality issues;
- making it easier for the public to have their water tested;
- gathering information about rural well age, construction and related factors;
- improving the redemption rate of testing vouchers.

The project was also designed to improve the database available to DELG for ongoing management and assessment of water supplies.

Sources of drinking water in New Brunswick

Drinking water in New Brunswick comes from various sources. The larger municipalities have controlled water treatment and delivery systems, with the water source being either surface or groundwater, or a combination (see table below). Water quality in such systems is regularly tested, and trained staff are employed to operate treatment and delivery systems. Municipal water supplies service about 60% of the population of the province, with most of this water being drawn from groundwater sources and some from surface sources. In some incorporated areas there is a mix of district water supply schemes, interspersed with individual wells on other properties (for example, New Maryland, south of Fredericton). In rural areas, people obtain their water almost exclusively from private wells. This method serves approximately 40% of the population (about 300,000 people). There are many well-drilling companies in operation, collectively drilling approximately 2,200 new wells annually. Water supplies of this type are generally not treated, and rarely tested. Also, homeowners frequently know little about their wells and water supply systems.

Water Sources for Municipal Drinking Water Supplies			
Surface Water	**Groundwater**		**Both**
Bathurst	Alma	Perth Andover	Bath
Campbellton	Aroostook	Petit Rocher	Edmundston
Dalhousie	Atholville	Plaster Rock	St-François-de-Madawaska
Fort Kent	Baker Brook	Port Elgin	St. Jacques
Moncton	Balmoral	Quispamsis	Sackville
Oromocto	Bas Caraquet	Richibucto	
Riverside-Albert	Black's Harbour	Rivière Verte	
Rothesay	Bouctouche	Shediac	
Saint John	Charlo	Shippagan	
St-Quentin	Doaktown	St-Antoine	
St. Andrews	Dorchester	St-Léonard	
	Drummond	St. Hilaire	
	Fredericton	St. George	
	Fredericton Junction	St. Stephen	
	Grand Falls	St. Louis-de-Kent	
	Hartland	St-Basile	
	Hillsborough	St-André	
	Kedgwick	St-Anne-de-Madawaska	
	Lamèque	Sussex Corner	
	McAdam	Sussex	
	Miramichi City	Tide Head	
	Nackawic	Tracadie-Sheila	
	New Maryland	Woodstock	

Regulation of water quality

Water supplies in New Brunswick are regulated by a number of Acts and Regulations. These are listed in the following table, which notes the principal features of each piece of legislation. All provincial legislation is available via the Internet at:

http://www.gnb.ca/justice/asrlste.htm

Over the years, New Brunswick legislation for the management and protection of water in the province has become increasingly comprehensive, to the point where it is regarded as one of the best legal drinking water frameworks in Canada. In addition to the Acts and Regulations listed in the table, a number of other pieces of legislation are also important in protecting water quality, such as the *Petroleum Product Storage and Handling Regulation*, and the *Pesticides Control Act*. Despite this relatively comprehensive system of legal management tools, there are still weaknesses where rural water supplies are concerned.

There is no legal requirement for the owners of existing private wells to have them routinely tested. Awareness among homeowners of

New Brunswick Water Quality Legislation	
Act or Regulation	Principal Features
Clean Water Act, C-6.1	Provides authority to regulate water quality and make related regulations. Allows Minister to issue orders to protect water quality, and control use of water supplies. Prohibits the contamination of water. Provides authority to designate water supply protected areas by order.
Potable Water Regulation, 93-203	Regulates the voucher system for testing of new wells, the tagging of wells, and the testing of municipal water supplies.
Wellfield Protected Area Designation Order, 2000-47	Controls land-use activities in the vicinity of water supply wells for selected wellfields.
Water Well Regulation, 90-79	Regulates the drilling of water supply wells via licensing of well drillers and contractors, water well location, construction, testing, and distance from potential sources of contamination.
Water Classification Regulation, 2002-13	Defines standards for classifying surface waters and maintaining their water quality and other characteristics, such as trophic status, and defines a public process for setting water quality goals.
Fees for Industrial Approvals, 93-201	Regulates how major sources of water pollution are managed through a system of permits.
Clean Environment Act, C-6	Provides authority to control contaminants in the environment, and to make regulations in respect of the management of substances or operations which may affect water quality.
Watershed Protected Area Designation Order, 2001-83	Controls many activities in designated watersheds, to protect public drinking water supplies.
Water Quality Regulation, 82-126	Sets the framework for issuing approvals to operate industrial facilities, typically setting limits for the discharge of contaminants to the environment.
Health Act, H-2	Provides the authority for issuing boil orders or closing down a water supply.
Health Act -General Regulation, 88-200	Regulates private sewage disposal systems to protect groundwater.

the need to test domestic water wells, of possible sources of contamination, and of recommended land use practices to minimise the risk of contamination, is believed to be low.

METHODOLOGY

In an effort to gain an improved understanding of the state of domestic water quality supplies across the province, the DELG coordinated a pilot project in summer 2001. The project was carried out in collaboration with the Departments of Health and Wellness and Training Employment and Development, and ran for a period of seven weeks. Homeowners in six separate regions of the province were encouraged to submit samples to DELG for analysis. Sample submission was facilitated by setting up a temporary information depot in each of the six regions. At these centres, information and sampling kits were made available, and samples were collected for analysis at the DELG laboratory. The program was advertised by sending out letters directly to randomly selected homeowners within each study region. DELG also issued 3 news releases about the project, and issued 10 advertisements in 8 different newspapers across the province to promote the study.

The six regions included in the project were Bathurst-Beresford, Miramichi -Sunny Corner, Moncton -Memramcook, Saint John - Quispamsis, Fredericton - Mazerolle Settlement and Edmundston - St-Joseph-de-Madawaska. The boundaries of the project in each of these six areas are shown on the following maps (Figures 1-6).

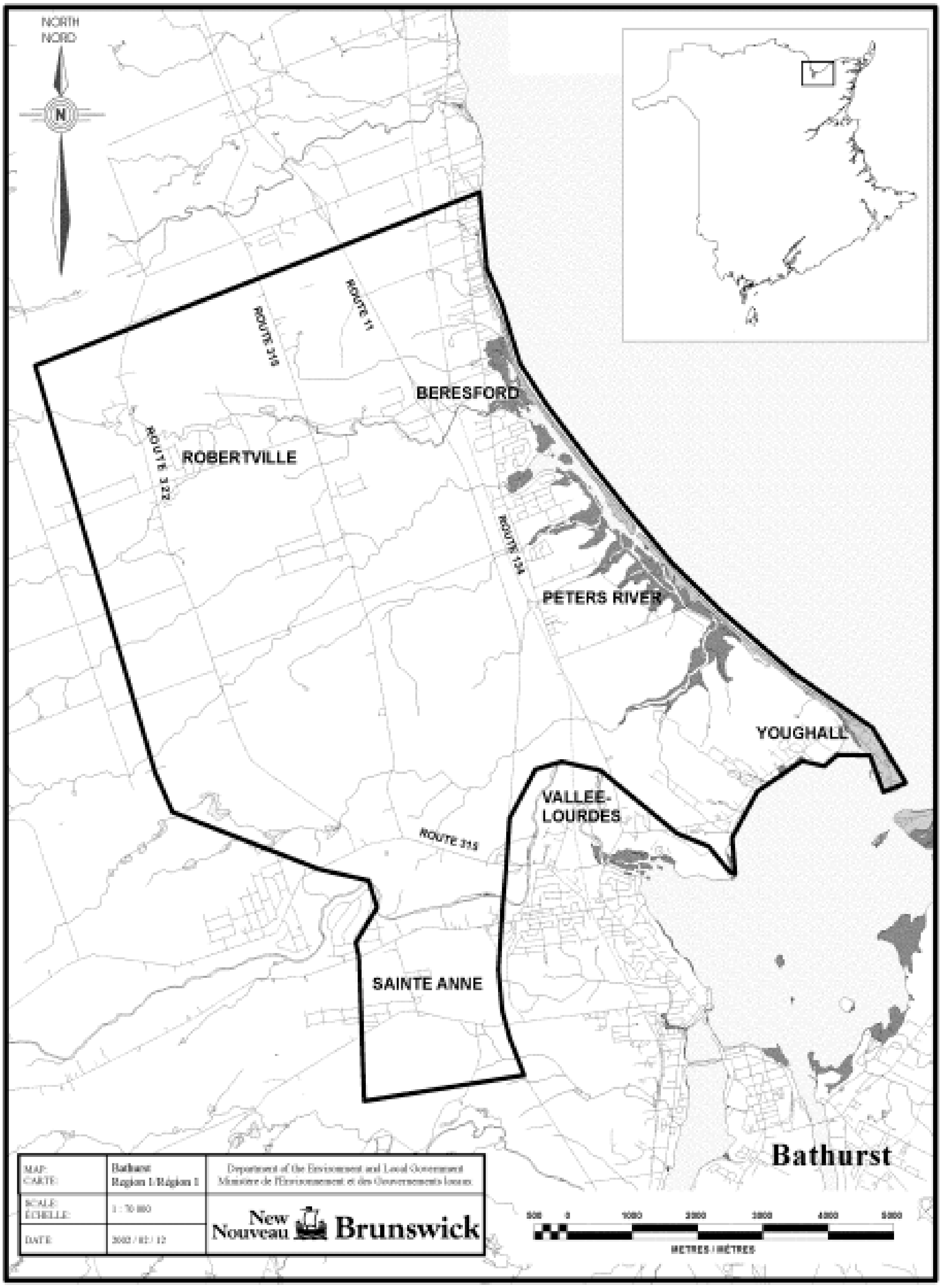

Figure 1. Region 1 (Bathurst) pilot project area.

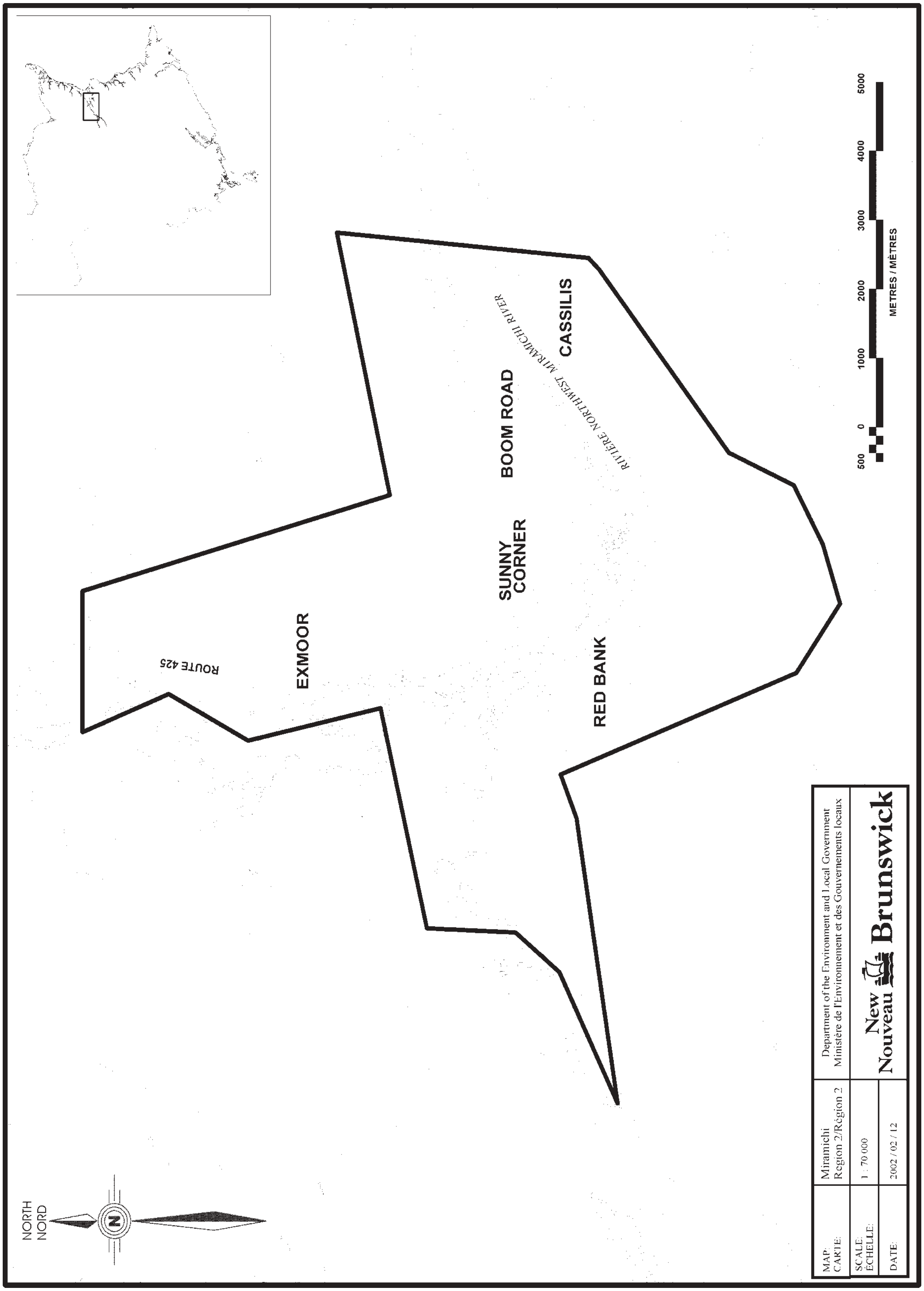

Figure 2. Region 2 (Miramichi) pilot project area.

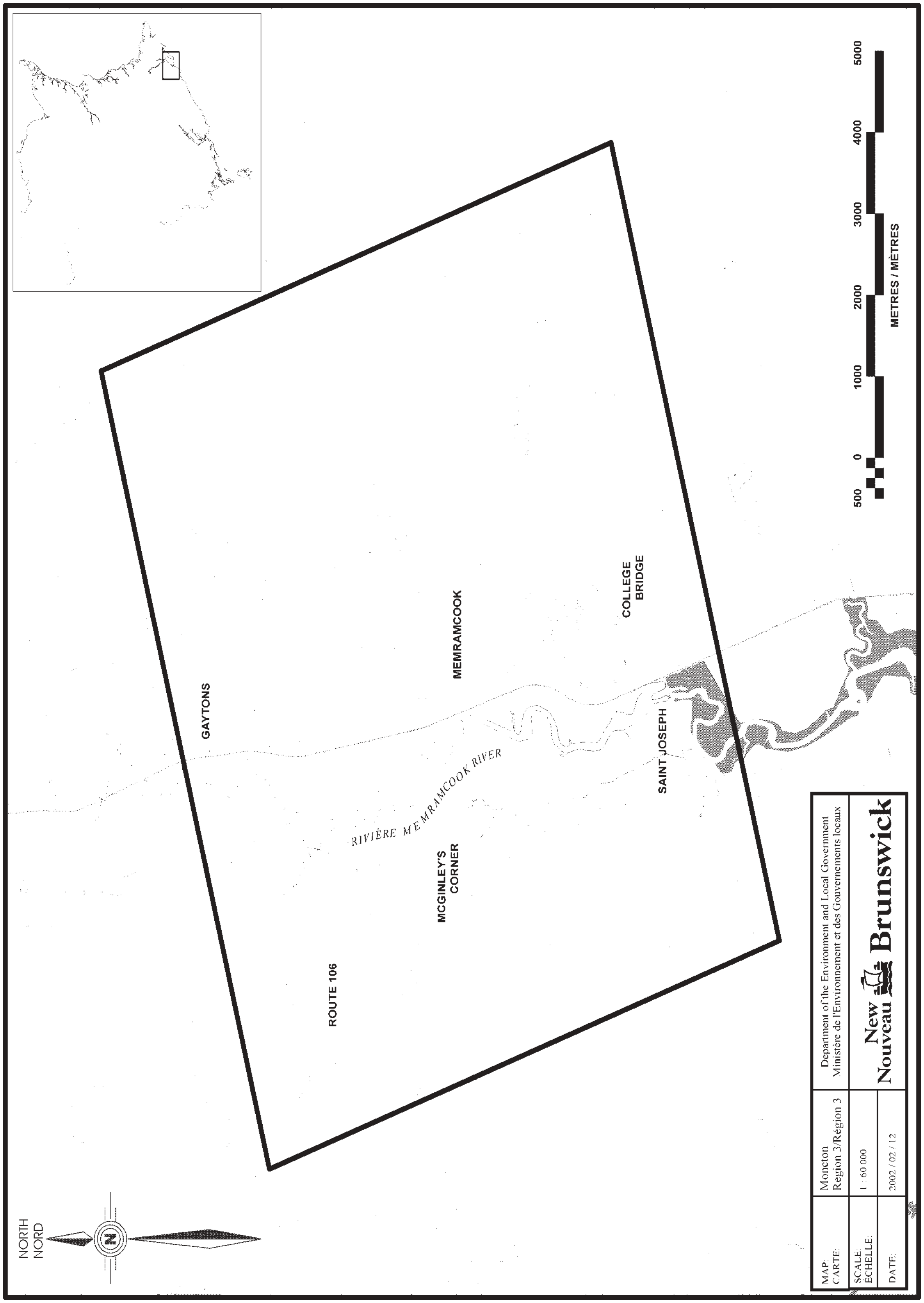

Figure 3. Region 3 (Moncton) pilot project area.

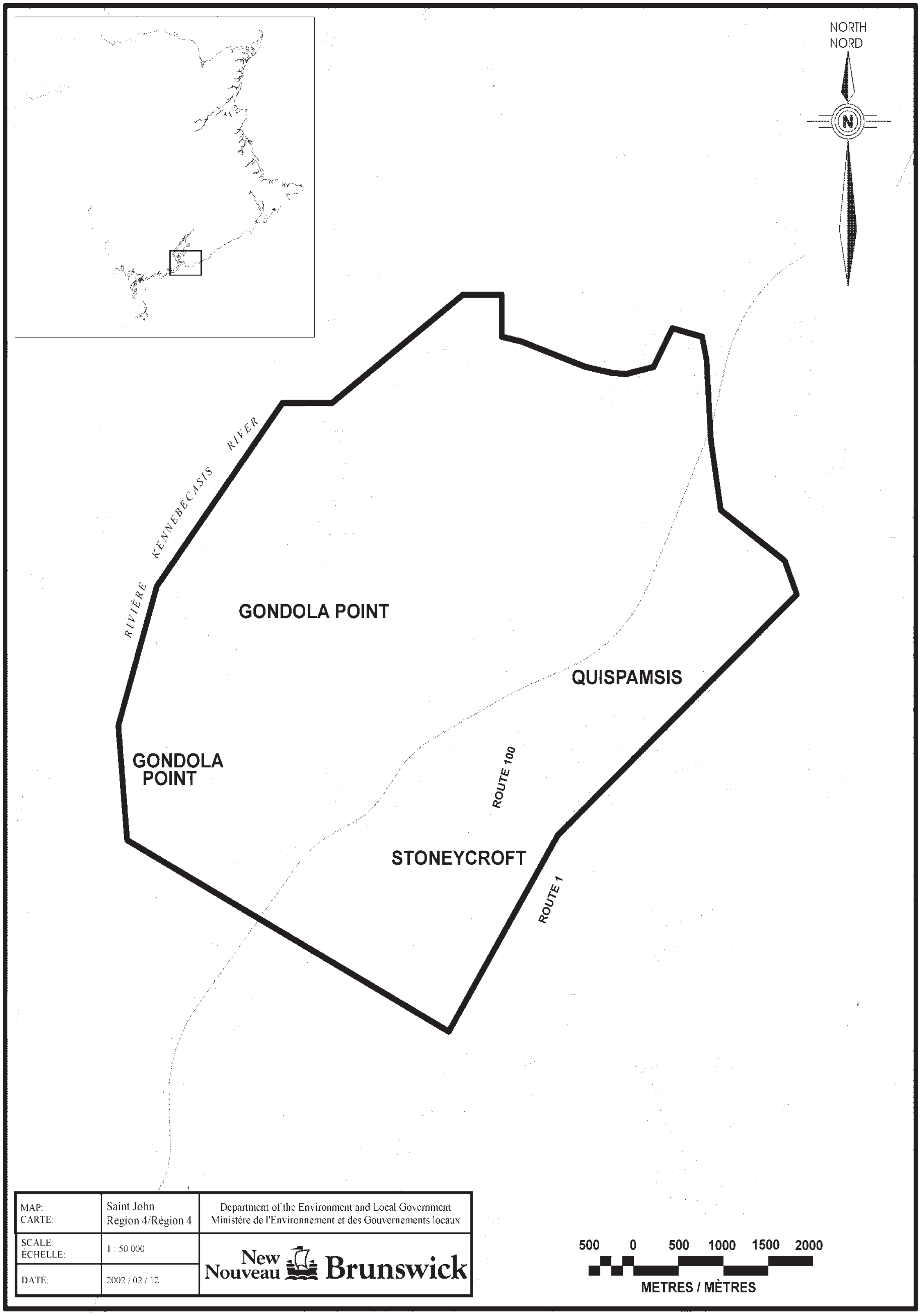

Figure 4. Region 4 (Saint John) pilot project area.

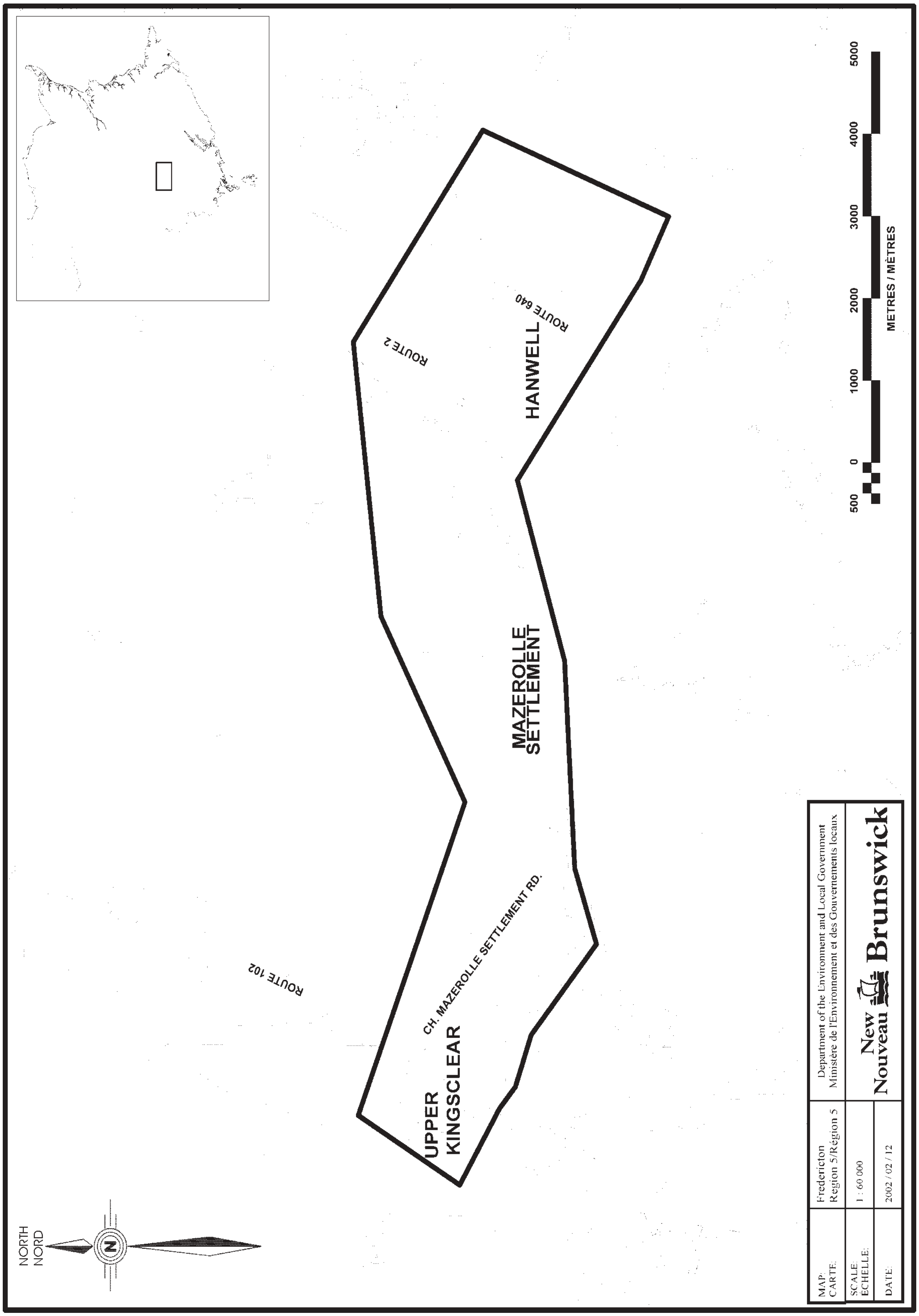

Figure 5. Region 5 (Fredericton) pilot project area.

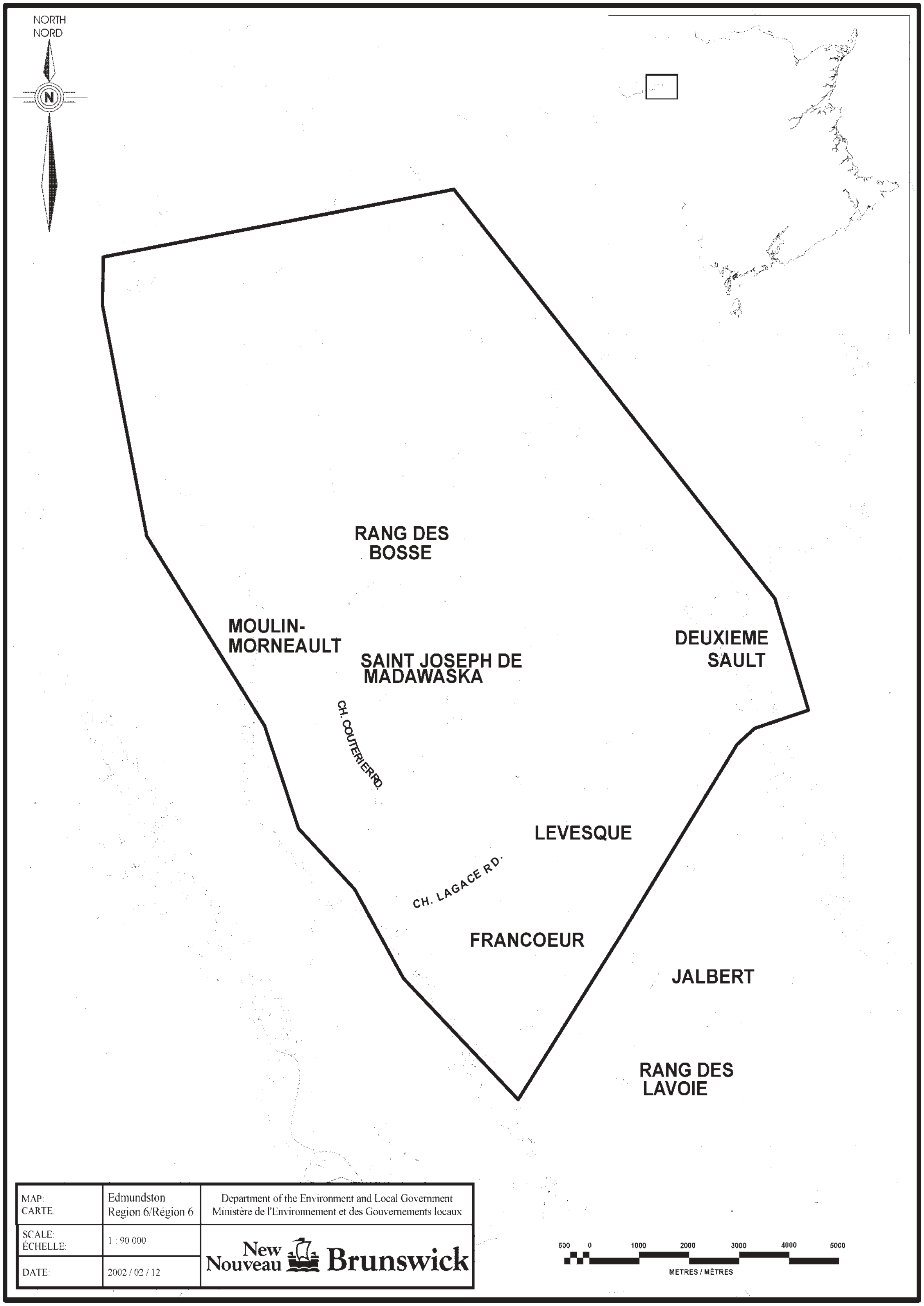

Figure 6. Region 6 (Edmundston) pilot project area.

The study areas were selected according to the following criteria:

The areas selected should:

- provide good coverage of the province;
- be of a manageable size;
- have contrasting geology, and represent geological units of interest;
- fall entirely within one of the existing DELG service regions, with one study area per region;
- be adequately populated;
- contain wells of different ages.

The final selections were made by DELG and DHW staff, using these criteria, and by attempting to include areas which were also known or suspected, based upon anecdotal evidence, to have some history of contamination. A total of 12 public information sessions were delivered across the province, one at the start and one at the end of the project, covering the following topics: "What is groundwater and how does it work?", "How do water wells become contaminated?" and "How do you prevent bacteria or other contaminants from entering your well?"

These sessions were advertised through local newspaper advertisements and in some cases via local radio stations. Attendance at the sessions varied from 1 to 55 attendees.

At each regional depot, members of the public were able to acquire sample bottles and instructions on how to collect a water sample, together with additional educational material dealing with water supplies, and a questionnaire, designed to gather information on the well installation and associated information. Samples were returned to the depot for transfer to the DELG laboratory.

The standard analysis was for total coliforms and E. coli bacteria. Optionally, homeowners were offered a more complete analysis covering all major inorganic elements and compounds. The charges were $35 (plus HST) for the bacteria test and $91.59 (plus HST) for the complete inorganic analysis. Information on the substances measured in each test are shown in the table on page 12. Information on Canadian Water Quality Guidelines is provided in Appendix II.

In instances where samples failed the total coliform test, results were sent from the DELG laboratory to the Department of Health and Wellness. DHW staff then informed the property owners of the results and provided advice on how to rectify the situation. Typically this would consist of disinfecting the well and pipe system with chlorine bleach and then re-testing. When the water continues to fail the total coliform test, this usually indicates an ongoing pathway of contamination, which requires a more detailed assessment by a specialised water supply contractor.

Follow-up questionnaires

As part of the pilot project, 25 households in each region were selected at random and contacted by telephone after the project was completed. The homeowners were asked a series of questions designed to gather information about their attitudes towards water testing; the usefulness of the information provided; their desire for more information, and opinions about the cost and convenience of water testing.

Substances Routinely Tested in Drinking Water	
Substance	**Description**
1. Bacteria-related	
Coliform bacteria, total coliforms (TC)	Occur naturally in the soil and in the human digestive system; most do not cause disease; higher coliform counts are associated with a greater risk of other harmful organisms being present.
Escherichia coli (E. coli)	A type of coliform bacteria which exists in many strains: some create toxins in the body which can cause illness; often ingested in contaminated ground beef; if cooked well, the organism is killed; also found in unpasteurised milk. Can cause diarrhea and
2. Non-bacteriological tests	
pH	A measure of the amount of acid or alkali present.
Alkalinity	A measure of the acid-neutralising capacity of the sample.
Conductivity	A measure of the total amount of dissolved ions.
Chloride, bromide, fluoride	A measure of chloride, bromide and fluoride in the sample (derived from the elements chlorine, bromine, and fluorine).
Hardness	A measure of dissolved calcium and magnesium in water, expressed as calcium carbonate.
Metals	Metallic elements in the sample; includes aluminum, arsenic, barium, calcium, cadmium, chromium, copper, iron, potassium, magnesium, manganese, selenium, sodium, lead, antimony, thallium and zinc.
Nitrate and nitrite	Nitrogen compounds (NO_3- and NO_2-). Associated measures include ammonium and total Kjeldahl nitrogen.
Sulphate	SO_4^{2-}, sulphur combined with oxygen.
Turbidity	Measures the optical clarity of the sample.
Petroleum hydrocarbons	Substances such as gasoline, oil, or hydrocarbon solvents. Note: not included as a standard analysis in this project.
Phosphorus, boron	Total concentration of the non-metals phosphorus and boron.

RESULTS

Participation

The response to the project was variable between regions, ranging from over 200 households taking part in Region 3, to only 10 in Region 6. In total, 633 well water samples were submitted for testing.

PID identifiers

Parcel identification numbers (PIDs) were provided on many (although not all) information sheets completed by property owners. A PID number provides reliable identification of the property on which the well is located and also allows mapping and analysis of the results using a computer geographic information system (GIS). When the data were being quality assured, efforts were made to check and fill in missing PID numbers.

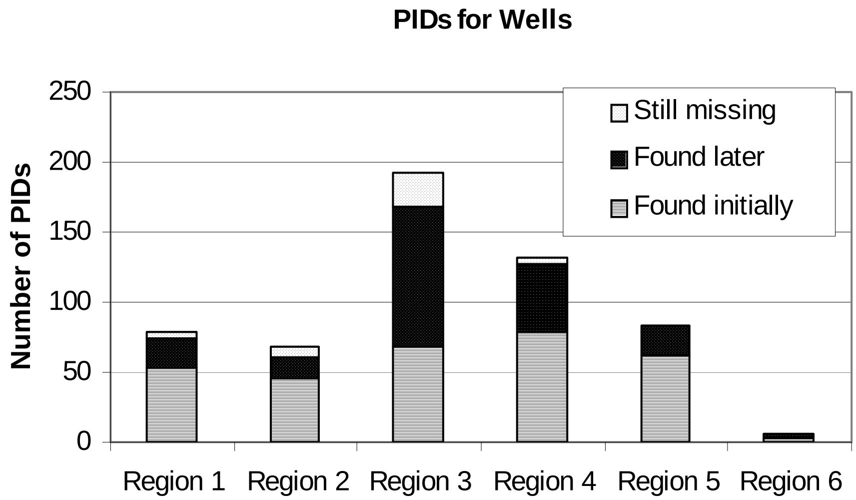

Figure 7. PID Information for Domestic Wells.

Some could still not be found. Figure 7 shows the rate of return of this information by region.

The pie chart (Figure 8) summarizes results for all regions.

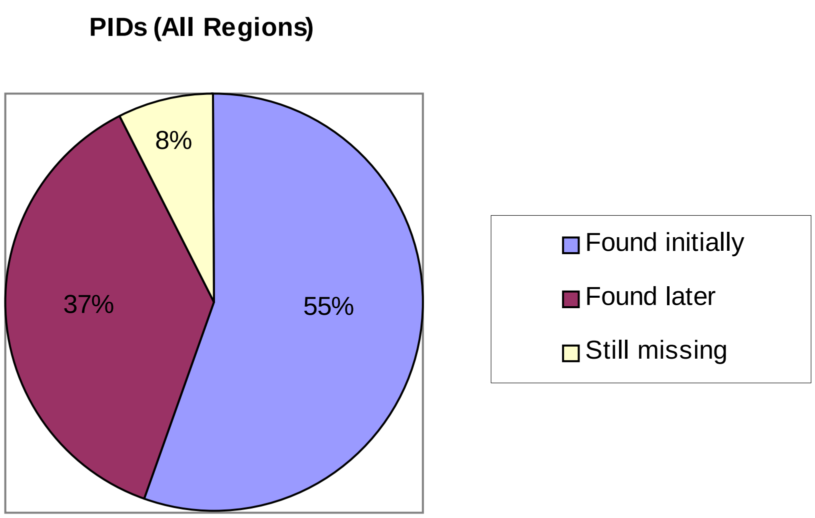

Figure 8. Percentage of well PID numbers found in study.

Positive Bacterial Tests

Total coliforms

The percentage of wells testing positive for coliform bacteria varied from 21% in Region 4 to 70% in Region 6, with an overall average of 44% (Figure 9). The figure for Region 6 should be treated with caution as it is based on a small sample size of only 10 wells. On the other hand, the result for region 3 of 62% is statistically the most reliable, based on 229 samples.

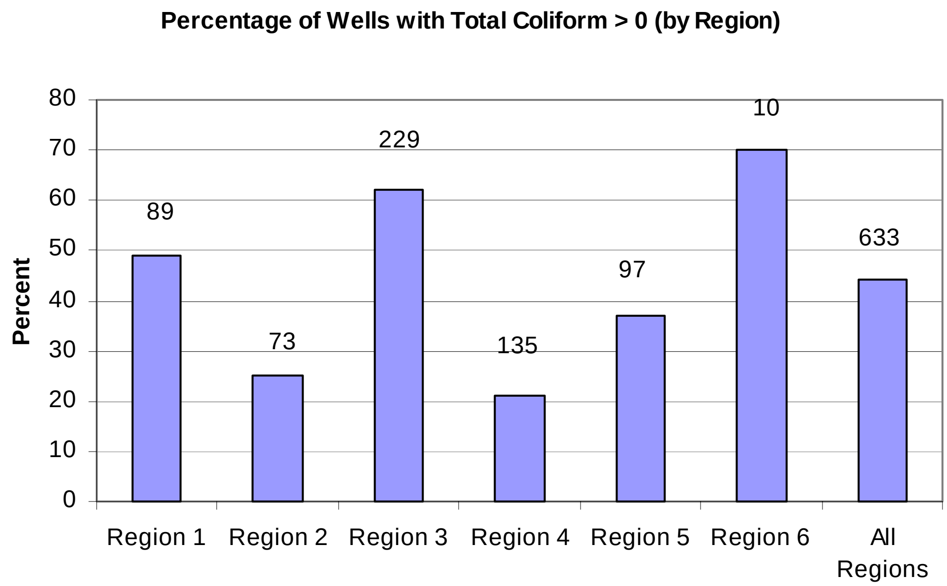

Figure 9. Percentage of wells showing the presence of total coliforms. (Numbers on bars indicate the total number of wells sampled in each region).

E. coli

The percentage of wells with E. coli varied from zero in Region 6 (and near zero in Region 4), to 11% of wells in Region 3 (Figure 10). The average percentage across all regions was 7%.

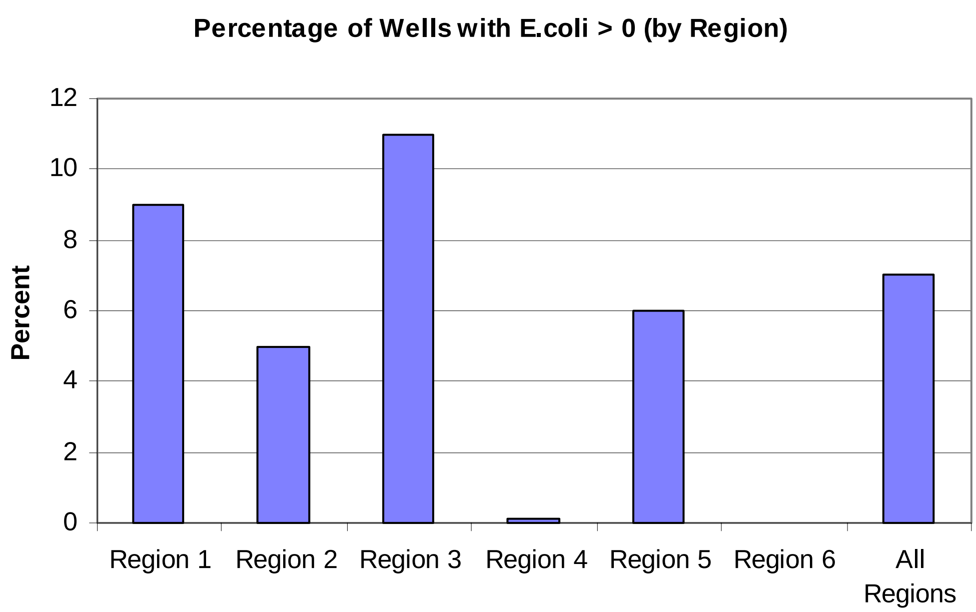

Figure 10. Percentage of wells contaminated with E. coli.

Wellhead above/below ground

Although wells constructed since approximately 1985 are built with the casing or wellhead extending above the ground surface, older wellheads are often below ground.

There were similar numbers of wellheads above and below ground in regions 1 and 4. Below ground wellheads predominated in region 2, while above ground predominated in regions 3 and 5. In all areas, there was a significant number of wells for which this information was unknown or not reported, ranging from 5% in Region 5 to 41% in Region 4.

Results are shown in the accompanying pie chart, which incorporates data from all regions (Figure 11).

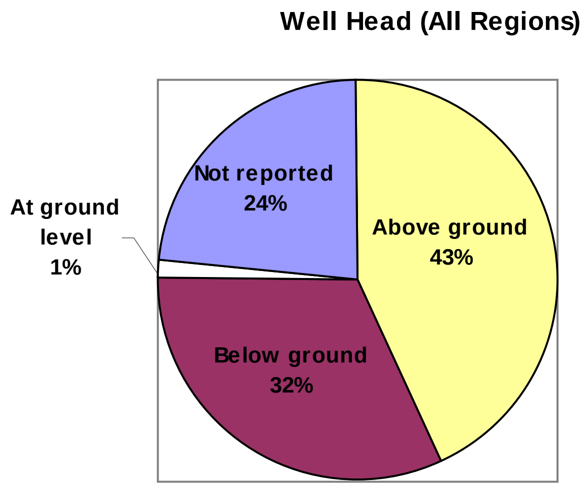

Figure 11. Wellhead location above or below ground.

Positive bacterial tests vs. wellhead location

The data were also examined for the possible influence of wellhead location on the occurrence of total coliforms and E. coli contamination. Results are shown in Figures 12 and 13.

In each case, results are shown as the percentage of wells with positive coliform results within each wellhead class. For example, of all the wells in the data set having the wellhead below ground, approximately 30% tested positive for total coliforms.

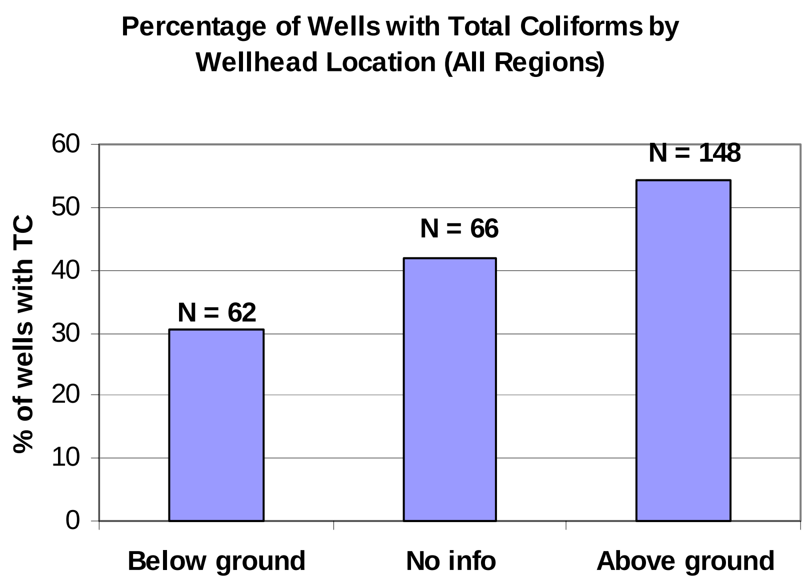

Figure 12. Percentage of wells with total coliforms by wellhead location. Labels on each bar show the number of wells with data in each category.

Wells with above-ground wellheads had a higher proportion of positive tests for total coliforms (over 60%).

Approximately 40% of the wells for which no information on wellhead location was reported had positive tests for total coliforms.

The same analysis for E. coli revealed that the “above ground” category had the highest percentage of positive tests, with “no information ” next highest, and “below ground” having the lowest percentage (Figure 13).

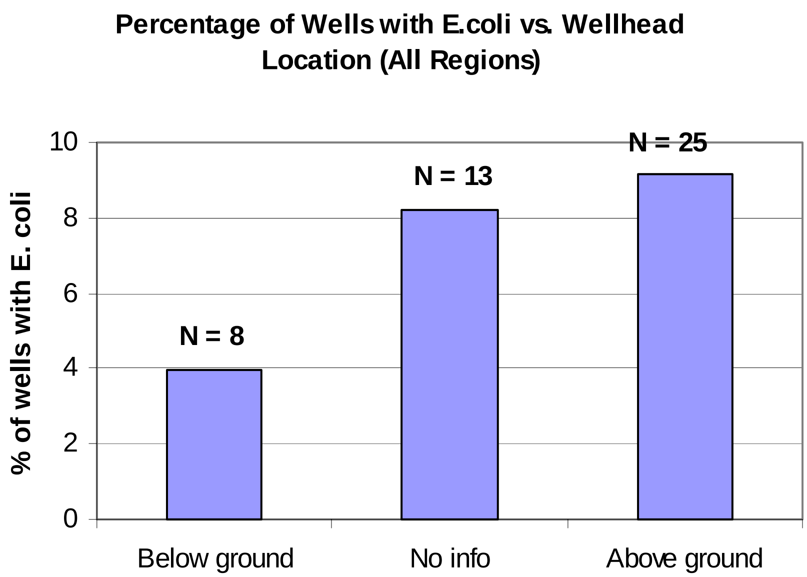

Figure 13. Percentage of wells with E. coli vs. wellhead locations.

Casing depth

The casing, or metal pipe used to line the upper part of the borehole, is an important part of the integrity of a water well. Data on casing depths are shown in Figure 14.

In most instances, well casings were seldom reported to extend beyond 60-80 feet. The proportion of wells for which information was not reported or unknown was substantial, ranging from 35% to 82% depending on the region.

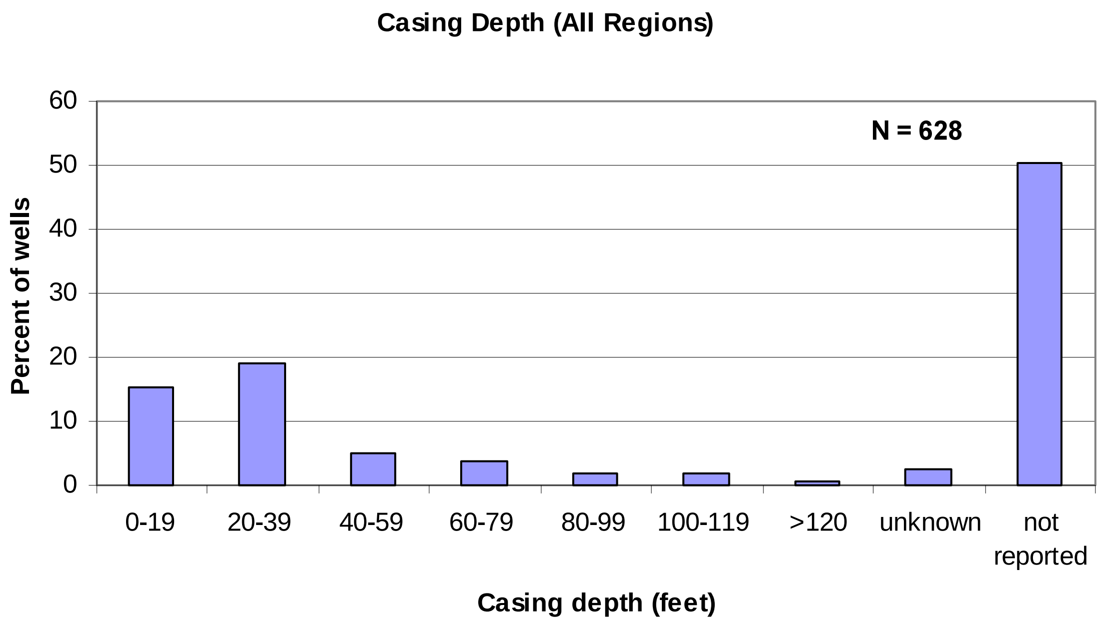

Figure 14. Casing depth for well in all regions.

Examination of total coliform count versus casing depth (Figure 15) revealed that high coliform counts were found in wells across the entire range of casing depths, and that average levels were apparently not closely correlated with casing depth. Total coliform counts reported as ">200", the upper limit of the method, were plotted as 201 in this figure. These "maximum" results can be seen to occur across the

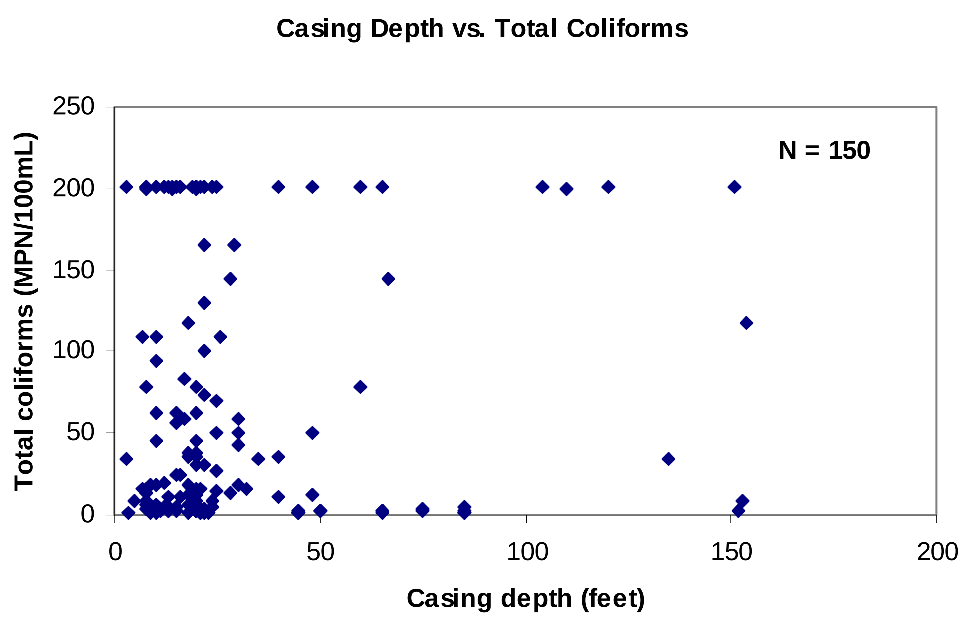

Figure 15. Casing depth vs. total coliform levels.

entire range of casing depths. The data are not uniformly distributed, as most wells have a casing of approximately 20 feet for practical reasons, and due to the requirements of the water well regulation, which specifies a minimum length of 6 m (19.7 feet). Hence the cluster around this depth.

Figure 16 shows E. coli contamination versus casing depth. Only 21 samples were available which had both a positive E. coli result and information on the casing depth. As for total coliforms, the results show no clear correlation of casing depth with E. coli contamination. The highest level of E. coli contamination was found in a well reported to have a casing depth of 120 feet.

This point has been omitted from the figure, to provide adequate resolution for the majority of results in the chart.

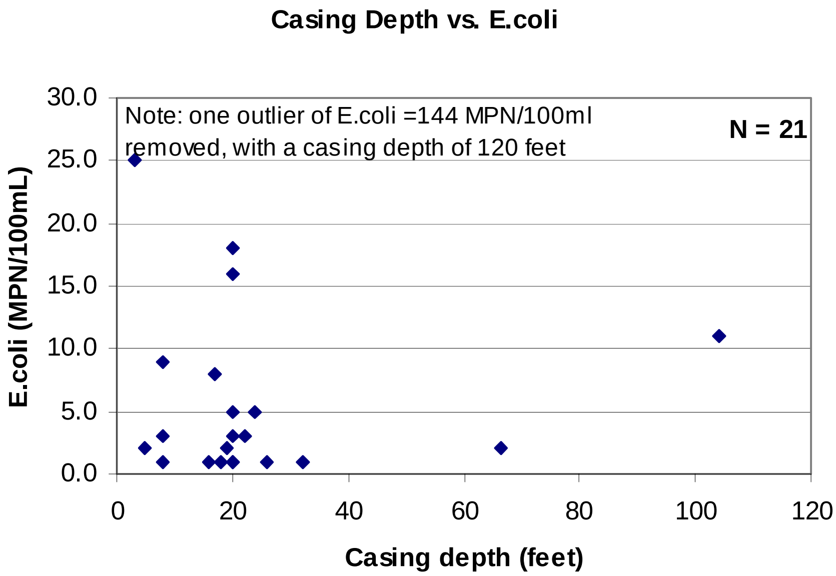

Figure 16. Casing depth vs. E. coli contamination.

Well type vs. total coliforms

Figure 17 shows the percentage of wells testing positive for total coliforms by well type. Positive tests in drilled wells occurred at a lower relative frequency than in other well types. Approximately 70% of springs and surface water sources in the data set were positive for total coliforms. Dug and driven wells were intermediate at about 65% and 35% respectively.

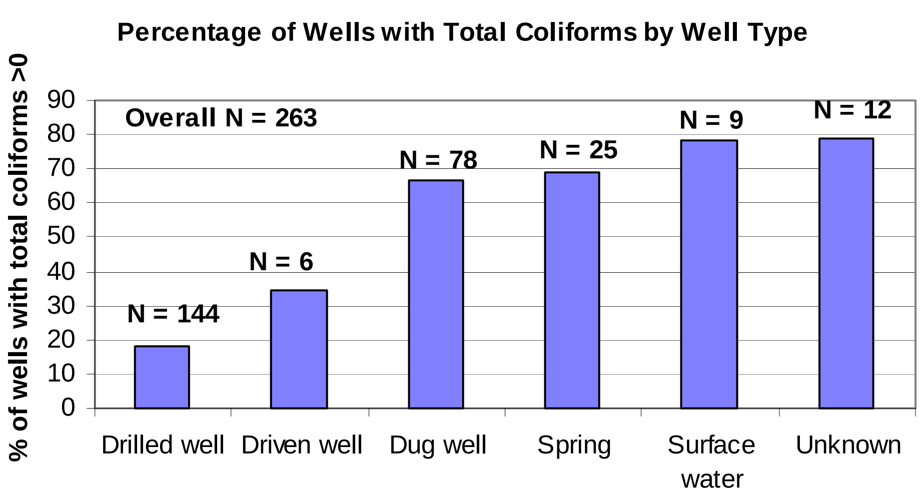

Figure 17. Percentage of wells with total coliforms by well type. Labels on each bar show the number of wells with data in each category.

This pattern was similar for contamination with E. coli (Figure 18), with springs and dug wells showing the greatest percentage of contamination and drilled wells having lower percentages.

These results must be interpreted with more caution than those for total coliforms, given the lower number of positive E. coli samples which also had information for well type (45 compared with 274 for total coliforms), but again, they were consistent with what would be expected. Note that for both these charts, the results refer to the percentages testing positive relative to the total number of wells of the same type. For example, of all the springs in the data set, 25, or about 70%, tested positive for total coliforms.

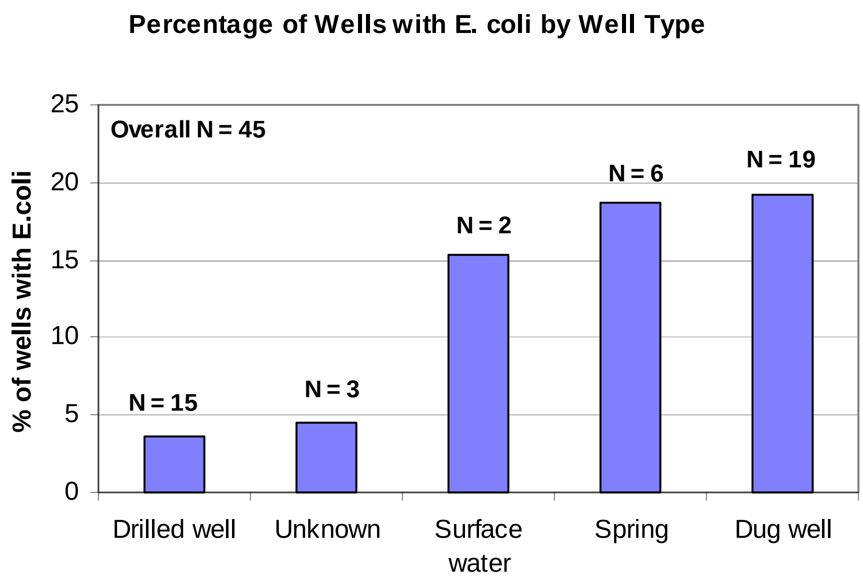

Figure 18. Percentage of wells with E. coli by well type. Labels on each bar show the number of wells with data in each category.

Well Age

In all regions the most common period for wells to be constructed was 1970-79, with wells newer than this slightly outnumbering those that were older. In all regions except region 5, a substantial proportion of those responding (from 30% to 70%) did not know the age of their well. In Region 5 the "unknown" rate was much lower, at 4.1%.

Well ages were not randomly distributed, with wells in the 1970s and 1980s predominating. Figure 19 presents summary information using data from all regions.

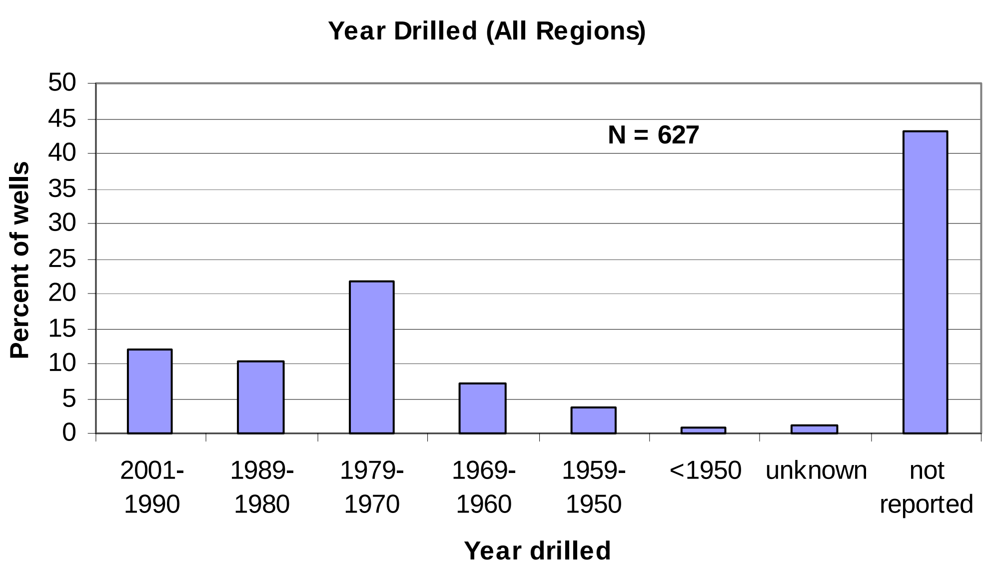

Figure 19. Well age classes for all wells in the project.

Positive Bacterial Test Results vs. Well Age

In this data set, the decade which had the highest percentage of wells with positive total coliform results was the 1980s, at over 50%. The lowest percentage occurred in wells constructed in the 1960s (about 27%), with other age classes being intermediate (Figure 20). Percentages were calculated in relation to the total number of wells in each age class.

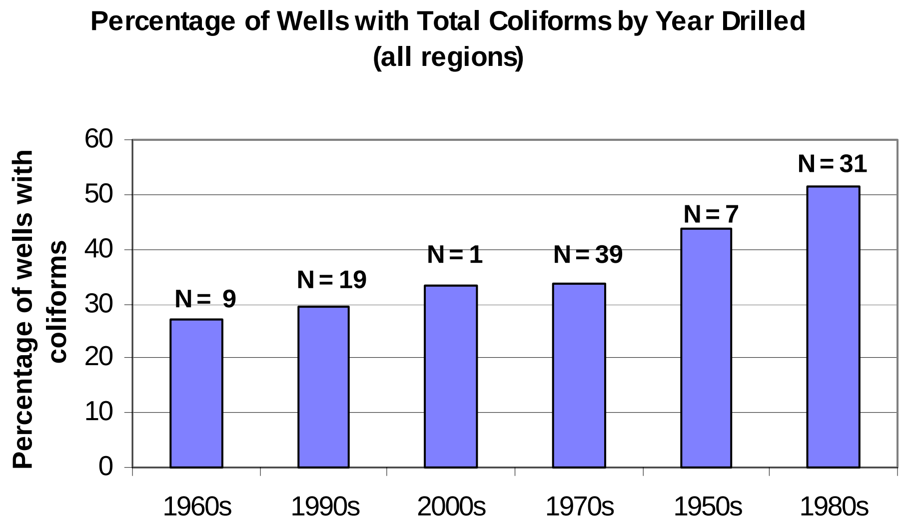

Figure 20. Percentage of wells with total coliforms by year drilled. Labels on each bar show the number of wells with data in each category.

Figure 21 shows an equivalent analysis for E. coli. There were not sufficient data points to generate meaningful age classes, hence the data are shown as a scatter plot. There is no clear tendency for newer wells to have lower rates of contamination, and there is some suggestion that the opposite might be true, although the small data subclass renders this inconclusive. It is notable that the highest level of E. coli was seen in a well drilled in 1996.

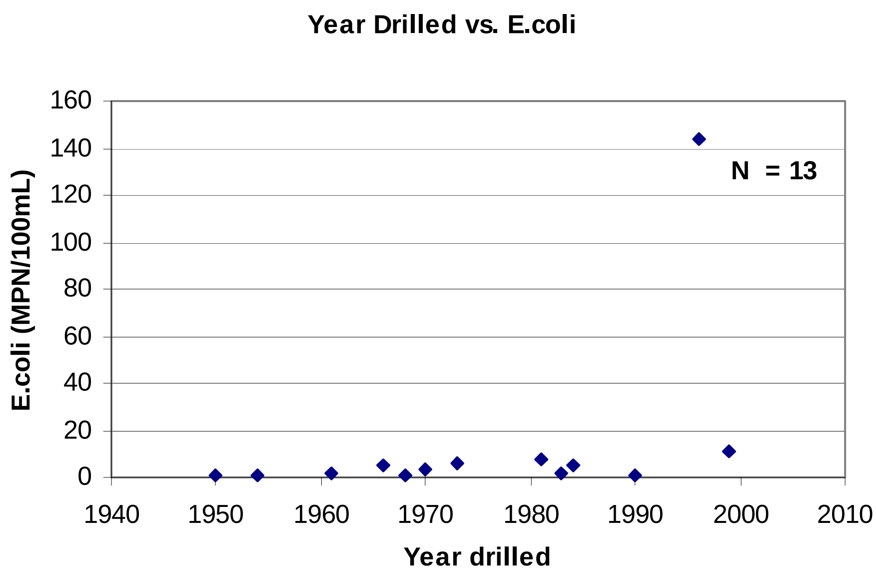

Figure 21. Percentage of wells with E. coli by well type.

Overburden depth

Overburden refers to soil, gravel, sand, silt and clay, or combinations of these, lying on top of bedrock. For the majority of wells this was either unknown or not reported. Where there were reports, the majority indicated thicknesses of less than 30 feet. Figure 22 presents summary information based on data from all regions.

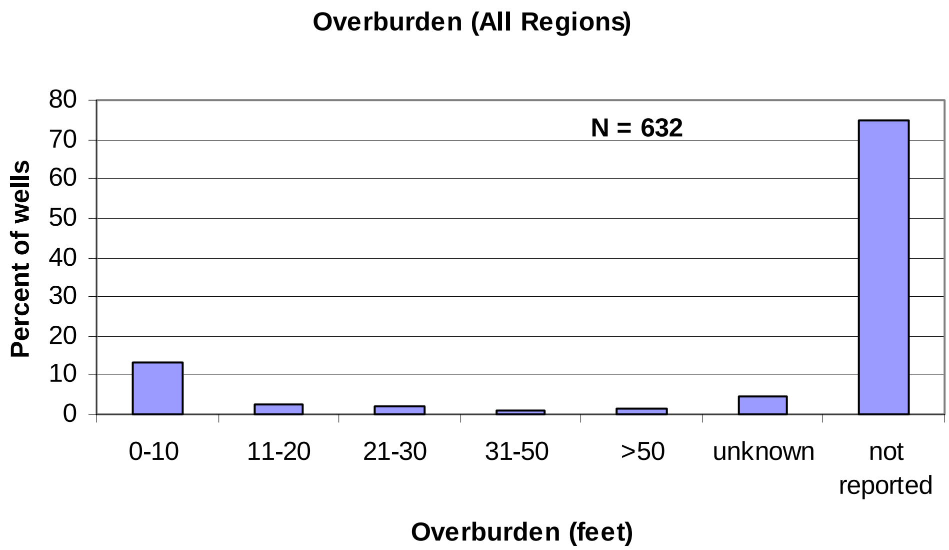

Figure 22. Overburden thickness classes.

Positive Bacterial Tests vs. overburden

The reported information showed overburden thicknesses generally less than 30 feet, but once again the proportion reporting no information was very high. Figure 23 displays overburden vs. average total coliform levels, for wells having data for both variables. The data are not normally distributed, as the overburden layer is typically less than 15-20 feet in thickness across New Brunswick, unless the site happens to be located on a large glacial deposit such as glacial outwash or a major fluvial sand or gravel deposit. It is also likely that self-reported data on overburden thickness may be unreliable. While bearing this in mind, there is some indication of lower bacterial levels with greater thickness of overburden.

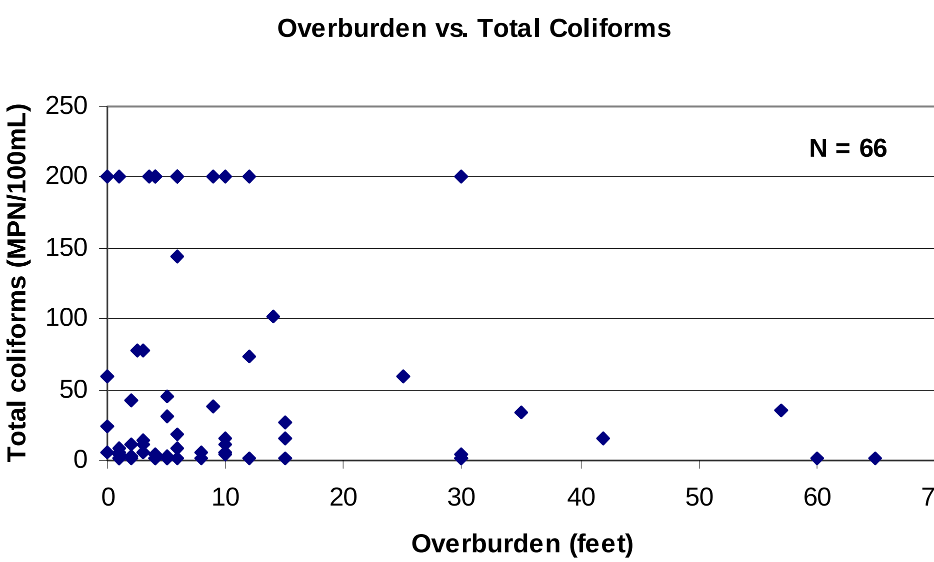

Figure 23. Overburden thickness vs. total coliform concentration.

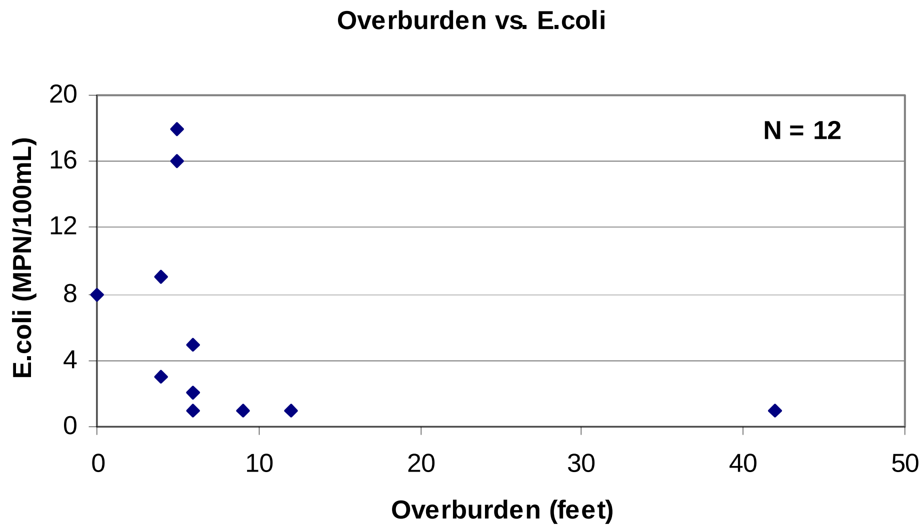

Figure 24 shows the equivalent results for wells contaminated with E. coli. There are few results, but the basic pattern appears similar to that for total coliforms, within the constraints of the sample size.

Figure 24. Overburden thickness vs. E. coli contamination (note: two wells have identical results (6 feet/E. coli = 2) which appears as a single plotted point).

Previous studies

Several previous surveys of domestic wells also provided information on bacteriological test results. In 1984, a study of approximately 300 wells was carried out in Carleton county, to investigate possible nitrate and pesticide contamination. This was reported on by Ecobichon, Allen and Hicks (1985). The results showed that over 20% of wells tested positive for coliforms at a level exceeding 10 counts per 100ml, and 31-35% of wells were contaminated with E. coli, using a threshold of 0 counts per 100ml. A similar follow-up study in Victoria and Madawaska counties in 1985-6 found on average 29% of wells tested positive for coliforms (greater than 10 colonies/100 ml) and 10% with E. coli (greater than 0 counts/100ml) (Ecobichon and Hicks, 1986).

Internal studies of private wells were carried out by the NB Department of the Environment in 1989 in Havelock and in 1989-90 in the Chipman area. These unpublished results revealed a positive test rate for coliform bacteria of 15% (54 wells sampled) in Chipman, and 38% (21 wells sampled) in Havelock.

QUESTIONNAIRE RESULTS

Immediately following the completion of the pilot project in June 2001, approximately 25 households were randomly selected in each region from the initial mailing list, and were asked a number of questions relating to the project. Results of the questionnaire survey are summarised in the following figures.

Figure 25 shows summarised responses. Data for all regions were considered together for this analysis. Eighty percent of those who were called acknowledged receiving a letter. Of those called, approximately 60% had taken part in the project. The vast majority (over 90%) of those receiving information had found it helpful, and more than 50% indicated that they did not need more information.

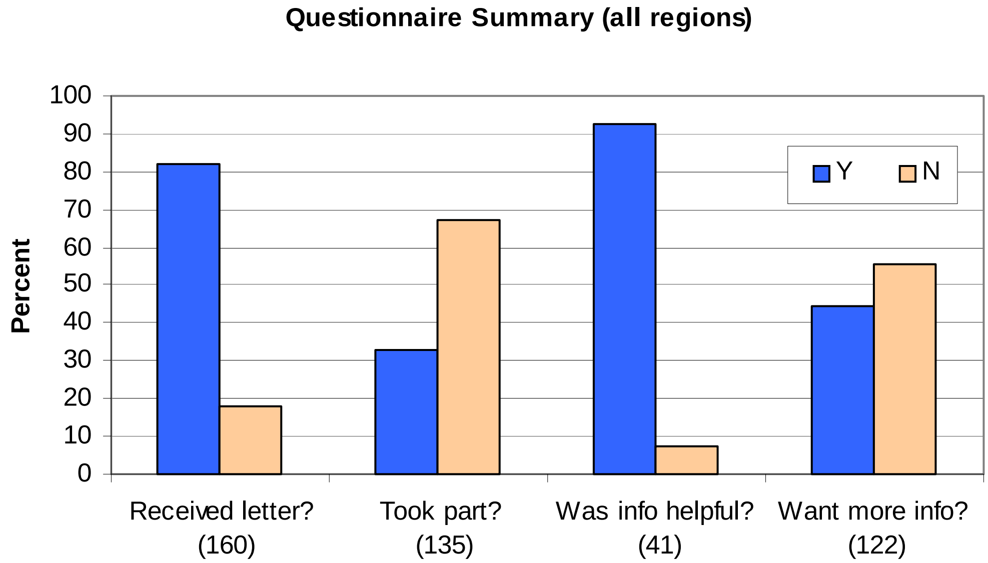

Figure 25. Summary of questionnaire questions.

Figures 26 and 27 display the reasons provided for either participating or not taking part in the project.

The principal reasons for participating were to take advantage of a good opportunity (over 25%), general concern over water quality (about 20%) and for peace of mind (over 15%). Miscellaneous reasons accounted for over 25% of the responses.

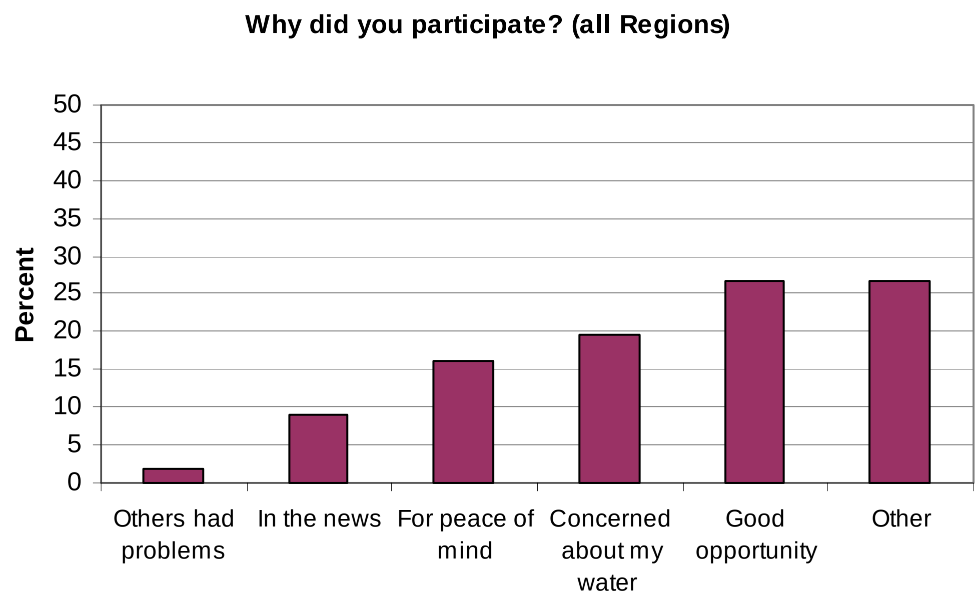

Figure 26. Reasons for participating in the project.

The main category for not participating was “other” or miscellaneous, such as too busy, meant to take part but missed the deadline, forgot, etc. The next most common reason was the cost (over 15%), believing their water was already good (about 15%), not being available (over 10%) or not wanting to know (8%).

In addition to being asked specific questions, those interviewed were asked for any general remarks, or suggestions for future improvements if the project were repeated. These comments are reproduced in full in Appendix I.

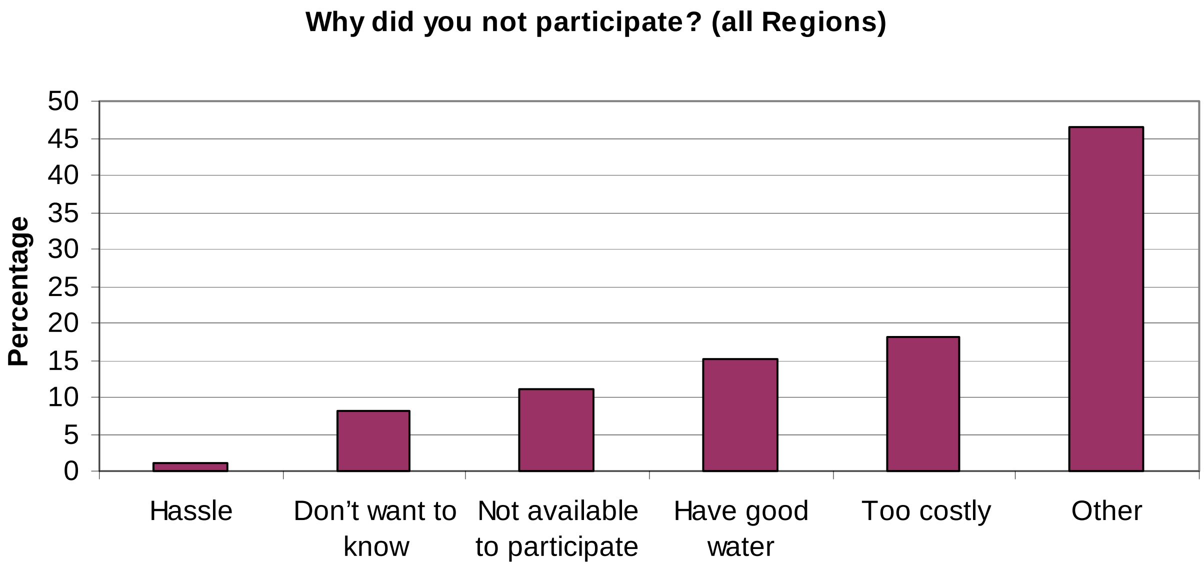

Figure 27. Reasons given for not participating in the project.

DISCUSSION

Participation

Public response to the 2001 Pilot Project was relatively good in regions 1-5 but poor in region 6. It was apparent that participation was variable during the period of the project, and increased significantly following media reports that a notable proportion of homeowners were experiencing adverse test results. The print media followed this project closely and the Fredericton-based Daily Gleaner also ran their own testing program, the results of which were similar to those presented in this report. This helped to generate and maintain awareness in areas where the Gleaner is read.

Variation in participation rate may be due to many factors, including the effectiveness of local media and information dissemination in each region, local experiences with water quality problems, variation in the local perception of risk and importance of water testing, and to some extent the logistics in each area in terms of distances to the drop-off depots.

PID numbers

Not everyone taking part in the project provided their PID number. This is a number that may not be readily at hand for many people, and not one they use very often. Nevertheless the PID number is the primary identifier for a property parcel and is of great value in terms of data analysis, especially for mapping purposes. The absence of a PID number considerably lessens the value of any data gathered. However, even a PID number is limited in precisely locating something like a well borehole, and a more accurate georeference is desirable. On large land parcels a PID number gives only a crude indication of the location of a well.

POSITIVE BACTERIA TESTS

Total Coliforms

The percentage of wells testing positive for coliform bacteria (44%) was similar in this project to that found in earlier studies in other parts of New Brunswick, and suggests that, on average, approximately one third or more of private wells may be affected by total coliforms at one time or another. Although the study regions were not selected in a completely random manner, and may not be representative of the province as a whole, the results were in broad agreement with those from other studies.

E. coli

The overall contamination rate with E. coli was also broadly similar to that found in earlier studies. The variation between regions was significant, for example the number of samples in regions 3 and 4 was sufficient to show a meaningful difference in the number of wells affected by E. coli, with Region 3 having over 10 times as many wells E. coli positive than Region 4. However, there is insufficient supporting information to speculate meaningfully on the causes for these differences. The other regions showed less dramatic differences from a mean of 7%.

The level of information gathered in the present project was not detailed enough to provide clear indications of contamination pathways. However the results did show some probable links between the type of well construction used and the presence of coliform bacteria. This is what would be expected, knowing that sources open to the atmosphere such as surface waters and springs are much more liable to be affected by surface runoff, animal droppings or other biological contact.

Casing Depth

The results indicated that the most common depth of well casing was 20-39 feet, although a wide range of other depths was reported. As for wellhead location (above/below ground), the most instructive finding of the survey was once again the high proportion (over 50%) of those taking part in the project who either did not know, or who did not supply any information. In some regions the proportion reporting no information was over 80%.

Positive Bacteriological Tests and Casing Depth

It is not possible to determine whether the average coliform count with shallower casings was higher than that with deeper casings, due to the upper limit of the coliform test at 200 MPN/100ml, which prevents calculation of the true average. However, if the results exceeding 200 MPN/100ml are omitted, there is still no clear indication that deeper casings result in lower coliform counts. This suggests that the pathways by which coliforms enter the water supply are not effectively blocked by the well casing.

If there is no grout or waterproof seal filling the annular space between the casing and the borehole at the top of the well, surface runoff or seepage can enter the borehole and run down until it reaches the water table, mixing with the water in the bore. Coliforms transported in water moving through larger voids in the overburden layer or through fractures in bedrock could enter the borehole at some depth below the surface and in a similar manner enter the well outside the casing, ultimately contaminating the water reserve in the well. The results of this project suggest that this kind of contamination is quite common.

The results of E. coli contamination examined against well casing depth appeared similar to those for total coliforms. Although the number of data points for both positive E. coli results and information on casing depth was relatively small (23), once again there was no clear trend for deeper casings to significantly affect the probability or degree of contamination by E. coli. Also, the data do not provide a uniform spread for comparison - the majority of wells feature the 6 m /20 foot minimum casing depth, with few deeper than this. Contamination pathways would be the same as discussed above for total coliforms.

Overburden

The proportion of homeowners reporting no information about overburden was very high. This is a further indication that the majority of property owners have few details at hand concerning their wells (such as a well log, which records the major soil, sand, gravel or rock layers found when the well was drilled) or that they did not understand such a log, could not find it, or did not think of looking for it to answer this question.

Well age

Consideration of coliform results versus well age showed that positive tests can occur in a well of any age. The most important finding from the data is that a relatively new well (less than 10 years old) may still be contaminated with coliforms.

For the wells showing contamination with E. coli, the conclusion was similar to that for total coliforms: contamination occurred in wells of all ages. The highest contamination with E. coli was found in a well drilled in 1996.

These results may be considered in relation to the findings on the effect of casing depth. If the casing does not provide an effective barrier to contamination with typical construction methods, and if the contamination route is surface or near-surface infiltration, then it follows that a newer well may not necessarily offer greater protection, as such infiltration may occur relatively quickly.

Wellhead above/below ground

Although it has been standard practice for the majority of wells installed in the past 15-20 years to have the well casing extend above the ground surface, many wells exist where the wellhead is below grade. This installation is common in conjunction with jet-type pumps, whereas submersible pumps are usually used with above-ground casing installations. Variations in local well drilling preferences and practices may explain why the proportion of above/below ground installations was not constant across the province (e.g. below ground predominated in region 2, while above ground was dominant in regions 3 and 5). It must be borne in mind that this project focused on specific communities within each region, and there may be local effects at such a scale. As such, extrapolation of the results to the entire province is not justifiable.

The main finding in terms of this variable was the high proportion of people who reported they did not know whether their wellhead was above or below ground. This is quite surprising given that this is a visible aspect of the well design, but it underlines a basic truth about private wells, that many homeowners are poorly informed about their wells and water systems.

Although it would be expected that below-ground wellheads would be more at risk of contamination than those extending above ground, the data from this project did not support this.

The well casing extending above ground design may not be as superior as expected to below-ground installation for several reasons. With the above-ground design, the pipe-ground interface is at the surface, where freeze-thaw activity and other thermal effects can produce a gap between the pipe and surrounding soil, via which runoff can easily pass. Once established, such a conduit for water may become enlarged through erosion, creating a preferential flow channel into the borehole. Secondly, the exposed wellhead is more at risk from tampering than one located below the surface.

Exposure to sun, the atmosphere and elements will degrade the seals more rapidly above ground. Insects can also more easily gain access to the well. The wellhead is also at risk of impacts from vehicles, and such an impact could create a funnel or channel for runoff in the ground if the pipe is dislodged sideways. Animals such as dogs are attracted to objects such as a wellhead, and may defecate close by, greatly increasing the risk that live bacteria may gain access to the well. Sometimes dogs are even tethered directly to well heads.

There are drawbacks to below-ground siting, including a possible lack of air supply to balance the negative pressure produced when water is pumped from the well, which could lead to surface water being sucked into the bore; difficulties if maintenance is needed, and risk of contamination by soil when the wellhead is opened. Another obvious drawback of this design is simply not knowing where the well is. However, the results of this project indicate that in routine use, the rate of positive coliform tests to be expected with a below-ground installation is not greater than if the casing extends above ground, and may in fact be less. Data on contamination with E. coli were also consistent with this finding.

Questionnaire Results

Participation

Although all of those phoned were sent an explanatory letter about the project, approximately 20% replied that they had not received one, suggesting that this proportion of letters had either been overlooked, lost, not read or were for some other reason not recalled by the respondent.

Although all those called were on the mailing list, it was not known at the time of the call how many had chosen to participate. Sixty-seven percent, or two-thirds of those who were interviewed said they were taking part. This was a relatively high participation rate, assuming this is representative of the study as a whole.

Reasons for taking part

The principal reasons cited for taking part were concern over water quality, that it represented a good opportunity, or other unspecified reasons. The convenience factor was rated higher than concern over water quality, but it can be assumed that however convenient the system may have been, a person would not bother taking part if they had no interest in the results. This same link can be made with the "peace of mind" option. Wanting peace of mind (indicated by over 15% of respondents) also implies concern about water quality. Taken together, the survey results clearly indicate that those taking part were concerned about their water quality and appreciated the convenience of the project.

The fact that the issue was "in the news recently" apparently had little effect, according to the survey results. It was rated a lesser factor in all regions relative to the other choices. "Others had problems" was rated the reason for taking part by the smallest number of those responding, and either implies that there was little awareness of neighbours or others experiencing positive bacterial test results, or little concern, even if the awareness were there.

Reasons for not participating

The most frequently given reasons for not taking part fell into the "other" or unspecified category such as "not enough time" or "forgot". If we consider those all as "neutral" reasons, i.e. not involving a definite decision against taking part, the major reason involving a definite decision for not participating was cost, noted by over 18% of those responding.

A similar percentage stated they "had good water" already, but it was unknown in this instance whether in fact tests had been done recently or whether this answer was based on any data. The smallest percentage said that they "did not want to know", which could mean either a genuine lack of interest or indifference to water quality, that they were convinced their water was good and therefore did not need testing, or that they feared the implications of an adverse test result.

Broader examination of the questionnaire results revealed that even among those taking part in the project, who could be assumed to be reasonably motivated, the comments sometimes suggested that homeowners felt it was not their responsibility to test their water. Linked to this was the perception that the tests cost too much. This raises questions over the perception of who is responsible for water quality in rural areas, and the (perceived) value of test results.

It might seem intuitive that people would be willing to pay even a significant cost to check the quality of their water, which is of fundamental value to their health. However, the feedback obtained indicates that cost is a concern, and in some cases a deterrent, to having water supplies tested. Possibly the fact that it was "the government" coming forward to invite tests in the first place made people feel that this is a “government issue”. They may have formed the opinion that if government is managing testing programs like this one, it should be assuming primary responsibility for making sure all rural domestic water wells are tested. In other words, the perception of responsibility may have been in the past, and during this project, coloured by the fact that a government department was the initiator.

There are possibly some other grounds for this confusion over roles and responsibilities in terms of domestic wells. The government has developed specific water well legislation (the Water Well Regulation and Potable Water Regulation) to regulate how wells are constructed, requiring the tagging and numbering of new wells, and requiring well drillers to submit records. The well tag carries the provincial government logo. This reinforces the fact that government is directly involved with domestic wells. However, individual homeowners are fully responsible for maintaining, repairing, operating and testing such wells once they are built. Perhaps these other visible aspects of government involvement lead to the persistent belief on the part of well owners that some of these key responsibilities lie with the government.

Information provided

The responses to questions regarding the usefulness of information provided were very positive, suggesting that the existing literature is appreciated and helpful. The almost even split on the follow-up question “Do you want more information?” suggests that many people felt they had all the information they needed, but a similar proportion wanted even more.

CONCLUSIONS

The pilot project was successful in inducing a significant number of rural property owners to have their water tested. The results obtained were broadly similar to those found in several previous studies of domestic water quality in other parts of the province and indicate that approximately one third of rural water supply wells can be expected to be contaminated with total coliforms, and approximately 5-10% with E. coli.

Other conclusions:

- Participation in the project varied significantly between regions;
- Coliform and E. coli bacteria were found in wells of all ages, being observed in both newer and older wells;
- In this survey, deeper well casings did not clearly provide significantly greater protection against coliform bacteria than shallower casings. More data would be needed to determine if this is a significant result.
- Having the wellhead above ground did not result in a lower probability of coliform bacteria entering the well, or lower bacterial counts, when bacteria are present;
- The category of water source with the lowest positive test rate for bacteria was found to be drilled wells. The highest positive test rate was seen in springs and surface water sources, with dug and driven wells intermediate;
- Many homeowners were poorly informed about their wells, often revealing they did not know even basic features such as the location of the wellhead above or below ground;
- Many of those taking part expressed their appreciation and support for the project;
- The participation rate was significant (over 28% of those invited to take part did so);
- Property owners frequently indicated that they believe responsibility for testing their water lies with the government. This appears to be part of a broader issue of confused perceptions over who is responsible for the management of private water supply systems;
- The cost of water quality tests was seen as a concern by some of those taking part in the project;
- Raising public awareness of domestic water quality was one goal of the pilot project, and it seems fairly certain that those who took part became better informed about their wells and associated issues.

MORE INFORMATION

For more information about your well, domestic well water quality or related issues, please contact the Sustainable Planning Branch of the Department of the Environment and Local Government at (506) 457 4846. You may also contact the Regional Water planning Officer in the Regional office nearest you:

DELG Regional Offices

Bathurst: telephone (506) 547 2092;

Miramichi: telephone (506) 778 6032;

Moncton: telephone (506) 856 2374;

Saint John: telephone (506) 658 2558;

Fredericton: telephone (506) 444 5149;

Edmundston-Grand Falls: telephone (506) 473 7744.

The following information brochures are available from any DELG office.

Facts on water. Describes water testing, what is tested, what to do if you are drilling a new well, testing fees, and responsibilities of well drillers.

Your well water, a safety checklist. Explains how to look after your well, how to collect a water sample, and how to interpret test results.

How to chlorinate your well water. Explains in detail the procedure to use if chlorination is recommended to treat a domestic well for bacterial contamination.

All About Your Well. Information brochure produced by the New Brunswick Environmental Industries Association. Available on-line at: http://www.nbeia.nb.ca/pdf/etfe.pdf

A variety of information on water quality is also available on the DELG web site:

http://www.gnb.ca/0009/0003e.asp

Testing your water:

If you want to get your water tested, contact your nearest DELG regional office. The staff will advise you on the most convenient and appropriate approach to take.

APPENDIX I: QUESTIONNAIRE COMMENTS

Region	Questionnaire - General Closing Comments and Suggestions
1	• Hopefully there will be one next year. • Hours (hours were limited). • Is satisfied with the project. • All of Martin St. residents are on town water supply (Beresford). • Samples are a bit expensive. • Good idea.
2	• Make it free it would be better! • Should have been a reduced cost. In letter should have mentioned about social assistance because some people when reading the letter, with the cost would not follow up on it (would not call to find out if there was a special program for them). • Enjoyed the seminar, thought presentation very worth while and very well done. • Thinks it's a good idea for people to have the opportunity to get water tested again. • Good idea if everyone in area could get water tested (should get water tested). Maybe looking towards water system in Sunny Corner • Wish more people would get water tested. Should be aware of it. Nothing more important than health.
4	• The cost is too much. • Cost is too much, he pays enough taxes as it is… • If the DOE is encouraging people to participate in the project, they shouldn't charge them for having their water tested. • Would've like to have more information on other tests e.g. general chemistry. • Pleased with service. • Satisfied with service. • Would've like to have more information on other test such as general chemistry tests (and uranium). • Would've like to have water tested for general chemistry and bacteria for a lower cost. • Satisfied with the service. • Hoping that the test would include the general chemistry testing. • The cost for water testing was an issue. Advertising from media was misleading, it didn't mention that there was a cost to have water tested. • It was great! • Should have more information sessions during fall, when people are less busy.

Region	Questionnaire - General Closing Comments and Suggestions
5	• Does not understand why it's not free. Someone should go around every year and test everybody's water. • Would test if it was no charge. • Should have some sort of program for people who can't pay for the test. • Should not have to pay to get the water tested. If it was free he would have tested. • Location at the Community Centre was a good idea because it's close but the timing for them was bad. They have the bottle and information and are planning on testing after • Planning on testing water this week because of relatives and neighbours bad results. • Finds the price too high if everybody in the province tests their water. • Would not have tested if she had not gotten a letter, the Community Centre was very convenient. Price was not an issue. • Send out reminders to people so we won't forget to test the water (every year). • Very convenient. • Project was a good idea and the weekends and evenings make it very easy to participate. When people work from 8-4:30 it's hard to find the time. • More contact between ELG and Health as to the results given to the public. • Waiting one month for results then given the boil order for 2 total coliform is not acceptable. • Very good project and should continue to be available in the years to come. The cost for him was not an issue but he was concerned about the others that can't afford it. • The price should be lowered.
3 and 6	• Costs too much. Offer the analysis free. • Give the correct address in the letters. Disappointed, as we thought the price was only for the follow-up sample. • Do not charge for the tests. • Can you offer well water sampling free? • Don't make a charge for the project.

APPENDIX II: CANADIAN DRINKING WATER GUIDELINES

Canadian Drinking Water Guidelines		
Substance	Guideline (mg/L)	Type of guideline
Total coliform bacteria	0 (if 1-10, re-sample)	MAC
E.coli	0	MAC
pH	6.5 - 8.5	AO
Turbidity	≤ 5 NTU	AO
Colour	≤ 15 TCU	AO
Barium	1	MAC
Cadmium	0.005	MAC
Lead	0.01	MAC
Manganese	≤0.05	AO
Chromium	0.05	MAC
Selenium	0.01	MAC
Copper	≤ 1.0	AO
Iron	≤0.3	AO
Sodium	≤ 200	AO
Zinc	≤5.0	AO
Antimony	0.006	IMAC
Arsenic	0.025	IMAC
Boron	5	IMAC
Sulphate	≤ 500	AO
Nitrate	45	MAC
Chloride	≤ 250	AO
Fluoride	1.5	MAC
Bromide	0.01	IMAC

Notes: MAC = maximum acceptable concentration.
IMAC = interim maximum acceptable concentration.
AO = aesthetic objective.
≤ means less than or equal to.
mg/L = milligrams per litre. One milligram equals one thousandth of a gram.
TCU = true colour units. NTU = nephelometric turbidity unit.
The units for total coliform and E. coli bacteria are number of colony forming units per 100 mL.

(Reference: Environmental Health Directorate, Heath Canada, 1999)

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