

**Summary Report of 1982-84 studies on the
Incidence of Legionella in (A) Canadian
Environmental Waters and (B) Water
Distribution Systems within Public and
Private Buildings**

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Management Perspective

This report summarizes a three year study on the distribution patterns and densities of Legionella organisms in Canadian surface waters and the occurrence of the organism in water distribution systems in private and public buildings within Canada. The study concludes that Legionella organisms are endemic to our fresh water at very low levels and to many potable water systems at variable concentrations levels. The suggested mechanism of contamination of potable distribution systems is by occasional passage of Legionella organisms through water treatment plants followed by proliferation in the more supportive and less stressful environment of potable distribution systems and cooling towers.

The results of this study should not be construed as alarming. The presence of the organisms in the natural environment and distribution systems does not imply a health hazard and no management action for the bulk handling of water to control the organism is required at this time. Although this is the first report of Legionella organisms being widespread in Canada, previous widespread distributions have been reported in countries with more moderate climates.

**SUMMARY REPORT OF 1982-1984 STUDIES ON THE
INCIDENCE OF LEGIONELLA ORGANISMS IN (A) CANADIAN
ENVIRONMENTAL WATERS AND (B) WATER DISTRIBUTION
SYSTEMS WITHIN PUBLIC AND PRIVATE BUILDINGS**

by

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ABSTRACT

This report summarizes a three-year study on the distribution patterns and densities of Legionella organisms in Canadian fresh waters and in water distribution systems within private and public buildings across Canada. The findings of this study lead us to believe that Legionella organisms are endemic to our fresh waters at very low levels and many potable water systems, where concentrations vary greatly.

The report suggests that the contamination of potable water supplies by Legionella organisms probably occurs through the occasional passage of Legionella organisms through the water treatment plant and then settles in a supportive less stressful and probably less competitive environment within potable water and cooling tower systems. Then when conditions are favourable for their proliferation, massive population increases and aerial contamination occurs. From current experience, colonization of a water system with Legionella does not imply a health hazard, but the converse is true: where an outbreak occurs, colonization with the organism is likely to have occurred.

RÉSUMÉ

Ce rapport résume une étude de trois ans sur les schémas de distribution et les masses volumiques des organismes Legionella dans les eaux douces et les réseaux de distribution de l'eau d'alimentation des édifices privés et publics du Canada. Les résultats de l'enquête indiquent que les eaux douces canadiennes contiennent toutes de très faibles quantités de Legionella et que leur concentration dans les réseaux d'eau potable varie considérablement.

Selon le rapport, la contamination de l'approvisionnement en eau potable par la Legionella peut se produire lorsque les organismes passent dans les usine de traitement des eaux et prolifèrent ensuite dans l'environnement plus favorable et moins menaçant des réseaux de distribution et des tours de refroidissement. Puis, lorsque les conditions sont propices à la prolifération, la population des organismes augmente de façon considérable et la contamination de l'air peut alors survenir. D'après les résultats de l'expérience dont il est ici question, la présence de colonies de Legionella dans les réseaux de distribution de l'eau ne comporte pas de risque pour la santé, mais l'inverse est vrai : lorsque des cas de la maladie se déclarent, ils ont en général été précédés d'une prolifération des organismes.

Management Perspective

This report summarizes a three year study on the distribution patterns and densities of Legionella organisms in Canadian surface waters and the occurrence of the organism in water distribution systems in private and public buildings within Canada. The study concludes that Legionella organisms are endemic to our fresh water at very low levels and to many potable water systems at variable concentrations levels. The suggested mechanism of contamination of potable distribution systems is by occasional passage of Legionella organisms through water treatment plants followed by proliferation in the more supportive and less stressful environment of potable distribution systems and cooling towers.

The results of this study should not be construed as alarming. The presence of the organisms in the natural environment and distribution systems does not imply a health hazard and no management action for the bulk handling of water to control the organism is required at this time. Although this is the first report of Legionella organisms being widespread in Canada, previous widespread distributions have been reported in countries with more moderate climates.

Perspective-gestion

Ce rapport résume une étude de trois ans sur les schémas de distribution et les masses volumiques des organismes Legionella dans les eaux de surface canadiennes et la fréquence de ces organismes dans les réseaux de distribution de l'eau d'alimentation des édifices privés et publics au Canada. Selon les résultats de l'enquête, on trouve de concentrations très faibles de Legionella partout dans les eaux douces canadiennes et diverses concentrations dans un grand nombre de réseaux d'eau potable. Le rapport avance que les réseaux de distribution peuvent être contaminés lorsque les organismes passent dans les usines de traitement des eaux et prolifèrent ensuite dans l'environnement plus favorable des réseaux de distribution de l'eau potable et des tours de refroidissement.

Il ne faudrait pas être alarmé par les résultats de cette étude. La présence des organismes dans l'environnement naturel et dans les systèmes de distribution ne comporte pas de risque pour la santé. À l'heure actuelle, il n'est pas nécessaire de prendre des mesures de limitation de la Legionella dans le traitement de grandes quantités d'eau. Ce rapport est le premier à signaler la dissémination de la Legionella au Canada, mais on a déjà fait état de cas de prolifération de cette bactérie dans d'autres pays au climat plus tempéré.

INTRODUCTION

Since 1979 there has been an increasing number of scientific papers and reports on the incidence of Legionnaires' Disease Bacillus in a variety of water sources. From the earlier papers (Morris *et al.*, 1979, Politi *et al.*, 1979 and Fliermans *et al.*, 1979) it would appear that the natural habitats of Legionella species are fresh and stagnant waters. In later reports (Tobin *et al.*, 1981, Dufour and Jakubowski, 1982 and Dutka *et al.*, 1984) there is strong evidence that potable and industrial water lines, both hot and cold, are also sites of semi-permanent or permanent Legionella lodgement.

In the fall of 1981, a preliminary survey was carried out by the Microbiological Laboratories Section of the National Water Research Institute, on the incidence of Legionella organisms in the Canadian Great Lakes. Results of this preliminary survey of these Great Lakes' waters indicated that Legionella organisms were present in Great Lakes' waters (Dutka and Ewan, 1983), therefore, it was decided to initiate a national survey on the distribution patterns of Legionella organisms in Canadian rivers and lakes as well as in various potable and cooling tower water supplies. Therefore, to this end in 1982, 221 one litre water samples were collected from Lake Ontario, Ontario and Quebec lakes and rivers (Table 1) as well as a total of 129 water samples from 31 public and private buildings in Central Ontario (Dutka *et al.*, 1983). These buildings were sampled under the premise that since Legionella organisms are present in

relatively clean Great Lakes' waters which are used as potable water sources, they may also be present in potable water treatment plants and thence spread into distribution lines and cooling towers in public and private buildings.

In 1983 this national survey was expanded with water samples being collected from Lake Superior (25 sampling sites), the rivers and lakes of the eastern provinces of New Brunswick (23 sites), Nova Scotia (25 sites), Prince Edward Island (15 sites) and Eastern Quebec (3 sites) (Table 2). To further give this project national scope a total of 32 building were sampled in the following cities: Vancouver, Edmonton, Calgary, Popular River (Saskatchewan), Regina, Winnipeg, St. Catharines, Mississauga, Ottawa, Montreal, Quebec City, Fredericton and Halifax. From the 32 buildings a total of 160 two litre samples were processed for Legionella organisms.

In 1984 the national survey was completed in June with the collection of two-litre water samples from rivers, lakes and hot springs in British Columbia (16), Alberta (14), Saskatchewan (15), Manitoba (16), Northwestern Ontario (13) and North Central Ontario (4) (Table 3). After the completion of the 1984 survey, five extra water samples were collected in September from hot springs in Banff (2) and Radium, B.C. (3).

This report summarizes the results of this three year Canada wide study on the distribution patterns of Legionella organisms.

METHODS

Bacteriological Tests

All water samples (natural, potable, cooling tower or hot springs) collected for Legionella isolation and enumeration studies were treated in the following manner: one or two litre samples were membrane filtered through 0.45 μm (Lake Superior and drinking water), 0.8 μm (cooling tower and samples heavily contaminated with algae) or 0.6 μm (the remainder of the samples) polycarbonate membrane filters. Where turbidity was very high, up to four membrane filters were occasionally required, with two being the usual. The membranes were then placed one face down and the second face up (to ensure that the bacteria could be easily dislodged in the sonication process) in 10 mL boiled tap water in 100 mL sterile capped ointment jars. Where four membranes were required, these were placed as noted above in two jars with 5 mL boiled tap water per jar.

The ointment jars were then placed in a sonic sink for ten minutes to dislodge the bacteria from the surface of the membrane filter and into the water. Then portions of the sonicated sample were removed and acidified with a pH 2 solution containing 0.2 M HCl and 0.2 M KCl. After ten minutes the sample was neutralized to pH 6.9 and 0.5 to 1.0 mL aliquots were plated on all or some of the following media: buffered charcoal yeast extract agar (CCVC) with (Bopp et al., 1981) and without (CCVC-) the addition of cephalothin, colistin,

vancomycin and cyclohexamide, glycine vancomycin-polymyxin B (GVP) agar (Wadowsky and Yee, 1981) and CCVC agar with the addition of 20 µg/ml Mg SO₄.7H₂O (CCVC+) as recommended by Tesh and Miller (1982).

The agar plates were incubated for five days at 37°C. All suspected Legionella colonies were streaked onto CCVC and nutrient agar plates and incubated at 20°C and 37°C for three days. Only colonies appearing on CCVC agar incubated at 37°C and not on any other plates were subjected to confirmation tests as Legionella spp. on the basis of growth, biochemical and immunological characteristics (Feeley and Gorman, 1980).

One variation of the above procedure was made with the 1984 samples. All 1984 samples were treated as related above plus the following: after sonication a four mL aliquot was removed from the capped ointment jars and placed in a sterile test-tube. The test tube of sample was placed in at 50°C water bath for 45 minutes, then removed and 0.5 mL to 1.0 mL aliquots plated on CCVC, CCVC-, CCVC+ and GVP agars or a combination of these agars with CCVC being used for all tests. Incubation and subsequent procedures were the same as detailed earlier.

At selected sites in the maritime and western Canada provinces surveys, the following additional microbiological tests were performed: heterotrophic plate count densities using spread plate procedures (Dutka, 1978); total microbial densities using acridine orange fluorescent microscopy techniques (Rao et al., 1981); total respiring microbial population as estimated by the INT-formazan

reduction microscopic technique (Rao et al., 1984); and Streptomyces densities using membrane filtration procedures and incubation for seven days at 20°C on Starch-casein agar of the following formulation: casein 0.3 g/L, NaNO₃ 2.0 g/L, NaCl 2.0 g/L, MgSO₄.7H₂O 0.05 g/L, CaCO₃ 0.02 g/L, FeSO₄.7H₂O 0.01 g/L, agar 15.0 g/L, cyclohexamide 0.05 g/L and Milli Q water 1 L.

Results

All during our studies on the incidence of Legionella organisms in natural water samples, we were continually plagued with overgrowth problems. One reason for this problem is that viable culturable Legionella organisms appear to occur at the rate of less than one organism per mL of lake or river water (Dutka et al., 1984) while 1 mL of lake water contains approximately 10⁵ bacteria. Thus the acid stress treatment proposed by Bopp et al. (1981) tended to fail with natural water samples.

Realizing that Legionella organisms are fairly commonly found in various hot water systems i.e. shower heads, hot water taps, it was decided to evaluate the efficiency of heat stress to select out Legionella organisms from the rather heavy concentration of natural aquatic flora. To this end several studies were performed to evaluate the effect of temperature stresses (40°C - 55°C) on the various steps involved in the final treatment of water samples prior to plating. We evaluated the effect of putting 1 or 2 mL of sonicated sample into 1

or 2 mL of hot acid (40°C - 55°C) for various periods of time, the effect of heating the sonicated sample for various periods followed by either hot or cold acid stress (conventional ten minutes) and the effect of putting hot or cold sonicated sample into hot acid (40°C - 55°C) followed by hot neutralizer mix (40°C - 55°C). From these various combinations, it was ascertained that the most efficient and least stressful (on Legionella) of the above procedures to isolate and enumerate Legionella spp. from the background flora was to suspend an aliquot of the sonicated sample in a 50°C waterbath for 45 minutes, then plating the sample on the various enumeration media. Typical results are shown in Table 4.

In 1982 a total of 31 commercial and private buildings' water distribution lines and cooling towers were sampled for Legionella organism incidence. Three of these buildings were sampled twice and each of the surveyed buildings had water samples collected from two or more different sites. The results of some chemical analyses, sample and site description are shown in Table 5. From Table 5 it can be seen that approximately 55% of the sites (17 out of 31) were positive for Legionella spp. Table 6 summarizes the sites within the buildings which were positive for Legionella as well as the media from which the organisms were isolated. The densities of Legionella spp. in these samples varied from 60 to 124,000 per litre and comprised five different L. pneumophila serogroups, 1,3,4,5 and 6. The highest overall concentration of Legionella organisms was obtained in the positive cooling tower water samples. For example on

CCVC agar, there were 1,680 organisms/L ($N = 10$) in positive cooling tower water samples whereas there were 1,060 organisms/L in positive potable water samples ($N = 18$) expressed as geometric means. The CCVC agar appeared to be slightly superior (26 isolations) to GVP (19 isolations) in recovering Legionella pneumophila, both in frequency of isolation as well as the number of bacteria isolated. However, since GVP agar occasionally (eight times) recovered the target organism when it was not detectable by CCVC agar, its inclusion in the study proved to be useful.

In 1982 a total of 112 water samples were collected from central and eastern Ontario and Quebec rivers and inshore lake sites (Table 1). Only one sample, collected from the bay approximately 100 metres west of the Carlson Fisheries Dock on Blind River, Ontario was found to contain Legionella. The organism found was Legionella dumoffi at a concentration of 60 organisms per litre on GVP agar. Of the 109 offshore Lake Ontario, Erie and St. Clair water samples tested, only three were found to contain viable culturable Legionella. Two of these were surface water samples collected from (a) between Wolfe and Amherst Islands off Kingston (Lake Ontario) which contained L. pneumophila serogroup 1, 60/L on GVP medium and (b) the Toronto harbour area (July 12, 1982) which contained L. pneumophila serogroup 5, 250/L on GVP medium. A depth sample (14 metres) collected at the same Toronto harbour site on November 19, 1982 yielded 60/L L. pneumophila serogroup 6 on CCVC agar.

In the 1983 Vancouver to Halifax survey of private and commercial buildings' cooling tower waters and water distribution systems for Legionella organisms, it was found that buildings in the following cities were positive for Legionella organisms: Vancouver, Calgary, Regina, St. Catharines, Mississauga, Ottawa, Montreal and Halifax (Table 7). For information, chlorine levels and other chemical and physical analyses of the water samples are presented in Table 7. The repeated sampling of four sites within a Mississauga and St. Catharines Ontario, building, confirmed 1982 studies which showed the presence of Legionella organisms in these buildings. Only two samples were positive for Legionella in the Mississauga building, both from the cooling tower sump, one collected in August and the other in September. The organism isolated from these cooling tower water samples was L. pneumophila serogroup 6, the same serogroup isolated during the 1982 study. In the St. Catharines building an unusual feature was noted in that all five samples collected from a cold water tap over a three month period were found to contain L. pneumophila, serogroup 1. Two of the St. Catharines cooling tower water samples were also positive for L. pneumophila, serogroup 1 while a shower sample produced a L. pneumophila with a serogroup 1-3 cross reaction. The majority of positive Legionella isolations from other cities were from cooling tower samples. The only other sampling cites positive for Legionella were shower facilities in Regina and Ottawa.

The concentration of Legionella organisms, their identification and the media from which they were recovered in this cross-Canada city survey are presented in Table 8. In this table it can be seen that Legionella concentrations varied from 30/L to 45,000/L (shower). In comparing which medium and media combination produced the most frequent number of Legionella isolations, it was found that GVP (12) and CCVC+ (11) were the most productive individual media; and when the following three media combinations were compared; CCVC and CCVC+, CCVC and GVP and CCVC- and GVP it was found that the CCVC+ and GVP media combination produced 18 of the 19 isolations, CCVC and GVP produced 15 of the 19 isolations and the combination of CCVC and CCVC+ only produced 12 positive Legionella isolations.

The location of the 25 sampling stations in Lake Superior which were sampled for Legionella organisms in 1983 are shown in Figure 1. A total of four sampling cruises were carried out on Lake Superior and on three of these cruises, Legionella organisms were found, each time at a different station: station #187, northeast of Ashland, Wisconsin (June), Legionella spp.; station #50, northeast of Munising, Michigan (September) L. pneumophila serogroup 1; and station #135 at the mouth of Black Bay east of Sibley, Ontario Provincial Park (November) L. pneumophila serogroup 6.

Also shown in Figure 1 are the other sampling sites from within the Canadian Great Lakes where Legionella organisms were previously isolated: (a) between Wolfe and Amherst Islands off Kingston in Lake Ontario (July 1982); (b) Toronto Harbour, surface and

14 metre depth samples (July and November 1982) (c) Lake St. Clair (September 1981) and (d) Georgian Bay (September 1981). The concentrations of these Legionella organisms isolated and the medium from which they were isolated are presented in Table 9. Here it can be seen that CCVC medium as compared to GVP medium agar was the most productive medium (see Table 6). However, as also seen in Table 6, the media tend to complement each other by isolating Legionella organisms from samples where the other medium had failed to do so.

The 66 water samples collected from the three maritime provinces and eastern Quebec in 1983 all were negative for Legionella organisms by the isolation and enumeration technique used. However, during this study at selected stations other bacteriological baseline data were collected in hopes of correlating positive and negative Legionella isolations with various bacteriological parameters. These data, for reference only, are presented in Table 10.

Of the 83 water samples collected during 1984, from the western provinces and northwestern and central Ontario lakes, rivers and hot springs, only three samples were positive for Legionella by culturing techniques and two solely by serological techniques. All of these positive samples were associated with hot springs (Table 11). During the original survey of western Canada, only the hot springs at Harrison and Fairmount were sampled and from these two samples, a positive isolation of Legionella pneumophila serogroups 1 and 4 was found at Fairmount. Because of this finding, five other hot spring

samples were collected later, three from Radium, B.C. and two from Banff, Alberta.

Four of these five samples showed signs of Legionella organisms, two by culturing techniques and two by serological techniques (Banff). In one instance, Radium Hot Springs, a sample (Table 11) from the container which collects the hot water out of the rock fissure, was found by culturing techniques to have 20 Legionella pneumophila serogroup 1 per litre and yet serological tests on the water failed to show any signs of Legionella. Usually the literature records the reverse set of events.

In testing the five extra hot spring samples, a modified CVCC+ medium was also evaluated. This new CVCC+ medium (CCVCA) contained an additional 0.08 g/L cyclohexamide and 0.002 g/L Terremycin, and in one instance, Radium Hot Springs, sample no. 891, the only Legionella cultured was on this modified medium. In Table 12 are presented, for information only, some microbiological data from selected stations in this western Canada survey.

Further studies are being carried out on the serological presence of Legionella organisms in some of the western Canada water samples that were negative by culturing techniques.

DISCUSSION

The results of our four year environmental sampling programme would indicate that culturable levels of Legionella organisms are not readily found in Canadian waters. In 1981 and 1982 studies, only one sample was found positive out of 112 water samples collected from Quebec and Ontario lakes, rivers and inshore waters of the Canadian Great Lakes. In addition only three samples were positive in 109 offshore samples in Lakes Ontario, Erie and St. Clair. The 1983 survey of the Maritime provinces' lakes and rivers which failed to find any Legionella, would suggest that Legionella organisms are not a major or even a minor part of the aquatic flora in this part of Canada. Also in 1983 of the 100 water samples collected from Lake Superior only three were positive for Legionella and the concentrations did not exceed 270 organisms per litre. The western Canada survey in 1984 failed to find any Legionella organisms in the 76 river and lake samples collected, however five of the seven hot spring samples were positive for Legionella pneumophila serogroup 1 and 4 and serogroup 1-4 by culture and serological techniques.

Aside from the hot spring samples, the authors of this report believe that Legionella organisms are present in some or many of the environmental waters tested, but at levels which are not detectable by the techniques used. The culturing techniques used, all seem to work on a hit-or-miss type of response, but none of them are able to sufficiently suppress background growth which, in many

instances, at the suspected Legionella concentration present, overgrows the agar medium. Then, when dilutions are made to solve the overgrowth problem, the few viable Legionella organisms which might be there are diluted out. Thus, in most instances, the finding of Legionella organisms in a water sample is like trying to find a needle in a haystack; you know it is there, but where.

It is assumed that the success we have encountered with hot spring samples, as well as hot water tap and cooling tower samples, is due to the heat of the samples which tends to reduce the normal background heterotrophic bacterial populations encountered in natural water samples. Thus these heat stressed samples give the media and selective techniques a better chance to isolate and enumerate the Legionella organisms present.

Other important factors which play a role in Legionella isolation are the stresses on the organism due to membrane filtration, sonic sink and acid or heat treatments. In a previous study by Dutka et al. (1983), it was reported that in pure culture studies, often only 10% or less of the potential population was isolated when the organisms were subjected to membrane filtration, sonic sink and acid stresses. Thus, background flora plus isolation technique stresses are believed to be responsible for the paucity of positive isolations of Legionella organisms from environmental samples. Notwithstanding the foregoing, the results of this study also strongly support the concept that Legionella organisms, when present in natural waters, form only a very minor fraction of the microbial flora.

In contrast with the low frequency of isolation of Legionella spp in the outdoor environment, cooling tower and potable waters in the indoor environment were often contaminated with L. pneumophila. In the Central Ontario, 1982 study of water supplies in various buildings, 27% of the samples contained the bacterium at a concentration of between 60-124,000 organisms per litre. In the 1983 survey of various waters in buildings across Canada, 12% of the water samples tested contained Legionella at concentrations varying from 30 to 45,000 organisms/litre. These samples included hot and cold potable water, water fountains, showers and cooling tower sumps and condensers. All of these waters originate from similar sources (closed system potable water supplies) and the finding of Legionella in so many widely separated distribution systems leads to the conclusion that Legionella organisms are common fresh water bacteria, and can survive potable water treatment processes. They then appear to colonize within the hot and cold water distribution systems of buildings (Tobin et al., 1980 and Tison and Seidler, 1982) without producing overt disease or clinical findings, except in rare instances.

It was observed that only L. pneumophila serogroups 1,3,4,5 and 6 were detected in water samples collected from various buildings during the course of this study. Serogroups 1 and 6 were predominant. It is of interest to note that the same serogroups are those most often detected in clinical specimens in Canada (Bernard and Ewan, unpublished data). This suggests that the frequency of

incidence of these types (1 and 6) as a cause of infection may be related to their predominance in the environment.

The data from this study and the philosophy we hold regarding the sources of Legionella found in water distribution lines (Dutka et al., 1983) are still in agreement with and more strongly support the conclusions of Dufour and Jakubowski (1982) that the main source of Legionella spp contamination is the environment, where they may be present at low (or sometimes high) levels. It is probable that contamination of potable water supplies by Legionella occurs through its occasional passage through the water treatment plant and then settling in a supportive less stressful and probably less competitive environment within potable water and cooling tower systems. Then when conditions are favourable for their proliferation, massive population increases and aerial contamination occurs. From current experience, colonization of a water system with the organism does not imply a health hazard, but the converse is true: where an outbreak occurs, colonization with the organism is likely to have occurred.

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FIGURE 1. 1983 Lake Superior Legionella sampling sites and sites of positive isolations from previous Great Lakes studies.

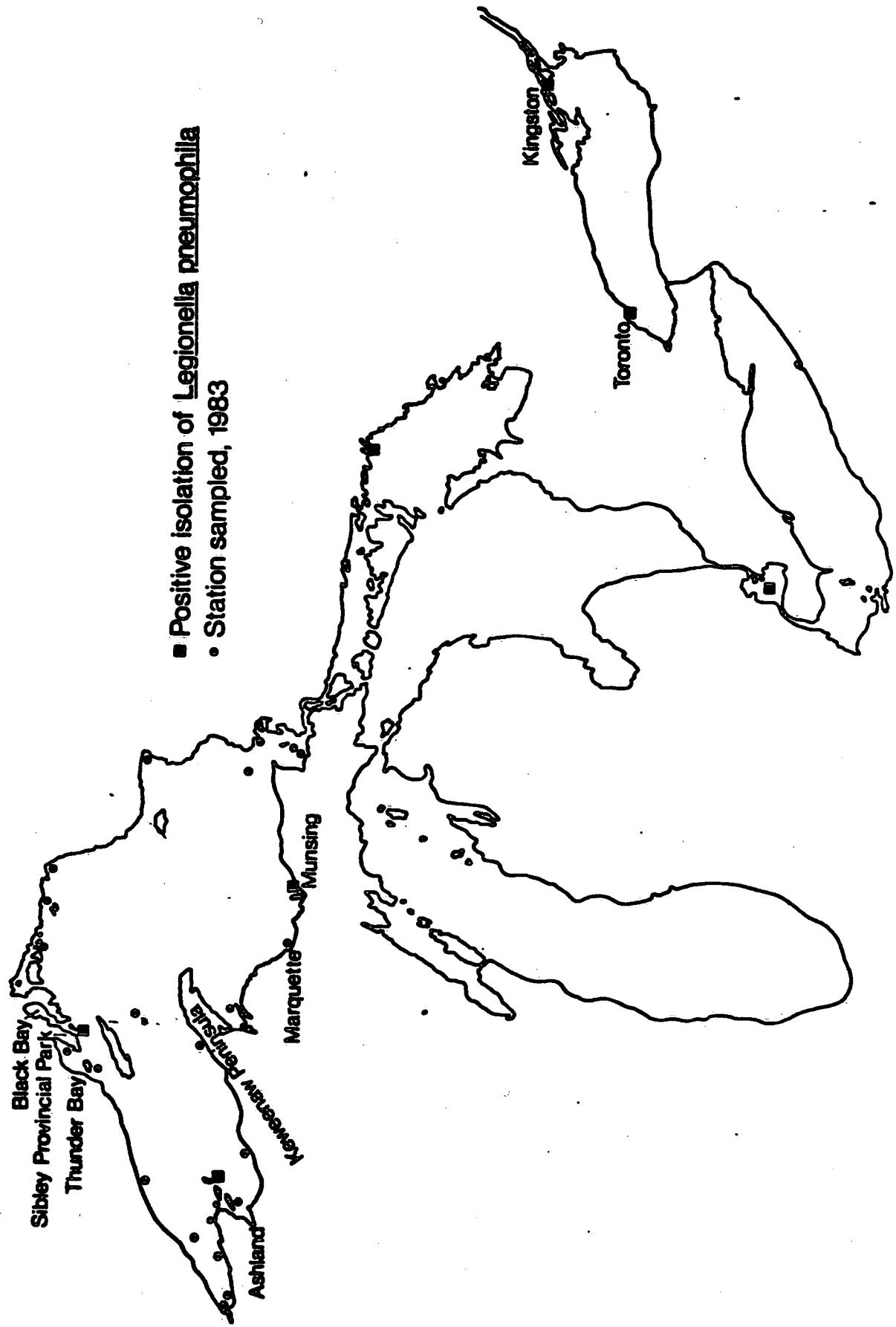


TABLE 1. Ontario and Quebec Legionella Sampling Sites, 1982

Great Lakes Shoreline Samples

Jordan Harbour - Lake Ontario
 Port Dalhousie - Lake Ontario
 Port Weller - Lake Ontario
 Wiarton - Georgian Bay
 Sauble Beach - Lake Huron
 Port Dover - Lake Erie
 Rock Point - Lake Erie
 Cornwall - Lake Ontario
 Prescott - Lake Ontario
 Kingston Mills - Lake Ontario
 Bay of Quinte - Lake Ontario
 Southampton - Lake Huron
 Meaford - Georgian Bay
 Blind River - Georgian Bay
 Thessalon - Georgian Bay
 Bronte - Lake Ontario
 Pt. Edward - Lake St. Clair
 Mitchell Bay - Lake St. Clair
 St. Clair Beach - Lake St. Clair
 Port Stanley - Lake Erie
 St. Joseph Island - Georgian Bay

Streams, Rivers and Canals

Stratford - Thames River
 Richelieu River
 Sorel - St. Lawrence River
 Hawkesbury - Ottawa River
 Courtright - St. Clair River
 La Salle - Detroit River
 Port Colbourne - Welland Canal
 Deep River - Ottawa River

Lakes

Crow Lake	Elliot Lake	Lac Magog
Sharbot Lake	Boulevard Lake	Lac Brompton
Marble Lake	Thunder Lake	Lac la Ronge
Stoco Lake	Plastic Lake	Lac St. Francis Xavier
Moira Lake	Turkey Lake	Cranenest Lake
Barry's Bay	Clearwater Lake	Lower Beverly Lake
Trout Lake	Hannah Lake	Mississippi Lake
Baptiste Lake	Richard Lake	Little Round Lake
Head Lake	McFarlane Lake	Silver Lake (PP)
Gull Lake	Silver Lake	Black Lake (PP)
Lake Dalrymple	Kelly Lake	Maxinaw Lake (PP)
Kahske Lake	Wavy Lake	Bon Echo Lake (PP)
Lake Couchching	Windy Lake	Rice Lake (PP)
Lake Scugog	Lahi Lake	Silent Lake (PP)
Lake Simcoe	Ramsey Lake	Carson Lake (PP)
Lake Muskoka	Lac Champlain	Lake St. Peter (PP)
Lake Nipissing	Lac Brome	Balsam Lake (PP)
Ramsey Lake	Lac Memphremagog	Lake Simcoe (PP)
Lake Timiskaming	Lac Massawippi	

PP = Provincial Park

Little Current - Georgian Bay
 South Bay Mouth - Georgian Bay
 Easterry Beach - L. Ontario
 West Cherry Beach - L. Ontario
 Parry Sound - Georgian Bay
 Cobourg - Lake Ontario
 Kingston - Lake Ontario
 Sandhurst - Lake Ontario
 Cyperus Lake - Georgian Bay (PP)
 MacGregor Pt. - Lake Huron (PP)
 Point Farms - Lake Huron (PP)
 Pinery - Lake Huron (PP)
 Ipperwash - Lake Huron (PP)
 Tremblay - Lake St. Clair (PP)
 Holiday Beach - Lake Erie (PP)
 Wheatley - Lake Erie (PP)
 Rondeau - Lake Erie (PP)
 Long Point - Lake Erie (PP)
 Turkey Point - Lake Erie (PP)
 Sault Ste. Marie - Georgian Bay

Point des Cascades - St. Lawrence R
 Richmond - St. Francis River
 Oka - St. Lawrence River
 Murray Canal
 Port Lambton - St. Clair River
 Amherstburg - Detroit River
 Fort Erie - Mouth of Niagara River

TABLE 2. Canadian Eastern Provinces and Eastern Quebec Legionella Sampling Sites, 1983

Eastern Quebec

St. Lawrence River at Rivière-de-loup
Lac-au-Saumon
St. Lawrence River at Mont Joli

New Brunswick

Lake Temiscouta
St. John River at Edmundston
St. John River at Grand Falls
Skiff Lake
Spednic Lake
Lake George
Magaguadavic Lake
St. John River at Maugerville
French Lake
Grand Lake at Princess Park
Youngs Cove
Washademoak Lake

Belleisle Bay
Kennebecasis Bay
Utopia Lake
Spruce Lake
Little Bear Reservoir
Centennial Park Pond at Moncton
Peticodiac River
Richibucto River
Miramichi River
Nepisiquit River
Restigouche River

Nova Scotia

Wentworth Lake
Pubnico Lake
Goose Lake
Lake George
10 Mile Lake
Cameron Lake
Hebb Lake
Little Mushamuch Lake
Waterloo Lake
Mira River
Baddeck River
Lake Ainslie

Henry Lake
Keamey Lake
Long Lake in Halifax
Lake Banook
Burnt Lake
East Sheet River
Gleneleg Lake
Guysborough River
Loch Lomond
Salt Lake
Harrison Lake

Prince Edward Island

Pisiquid River
Fortune River
Boughton River
Cardigan River
Murray River
Belle River
Vernon River
Lake at Avondale

Bradshaw River
McAugland Pond
Trout River
Ellis River
Pond on Margate River
Pond above dam on Hunter River
Stewarts Pond

TABLE 3. Canadian Western Provinces and Northwestern and North Central Ontario Legionella Sampling Sites, 1984

British Columbia

Pitt River	Nicola Lake
Hayward Lake	St. Thompson River
Fraser River at Mission City	Shuswap Lake
Harrison Hot Springs	Mara Lake
Harrison Lake	Okanagan Lake
Fraser River at Hope	Columbia River at Revelstoke
Stagit River	Fairmount Hot Springs
Similkamen River	Radium Hot Springs
	Windermere Lake

Alberta

Minnewanka Lake	Slough near Bittern Lake
Banff Hot Springs	Pigeon Lake
Bow River at Banff	Cooking Lake
Abraham Lake	Vermillion River at Vegreville
N. Saskatchewan River at Rocky Mt. Howe	Vermillion River at Vermillion
Sylvan Lake	Kenilworth Lake
Gull Lake	Battle River
Buffalo Lake	

Saskatchewan

North Saskatchewan River at Battleford	Mountain Lake
Whiteshore Lake	Katepwa Lake
Saskatchewan River at Saskatoon	Big Quill Lake
South Saskatchewan River	Saskatchewan River, Highway 6
Reed Lake	Tobin Lake
Lake Diefenbaker	Prairie River
Buffalo Pound	Deer River
Wescana Lake	

Manitoba

Steeprock River	Pelican Lake
Swan River	Crescent Lake
Lake Winnipegosis at Camperville	Lake Manitoba
Lake Winnipegosis at Winnipegosis	Red River
Dauphin Lake	Lake Winnipeg at Grand Beach
Clear Lake	Lac du Bonnet
Assiniboine River	Winnipeg River
Souris River	Westhawk Lake

Northwestern and North Central Ontario

Lake of the Woods	Remi Lake
Crow Lake Kettle Lakes	Kettle Lakes
Rainy River at Fort Francis	Lake Timiskaming
Shebandowan Lake	Lake Timagami
Boulevard Lake in Thunder Bay North	Lake Nipissing
Wild Goose Lake near Geraldton	Vernon Lake
Long Lake at Longlac	Muskoka Lake
Nagagami River	Conestoga Lake

TABLE 4. Comparison of the sonication - heat stress enumeration procedure with conventional sonication acid stress procedure to screen out background microbial flora to allow Legionella organisms to grow. Counts reported per mL.

Selection Treatment	No. of <i>Legionella</i> pneumophila serogroup 1		No. of Heterotrophic Bacteria Nutrient Agar
	CCVC Agar	GVP Agar	
No treatment direct plating after sonication	178	90	180
Conventional sonication and acidification	88	75	13
Sonication + 30 min at 50°C	89	99	3
Sonication + 40 min at 50°C	73	80	1
Sonication + 50 min at 50°C	51	76	1
Sonication + 60 min at 50°C	49	53	1

TABLE 5. Legionella incidence in and chemical composition of water samples collected from public, private and commercial buildings in Central Ontario, 1982

Site No.	Site Description	Sample Description	Temp °C	pH	POC mg/L	TKN-N mg/L	Alk /CO ₃ mg/L	SO ₄ mg/L	Fe mg/L	TPN ng/L	Legionella
1 Hospital	Potable water	13	7.8	0.067	0.1	9 ₄	27	0.1	0.011	pos.	
1 Hospital	Cooling tower-condenser valve	14	8.75	0.131	0.2	202	28	1.12	0.015	pos.	
1 Hospital	Cooling tower-chiller valve	30.5	9.0	0.884	6.3	650	275	0.14	0.174	neg.	
1 Hospital	Hot water	47	8.0	0.063	0.1	9 ₄	27	0.1	0.012	pos.	
1 Hospital	Shower	27	7.9	0.095	0.1	88	27	0.1	0.013	neg.	
2 Residence	Hot water	63	7.9	0.078		88	26.6	0.1	0.010	pos.	
2 Residence	Shower	41	7.8	0.103		86	26.6	0.1	0.012	pos.	
2 Residence	Cooling tower-condenser valve	23	9.0	4.15		630	189	0.28	0.250	neg.	
2 Residence	Water Fountain-potable	22	8.0	0.143		85	27.5	0.1	0.020	neg.	
3 University	Water Fountain-potable	22	8.0							neg.	
3 University	Hot water	44.5	8.0							neg.	
3 University	Cooling tower-condenser valve	33	8.8							neg.	
3 University	Shower	28.5	8.1							neg.	
4 Shopping Centre	Cooling tower-condenser valve	25.5	8.75	0.470	0.4	176	77.4	0.1	0.080	pos.	
4 Shopping Centre	Hot water-tap	60	8.0	0.072		8 ₄			0.011	neg.	
4 Shopping Centre	Potable water-cold tap	24	7.95	0.044		8 ₄			0.006	neg.	
5 Hotel	Hot water-tap	50	8.0	0.053	0.2	80	44.1	0.1	0.008	pos.	
5 Hotel	Potable water-fountain	8.5	7.85	0.044		81			0.005	neg.	
5 Hotel	Shower	28	8.0	0.063		80			0.008	neg.	
6 Shopping Centre	Potable water-fountain	17	8.0							neg.	
6 Shopping Centre	Hot water	58	7.75							neg.	
6 Shopping Centre	Cooling tower-condenser valve	33.5	9.85							neg.	
6 Shopping Centre	Shower	18.5	8.05							neg.	
7 College	Hot water	43	8.0	0.039	0.1	82	30.4	0.1	0.005	pos.	
7 College	Cooling tower-condenser valve	32	8.85	0.429		242			0.042	neg.	
7 College	Potable water-fountain	17	7.8	0.057		82			0.006	neg.	
7 College	Shower	38	8.0	0.068		82			0.007	neg.	
8 Hotel	Cooling tower-condenser valve	25	8.8	0.756	1.7	212	74.5	0.1	0.144	pos.	
8 Hotel	Hot water	45	7.6	0.045		80			0.007	neg.	
8 Hotel	Shower	35	7.65	0.083		80			0.010	neg.	
8 Hotel	Potable water-fountain	14	7.55	0.053		80			0.007	neg.	
8 Hotel	Fountain	21	8.55	0.141		110			0.019	neg.	

TABLE 5 (con't) Legionella incidence in and chemical composition of water samples collected from public, private and commercial buildings in Central Ontario, 1982

Site No.	Site Description	Sample Description	Temp °C	pH	POC mg/L	TKN-N mg/L	Alk/CO ₃ mg/L	SO ₄ mg/L	Fe mg/L	TPN mg/L	Legionella
9	Public Building	Potable water-fountain	11	7.6							neg.
9	Public Building	Hot water	44	7.5							neg.
9	Public Building	Cooling tower-condenser valve	18	8.0							neg.
9	Public Building	Fountain	24.5	7.6							neg.
10	Office Building	Potable water-fountain	19.5	7.6							neg.
10	Office Building	Hot water	46	7.6							neg.
10	Office Building	Cooling tower-condenser valve	24	7.5							neg.
10	Office Building	Fountain	37	8.05							neg.
11	Office Building	Cooling tower-condenser valve	24	7.5	1.450	0.6		36	22.6	0.1	0.233 pos.
11	Office Building	Potable water-fountain	13	7.6	0.104			79		0.013	neg.
11	Office Building	Hot water	44	7.6	0.08			79		0.010	neg.
12	Hospital	Cooling tower-sump	27	8.9	0.449	1.1		310	126	0.1	0.078 pos.
12	Hospital	Hot water	42	7.95	0.071			80		0.008	neg.
12	Hospital	Potable water-cold tap	20	7.85	0.081			82		0.010	neg.
13	Shopping Centre	Potable water-fountain	15.5	7.7							neg.
13	Shopping Centre	Cooling tower-Condenser valve	27	8.2							neg.
13	Shopping Centre	Fountain	22	8.45							neg.
14	Hotel	Potable water-fountain	22	8.1							neg.
14	Hotel	Hot water	41	8.4							neg.
14	Hotel	Shower	31	8.3							neg.
14	Hotel	Fountain	21	8.3							neg.
15	Hotel	Cooling tower-condenser valve	27	8.9	1.25	1.2		338	84.2	0.1	0.249 pos.
15	Hotel	Potable water-fountain	18.5	7.95	0.074			83		0.011	neg.
15	Hotel	Shower	32	7.95	0.069			83		0.010	neg.
15	Hotel	Hot water	48	7.95	0.053			83		0.008	neg.
16	Office Building	Cooling tower-sump	30	8.85	0.779	0.9		248	139	0.21	0.113 pos.
16	Office Building	Potable water-fountain	18.5	7.75	0.109			78		0.014	neg.
16	Office Building	Hot water	48	7.75	0.071			78		0.010	neg.
17	Hospital	Cooling tower-sump	29.5	8.95	0.778	1.3		316	134	0.1	0.139 pos.
17	Hospital	Shower	32	7.9	0.113	0.1		78	32.6	0.11	0.016 pos.
17	Hospital	Potable water-fountain	23	7.8	0.139			78		0.022	neg.
17	Hospital	Hot water	41	7.8	0.099			78		0.014	neg.

TABLE 5 (con't) Legionella incidence in and chemical composition of water samples collected from public, private and commercial buildings in Central Ontario, 1982

Site No.	Site Description	Sample Description	Temp °C	pH	POC mg/L	TKN-N mg/L	Alk./CO ₃ mg/L	SO ₄ mg/L	Fe mg/L	TPN mg/L	Legionella
18	University	Cooling tower-sump	36	8.6	0.963	0.5	140	295	0.3	0.119	pos.
18	University	Potable water-fountain	25	7.7	0.066		78			0.009	neg.
18	University	Hot water	34.5	7.85	0.057		78			0.008	neg.
18	University	Shower	28	7.8	0.062		78			0.009	neg.
19	University	Hot water	29	7.8	0.111		79			0.019	pos.
19	University	Cooling tower-condenser valve	26	7.55	1.78	0.3	28		0.1	0.318	neg.
19	University	Potable water-fountain	20	7.8	0.128		79			0.021	neg.
20	Hospital	Potable water-fountain	18.5								neg.
20	Hospital	Hot water	45	8.2							neg.
20	Hospital	Cooling tower-condenser valve	26	8.75							neg.
20	Hospital	Shower	27	8.2							neg.
21	University	Potable water	18	7.85							neg.
21	University	Hot water	40	7.85							neg.
21	University	Cooling tower-sump	19	8.55							neg.
21	University	Shower	20.5	7.85							neg.
22	Hospital (1)	Potable water-fountain	13	7.85	0.056	0.3	87	27	0.1	0.008	pos.
22	Hospital (1)	Cooling tower-condenser valve	25.5	8.85							neg.
22	Hospital (1)	Shower	30	7.85	0.081	0.4	87	29	0.1	0.010	pos.
23	Residence (2)	Potable water-fountain	20	7.85							neg.
23	Residence (2)	Cooling tower-condenser valve	25.5	8.85	0.523	324				0.092	neg.
23	Residence (2)	Shower	21	7.85							neg.
24	Hotel (15)	Potable water-fountain	17	7.8	0.066	0.3	88	29	0.1	0.011	pos.
24	Hotel (15)	Hot water	61	8.0	0.057		89			0.008	neg.
24	Hotel (15)	Cooling tower-sump	31	8.95	2.06	1.3	312	114	0.14	0.011	pos.
25	University	Potable water	11.5	7.5							neg.
25	University	Hot water	64	7.7							neg.
25	University	Cooling tower-condenser valve	30	8.35							neg.
25	University	Shower	39.5	7.85							neg.
26	Office Building	Potable water-fountain	17	7.55							neg.
26	Office Building	Hot water	50	7.95							neg.
27	University	Cooling tower-condenser valve	25	7.75	1.7	1.2	33	1000	0.56	0.308	pos.
27	University	Potable water-fountain	8	7.4	0.022		236		0.001	neg.	
27	University	Hot water	46	7.7	0.025		236		0.001	neg.	
27	University	Shower	33	7.8	0.021		230		0.001	neg.	

TABLE 5 (con't) *Legionella* incidence in and chemical composition of water samples collected from public, private and commercial buildings in Central Ontario, 1982

TABLE 6. Summary of positive isolations and concentrations of Legionella organisms in Central Ontario water samples from public, private and commercial buildings, 1982

Sampling Site	Sample	Organism	Media and Concentration of Legionella/Litre CCVC GVP
Hospital	Potable water-fountain	L. pneumophila Serogroup 6	750
Hospital	Hot water	L. pneumophila Serogroup 1	1100
Hospital	Cooling tower-condenser valve	L. pneumophila Serogroup 1	300
Residence	Hot water	L. pneumophila Serogroup 5	1700
Residence	Shower	L. pneumophila Serogroup 1	450
Shopping Centre	Cooling tower-condenser valve	L. pneumophila Serogroup 1	1400
Hotel	Hot water	L. pneumophila Serogroup 1	1500
College	Hot water	L. pneumophila Serogroup 1	1200
Hotel	Cooling tower-condenser valve	L. pneumophila Serogroup 5	60
Office Building	Cooling tower-condenser valve	L. pneumophila Serogroup 3	60
Hospital	Cooling tower-sump	L. pneumophila Serogroup 6	3100
Hotel	Cooling tower-condenser valve	L. pneumophila Serogroup 6	500
Office Building	Cooling tower-sump	L. pneumophila Serogroup 1-4	500
Hospital	Cooling tower-sump	L. pneumophila Serogroup 6	21000
Hotel	Cooling tower-sump	L. pneumophila Serogroup 6	120
Office Building	Cooling tower-sump	L. pneumophila Serogroup 6	62000
Hospital	Cooling tower-sump	L. pneumophila Serogroup 6	750
Hospital	Shower	L. pneumophila Serogroup 6	380
University	Cooling tower-sump	L. pneumophila Serogroup 6	190
University	Hot water	L. pneumophila Serogroup 6	120
Hospital	Potable water-fountain	L. pneumophila Serogroup 1	1200
Hospital	Shower	L. pneumophila Serogroup 1	4400
Hotel	Potable water-fountain	L. pneumophila Serogroup 1	250
Hotel	Cooling tower-sump	L. pneumophila Serogroup 1	190
University	Cooling tower-condenser valve	L. pneumophila Serogroup 6	60
Shopping Centre	Cooling tower-condenser valve	L. pneumophila Serogroup 5	60
Hospital	Hot water	L. pneumophila Serogroup 1	60
Office Building	Cooling tower-condenser valve	L. pneumophila Serogroup 5	60
Office Building	Hot/cold water mix-SE main floor	L. pneumophila Serogroup 1	12000
Office Building	Potable water-fountain NW nn flr	L. pneumophila Serogroup 6	16000
Office Building	Hot/cold water mix 4th floor	L. pneumophila Serogroup 6	8400
Office Building	Hot/cold water mix 5th floor	L. pneumophila Serogroup 6	120
Office Building	Hot/cold water mix 6th floor	L. pneumophila Serogroup 6	48000
Office Building	Hot/cold water mix 7th floor	L. pneumophila Serogroup 6	2000
Office Building		L. pneumophila Serogroup 6	1380
		L. pneumophila Serogroup 6	16500
	TOTAL ISOLATIONS BY EACH MEDIUM		19
			26

T-7. Legionella incidence in water samples collected from buildings in various Canadian cities

Site No.	City	Date 1983	Sample Description	Temp. C	pH	Alkalinity	Conductivity	Chlorine		
								Free	Total	Results
1B	Mississauga	4/7	Potable Water - Cold Tap	13	7.24	84	340	<0.1	0.3	NEG
		13/7	Potable Water - Cold Tap	11	7.26	82	350	0.3	0.6	NEG
		8/8	Potable Water - Cold Tap	16	7.76	82	360	0.2	0.3	NEG
		24/8	Potable Water - Cold Tap	18	7.74	80	350	<0.1	0.25	NEG
		26/9	Potable Water - Cold Tap	15	7.65	82	350	<0.1	0.3	NEG
		4/7	Hot Water	65	7.24	84	375	<0.1	<0.1	NEG
1B	Mississauga	13/7	Hot Water	65	7.28	86	355	0.1	0.2	NEG
		8/8	Hot Water	61	7.86	82	360	<0.1	0.2	NEG
		24/8	Hot Water	62	8.02	80	350	<0.1	<0.1	NEG
		26/9	Hot Water	66	8.20	82	350	<0.1	0.2	NEG
		4/7	Shower	40	7.34	84	375	<0.1	0.2	NEG
		13/7	Shower	38	7.32	88	360	0.1	0.2	NEG
1B	Mississauga	8/8	Shower	42	7.88	82	360	<0.1	0.2	NEG
		24/8	Shower	42	8.01	80	335	<0.1	<0.1	NEG
		26/9	Shower	42	8.20	82	340	<0.1	0.25	NEG
		4/7	Cooling Tower - Sump	32	8.65	500	1800	<0.1	<0.1	NEG
		13/7	Cooling Tower - Sump	27	8.54	286	975	0.2	0.25	POS
		8/8	Cooling Tower - Sump	33	8.81	310	1100	0.2	0.3	NEG
1B	Mississauga	24/8	Cooling Tower - Sump	30	8.68	230	800	<0.1	<0.1	NEG
		26/9	Cooling Tower - Sump	24	8.65	114	465	0.2	0.25	POS
		4/7	Potable Water - Cold Tap	22	7.82	82	310	<0.1	0.2	POS
		13/7	Potable Water - Cold Tap	22	7.45	88	310	<0.1	<0.1	POS
		8/8	Potable Water - Cold Tap	26	7.65	84	310	<0.1	0.2	POS
		24/8	Potable Water - Cold Tap	24.5	7.70	84	320	<0.1	0.2	POS
2A	St. Cath.	26/9	Potable Water - Cold Tap	20	7.75	82	315	<0.1	0.2	POS
		4/7	Hot Water	61	7.84	98	325	<0.1	<0.1	NEG
		13/7	Hot Water	60	7.51	88	325	<0.1	<0.1	NEG
		8/8	Hot Water	61	7.73	84	315	<0.1	0.2	NEG
		24/8	Hot Water	60	7.85	84	310	<0.1	0.2	NEG
		26/9	Hot Water	60	8.00	82	315	<0.1	0.15	NEG

All analyses are expressed as mg/L except conductivity which is in micromhos/cm

TABLE 7 (Cont'd) Legionella incidence in water samples collected from buildings in various Canadian cities

Site No.	City	Date 1983	Sample Description	Temp. C	pH	Alkalinity	Conductivity	Chlorine		
								Free	Total	Results
2A	St. Cath.	4/7	Shower	41	7.73	88	325	<0.1	0.1	NEG
		13/7	Shower	40	7.61	88	310	<0.1	0.1	POS
		8/8	Shower	42	7.71	84	315	<0.1	0.2	NEG
		24/8	Shower	42	7.70	84	310	<0.1	0.1	NEG
		26/9	Shower	38	7.90	82	315	<0.1	0.15	NEG
2A	St. Cath.	4/7	Cooling Tower - Condenser Valve	31	8.92	580	1800	<0.1	<0.1	POS
		13/7	Cooling Tower - Condenser Valve	27	8.72	396	1250	6.0	6.5	POS
		8/8	Cooling Tower - Condenser Valve	32	8.94	560	1650	7.5	7.5	NEG
		24/8	Cooling Tower - Condenser Valve	28	8.62	385	1250	11.0	11.0	NEG
		26/9	Cooling Tower - Condenser Valve	26	8.90	290	930	7.5	7.5	NEG
3A	Ottawa	20/7	Potable Water	24	6.5	20	140	0.15	0.2	NEG
		20/7	Hot Water	51	6.5	20	150	0.15	0.2	NEG
		20/7	Shower	41	6.5	20	140	0.15	0.2	POS
3B	Ottawa	21/7	Potable Water	24	6.6	22	135	0.15	0.2	NEG
		21/7	Hot Water	52	6.5	22	150	0.1	0.2	NEG
		21/7	Shower	38	6.6	22	145	0.15	0.2	NEG
		21/7	Cooling Tower	24	6.5	142	1050	0.5	0.5	POS
3C	Ottawa	20/7	Potable Water	24	6.8	24	145	0.3	0.4	NEG
		20/7	Hot Water	52	6.8	22	150	0.15	0.2	NEG
		20/7	Shower	40	6.8	24	145	0.2	0.2	NEG
		20/7	Cooling Tower	29	6.8	42	260	0.15	0.2	POS
4A	Montreal	25/7	Potable Water	24	7.1	82	360	0.1	0.15	NEG
		25/7	Hot Water	52	7.2	82	375	0.1	0.15	NEG
		25/7	Shower	43	7.2	82	370	0.1	0.15	NEG
		25/7	Cooling Tower	33	7.9	242	950	0.6	0.6	NEG
		26/7	Potable Water	24	7.5	82	350	0.3	0.4	NEG
4B	Montreal	26/7	Hot Water	50	7.0	82	350	0.15	0.15	NEG
		26/7	Shower	41	7.6	82	350	0.2	0.2	NEG
		26/7	Cooling Tower	34	10.0	366	1160	<0.1	<0.1	NEG

TABLE 7 (Cont'd) Legionella incidence in water samples collected from buildings in various Canadian cities

Site No.	City	Date 1983	Sample Description	Temp. C	pH	Alkalinity	Conductivity	Chlorine			Results
								Free	Total		
4C	Montreal	25/7	Potable Water	17	7.5	82	350	0.1	0.1	NEG	
		25/7	Hot Water	62	7.8	82	350	0.1	0.1	NEG	
		25/7	Shower	42	7.8	82	350	0.1	0.15	NEG	
		25/7	Cooling Tower	32	8.2	244	1000	0.6	0.7	NEG	
5A	Quebec	23/7	Potable Water	30	7.0	58	300	0.15	0.2	NEG	
		23/7	Hot Water	58	7.1	58	320	0.15	0.15	NEG	
		23/7	Shower	37	7.0	58	310	0.15	0.2	NEG	
		23/7	Cooling Tower	28	6.9	72	1160	1.1	1.2	NEG	
5B	Quebec	24/7	Potable Water	24	7.2	22	190	0.15	0.2	NEG	
		24/7	Hot Water	56	7.2	22	190	0.15	0.2	NEG	
		24/7	Shower	33	7.4	22	190	0.15	0.15	NEG	
		24/7	Cooling Tower	26	6.4	92	920	0.5	0.5	NEG	
5C	Quebec	23/7	Potable Water	24	6.7	66	330	0.2	0.2	NEG	
		23/7	Hot Water	48	6.5	66	325	0.15	0.15	NEG	
		23/7	Shower	39	6.8	66	330	0.15	0.15	NEG	
		23/7	Cooling Tower	26	8.0	290	1320	0.6	0.6	NEG	
6A	Fredericton	10/8	Potable Water	21	6.8	56	220	<0.1	<0.1	NEG	
		10/8	Hot Water	43	6.8	56	275	<0.1	<0.1	NEG	
		10/8	Shower	32	6.8	56	230	<0.1	<0.1	NEG	
		10/8	Cooling Tower	33	8.6	270	1000	0.6	0.6	NEG	
6B	Fredericton	10/8	Potable Water	13	7.0	56	200	<0.1	<0.1	NEG	
		10/8	Hot Water	65	6.9	56	280	<0.1	<0.1	NEG	
		10/8	Shower	38	6.9	56	250	<0.1	<0.1	NEG	
		10/8	Cooling Tower	25	8.6	232	900	0.5	0.5	NEG	
6C	Fredericton	10/8	Potable Water	11	6.5	56	180	0.1	0.1	NEG	
		10/8	Hot Water	48	6.7	56	275	0.1	0.1	NEG	
		10/8	Shower	34	6.8	56	250	0.1	0.1	NEG	
		10/8	Cooling Tower	29	8.2	430	1750	0.4	0.4	NEG	

TABLE 7 (Cont'd) Legionella incidence in water samples collected from buildings in various Canadian cities

Site No.	City	Date	Sample Description	Temp. C	pH	Alkalinity	Conductivity	Chlorine		
								Free	Total	Results
7A	Halifax	15/8	Potable Water	21	8.9	14	100	<0.1	4.0	NEG
		15/8	Hot Water	65	8.5	14	150	<0.1	4.0	NEG
		15/8	Shower	49	8.8	14	125	<0.1	4.0	NEG
		15/8	Drinking Fountain	19	8.9	14	100	<0.1	4.0	NEG
		15/8	Potable Water	24	7.9	32	150	<0.1	<0.1	NEG
7B	Halifax	15/8	Hot Water	58	8.0	32	150	<0.1	<0.1	NEG
		15/8	Shower	32	8.0	32	170	<0.1	<0.1	NEG
		15/8	Cooling Tower	23	8.3	330	7000	0.7	0.8	POS
		15/8	Potable Water	20	8.0	32	175	<0.1	0.2	NEG
		15/8	Hot Water	80	7.5	32	200	<0.1	<0.1	NEG
7C	Halifax	15/8	Shower	33	7.8	32	175	<0.1	<0.1	NEG
		15/8	Cooling Tower	30	8.1	170	600	0.8	1.0	NEG
		15/8	Potable Water	18	7.2	60	180	0.3	0.5	NEG
		15/8	Hot Water	55	7.3	60	180	0.1	0.2	NEG
		15/8	Shower	42	7.4	60	180	0.2	0.3	NEG
8A	Winnipeg	19/9	Cooling Tower	22	7.6	44	1075	0.1	0.4	NEG
		19/9	Potable Water	20	7.4	62	175	0.25	0.5	NEG
		19/9	Hot Water	51	7.4	62	175	<0.1	0.25	NEG
		19/9	Shower	38	7.4	62	175	0.15	0.25	NEG
		19/9	Cooling Tower	15	8.5	164	410	0.2	0.2	NEG
8B	Winnipeg	19/9	Potable Water	18	7.2	62	180	0.25	0.4	NEG
		19/9	Hot Water	67	7.4	62	180	<0.1	<0.1	NEG
		19/9	Shower	42	7.4	62	180	0.2	0.25	NEG
		19/9	Drinking Fountain	13	7.2	62	180	0.3	0.4	NEG

TABLE 7 (Cont'd) Legionella incidence in water samples collected from buildings in various Canadian cities

Site No.	City	Date	Sample Description	Temp. C	pH	Alkalinity	Conductivity	Chlorine			Results
								Free	Total	Results	
9A	Regina	12/9	Potable Water	13	7.1	276	1130	<0.1	<0.1	NEG	
		12/9	Hot Water	62	7.2	281	1050	<0.1	<0.1	NEG	
		12/9	Shower	40	7.5	280	1050	<0.1	<0.1	NEG	POS
		12/9	Cooling Tower	26	8.9	630	2800	<0.1	<0.1	NEG	
9B	Regina	12/9	Potable Water	14	7.4	290	1350	<0.1	<0.1	NEG	
		12/9	Hot Water	67	7.4	295	1200	<0.1	<0.1	NEG	
		12/9	Shower	41	7.4	290	1350	<0.1	<0.1	NEG	
		12/9	Cooling Tower	19	8.35	312	3950	<0.1	<0.1	NEG	
9C	Regina	12/9	Potable Water	16	7.2	220	970	0.1	0.2	NEG	
		12/9	Hot Water	50	7.4	220	1050	<0.1	<0.1	NEG	
		12/9	Shower	36	7.5	220	1050	<0.1	<0.1	NEG	
		12/9	Cooling Tower	19	8.05	150	4400	0.2	0.25	NEG	
9D	Poplar River	17/9	Potable Water	15	8.4	630	1500	1.0	1.4	NEG	
		17/9	Hot Water	59	8.4	640	1500	<0.1	0.2	NEG	
		17/9	Shower	46	8.6	630	1500	<0.1	0.2	NEG	
		17/9	Drinking Fountain	11	8.4	630	1500	0.6	0.7	NEG	
10A	Calgary	31/8	Potable Water	18	8.0	98	270	<0.1	0.3	NEG	
		31/8	Hot Water	55	8.2	98	320	<0.1	0.2	NEG	
		31/8	Shower	34	8.1	98	270	<0.1	0.3	NEG	
		31/8	Cooling Tower	25	8.6	432	1850	<0.1	<0.1	NEG	
10B	Calgary	31/8	Potable Water	21	8.2	98	280	<0.1	0.25	NEG	
		31/8	Hot Water	70	8.4	96	310	<0.1	<0.1	NEG	
		31/8	Shower	32	8.2	98	275	<0.1	0.1	NEG	
		31/8	Cooling Condenser (Heat exchanger)	28	8.4	100	275	<0.1	<0.1	POS	
10C	Calgary	31/8	Potable Water	20	7.9	98	320	0.1	0.2	NEG	
		31/8	Hot Water	41	7.9	100	340	0.1	0.2	NEG	
		31/8	Shower	35	7.9	98	340	0.1	0.2	NEG	
		31/8	Cooling Tower	25	8.5	424	900	0.1	<0.1	POS	

TABLE 7 (Cont'd) *Legionella* incidence in water samples collected from buildings in various Canadian cities

Site No.	City	Date 1983	Sample Description	Temp.			Chlorine			Total Results
				C	pH	Alkalinity	Conductivity	Free	Total	
11A	Edmonton	2/9	Potable Water	20	7.6	96	330	<0.1	2.5	NEG
		2/9	Hot Water	52	7.6	96	325	<0.1	2.0	NEG
		2/9	Air Washer (Scrubber)	10	8.0	86	300	<0.1	<0.1	NEG
		2/9	Cooling Tower	21	8.7	316	800	<0.1	<0.1	NEG
11B	Edmonton	2/9	Potable Water	19	7.6	94	320	<0.1	2.0	NEG
		2/9	Hot Water	59	7.6	94	340	<0.1	1.5	NEG
		2/9	Shower	36	7.6	94	325	<0.1	2.0	NEG
		2/9	Cooling Tower	21	8.3	380	1300	<0.1	<0.1	NEG
11C	Edmonton	2/9	Potable Water	19	7.8	96	310	<0.1	2.0	NEG
		2/9	Hot Water	58	7.9	96	320	<0.1	2.0	NEG
		2/9	Shower	37	7.8	96	310	<0.1	-2.0	NEG
		2/9	Cooling Tower (Heat Exchanger)	25	8.2	112	325	<0.1	<0.1	NEG
12A	Vancouver	6/9	Potable Water	16	6.7	3	25	<0.1	<0.1	NEG
		6/9	Hot Water	52	6.7	3	26	<0.1	<0.1	NEG
		6/9	Shower	29	6.7	3	26	<0.1	<0.1	NEG
		6/9	Cooling Tower	25	8.6	180	350	<0.1	<0.1	NEG
12C	Vancouver	6/9	Potable Water	18	6.5	4	26	<0.1	<0.1	NEG
		6/9	Hot Water	55	6.3	4	26	<0.1	<0.1	NEG
		6/9	Shower	34	6.4	4	26	<0.1	<0.1	NEG
		6/9	Cooling Tower	15	6.3	4	28	<0.1	<0.1	POS

TABLE 8. Summary of positive isolations and concentrations of Legionella organisms in the cross-Canada survey of waters collected from building water distribution lines and cooling towers, 1983

Sampling Site	Sample	Organism	Media and Concentration of <u>Legionella</u> ^a			
			CCVC	CCVC-	CCVC+	GVP
Mississauga	Cooling tower	<u>L. pneumophila</u> Serogroup 6	0	0	0	90/L
Mississauga	Cooling tower	<u>L. pneumophila</u> Serogroup 6	780/L	0	660/L	990/L
St. Catharines	Cold water tap	<u>L. pneumophila</u> Serogroup 1	0	0	210/L	0
St. Catharines	Cold water tap	<u>L. pneumophila</u> Serogroup 1	120/L	0	30/L	0
St. Catharines	Cold water tap	<u>L. pneumophila</u> Serogroup 1	180/L	0	0	0
St. Catharines	Cold water tap	<u>L. pneumophila</u> Serogroup 1	0	90/L	90/L	0
St. Catharines	Cold water tap	<u>L. pneumophila</u> Serogroup 1	0	0	30/L	0
St. Catharines	Shower	<u>L. pneumophila</u> Serogroup 1	0	0	30/L	0
St. Catharines	Cooling tower	<u>L. pneumophila</u> Serogroup 1	0	0	0	360/L
St. Catharines	Cooling tower	<u>L. pneumophila</u> Serogroup 1	0	0	0	60/L
Ottawa 3A	Shower	<u>L. pneumophila</u> Serogroup 3	45,000/L	24,000/L	45,000/L	45,000/L
Ottawa 3B	Cooling tower	<u>L. pneumophila</u> Serogroup 1	0	0	0	210/L
Ottawa 3C	Cooling tower	<u>L. pneumophila</u> Serogroup 1	0	0	30/L	0
Montreal 4A	Cooling tower	<u>L. pneumophila</u> Serogroup 6	0	0	0	60/L
Halifax 7B	Cooling tower	<u>L. pneumophila</u> Serogroup 6	9,000/L	15,000/L	9,000/L	15,000/L
Regina 9A	Shower	<u>L. dumoffei</u>	900/L	2,550/L	1,200/L	2,010/L
Calgary 10B	Cooling condenser	<u>L. pneumophila</u> Serogroup 4	0	0	1,290/L	270/L
Calgary 10C	Cooling tower	<u>L. pneumophila</u> Serogroup 1	6,000/L	0	0	9,000/L
Vancouver 12C	Cooling tower	<u>L. pneumophila</u> Serogroup 6	0	0	0	300/L
Total positive isolations by each medium			7	4	11	12

TABLE 9. Summary of Legionella isolations from the Canadian Great Lakes
during the period 1981-1983

Sampling Site	Organism	Media used and Concentration of Legionella/L			
		CCVC	CCVC-	CCVC+	GVP
L. Superior #187	<u>L. pneumophila</u> (1)	30	0	270	120
L. Superior #50	<u>L. pneumophila</u> Serogroup 1	30	0	0	0
L. Superior #135	<u>L. pneumophila</u> Serogroup 6	0	30	0	0
L. Ont. Kingston area	<u>L. pneumophila</u> Serogroup 1	0	NT*	NT*	60
L. Ont. Toronto Harbour 1 m	<u>L. pneumophila</u> Serogroup 5	0	NT	NT	250
L. Ont. Toronto Harbour 14 m	<u>L. pneumophila</u> Serogroup 6	60	NT	NT	0
Georgian Bay	<u>L. pneumophila</u> Serogroup 6	250	NT	NT	0
L. St. Clair	<u>L. pneumophila</u> Serogroup 6	600	NT	NT	0

*NT = not tested

(1) Organism lost before final serotyping could be completed.

TABLE 10. Microbiological data, selected stations, Maritime Provinces, 1983

Sampling Site	Province	Heterotrophic Plate Count /mL	Streptomyces /100 mL	Total Count /mL	INT Reducing Bacteria /mL	% INT of Total Count
Rivière-de-loup St. Lawrence River	Que	34,000	130	5.5 x 10 ⁶	1.9 x 10 ⁵	3.4
Edmundston St. John River.	NB	40,000	30	4.6 x 10 ⁶	9.4 x 10 ⁵	20.4
Maugerville St. John River	NB	7,400	30	6.7 x 10 ⁶	2.1 x 10 ⁵	3.1
Belleisle Bay	NB	5,800	40	2.6 x 10 ⁶	1.9 x 10 ⁵	7.3
Spruce Lake	NB	1,000	4	9.7 x 10 ⁶	3.3 x 10 ⁵	3.4
Ventworth Lake	NS	600	10	3.5 x 10 ⁶	<2.4 x 10 ⁴	0.6
Waterloo Lake	NS	1,340	10	3.7 x 10 ⁶	4.7 x 10 ⁴	1.3
Keamey Lake	NS	500	<2	2.4 x 10 ⁶	1.2 x 10 ⁵	5.0
Banook Lake	NS	5,400	10	2.0 x 10 ⁶	9.5 x 10 ⁴	4.7
East Sheet River	NS	7,200	80	4.4 x 10 ⁶	2.4 x 10 ⁴	0.5
Guyborough R.	NS	1,640	80	3.4 x 10 ⁶	2.6 x 10 ⁵	7.6
Ainslie Lake	NS	800	24	1.8 x 10 ⁶	4.7 x 10 ⁴	2.6
Harrison Lake	NS	980	102	3.9 x 10 ⁶	9.5 x 10 ⁴	2.4
Pisquid River	PEI	380	220	3.4 x 10 ⁶	1.7 x 10 ⁵	5.0
Avondale Lake	PEI	2,180	120	7.6 x 10 ⁶	1.4 x 10 ⁶	18.4
McAusland Pond	PEI	44,800	80	2.8 x 10 ⁶	4.0 x 10 ⁵	14.2
Moncton Centennial Park Pond	NB	3,600	15	6.7 x 10 ⁶	1.4 x 10 ⁵	2.1
Richibucto River	NB	1,300	80	1.7 x 10 ⁶	3.6 x 10 ⁴	2.1
Restigouche River	NB	22,600	12	2.6 x 10 ⁶	2.1 x 10 ⁵	8.1

TABLE II. Summary of *Legionella* isolations from western Canadian hot springs, 1984

Sampling Site	Organisms Found	Media Used, Acid or Heat Treatment and Concentration/L									
		By Culturing Techniques		By Serological Techniques		CCVC Acid	CCVC+ Heat	CCVCA Acid	CCVCA Heat	GVP Acid	GVP Heat
818B Fairmount Hot Springs	<i>L. pneumophila</i> Serogroup 1	NT ¹	6000	140	0	0	0	NT	NT	0	4000
	<i>L. pneumophila</i> Serogroup 4	NT	0	3600	0	0	0	NT	NT	3600	40000
888 Banff Upper Spring	<i>L. pneumophila</i> Serogroup 1-4		0	0	0	0	0	0	0	0	0
889 Banff Upper Outflow	<i>L. pneumophila</i> Serogroup 1-4		0	0	0	0	0	0	0	0	0
890 Radium Fissure Site	<i>L. pneumophila</i> Serogroup 1	0	0	20	0	0	0	0	0	0	0
891 Radium Upper Pool Collecting Tank	<i>L. pneumophila</i> Serogroup 1	<i>L. pneumophila</i> Serogroup 1-4	0	0	60	0	0	0	0	0	0

NT¹ = not tested.

TABLE II. Summary of Legionella isolations from western Canadian hot springs, 1984

Sampling Site	Organisms Found	Media Used, Acid or Heat Treatment and Concentration/L					
		By Culturing Techniques	By Serological Techniques	CCVC Acid	CCVC+ Heat	CCVCA Acid	GYP Heat
8188 Fairmount Hot Springs	L. pneumophila Serogroup 1 L. pneumophila Serogroup 4	NT ¹ NT	6000 0	140 3600	0 0	NT NT	NT 3600
888 Banff Upper Spring	L. pneumophila Serogroup 1-4	L. pneumophila Serogroup 1-4	0	0	0	0	0
889 Banff Upper Outflow	L. pneumophila Serogroup 1-4	L. pneumophila Serogroup 1-4	0	0	0	0	0
890 Radium Pissure Site	L. pneumophila Serogroup 1	0	0	20	0	0	0
891 Radium Upper Pool Collecting Tank	L. pneumophila Serogroup 1	L. pneumophila Serogroup 1-4	0	0	60	0	0

¹NT = not tested.

TABLE 12. Microbiological data, selected stations, western Canada and northern Ontario, 1984

Sampling Site	Province	pH	Heterotrophic Count/mL	Streptomyces /100 mL	Total Count /mL	INT. Foresman Reducing Bacteria/mL	% INT. of Total Count
Pitt River	B.C.	6.45	8900	110	1.0x10 ⁶ 9.2x10 ⁵	4.7x10 ⁴ 2.4x10 ⁴	4.7% 2.6%
Harrison Lake	B.C.	6.80	450	7	-	-	-
Harrison Hot Spring	B.C.	7.40	170	<1	-	-	-
Similkameen River	B.C.	6.80	6300	20	-	-	-
Nicole Lake	B.C.	6.85	1600	2	-	-	-
Mara Lake	B.C.	6.85	1400	56	6.9x10 ⁵	1.2x10 ⁴	1.7%
Windemere Lake	B.C.	7.05	11600	46	-	-	-
Minnewanka Lake	Alberta	7.05	5400	6	9.9x10 ⁵	7.1x10 ⁴	7.2%
Sylvan Lake	Alberta	7.45	52000	<3	-	-	-
Buffalo Lake	Alberta	8.55	156000	<5	2.1x10 ⁶	1.4x10 ⁵	4.8%
Pigeon Lake	Alberta	7.40	12700	5	3.0x10 ⁶	1.7x10 ⁵	5.7%
Battle River	Alberta	8.40	15700	30	3.3x10 ⁶	1.4x10 ⁵	4.2%
Saskatchewan River (Saskatoon)	Sask.	7.20	3200	<10	3.2x10 ⁶	7.1x10 ⁴	2.2%
Lake Dieffenbaker	Sask.	8.45	9100	20	2.5x10 ⁶	2.4x10 ⁴	1.0%
Mountain Lake	Sask.	7.50	2300	<5	3.3x20 ⁶	7.1x10 ⁴	2.2%
Tobin Lake	Sask.	8.35	61000	<5	-	-	-
Steeprock River	Man.	7.95	1500	3	4.3x10 ⁶	9.5x10 ⁴	2.2%
Assiniboine River	Man.	7.10	17500	<5	6.3x10 ⁶	1.4x10 ⁵	2.2%
Dauphin Lakes	Man.	8.40	35000	<5	-	-	-
Crescent Lake	Man.	8.60	68000	5	2.9x10 ⁶	1.2x10 ⁵	0.4%
Winnipeg River at Pinawa	Man.	8.35	9800	3	4.3x10 ⁶	4.7x10 ⁴	1.1%
Crow Lake	Ont.	8.35	150000	2	4.2x10 ⁶	1.2x10 ⁵	0.3%
Shebandowan Lake	Ont.	7.20	1500	7	3.3x10 ⁶	4.7x10 ⁴	1.4%
Wild Goose Lake	Ont.	7.35	1160	12	3.3x10 ⁶	5.9x10 ⁴	0.2%
Geraldton	Ont.	6.85	9100	40	3.3x10 ⁶	2.4x10 ⁴	0.7%
Renu Lake	Ont.	7.70	9700	3	3.0x10 ⁶	2.4x10 ⁴	0.8%
Timagami Lake	Ont.	7.20	6000	<3	3.3x10 ⁶	3.0x10 ⁴	0.9%
Vernon Lake	Ont.	-	-	-	-	-	-