WATER QUALITY AND DIGESTIVE CANCER IN CANADA, WITH EMPHASIS ON BRITISH COLUMBIA

by

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ABSTRACT

Evidence is accumulating to support the view that variations in cancer incidence are often related to characteristics of the physical environment, namely its climate, geology, soils and water supply.

This study explores possible links between Canada's and British Columbia's mortality from cancers of the digestive tract and certain aspects of drinking water quality. Two sets of data were used in this analyses. The first undertaken at the national scale, used published mortality and water quality data, at the census division level. The second British Columbia data set consisted of unpublished mortality data provided by the British Columbia Cancer Control Agency, and comprehensive water quality data collected and assembled by the author, at the school district level.

Pearson's Correlation analyses of both study sets, suggests that copper or zinc found in potable water supplies have only a minor influence on carcinogeneses. In contrast, repeated negative correlations were found to occur at the national scale, between mortality from cancers of the digestive tract and calcium and magnesium levels in drinking water. Water hardness is also negatively correlated with these cancers, as has been postulated elsewhere in the literature. Such associations were not as evident at the provincial scale, although repeated negative links were found between these elements and cancer of the rectum.

The biological and medical literature suggests various reasons why elevated levels of calcium and magnesium in drinking water might reduce cancer incidence in the lower digestive tract. Calcium for example, has been found to influence terminal differentiation in rat esophageal epithelial cells and may also convert fatty acids and free bile to insoluble soaps in the human colon. The roles of magnesium and lithium in reducing cancer mortality, if any, were less clearly understood.

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DEDICATION

The author wishes to dedicate this thesis
to his parents Walter and Isabel,
his wife Gerry,
and his children
Joanne, Darryl and Cheryl.
Their patient understanding
has allowed for the completion of this work

CHAPTER ONE

CANCERS AND THE ENVIRONMENT

INTRODUCTION

There is a considerable literature which suggests that there may be associations between variations in drinking water quality and spatial differences in mortality from cancers. (Reicher, 1977; Zielhuis and Haring, 1981; Durlach and Bara, 1985; Foster, 1986). This thesis sets out to provide an international overview of the evidence both for, and against, such potential relationships, especially with respect to digestive cancers. Emphasis is then placed on the situation in Canada, especially in British Columbia.

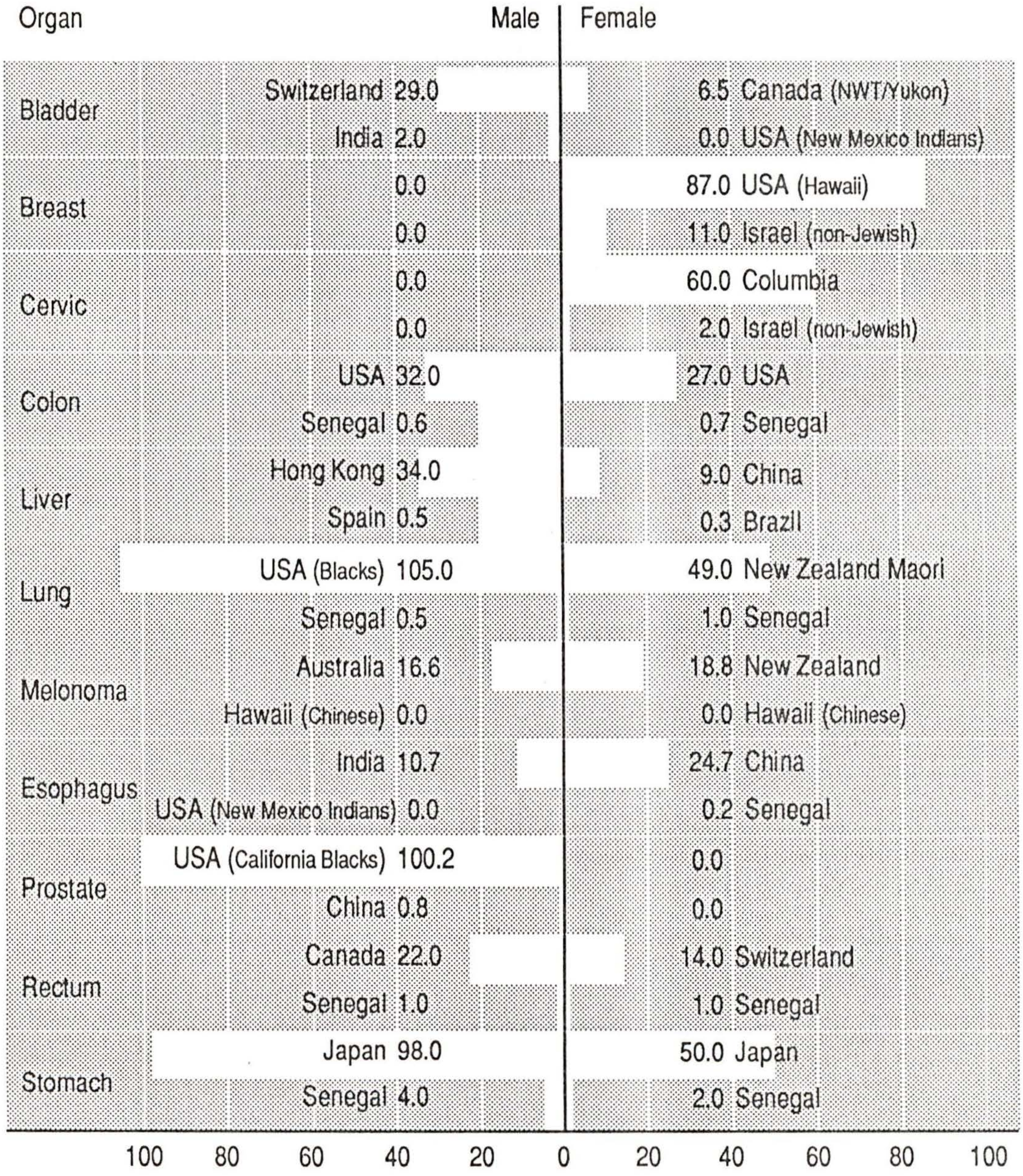
In the Developed World, cancer is the second leading cause of death after diseases of the heart (Hayakawa and Kurihara, 1981). In its many forms, it is thought to be responsible for an estimated 4.3 million global deaths annually, with 5.9 million additional cases being diagnosed each year (Howe, 1986). However, the spatial distribution of cancer, shows major international variations. To illustrate, although 75% of the world's population live in the Developing World, it accounts for only 2.3 million annual cancer deaths. In contrast, in the Developed World, with only some 25% of the global population, the mortality rate is roughly triple, with 2.0 million cancer deaths occurring annually (Howe, 1986).

This phenomenon is illustrated in Table 1,1, which provides global age-adjusted incidence rates for specific cancer sites, per 100,000 population, for the year 1984. Highest rates for cancer of the colon, lung and prostrate, for example, are experienced by United States males, whilst the greatest rates of breast and colonic cancer occur in United States females. In contrast, the Japanese have the highest incidence rates of stomach cancer, in both males and females. Canadian males, in contrast, experience the highest global incidence rates for rectal cancer, which peaks in Switzerland amongst females. It is also clear from Table 1,1, that the lowest incidence rates for many specific cancers occur in the Developing World. To illustrate, in males, age adjusted incidence rates for cancer of the stomach, colon, rectum and lung, are lowest in Senegal. Other equally dramatic global relationships can be seen in regard to cancers of the bladder, breast, cervix and liver (Howe, 1986).

However, it is clear that cancer incidence does not merely rise as a simple consequence of industrialization. As it can be seen in Table 1,1 the world's highest age adjusted incidence rates for esophageal cancer, in males, occurs in India, whilst the

TABLE 1,1

The highest and lowest global age-adjusted incidence rates for specific cancer sites for 100,000 population, 1984



Organ	Male	Female
Bladder	Switzerland 29.0	6.5 Canada (NWT/Yukon)
	India 2.0	0.0 USA (New Mexico Indians)
Breast	0.0	87.0 USA (Hawaii)
	0.0	11.0 Israel (non-Jewish)
Cervic	0.0	60.0 Columbia
	0.0	2.0 Israel (non-Jewish)
Colon	USA 32.0	27.0 USA
	Senegal 0.6	0.7 Senegal
Liver	Hong Kong 34.0	9.0 China
	Spain 0.5	0.3 Brazil
Lung	USA (Blacks) 105.0	49.0 New Zealand Maori
	Senegal 0.5	1.0 Senegal
Melonoma	Australia 16.6	18.8 New Zealand
	Hawaii (Chinese) 0.0	0.0 Hawaii (Chinese)
Esophagus	India 10.7	24.7 China
	USA (New Mexico Indians) 0.0	0.2 Senegal
Prostate	USA (California Blacks) 100.2	0.0
	China 0.8	0.0
Rectum	Canada 22.0	14.0 Switzerland
	Senegal 1.0	1.0 Senegal
Stomach	Japan 98.0	50.0 Japan
	Senegal 4.0	2.0 Senegal

Source: Global Geocancerology: A World Geography of Human Cancers. Churchill Livingstone. New York, 1986

highest incidence rates for cancer of the esophagus and liver, in females, are found in China.

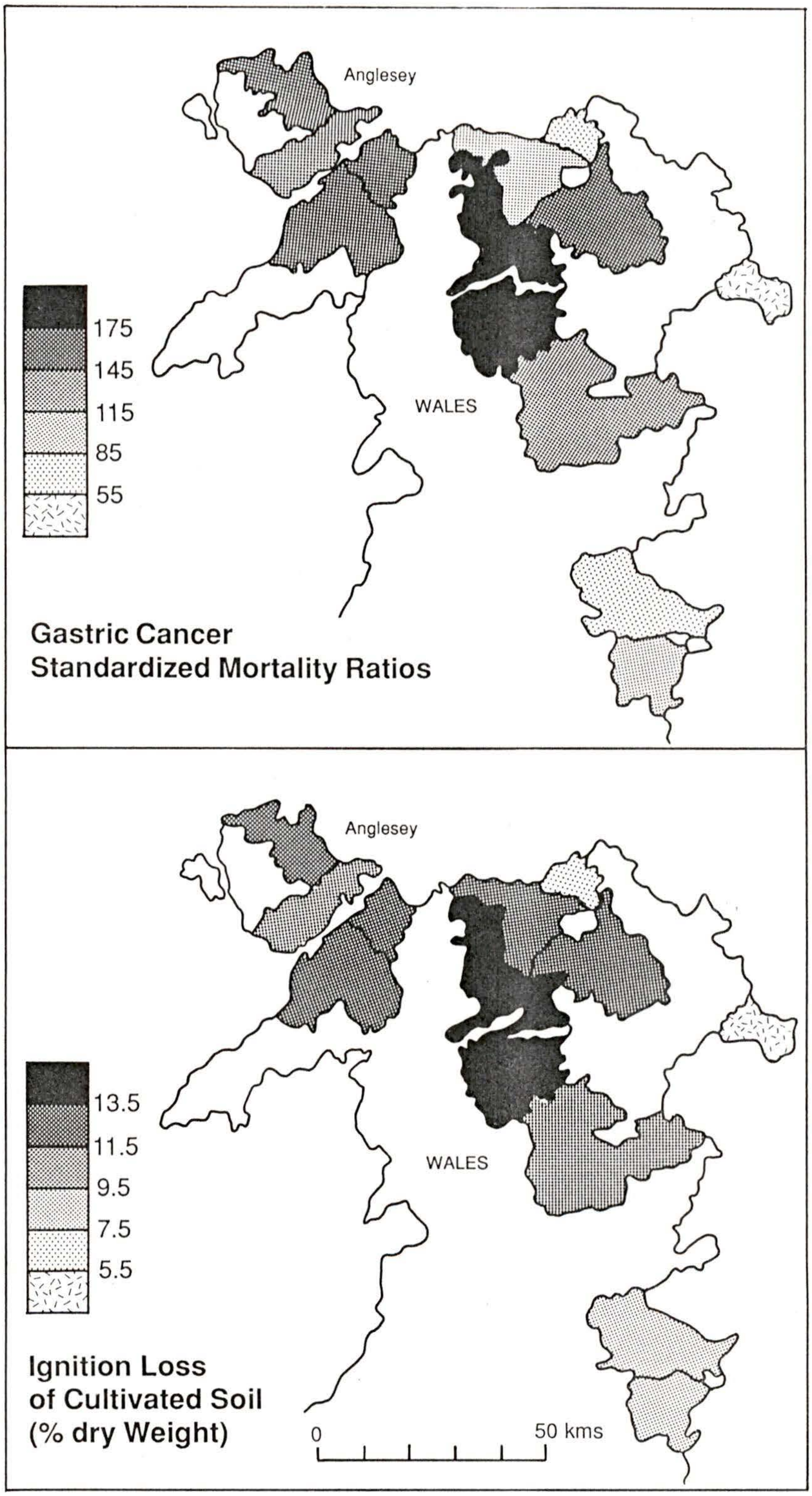
SEARCHING FOR CAUSAL VARIABLES

Obviously, it is extremely important to identify why such spatial variations occur at the international and national levels in the incidence of cancer. Interestingly enough, epidemiological evidence in the United States does not tend to support the widely held belief that cancer is primarily due to industrial pollution. To illustrate, in 1981, an extremely comprehensive overview of the epidemiology of cancer in the United States was undertaken by Doll and Peto. After an extensive analysis of available data, they concluded that, since there is no rapid increase in the probability of an individual of a given age developing most specific types of cancer, current United States mortality is far more likely to be due to long established aspects of American lifestyle and environment, than it is to various aspects of the modern environment.

Doll and Peto (1981) claim that the epidemiological evidence suggests that, with the exception of tobacco-related lung cancer, the causes of cancer are generally traditional, not modern. This is an extremely significant finding, given the enormous amount of research time and effort directed towards the carcinogenic risk assessment of man-made chemicals, and the relative neglect of naturally occurring environmental variables such as variations in bulk and trace elements in soil and drinking water. However, evidence has been slowly accumulating for many years to suggest that Doll and Peto (1981) are correct and that permanent characteristics of the physical environment may be of major significance in determining the incidence rates of many types of cancer.

DRINKING WATER AND SOILS

Several researchers have suggested, for example, that the mineral content of either, or both, drinking water and soils may influence the spatial distribution of cancer. To illustrate, as early as 1952, Legon argued that stomach cancer rates were highest amongst those inhabitants of North Wales and Cheshire, who lived in areas of highly organic soils. In this study the amount of organic material was established by percent weight loss after burning. Figure 1,1 illustrates the geographical distribution of age-adjusted standardized mortality rates for stomach cancer and ignition loss of cultivated soils in rural districts of North Wales. As can be seen from this illustration, a strikingly similar spatial relationship appears to exist for both stomach cancer and organic soil content in this area.


Gastric Cancer Standardized Mortality Ratios

Ignition Loss of Cultivated Soil (% dry Weight)

FIGURE 1,1 Comparison of cancer mortality ratios and ignition loss of cultivated soils in North Wales.

After Legon, 1952

Three years later, Tromp (1955) suggested that, in the Netherlands the incidence of cancer was highest where residents obtained their drinking water supplies from surface, rather than ground water sources. He argued that this was because surface waters were less mineralized. In 1960, Stocks and Davies confirmed Legon's (1952) earlier observations that stomach cancer was more common in Wales and North Cheshire amongst those living in areas of highly organic soils. These research workers further suggested that this relationship might be due to elevated levels of chromium, cobalt and zinc in such soils.

In contrast, Allen-Price (1960) provided evidence to support Tromp's view (1955) that there was a link between water quality and cancer incidence. In a study of stomach cancer incidence in West Devon, Allen-Price found this disease to be most common amongst those drinking soft, highly mineralized ground water, derived from Devonian bedrock. This relationship is illustrated in Figure 2,1, which shows both the geology of West Devon, England, and high and low stomach cancer incidence zones. As can be seen, the highest rates of stomach cancer appear to be associated with drinking water derived from highly mineralized Devonian aquifers. In contrast, the lowest incidence rates for this cancer seem to be associated with drinking water derived from

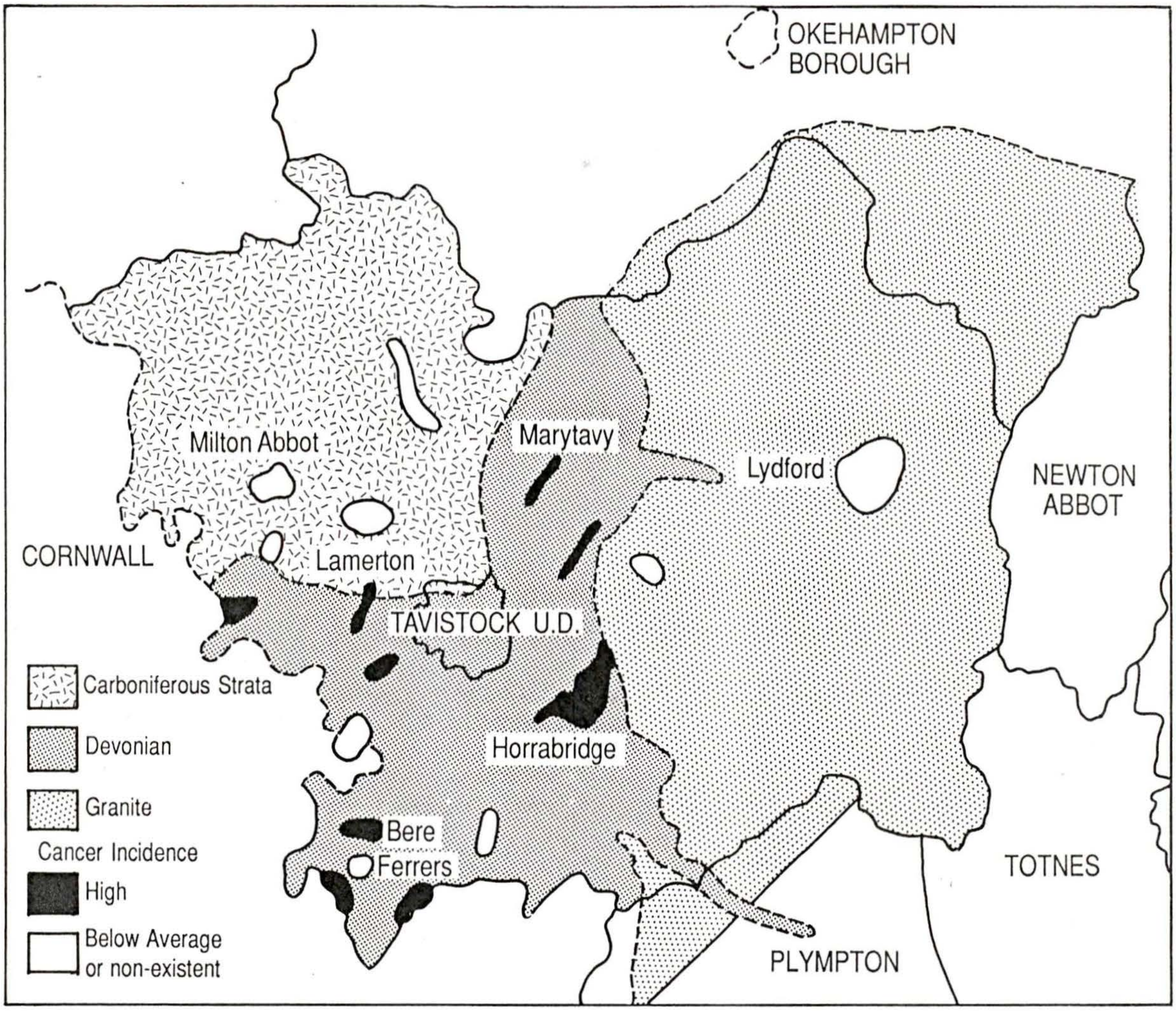


FIGURE 2,1 Comparison of cancer incidence and regional geology in West Devon, England. After Allen-Price, 1960

carboniferous sediments. The poorly mineralized granites of Devon were also seen to be associated with low stomach cancer incidence.

Crawford and his colleagues (1968) provided additional support for the view that water hardness is linked to the incidence of a variety of cancers. These research workers studied cancer mortality in 61 county boroughs in England and Wales, concluding that hard water appeared particularly protective against cancers of the stomach and uterus. They suggested that this protection was provided by the high levels of calcium and magnesium commonly found in hard water.

Since 1968, there has been much interest in studying geographical patterns of site-specific cancer incidence and how these might be explained by the regional variability in the levels of natural bulk and trace elements, in soils and drinking water supplies. Some of the more notable of these studies will now be reviewed chronologically, in order to illustrate how the general focus of interest from that period has narrowed to that of studying very specific environmental conditions as they relate to the present.

In 1970, Shamberger, published a paper in which he argued that soil selenium levels, in the continental United States, correlated negatively with mortality from gastro-intestinal cancers, in both males and females. Similarly, in the same year, Spencer (1970) suggested that in the United States, breast cancer was elevated where the environment was deficient in iodine. In contrast, Kmet and Mahboubi (1972), studied the incidence of esophageal cancer in northern Iran, near the Caspian Sea. In this region, esophageal cancer incidence varied markedly over very short distances. Kmet and Mahboubi attempted to explain these marked spatial differences, evaluating the impact of variables such as climate, soils, vegetation and agricultural practices. The results of this study are shown in Figure 3,1 which illustrates possible links between age-adjusted incidence rates for esophageal cancer and soil types in the Caspian Littoral of Iran. It was found that the strongest positive correlations for cancer of the esophagus were with soil salinity. This in turn, appeared to reflect precipitation patterns. Although not specially mentioned in the article, it follows that drinking water derived from springs or wells in these areas would also have a high salt content.

Haenszel et al. (1976), in a study of stomach cancer in Japan, found that consumers of leafy vegetables had lower rates of mortality than those eating western diets. He postulated that the high levels of calcium in leafy vegetables, might have had a beneficial effect in reducing the incidences of disease.

Attention again returned to drinking water quality when Reicher (1977) argued that in the United States cancer appeared to be much more common in those

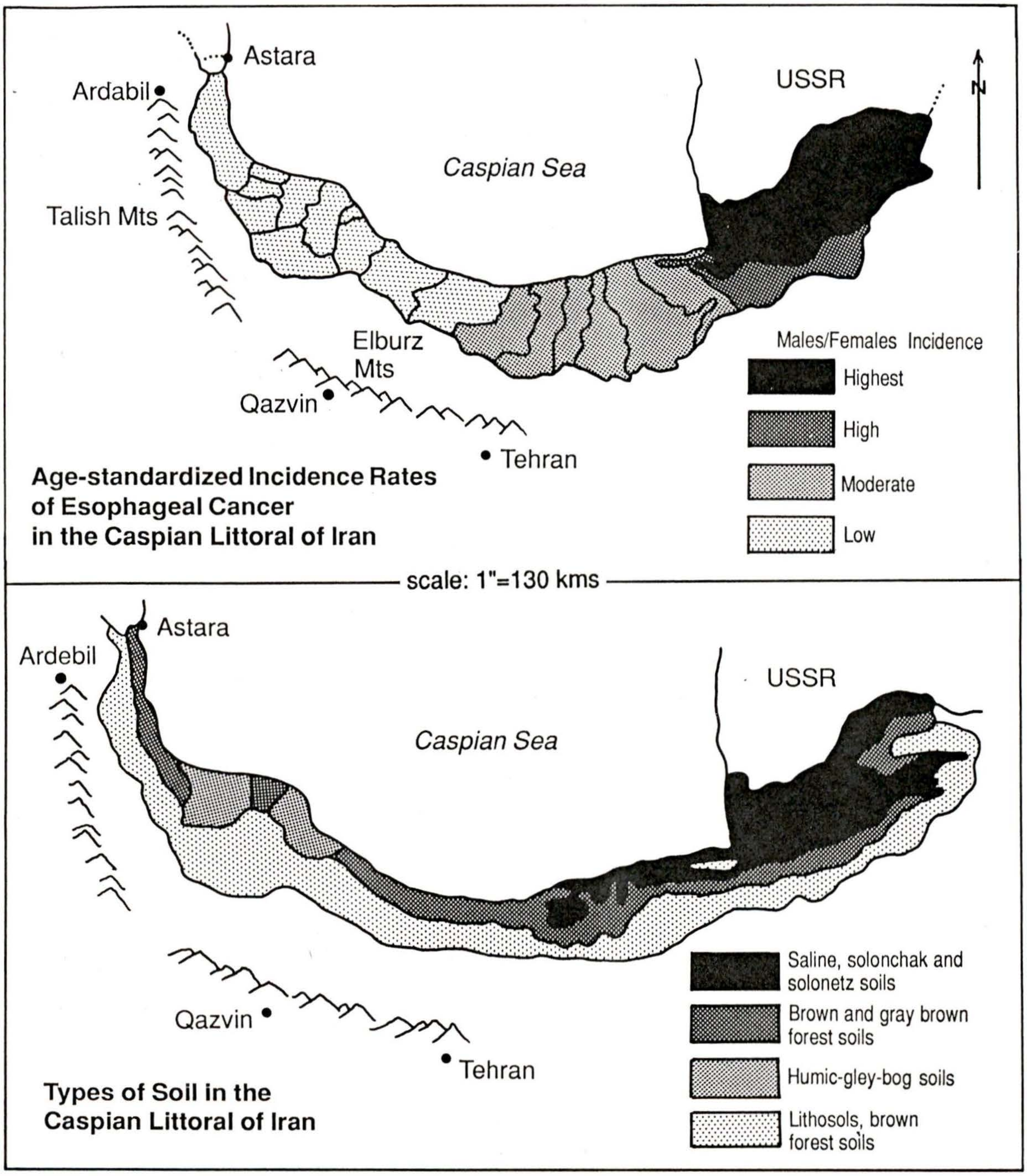


FIGURE 3,1 Comparison of esophageal cancer incidence and soil types in the Caspian Littoral of Iran.

After Kmet and Mahboubi, 1972

communities using poor quality acidic drinking water. Similar conclusions were reached in the same year by Kuzma and his colleagues (1977), who studied the relationship between cancer incidence and drinking water quality in Ohio. These researchers concluded that cancer rates were highest amongst those consuming acidic surface water. Similarly Tuthill and his colleagues (1978) argued that in Massachusetts there were important associations between cancer incidence and the pH, alkalinity,, chlorine and nitrate content of drinking water.

Further support for the view that spatial variations in the incidences of cancer reflected geographical variables came from Armstrong (1980), who studied disease patterns in Southeast Asia. He concluded that both water quality and diet were of major significance in understanding spatial variations in the incidence of cancer. In the same year, Marjanen (1980), argued that soil manganese appeared to be a significant cancer preventative in Finland, while high levels of zinc and copper seemed associated with elevated cancer mortality.

In 1980, Kendrick, published a major review of the relationships between socio-economic variables and cancer incidence in New Zealand. His published correlations indicated that environmental and socio-economic factors were strongly involved in the aetiology of the disease. Kendrick argued that, not only did water quality parameters give more meaningful correlations, but that water provided a useful means of measuring the impact of local geochemical variations. This was because, unlike foods which may have been derived from many locations, water is generally taken from the immediate vicinity and utilized by the total population. Results of statistical correlations between site-specific cancers and water quality variables for New Zealand are shown in Table 2,1. Interestingly, unlike the previous research workers quoted, Kendrick found no relationship between the hardness of water and colonic cancer incidence in New Zealand.

However, in contrast, Zeilhuis and Haring (1981), in their study of water hardness and mortality in the Netherlands, found strong negative correlations between water hardness and both cancer and heart disease. They argued that leafy vegetables lose up to 30% of their natural calcium and magnesium when food is cooked in soft water, and felt that this loss might play a significant role in the aetiology of several diseases.

TABLE 2,1

Significant Correlations between
Digestive Cancer Deaths in New Zealand, 1971
and Water Borne Elements (p = 0.01)

	pH	Hardness	Chloride	Sulphate	Iron	Manganese
Esophagus						
Total Males	-	0.12	-0.21	-0.26	-0.23	-0.12
Total Females	-	-	-	-	-	-
Stomach						
Total Males	0.20	-	-0.23	-	0.22	-
Total Females	-	-	-	-	-0.13	0.19
Colon						
Total Males	0.13	-	-	-	-0.12	-0.27
Total Females	-0.23	-	-	-	-0.27	-0.26
Rectum						
Total Males	0.15	0.13	-	0.24	-	-
Total Females	-	-0.11	0.26	-0.19	-	-
All Cancers						
Total Males	0.25	0.25	-	-	0.17	-
Total Females	-0.14	-	-	-	-0.25	-

Source: After Kendrick, 1980.

Further support for the view that cancer mortality reflects environmental variables, came from Shimada and his colleagues in their 1981 Brazilian research. This involved a study of the geographical distribution of cancers of the esophagus, stomach, and colon. It was found that in certain regions of Brazil, particularly those areas having large stock farms, the mortality rate for cancers of the esophagus and stomach were the highest in the world. Shimada and his colleagues concluded "that the geographical distribution patterns of these diseases show a strong geographical dependency indicating that environmental factors are important in the aetiology of the disease." However, these causal variables were not identified.

Thouez, Beauchamp and Simard (1981) attempted to identify links between cancer and the physio-chemical quality of drinking water in Quebec. A major objective of this study was to examine possible relationships between drinking water hardness and the incidence of site-specific cancers.

Statistics presented by these authors indicated that the cancer risk in Canadian males was greatest in Quebec, with female cancer incidence being similar to that of Nova Scotia. It was argued, by Thouez and his colleagues (1981), that 80 to 90 percent of all cancer was directly related to environmental factors.

The results of Thouez et al.'s (1981) correlation analysis are shown in Table 3,1. The negative association between water hardness and the incidence of stomach cancer, and to a lesser extent, other organs of the digestive system should be noted. Thouez and his colleagues pointed out that these results confirmed, in part, those of Crawford (1968) and Stocks (1973).

TABLE 3,1

Significant associations between digestive cancer incidence and water borne elements in Quebec, 1981.

Type of Cancer	pH	Mn	Fe	Ca	$CaCO_3$	Mg	Na	NO_2NO_3
Stomach	-0.82 (-0.62)	0.20* (0.24)	-0.25 (-0.15)	0.25 (0.18)	-0.36 (-0.20)	-0.21 (-0.20)	0.46 (0.07)	-
Intestine		-0.24 (-0.30)	0.12 (0.08)	0.31 (0.24)	-0.44 (-0.26)			0.12 (0.10)
Rectum	-0.55 (0.26)	0.12 (0.15)		0.10 (0.07)	-0.54 (-0.30)	0.21 (0.20)	0.25 (0.03)	-0.32 (-0.25)
Other digestive system	-0.67 (-0.37)	-0.34) (-0.47)	-0.47 (0.03)	0.19 (0.16)	-0.69* (-0.44)	0.36 (0.39)		0.18 (0.16)

* = $P < 0.05$ + $p < 0.01$. Values in parenthesis are coefficients.

In 1986, Foster undertook a major statistical study of cancer mortality in the United States. His results suggested that the distribution of deaths from cancers of the digestive system, the respiratory system and the reproduction system are strongly influenced by soil trace elements excesses, or deficiencies. He further argued that this is also true of the skin cancers. The lymphomas and leukemias, however, were thought to be linked to the use of herbicides and pesticides. The elements identified as significant in the aetiology of cancer were identified as sodium, calcium, magnesium, potassium, phosphorus, iodine, zinc and selenium. In addition, antagonists of some of these elements including mercury, which appears to influence the bio-availability of selenium, and barium, which may cause potassium, loss were thought to be involved. Foster (1986, 1989) examined these relationships in a less rigorous manner in a variety of other countries, demonstrating that such links appear to hold true at the international scale.

CONCLUSIONS

It is clear from the proceeding discussion of the literature that there is growing evidence to suggest that, in both the Developed and Developing Worlds, soil and water quality may play a key role in determining variations in cancer incidence. Several research workers (Crawford et al, 1968; Kendrick, 1980; Zeilhuis and Haring, 1981; Foster, 1986), for example, have suggested negative links between water hardness and the incidence of cancers of the digestive tract. It is this aspect of the possible relationship between cancer and the environment that is explored further in this thesis.

The hypothesis of this thesis, therefore, is that Canadian and British Columbian mortality from digestive cancers are related to the elemental quality of drinking water. Specifically, esophageal, stomach, small intestinal, colonic and rectal cancers are a function of elevated or depressed levels of either pH, calcium, copper, fluoride, iron, hardness, lithium, magnesium, nitrates, sodium or zinc. The author intends to test the hypothesis at both the national and provincial scales, using separate data sets.

For the Canadian study, digestive cancer mortality rates will be obtained from the Mortality Atlas of Canada, Volume 1: Cancer (1980), the water quality data being derived from a national study by Neri (1977), who explored possible links between drinking water quality and heart disease in Canada. Both data sets are organized by provincial census division boundaries, for years 1966 to 1976.

The major objective of this thesis, however, is to test the hypothesis for conditions in British Columbia. To satisfy the requirements of such a test, it will be necessary for the author to research and assemble a comprehensive set of medical and water quality data for the province. Mortality rates for site-specific digestive cancers will be obtained with the kind cooperation of the British Columbia Cancer Control Agency, while a comprehensive listing of water quality data will be achieved by requesting water quality analyses reports from provincial agencies, by the way of form letters, for years 1966 to 1978. Once received the author will classify and assemble both sets of provincial data in preparation for statistical evaluation and review. The following chapters will outline in detail, the various procedures to be used in the collection and analyses of the data for this study.

CHAPTER TWO

SOURCES AND QUALITY OF DRINKING WATER

INTRODUCTION

It is clear from the preceding literature review that several authors (Riecher, 1977; Kendrick, 1980; Zielhaus and Haring, 1981; Durlack and Bara, 1985; Foster, 1986), have argued that there are statistically significant negative correlations between water hardness and cancer mortality. Such links seem to be particularly evident for cancers of the digestive tract. However, in contrast Kendrick (1980) has suggested that in New Zealand there are clear positive correlations between this aspect of water quality and cancer of the colon, in both sexes, and cancer of the rectum in males.

Given this apparent contradiction in the literature, the present author will attempt to review the situation in Canada, especially in British Columbia, in an attempt to clarify this issue. Clearly, the first step in testing these hypotheses involves the development a data bank of Canadian drinking water quality, with special reference to hardness, and therefore to calcium and magnesium content.

WATER DATA SOURCES

Canadian Water Quality

Fortunately, considerable attention has already been paid to water hardness in Canada, by both epidemiologists and geographers, largely because of the widely held belief that it provides protection against diseases of the heart. (Anderson et al., 1969; Fodor, 1973; Neri, 1977; Marier, 1985; Foster, 1986). The most comprehensive water quality data available is that collected by Neri and his colleagues, in 1977, to test this hypothesis.

The author has researched and assembled this large quantity of data over a period of four months. The results are summarized in Table 1,2, which shows typical water quality conditions for selected Canadian population centres, by province in 1977. This table clearly illustrates the great regional variability in water quality conditions across Canada, especially with respect to water hardness, one of the primary factors in this study. This is confirmed by Figure 1,2 an illustration taken from the National Hydrological Atlas of Canada.

TABLE 1,2

Typical Water Quality Parameters for selected
Canadian Population Centre, 1977

	pH	HD	Ca	Cu	Li	Mg	Zn
British Columbia							
Armstrong	8.08	124.0	0.0	0.0	0.02	2.42	0.0
Fernie	7.99	86.0	26.18	0.0	0.25	5.03	0.0
Kelowna	7.74	105.0	31.80	0.0	0.19	6.30	0.01
Merritt	7.40	107.0	30.00	0.0	0.26	7.80	0.03
Nanaimo	7.45	8.0	2.70	0.0	0.01	0.33	0.0
Saanich	7.38	12.0	3.50	0.11	0.01	0.88	0.02
Vancouver	6.60	6.0	1.48	0.40	0.05	0.22	0.0
Means	7.52	64.0	13.67	0.08	0.11	3.28	0.01
Alberta							
Calgary	8.20	183.0	50.00	0.0	0.78	14.25	0.05
Edmonton	8.88	80.0	14.63	0.0	0.31	10.60	0.0
Grande Prairie	7.62	157.0	46.00	0.46	0.24	10.25	0.06
Lethbridge	7.78	142.0	40.00	0.0	0.24	10.25	0.01
Medicine Hat	---	127.0	30.50	0.0	0.31	12.30	0.04
Means	8.12	137.8	36.23	0.09	0.38	11.53	0.03
Saskatchewan							
Estevan	7.78	222.0	42.00	0.0	0.14	28.60	0.0
Moose Jaw	7.82	217.0	50.00	0.0	0.48	22.50	0.02
Regina	7.48	276.0	69.50	0.10	0.92	25.00	0.08
Saskatoon	8.18	100.0	20.00	0.0	0.38	12.10	0.0
Swift Current	---	182.0	36.00	0.0	0.35	22.30	0.82
Means	7.82	199.4	43.50	0.02	0.45	22.10	0.18
Manitoba							
Brandon	8.40	138.0	36.00	0.0	0.41	11.60	0.0
Flin Flon	7.39	53.0	14.90	0.0	0.10	3.70	0.8
Portage	7.80	182.0	37.80	0.0	0.38	21.20	0.01
Winnipeg	8.07	89.0	24.75	0.25	0.33	6.50	0.0
Means	7.92	115.5	28.36	0.06	0.31	10.75	0.20
Ontario							
Guelph	7.68	418.0	---	0.38	0.75	26.00	0.35
Kingston	7.40	128.0	37.50	0.0	0.29	8.25	0.09
Kitchner	7.32	447.0	115.20	0.12	0.79	38.50	3.12
North Bay	6.83	23.0	6.71	0.0	0.13	1.63	0.08
Ottawa	7.50	57.0	---	0.0	0.10	2.42	0.0
Sudbury	6.80	53.0	12.54	2.6	0.14	5.25	0.15
Thunder Bay	8.02	40.0	11.42	0.0	0.10	2.81	0.0
Toronto	7.56	151.0	46.00	0.05	0.54	8.90	0.25
Means	7.38	183.75	38.23	0.36	0.32	13.30	0.48

TABLE 1,2 (continued)

Typical Water Quality Parameters for selected
Canadian Population Centres by Province, 1977

	pH	HD	Ca	Cu	Li	Mg	Zn
Quebec							
Chicoutimi	7.40	24.0	8.58	0.0	0.07	0.66	0.05
Montreal	7.75	130.0	38.50	0.03	0.50	8.25	0.08
Quebec City	7.02	59.0	16.06	0.93	0.14	4.51	0.05
Sherbrooke	7.50	44.0	12.93	0.70	0.10	2.81	0.10
Trois Pistoles	7.52	153.0	52.50	0.05	0.54	5.25	0.01
Means	7.44	82.0	25.71	0.34	0.25	4.30	0.06
New Bruswick							
Bathurst	7.15	49.0	16.80	0.0	0.03	0.01	0.01
Fredericton	7.50	81.0	26.50	0.07	0.05	3.50	0.0
Moncton	6.60	8.0	2.10	0.0	0.0	0.68	0.03
St. John	6.61	14.0	4.40	0.12	0.07	0.67	0.08
Means	6.97	38.0	12.45	0.05	0.04	1.22	0.03
Nova Scotia							
Dartmouth	5.26	9.0	2.76	0.03	0.0	0.51	0.02
Digby	6.60	19.0	4.62	0.03	0.0	1.71	0.04
Halifax	6.64	18.0	6.16	0.17	0.13	0.66	0.05
North Sydney	7.00	10.0	2.50	0.84	0.01	1.01	0.18
Means	6.38	14.0	16.04	0.27	0.04	0.97	0.07
Prince Edward Island							
Charlotteville	7.30	96.0	19.00	0.15	0.03	11.80	0.01
Summerville	7.45	128.0	49.00	0.28	0.09	1.32	0.12
Means	7.38	112.0	34.00	0.22	0.06	6.56	0.07
Newfoundland							
Cornerbrook	7.20	23.0	6.93	0.0	0.0	1.30	0.01
St. Anthony	7.52	13.0	0.44	0.09	0.0	2.90	0.05
St. John s	6.41	5.0	1.20	0.34	0.0	0.57	0.0
Means	7.04	13.66	2.86	0.14	0.0	1.59	0.02

Source: After Neri, 1977

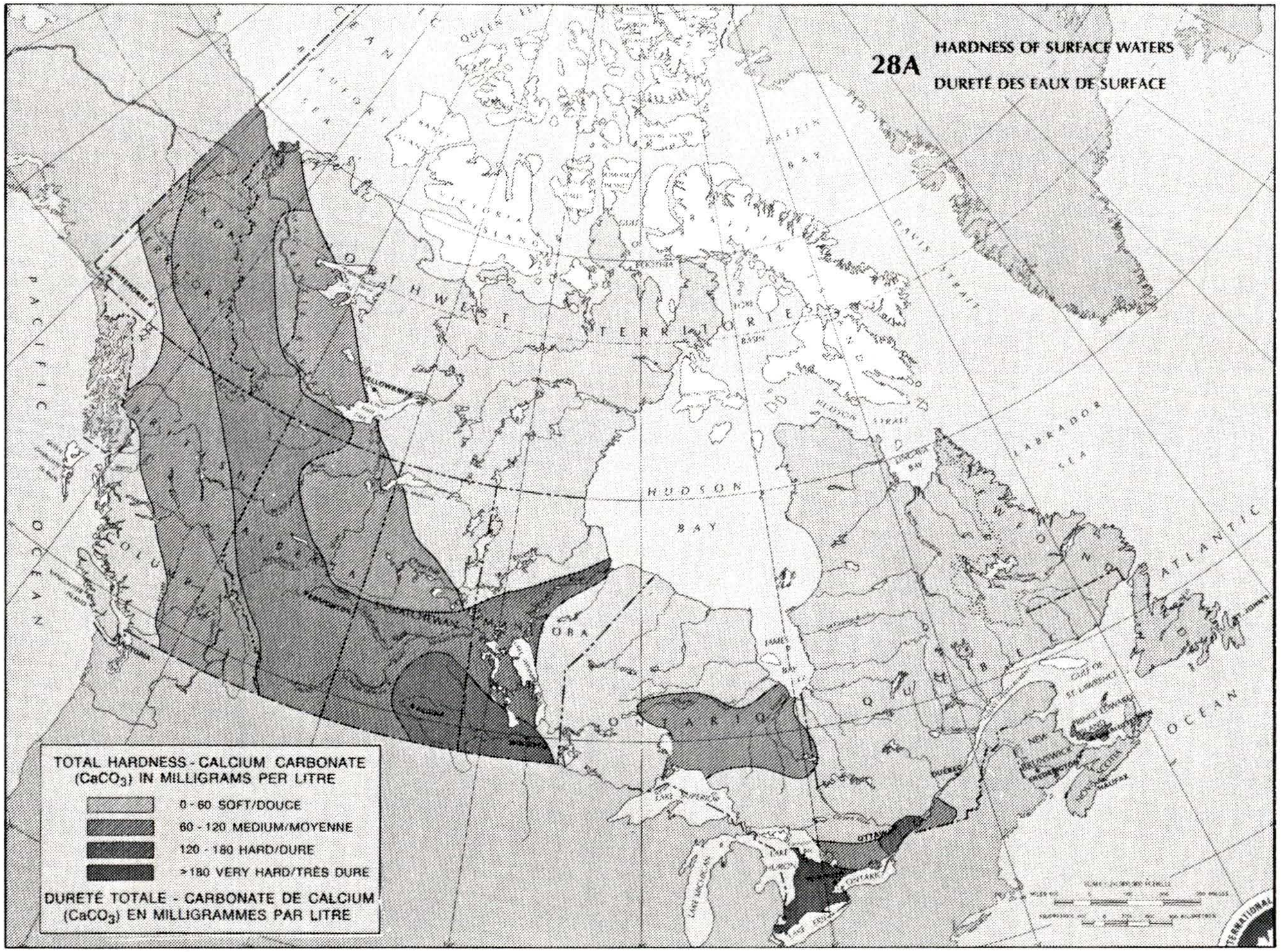


FIGURE 1,2 Canadian surface water hardness
Source: Hydrological Atlas of Canada, 1978.

Water Hardness

The major aim of this thesis is to test the hypothesis that water quality, in British Columbia, in particular its hardness, may in part, account for variation in mortality from digestive cancer. It is important, therefore, to clearly define what is meant by water hardness, since there is no universally agreed definition.

Originally, water hardness was a term used to describe the inherent characteristics of a water source, meaning the degree to which soap would lather while using it. More recently, however, the term hardness has been used to describe the level of dissolved calcium and magnesium ions which may be present in a sample, the level of hardness being reported in milligrams per litre (mg/l.) or parts per million (ppm).

Although calcium and magnesium account for most of the hardness in any water sample, it should be noted that other trace elements such as barium, iron, manganese and strontium may also be present and can contribute to hardness. Trace elements such as lithium, potassium and sodium which may also be present do not add to hardness.

In most studies of the human health effects of water, the term hardness is generally accepted to be the level of total hardness based on the measurement of water borne calcium and magnesium. Marier (1979) outlined a simple equation based on molecular weight which can be used for this calculation:

$$\text{Total Hardness} = (2.5 * \text{Ca}) + (4.12 * \text{Mg})$$

There has been considerable international controversy over various water softness-hardness classifications, since many countries and research bodies have their own definitions. Table 2,2 provides some examples of the wide variety of interpretations of water hardness. It is generally accepted, however, that drinking water with a hardness level of less than 75 mg/l., is considered soft, whilst those with values greater than 100 mg/l. are considered hard. It should also be noted that the geochemistry of water varies greatly and the influence of other trace elements, such as barium and strontium, may have an effect on the way some countries classify water hardness. Neri's (1977) hardness classifications system will be used in this thesis since his data forms an integral part of this study.

TABLE 2,2

Examples of water hardness classifications

Water Classification	Thomas (1954)	Stocks (1973)	Neri et al. (1975)	DeFulvio & Olori (1975)	EPA (1976)
Ultra Soft			0- 14		
Very Soft			15- 29		
Soft	0- 60	0- 50	30- 59	<50	0- 75
Moderately Soft		50-100	60- 99	50-100	
Slightly Hard		100-150	100-149	100-150	
Moderately Hard	61-120	150-200		150-200	75-150
Hard	121-180	200-300	150-249	250-350	150-300
Very Hard	>180	>300	>250	>350	>300

Note: Each unit of hardness is equivalent to 1 mg. $CaCO_3$ per litre

Some of the hardest water in Canada is found in southern Ontario, in a relatively small region bounded by Lakes Huron, Erie and Ontario. Here the bedrock consists of Paleozoic materials including limestone, dolomite, gypsum, shale and conglomerates, which contribute to the high levels of calcium and magnesium and consequently to the hardness of the drinking water (Douglas, 1976). The water hardness in the Guelph-Kitchner region, for example, averages 571.0 mg/l.. This isolated region of extreme water hardness is not, however, typical of Ontario's water as a whole. Outside this very hardwater zone, the levels of water hardness in Ontario range from 23.0 mg/l. in North Bay to 151.0 mg/l. in Toronto. As a result of these variations, the average level of hardness for the province as a whole is approximately 183.75 mg/l.. However, clearly this is a fairly meaningless figure, since the province contains both extremely hard and moderately soft water sources. Indeed, regions situated outside the sedimentary deposits of the Guelph-Kitchner area have moderately soft drinking water, reflecting the chemical characteristics of the rocks of the Canadian Shield.

The second largest concentration of very hard water in Canada is found in south-eastern Saskatchewan and in the extreme southwestern corner of Manitoba, particularly in the Qu'Appelle River system. Regina, located in the western portion of this latter drainage basin, for example, uses very hardwater, with a calcium carbonate hardness of 276.0 mg/l. To the east, Portage Manitoba has a water hardness averaging 182.0 mg/l.. Water hardness in Saskatchewan does, however, vary from north to south, with Saskatoon's water having a hardness of 100.0 mg/l. whilst inhabitants of Swift Current, Moose Jaw and Estevan drink water with hardness levels of 182.0 mg/l., 217.0 mg/l. and 222 mg/l. respectively. Based on Neri's data, the average level of drinking water hardness for Saskatchewan is very high and appears to be some 199.4 mg/l..

The main contributing factors to the hardness of Saskatchewan's drinking water are the low rates of precipitation, high levels of evaporation and the calcium and magnesium producing sedimentary formations through which the water flows. To illustrate, some of the major cities in Saskatchewan, such as North Battleford, Saskatoon and Prince Albert, obtain their drinking water from either the North or South Saskatchewan River systems. The main tributaries of the North and South Saskatchewan Rivers include the Battle, Red Deer and Bow Rivers which originate in the Rocky Mountains. It is from these tributaries that the water obtains its hardness.

The Rocky Mountains and foothills are formed of sedimentary rocks, often of Devonian age, composed mainly of limestones, dolomites, shales and conglomerates. Water originating in these areas contains high levels of calcium and magnesium and, as a consequence, is hard. As the water continues to flow eastward, through the calcium and magnesium producing Paleocene and Cretaceous sedimentary formations of the Alberta and Saskatchewan plains, the levels of hardness continues to increase.

In southern Saskatchewan, the citizens of Moose Jaw, Regina and Estevan also drink very hard water, obtained from the Qu'Appelle River, or its tributaries. The Qu'Appelle River systems also originates entirely within Upper Cretaceous or Paleocene sedimentary rocks, the associated shales contributing to the high levels of calcium and magnesium and consequently to the hardness of the associated drinking water.

A third major region of hard water in Canada occurs in Alberta and northeastern British Columbia, reflecting the geology of the western section of the Great Central Plains and the Rocky Mountains. To illustrate, water hardness levels are 183.0 mg/l. in Calgary, 157.0 mg/l. in Grande Prairie, 142.0 mg/l. in Lethbridge, 127.0 mg/l. in Medicine Hat and 80.0 mg/l. in Edmonton. The average level of hardness for the province as a whole would appear to be some 137.8 mg/l..

Most of Alberta's major cities such as Edmonton, Calgary, Red Deer, Lethbridge and Medicine Hat obtain their drinking water from either the North or South Saskatchewan Rivers, or its tributaries the Battle, Red Deer and Bow Rivers. As has previously been described with reference to water drunk in Saskatchewan, water flowing eastward from the calcareous sedimentary deposits of the Rocky Mountains and over the western plains is very hard.

Manitoba's water, although generally considered moderately hard, also varies greatly from region to region. Portage, in the extreme southwest corner of the province, for example, has very hard water at 182.0 mg/l. In contrast, Winnipeg and Flin Flon have hardness levels averaging 89.0 mg/l. and 53.0 mg/l. respectively. Those regions of Manitoba experiencing high levels of hardness, draw their water from the Assiniboine River. The basin of this river and its tributaries lies entirely within Upper Cretaceous sedimentary deposits. These areas of Manitoba having moderately soft drinking water extract it from basins originating in the igneous rocks of the Canadian Shield. The average level of hardness for province of Manitoba appears to be some 115.5 mg/l., but again this figure tends to mask major spatial variations.

In contrast, the quality of drinking water in Quebec is considered to be only moderately hard, with levels ranging from 24.0 mg/l. in Chicoutimi to 130.0 mg/l. in Montreal and 153.0 mg/l. in Trois-Pistoles. As with other provinces, the quality of water reflects geologic realities. Water derived from igneous outcrops on the Canadian Shield is much softer than that obtained from the Ordovician sedimentary deposits, which outcrop along the St. Lawrence Valley (Wilson, 1946).

The softest water in Canada is found on both the East and West coasts and in regions situated on, or near, the Canadian Shield. To illustrate, Newfoundland and Nova Scotia have some of the softest water in Canada. The range of hardness for Newfoundland's water for example, only extends from 5.0 mg/l. in St. Johns to 23.0 mg/l. in Corner Brook. While in Nova Scotia hardness ranges from 9.0 mg/l. in Dartmouth to 19.0 mg/l. in Digby. Water hardness in New Bruswick ranges more widely, from 8.0 mg/l at Moncton to 81.0 mg/l. at Fredericton. The average level of hardness for the province is some 38.0 mg/l.. Prince Edward Island's drinking water, however, is moderately hard, with an average hardness level of 112.0 mg/l.. This is due mainly to the fact that Prince Edward Island is formed of Carboniferous and Permian sedimentary materials which contain limestones, shales and conglomerates.

Similar water hardness patterns are also evident on Canada's west coast. However, there is greater variability between the coastal regions of British Columbia and its interior plateau. As an example, Neri's data indicates that Vancouver, Nanaimo and Saanich have very soft water, with average levels of 6.0 mg/l., 8.0 mg/l. and 12 mg/l. respectively. In contrast, however, in the west central interior of the province, levels of hardness increase dramatically. To illustrate, Kelowna's drinking water has an average calcium carbonate water hardness of 105 mg/l., Merritt 107.0 mg/l. and Armstrong 124 mg/l.. Further to the east, Fernie, situated in the Rocky Mountain Trench, uses drinking water with a moderate level of hardness, 86.0 mg/l.. In the province of British Columbia, as a whole however, the average level of water hardness appears to be 64.0 mg/l., a figure which again masks significant regional variations.

Other Water Quality Parameters

The pH levels of Canadian drinking water also appear to display marked regional variations. As an example, water in Dartmouth, Nova Scotia has a pH of 5.26 whilst that in Saskatoon, Saskatchewan has a pH of 8.18. Although pH levels generally reflect hardness, this is not always the case.

Copper, lithium and zinc do not appear to have such marked geographical patterns. However, copper and zinc appear associated with regions of high mineralization and lithium seems to be associated with the sedimentary deposits of the Prairies.

British Columbia Water Quality

To successfully test the hypothesis at a provincial scale it was necessary to have a very comprehensive water quality data set for British Columbia. In British Columbia, each water distribution authority is responsible for its own water quality conditions. The bulk of the water quality testing conducted in British Columbia is carried out by the Ministry of Environment, which contracts analysis to private laboratories. By provincial statute, each water distribution authority must have its drinking water quality tested on a regular basis. Normal analysis generally involves establishing the condition of the drinking water, and providing details of concentration of a variety of elements.

Tests usually conducted to determine the general condition of the water include determining its colour, pH, alkalinity, hardness, specific conductance and the amount of suspended solids. Colour and levels of suspended solids (turbidity) are recorded in relative photometric and nephelometric units, pH on a scale of 0 to 10 (acid=0 to alkaline =10), specific conductance is recorded in micromhos per centimetre (UMHO/cm) and alkalinity and hardness in milligrams per litre (mg/l). Also routinely tested for are nitrates and nitrate compounds (N, NO_2, NO_3) and phosphates, the levels of which are recorded in milligrams per litre (mg/l).

Analysis is also carried out to establish levels of a variety of other elements. Many of these occur naturally in fresh water, although others reflect human activities. Elements which may be identified and measured include aluminum, arsenic, barium, bromium, cadmium, calcium, chlorine, chromium, copper, fluorine, iodine, lead, lithium, magnesium, manganese, molybdenum, nickel, selenium, sulphur and zinc. Unlike the tests for general water quality, routinely conducted in all areas, which of these additional elements are measured depends very much on the discretion of local officials. As a consequence, the availability of such data in British Columbia varies widely.

Although governed under the Ministries of Environment and Health, most of the water district distribution systems within the province are administered by Regional District authority. The operation and quality control of the water distribution systems are undertaken by the various cities, towns or villages within each district.

For this reason, no comprehensive set of water quality data for the province is available in published form. In order to develop one, it was necessary for the author to contact all administrative bodies responsible for water distribution and quality control in the province by form letter. These included cities, towns and villages, company towns, private subdivisions, irrigation and water improvement districts, as well as the Federal Department of Indian Affairs.

Extensive water quality information was received in response to the form letters, although it was not always complete. Fortunately information on those parameters which were of particular importance to this study was generally available. This included the source of the water, its pH, hardness, and calcium, copper, iron, fluoride, magnesium, nitrogen, sodium and zinc levels. An example of a water quality analysis report is shown in Appendix 1,2. It should be noted that, in all cases, analysis was conducted on primary water sources before any treatment had taken place. Appendix 2,2 gives a complete listing of the primary sources of drinking water for all major centres in the province. As anticipated, water quality was found to vary markedly from region to region.

Water derived from the igneous intrusions of the Coastal Mountains is very soft and generally low in many of the bulk and trace elements. Vancouver's water, for instance, has a pH of 6.0, hardness is rated at 4.2 mg/l., while its calcium and magnesium content is 1.4 mg/l., and 0.26 mg/l. respectively. Vancouver's water only contains minor levels of other bulk or trace elements.

This can be contrasted with the drinking water of Williams Lake, located in British Columbia's second major physiographic subdivision, the Interior Plateau. The Interior Plateau consists of a wide band of unconsolidated sedimentary materials and intrusive volcanic rocks. Generally speaking, the water found in this area is hard to very hard, depending on geographical location. Hardness levels range from 142.0 to 452.0 mg/l., calcium content from 41.0 to 85.0 mg/l., and magnesium from 10.3 to 54.0 mg/l., while pH varies from 7.2 to 8.0.

The water quality of the Coastal Mountains and the Interior Plateau can be further contrasted with that of the Eastern, or Rocky Mountain region, which is formed of Paleozoic sediments. These include a variety of limestones, shales, argillites, quartzites, and carboniferous materials. Water in this area is moderately hard to very hard, varying from 170 to 334 mg/l., calcium content ranges from 36.6 to 80.2 mg/l. and that of magnesium from 19.1 to 32.5 mg/l.. The water is alkaline, with a pH varying from 7.2 to 8.3.

While these major generalizations are correct, it should be noted, however, that there are often subregional variations in water quality which do not reflect local geological characteristics, particularly when water is drawn from a river. For example, the quality of water for the City of Castlegar is very different from that which one would anticipate from the local geology, since the source of supply for the city are the Arrow Lakes, part of the Columbia River system.

WATER DATA MANAGEMENT

Canada

To explore the possibility that regional variations in Canadian digestive cancer mortality from 1966 to 1976 were due, in part, to water quality differences, it was necessary to collect drinking water data, from the same time period, or slightly earlier.

Obviously, in any correlations between diseases and environmental factors, it is necessary to use geographical data for a time period synchronous with, or pre-dating, the onset of the illness. Fortunately, in 1970, a group of research workers from the University of Ottawa and from Health and Welfare Canada began to explore the possibility of significant links between the chemical content of Canadian drinking water and cardiovascular health (Neri et al, 1977). To explore this hypothesis they undertook a nation-wide analysis of drinking water quality. Samples were collected from five hundred and twenty six communities, with populations of at least 1,000, between June 1970 and December 1972, particularly during the winter of 1971. One-hundred and fifty-two of these locations were then re-sampled at random, to gauge seasonal fluctuations in water quality. In addition, all settlements with a water hardness of over 100 mg/l. and cities with populations greater than 100,000 were sampled again in

1972 in greater detail. All information collected from November 1970 to December 1972 was then collated and published (Neri et al, 1977). The resulting data bank included extensive information on water hardness and on the total calcium, magnesium, lithium, copper, zinc, chromium and cadmium content of the drinking water of the communities involved. During laboratory analysis, Neri and his colleagues (Neri et al, 1977) established the levels of some elements, especially magnesium and lithium, more frequently than others. For example, magnesium had been sampled at 525 locations, whilst information on the chromium content of drinking water was provided for only 247 locations. Nevertheless the magnitude of the sampling effort, its national scope and the time period involved meant that this survey represented an ideal source of water quality information for use in the present study. Permission was kindly received from Dr. L. C. Neri to re-use this information and to enter it into a computer data bank, to determine whether there were any statistically significant links between such water quality parameters and Canadian age-standardized cancer mortality rates. Since the location of each water sample had been identified by latitude and longitude, it was possible to establish from which census division it had been taken. In cooperation with Dr. Harold D. Foster and Miss Ragan

Johnson, the data was computerized, and mean values were established for a variety of water quality parameters including pH, hardness, calcium, copper, lithium, magnesium and zinc at the census division scale.

British Columbia

A separate, more comprehensive independent data base was also developed for British Columbia. As previously described, this contained information on water quality supplied as the result of a form letter which had been sent to various government agencies.

A very select and efficient system of data management is required to handle such an enormous amount of information. Since medical data was available at the school district level, the author decided that the study would include the identification of all data under a field system by school district, as shown in Figure 2,2. Data collected also included the school district name, its water source, latitude, longitude, and the ten water quality parameters utilized for this study.

Coding sheets where then developed by the author to assist in the organization of this data and to provide an efficient way of loading it into the computer system by field. In most cases, respondents to the form letter asking for water quality information sent several year's records, including the most recent. In an effort to deep data from this study synchronized, only information collected during the period 1975 to 1978 was coded. In a few instances, however, the only records available were more recent, and where relevant, this updated information was used.

One difficultly involved in this process was determining the location of the distribution system within school district boundaries. This was necessary so that the author could code the specific water quality data by school district number. Where more information was required, assistance was requested from representatives of the various regional districts and of the Ministries of Education, Environment, Health and Municipal Affairs, as well as the Federal Department of Indian Affairs.

A second problem encountered in this process involved establishing representative water quality levels when two or more population centres, with differing water sources, were situated within a single school district boundary. On the advice of John Spinelli of the B. C. Cancer Control Agency, the author aggregated or weighted the elemental listings for different water sources as a percent of the total population within a school district. As a result, aggregate listings were developed for each district which included pH, hardness, calcium, copper, iron, fluoride, magnesium, nitrogen, sodium, and zinc.

FIGURE 2,2 British Columbia School District Boundaries.

After Band, 1988

Table 3,2 illustrates how such aggregation was achieved for calcium in School District Number 1, which includes the towns of Elkford, Fernie and Sparwood. A similar process was used to calculate other water quality parameters in School District Number 1, as well as for other school districts in the province where more than one source of water was used.

Once aggregate values had been established for each school district, data was then entered under the previously developed field system. It was felt that this weighted information gave a reliable representative sample of the water quality parameters for each school district. Table 4,2 shows a complete listing of aggregate water quality values for all school districts within British Columbia. Rank order listings of pH, hardness, calcium, copper, fluoride, iron, magnesium, sodium, nitrates and nitrites and zinc are shown as Appendices 5,2 through 14,2.

TABLE 3,2

Example of calculating aggregate values for Calcium in School District 1, including Towns of Elkford, Fernie and Sparwood.**

Place	Population*	% Total Aggregation
Elkford	1,875	18
Fernie	4,646	44
Sparwood	4,050	38
	10,571	100%

Calcium levels by place as a % of total population

	Total	%	Aggregate Value
Elkford	45.0 mg/l	18	8.26 mg/l
Fernie	44.0 mg/l	44	20.20 mg/l
Sparwood	47.8 mg/l	38	17.44 mg/l
		100%	45.90 mg/l

* Population for School District No. 1 based on Census Canada, 1976, pp. 4-6.

** Method for aggregating elemental values was recommended by J. Spinelli, Chief Statistician, B. C. Cancer Control Agency.

As can be seen from the aggregate listings in Table 4,2 some aspects of water quality clearly show regional trends. This, of course, confirms the conclusions drawn from the data collected by Neri and his colleagues (1977). The water in coastal regions, for example particularly that used for domestic consumption in Vancouver and in the lower Fraser Valley, has a very low pH, approximately 6.0. In contrast, drinking water in the Peace River region has a pH of 8.4. It is also interesting to note that the coastal areas tend to have the lowest concentrations of calcium, iron and magnesium. For example, water from Vancouver contains 1.40 mg/l. of calcium, 0.15 mg/l. of iron and 0.26 mg/l.of magnesium. Water from the central interior regions, such as the District of Cariboo have the highest concentrations of these elements, 85.0 mg/l. of calcium, 1.10 mg/l. of iron and 54.25 mg/l. of magnesium. The geographic distribution of drinking water pH, hardness, calcium, copper, fluoride, iron, magnesium, nitrates-nitrites and zinc, in British Columbia by school district ,are shown in Figures 3,2 through 12,2. The geographic distribution of the nine water parameters to be used later in the correlation analyses with digestive cancers are shown in Figure 3,2 to 12,2.

TABLE 4,2

Aggregate listing of nine water quality parameters in British Columbia, by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010

TABLE 4,2
continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022

In contrast, the author could find no clearly defined relationships between geography and the occurrence of copper, nitrates and nitrites, sodium or zinc. However, those districts experiencing high levels of nitrates and nitrites tend to be situated in agricultural areas. High nitrate and nitrite levels were experienced, for example, in the southern Okanagan (4.4 mg/l.), Grand Forks (5.04 mg/l.) and Kettle Valley (8.12 mg/l.).

The sodium content of drinking water which may have a relationship to esophageal cancer, tends to vary both locally and regionally. The highest levels either occur on the coast, perhaps due to salt water intrusion, or in interior towns experiencing heavy snowfalls, where high readings probably reflect the use of road salts. High levels of sodium were observed in the districts of Central and South Okanagan, Cariboo, Smithers and Queen Charlotte Islands. The copper and zinc content of drinking water does not display marked regional variations, although high levels seem to be found in heavily mineralized areas, such as Trail and Merritt.

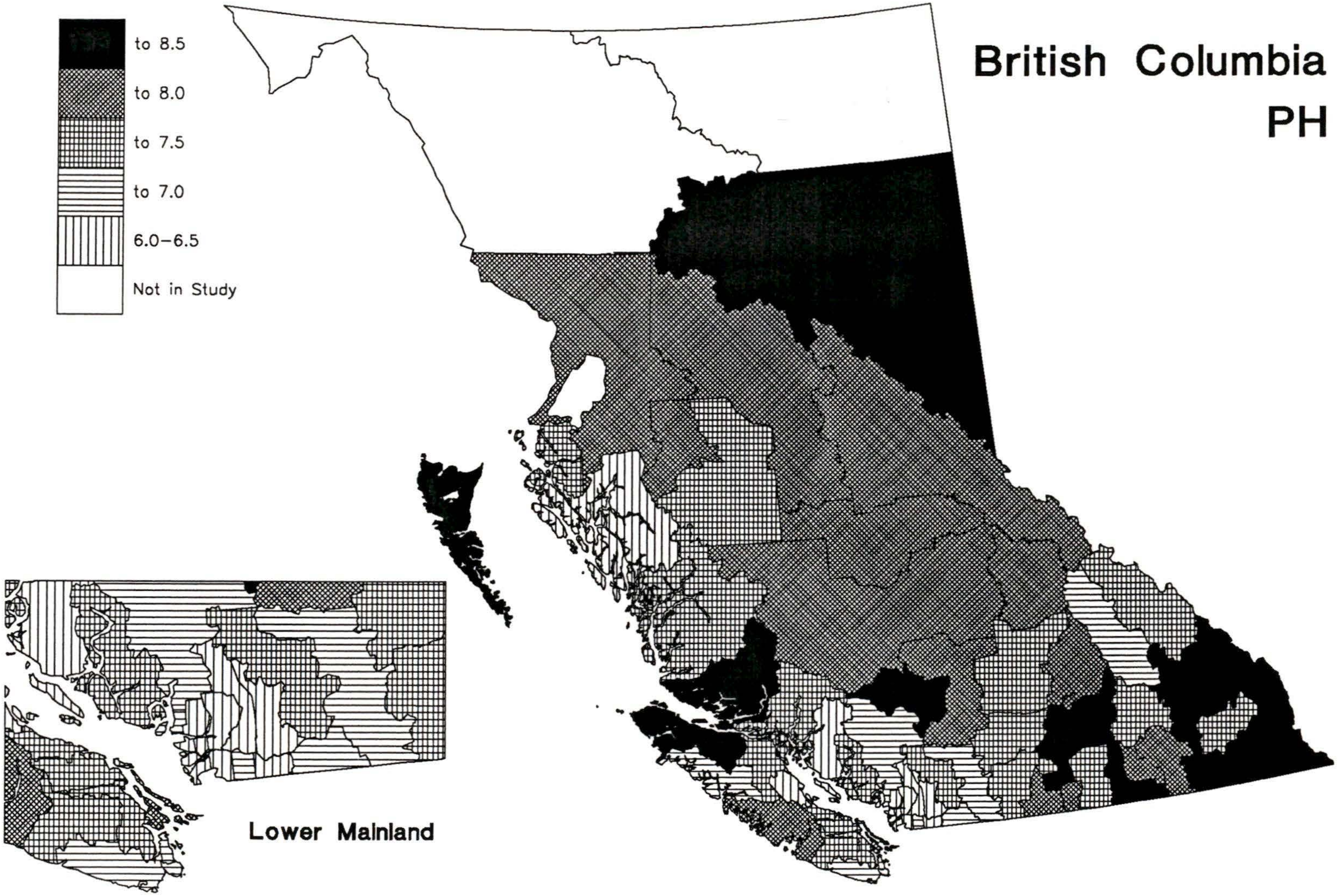


Figure 3,2: The pH of drinking water in British Columbia by School District

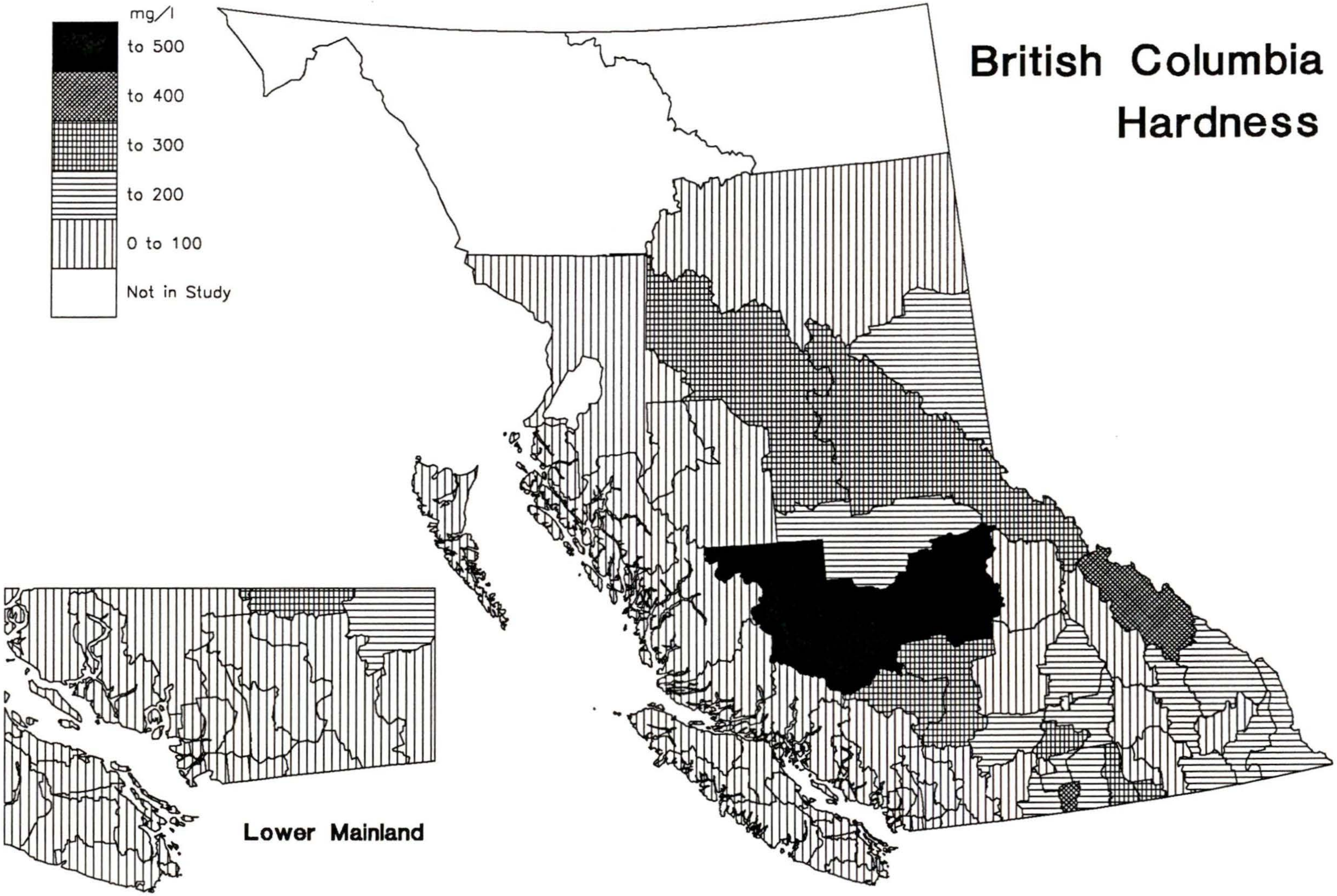


Figure 4,2: Hardness in British Columbia drinking water by School District

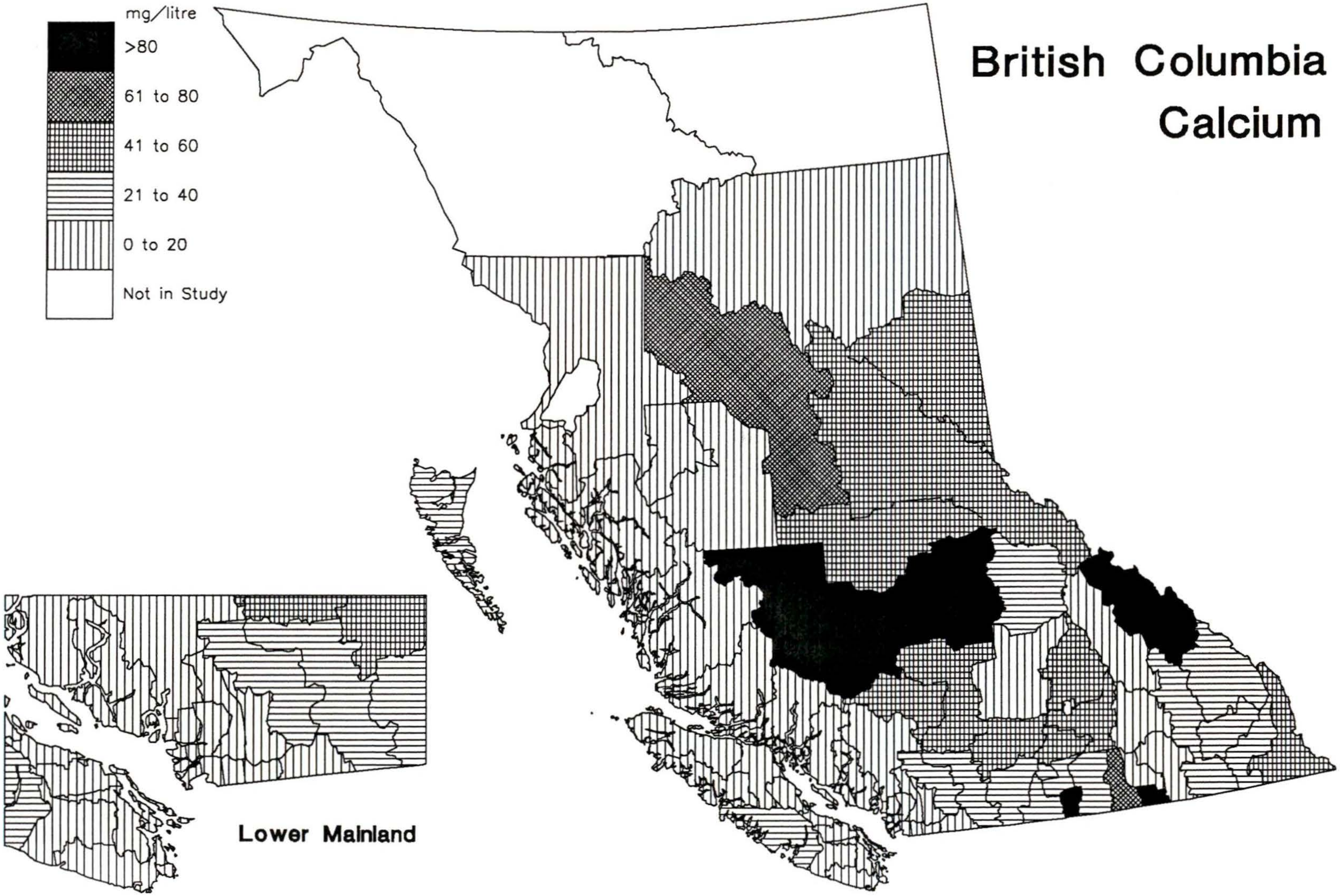


Figure 5,2: Calcium in British Columbia drinking water by School District

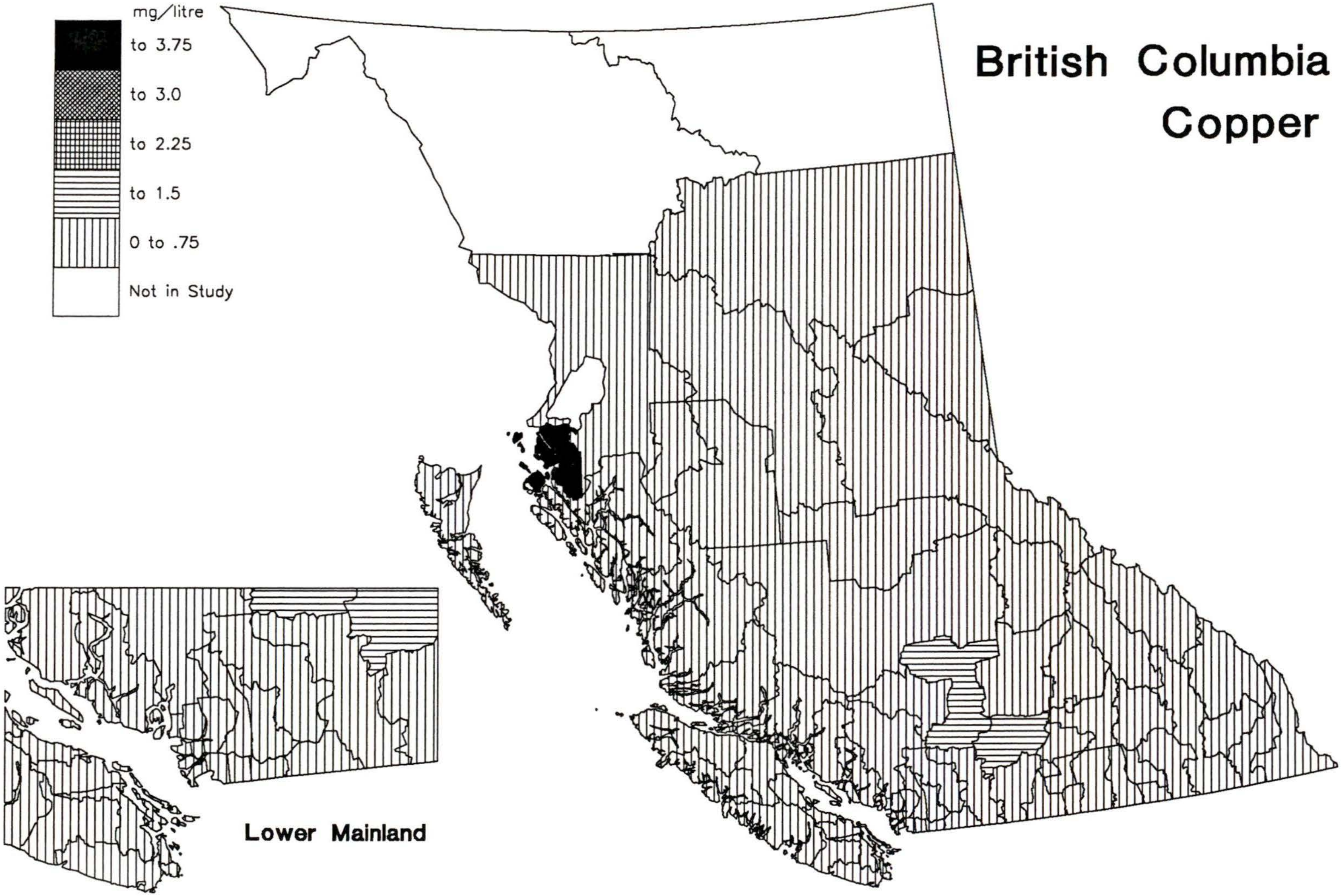


Figure 6,2: Copper in British Columbia drinking water by School District

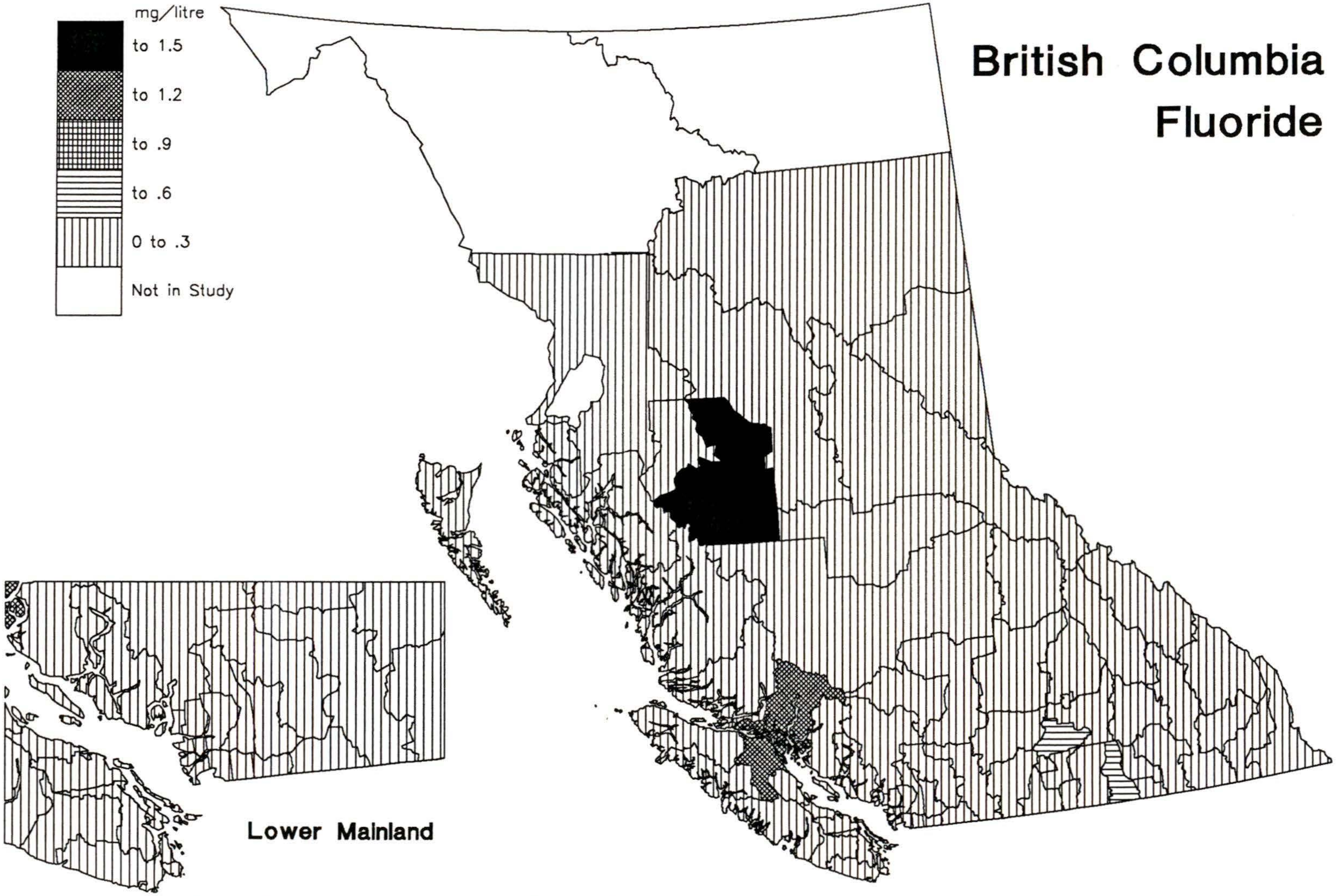


Figure 7,2: Fluoride in British Columbia drinking water by School District

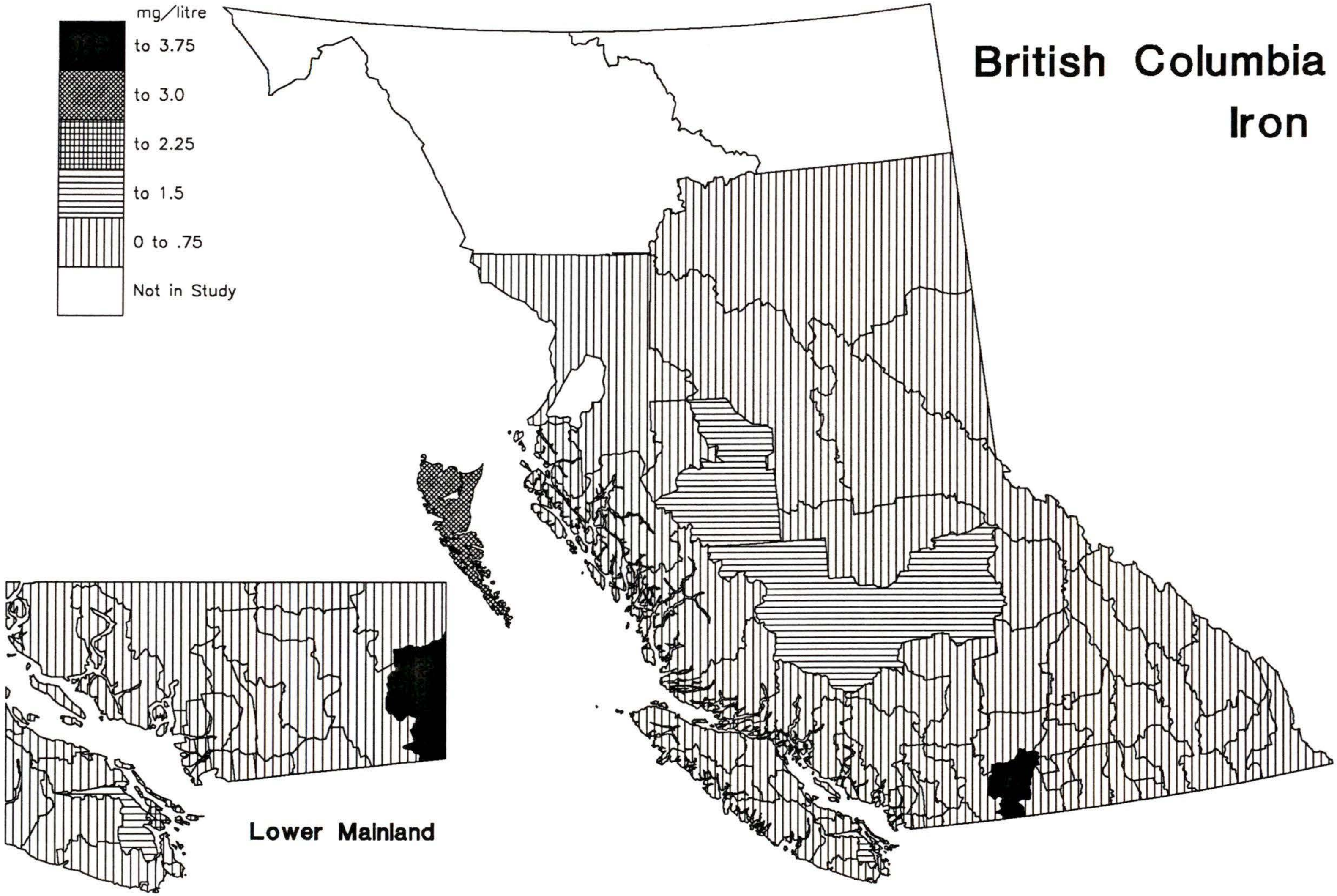


Figure 8,2: Iron in British Columbia drinking water by School District

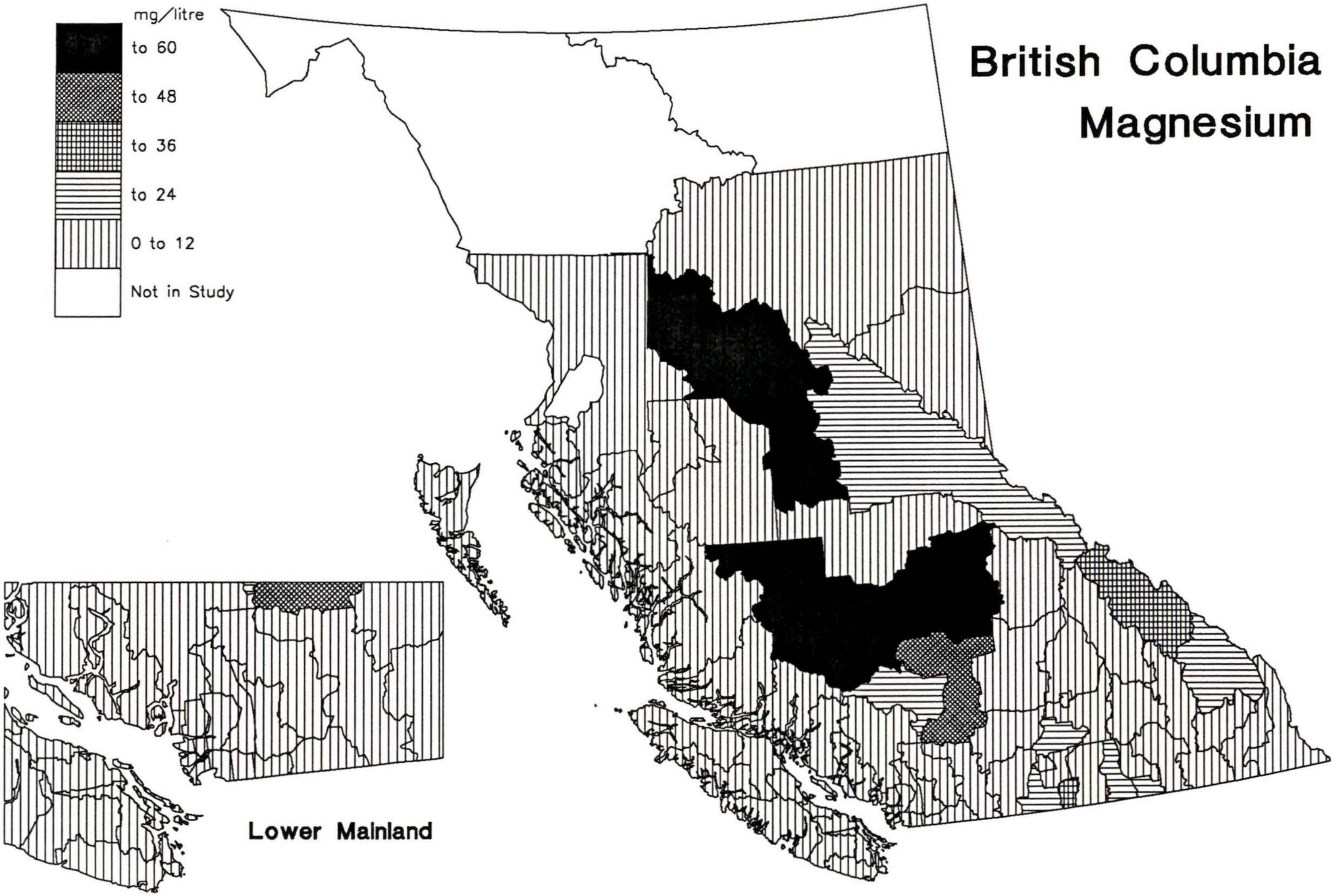


Figure 9,2: Magnesium in British Columbia drinking water by School District

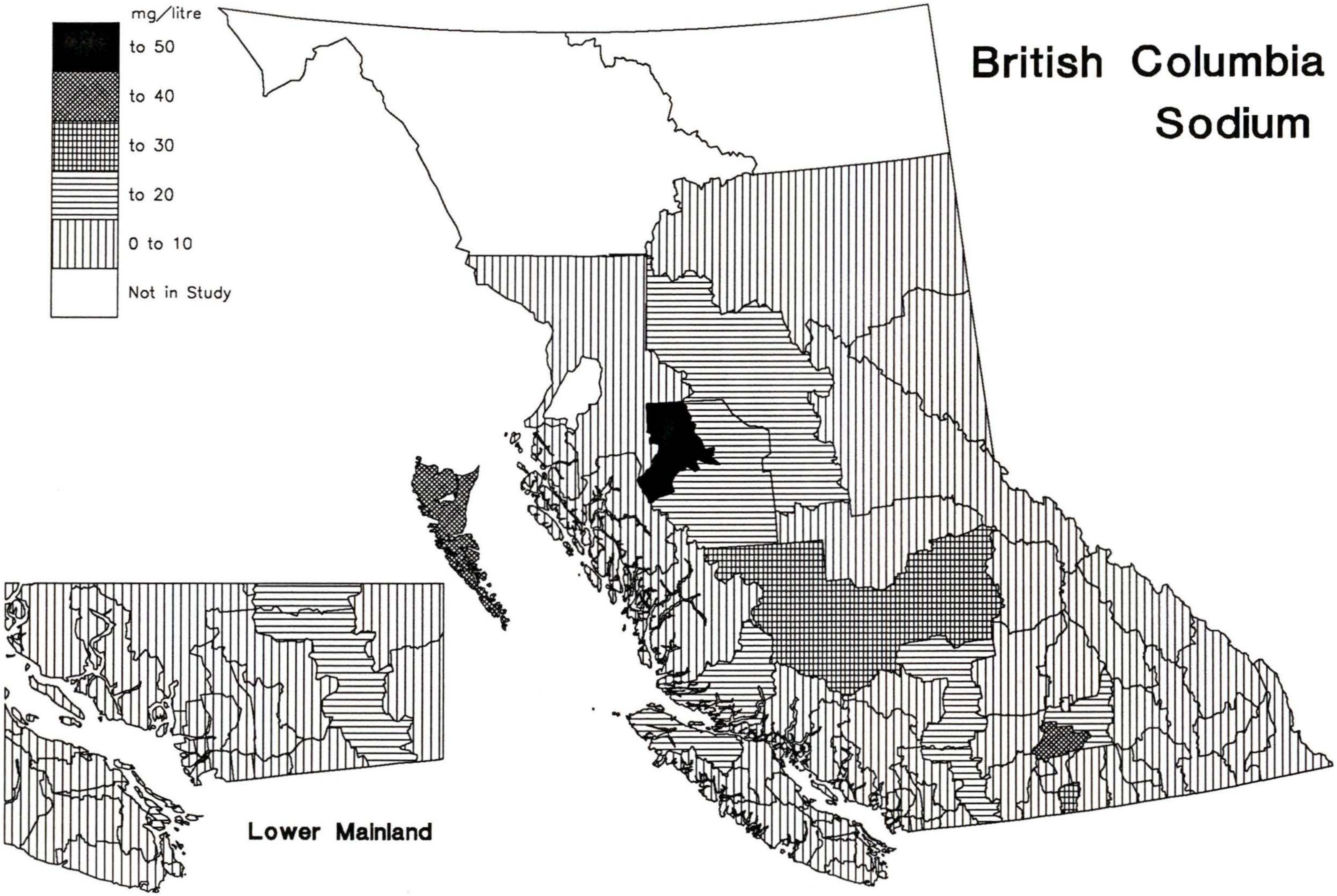


Figure 10,2: Sodium in British Columbia drinking water by School District

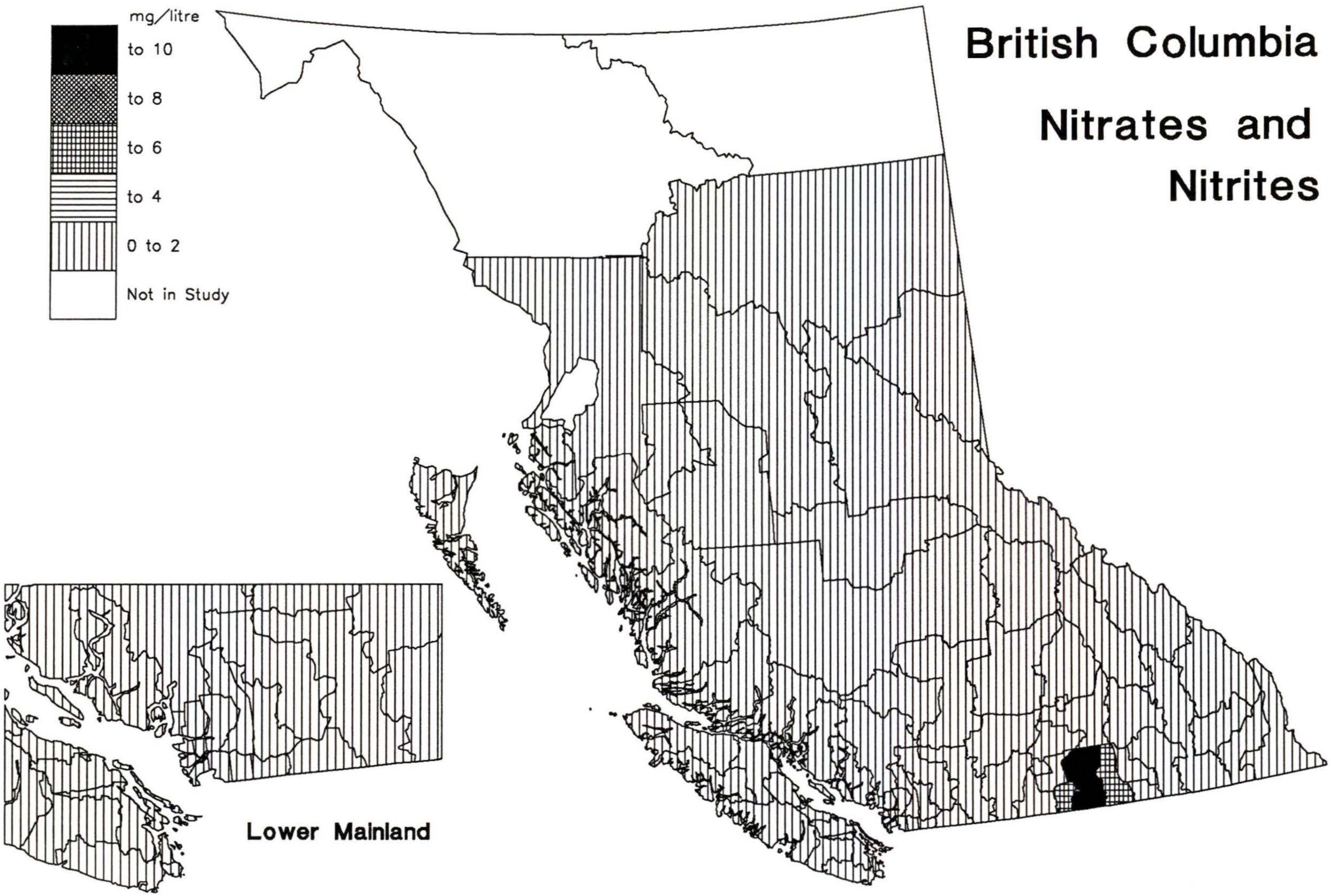


Figure 11,2: Nitrates and Nitrites in British Columbia drinking water by School District

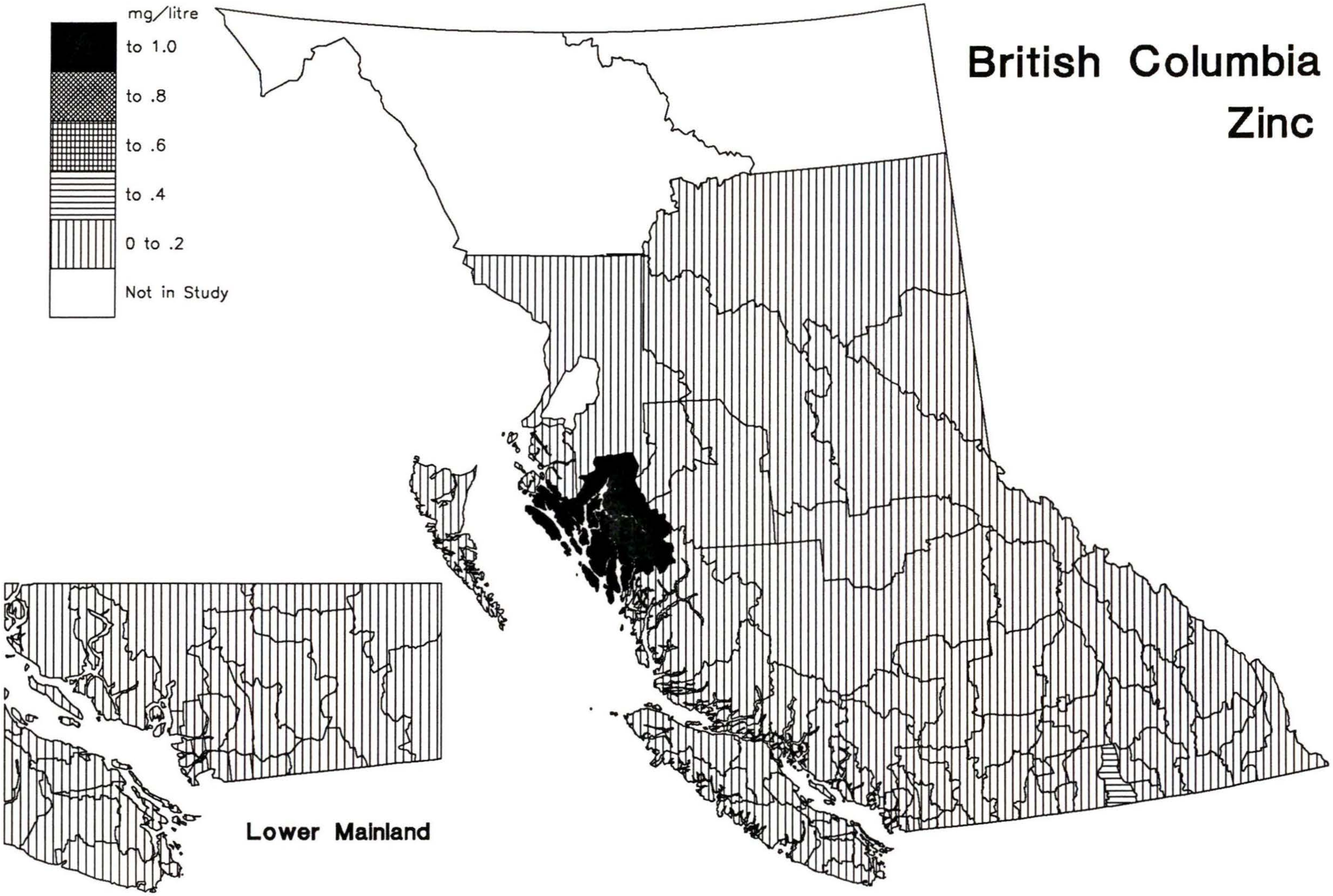


Figure 12,2: Zinc in British Columbia drinking water by School District

DATA LIMITATIONS

Canada

Clearly, the data collected by Neri and his colleagues (1977) was of high quality. However, due to the enormous scale of this project, sampling tended to be limited. To illustrate, in British Columbia, water was only sampled from 24 of 120 or more population centres. Most of these were located in the southern interior, or on Vancouver Island. In consequence, the author found that all major centres in northern and central British Columbia, including Prince George, Terrace, Smithers, Prince Rupert and the Queen Charlotte Islands were not included in the survey and resulting data bank.

A second limitation of this data stemmed from the fact that census divisions do not necessarily correspond to physiographic regions, as do many of the school district boundaries in British Columbia. As a consequence, although Neri and his colleagues provided a very good overview of Canadian water quality as it related to those parameters studied, regional or local water sources could not be isolated and studied at the basin scale.

Neri (1977) also admitted to a third data limitation, claiming that although a substantial degree of confidence could be placed on the representative sampling and analysis of the bulk elements, such as calcium and magnesium, only minimal levels of confidence could be given to the accuracy of the other trace elements, since many samples contained levels less than the detectable limits. Although analysis was conducted on treated tap water, the levels of bulk and trace elements varied considerably by season. One might, therefore, expect this to be true of local health effects.

It was also found that water quality varies with the time of day. For example, in soft water areas the levels of copper and zinc increased dramatically overnight, as soft acidic water interacted with the galvanized and copper plumbing. In hard water areas, the reverse effect took place and calcium and magnesium appeared to provide a protective coating, thereby reducing the chemical interaction between pipes and the drinking water.

British Columbia

The water quality data collected by form letter from British Columbia for use in this study has several inherent strengths and weaknesses. In particular, these are related to the nature of sampling and analysis techniques, and the unknown quality of the water after treatment and distribution.

The bulk of the water quality testing in British Columbia is conducted by the Ministry of Environment, which contracts such analyses to private laboratories. Problems connected with this type of analytical process include the possibility of variable standards between private laboratories, and differing sampling and analytical techniques. In remote locations, water cannot be tested on site and has to be refrigerated and shipped by courier for later analysis in the laboratory.

Another weakness inherent in the use of this type of water quality data involves inconsistency between the years of testing, and more importantly, problems with seasonality. As has been previously discussed, data was supplied for a variety of years, however, in some cases, the only available analytical data was either collected before the mortality figures, or after the 1978 period. In these cases there was no alternative but to use such information. Seasonality, however, is a problem, particularly with surface water sources, since mineral content can vary markedly, reflecting periods of heavy precipitation or drought. Fortunately, in most cases in British Columbia, large reservoirs and major drainage systems tend to modify such extremes. Water testing in the province is also usually carried out during the summer months, although exceptions to this rule can be often found.

A third inherent problem involved in using primary water analysis for this type of study concerns the changes to water quality which occur as a result of treatment and delivery. It is generally accepted that the quality of water deteriorates as it passes from its primary source through treatment and delivery systems to the consumer. Neri (1977), in his investigation of Canadian water supplies, provided dramatic evidence that the quality of water can deteriorate rapidly when standing in pipes. This point will be discussed in more detail in Chapter Six. It is possible, therefore, that domestic water, at the tap, may have a much higher concentrations of copper, lead and zinc, which may modify its impact on health.

CONCLUSIONS

It is evident from the preceding review of the national and provincial water quality data sets, that the geographic distribution of the various bulk and trace elements, vary considerably. This apparently reflects equally variable geological conditions. Although the regional variability of these elements are important to this study, the literature suggests that particular attention should be paid to the equally variable levels of water hardness, and its major constituents calcium and magnesium, at both the national and provincial scales.

To illustrate the extremes experienced, water consumed in the Guelph-Kitchner region of Ontario is extremely hard (571.0 mg/l.) with a calcium content of over 100.0 mg/l. and a magnesium content of 38.91.0 mg/l.. In contrast, in St. Anthony, Newfoundland the drinking water is exceptionally soft, containing only 0.44 mg/l. of calcium and 2.90 mg/l. of magnesium (Neri, 1977).

At the provincial scale, the preceding evidence has also shown that in British Columbia, there is also great regional variability in the nine water quality parameters studied, particularly water hardness. To illustrate these extremes, water consumer in metropolitan Vancouver has a hardness rating of 4.2 mg/l., with a calcium content of 1.4 mg/l. and a magnesium content of 0.15 mg/l. This can be contrasted with that found in the Caribou which has a hardness rating of 452 mg/l., a calcium content of 85.0 mg/l., and a magnesium content of 54.25 mg/l.

It has been previously suggested that these national and region variations in local water hardness and associated bulk and trace elements influence mortality from heart disease (Fordor, 1976; Neri, 1977; and Foster, 1986). To date however, there has been no evidence to indicate whether or not these elements and the hardness levels of Canadian drinking water influences cancer death rates. To test this hypothesis, of course, detailed medical data is required at the national and provincial scales. The availability of such information will now be discussed.

CHAPTER THREE

MEDICAL DATA SOURCES

INTRODUCTION

Canadian Cancer Mortality

Considerable research has been carried out by epidemiologists and geographers into the spatial distribution of cancer in Canada. One of the most comprehensive of these studies was that undertaken in 1978 by the Bureau of Epidemiology, Health and Welfare Canada in collaboration with the Health Division of Statistics Canada. Results were published as the Mortality Atlas of Canada, Volume 1: Cancer. This volume appeared in 1980, and shows the spatial distribution, by census division, of cancer mortality, during the period 1966 to 1976, in each province. Maps of sixteen cancers, or groups of cancers are provided, together with an appendix of age-standardized mortality rates calculated by the direct method, using the 1971 Canadian population as a standard.

Data from these tables, for both sexes, was abstracted by the author for use in the current study. It consisted of mortality rates for five cancer categories related to the digestive tract; namely those of the tongue, mouth and pharynx; stomach, large intestine, rectum and colo-rectal cancer.

Age-standardized mortality rates, for site-specific cancers are established by taking the ratio of the observed number of deaths in a particular census district, to the number of deaths expected in that census district, based on age specific provincial or national mortality rates. This ratio is then multiplied by 100 to give the age-standardized mortality rates for that district. The statistical significance of the age-standardized mortality rates is based on the assumption that the number of deaths in each district followed a poisson distribution.

Mean age-standardized mortality rates indicate that there was great variation in mortality levels between provinces, for specific cancers of the digestive system, including the stomach, colon and rectum. This is illustrated in Table 1,3 which presents mean male age-standardized mortality rates, by province, for cancers of the stomach, colon, rectum and for all cancer sites combined. As can be seen, the highest mean-age standardized mortality rate for stomach cancer in Canadian males, for the period 1966 to 1976, was found in Newfoundland (29.45), whilst the lowest rates, occurred in Saskatchewan (10.87). Cancers of the colon and rectum, in males, were also highest in Newfoundland (19.52 and 8.62); while the lowest rates for colonic and rectal cancer occurred in Saskatchewan (10.22 and 4.98). Quebec had the highest rate (188.61) for total cancer in males, the lowest being found in the province of Saskatchewan (137.48).

The geographic distribution of site-specific cancers tended to differ in females, although the high rates for stomach cancer, for both sexes, had occurred in Newfoundland. As can be seen from Table 2,3, the highest mean age standardized mortality rate for stomach cancer in females were found in Newfoundland (18.32) but the lowest rates occurred Ontario (5.75). The distribution of colonic cancers in females differed from that of males, the highest mean age standardized rate occurring in Nova Scotia (21.04). However, as with males, the lowest rates, were found in Saskatchewan (10.12). The highest female rectal cancer rates were found in New Brunswick (5.70) and the lowest in Newfoundland (1.64). This is almost the reverse of male mortality. In contrast, total cancer mortality for Canadian females peaked in Nova Scotia (126.84), being lowest in Saskatchewan (97.6).

TABLE 1,3

Mean age-standardized mortality rates for site-specific digestive cancers for Canadian males by Province, 1966-1976.

Province (Census Divisions)	Stomach	Colon	Rectum	All Sites
Newfoundland (10)	29.45	19.52	8.62	178.36
Prince Edward Island (3)	10.88	14.77	5.92	140.61
Nova Scotia (18)	17.41	19.20	6.58	165.25
New Brunswick (15)	17.04	14.55	7.17	154.63
Quebec (99)	22.56	18.48	7.40	188.61
Ontario (60)	12.74	16.46	7.99	163.13
Manitoba (23)	15.81	13.58	5.60	158.47
Saskatchewan (18)	10.87	10.22	4.98	137.48
Alberta (15)	14.99	12.08	6.13	141.47
British Columbia (57)	11.47	12.22	7.83	156.48

Source: Health and Welfare Canada/Statistics Canada. Mortality Atlas of Canada, Volume 1: Cancer, 1980.

TABLE 2,3

Mean age-standardized mortality rates for site-specific digestive cancers for Canadian females by Province, years 1966-1976.

Province (Census Divisions)	Stomach	Colon	Rectum	All Sites
Newfoundland (10)	18.32	15.76	1.64	115.70
Prince Edward Island (3)	7.30	20.66	2.54	119.53
Nova Scotia (18)	8.65	21.04	4.01	126.84
New Brunswick (15)	7.60	16.07	5.70	116.00
Quebec (99)	10.52	17.70	4.74	124.76
Ontario (60)	5.75	16.49	4.51	114.17
Manitoba (23)	8.66	14.11	3.34	113.02
Saskatchewan (18)	5.96	10.12	2.23	97.60
Alberta (15)	6.82	11.94	3.58	103.99
British Columbia (57)	6.30	11.67	4.16	109.22

Source: Health and Welfare Canada/Statistics Canada. Mortality Atlas of Canada, Volume 1: Cancer, 1980.

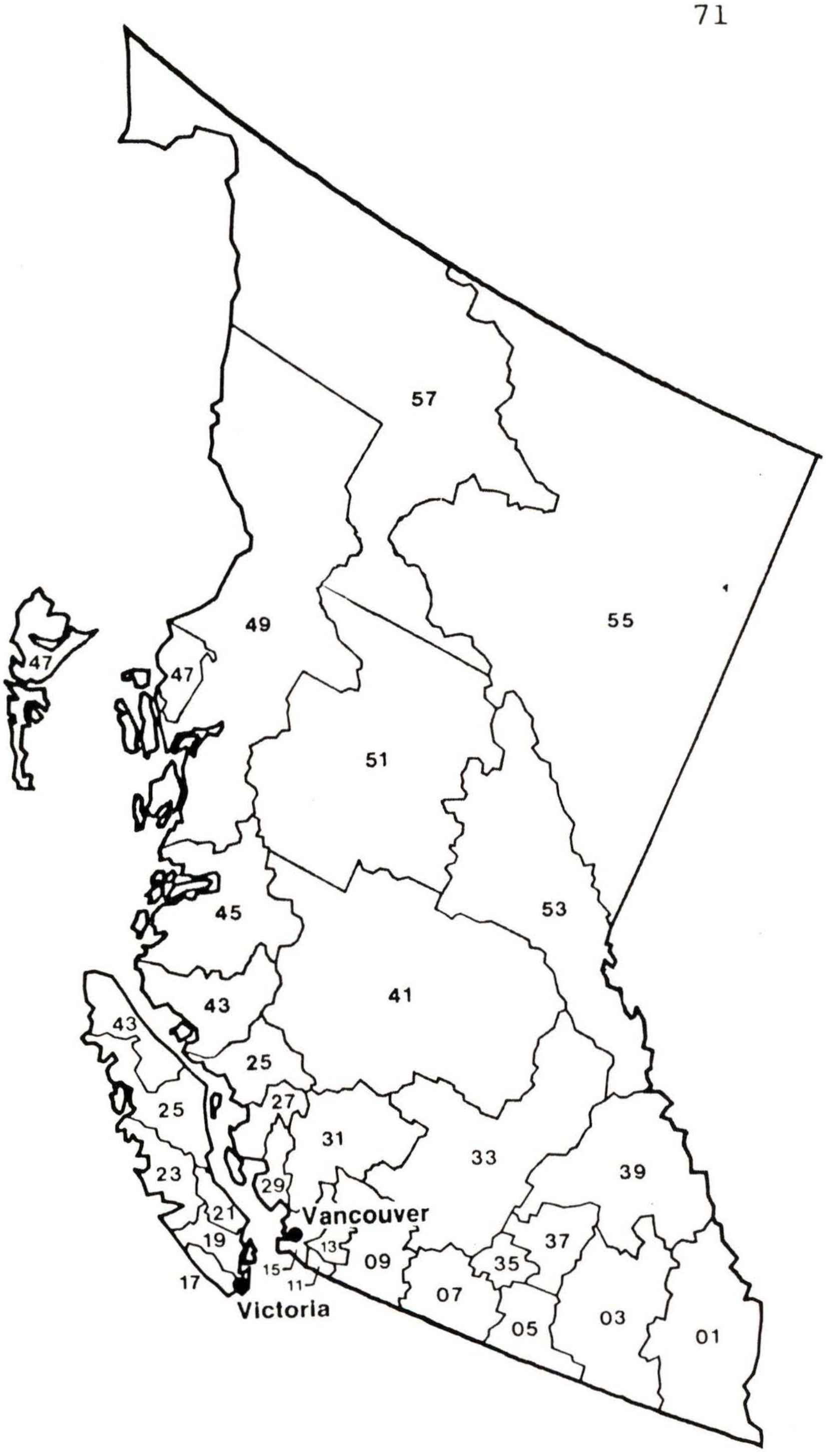
for the province was provided by the British Columbia Cancer Control Agency, the mortality rates being given by school district.

British Columbia Cancer Mortality by Census Division

As previously described, age-standardized mortality data by census division was provided in the Mortality Atlas of Canada, Volume 1: Cancer. The census division boundaries used in that study are shown in Figure 1,3.

This data, as can be seen from Tables 3,3 and 4,3, indicates that, during the period 1966 to 1976, stomach cancer mortality in males was highest in coastal British Columbia. As an example, high male mortality rates for stomach cancer were particularly evident in census divisions such as Skeena-Queen Charlotte (24.1), Nanaimo (18.1), Powell River (17.6) and Fraser-Fort George (17.7). In contrast, low mortality rates occurred in the Stikine and Squamish-Lillooet districts where they were 0.0 and 4.0 respectively.

Mortality rates for male colonic and rectal cancer in British Columbia, by census division, also indicated marked regional variations. To illustrate, the highest rates of colonic cancer were found in Kitimat-Stikine (23.7), Fraser-Fort George (20.3) and Cowichan Valley (20.2). The lowest rates in the Province occurred in the districts of Stikine and Squamish-Lillooet (0.0, 5.0) respectively. The highest male rates for rectal



23. Alberni-Clayoquot
51. Bulkley-Nechako
17. Capital
41. Cariboo
45. Central Coast
11. Central Fraser Valley
03. Central Kootenay
35. Central Okanagan
39. Columbia-Shuswap
25. Comox-Strathcona
19. Cowichan Valley
13. Dewdney-Alouette
01. East Kootenay
09. Fraser-Cheam
53. Fraser-Fort George
15. Greater Vancouver
49. Kitimat-Stikine
05. Kootenay Boundary
43. Mount Waddington
21. Nanaimo
37. North Okanagan
07. Okanagan-Similkameen
55. Peace River-Liard
27. Powell River
47. Skeena-Queen Charlotte
31. Squamish-Lillooet
57. Stikine
29. Sunshine Coast
33. Thompson-Nicola

FIGURE 1,3 British Columbia Census Division Boundaries.
After *Mortality Atlas of Canada*, Vol. 1, 1980.

cancer were found in Stikine (59.9), and Squamish-Lillooet (17.1), with the lowest occurring in Central Coast (0.0) and North Okanagan and Fraser-Fort George both of which had age-standardized rates of 3.5.

For all digestive cancer sites in British Columbia, the census division of Sunshine Coast had the highest rates (191.2) whilst the division of Stikine had the lowest (90.3).

Female digestive cancer mortality rates in British Columbia presented in Table 4,3 showed marked differences from those of males. For example, the age-standardized mortality rates for stomach cancer, in females, was highest in the census divisions of Skeena-Queen Charlotte and Sunshine Coast (22.0, 21.2) respectively. In contrast, the lowest rates for female stomach cancer were found in several districts including Squamish-Lillooet, Mount Waddington, Central Coast and Stikine at 0.0.

The highest mortality rates for female colonic cancer were found in Mount Waddington (28.2) and Skeena-Queen Charlottes (26.8) and the lowest in the Central Coast and Stikine, both at 0.0. Female rectal cancers were most common in East Kootenay (7.9) and Powell River (7.0), while the lowest mortality rates were all recorded in the coastal districts (0.0).

TABLE 3,3

Age-Standardized Mortality rates for British Columbia
Male Digestive Cancers, years 1966 to 1976

Census Districts	Stomach	Colon	Rectum	All Sites
1.	9.7	6.9	8.2	149.2
3.	11.0	9.8	6.6	148.4
5.	11.1	11.8	7.7	147.9
7.	11.0	10.9	8.4	132.7
9.	11.9	15.9	5.8	148.8
11.	14.5	10.8	9.9	155.4
13.	12.4	8.0	10.8	156.7
15.	12.3	14.0	7.6	171.2
17.	10.4	14.7	5.8	158.7
19.	14.1	20.2	5.0	156.5
21.	18.1	9.4	5.9	164.3
23.	7.2	6.7	10.8	162.1
25.	11.7	11.0	8.4	160.9
27.	17.6	20.0	7.2	152.5
29.	14.1	9.0	15.3	191.2
31.	4.0	5.0	17.1	133.3
33.	10.5	13.6	7.8	162.1
35.	12.8	10.3	7.1	146.5
37.	12.0	17.7	3.5	152.4
39.	8.0	5.2	4.9	133.6
41.	15.6	8.1	7.2	117.7
43.	12.0	13.3	4.6	96.5
45.	10.6	15.5	0.0	157.2
47.	24.1	11.0	7.8	163.4
49.	15.0	23.7	11.8	154.8
51.	12.8	11.6	4.9	134.1
53.	17.7	20.3	3.5	183.8
55.	16.3	8.9	7.5	140.1
57.	0.0	0.0	59.9	90.3

Source: Mortality Atlas of Canada, Volume 1: Cancer,
1980, pp. 104-106.

TABLE 4,3

Age-Standardized Mortality rates for British Columbia
Female Digestive Cancers, years 1966 to 1976

Census Districts	Stomach	Colon	Rectum	All Sites
1.	8.3	8.4	7.9	112.8
3.	7.3	6.5	5.0	110.2
5.	4.9	11.6	2.0	104.3
7.	3.8	12.3	6.9	93.7
9.	7.8	16.0	3.2	97.8
11.	5.6	11.4	2.7	111.0
13.	7.1	12.0	2.4	116.1
15.	5.4	12.5	4.4	114.0
17.	6.5	14.2	3.5	114.3
19.	6.7	13.8	2.1	104.4
21.	8.3	14.8	6.8	122.1
23.	6.8	7.6	5.1	112.2
25.	5.2	16.8	4.6	105.6
27.	11.3	13.7	7.0	116.5
29.	21.2	3.9	4.6	133.2
31.	0.0	11.5	0.0	156.8
33.	6.5	12.1	4.9	102.6
35.	7.2	7.1	3.6	88.2
37.	5.4	15.2	2.4	113.5
39.	7.5	13.2	5.5	112.4
41.	7.1	7.3	0.0	105.3
43.	0.0	28.2	0.0	134.8
45.	0.0	0.0	0.0	91.2
47.	22.0	26.8	0.0	160.5
49.	12.0	11.9	2.8	81.9
51.	0.0	7.8	3.4	98.4
53.	6.6	12.4	2.1	107.9
55.	3.7	10.1	3.2	92.1
57.	0.0	0.0	0.0	0.0

Source: Mortality Atlas of Canada, Volume 1: Cancer, 1980, pp. 104-106.

British Columbia Cancer Mortality by School District

A second and more comprehensive set of mortality data was kindly made available for this study by the Statistics Division of the B. C. Cancer Control Agency, Vancouver. This would be used to compare statistical results to that of the national study by census division. The complete tape contained data on all cancer-related deaths, in British Columbia for the period 1956 to 1978, at the school district level. Standardized mortality rates (SMR) per 100,000 population, by age and sex were provided for seventy-five school districts. This data was originally collected from death certificates by the Division of Vital Statistics, Ministry of Health, Province of British Columbia. Certificates included the deceased's age, sex, place of residence and principle cause of death. This information was subsequently coded and classified according to the International Classification of Diseases.

The school districts for which mortality rates are available are shown in Figure 2,2. The B.C. Cancer Control Agency used School districts rather than Health districts, since school district boundaries have remained virtually unchanged for some 30 years. Health district boundaries, in contrast, have altered regularly as new population centres have developed. It should be noted, however, that although mortality rates for 75 school districts were provided by the B. C. Cancer Control Agency, only 72 were used for this study. School districts number 81 (Fort Nelson), 87 (Stikine) and 92 (Nisgha) were omitted from the analysis because these districts are very sparsely populated and, as a result, medical data is misleading.

MEDICAL DATA MANAGEMENT

Canadian Mortality Data

Data on digestive cancer mortality in Canada was derived directly from appendices of the *Mortality Atlas of Canada*, *Volume 1: Cancer*. Once computerized, listings and other statistical correlations could be made from this information.

Tables 1,3 and 2,3, for example, illustrate the variability in provincial age-standardized mortality rates for site-specific cancers, for males and females, for years 1966 to 1976. This data bank also provided a complete set of age-standardized mortality rates, by census division, for male and female digestive cancers in British Columbia, as shown in Table 3,3 and 4,3.

British Columbia Mortality Data

To more clearly understand the patterns of cancer distribution, within the 72 school districts of the province, required the use of a more comprehensive cancer mortality data bank provided by the British Columbia Cancer Control Agency. This included information on mortality from 46 cancers at the school district level. The Cancer Control Agency's data was sorted by site-specific designation and classified by school district. The results for Fernie School District (1) are shown as Table 5,3. This provided the basis from which the distribution of standardized digestive cancer mortality rates were derived. A complete listing of mean-age adjusted mortality rates for male and female digestive cancers for British Columbia, by school district, for the period 1956-1978, are shown in Tables 6,3 and 7.3. A complete set of rank order listings for cancers of the esophagus, stomach, small intestine, colon and rectum, for both males and females, for the years 1956-1978, can be seen in Appendices 1,3 through 10,3.

TABLE 5,3

Mean age-standardardized mortality rates per 100,000, for all cancers in the Fernie School District (1) years 1956-1978.

FERNIE (1)

	MALES				FEMALES		
CANCER CATEGORY	DEATHS	SMR	RANK	P	DEATHS	SMR	RANK
LIP	1	520.3	5.0		0	0.0	38.0
MOUTH	3	180.9	8.0		2	257.4	7.0
OROPHARYNX	1	286.1	5.0		0	0.0	43.0
NASOPHARYNX	0	0.0	52.5		0	0.0	48.5
HYPOPHARYNX	0	0.0	44.5		0	0.0	43.0
PHARYNX	3	210.1	5.0		0	0.0	53.5
HEAD & NECK	6	194.4	2.0		2	154.1	15.0
ESOPHAGUS	2	56.2	49.0		4	292.2	4.0
STOMACH	22	133.1	6.0		11	177.1	9.0
SMALL INTESTINE	0	0.0	54.0		1	250.7	9.0
COLON	7	50.6	66.0		10	88.6	43.5
RECTUM	11	133.7	6.0		11	255.6	2.0
COLO-RECTAL	18	81.6	45.0		21	134.7	5.0
LIVER	2	93.0	26.0		2	216.7	7.0
GALLBLADDER	3	151.1	9.0		6	259.3	10.0
PANCREAS	12	114.4	16.0		10	184.5	7.0
GASTRO-INTESTINAL	59	101.8	16.0		56	171.2	1.0
NOSE & NASAL SINUS	0	0.0	49.0		0	0.0	47.0
LARYNX	0	0.0	64.0		0	0.0	50.5
LUNG	38	84.4	36.0		6	75.4	51.0
PLEURAL CAVITY	0	0.0	48.5		0	0.0	40.5
BREAST	0	0.0	48.5		17	76.9	57.0
CERVIX					4	78.9	54.0
ENDOMETRIUM					5	172.4	8.0
OVARY					1	12.7	70.0
PROSTATE	18	118.7	21.5				
TESTIS	0	0.0	57.5				
KIDNEY	3	73.3	55.0		3	180.9	11.0
BLADDER	11	195.6	1.0	*	3	188.4	6.0
GENITO-URINARY	32	123.2	5.0		19	96.5	36.0
MELANOMA	1	71.8	40.0		0	0.0	62.5
OTHER SKIN	0	0.0	57.5		0	0.0	53.0
EYE	2	697.4	2.0	&	0	0.0	48.0
BRAIN & NERV. SYST	5	88.6	34.0		2	59.0	60.0
THYROID	0	0.0	52.0		0	0.0	59.0
BONE	2	226.8	11.0		0	0.0	54.0
SOFT TISSUE	1	151.1	24.0		0	0.0	55.5
LYMPHO-SARCOMA	5	105.1	29.0		2	74.4	45.0
HODGKIN'S DISEASE	1	49.7	41.0		3	328.3	1.0
MYELOMA	2	85.5	41.5		1	71.7	42.0
LEUKEMIA	5	61.7	64.0		2	44.7	59.0
LYMPH. & HEMATOPOET.	13	75.4	56.0		8	84.3	44.0
ALL CANC. (NOT LUNG)	131	108.4	6.0		108	113.6	7.0
ALL CANCERS	169	101.9	12.0		114	110.6	9.0
ALL TUM,BR & NERV SY	6	95.8	32.0		2	49.6	65.0
ALL DEATHS	1089	116.8	13.0	&	544	109.5	27.0

REVIEW OF BRITISH COLUMBIA MEDICAL DATA

Cancer of the Esophagus

It is evident from the mortality data provided as Table 6,3 and Figure 2.3, that male esophageal cancer has been most common in the western, north-central and eastern regions of British Columbia. In the northwest, for example, elevated male esophageal cancer mortality has occurred in Smithers (326.3) and on the south coast at Howe Sound (340.1). Indeed, the highest rates in British Columbia for cancer of the esophagus in males (379.0) occurred in the Queen Charlotte Islands. Higher than normal rates of male esophageal cancer also occurred in the districts of Trail (190.2), Revelstoke (161.4), Golden (151.6), Terrace (144.8), Vancouver (132.1) and Hope (131.2).

It is interesting to note that some of the lower mortality esophagal cancer occurred in parts of the south coast of British Columbia, including the school districts of the Gulf Islands (45.7), Vancouver Island North (38.1), Powell River (32.0) and in the south-central interior, in Summerland (26.4) and South Cariboo (41.0). Lower rates were also evident in the south-eastern part of the province including Fernie (56.2) and Cranbrook (44.3) and in the central interior in Nechako (38.4).

In British Columbia, as in most other provinces, female mortality rates from esophageal cancer were generally lower than those for males. Spatial variations, however, still existed, as shown in Table 7,3 and Figure 3,3. Female esophageal cancer appears to have been most common in the school districts of North Thompson (397.3), Queen Charlotte Islands (368.4), Windermere (364.7), Fernie (292.2), Nechako (246.8) and in the south coast Langley (232.8).

In contrast, some of the lowest female esophageal cancer mortality rates occurred in coastal areas, including the school districts of Coquitlam (19.7), Powell River (41.0), Delta (47.9), Maple Ridge (58.3), and Cowichan (60.2). In the southern part of the province, the districts of Nelson (24.2), Vernon (52.0), Shuswap (54.7), Penticton (56.4) and Summerland (62.0) also had low mortality rates for female esophageal cancer.

Stomach Cancer

The distribution of mortality from stomach cancer in British Columbia is very different from that of cancer of the esophagus. As can been seen from Table 6,3 and Figure 4,3, the mortality rates for stomach cancer, in males, was very high in the Prince Rupert school district (170.2), followed in descending order by Castlegar (148.3), Hope (141.5), Grand Forks (141.2)

TABLE 6,3

Mean age-standardized mortality rates per 100,000, for MALE digestive cancers in British Columbia by School District, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
FERNIE	1	56.2	133.1	100.0	50.6	133.7
CRANBROO	2	44.3	100.2	100.0	118.6	114.5
KIMBRLY	3	98.0	113.3	100.0	110.9	70.8
WINDERMR	4	100.0	85.9	100.0	73.6	98.8
NELSON	7	87.5	87.1	87.3	71.6	88.2
CASTLGAR	9	100.0	148.3	100.0	70.5	58.9
ARROWLK	10	50.6	98.1	100.0	102.3	43.2
TRAIL	11	190.2	103.3	100.0	99.6	103.3
GRANDFOR	12	100.0	141.2	100.0	53.0	89.7
KETTLE.V	13	76.9	67.3	100.0	20.2	100.0
S.OKAN	14	73.9	104.0	149.1	80.1	47.9
PENTCTON	15	94.6	85.5	100.0	100.2	100.2
KEREMEOS	16	53.5	104.7	435.5	123.4	46.6
PRINCTON	17	100.0	101.4	461.9	163.2	100.4
GOLDEN	18	151.6	32.6	100.0	116.9	32.3
REVLSTOK	19	161.4	60.8	100.0	114.5	121.9
ARMSTRNG	21	81.9	80.1	100.0	41.6	35.5
VERNON	22	56.4	107.5	192.2	95.6	58.5
CENT.OK	23	91.0	94.6	99.5	87.1	81.8
KAMLOOPS	24	76.7	94.4	51.7	88.8	124.9
N.THOMP	26	100.0	47.3	100.0	86.0	48.2
CARIBOU	27	83.3	89.7	100.0	70.2	89.5
QUESNEL	28	97.2	94.9	175.1	89.2	95.9
LILLOET	29	100.0	53.0	100.0	125.1	52.8
SCARIBOU	30	41.0	61.7	100.0	52.4	70.3
MERRITT	31	49.3	85.4	100.0	64.0	171.4
HOPE	32	131.2	141.5	100.0	90.8	113.6
CHILLWAK	33	51.6	110.0	51.1	86.8	99.8
ABBTSFOR	34	89.1	112.1	118.8	82.7	86.1
LANGLEY	35	124.9	89.7	130.9	97.1	114.4
SURREY	36	80.0	95.2	70.9	93.8	96.9
DELTA	37	91.1	104.6	81.1	92.2	96.7
RICHMND	38	120.8	109.5	100.0	118.8	109.0
VANCOUVR	39	132.1	112.7	83.7	113.9	116.3
N.W.M.	40	104.1	120.2	167.6	117.2	102.5
BURNBY	41	81.7	104.7	123.2	89.6	104.6
MAPLRDG	42	51.6	96.6	206.3	67.5	103.5
COQUITLM	43	52.5	80.7	76.7	92.3	92.8
N.VANC	44	123.8	86.0	31.4	111.7	114.1
W.VANC	45	108.7	75.1	281.1	119.1	108.8
SUNCOAST	46	95.4	130.6	127.2	105.5	130.6
POWELLR	47	32.0	97.0	100.0	127.7	89.6
HOWESD	48	340.1	83.9	100.0	37.8	145.7
C.COAST	49	100.0	51.6	100.0	20.9	100.0

TABLE 6,3
continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
QUEENCHA	50	379.0	80.5	100.0	71.8	100.0
PR.RUPRT	52	104.4	170.2	100.0	138.3	89.0
SMITHERS	54	326.3	117.1	100.0	112.1	93.3
BURNSLK	55	121.3	92.2	456.9	47.2	26.4
NECHAKO	56	38.4	82.8	100.0	78.7	49.5
PRGEORGE	57	110.7	120.6	100.0	106.5	63.1
PEACE.S	59	72.4	132.9	264.6	84.3	54.8
PEACE.N	60	100.0	57.4	207.9	53.3	88.7
VICTORIA	61	96.0	85.0	201.0	111.2	93.5
SOOKE	62	96.7	74.4	100.0	102.2	101.1
SAANICH	63	110.1	58.4	344.7	89.7	86.8
GULF.IS	64	45.7	78.9	191.6	98.0	49.0
COWICHAN	65	111.2	88.4	100.0	86.5	87.5
COWICHL.	66	106.1	80.0	100.0	122.7	45.3
NANAIMO	68	84.4	114.8	165.6	92.5	108.4
QUALICUM	69	98.6	92.8	100.0	88.4	57.0
ALBERNI	70	98.9	101.6	90.4	80.2	85.5
COURTENA	71	75.8	70.0	100.0	71.4	111.2
CAMPBRIV	72	81.0	91.8	100.0	89.2	139.7
MISSION	75	60.8	99.2	243.3	74.4	93.0
AGAS.HAR	76	57.4	37.0	449.1	43.4	24.2
SUMMERLD	77	26.4	97.1	100.0	80.5	79.8
KITIMAT	80	100.0	83.5	100.0	84.6	138.8
VAN.IS.W	84	100.0	100.0	100.0	100.0	156.4
VAN.IS.N	85	38.1	65.2	100.0	68.8	32.4
CRES.KAS	86	97.0	68.9	100.0	80.8	65.7
TERRACE	88	144.8	135.2	100.0	108.2	129.7
SHUSWAP	89	54.0	98.4	86.0	69.4	93.7

TABLE 7,3

Mean age-standardized mortality rates per 100,000, for FEMALE digestive cancers in British Columbia by School District, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
FERNIE	1	292.2	177.1	250.7	88.6	255.6
CRANBROO	2	225.3	73.9	100.0	88.3	177.4
KIMBRLY	3	100.0	169.7	100.0	118.9	25.9
WINDERMR	4	364.7	82.0	100.0	129.9	56.4
NELSON	7	24.2	79.1	100.0	92.0	148.2
CASTLGAR	9	100.0	179.0	220.8	88.6	63.2
ARROWLK	10	100.0	54.7	100.0	100.0	40.3
TRAIL	11	108.2	109.3	354.6	84.3	93.2
GRANDFOR	12	76.0	199.9	100.0	55.8	147.5
KETTLE.V	13	100.0	171.2	813.7	90.0	79.5
S.OKAN	14	100.0	160.8	163.5	110.5	123.0
PENTCTON	15	56.4	78.2	270.9	87.8	128.7
KEREMEOS	16	163.0	145.6	100.0	59.3	105.0
PRINCTON	17	100.0	144.4	100.0	99.4	51.8
GOLDEN	18	100.0	43.2	100.0	94.3	100.0
RELSTOK	19	100.0	135.5	100.0	122.7	191.6
ARMSTRNG	21	100.0	100.0	100.0	132.5	63.3
VERNON	22	52.0	78.8	255.1	102.2	50.3
CENT.OK	23	91.2	94.0	163.9	90.4	67.9
KANLOOPS	24	100.0	81.3	114.8	87.3	110.9
N.THOMP	26	397.3	100.0	100.0	93.1	100.0
CARIBOU	27	100.0	53.6	100.0	113.0	36.3
QUESNEL	28	100.0	127.9	100.0	50.9	65.7
LILLOET	29	100.0	50.5	100.0	53.3	100.0
SCARIBOU	30	100.0	125.5	100.0	114.8	85.5
MERRITT	31	100.0	111.8	100.0	182.5	78.5
HOPE	32	100.0	115.1	100.0	106.9	39.9
CHILLWAK	33	68.8	108.3	49.4	92.7	120.3
ABBTSFOR	34	130.0	92.0	117.4	85.7	73.6
LANGLEY	35	232.8	84.5	139.3	87.7	43.5
SURREY	36	101.6	89.0	53.1	97.9	114.3
DELTA	37	47.9	77.8	82.5	72.0	134.9
RICHMND	38	133.0	104.6	100.0	108.3	87.1
VANCOVR	39	127.6	106.8	89.1	104.9	109.5
N.W.M.	40	149.2	83.8	196.4	108.6	143.5
BURNBY	41	89.8	98.7	104.4	84.9	91.4
MAPLERDG	42	58.3	109.6	141.5	104.9	125.7
COQUITLM	43	19.7	58.8	100.0	71.8	52.8
N.VANC	44	73.2	84.0	180.9	117.2	111.2
W.VANC	45	88.2	66.9	81.1	135.5	106.6
SUNCOAST	46	127.4	207.1	149.5	77.6	150.8
POWELLR	47	41.0	155.6	270.3	83.7	90.3
HOWESD	48	148.9	33.2	100.0	17.5	135.6
C.COAST	49	100.0	58.8	812.2	31.0	80.2

TABLE 7,3
continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
QUEENCHA	50	368.4	250.2	100.0	130.1	112.5
PR.RUPRT	52	60.8	231.2	195.2	137.5	132.0
SMITHERS	54	100.0	58.4	440.4	127.3	82.9
BURNSLK	55	100.0	46.7	100.0	49.8	64.1
NECHAKO	56	246.8	54.4	100.0	43.7	37.7
PRGEORGE	57	142.0	75.0	100.0	85.7	59.1
PEACE.S	59	52.5	69.8	100.0	68.6	97.6
PEACE.N	60	100.0	69.2	100.0	119.7	122.9
VICTORIA	61	115.7	94.8	92.8	106.5	94.7
SOOKE	62	100.0	123.2	106.3	75.6	84.1
SAANICH	63	93.7	114.6	100.0	98.8	72.7
GULF.IS	64	100.0	53.4	218.7	89.2	99.0
COWICHAN	65	60.2	70.7	140.4	107.2	76.7
COWICHL.	66	100.0	152.2	100.0	58.6	100.9
NANAIMO	68	139.9	125.7	81.9	118.0	89.8
QUALICUM	69	100.0	143.4	100.0	133.8	105.0
ALBERNI	70	89.2	99.1	97.2	71.1	111.1
COURTENA	71	100.0	77.3	100.0	107.5	88.7
CAMPBRIV	72	167.8	75.0	179.5	79.5	51.6
MISSION	75	76.5	210.1	134.8	102.5	98.4
AGAS.HAR	76	100.0	100.0	100.0	77.9	154.0
SUMMERLD	77	62.0	82.0	225.1	144.5	100.3
KITIMAT	80	223.9	146.6	100.0	99.4	124.5
VAN.IS.W	84	100.0	100.0	100.0	0.0	180.1
VAN.IS.N	85	175.7	320.1	100.0	100.4	102.8
CRES.KAS	86	77.8	112.2	100.0	57.1	63.0
TERRACE	88	100.0	205.7	100.0	117.9	46.6
SHUSWAP	89	54.7	114.9	286.7	103.1	78.8

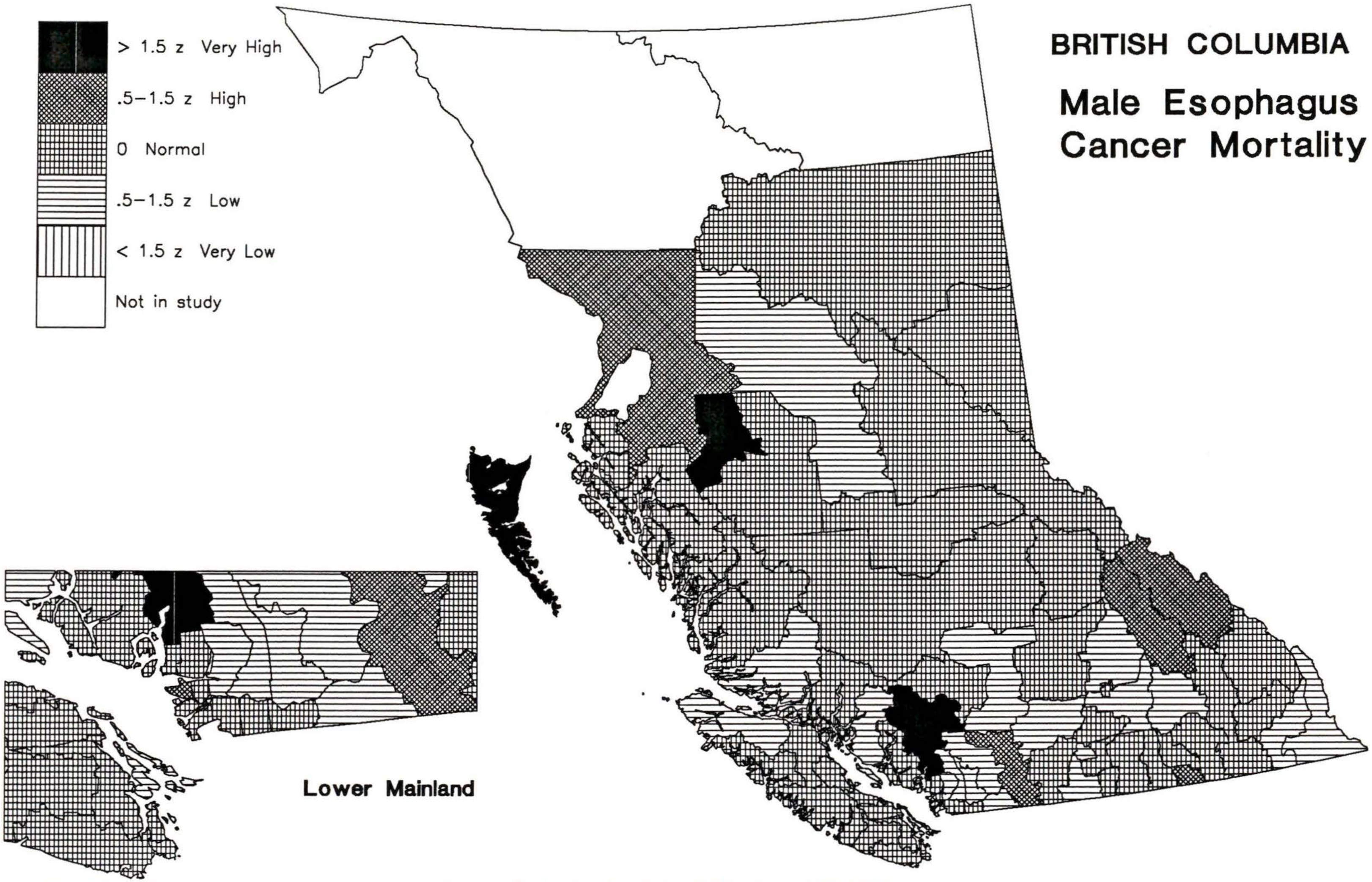


Figure 2,3: Male Esophagus cancer mortality in British Columbia by School District, 1956-1978.

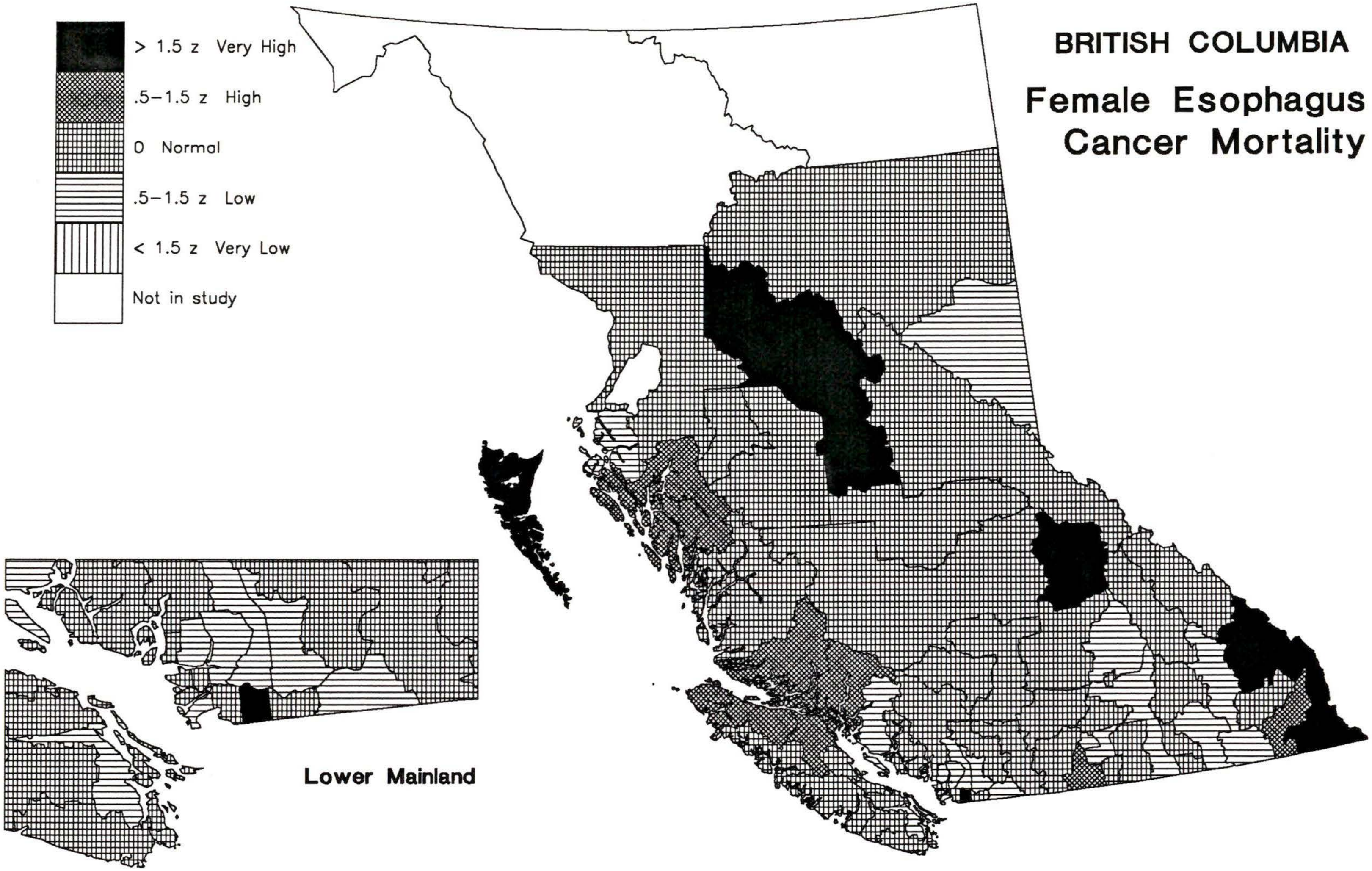


Figure 3,3: Female Esophagus cancer mortality in British Columbia by School District, 1956-1978.

Terrace (135.2), Fernie (133.1) and Peace River South (132.9). High rates of stomach cancer, in males, was also evident in the districts of Sunshine Coast (130.6), Prince George (120.6), Smithers (117.1) and Nanaimo (114.8). In contrast, very low rates were found in Golden (32.6), Agassiz-Harrison (37.0), North Thompson (47.3), Central Coast (51.6) and Lillooet (53.0), with lower than average rates in Saanich (58.4), Revelstoke (60.8) and South Cariboo (61.7) to mention a few.

Female age-standardized mortality rates for stomach cancer are shown in Tables 7,3 and Figure 5,3. As can be seen, very high mortality rates occurred in the school districts of Vancouver Island North (320.1), Queen Charlotte Islands (250.2) and Prince Rupert (231.2) followed in descending order by Mission (210.1), Sunshine Coast (207.1), Terrace (205.7) and Grand Forks (199.9). Some of the districts that experienced higher than normal rates of female stomach cancer included Castlegar (179.0), Fernie (177.1), Kettle Valley (171.2) and Kimberley (169.7).

In contrast, very low rates for female stomach cancer were not evident, however, lower than normal levels were found in the school districts of Howe Sound (33.2), Golden (43.2) and Burns Lake (46.7), followed in ascending order by Lillooet (50.5), Gulf Islands (53.4) and Cariboo (53.6).

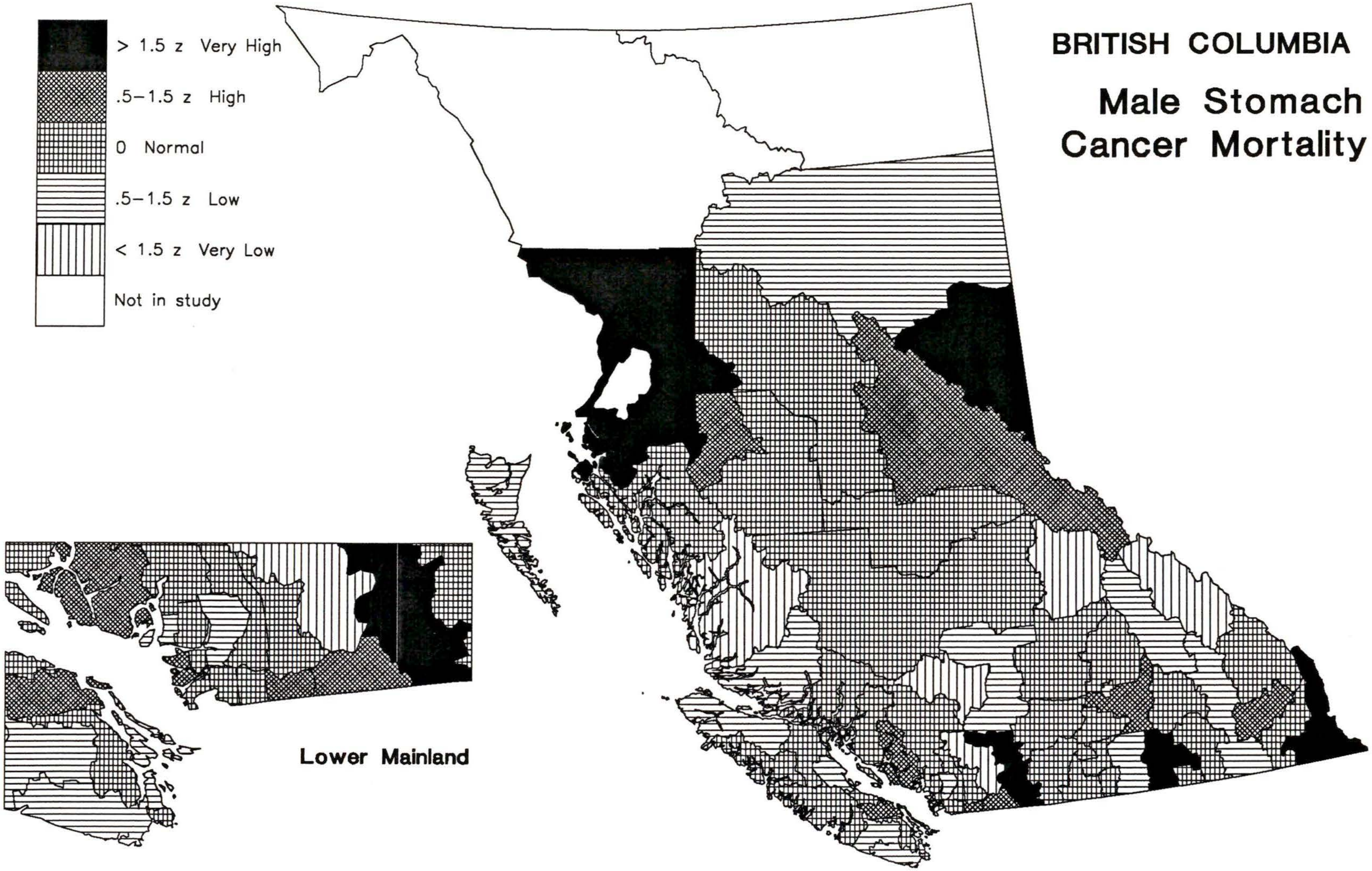


Figure 4,3: Male Stomach cancer mortality in British Columbia by School District, 1956-1978.

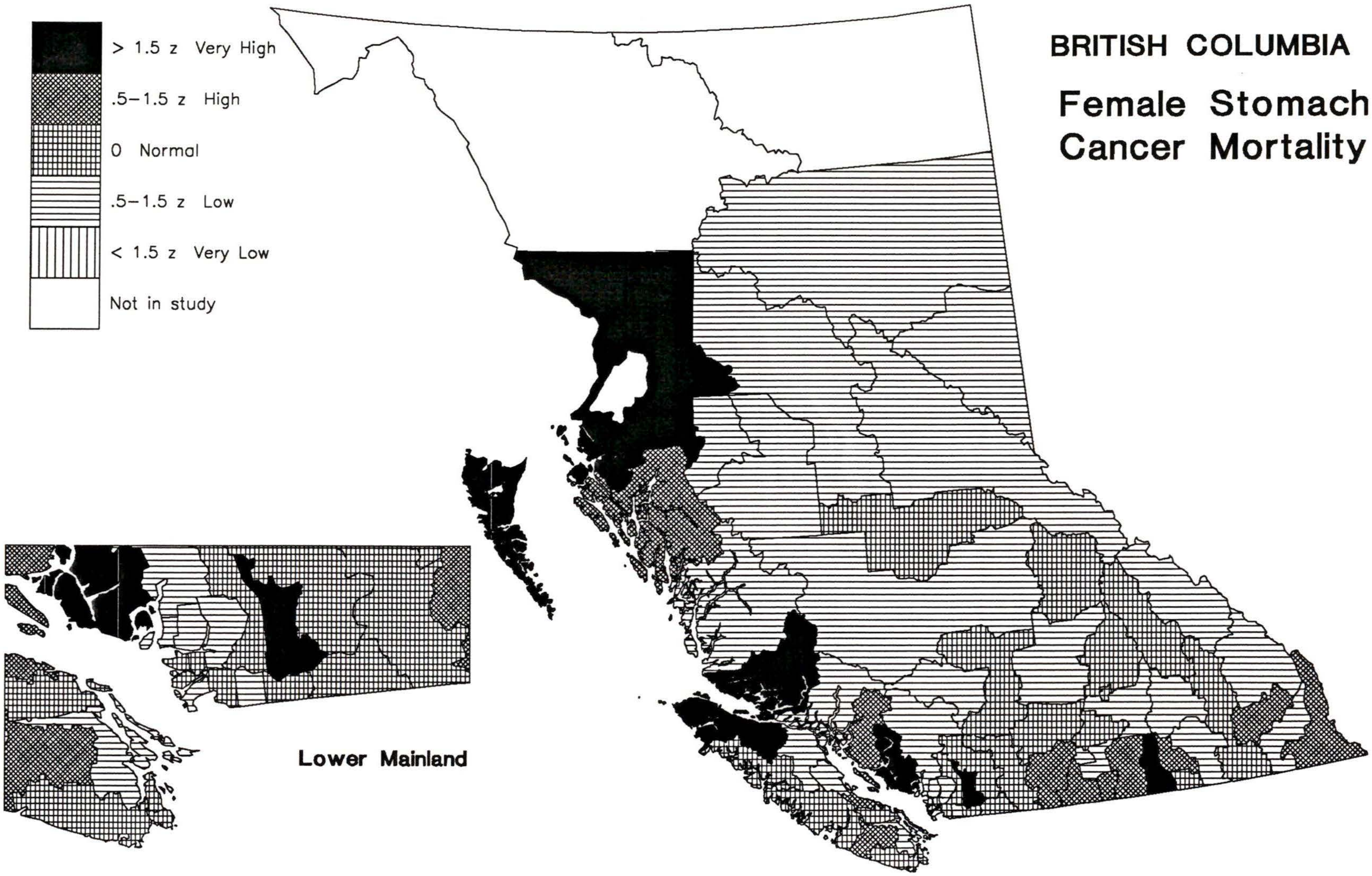


Figure 5,3: Female Stomach cancer mortality in British Columbia by School District, 1956-1978.

Cancer of the Small Intestine

The geographic distribution of mortality from cancer of the small intestinal, in males, is no less interesting than that of stomach cancer. It can be seen from Table 6,3 and Figure 6,3 that the highest rates of small intestinal cancer in males occurred in six school districts within the province, the highest rates being found in Princeton (461.9), followed in descending order by Burns Lake (456.9), Agassiz-Harrison (449.1), Kememeos (435.5), Saanich (344.7) and West Vancouver (281.1). Higher than normal rates for small intestinal cancer, in males, was also evident in the school districts of Peace River South (264.6), Mission (243.3), Peace River North (207.9), Maple Ridge (206.3) and Victoria (201.0).

There are no school districts, however, that experienced abnormally low mortality rates of male small intestinal cancer, however, lower than normal levels were found in the districts North Vancouver (31.4), Chilliwack (51.1), Kamloops (51.7), followed in ascending order by Surrey (70.9), Coquitlam (76.7) and Delta (81.1).

Mortality rates for small intestinal cancer, in females in British Columbia, are shown in Table 7,3 and Figure 7,3. This data illustrates a much higher rate than that for males, especially in the school districts

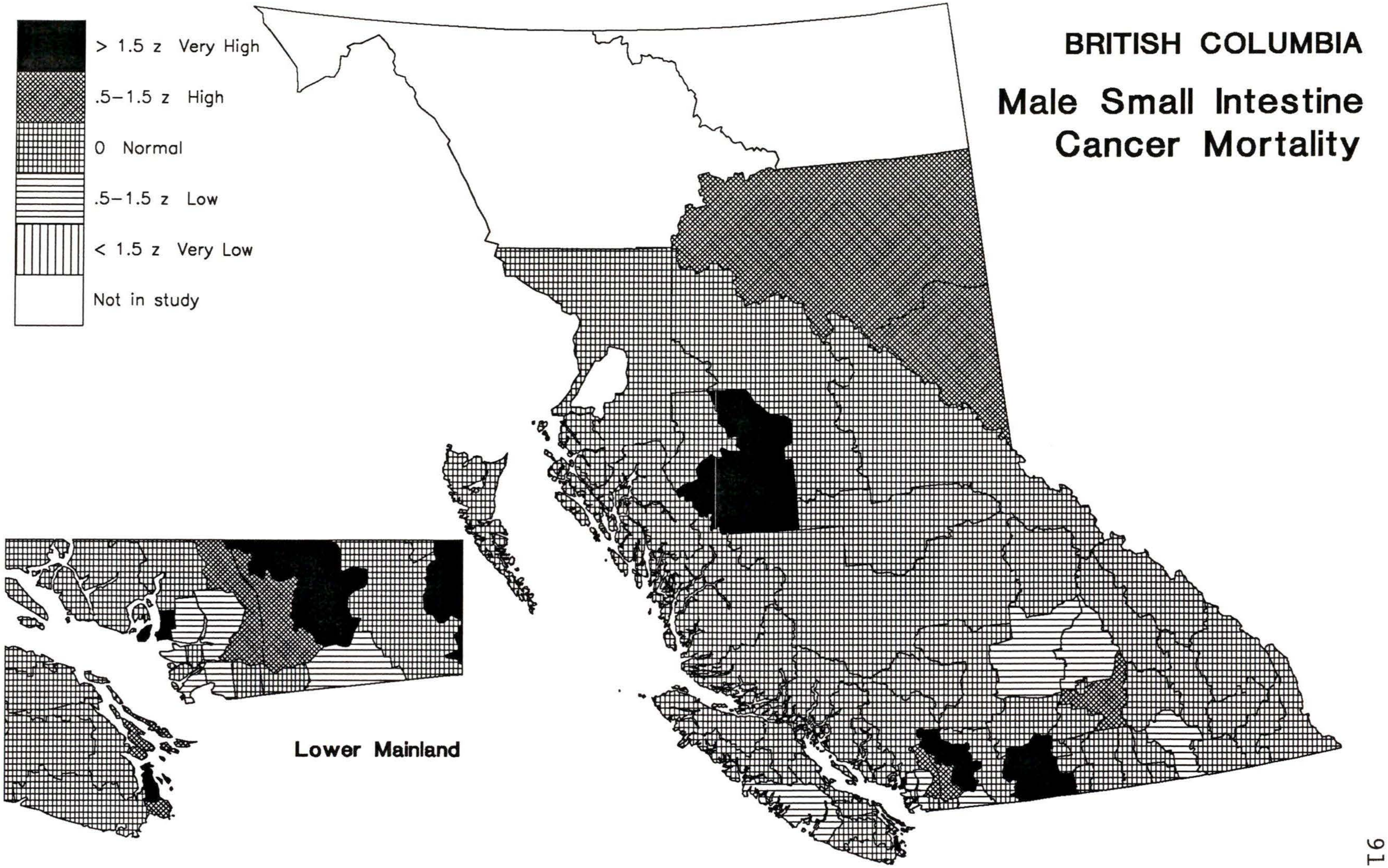


Figure 6,3: Male Small Intestinal cancer mortality in British Columbia by School District, 1956-1978.

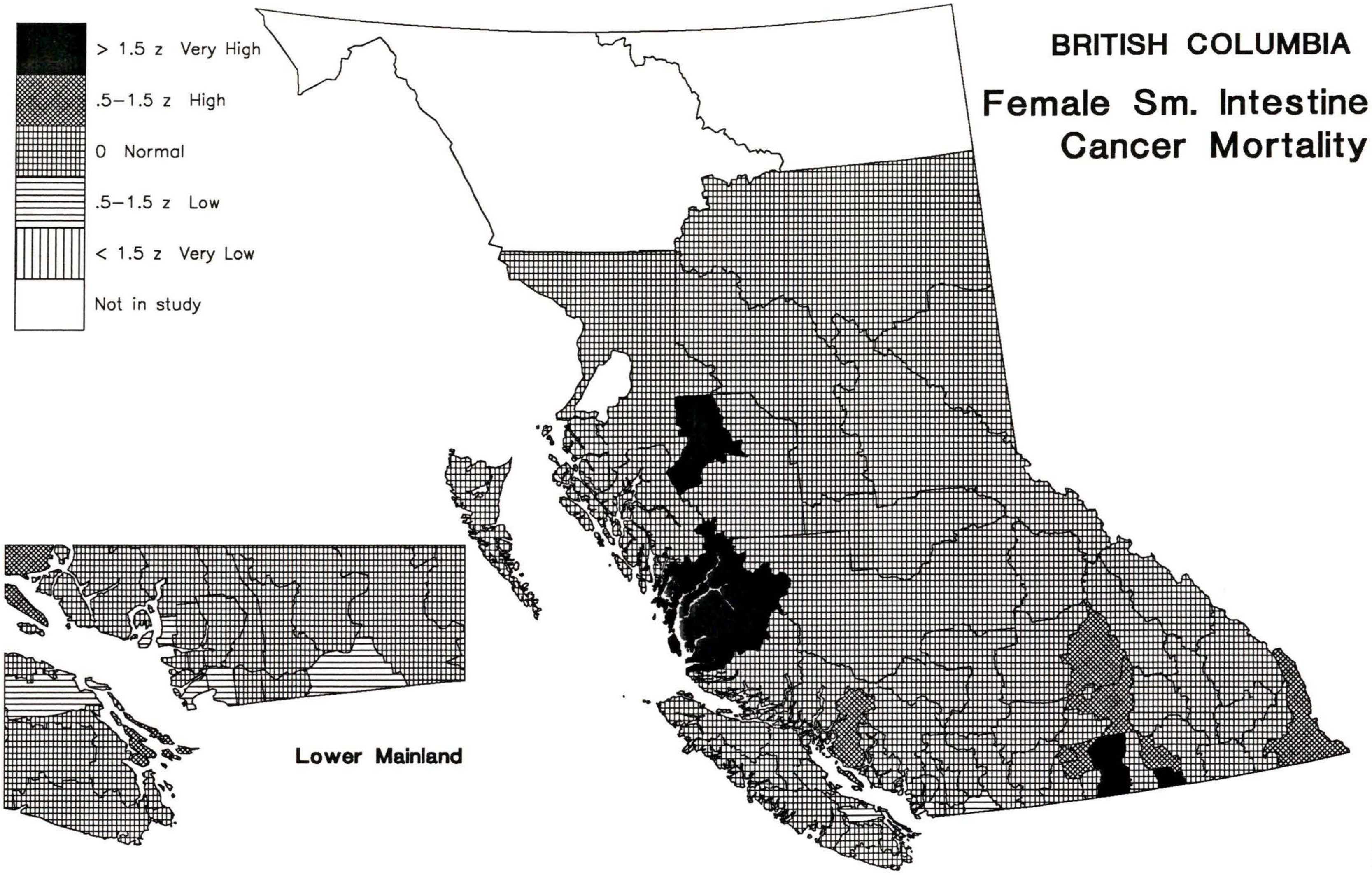


Figure 7,3: Female Small Intestinal cancer mortality in British Columbia by School District, 1956-1978.

of Kettle Valley (813.7) and Central Coast (812.2). Other regions experiencing very high rates of small intestinal cancer in females, include Smithers (440.4) and Trail (354.6). High rates were also found in the school districts of Shuswap (286.7), Penticton (270.9) and Powell River (270.3).

As with male small intestine cancer, there are few regions where female mortality is depressed. The school districts having the lowest rates of small intestinal cancers include Chilliwack (49.4) and Surrey (53.1). For the larger part of the province, mortality rates from small intestinal cancer could be considered as normal (100.0) as can be seen in Table 7,3.

It should be noted that there are a number of school districts on the coast that have experienced high mortality rates for both male and female small intestinal cancer. These include the coastal school districts of Gulf Islands (191.6/218.7), Sunshine Coast (127.2/149.5), and in the Fraser Valley, the school districts of Langley (130.9/139.3), Abbotsford (118.8/117.4), Mission (243.3/134.8) and Maple Ridge (206.3/141.5). In the central interior, the school districts of South Okanagan (149.1/163.5) and Vernon (192.2/255.1), also have experienced high mortality rates for both males and females. Surrey was the only school district having low mortality rates for both male and female small intestinal cancer (70.9/53.1).

Colonic Cancer

As shown in Table 6,3 and Figure 8,3 in the south coastal region of British Columbia, very high mortality rates for colonic cancer, in males, occurred in the school districts of Princeton (163.2) and Prince Rupert (138.3). Higher than normal rates also occur in Powell River (127.7) followed in descending order by Lillooet (125.1), Keremeos (123.4) and Cowichan Lake (122.7). The lowest male colonic cancer rates were experienced in the districts of Kettle Valley (20.2), Central Coast (20.9), Howe Sound (37.8), Armstrong (41.6), Agassiz-Harrison (43.4) and Burns Lake (47.2). As can be seen from Figure 8,3, there are also a number of other school districts that have low rates of cancer mortality, but these are too numerous to mention individually. It is interesting to note, however, that approximately 60 percent of all the school district's in the province experienced low mortality rates for male colonic cancer.

The distribution of mortality from colonic cancer in females within British Columbia is shown in Table 7,3 and Figure 9,3. Very high rates of female colonic cancer were found in the school districts of Merritt (182.5) and Summerland (144.5). High rates of female colonic cancer were also evident in Prince Rupert

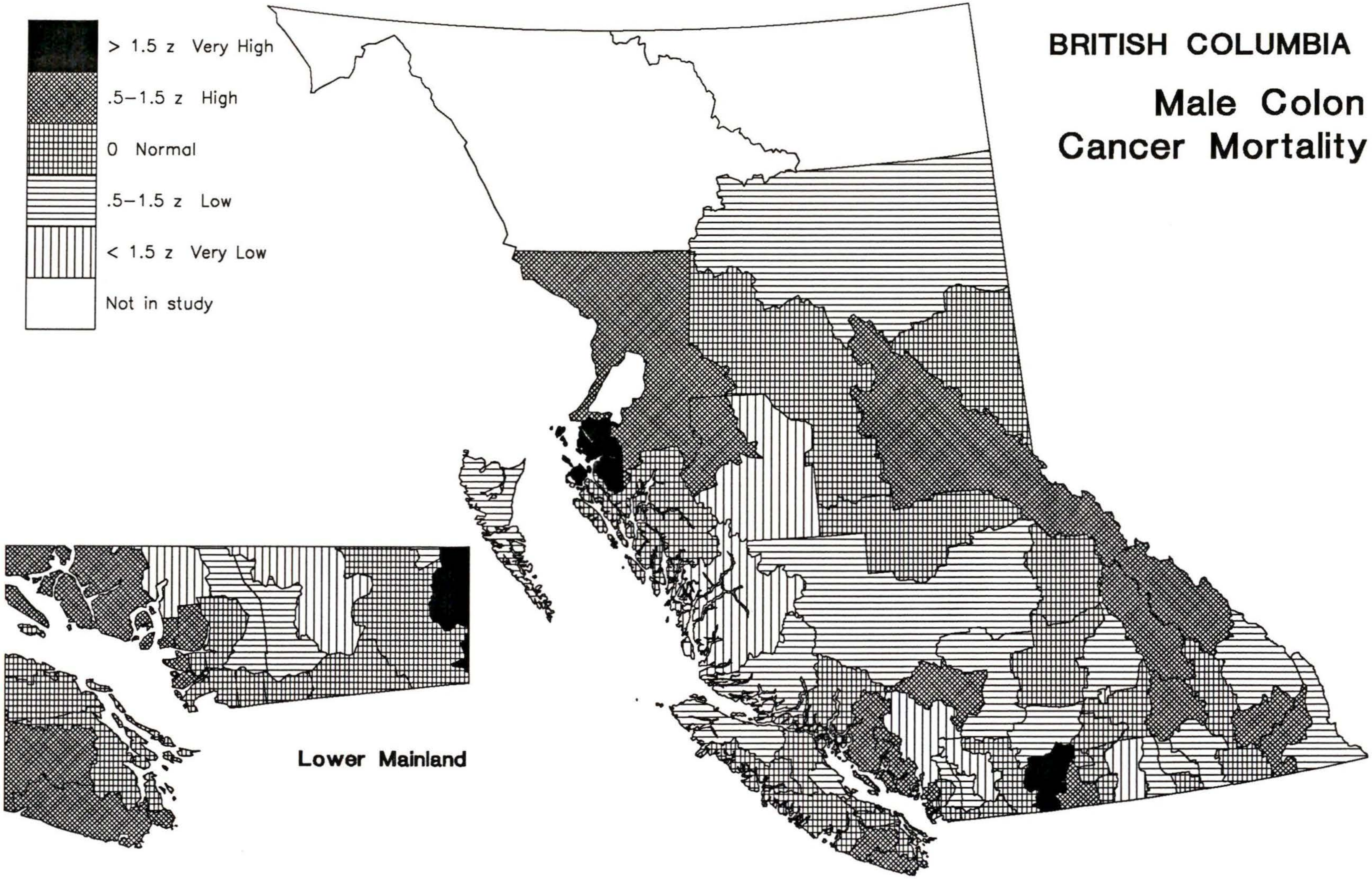


Figure 8,3: Male Colonic cancer mortality in British Columbia by School District, 1956-1978.

(137.5), followed in descending order by the districts of West Vancouver (135.5), Qualicum (133.8), Armstrong (132.5), Queen Charlotte Islands (130.1), Windermere (129.9), Smithers (127.3), Revelstoke (122.7), Peace River North (119.7), Kimberley (118.9) and Nanaimo (118.0).

In contrast, and similar in pattern to that of male colonic cancer, at least 60 percent of the province's school districts had low female colonic cancer rates. Very low rates were found in the school districts of Vancouver Island West (0.0), Howe Sound (17.5), Central Coast (31.0), and in the central interior, Nechako (43.7). Districts having low rates included Burns Lake (49.8), Quesnel (50.9), Lillooet (53.3), Grand Forks (55.8), and Creston-Kaslo (57.1).

There are, however, seven school districts in the province that have low mortality rates for both male and female colonic cancer. These include the coastal school districts of Howe Sound (37.8/17.5), Central Coast (20.9/31.0) and, in the central interior of the province, the school districts of Burns Lake (47.2/49.8) and Nechako (78.7/43.7). Other school districts having low female colonic cancer mortality rates include Peace River South (84.3/68.6), Grand Forks (53.0/55.8) and Creston-Kaslo (80.8/57.1).

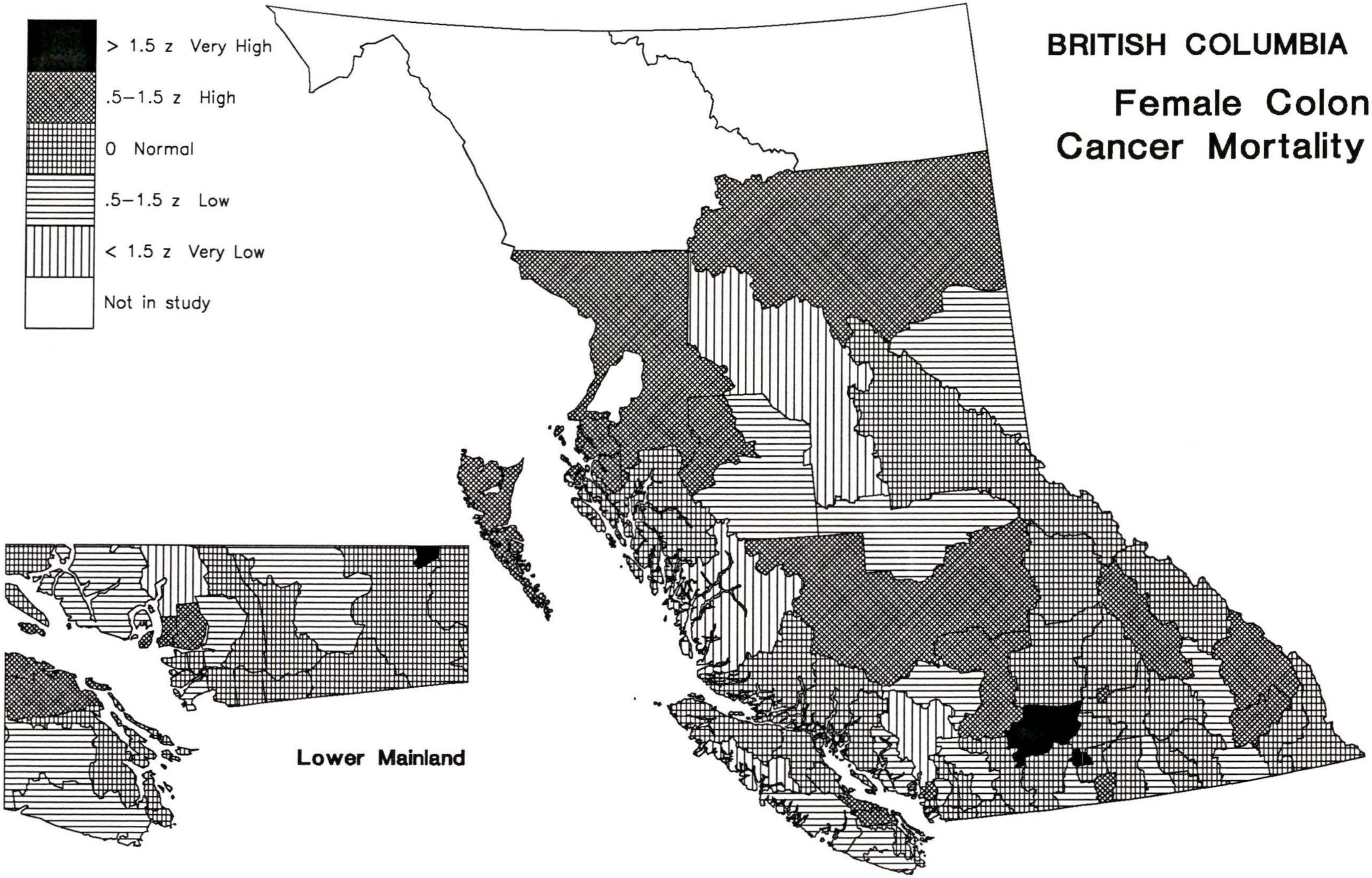


Figure 9,3: Female Colonic cancer mortality in British Columbia by School District, 1956-1978.

Rectal Cancer

Mortality rates for male rectal cancer are shown in Table 6,3 and Figure 10,3. The very high rates of mortality from rectal cancer, in males, were found in the school districts of Merritt (171.4), Vancouver Island West (156.4), Howe Sound (145.7), Campbell River (139.7) and Kitimat (138.8). As can be seen from Figure 10,3 high rates were also experienced in the districts of Fernie (133.7), and in the Sunshine Coast (130.6), Terrace (129.7), Kamloops (124.9), Revelstoke (121.9), as well as numerous districts in the Lower Mainland.

The lowest mortality rates for male rectal cancer were experienced in the school districts of Agassiz-Harrison (24.2), Burns Lake (26.4), Golden (32.3), Vancouver Island North (32.4) and Armstrong (35.5). Lower than normal rates were also evident in Cowichan Lake (45.3), Keremeos (46.6), South Okanagan (47.9) and North Thompson (48.2).

Higher than normal mortality rates were also found in various parts of the province for female rectal cancer. As shown in Table 7,3 and Figure 11,3, very high mortality rates, for example, occurred in the school districts of Fernie (255.6), Revelstoke (191.6) and Vancouver Island West (180.1). High rates were also evident in the school districts of Agassiz-Harrison (154.0), Sunshine Coast (150.8), Nelson (148.2) and

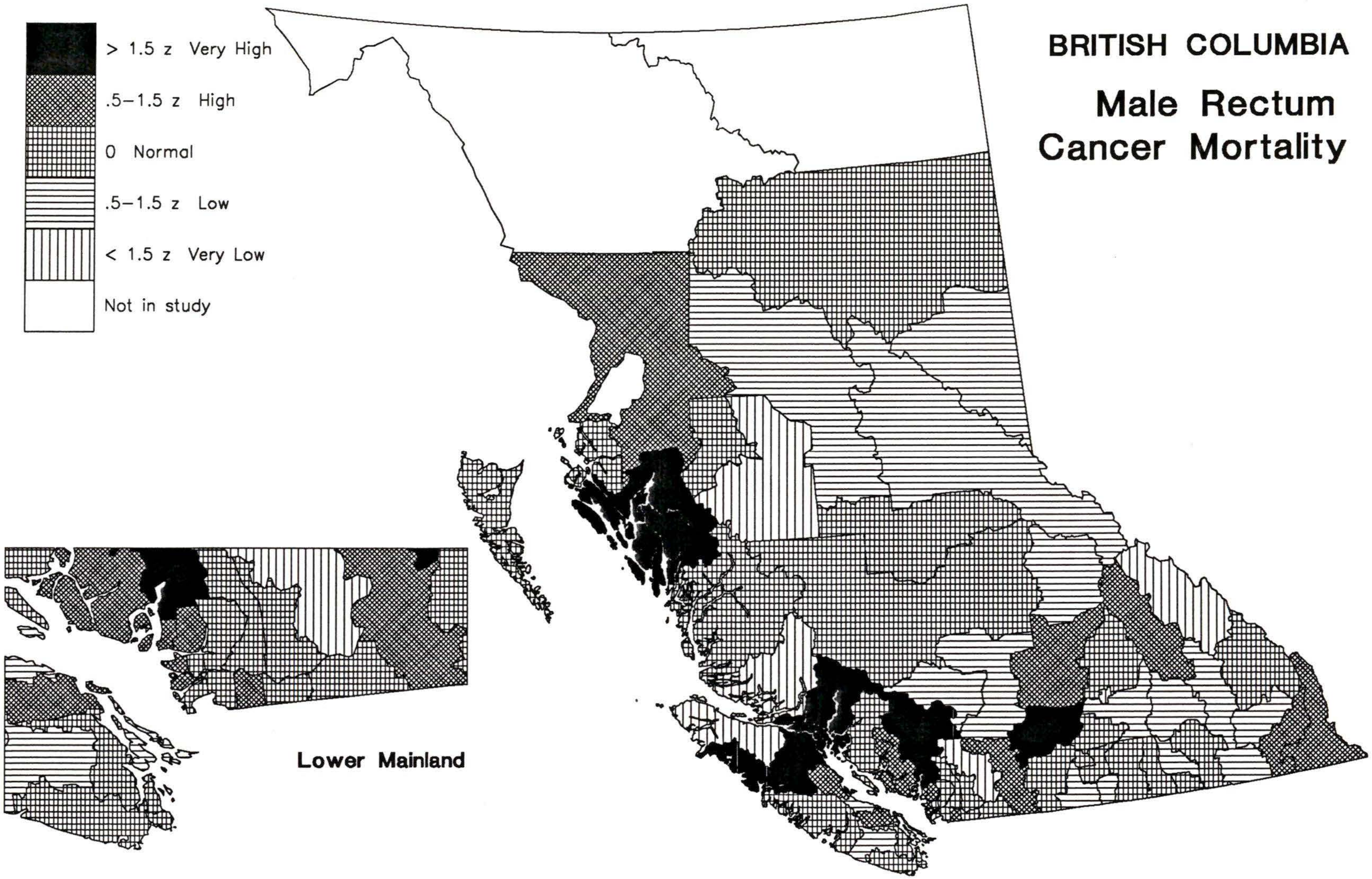


Figure 10,3: Male Rectal cancer mortality in British Columbia by School District, 1956-1978.

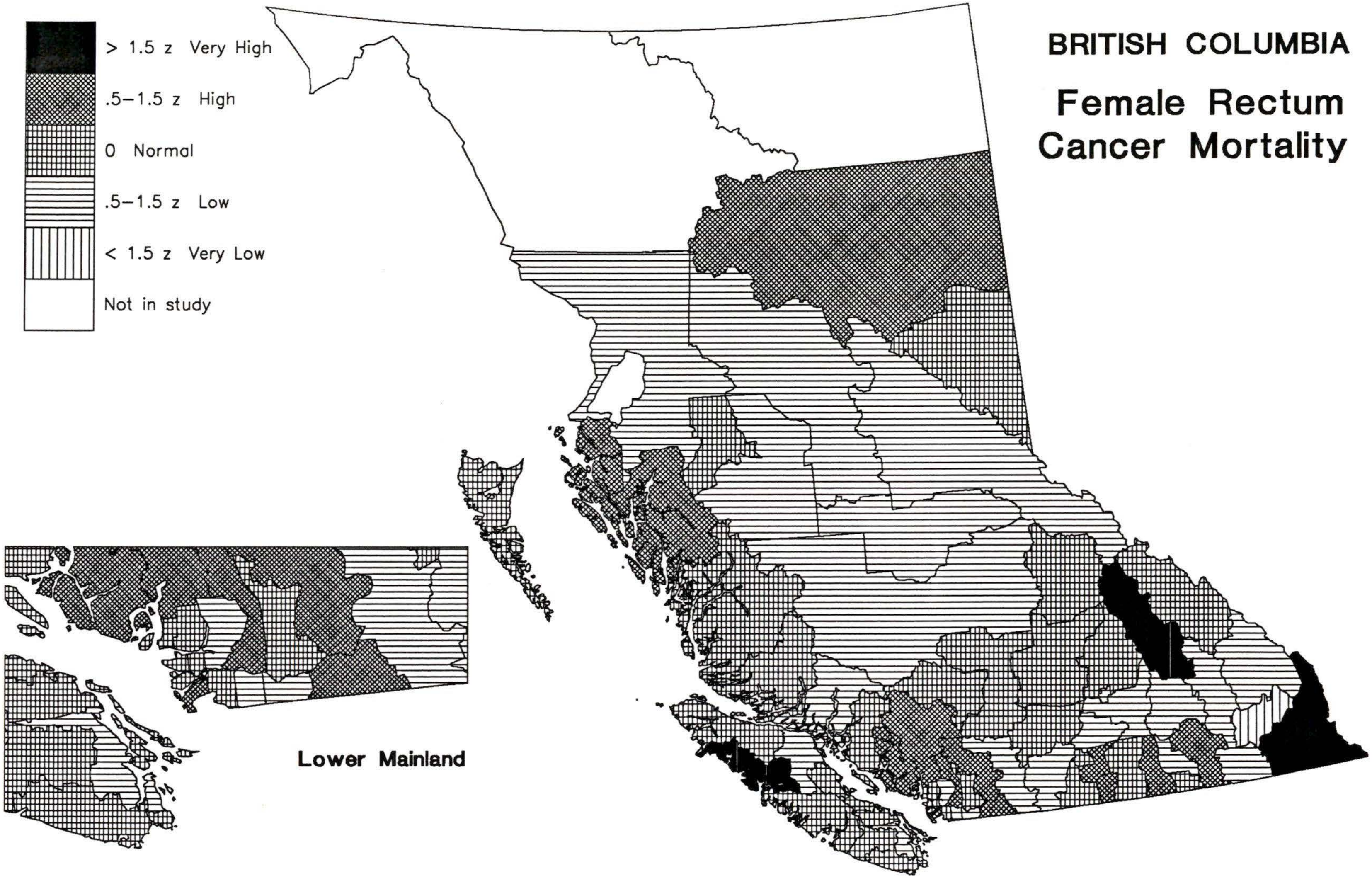


Figure 11,3: Female Rectal cancer mortality in British Columbia by School District, 1956-1978.

Grand Forks (147.5). Other districts experiencing high rates of female rectal cancer can be seen in Figure 11,3.

More than half the school districts in the province have lower than normal rates for rectal cancer mortality in females. Very low rates were found in the districts of Kimberley (25.9), whilst low rates of female rectal cancer were experienced in numerous school districts including Cariboo (36.3), Nechako (37.7), Hope (39.9), Arrow Lakes (40.3) and Langley (43.5).

It should be noted that there are several school districts that have high rectal mortality rates for both males and females. These include the coastal school districts of Vancouver Island West (156.4/180.1), Howe Sound (145.7/135.6), Sunshine Coast (130.6/150.8), Kitimat (138.8/124.5), and in the southeastern part of the province the school districts of Revelstoke (121.9/191.6) and Fernie (133.7/255.6).

Several school districts also experienced low mortality rates for both male and female rectal cancers. These included Burns Lake (26.4/64.1), Nechako (49.5/37.7) and Prince George (63.1/59.1), in the central interior of the province. Vernon (58.5/50.3), Armstrong (35.5/63.3), Castlegar (58.9/63.2), Arrow Lakes (43.2/40.3) and Creston-Kaslo (65.7/63.0) in the south.

DATA LIMITATIONS

Canadian Cancer Mortality Data

In Canada, the registration of deaths and the responsibility for recording vital statistics on diseases comes under the jurisdiction of provincial governments, whom in turn pass the data on to the Federal Department of Health and Welfare. It was from these sources that the *Mortality Atlas of Canada*, *Volume 1: Cancer* was produced. The data used for this purpose appears to have at least four significant limitations, specifically:

1. The size of census divisions varies. Census divisions having relatively small populations, may limit the accuracy of determining statistically significant mortality rate differences when compared to census divisions with large populations.
2. Normal mortality rates in census districts with large populations may obscure high mortality rates in any sub-population.
3. Migration of individuals from one region to another may obscure possible cause-effect environmental relationships, due to a latency period between exposure to carcinogens and any resulting mortality.

British Columbia Cancer Mortality Data

The British Columbia age-standardized cancer mortality statistics, provided on tape by the British Columbia Cancer Control Agency, is a very comprehensive set of data for years 1956 to 1978.

The original data was obtained by the Cancer Control Agency from the Provincial Division of Vital Statistics, Ministry of Health, Province of British Columbia. During initial processing, the principal cause of death was abstracted from each death certificate, it was then coded and classified according to the International Classification of Diseases. The deceased's residence was also located within one of the seventy-five provincial school districts. Although of high quality, this data also has certain limitations, namely:

1. The provincial school districts also vary in size and population, leading to potential problems in accurately calculating differences in mortality rates between districts.
2. Although most school district populations are fairly homogeneous, several districts are situated within more than one physiographic unit. They, therefore, tend to receive drinking water from several drainage basins

and geological regions. This diversity ultimately complicates the interpretation of correlations.

3. Mortality rates for site-specific cancers may be erroneously influenced by the highly migrant nature of some of the province's work force. This problem is magnified by the latency period from exposure to carcinogens and resulting cancer mortality.

CONCLUSIONS

It has been clearly outlined in the preceding discussion that, at both the national and provincial scales, there is great regional variability in the mortality rates of site-specific digestive cancers between the provinces and indeed between regions within provinces, as in British Columbia. Although the national data clearly demonstrates these trends at the census division level, it is difficult to evaluate the geographical distribution of site-specific digestive cancers in British Columbia. This is due to the fact that the census division boundaries cover a very large population base, making it difficult to study regional parameters.

The more relevant set of mortality data, from a regional point of view, was the provided by the British

Columbia Cancer Control Agency. The number of statistical data sets, by school district, was nearly twice that given by the national census division study. The associated Tables 6,3 and 7,3 clearly outline the regional differences in the rates of esophageal, stomach, small intestinal, colonic and rectal cancers for both males and females throughout the province. Although these rates provide evidence of regional variability, the geographic distribution of the various site-specific cancers, as shown in the Figure 2,3 through 11,3 cannot be easily explained. They may in part be due to differences in regional water quality. This possibility and others will be examined in detail later in this thesis using statistical correlations.

CHAPTER FOUR

STATISTICAL METHODS FOR GEOGRAPHICAL INVESTIGATIONS OF CANCER MORTALITY

INTRODUCTION

The null hypothesis of this thesis is that Canadian and British Columbia mortality from digestive cancers are unrelated to the elemental quality of drinking water, and specifically that the six types of digestive tract cancers are not a function of elevated or depressed levels of bulk or trace elements in drinking water. These hypothesized relationships are shown in Table 1,4. The author intends on testing the null hypothesis at both the national and provincial scales, using separate data sets. A research plan for the assembly and management of all data pertinent to this study is shown in Table 1,4.

For the Canadian study, digestive cancer mortality rates were obtained from the Mortality Atlas of Canada, Volume 1: Cancer (1980), the water quality data being derived from a national study by Neri (1977), who explored for possible links between drinking water quality and heart disease in Canada. Both data sets are organized by provincial census division boundaries, for years 1966 to 1976.

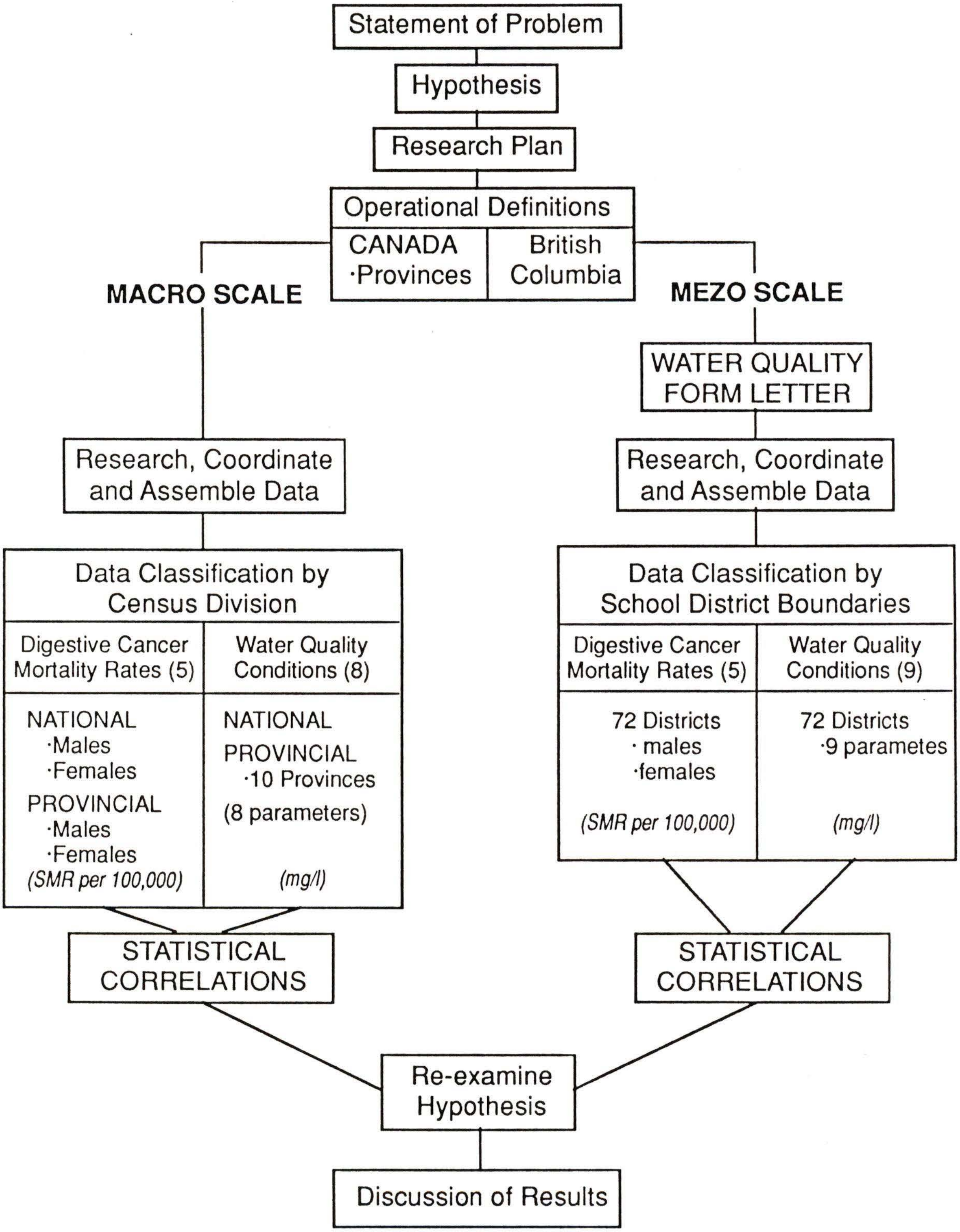
TABLE 1,4

Possible relationships between six digestive tract cancers and twelve water quality conditions

Site-specific Cancers		Water quality conditions
Mouth, Tongue and Pharynx		pH
		Calcium
		Cadmium
Esophagus	Cancers a function of elemental excesses or deficiencies rated in mg/l.	
		Chromium
Stomach		
		Copper
Small Intestine		
		Fluoride
Colon		
		Hardness
Rectum		
		Iron
		Magnesium
		Nitrates
		Sodium
		Zinc

FIGURE 1,4

Research Plan for assembly of data
and testing the hypothesis



The major emphasis of this thesis, however, is to test the null hypothesis for conditions in British Columbia. To satisfy the requirements for such a test, it was necessary for the author to research and assemble a comprehensive set of medical and water quality data for the province. Mortality rates for site-specific digestive cancers were obtained with the kind cooperation of the British Columbia Cancer Control Agency, while a comprehensive listing of water quality data was achieved by the author, who requesting water quality analyses reports from provincial agencies by the way of form letters for years 1966 to 1978. Once received the author classified and assembled both sets of provincial data in preparation for statistical evaluation and review.

From reviewing work by others and from discussions with representatives from the B. C. Cancer Control Agency, the University of Victoria Social Sciences Statistics Department, and department colleagues, it would appear reasonable to expect that Pearson's correlations would provide the most satisfactory method of proving or disproving the hypothesis of this thesis. To support this view the following literature is presented in chronological order.

STATISTICAL METHODS

As will be seen later in this chapter, it would appear that no single statistical method is universally accepted as the most appropriate for this type of study. Indeed, in very few instances in the literature were the actual statistical methods discussed in detail. Often in cases where methods were described, their limitations were usually mentioned and alternatives reviewed. (Greenberg, et al., 1980; Shimada et al., 1981).

To illustrate, Greenberg et al. (1980) undertook an extensive study of cancer in the Northeast Urban Corridor, which involved examining mortality rates from 26 specific cancers for the period from 1950 and 1960, for 49 counties of New York, New Jersey, Pennsylvania, Connecticut and Delaware. During this time period, the region had some of the highest rates for cancer mortality in the United States. The technique used in this interregional study was to isolate disease-risk and factor-place combinations. Three sets of related mortality data were used from similar time periods. They included the National Cancer Institute's standardized age-adjusted mortality rates for the years 1950 to 1969 and the National Centre for Health Statistics cancer mortality rates for 27 specific sites, during the years 1968 to 1972. The third data set included probable cancer causes for 26 specific sites, and was based on a literature review of publications dealing with links between cancer and the physical and social environments. Greenberg and his colleagues (1980) identified more than one thousand potential indicators of occupational or environmental risk from this literature review. From these potential variables, 39 were selected for future evaluation. These included various parameters of social-economic status, ethnicity, mobility, alcohol consumption, smoking, occupation, air quality and water supply. Multivariate correlation and regression analysis were then used to search for associations between specific cancers and such potential risk factors.

This very complex study, undertaken over a period of three years, produced weak associations and disappointing results. From the 71 hypothesized risk factors only two were strongly correlated with cancer mortality. These included strong positive correlation between smoking ($r = 0.86$) and traffic density ($r = 0.91$) and male and female stomach cancer, in people of Polish descent, and a strong positive correlation between traffic density, leukemia and Hodgkins Lymphomas, in people of Russian descent. Levels of significance for these correlations were not given.

The poor results derived from this study may have been largely due to the use of aggregate cause and risk factor data, and unforeseen problems with inter-correlated, multi-variate analysis while using weighted information. The authors suggested guidelines that other researchers might follow to improve the quality of their results. Specifically they suggested that:

1. Bi-variant correlations be consistent with the same time periods.
2. Risk factors that produce confusing results should be eliminated.
3. More than one indicator of the same risk factor should be tested.
4. General control variables based on population density should be used.
5. The correlation of non-related cancers (i.e. prostate and lung) should be eliminated.
6. The use of regression equations to analyses residuals which often lead to erroneous relationships should be restricted.

The disappointing results obtained by Greenberg and his colleagues (1980), would tend to suggest that other statistical methods might have been more appropriate for identifying links between environmental factors and disease.

One of the more interesting studies which has sought to link geography and disease was undertaken by Kendrick (1980), who correlated a variety of socio-economic and environmental factors in an attempt to establish possible links with mortality from cancer in New Zealand. In this study regional mortality rates, for 24 hospital districts for the years 1961 to 1971, were correlated with a variety of socio-economic variables such as urbanism, ethnicity, and income, as well as environmental factors such as climate, soil type, and the quality of drinking water.

The results of linear correlations between socio-economic variables and site-specific cancers gave very poor results, mainly as a result of erroneous data related to patterns of economic growth and living conditions. In contrast, correlations between cancer mortality and the chemical composition of drinking water, produced a variety of suggestive relationships as previously illustrated in Table 2,1. For example, in males, cancer of the esophagus appeared to have weak negative associations ($p = 0.01$) with chlorides, sulphate and iron ($r = -0.26$ to -0.21) and a positive association with water hardness ($r = 0.12$).

For stomach cancer, in males, a significant ($p = 0.01$) negative association was found with chlorides ($r = -0.23$) and positive association with iron and pH (r =

0.22 and 0.20). Colonic cancer, in New Zealand males, had a weak positive association with water hardness (r = 0.13, p = 0.01). Rectal cancer in males was associated positively with pH, hardness and sulphate (r = 0.13 to 0.24, p = 0.01). For all cancers in males, there were significant positive associations with both pH and hardness (r = 0.25, p = 0.01).

In contrast, the correlation between digestive cancers of New Zealand females and water quality parameters provided few statistically significant associations (p = 0.01), the most notable were the negative associations between colonic cancer and pH (r = -0.23), iron (r = -0.27) and manganese (r = -0.26) and with cancer of the rectum, the negative association of sulphate (r = -0.19) and the positive association of chloride (r = 0.26). For all cancers, in females, statistically significant, negative associations were found between pH (r = -0.14, p = 0.01) and iron (r =-0.25, p = 0.01).

Correlations between Kendrick's variables were not strong, but some illustrate associations that have been referred to elsewhere in the literature of Chapter 1. The quality of data used is unclear from Kendrick's article and it is not obvious whether it was adjusted by weighting, or transformation, before use.

In a similar study in Japan, Inaba et al. (1981) reviewed the geophysical patterns of specific cancer mortality in 46 Japanese prefectures and 24 other countries, using factorial analysis to isolate common factors. It was thought that the geographic distribution of specific cancers was based, in part, on common factors and that their mutual relationships were involved in the pathogenesis. Inaba and his colleagues decided to apply factorial analysis on the grounds that it had been used successfully in the fields of psychology, economics and medicine.

The results of factorial analysis provided no meaningful information on the aetiology of site-specific cancers, other than to suggest that bone, bladder, skin and buccal cancers appeared to be related to atmospheric temperature. In contrast, linear correlation as used later in the study between site-specific cancer in the 24 countries, indicated strong interdependence between digestive cancers. It was noted that the strength of organ interdependence for specific digestive cancers also varied considerably between countries.

In reviewing Inaba's work, it would appear that in this particular case, factorial analysis was not a successful way of determining the aetiology of cancer, although Burbank (1972) argued that factorial analysis and clustering provided a successive hierarchial structure of cancer sites. It should be noted however, that the weakness of this approach is that elements common to a cluster analysis are interdependent and such mutual relationships make if difficult to produce a hypothesis about the condition of a specific element and the aetiology of a specific cancer site.

In contrast, the linear correlations related to the geographic distribution and interrelationships between site-specific cancers for Japan and the 24 countries provided more meaningful information such as that of lung cancer and atmospheric temperatures. It was also suggested that the biased, or weak results, were due mainly to modes of sampling and the use of weighted data.

In another Japanese study, Miyawaki and Chen (1981) provided a review of statistical mapping of mortality, emphasizing the problems associated with class intervals. They illustrated that class intervals, necessary for mortality mapping, are different from those used for statistical research. It was shown that, from a geographical perspective, the illustration of mortality rates for chronic diseases is more meaningful if it can be divided into smaller units for regional comparisons. This does not hold true from a statistical point of view, where as each areal unit becomes smaller the number of deaths also become fewer, leading to the influence of random error, and false associations. In contrast, however, it must be recognized that the larger the areal unit becomes, the more likely the risk of other heterogeneous factors becoming involved, leading to the problem of the ecological fallacy and the increased probability of biased relationships (Clark and Hosking, 1986).

The second major influence involved in statistically analysing standardized mortality ratios, relates to how the regional areal units are established. As an example, when a representative sample is collected from a population, it is generally assumed that the population is normally distributed, and that the samples reflect the true state of the population. From a statistical or mathematical point of view, however, this may not be the case as classification of sampling unit boundaries is often based solely on the interpretation of socio-economic values, which in some cases ignore other associated geographical or environmental factors. For this reason, Miyawaki and Chen (1981) stressed the importance of setting up areal units that represent both the statistical and medical-geographical points of view, when analysing causal factors related to mortality.

It was also recommended by Miyawaki and Chen (1981) that a Pearson distribution, or a modified Pearson distribution would be the most suitable statistical process when studying the regional distribution of morbidity, or mortality, from a medical-geographical point of view, since it is widely accepted that the spatial patterns of diseases have poisson distributions, being rare and independent events (Miyawaki and Chen, 1981). This suggests that Pearson's correlation would be a suitable method of statistical analysis for use in this thesis, as the data used in this thesis would fit these requirements.

In another study in the same year, Shimada et al. (1981) investigated regional differences in death from chronic diseases in Rio Grande Do Sul, Brazil, during the years 1970 to 1976. They found strong geographic dependency, supporting the view that environmental factors were important in the aetiology of both heart disease and cancer. In this study the rank order of Age Adjusted District Rates (AARD) of various cancers of the digestive tract, for both males and females, were calculated and compared to age-adjusted death rates from Japan, U.S.A., Mexico, Columbia and Chile. Spearman's rank order correlations were then used to examine the age-adjusted death rates for specific diseases, by both Health Districts and socio-economic units.

Results of this study indicated that higher than normal Age-Adjusted rates of malignant neoplasms were found in the stock farming regions, including some of the highest esophageal cancer rates in the world. There were thought to be linked to very high sodium chloride consumption (16 milligrams per day). It was also found that stomach cancer was 2.5 times more prevalent than colonic cancer, in Rio Grade do Sul, in spite of the heavy beef consumption. This led to the suggestion that other environmental factors might be involved. Spearman's Rank Order Correlations were also used to study the relationships between cancer incidence and various socio-economic factors, including parasitic diseases, urbanization, population density, education, crime and diet including beef consumption. The results of these analyses were very weak and inconclusive.

In assessing the statistical methods used by Shimada and his colleagues (1981), it would appear that cause and effect associations might have been more evident if Pearson's correlations had been used. This is because Spearman's rank order correlations is a non-parametric measure of the relationship between two sets of rank values on an ordinal scale, whereas Pearson's product moment correlations coefficient is a parametric measure of covariance between two specific variables on an interval scale. The major focus of this thesis is on the strength and direction of covariance between specific environmental factors and disease, data being given on an interval scale. For this reason Spearman's rank order correlations may not be a suitable method of statistical evaluation in this study.

In one of the few Canadian studies related to environmental factors and disease, Thouez, Beauchamp and Simard (1981), reviewed cancer incidence and the physio-chemical quality of drinking water in Quebec, in an attempt to discover whether there were relationships between the hardness of drinking water and site-specific cancers. In this study, age-standardized incidence rates for site-specific digestive cancers by census district, were obtained from Statistics Canada, for the five year period 1970-75. Data on the physio-chemical characteristics of drinking water, provided by the Epidemiology Studies Services of the Quebec Department of Social Affairs, had originally been collected by the Quebec Environmental Protection Service.

In all, 46 Counties were evaluated, the criteria for selection being that at least 50 percent of the drinking water for that County was supplied by water analysed for this study. Significant associations between water quality parameters and site-specific digestive cancers were found using Canonical Correlations, and, for the first descriminant function, Wilk's Lamda. Results of this study can be seen in Table 2,1. The most significant of these findings was the negative association between water hardness and the incidence of both stomach cancer (r = -0.36, p = 0.01) and rectal cancer (p = -0.54, p = 0.01), and to a lesser extent, other organs of the digestive system. It was felt that results were weakened by the randomness of medical data and that aggregate ecological data related to water quality did not explain the difference between short-term and long-term effects.

In conclusion, although these results were not outstanding, it would appear that the statistical methods used by Thouez and his colleagues (1981), provided results which were able to confirm similar relationships found by other researchers.

In a study of cancer mortality, McGlashan (1983) used cluster analyses to further explain Pearson's Correlations. It was argued that such cluster analyses could provide a hierarchical structure from which dendograms could be produced which would help identify any geographical pathology. McGlashan used two completely separate data sets. The first set consisted of crude digestive cancer mortality rates (CMR), in black coal miners, from 10 different home territories in Africa, the second was of standardized digestive cancer mortality rates (SMR) from 10 separate island territories in the Caribbean. Separate Pearson's Correlations were then used to establish levels of covariance between site-specific mortality rates and place of residence, for each of the two study groups. The results from Pearson's Correlations were then run through a Cluster Program, converting the correlation values into a hierarchical structure from which dendograms could be constructed. The dendograms were then used to visually explain the Pearson's Correlations and to assist with the identification of factors common to both populations.

It is apparent that this type of cluster analysis is not a suitable way of explaining the results of Pearson's Correlations derived in this thesis since McGlashan admitted that inverse relationships cannot be accommodated in this process.

A more successful study was undertaken by Giggs (1983) in Britain. This examined the incidence of schizophrenia in Nottingham and how the disease may be related to the ecological structure. The main objective of the study was to identify the biological, social and environmental correlates of this mental disorder. The data used in this survey included sixty-two physical and social variables and spatial variations in the incidence of schizophrenia within the Nottingham study area. Multi-variate analyses was used to produce linear relationships between the variates, the results of which were then grouped by using a non-hierarchial cluster analyses to indicate common relationships between variates.

The successful results of this process indicated that, in cases where variates are highly correlated, multi-variate and cluster analyses is a successful way of identifying causal relationships between socio-environmental factors and disease.

In another study related to environmental factors and disease, Van Rensberg (1985) investigated the incidence of esophageal cancer amongst Zulu men in South Africa. This was a case control study, based on reliable data and involved a wide variety of socio-economic factors including diet, nutrition and health practise. Step-wise logistic regression was used to correlate these variables with age adjusted incidence rates, in an attempt to identify causal relationships. The correlations indicated associative relationships, but it was not possible to detect quantitative differences using this methodology. The author concluded that a multi-variate type of regression might have been more valuable.

It is not clear from Van Rensberg's study, why step-wise logistic regression was used to identify the causes of esophageal cancer in Zulu men, especially where more emphasis was placed on the personal habits of the individuals rather than the dietary and environmental factors required to establish causal relationships. It would appear that unless correlations between variables are significantly strong, step-wise multiple regression is not a suitable means of explaining covariance between water quality and site-specific cancers.

In a more recent study of cancer mortality in the United States, Foster (1986) used Pearson product-moment correlation coefficients and multiple step-wise regression, to research for links between 219 environmental variables and 66 specific cancers, or groups of cancers in the United States. The resulting some 13,000 correlations suggested, as shown in Table 1,4, that many digestive cancers were either strongly negatively or positively linked ($r = >0.80$, $p = 0.0001$) to soil bulk and trace elements and to some of their antagonists. In digestive cancers, numerous elements were found to be associated with cancer mortality these included beryllium, calcium, manganese, magnesium, mercury, potassium, phosphorus, selenium and sodium.

Another approach to spatially identifying geographic patterns of disease in the United States, was undertaken by Hopps (1986) who prepared maps to allow visual comparisons between regions. Hopps (1986) studied how the chemical qualities of drinking water, contributed to human health in a positive way. Using a series of maps and overlays he discovered that high levels of calcium and magnesium in drinking water, appeared linked to dramatic increases in longevity, especially in the north central United States. Tabular comparisons also indicated that enriched hardwater sources can supply all of the recommended dietary intake for such elements as magnesium, fluorine and sodium and up to 30 percent of daily calcium requirements.

Maps and tabular comparisons would be one method that could be used to illustrate links, if any, between water quality and digestive cancers in British Columbia. However, since many factors may be involved, it might be very difficult to illustrate the strength, or direction of associated covariance by using maps.

CONCLUSIONS

It can seen from this review that there appear to be inherent drawbacks to most statistical methods when applied to medical geography research. It is clear, however, that one should be aware of the problems involved in using aggregate cause and effect factor data, which may yield biased correlation co-efficients. Often referred to as the ecological fallacy, weakly related data are often aggregated, and through the process of auto-correlation can either lead to incorrect inferences or biased relationships between variables.

Clark and Hosking (1986) in a review of statistical methods used by Robinson (1950) and Blalock (1964) state that "although ecological correlations cannot be used to make valid individual level inferences, there are two situations in which aggregate variables are appropriate." (Clark and Hosking, 1986:405)

> (1) "when the variables are functions of some commonly underlying causal structure inherent not in the individuals themselves, but in the properties of the areas." (Clark and Hosking, 1986: 405)
>
> (2) "When one aggregate variable is related to another and an individual correlation would be impossible." (Clark and Hosking, 1986:405)

In reference to this thesis, both conditions are applicable. It would appear that (1) the properties of the areas would include water quality variables, and that (2) an aggregate variable related to another would be a site-specific digestive cancer.

One of the most commonly used forms of statistical measure is the Pearson's product-moment correlation, which, as discussed in this chapter, has been widely used by both geographical and medical researchers. The Pearson's correlation coefficient is a standardized parametric measure of linear covariance (r) which indicates the strength of association between two variables at an interval scale (Kendrick, 1980; Miyakawa and Chen, 1981; Foster, 1986).

Pearson's correlation is also very convenient for measuring large numbers of correlation coefficients, and has been successfully used by several researchers including Band and Spinelli of the British Columbia Cancer Control Agency; Foster (1986) in a review of potential links between cancer mortality and environmental factors in the United States and elsewhere, and Norie and Foster (1988) in a study to explore possible links between Canadian cancer mortality and elemental quality of drinking water.

Given the similar characteristics of this research project and those of Kendrick (1980) and Foster (1986), it would appear that Pearson's correlation would provide the most suitable method to identify suggestive links, if any, between mortality from digestive cancers and the regional quality of drinking water in British Columbia.

CHAPTER FIVE

RESULTS OF STATISTICAL CORRELATIONS

INTRODUCTION

As has been described in previous chapters, Canadian water quality information by provincial census divisions and British Columbia water quality by school district boundaries, was assembled into two separate data sets. Age-standardized digestive cancer mortality rates, at both the national and provincial levels, along with that of British Columbia by school district, were also incorporated into the same data system. As a consequence, it was then possible for the author, using Pearson's correlation coefficients, to test the hypothesis that they may be an association between cancers of the mouth, esophagus, stomach, small intestine, colon and rectum and elevated or depressed levels of water hardness, and pH, calcium, cadmium, chromium, copper, fluoride, iron, lithium, magnesium, nitrates, sodium and zinc.

To achieve this objective, Neri's Canadian water quality data was first correlated with Canadian cancer mortality data, derived from the Mortality Atlas of Canada, Volume 1: Cancer. Secondly, mortality data, provided by the British Columbia Cancer Control Agency, was then correlated with the detailed water quality information from British Columbia as collected and assembled by this author.

CANADA

Two methods of analysis were used in the national Canadian study. These procedures were chosen because of the nature of water sampling procedure and differences in the size of census divisions, which resulted in variations in the availability of water quality data. In the first set of analyses, all water data, in the form provided by Neri and his associates, was utilized in Pearson's correlations. In the second set, an arithmetic mean was calculated for each water quality parameter, for each census division for which such data was available. This mean was then used to represent this parameter when calculating Pearson correlation coefficients. Whilst these two approaches resulted in minor variations in the strength and statistical significance of resulting correlations, both methods identified the same major trends. For this reason only the results obtained using the first method of analysis will be presented in this thesis. As there were fairly large samples a significance level of $p = > 0.0001$ was used.

As shown in Tables 1,5 and 2,5 there is little evidence of statistically significant ($p = > 0.0001$)

correlations between mortality from cancer of the digestive system and levels of copper, chromium, cadmium and zinc in Canadian drinking water. While this generalization is true for both males and females, a few minor exceptions should be noted. On the national scale, for example, the analysis established low, yet still significant, negative correlations with copper and cancers of the tongue, mouth and pharynx in females, and positive correlations between copper and cancers of the stomach in both males ($r = 0.11170$, $p = 0.0001$), and females ($r = 0.08921$, $p = 0.0001$). At the provincial scale, it was also noted that there were low negative correlations between copper and cancers of the tongue, mouth and pharynx ($r = -0.23637$, $p = 0.0002$) in Albertan males.

The levels of cadmium in drinking water was also found to be correlated with certain digestive cancers at the provincial scale but at a lower level of significance. For example, it was found that in Ontario, cadmium correlated negatively with cancers of the esophagus in both males ($r = -0.18586$, $p = 0.0001$), and females ($r = -0.12048$, $p = 0.0031$), and with cancer of the stomach in both males ($r = -0.12491$, $p = 0.0022$) and females $r = -0.13363$, $p = 0.0010$). A low, yet significant, positive correlation was also found between cadmium and cancer of the rectum in Ontario females (r =

TABLE 1,5

Pearson's correlation coefficients between cancers of the digestive trace in Canadian MALES and the cadmium, chromium, copper and zinc content of drinking water.

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
CANADA					
Cadmium	-0.05519	-0.04776	-0.04783	0.03075	-0.02680
	0.0125	0.0306	0.0304	0.1642	0.2253
	2049	2049	2049	2049	2049
Chromium	0.00293	0.00673	-0.03109	0.00216	-0.02616
	0.8947	0.7609	0.1597	0.9221	0.2368
	2047	2047	2047	2047	2047
Copper	-0.02522	0.11170	0.03805	-0.02367	0.02285
	0.2302	0.0001	0.0702	0.2601	0.2769
	2266	2266	2266	2266	2266
Zinc	0.01402	-0.00545	-0.01959	-0.07011	-0.04374
	0.5063	0.7963	0.3533	0.0009	0.0381
	2248	2248	2248	2248	2248
BRITISH COLUMBIA					
Cadmium	-0.05941	-0.12594	-0.14222	0.20860	-0.06705
	0.5157	0.1669	0.1181	0.0211	0.4631
	122	122	122	122	122
Chromium	-0.03717	-0.01729	-0.06345	-0.04014	-0.11035
	0.6844	0.8501	0.4875	0.6607	0.2263
	122	122	122	122	122
Copper	0.20076	0.16683	0.22850	-0.09683	0.25893
	0.0248	0.0630	0.0104	0.2827	0.0035
		125	125	125	125
Zinc	-0.12741	-0.01106	0.03959	-0.01368	0.04597
	0.1585	0.9029	0.6624	0.8802	0.6122
	124	124	124	124	124
ALBERTA					
Cadmium	-0.09256	0.13399	0.01069	-0.00406	0.00537
	0.2016	0.0639	0.8830	0.9554	0.9411
	192	192	192	192	192
Chromium	-	-	-	-	-
Copper	-0.23637	0.14704	-0.09507	-0.16462	-0.15898
	0.0002	0.0195	0.1323	0.0088	0.0115
	252	252	252	252	252
Zinc	0.04127	-0.01341	0.02531	-0.09580	-0.03877
	0.5186	0.8339	0.6922	0.1332	0.5442
	247	247	247	247	247

TABLE 1,5 MALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
SASKATCHEWAN					
Cadmium	-019013	-0.11639	-0.09405	-0.00939	-0.06699
	0.0206	0.1589	0.2555	0.9898	0.4185
	148	148	148	148	148
Chromium	-	-	-	-	-
Copper	-0.14141	0.10845	-0.04742	-0.08614	0.01433
	0.0605	0.1507	0.5308	0.2543	0.8499
	177	177	177	177	177
Zinc	-0.1643	0.01440	-0.23190	-0.32051	-0.31313
	0.0300	0.8500	0.0020	0.0001	0.0001
	175	175	175	175	175
MANITOBA					
Cadmium	-0.12291	-0.13579	-0.23260	0.19837	-0.09152
	0.2116	0.1672	0.0170	0.0425	0.3531
	105	105	105	105	105
Chromium	-0.00601	0.15049	-0.21582	0.00253	-0.16599
	0.9515	0.1254	0.0270	0.9796	0.0906
	105	105	105	105	105
Copper	-0.06486	0.09900	-0.01631	-0.10313	-0.06302
	0.4989	0.3013	0.8651	0.2814	0.5111
	111	111	111	111	111
Zinc	-0.16529	0.03454	-0.21164	0.15469	-0.09087
	0.0830	0.7189	0.0258	0.1050	0.3429
	111	111	111	111	111
ONTARIO					
Cadmium	-0.18586	-0.12491	-0.03625	0.04898	-0.00702
	0.0001	0.0022	0.3888	0.2309	0.8637
	600	600	600	600	600
Chromium	-	-	-	-	-
Copper	0.01579	0.00792	0.02420	-0.00934	0.02209
	0.6782	0.8352	0.5247	0.8062	0.5615
	693	693	693	693	693
Zinc	-0.00496	-0.3238	0.02244	-0.03952	0.00216
	0.8970	0.3913	0.5579	0.3020	0.9550
	684	684	684	684	684

TABLE 1,5 MALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
QUEBEC					
Cadmium	-0.00843	-0.02442	-0.00340	0.01980	0.00552
	0.8458	0.5730	0.9374	0.6478	0.8986
	535	535	535	535	535
Chromium	0.00349	-0.01696	-0.01861	0.01810	-0.00766
	0.9358	0.6961	0.6682	0.6767	0.8599
	533	533	533	533	533
Copper	0.04303	0.00320	-0.06070	-0.03963	-0.06634
	0.3124	0.9402	0.1540	0.3523	0.1192
	553	553	553	553	553
Zinc	0.01726	0.00586	-0.08720	-0.10300	-0.11580
	0.6857	0.8907	0.0406	0.0155	0.0065
	552	552	552	552	552
NEW BRUNSWICK					
Cadmium	-0.02513	0.24111	-0.23152	0.06204	-0.15731
	0.8011	0.0140	0.0186	0.5336	0.1125
	103	103	103	103	103
Chromium	-	-	-	-	-
Copper	0.07834	0.01462	-0.12491	-0.03680	0.07111
	0.4315	0.8835	0.2087	0.7121	0.4754
	103	103	103	103	103
Zinc	0.03203	0.07332	0.00027	-0.12129	-0.06732
	0.7481	0.4617	0.9979	0.2223	0.4993
	103	103	103	103	103
NOVA SCOTIA					
Cadmium	0.01092	0.11669	0.15169	-0.06424	0.10399
	0.8930	0.1495	0.0604	0.4286	0.1993
	154	154	154	154	154
Chromium	-	-	-	-	-
Copper	-0.11190	0.11211	0.19830	0.03685	0.20207
	0.1629	0.1622	0.0128	0.6468	0.0112
	157	157	157	157	157
Zinc	0.12524	0.01061	0.01020	-0.11569	-0.04949
	0.1181	0.8951	0.8991	0.1491	0.5382
	157	157	157	157	157

TABLE 1,5 MALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
NEWFOUNDLAND					
Cadmium	0.02276	-0.11182	-0.15713	-0.01714	-0.14743
	0.8422	0.3265	0.1667	0.8804	0.1948
	79	79	79	79	79
Chromium	-	-	-	-	-
Copper	-0.09195	0.26696	0.04584	0.18424	0.12580
	0.4055	0.0141	0.6788	0.0934	0.2542
	84	84	84	84	84
Zinc	0.08627	0.14914	0.00986	-0.06259	-0.01967
	0.4252	0.1757	0.9291	0.5716	0.8590
	84	84	84	84	84

0.23288, p = 0.0001). In Manitoba, a negative association was also found between cadmium and colonic cancers (r = -0.29706, p = 0.0021).

No strong correlations were established at either the national or provincial scales, with zinc in the water supply and digestive cancers. However, zinc was found to have a low, yet significant, negative correlation at the national scale with cancer of the rectum in males (r = -0.07011, p = 0.0009). Low, and less significant, negative correlations were also found between the levels of zinc in Saskatchewan's drinking water and cancers of the colon (r = -0.23190, p = 0.0020) and rectum (r = - 0.32051, p = 0.0001) in males.

TABLE 2,5

Pearson's correlation coefficients between cancers of the digestive tract in Canadian FEMALES and the cadmium, chromium, copper and zinc content of drinking water.

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
CANADA					
Cadmium	-0.03905	-0.01979	-0.04156	0.02543	-0.02792
	0.0836	0.3806	0.0655	0.2598	0.2161
	1965	1965	1965	1965	1965
Chromium	0.00816	0.00590	-0.03580	-0.00203	-0.03224
	0.7179	0.7937	0.1128	0.9285	0.1533
	1963	1963	1963	1963	1963
Copper	-0.06377	0.08921	0.04337	0.00914	0.04106
	0.0029	0.0001	0.0430	0.6701	0.0555
	2177	2177	2177	2177	2177
Zinc	0.00423	0.00679	0.03482	-0.02425	0.02266
	0.8443	0.7524	0.1058	0.2601	0.2927
	2159	2159	2159	2159	2159
ALBERTA					
Cadmium	-0.04690	0.05533	-0.01739	-0.06957	-0.04020
	0.5183	0.4459	0.8108	0.3376	0.5798
	192	192	192	192	192
Chromium	-	-	-	-	-
Copper	0.08719	0.06180	0.05806	0.00906	0.04725
	0.1676	0.3285	0.3587	0.8862	0.4552
	252	252	252	252	252
Zinc	0.01837	-0.08085	0.02626	0.03277	0.03347
	0.7738	0.2054	0.6813	0.6082	0.6006
	247	247	247	247	247
BRITISH COLUMBIA					
Cadmium	-0.17730	-0.10895	0.12881	0.00889	0.14367
	0.0507	0.2323	0.1574	0.9226	0.1144
	122	122	122	122	122
Chromium	0.03732	0.09225	-0.15416	0.03608	-0.14658
	0.6832	0.3122	0.0900	0.6932	0.1072
	122	122	122	122	122
Copper	-0.17731	-0.01809	0.10430	-0.10403	0.05503
	0.0479	0.8413	0.2471	0.2483	0.5422
	125	125	125	125	125
Zinc	-0.03994	-0.17572	0.05881	-0.17846	-0.03313
	0.6597	0.0509	0.5165	0.0474	0.7149
	124	124	124	124	124

TABLE 2,5 FEMALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
SASKATCHEWAN					
Cadmium	-0.02421 0.7703 148	-0.05338 0.5193 148	0.00895 0.9141 148	-0.12569 0.1280 148	-0.05148 1.5343 148
Chromium	-	-	-	-	-
Copper	-0.03372 0.6559 177	0.03851 0.6108 177	-0.01543 0.8385 177	0.13349 0.0765 177	0.04806 0.5253 177
Zinc	0.12683 0.0944 175	0.24227 0.0012 175	-0.04739 .5334 175	0.03901 0.6083 175	-0.02350 0.7576 175
MANITOBA					
Cadmium	-0.08107 0.4110 105	0.07865 0.4251 105	-0.29706 0.0021 105	-0.00545 0.9560 105	-0.23868 0.0142 105
Chromium	0.09375 0.3415 105	0.17233 0.0788 105	-0.01458 0.8826 105	-0.17937 0.0671 105	-0.09054 0.3583 105
Copper	0.03241 0.7356 111	0.11311 0.2372 111	-0.18526 0.0516 111	-0.06820 0.4769 111	-0.17654 0.0638 111
Zinc	-0.04027 0.6747 111	0.03198 0.7390 111	-0.01557 0.8711 111	0.01362 0.8811 111	-0.00647 0.94963 111
ONTARIO					
Cadmium	-0.12048 0.0031 600	-0.13363 0.0010 600	0.04060 0.3208 600	0.23288 0.0001 600	0.11781 0.0039 600
Chromium	-	-	-	-	-
Copper	-0.01330 0.7268 693	-0.09260 0.0148 693	0.08355 0.0279 693	0.00349 0.9269 693	0.07293 0.0550 693
Zinc	0.00453 0.9059 684	-0.07526 0.0491 684	0.04748 0.2149 684	0.01403 0.7142 684	0.04726 0.2171 684

TABLE 2,5 FEMALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
QUEBEC					
Cadmium	0.00998	-0.06796	-0.02034	0.03634	-0.00573
	0.8179	0.1164	0.6388	0.4016	0.8947
	535	535	535	535	535
Chromium	0.00733	-0.05675	-0.04579	0.03780	-0.02824
	0.8659	0.1909	0.2914	0.3838	0.5154
	533	533	533	533	533
Copper	-0.02796	0.05963	-0.06848	0.02109	-0.05089
	0.5117	0.1614	0.1278	0.6206	0.2321
	553	553	553	553	553
Zinc	-0.06021	0.04809	0.05154	-0.05735	0.02501
	0.1578	0.2593	0.2266	0.1784	0.5576
	552	552	552	552	552
NEW BRUNSWICK					
Cadmium	0.10482	-0.23439	-0.23400	-0.16938	-0.27709
	0.3147	0.0230	0.0232	0.1027	0.0069
	94	94	94	94	94
Chromium	-	-	-	-	-
Copper	-0.08998	-0.00946	0.29247	0.17235	0.33444
	0.3884	0.9279	0.0042	0.0967	0.0010
Zinc	0.13397	-0.02440	-0.16649	-0.12227	-0.19732
	0.1980	0.8154	0.1088	0.2404	0.0566
	94	94	94	94	94
NOVA SCOTIA					
Cadmium	-0.16771	0.15892	0.12212	0.09347	0.15841
	0.0376	0.0490	0.1314	0.2489	0.0497
	154	154	154	154	154
Chromium	-	-	-	-	-
Copper	-0.16007	0.14544	0.14478	0.06511	0.16911
	0.0452	0.0691	0.0704	0.4178	0.0342
	157	157	157	157	157
Zinc	0.11217	0.01697	0.11205	-0.11901	0.07168
	0.1619	0.8329	0.1624	0.1377	0.3724
	157	157	157	157	157

TABLE 2,5 FEMALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
NEWFOUNDLAND					
Cadmium	-	-	-	-	-
Chromium	-	-	-	-	-
Copper	0.36923	-0.20776	-0.60463	-0.33333	-0.58004
	0.6308	0.7922	0.3954	0.6667	0.4200
	4	4	4	4	4
Zinc	-0.36923	-0.02776	-0.60463	-0.33333	-0.58004
	0.6308	0.7922	0.3954	0.6667	0.4200
	4	4	4	4	4

In females a low positive association with cancer of the stomach ($r = 0.24227$, $p = 0.0012$) was also noted in Saskatchewan.

In contrast, as shown in Table 3,5, the analysis established repeated significant negative correlations between the hardness and lithium, calcium and magnesium content of drinking water and cancers of the tongue, mouth and pharynx; stomach, large intestine, rectum and colo-rectal cancer. Although some exceptions to this generalization occurred, a preponderance of significant negative associations were established at both national and provincial scales. To illustrate, in males, there were repetitive negative correlations between drinking

TABLE 3,5

Pearson's correlations coefficients between cancers of the digestive tract in Canadian MALES and the hardness and calcium, magnesium and lithium content of drinking water.

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
CANADA					
Calcium	-0.16421	-0.26537	-0.26297	-0.07704	-0.24542
	0.0001	0.0001	0.0001	0.0374	0.0001
	730	730	730	730	730
Hardness	-0.24759	-0.30928	-0.29368	-0.10594	-0.28308
	0.0001	0.0001	0.0001	0.0031	0.0001
	780	780	780	780	780
Lithium	-0.09417	-0.21464	-0.21742	-0.01758	-0.18500
	0.0001	0.0001	0.0001	0.4023	0.0001
	2272	2272	2272	2272	2272
Magnesium	-0.30440	-0.29556	-0.34180	-0.16284	-0.34462
	0.0001	0.0001	0.0001	0.0001	0.0001
	2130	2130	2130	2130	2130
BRITISH COLUMBIA					
Calcium	-0.44264	-0.19848	-0.24726	-0.02749	-0.33866
	0.0042	0.2195	0.1240	0.8663	0.0326
	40	40	40	40	40
Hardness	-0.58692	-0.23520	-0.23674	-0.03263	-0.34324
	0.0001	0.1001	0.0979	0.8220	0.0147
	50	50	50	50	50
Lithium	-0.44270	-0.14673	-0.16551	-0.07044	-0.27485
	0.0001	0.0971	0.0609	0.4276	0.0016
	129	129	129	129	129
Magnesium	-0.52745	-0.11370	-0.22171	0.04857	-0.27924
	0.0001	0.1995	0.0116	0.5847	0.0014
	129	129	129	129	129
ALBERTA					
Calcium	-0.13589	-0.31028	-0.09306	0.12977	0.01416
	0.2264	0.0048	0.4086	0.2482	0.9002
	81	81	81	81	81
Hardness	-0.23632	-0.25377	-0.01451	0.21884	0.11703
	0.0266	0.0170	0.8933	0.0405	0.2775
	88	88	88	88	88
Lithium	-0.15301	-0.35232	-0.08252	0.16915	0.04489
	0.0151	0.0001	0.1916	0.0071	0.4781
	252	252	252	252	252
Magnesium	-0.25901	-0.05972	-0.13512	0.22846	0.22294
	0.0001	0.3780	0.0453	0.0006	0.0009
	220	220	220	220	220

TABLE 3,5 MALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
SASKATCHEWAN					
Calcium	-0.20569	0.12993	-0.08077	0.05038	-0.02633
	0.1214	0.3310	0.5467	0.7072	0.8445
	58	58	58	58	58
Hardness	-0.26747	-0.05411	0.02449	0.11322	0.07397
	0.0326	0.6711	0.8477	0.3730	0.5613
	64	64	64	64	64
Lithium	-0.17041	0.18312	-0.05700	-0.13817	-0.10604
	0.0233	0.0147	0.4511	0.0667	0.1601
	177	177	177	177	177
Magnesium	-0.17338	0.10422	-0.07428	0.13851	0.02567
	0.0283	0.1897	0.3505	0.0807	0.7473
	160	160	160	160	160
MANITOBA					
Calcium	-0.28712	0.26821	-0.35203	-0.18337	-0.35134
	0.0805	0.1035	0.0302	0.2705	0.0305
	38	38	38	38	38
Hardness	-0.40655	0.21213	-0.43678	-0.20310	-0.43622
	0.0102	0.1948	0.0054	0.1588	0.0055
	39	39	39	39	39
Lithium	-0.12713	0.26282	-0.10658	-0.16192	-0.00785
	0.1836	0.0053	0.2655	0.0895	0.9349
	111	111	111	111	111
Magnesium	-0.44400	0.13490	-0.39838	-0.15735	-0.37449
	0.0001	0.1659	0.0001	0.1055	0.0001
	107	107	107	107	107
ONTARIO					
Calicum	-0.02576	-0.17393	-0.14904	0.10542	-0.07783
	0.7085	0.0110	0.0297	0.1251	0.2581
	213	213	213	213	213
Hardness	-0.09566	-0.19565	-0.10737	0.09407	-0.04335
	0.1555	0.0034	0.1106	0.1625	0.5205
	222	222	222	222	222
Lithium	0.08438	-0.08928	-0.23525	0.14197	-0.13637
	0.0259	0.0184	0.0001	0.0002	0.0003
	697	697	697	697	697
Magnesium	-0.22669	-0.19436	-0.04508	0.04485	-0.00586
	0.0001	0.0001	0.2628	0.2652	0.8843
	619	619	619	619	619

TABLE 3,5 MALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
QUEBEC					
Calcium	-0.16983	-0.03697	-0.10437	-0.11197	-0.13352
	0.0215	0.6193	0.1597	0.1313	0.0716
	183	183	183	183	183
Hardness	-0.20380	-0.07950	-0.10465	-0.17176	-0.16015
	0.0047	0.2743	0.1497	0.0175	0.0269
	191	191	191	191	191
Lithium	-0.09081	-0.01059	-0.16200	-0.14853	-1.19540
	0.0324	0.8033	0.0001	0.0004	0.0001
	555	555	555	555	555
Magnesium	-0.15014	-0.07204	-0.11677	-0.18843	-0.17627
	0.0004	0.0932	0.0064	0.0001	0.0001
	544	544	544	544	544
NEW BRUNSWICK					
Calcium	-0.52356	-0.20409	-0.23563	-0.54950	-0.12771
	0.0018	0.2546	0.1868	0.0009	0.4788
	33	33	33	33	33
Hardness	-0.48303	-0.15414	0.29142	-0.40306	0.01803
	0.0018	0.3488	0.0719	0.0110	0.9133
	39	39	39	39	39
Lithium	-0.31017	-0.06934	0.38677	-0.25835	0.17967
	0.0014	0.4864	0.0001	0.0084	0.0694
	103	103	103	103	103
Magnesium	-0.32619	-0.10198	0.25429	-0.21173	0.09715
	0.0008	0.3053	0.0095	0.0318	0.3289
	103	103	103	103	103
NOVA SCOTIA					
Calcium	0.30217	-0.06313	-0.25750	-0.27318	-0.37514
	0.0223	0.6408	0.0531	0.0398	0.0040
	57	57	57	57	57
Hardness	0.32304	-0.06944	-0.23173	-0.28231	-0.36473
	0.0142	0.6078	0.0828	0.0334	0.0053
	57	57	57	57	57
Lithium	0.31009	0.00776	-0.12659	-0.24243	-0.24152
	0.0001	0.9232	0.1141	0.0022	0.0023
	157	157	157	157	157
Magnesium	0.17906	0.01456	-0.26084	-0.24472	-0.36612
	0.0248	0.8564	0.0010	0.0020	0.0001
	157	157	157	157	157

TABLE 3,5 MALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
NEWFOUNDLAND					
Calcium	-0.01231	-0.23406	-0.46487	-0.40341	-0.57518
	0.9534	0.2601	0.0192	0.0455	0.0026
	25	25	25	25	25
Hardness	0.08186	-0.20009	-0.18726	-0.16278	-0.24269
	0.6786	0.3073	0.3400	0.4079	0.2134
	28	28	28	28	28
Lithium	-0.20490	-0.14630	-0.51130	-0.19115	-0.53424
	0.0683	0.1953	0.0001	0.0894	0.0001
	80	80	80	80	80
Magnesium	-0.14339	-0.39386	-0.68162	-0.21958	-0.69628
	0.2045	0.0003	0.0001	0.0503	0.0001
	80	80	80	80	80

water magnesium levels and cancer of the tongue, mouth and pharynx. This can be seen for Canada as a whole (r = -0.30440, p = 0.0001), and also in British Columbia (r = -0.52745, p = 0.0001); Alberta (r = -0.25901, p = 0.0001); Manitoba (r = -0.44400, p = 0.0001); Ontario (r = -0.22669, p = 0.0001); Quebec (r = -0.15014, p = 0004) and New Brunswick (r = -0.32619, p = 0.0008). No analysis could be undertaken for Prince Edward Island because of the very limited water quality data available from that province.

As can be seen in Tables 3,5 and 4,5, the strongest negative correlations, at the national level, were between colo-rectal cancer and magnesium in both males and females. In addition, with one exception, all correlations between digestive cancer mortality and water hardness, lithium, calcium and magnesium content were negative, for both males and females, at the national scale. However, it should be noted that the strength of the correlations appear generally higher for males than for females. Similarly, the strongest negative correlations tend to be with magnesium, followed in declining order by those with hardness, calcium and lithium. To illustrate, in cancer of the large intestine in Canadian males, the correlations, all significant at the 0.0001 level, were as follows: magnesium (r = -0.34180), hardness (r = -0.29368), calcium (r = -0.26297) and lithium (r = -0.21742).

While such statistical correlations, in and by themselves, can never prove causal relationships, these results are suggestive. For example, interpretation, is complicated by the fact that hardness, calcium, magnesium and lithium in drinking water are themselves strongly positively correlated. In Canadian water supplies, for example, lithium content correlated at the 0.0001 level with magnesium (r = 0.58691), calcium (r = 0.74801), and hardness (r = 0.70111). Similarly there are marked positive correlations, at the same level of significance, between magnesium and both calcium (r = 0.68231) and water hardness (r = 0.83200).

TABLE 4,5

Pearson's correlation coefficients between cancers of digestive trace and Canadian FEMALES and the hardness and calcium magnesium and lithium content of drinking water.

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
CANADA					
Calcium	-0.00360	-0.22765	-0.15345	-0.07567	-0.15712
	0.9227	0.0001	0.0001	0.0410	0.0001
	730	730	730	730	730
Hardness	-0.03413	-0.23991	-0.19684	-0.12956	-0.21354
	0.3412	0.0001	0.0001	0.0003	0.0001
	780	780	780	780	780
Lithium	0.03759	-0.17607	-0.13830	-0.04802	-0.13507
	0.0733	0.0001	0.0001	0.0221	0.0001
	2272	2272	2272	2272	2272
Magnesium	-0.02377	-0.23586	-0.27701	-0.15216	-0.29142
	0.2728	0.0001	0.0001	0.0001	0.0001
	2130	2130	2130	2130	2130
BRITISH COLUMBIA					
Calcium	0.04824	0.17296	-0.43184	-0.05503	-0.47890
	0.7675	0.2858	0.0054	0.7359	0.0018
	40	40	40	40	40
Hardness	0.12566	0.10759	-0.30242	-0.06026	-0.35493
	0.3846	0.4571	0.0328	0.6776	0.0114
	50	50	50	50	50
Lithium	0.14917	0.22140	-0.31866	0.07718	-0.30397
	0.0916	0.0117	0.0002	0.3846	0.0005
	129	129	129	129	129
Magnesium	0.21316	-0.05047	-0.30807	-0.03822	-0.35792
	0.0153	0.5700	0.0004	0.6672	0.0001
	129	129	129	129	129
ALBERTA					
Calcium	-0.06713	-0.15195	-0.26480	-0.26243	-0.30269
	0.5515	0.1757	0.0169	0.0179	0.0060
	81	81	81	81	81
Hardness	0.15266	-0.15830	-0.34067	-0.22986	-0.34733
	0.1556	0.1407	0.0012	0.0312	0.0009
	88	88	88	88	88
Lithium	-0.00220	-0.25726	-0.31387	-0.32882	-0.36461
	0.9723	0.0001	0.0001	0.0001	0.0001
	252	252	252	252	252
Magnesium	0.40291	-0.14978	-0.29262	-0.08340	-0.25381
	0.0001	0.0263	0.0001	0.2179	0.0001
	220	220	220	220	220

TABLE 4,5 FEMALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
SASKATCHEWAN					
Calcium	-0.14466	0.20425	0.03306	0.18945	0.12012
	0.2786	0.1241	0.8054	0.1544	0.3691
	58	58	58	58	58
Hardness	-0.23538	0.11483	0.10143	0.10057	0.14080
	0.6212	0.3662	0.4252	0.4291	0.2671
	64	64	64	64	64
Lithium	0.01124	0.31111	-0.11744	0.26416	0.01822
	0.8820	0.0001	0.1195	0.0004	0.8098
	177	177	177	177	177
Magnesium	-0.14866	0.17072	0.03116	0.23832	0.13908
	0.0606	0.0309	0.6957	0.0024	0.0794
	160	160	160	160	160
MANITOBA					
Calcium	-0.32616	0.04131	-0.01249	0.12169	0.04066
	0.0457	0.8055	0.9406	0.4667	0.8085
	38	38	38	38	38
Hardness	-0.31593	0.05116	-0.01778	0.18116	0.06062
	0.0501	0.7571	0.9145	0.2697	0.7139
	39	39	39	39	39
Lithium	-0.22714	0.06426	0.06802	0.18766	0.13214
	0.0165	0.5028	0.4781	0.0486	0.1668
	111	111	111	111	111
Magnesium	-0.22907	0.06066	0.01087	0.28803	0.13199
	0.0176	0.5348	0.9115	0.0026	0.1754
	107	107	107	107	107
ONTARIO					
Calcium	-0.10649	0.01143	0.13664	0.12092	0.16271
	0.1213	0.8683	0.0464	0.0783	0.0175
	213	213	213	213	213
Hardness	-0.17003	0.04983	0.15915	0.08034	0.16951
	0.0112	0.4601	0.0176	0.2332	0.0114
	222	222	222	222	222
Lithium	-0.00392	0.11982	0.06209	0.01585	0.06225
	0.9177	0.0015	0.1015	0.6762	0.1006
	697	697	697	697	697
Magnesium	-0.29224	0.08164	0.13432	0.02706	0.13037
	0.0001	0.0423	0.0008	0.5016	0.0012
	619	619	619	619	619

TABLE 4,5 FEMALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
QUEBEC					
Calcium	0.00583	-0.12114	-0.00206	-0.23729	-0.09027
	0.9376	0.1023	0.9779	0.0012	0.2243
	183	183	183	183	183
Hardness	0.05073	-0.13790	-0.02059	-0.19949	-0.09324
	0.4859	0.0571	0.7774	0.0057	0.1995
	191	191	191	191	191
Lithium	-0.09627	-0.07431	-0.06679	-0.11602	-0.10408
	0.0233	0.0803	0.1160	0.0062	0.0142
	555	555	555	555	555
Magnesium	0.00825	-0.12785	-0.02952	-0.03696	-0.03979
	0.8478	0.0028	0.4920	0.3896	0.3543
	544	544	544	544	544
NEW BRUNSWICK					
Calcium	-0.39099	-0.19074	-0.42815	-0.30409	-0.54703
	0.0245	0.2877	0.0129	0.0853	0.0010
	33	33	33	33	33
Hardness	-0.18746	0.07361	-0.19191	-0.30375	-0.30986
	0.2531	0.6561	0.2419	0.0601	0.0549
	39	39	39	39	39
Lithium	0.02071	0.07135	-0.16723	-0.19503	-0.23374
	0.8355	0.4739	0.0913	0.0484	0.0175
	103	103	103	103	103
Magnesium	0.00266	0.10202	-0.04576	-0.30713	-0.15942
	0.9787	0.3051	0.6463	0.0016	0.1077
	103	103	103	103	103
NOVA SCOTIA					
Calcium	0.30232	-0.19439	0.17965	-0.35181	0.05478
	0.0223	0.1474	0.1811	0.0073	0.6857
	57	57	57	57	57
Hardness	0.30877	-0.19561	0.22075	-0.34829	0.09539
	0.0194	0.1448	0.0989	0.0079	0.4803
	57	57	57	57	57
Lithium	0.34173	-0.09476	0.17885	-0.30555	0.07300
	0.0001	0.2378	0.0250	0.0001	0.3636
	157	157	157	157	157
Magnesium	0.21967	-0.09081	0.04122	-0.15294	-0.01042
	0.0057	0.2580	0.6083	0.0558	0.8970
	157	157	157	157	157

TABLE 4,5 FEMALES, continued

	Tongue Mouth Pharnyx	Stomach	Large Intestine excluding Rectum	Rectum	Large Intestine and Rectum
NEWFOUNDLAND					
Calcium	0.03011	-0.14980	0.04122	0.16500	0.06980
	0.8864	0.4748	0.8449	0.4306	0.7402
	25	25	25	25	25
Hardness	-0.02984	-0.15137	0.12553	0.22561	0.15848
	0.8802	0.4420	0.5245	0.2484	0.4205
	28	28	28	28	28
Lithium	-0.08854	-0.08787	-0.05104	0.18659	-0.00629
	0.4348	0.4383	0.6530	0.0975	0.9559
	80	80	80	80	80
Magnesium	-0.07176	-0.35279	-0.26634	0.05761	-0.22571
	0.5270	0.0013	0.0169	0.6117	0.0441
	80	80	80	80	80

There is also a very strong positive link between calcium and water hardness (r = 0.93448). These correlations reflect geological realities. Water flowing over, or through, sedimentary rocks, as in the Canadian Rockies, tends to be hard and relatively enriched in these three elements. In contrast, soft water, from igneous or metamorphic aquifers or drainage basins, for example from the Canadian Shield, is relatively deficient in these three substances.

BRITISH COLUMBIA

As the preceding national study has shown (Tables, 1,5 through 4,5) there was little evidence in British Columbia, of statistically significant (r = 0.0001) correlations between mortality from male and female digestive cancers and the levels of cadmium, chromium, copper and zinc in drinking water. In contrast, however, there were several significant (r = 0.0001) negative correlations for British Columbia males, between levels of hardness, magnesium and lithium and cancers of the tongue, mouth and pharynx (r = -0.58692, r = -0.52745 and r = -0.44270 respectively) suggesting that these elements may provide a protective effect against cancer. This was also evident for British Columbia females where a significant correlation was found between magnesium and colo-rectal cancer (r =-0.35792, p = 0.0001) and at a less significant level (r = < 0.0005) between female colonic cancer and lithium (r = -0.31866, p = 0.0002); and magnesium (r = -0.30807, p = 0.0004) and female colo-rectal cancer and lithium (r = -0.30397, p = 0.0005). Again the negative correlations suggest the protective effect of these elements.

In contrast, as can be seen from Tables 5,5 and 6,5, analysis at the provincial school district level, produced far fewer significant correlations (p = > 0.01) than the national study. These weak associations did, however, indicate similar relationships to those found in the Canadian study, and cited elsewhere in the literature. For example, in males, positive associations were found between male esophageal cancer

TABLE 5,5

Pearson's correlation coefficients between cancer of the digestive tract in British Columbia MALES and nine water quality conditions.

	Esophagus Cancer	Stomach Cancer	Small Intestinal Cancer	Colon Cancer	Rectal Cancer
pH	0.03182 0.7907 72	-0.00582 0.9613 72	0.03863 0.7473 72	-0.21201 0.0738 72	-0.31828 0.0064 72
Calcium	-0.04618 0.7001 72	-0.04404 0.7133 72	-0.01831 0.8787 72	-0.14690 0.2182 72	-0.31251 0.0075 72
Copper	-0.04170 0.7280 72	0.29371 0.0123 72	-0.06499 0.5876 72	0.14030 0.2398 72	0.05952 0.6195 72
Fluoride	0.04534 0.7053 72	0.00947 0.9371 72	0.28515 0.0152 72	-0.23000 0.0519 72	-0.11781 0.3243 72
Iron	0.22156 0.0614 72	-0.03406 0.7764 72	0.33585 0.0039 72	0.15091 0.2057 72	-0.07313 0.5416 72
Hardness	-0.07747 0.5178 72	-0.07138 0.5513 72	-0.00708 0.9529 72	-0.14097 0.2376 72	-0.29605 0.0116 72
Magnesium	-0.13284 0.2660 72	-0.11872 0.3206 72	-0.02009 0.8670 72	-0.11409 0.3399 72	-0.31554 0.0069 72
Nitrates	-0.08785 0.4631 72	0.01353 0.9102 72	0.00003 0.9998 72	-0.33873 0.0036 72	-0.06959 0.5614 72
Sodium	0.36508 0.0016 72	0.01610 0.8932 72	0.00870 0.9422 72	-0.09657 0.4197 72	-0.18340 0.1231 72
Zinc	-0.03534 0.7682 72	0.02860 0.8115 72	-0.06331 0.5973 72	-0.05887 0.6233 72	0.22829 0.0538 72

TABLE 6,5

Pearson's correlation coefficients between cancers of the digestive tract in British Columbia FEMALES and nine water quality conditions.

	Esophagus Cancer	Stomach Cancer	Small Intestinal Cancer	Colon Cancer	Rectal Cancer
pH	0.20685	0.15854	0.16072	-0.02336	-0.02505
	0.0813	0.1835	0.1774	0.8456	0.8345
	72	72	72	72	72
Calcium	0.09317	-0.06063	0.05594	-0.06718	-0.09508
	0.4363	0.6129	0.6407	0.5750	0.4269
	72	72	72	72	72
Copper	-0.10883	0.25539	0.01029	0.27902	0.07810
	0.3628	0.0304	0.9316	0.0176	0.5144
	72	72	72	72	72
Fluoride	0.04049	-0.13663	0.03327	-0.21335	-0.12439
	0.7359	0.2525	0.7815	0.0720	0.2979
	72	72	72	72	72
Iron	0.14364	0.05215	-0.06524	0.07239	-0.16027
	0.2287	0.6635	0.5861	0.5456	0.1787
	72	72	72	72	72
Hardness	0.09036	-0.07375	0.02522	-0.05475	-0.09526
	0.4503	0.5381	0.8335	0.6478	0.4261
	72	72	72	72	72
Magnesium	0.13875	-0.13220	-0.06717	-0.06165	-0.16019
	0.2451	0.2683	0.5751	0.6069	0.1789
	72	72	72	72	72
Nitrates	-0.03433	0.27614	0.42513	-0.03892	0.04051
	0.7746	0.0189	0.0002	0.7455	0.7354
	72	72	72	72	72
Sodium	0.11625	0.02185	0.14221	0.14300	-0.15910
	0.3308	0.8554	0.2334	0.2308	0.1819
	72	72	72	72	72
Zinc	0.11472	0.12019	-0.07853	0.03695	0.12374
	0.3373	0.3146	0.5120	0.7579	0.2663
	72	72	72	72	72

and sodium (r = 0.36508, p = 0.0016), and between small intestinal cancer and iron (r = 0.33585, p = 0.0039) suggesting an antagonistic association. In contrast, a negative association was found between male colonic cancer and nitrates (r = -0.33873, p = 0.0036). The strongest and most significant protective associations in males, were the negative correlations between cancer of the rectum and pH (r = -0.31828, p = 0.0064); calcium (r = -0.31251, p = 0.0075) and magnesium (r = -0.31554, p = 0.0069).

As can be seen from Table 6,5, the analysis indicated that, for British Columbia females, meaningful associations between site-specific digestive cancers and water quality were much less frequent. The only significant correlations, in females, was the positive association between nitrates and small intestinal cancer (r = 0.42513, p = 0.0002).

As can be seen from Tables 1,5 through 6,5, the strengths of association between drinking water parameters and site-specific digestive cancers in British Columbia were, for the most part, not strongly significant. The repeated negative associations between calcium and magnesium and site-specific digestive cancers, in males, was however notable. So too were the positive correlations between sodium and esophageal cancer in males.

TABLE 7,5

Summary of Significant Correlations between
site-specific digestive cancers, water hardness
and associated water quality parameters in Canada
and British Columbia

	Calcium	Hardness	Lithium	Magnesium
Tongue Mouth Pharynx	Can/M -0.16*	Can/M -0.25*	Can/M -0.09*	Can/M -0.30*
				Can/F/AB -0.40*
				Can/F/ON -0.29*
Stomach	Can/M -0.26*	Can/M -0.31*	Can/M -0.21*	Can/M -0.29*
	Can/F -0.23*	Can/F -0.23*	Can/F -0.17*	Can/F -0.23*
			Can/F/AB -0.25*	
			Can/F/SK +0.31*	
Colon	Can/M -0.26*	Can/M -0.29*	Can/M -0.22*	Can/M -0.34*
	Can/F -0.15*		Can/F -0.14*	Can/F -0.28*
	Can/F/BC -0.43#		Can/F/BC -0.31+	Can/F/BC -0.30+
			Can/F/AB -0.31*	Can/F/AB -0.29*
Rectum	BC/M -0.31*	Can/M -0.11*	Can/F/AB -0.32*	Can/M -0.16*
		Can/F -0.13+	Can/F/NS -0.33*	Can/F -0.15*
				BC/M -0.31*

Legend: Can - Canadian Study/Province
BC - British Columbia Study
M = Male
F = Female

Significance Levels * = 0.0001
\+ = 0.001
\# = 0.01

CONCLUSIONS

In review of the results of the two analyses, there is sufficient evidence to suggest that the null hypothesis can now be rejected, thereby accepting and giving support to the research hypothesis. While the results of these two analyses, at the national and provincial levels, do not prove causal links between specific digestive cancers and water quality, they are suggestive. The evidence presented in summary Table 7,5 tends to imply that water hardness and its major constituents, calcium and magnesium, along with lithium play a role in reducing mortality from cancers of the tongue, mouth, stomach, colon and rectum. This association has been found elsewhere, in literature reviewed earlier in this thesis (Reicher, 1977, Armstrong, 1980, Thouez, 1981 and Foster, 1986). However, it has been suggested that other soil and water parameters, such as the concentrations of barium, mercury, phosphorus and selenium, may also play causal roles (Foster, 1986). If this is true, then this may help to explain why some of the correlations produced by the current study are not stronger since data was unavailable for these elements.

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CHAPTER SIX

DISCUSSION AND CONCLUSIONS

INTRODUCTION

The proceeding analyses appear to identify two areas that warrant further discussion. Firstly, why were the Pearson's correlations generated at the census division level more statistically significant than those produced by analysis at the school district scale? Secondly, what medical evidence is there that hardwater can reduce digestive cancer mortality? Both of these issues will now be discussed in more detail.

VARIATIONS WITH SCALE

As has been described, statistical correlations between water quality and digestive cancer mortality in British Columbia at the school district scale, were weaker than those produced nationally, at the census division level.

One probable reason for this is that the water quality data used at the national scale, indicated the mineral content of potable water at the tap. That is it reflected what was being drunk. In contrast, data used at the school district level was obtained by the analysis of raw, untreated water, usually sampled at major wells or reservoirs. This data may not have been a good indication of final water quality, since treatment and reaction with pipes can greatly change water before it reaches the consumer.

In British Columbia, for example, water treatment processes may include filtration to remove suspended solids, chemical treatment such as chlorination and fluoridation to kill bacteria, and domestic water softening to reduce hardness.

Recently it was been found that chlorination of water encourages the development of trihalomethanes, which are halogen by-products of naturally occurring organic substances, such as the algae found in reservoirs and plumbing systems. The trihalomethanes produced as a consequence of the chlorination process are thought to be carcinogenic and harmful to human health (Cornaby, 1981).

The condition of raw or treated water can also be further altered by water softening, a process which is commonly used in central and northern British Columbia. In this process, raw, chlorinated or fluoridated water is run through a system of resin beds which trap calcium, iron, magnesium and related salts, thereby reducing the effective level of hardness. The resin beds eventually become clogged and are cleaned and regenerated by flushing with sodium chloride. Although water can be effectively softened by this method, it substantially increases the levels of sodium chloride, which can be harmful to health.

A third major alteration to the quality and chemical composition of drinking water takes place in the pumping and distribution systems, where the levels of copper, iron, lead and zinc tend to increase through chemical interactions with pipes and soldered joints.

The degree to which the concentration of metals, such as copper and zinc, differs between primary and tap water is, clearly greatly influenced by water hardness. For example, in very soft water regions, the amount of copper can double by the time it reaches the tap. In contrast, in hard water areas, copper at the tap may actually be reduced, perhaps as a result of coating of the pipes by calcium or magnesium (Neri, 1977). As an example, in coastal British Columbia, levels of metals in drinking water can increase dramatically, as the characteristically soft, acidic water interacts with plumbing systems, releasing higher than acceptable levels of copper, iron and zinc. It has been observed that the rates of such releases tend to be much higher in recently built homes, containing newly manufactured copper pipes with lead joints.

Increases in the metal content of drinking water is most noticeable after water stands in pipes overnight. Neri (1977), in his study of Canadian drinking water supplies, provided evidence to show the effect of this process on the water content of copper, lithium, manganese and zinc. Results of his investigation are shown in Table 1,6.

TABLE 1,6

Effect of distribution system in soft and hard water areas overnight average gains (+) and losses (-) mg/l.

Area	Copper	Lithium	Magnesium	Zinc
Soft Water City				
# of paired values	84	84	46	46
Mean difference	+24.4	+ 3.5	+16,600	+21.7
Hard Water City				
# of paired values	15	15	15	15
Mean difference	-85.1	-98.3	-6,600	-63.3

Source: After Neri (1977)

In soft water regions, the levels of copper and zinc in drinking water can increase dramatically overnight. In hard water areas, however, standing water experiences the opposite effect with levels of calcium and zinc gradually decreasing. It is thought that as calcium and/or magnesium adhere to the inside of the pipes, the coating reduces interactions between the water and the materials of the pipe.

It should also be noted that there may be various chemical reactions between naturally occurring elements in the drinking water and those added during treatment and by the delivery systems. There is often a mistaken assumption that because certain elements occur below "safe" threshold levels, they do not pose a threat to health. This basic assumption of independent action may not hold true, because of the possibility of multiple interactions with other environmental contaminants. Metal mixtures in drinking water, especially those containing cadmium, copper, mercury and zinc are of great concern because of the creation of other toxic compounds. Although the pH of drinking water can modify the rate in which these interactions take place, it has been found that hard water is a significant modifier of metal toxicity and that soft water seems to accelerate this process (Neri, 1977).

For all these reasons, it is clear that it is far better to use data derived from the analysis of tap water, rather than from reservoirs or wells. This may explain why correlations, at the census division scale using tap water, were more significant than those at the school district level, where raw water data was used. However, this may also have been due, at least in part, to seasonality problems. As shown in Table 2,6 water quality, even from the same source, varies with the time of year. Attempts were made to accommodate this problem in the national water quality data bank by repeated testing in different seasons. Such repetition was not undertaken at the school district scale.

TABLE 2,6

Examples of average concentration values for high and low water table time periods

	Soft Water Localities <60 mg/l.			Hard Water Localities >60 mg/l.		
	High	Low	Diff	High	Low	Diff
Cadmium	.001	.001	0	.000	.000	0
Copper	.280	.119	58	.089	.043	52
Lithium	.052	.035	33	.319	.369	-16
Zinc	.141	.067	52	.246	.062	75
Magnesium	3.241	1.439	56	18.482	17.016	8
pH (units)	6.92	7.01	-01	7.75	7.96	-03
Calcium	4.68	3.22	31	46.08	54.90	-19

Source: After Neri, 1977.

CARCINOGENESIS

The hypothesis of this thesis was that digestive cancer mortality may be linked to elevated or depressed levels of bulk or trace elements in drinking water. This was suggested by the literature which also indicated that water hardness and its major constituents, calcium and magnesium appeared to provide a protective effect from digestive cancers. Some of these relationships with water hardness have also been confirmed, in part, by the results of this thesis, especially with regard to cancers of the lower digestive tract, such as that of the colon and rectum.

Given the apparent negative correlations between cancers of the digestive tract and water hardness, how likely is it that calcium and/or magnesium in drinking water, can influence carcinogenesis? Calcium is the medium for all cell communication, carrying vital messages between cells. It is also known that in low serum calcium environments, cell division is stimulated. This leads to hyperplasia, which appears to be an initial pre-cancerous stage. An individual living in a high calcium environment, such as the typical hardwater areas of British Columbia, is less likely to be calcium deficient. They are, therefore, probably less prone to develop hyperplasia (Garland and Garland, 1989). Under these circumstances it seems logical that many cancers, especially those of the digestive tract, will be less common in hard water areas.

There is also growing evidence to suggest a link between high fat diets and the incidence of colo-rectal cancer. It is thought that an elevated fat intake may increase the secretation of bile acids, which are needed to digest fat, altering bacterial populations in the large bowel, and thereby increasing the levels of secondary acids. These secondary acids, in turn, are thought to promote lesions in the bowel, so encouraging carcinogeneses. Medical research has suggested that the level of calcium in the lower digestive tract may be a key factor in the aetiology of this disease. It is

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thought that calcium may convert fatty acids and free bile, in the colon, to insoluble soaps, so reducing this postulated carcinogenic process. Such negative links between calcium and colo-rectal cancer have been noted by Garland, et al (1985) and Lipkin and Newmark (1985).

These theories have recently been re-confirmed by Stanfield (1986), an Australian medical researcher, who found that all excitable membranes have voltage-dependant calcium channels which provide a link between membrane changes and cellular responses, being controlled by cytosolic Ca^{2+}. The channel openings are activated by modulated changes in Ca^{2+}, signalled by hormones and neutral transmitters. Calcium channels appear to select Ca^{2+} over monovalent cations such as sodium and potassium by momentarily binding Ca^{2+} as it permeates. It was also found that divalent cations like Cd^{2+}, block channels as to other organic calcium antagonists.

While the potential role of calcium in reducing carcinogenesis appears relatively easy to justify from the medical literature, it is more difficult to account for the relatively strong negative correlations between digestive cancer mortality and the magnesium content of drinking water. However, such protective relationships seem apparent from the proceeding analyses.

There is also considerable epidemiological evidence to suggest that cancer mortality appears to be depressed, in regions where levels of environmental selenium are high. This apparently protective effect of selenium has been well documented by animal experiments. Carcinogenesis is most likely to occur in animals that are selenium deficient. Protection against tumorigeneses appears to increase with selenium dose until toxic levels are reached (Shamberger, 1970; Shamberger, et al. (1973). In the Peoples Republic of China, researchers found that the mean selenium content of the hair of control patients was far higher than that of fifty-four patients suffering from cancer of the digestive tract (Foster, 1989). It is also thought that elevated levels of serum selenium discourage the accumulation, in the body, of harmful elements such as arsenic and mercury.

It is possible, therefore, that the negative correlations between hard water and digestive cancer mortality, described in this thesis, occur simply because high calcium and magnesium environments elevate selenium absorption by crops and increase its presence in local food and water supplies.

POLICY IMPLICATIONS

It is evident, from both the literature review and the results of this study, that there are highly suggestive inverse correlations between the spatial distributions of variations in the calcium and magnesium content of drinking water and digestive tract cancer incidence and mortality. These links have been demonstrated in both the Developed and Developing Worlds. Such findings, however, cannot be considered in isolation from other medical research related to water hardness and disease. There is considerable evidence in the literature, for example, to indicate that there is also a significant negative correlation between the incidence of heart disease, hypertension and stroke and water hardness. (Anderson et al., 1969; Clayton and Crawford, 1973; Stocks, 1973; Allwright, 1974; Crawford et al., 1977; Neri et al., 1977; Zielhaus et al., 1981, Marier and Neri, 1985; and Foster, 1986).

These degenerative diseases are the major causes of death in the Developed World. Annually, in the United States alone, heart disease accounts for more than one million deaths (U. S. National Committee for Geochemistry of Water in Relation to Cardiovascular Disease, 1979), while digestive cancer is responsible for at least another 100,000 mortalities (Howe, 1986).

Death rates in Canada are proportional, with 9,540 mortalities from digestive cancers being estimated for 1985 (Canadian Cancer Society, 1985). Obviously, if this toll could be reduced by hardening drinking water, then the policy implications of such possible environment-health relationships are enormous.

Given the enormous available literature, suggesting the apparent beneficial effects that water hardness provides in reducing mortality from heart disease, hypertension, stroke and digestive cancers, it would seem logical to at least test this hypothesis, in the field, by adding suitable amounts of bulk and trace elements during water treatment, in selected soft water regions.

Several examples of the health implications of such water hardness modification exist. In Britain, the drinking water of Scunthorpe, which is derived from wells situated in chalk, was considered too hard for domestic consumption. To rectify this situation, in 1958, the regional water authority installed two water softening treatment systems to reduce its calcium content and hence its hardness. It was later found, that over the twenty year period that these systems were in operation, there was a significant increase in sudden infancy deaths (SIDS). This rise did not occur in adjacent counties which were still using untreated hard water from the same hardwater aquifers. The dramatic increase in SIDS was attributed to a substantial increase in levels of sodium in the local water supply, a by-product of the water softening process (Robertson and Parker, 1978). However, there is a considerable literature to suggest infant mortality falls as the hardness levels of water rise (Caddell, 1972; Marier, et al., 1979).

In the People's Republic of China, however, it has been demonstrated that the incidence of digestive cancer can be reduced by the addition of certain minerals to natural drinking water. For example high incidence rates of esophageal cancer in Xingtai, Hebei Province, were dramatically reduced by the addition of "Jiang-Shi" to the well water of several villages. "Jiang-Shi" are natural loess concretions, which contains high levels of calcium, selenium and a variety of other trace elements and have been used as a preventative and treatment for esophageal cancer since the 16th century. During 1974, new wells were constructed in the five villages of Baian. "Jiang-Shi" were either incorporated into their structures, or added to the ground water. Since that date, no new cases of esophageal cancer have been reported in an area that had formerly experienced one the world's highest incidence rates. This Chinese evidence obviously strongly supports the hypothesis that water hardness, and perhaps selenium, have a protective effect against certain digestive cancers (Zhu and An, 1988). This field test adds further support to the growing evidence in the medical literature that there is a need to clearly assess the metabolic role of dietary selenium and its apparently protective effects in digestive cancers (Shamberger, et al., 1973; Hansford, et al., 1975; Jansson, et al., 1975; Schrauzer, et al., 1977; Peng and Langqui, 1987 and Foster, 1989).

The addition of bulk or trace elements to drinking water, is not an innovation. Fluoride has been added to the drinking water of many North American cities for decades, in the attempt to reduce tooth decay. However, perhaps initially field trials should be undertaken to determine whether heart disease, hypertension, stoke and digestive cancer mortality can be reduced by treating soft drinking water by adding calcium, magnesium and perhaps selenium. Evident suggests this is most likely to be productive in very soft water areas, such as the Victoria and Vancouver metropolitan areas.

It should be recognized, however, that the intake of minerals from drinking water can have subtle, unpredictable results. For this reason, alteration or enrichment of raw water with calcium, magnesium or selenium, should be carried out over a lengthy period of time, and with great caution, so as to be able to clearly identify any unanticipated negative effects.

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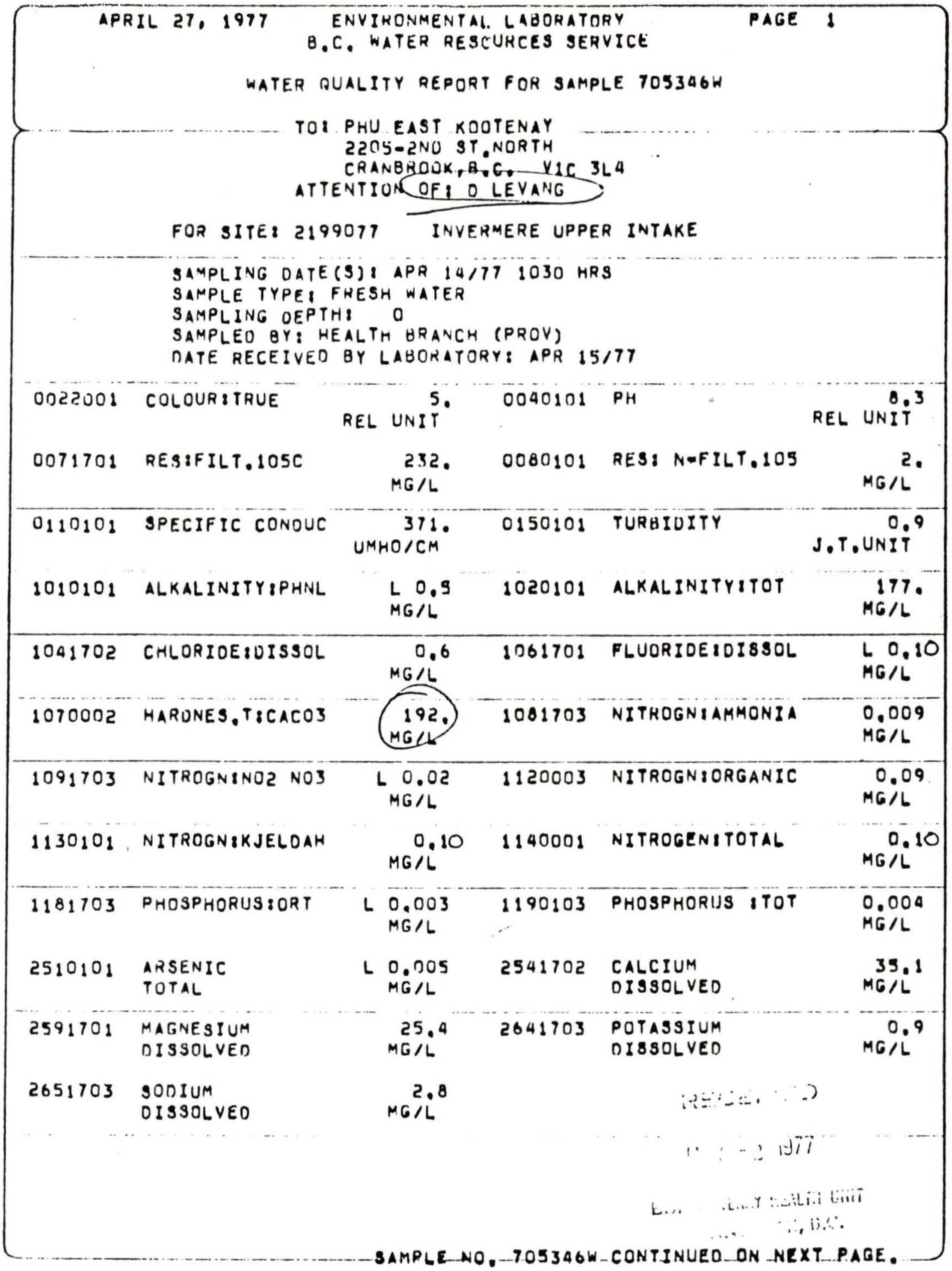
APPENDIX 1,2

Examples of water quality analyses report



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APRIL 27, 1977        ENVIRONMENTAL LABORATORY              PAGE  1
                   B.C. WATER RESOURCES SERVICE

              WATER QUALITY REPORT FOR SAMPLE 705346W

                   TO: PHU EAST KOOTENAY
                       2205-2ND ST.NORTH
                       CRANBROOK,B.C.   V1C 3L4
                   ATTENTION OF: D LEVANG

          FOR SITE: 2199077     INVERMERE UPPER INTAKE

          SAMPLING DATE(S): APR 14/77 1030 HRS
          SAMPLE TYPE: FRESH WATER
          SAMPLING DEPTH:    0
          SAMPLED BY: HEALTH BRANCH (PROV)
          DATE RECEIVED BY LABORATORY: APR 15/77

0022001  COLOUR:TRUE             5.    0040101  PH                        8.3
                           REL UNIT                                  REL UNIT

0071701  RES:FILT.105C         232.    0080101  RES: N-FILT.105            2.
                               MG/L                                      MG/L

0110101  SPECIFIC CONDUC       371.    0150101  TURBIDITY                 0.9
                            UMHO/CM                                  J.T.UNIT

1010101  ALKALINITY:PHNL      L 0.5    1020101  ALKALINITY:TOT           177.
                               MG/L                                      MG/L

1041702  CHLORIDE:DISSOL        0.6    1061701  FLUORIDE:DISSOL        L 0.10
                               MG/L                                      MG/L

1070002  HARDNES.T:CACO3       192.    1081703  NITROGN:AMMONIA         0.009
                               MG/L                                      MG/L

1091703  NITROGN:NO2 NO3     L 0.02    1120003  NITROGN:ORGANIC          0.09
                               MG/L                                      MG/L

1130101  NITROGN:KJELDAH       0.10    1140001  NITROGEN:TOTAL           0.10
                               MG/L                                      MG/L

1181703  PHOSPHORUS:ORT     L 0.003    1190103  PHOSPHORUS :TOT         0.004
                               MG/L                                      MG/L

2510101  ARSENIC            L 0.005    2541702  CALCIUM                  35.1
         TOTAL                 MG/L             DISSOLVED                MG/L

2591701  MAGNESIUM             25.4    2641703  POTASSIUM                 0.9
         DISSOLVED             MG/L             DISSOLVED                MG/L

2651703  SODIUM                 2.8
         DISSOLVED             MG/L
                                                    RECEIVED

                                                    [illegible] 1977

                                                    [illegible] HEALTH UNIT
                                                    [illegible], B.C.

                    SAMPLE NO. 705346W CONTINUED ON NEXT PAGE.
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APPENDIX 2,2

Listing of primary sources of drinking water for major population centres in British Columbia

Place	SD	Sfc Source	GW Source
Alert Bay (Village)	85		Airport Well
Armstrong	21	Fortune Creek	
Blue River	26	White Creek	
Burns Lake (Village)	55	Burns Lake	
Burns Lake (Village)	55	Burns Lake	
Cache Creek	30	Cache Creek	
Capital Regional District		(see Victoria for details)	
Campbell River	71	Puntlege River Campbell Lake Oyster River	
Castlegar	9	Arrow Lake	
Chilliwack	33	Elk Creek Dunville Crk	Watson Rd Wells CFB Wells Treatment Plant Well
Clinton	30	Clinton Res.	
Comox	71	Comox Lake	
Colwood	62	G. Vic. W.B.	
Courtenay	71	Oyster River	
Cowichan Valley	65	Ladysmith River Cowichan River	Mill Bay
Cowichan Lake	66	Cowichan Lake	
Coquitlam	43	G. Van. W.D.	

APPENDIX 2,2 continued

Place	SD	Sfc Source	GW Source
Cranbrook	2	Joseph Creek Gold Creek Reservoir	
Dawson Creek	59	Kiskatinaw River	
Delta	37	G. Van. W.D.	
Esquimalt	61	G. Vic. W.B.	
Elkford	1	Boivin Creek	
Fernie	1	Fairey Creek	
Fort Fraser	56		
Fort Nelson	81		
Fort St. John	60	Charlie Lake	
Fort St. James	56		Bedrock Well
Ganges	64	St. Mary Lake Lake Maxwell	
Gibsons	46		Well No. 3
Gold River	84	McKelvie Crk.	New Well No. 2
Golden	18		Well No. 4 Well No. 5
Grand Forks	12		Well No. 1 Well No. 2 Well No. 3
Greenwood	13		Well No. 1 Well No. 2 Well No. 4
Hope	32		Wells 1 & 2
Harrison Hot Springs	76		Aug. Test from 3 wells comb. for 300 homes

APPENDIX 2,2 continued

Place	SD	Sfc Source	GW Source
Invermere	4	Goldie Creek Upper Intake Lower Intake	
Kamloops	24	South Thompson	
Kaslo	86	Kemp Creek	
Kelowna	23	Okanagan Lake Mission Creek Hydraulic Crk.	Well No. 5 Well No. 7A
Keremous	16		
Kimberley	3	Mathew Creek Mark Creek St. Mary Creek	
Kitimat	80	Kitimat River	Thornhill Well Cablecar Subwell
Langley City	35	G. Van. W.D.	
Langley Township (10 sources)	35	Fraser River No. 2 Fort Langley (2)	Salmon River Wells (2) Forest Knoll Truscan Tall Timber No. 2 (2) Kumbrook Stawberry Hill
Lillooet	29	Town Creek Cayoosh Creek	
Mackenzie	57	Morfee Lake	Well No. 1 Well No. 2 Well No. 3 Well No. 4
Maple Ridge	42	G. Van. W.D. (Coquitlam Lake)	
Massett	50		Well
Matsqui	34	Norrish Creek	

APPENDIX 2,2 continued

Place	SD	Sfc Source	GW Source
Merritt	31		Vouche Park Well Quilchena Well May Street Well
Metchosin	62	G. Vic. W.B.	
Mission (Matsqui)	75	Norrish Creek	
Nakusp	10	Kuskanan Creek Browse-Halfway Creek	
Nanaimo	68	Nanaimo River	
Nelson	7	Anderson Creek 5 Mile Creek Selous Creek	
New Westminister	40	G. Van. W.D.	
North Cowichan	65	Holyoak Lake (Chemanius) Crofton Lake	Southend No. 1 Southend No. 2 Southend No. 3 (Cowichan River)
North Saanich	63	G. Vic. W.B.	
North Vancouver		G. Van. W.B.	
Osoyoos	14		Well No. 3 Well No. 5
Parksville	69	Englishman River	City Well Ind. Well
Pemberton (also Whistler)	48	Pemberton Creek	
Penticton	15	Penticton Creek Okanagan Lake	Warren Well
Pitt Meadows		G. Van. W.D.	
Port Alberni	70	Somass Creek China Creek Bainbridge Lake	

APPENDIX 2,2 continued

Place	SD	Sfc Source	GW Source
Port Moody	43	G. Van. W.D.	
Powell River	47	Hammill Lake Haslam Lake Powell Lake	
Prince George	57		Well 602 Well 605 Well 607 Well 624 Well 626 Well 627
Princeton	17		New Well No.2
Prince Rupert	52	Shawatland Woodworth Lake	
Queen Charlotte City	50		City Well No. 1
Quesnel	28		Rolf St. Well Well No. 3 Well No. 4 Well No. 5 Well No. 6
Revelstoke	19		
Richmond	38	G. Van. W.D.	
Saanich	61/63	G. Vic. W.B.	
Central Saanich	63	G. Vic. W.B.	
Salmon Arm	89	Shuswap Lake (1) Gordon Creek Canoe Creek Shuswap Lake (2) White Cliff Gordon Creek	
Sechelt	46	Champman Crk	Well Wescan Road

APPENDIX 2,2 continued

Place	SD	Sfc Source	GW Source
Smithers	54		Well No. 2 Well No. 3 Well No. 4 Riverside
Sparwood	1		West Well East Well
Squamish	48	Town Supply Chekeye Creek Stawamus River Mashiter River	
Summerland	77	Trout Creek	
Surrey		G. Van. W.D.	
Terrace	88	(Glacier Feed)	Well
Tofino	70	Ginnard Creek Close Creek	
Trail	11	Violin Lake Cambridge Creek	Sunningdale No. 1 Bear Creek McLean Stream
West Vancouver		Eagle Lake Seymour Capilano Coquitlam Sunset Creek	
Vanderhoof	56		
Vaverby			Well
Vernon	22	Kalamalka Lake BX Creek McMechan Reservoir	
Victoria	61	G. Vic. W.B. Humpback Res. Japan Gulch Charters Creek	

APPENDIX 2,2 continued

Place	SD	Sfc Source	GW Source
White Rock	37	G. Van. W.D. (Coquitlam)	White Rock Utilities Well 1 and 2
Williams Lake	27		Well No. 1 Well No. 2 Well No. 3 Well No. 4 (All on Scout Island)
Windermere	4	Windermere Lake Site A Site B Site C	
Whistler	48		Well No. 1 Well No. 2 Well No. 3

APPENDIX 3,2

The pH of drinking water in British Columbia by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029

APPENDIX 3,2

pH continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060

APPENDIX 4,2

Hardness in British Columbia drinking water by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019

APPENDIX 4,2
Hardness continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010

APPENDIX 5,2

Calcium in British Columbia drinking water by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019

APPENDIX 5,2

Hardness continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000

APPENDIX 6,2

Copper in British Columbia drinking water by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023

APPENDIX 6,2

Copper continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010

APPENDIX 7,2

Fluoride in British Columbia drinking water by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010

APPENDIX 7,2
Fluoride continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004

APPENDIX 8,2

Iron in British Columbia drinking water by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020

APPENDIX 8,2

Iron continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000

APPENDIX 9,2

Magnesium in British Columbia drinking water by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000

APPENDIX 9,2

Magnesium continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010

APPENDIX 11,2

Nitrates and Nitrites in British Columbia drinking water by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035

APPENDIX 11,2

Nitrates and Nitrites continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005

APPENDIX 10,2

Sodium in British Columbia drinking water by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010

APPENDIX 10,2

Sodium continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021

APPENDIX 12,2

Zinc in British Columbia drinking water by School District

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
TRAIL	11	8.05	91.00	0.006	0.100	290.00	0.200	14.85	0.160	3.10	0.000
CRES.KAS	86	8.10	37.70	0.001	0.100	110.00	0.010	3.87	0.080	0.90	0.000
ARROWLK	10	7.20	15.00	0.001	0.120	28.10	0.100	1.05	0.150	2.10	0.000
WINDERMR	4	8.30	36.60	0.002	0.100	170.00	0.030	19.10	0.190	2.80	0.000
CASTLGAR	9	7.73	19.80	0.020	0.100	64.20	0.050	4.05	0.170	0.90	0.000
PRINCTON	17	7.20	26.40	0.002	0.100	83.20	3.500	4.20	0.170	4.40	0.000
COWICHL.	66	7.10	10.00	0.001	0.100	27.00	0.030	1.93	0.100	1.20	0.000
PEACE.N	60	8.40	19.10	0.001	0.110	69.10	0.160	5.20	0.020	4.70	0.000
RICHMND	38	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
MAPLRDG	42	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.000
VANCOVR	39	6.00	1.40	0.001	0.050	4.20	0.150	0.26	0.090	0.85	0.000
BURNSLK	55	7.40	20.00	0.040	1.320	73.00	1.000	5.10	0.650	16.40	0.004
QUEENCHA	50	8.35	22.64	0.004	0.150	62.29	2.510	0.39	0.078	34.01	0.004
SCARIBOU	30	7.92	58.00	0.840	0.110	288.20	0.160	41.25	0.178	14.40	0.004
KETTLE.V	13	7.45	37.20	0.002	0.180	114.00	0.050	5.36	8.120	7.10	0.005
BURNBY	41	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
LANGLEY	35	6.54	6.05	0.003	0.037	28.15	0.110	0.25	0.080	0.85	0.005
FERNIE	1	8.38	45.90	0.004	0.260	158.90	0.060	10.70	0.120	0.30	0.005
DELTA	37	6.00	1.10	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
SURREY	36	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
LILLOET	29	8.30	49.30	0.001	0.170	213.00	0.100	21.70	0.010	6.10	0.005
ABBTSFOR	34	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.005
HOPE	32	6.80	20.10	0.001	0.010	70.00	0.010	4.70	0.010	10.80	0.008
PRGEORG	57	7.69	46.22	0.009	0.070	201.64	0.196	18.72	0.158	6.24	0.009
QUESNEL	28	8.00	41.30	0.010	0.001	147.00	0.010	10.63	0.090	4.10	0.010
REVLSTOK	19	6.70	13.70	0.020	0.100	39.30	0.160	1.23	0.020	1.10	0.010
CARIBOU	27	8.00	85.00	0.010	0.300	452.00	1.100	54.25	0.017	30.00	0.010
C.COAST	49	7.50	3.80	0.001	0.100	10.70	0.110	0.32	0.020	1.20	0.010
KIMBERLY	3	7.10	35.00	0.002	0.150	16.50	0.030	1.30	0.020	0.92	0.010
PR.RUPRT	52	7.40	3.55	3.550	0.100	9.84	0.090	0.32	0.020	1.26	0.010
VICTORIA	61	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
SAANICH	63	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
ARMSTRNG	21	7.70	19.40	0.040	0.100	43.76	0.200	1.10	0.020	1.20	0.010
GULF.IS	64	7.60	5.40	0.015	0.100	18.20	1.800	1.30	0.195	19.00	0.010
VAN.IS.N	85	8.30	10.00	0.015	0.100	72.50	0.050	5.00	0.860	10.30	0.010
CRANBROO	2	8.12	39.20	0.010	0.100	131.00	0.010	7.95	0.021	0.80	0.010
SOOKE	62	6.80	4.49	0.010	0.100	15.50	0.030	1.04	0.060	2.30	0.010
N.VANC	44	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	1.20	0.010
VAN.IS.W	84	6.60	8.00	0.020	0.100	15.20	0.100	0.85	0.030	1.20	0.012
N.THOMP	26	7.55	24.00	0.010	0.050	80.00	0.060	4.76	0.520	5.60	0.015
SUMMERLD	77	7.20	21.80	0.010	0.130	70.10	0.200	3.90	0.070	5.20	0.019
PENTCTON	15	8.21	32.00	0.010	0.180	117.00	0.060	8.72	0.010	9.40	0.019
COQUITLM	43	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.020
CENT.OK	23	8.11	54.20	0.010	0.350	243.00	0.250	12.13	0.810	36.20	0.020

APPENDIX 12,2

Zinc continued

School District	District Number	pH	Calcium	Copper	Fluoride	Hardness	Iron	Magnes.	Nitrates/ Nitrites	Sodium	Zinc
GOLDEN	18	7.20	80.20	0.010	0.100	334.00	0.030	32.50	0.021	2.10	0.020
VERNON	22	8.27	42.00	0.060	0.220	156.00	0.030	9.10	0.023	11.00	0.020
NELSON	7	7.90	10.60	0.090	0.100	29.10	0.020	0.68	0.050	0.90	0.020
S.OKAN	14	7.71	85.30	0.002	0.120	351.00	0.170	34.20	4.440	29.00	0.021
SMITHERS	54	7.89	15.90	0.010	0.143	62.00	0.030	5.65	0.088	47.46	0.021
SHUSWAP	89	7.98	40.30	0.010	0.108	156.00	0.180	2.60	0.036	2.36	0.022
TERRACE	88	7.85	2.25	0.010	0.135	12.00	0.050	0.46	0.091	0.99	0.023
NECHAKO	56	7.56	78.11	0.008	0.200	265.07	0.658	53.00	0.134	13.71	0.029
KEREMEOS	16	7.97	37.10	0.010	0.220	172.00	0.080	19.00	1.380	4.50	0.030
W.VANC	45	6.70	3.28	0.021	0.050	9.26	0.032	0.25	0.060	1.16	0.030
HOWESD	48	6.52	8.72	0.032	0.230	15.10	0.080	0.40	0.061	1.68	0.032
AGAS.HAR	76	7.10	24.00	0.010	0.100	83.00	0.025	5.10	0.090	2.60	0.035
ALBERNI	70	7.76	26.50	0.030	0.034	72.00	0.030	1.29	0.062	2.67	0.040
COWICHAN	65	7.05	16.00	0.001	0.145	48.00	1.280	3.65	0.320	6.30	0.050
NANAIMO	68	7.02	4.62	0.050	0.100	10.00	0.180	0.44	0.052	1.35	0.050
COURTENA	71	6.50	4.19	0.010	0.100	15.00	0.190	1.08	0.390	1.90	0.050
CAMPBRIV	72	7.20	5.00	0.010	0.960	19.90	0.030	1.03	0.390	4.00	0.050
MISSION	75	6.28	1.40	0.010	0.031	8.60	0.030	0.15	0.100	3.40	0.050
KAMLOOPS	24	7.49	12.40	0.009	0.080	40.00	0.100	1.88	0.020	5.92	0.060
SUNCOAST	46	7.50	3.65	0.001	0.020	42.80	0.040	0.48	0.090	8.40	0.060
POWELLR	47	6.50	3.88	0.010	0.100	12.00	0.180	0.59	0.130	1.50	0.060
PEACE.S	59	8.40	50.20	0.020	0.100	168.00	0.290	10.30	0.030	5.70	0.060
N.W.M.	40	6.00	1.40	0.001	0.050	4.20	0.150	0.15	0.090	0.85	0.080
CHILLWAK	33	6.56	8.20	0.001	0.040	24.10	0.100	0.35	0.093	1.16	0.090
QUALICUM	69	7.15	19.00	0.015	0.100	16.00	0.150	7.40	0.602	5.85	0.100
MERRITT	31	7.20	41.50	1.002	0.100	142.00	0.100	10.30	0.990	6.20	0.130
GRANDFOR	12	8.20	78.00	0.020	0.410	293.00	0.130	23.90	5.040	9.90	0.240
KITIMAT	80	6.40	3.00	0.010	0.100	9.59	0.100	0.47	0.040	3.60	0.900

APPENDIX 1,3

Mean age-standardized mortality rates per 100,000, for male esophageal cancer in British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
SUMMERLD	77	26.4	97.1	100.0	80.5	79.8
POWELLR	47	32.0	97.0	100.0	127.7	89.6
VAN.IS.N	85	38.1	65.2	100.0	68.8	32.4
NECHAKO	56	38.4	82.8	100.0	78.7	49.5
SCARIBOU	30	41.0	61.7	100.0	52.4	70.3
CRANBROO	2	44.3	100.2	100.0	118.6	114.5
GULF.IS	64	45.7	78.9	191.6	98.0	49.0
MERRITT	31	49.3	85.4	100.0	64.0	171.4
ARROWLK	10	50.6	98.1	100.0	102.3	43.2
MAPLRDG	42	51.6	96.6	206.3	67.5	103.5
CHILLWAK	33	51.6	110.0	51.1	86.8	99.8
COQUITLM	43	52.5	80.7	76.7	92.3	92.8
KEREMEOS	16	53.5	104.7	435.5	123.4	46.6
SHUSWAP	89	54.0	98.4	86.0	69.4	93.7
FERNIE	1	56.2	133.1	100.0	50.6	133.7
VERNON	22	56.4	107.5	192.2	95.6	58.5
AGAS.HAR	76	57.4	37.0	449.1	43.4	24.2
MISSION	75	60.8	99.2	243.3	74.4	93.0
PEACE.S	59	72.4	132.9	264.6	84.3	54.8
S.OKAN	14	73.9	104.0	149.1	80.1	47.9
COURTENA	71	75.8	70.0	100.0	71.4	111.2
KAMLOOPS	24	76.7	94.4	51.7	88.8	124.9
KETTLE.V	13	76.9	67.3	100.0	20.2	100.0
SURREY	36	80.0	95.2	70.9	93.8	96.9
CAMPBRIV	72	81.0	91.8	100.0	89.2	139.7
BURNBY	41	81.7	104.7	123.2	89.6	104.6
ARMSTRNG	21	81.9	80.1	100.0	41.6	35.5
CARIBOU	27	83.3	89.7	100.0	70.2	89.5
NANAIMO	68	84.4	114.8	165.6	92.5	108.4
NELSON	7	87.5	87.1	87.3	71.6	88.2
ABBTSFOR	34	89.1	112.1	118.8	82.7	86.1
CENT.OK	23	91.0	94.6	99.5	87.1	81.8
DELTA	37	91.1	104.6	81.1	92.2	96.7
PENTCTON	15	94.6	85.5	100.0	100.2	100.2
SUNCOAST	46	95.4	130.6	127.2	105.5	130.6
VICTORIA	61	96.0	85.0	201.0	111.2	93.5
SOOKE	62	96.7	74.4	100.0	102.2	101.1
CRES.KAS	86	97.0	68.9	100.0	80.8	65.7
QUESNEL	28	97.2	94.9	175.1	89.2	95.9
KIMBRLY	3	98.0	113.3	100.0	110.9	70.8
QUALICUM	69	98.6	92.8	100.0	88.4	57.0
ALBERNI	70	98.9	101.6	90.4	80.2	85.5
C.COAST	49	100.0	51.6	100.0	20.9	100.0
GRANDFOR	12	100.0	141.2	100.0	53.0	89.7

APPENDIX 1,3

Male esophageal cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
PEACE.N	60	100.0	57.4	207.9	53.3	88.7
CASTLGAR	9	100.0	148.3	100.0	70.5	58.9
WINDERMR	4	100.0	85.9	100.0	73.6	98.8
KITIMAT	80	100.0	83.5	100.0	84.6	138.8
N.THOMP	26	100.0	47.3	100.0	86.0	48.2
VAN.IS.W	84	100.0	100.0	100.0	100.0	156.4
LILLOET	29	100.0	53.0	100.0	125.1	52.8
PRINCTON	17	100.0	101.4	461.9	163.2	100.4
N.W.M.	40	104.1	120.2	167.6	117.2	102.5
PR.RUPRT	52	104.4	170.2	100.0	138.3	89.0
COWICHL.	66	106.1	80.0	100.0	122.7	45.3
W.VANC	45	108.7	75.1	281.1	119.1	108.8
SAANICH	63	110.1	58.4	344.7	89.7	86.8
PRGEORGE	57	110.7	120.6	100.0	106.5	63.1
COWICHAN	65	111.2	88.4	100.0	86.5	87.5
RICHMND	38	120.8	109.5	100.0	118.8	109.0
BURNSLK	55	121.3	92.2	456.9	47.2	26.4
N.VANC	44	123.8	86.0	31.4	111.7	114.1
LANGLEY	35	124.9	89.7	130.9	97.1	114.4
HOPE	32	131.2	141.5	100.0	90.8	113.6
VANCOUVR	39	132.1	112.7	83.7	113.9	116.3
TERRACE	88	144.8	135.2	100.0	108.2	129.7
GOLDEN	18	151.6	32.6	100.0	116.9	32.3
REVLSTOK	19	161.4	60.8	100.0	114.5	121.9
TRAIL	11	190.2	103.3	100.0	99.6	103.3
SMITHERS	54	326.3	117.1	100.0	112.1	93.3
HOWESD	48	340.1	83.9	100.0	37.8	145.7
QUEENCHA	50	379.0	80.5	100.0	71.8	100.0

APPENDIX 2,3

Mean age-standardized mortality rates per 100,000, for female esophageal cancer in British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
COQUITLM	43	19.7	58.8	100.0	71.8	52.8
NELSON	7	24.2	79.1	100.0	92.0	148.2
POWELLR	47	41.0	155.6	270.3	83.7	90.3
DELTA	37	47.9	77.8	82.5	72.0	134.9
VERNON	22	52.0	78.8	255.1	102.2	50.3
PEACE.S	59	52.5	69.8	100.0	68.6	97.6
SHUSWAP	89	54.7	114.9	286.7	103.1	78.8
PENTCTON	15	56.4	78.2	270.9	87.8	128.7
MAPLERDG	42	58.3	109.6	141.5	104.9	125.7
COWICHAN	65	60.2	70.7	140.4	107.2	76.7
PR.RUPRT	52	60.8	231.2	195.2	137.5	132.0
SUMMERLD	77	62.0	82.0	225.1	144.5	100.3
CHILLWAK	33	68.8	108.3	49.4	92.7	120.3
N.VANC	44	73.2	84.0	180.9	117.2	111.2
GRANDFOR	12	76.0	199.9	100.0	55.8	147.5
MISSION	75	76.5	210.1	134.8	102.5	98.4
CRES.KAS	86	77.8	112.2	100.0	57.1	63.0
W.VANC	45	88.2	66.9	81.1	135.5	106.6
ALBERNI	70	89.2	99.1	97.2	71.1	111.1
BURNBY	41	89.8	98.7	104.4	84.9	91.4
CENT.OK	23	91.2	94.0	163.9	90.4	67.9
SAANICH	63	93.7	114.6	100.0	98.8	72.7
GOLDEN	18	100.0	43.2	100.0	94.3	100.0
BURNSLK	55	100.0	46.7	100.0	49.8	64.1
LILLOET	29	100.0	50.5	100.0	53.3	100.0
GULF.IS	64	100.0	53.4	218.7	89.2	99.0
CARIBOU	27	100.0	53.6	100.0	113.0	36.3
ARROWLK	10	100.0	54.7	100.0	100.0	40.3
SMITHERS	54	100.0	58.4	440.4	127.3	82.9
C.COAST	49	100.0	58.8	812.2	31.0	80.2
PEACE.N	60	100.0	69.2	100.0	119.7	122.9
COURTENA	71	100.0	77.3	100.0	107.5	88.7
KANLOOPS	24	100.0	81.3	114.8	87.3	110.9
VAN.IS.W	84	100.0	100.0	100.0	0.0	180.1
AGAS.HAR	76	100.0	100.0	100.0	77.9	154.0
ARMSTRNG	21	100.0	100.0	100.0	132.5	63.3
COWICHL.	66	100.0	152.2	100.0	58.6	100.9
MERRITT	31	100.0	111.8	100.0	182.5	78.5
S.OKAN	14	100.0	160.8	163.5	110.5	123.0
SOOKE	62	100.0	123.2	106.3	75.6	84.1
KIMBRLY	3	100.0	169.7	100.0	118.9	25.9
QUESNEL	28	100.0	127.9	100.0	50.9	65.7
KETTLE.V	13	100.0	171.2	813.7	90.0	79.5
QUALICUM	69	100.0	143.4	100.0	133.8	105.0

APPENDIX 2,3

Female esophageal cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
HOPE	32	100.0	115.1	100.0	106.9	39.9
SCARIBOU	30	100.0	125.5	100.0	114.8	85.5
RELSTOK	19	100.0	135.5	100.0	122.7	191.6
PRINCTON	17	100.0	144.4	100.0	99.4	51.8
CASTLGAR	9	100.0	179.0	220.8	88.6	63.2
TERRACE	88	100.0	205.7	100.0	117.9	46.6
SURREY	36	101.6	89.0	53.1	97.9	114.3
TRAIL	11	108.2	109.3	354.6	84.3	93.2
VICTORIA	61	115.7	94.8	92.8	106.5	94.7
SUNCOAST	46	127.4	207.1	149.5	77.6	150.8
VANCOVR	39	127.6	106.8	89.1	104.9	109.5
ABBTSFOR	34	130.0	92.0	117.4	85.7	73.6
RICHMND	38	133.0	104.6	100.0	108.3	87.1
NANAIMO	68	139.9	125.7	81.9	118.0	89.8
PRGEORGE	57	142.0	75.0	100.0	85.7	59.1
HOWESD	48	148.9	33.2	100.0	17.5	135.6
N.W.M.	40	149.2	83.8	196.4	108.6	143.5
KEREMEOS	16	163.0	145.6	100.0	59.3	105.0
CAMPBRIV	72	167.8	75.0	179.5	79.5	51.6
VAN.IS.N	85	175.7	320.1	100.0	100.4	102.8
KITIMAT	80	223.9	146.6	100.0	99.4	124.5
CRANBROO	2	225.3	73.9	100.0	88.3	177.4
LANGLEY	35	232.8	84.5	139.3	87.7	43.5
NECHAKO	56	246.8	54.4	100.0	43.7	37.7
FERNIE	1	292.2	177.1	250.7	88.6	255.6
WINDERMR	4	364.7	82.0	100.0	129.9	56.4
QUEENCHA	50	368.4	250.2	100.0	130.1	112.5
N.THOMP	26	397.3	100.0	100.0	93.1	100.0

APPENDIX 3,3

Mean age-standardized mortality rates per
100,000, for male stomach cancer in
British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
GOLDEN	18	151.6	32.6	100.0	116.9	32.3
AGAS.HAR	76	57.4	37.0	449.1	43.4	24.2
N.THOMP	26	100.0	47.3	100.0	86.0	48.2
C.COAST	49	100.0	51.6	100.0	20.9	100.0
LILLOET	29	100.0	53.0	100.0	125.1	52.8
PEACE.N	60	100.0	57.4	207.9	53.3	88.7
SAANICH	63	110.1	58.4	344.7	89.7	86.8
REVLSTOK	19	161.4	60.8	100.0	114.5	121.9
SCARIBOU	30	41.0	61.7	100.0	52.4	70.3
VAN.IS.N	85	38.1	65.2	100.0	68.8	32.4
KETTLE.V	13	76.9	67.3	100.0	20.2	100.0
CRES.KAS	86	97.0	68.9	100.0	80.8	65.7
COURTENA	71	75.8	70.0	100.0	71.4	111.2
SOOKE	62	96.7	74.4	100.0	102.2	101.1
W.VANC	45	108.7	75.1	281.1	119.1	108.8
GULF.IS	64	45.7	78.9	191.6	98.0	49.0
COWICHL.	66	106.1	80.0	100.0	122.7	45.3
ARMSTRNG	21	81.9	80.1	100.0	41.6	35.5
QUEENCHA	50	379.0	80.5	100.0	71.8	100.0
COQUITLM	43	52.5	80.7	76.7	92.3	92.8
NECHAKO	56	38.4	82.8	100.0	78.7	49.5
KITIMAT	80	100.0	83.5	100.0	84.6	138.8
HOWESD	48	340.1	83.9	100.0	37.8	145.7
VICTORIA	61	96.0	85.0	201.0	111.2	93.5
MERRITT	31	49.3	85.4	100.0	64.0	171.4
PENTCTON	15	94.6	85.5	100.0	100.2	100.2
WINDERMR	4	100.0	85.9	100.0	73.6	98.8
N.VANC	44	123.8	86.0	31.4	111.7	114.1
NELSON	7	87.5	87.1	87.3	71.6	88.2
COWICHAN	65	111.2	88.4	100.0	86.5	87.5
LANGLEY	35	124.9	89.7	130.9	97.1	114.4
CARIBOU	27	83.3	89.7	100.0	70.2	89.5
CAMPBRIV	72	81.0	91.8	100.0	89.2	139.7
BURNSLK	55	121.3	92.2	456.9	47.2	26.4
QUALICUM	69	98.6	92.8	100.0	88.4	57.0
KAMLOOPS	24	76.7	94.4	51.7	88.8	124.9
CENT.OK	23	91.0	94.6	99.5	87.1	81.8
QUESNEL	28	97.2	94.9	175.1	89.2	95.9
SURREY	36	80.0	95.2	70.9	93.8	96.9
MAPLRDG	42	51.6	96.6	206.3	67.5	103.5
POWELLR	47	32.0	97.0	100.0	127.7	89.6
SUMMERLD	77	26.4	97.1	100.0	80.5	79.8
ARROWLK	10	50.6	98.1	100.0	102.3	43.2
SHUSWAP	89	54.0	98.4	86.0	69.4	93.7

APPENDIX 3,3

Male stomach cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
MISSION	75	60.8	99.2	243.3	74.4	93.0
VAN.IS.W	84	100.0	100.0	100.0	100.0	156.4
CRANBROO	2	44.3	100.2	100.0	118.6	114.5
PRINCTON	17	100.0	101.4	461.9	163.2	100.4
ALBERNI	70	98.9	101.6	90.4	80.2	85.5
TRAIL	11	190.2	103.3	100.0	99.6	103.3
S.OKAN	14	73.9	104.0	149.1	80.1	47.9
DELTA	37	91.1	104.6	81.1	92.2	96.7
BURNBY	41	81.7	104.7	123.2	89.6	104.6
KEREMEOS	16	53.5	104.7	435.5	123.4	46.6
VERNON	22	56.4	107.5	192.2	95.6	58.5
RICHMND	38	120.8	109.5	100.0	118.8	109.0
CHILLWAK	33	51.6	110.0	51.1	86.8	99.8
ABBTSFOR	34	89.1	112.1	118.8	82.7	86.1
VANCOUVR	39	132.1	112.7	83.7	113.9	116.3
KIMBRLY	3	98.0	113.3	100.0	110.9	70.8
NANAIMO	68	84.4	114.8	165.6	92.5	108.4
SMITHERS	54	326.3	117.1	100.0	112.1	93.3
N.W.M.	40	104.1	120.2	167.6	117.2	102.5
PRGEORGE	57	110.7	120.6	100.0	106.5	63.1
SUNCOAST	46	95.4	130.6	127.2	105.5	130.6
PEACE.S	59	72.4	132.9	264.6	84.3	54.8
FERNIE	1	56.2	133.1	100.0	50.6	133.7
TERRACE	88	144.8	135.2	100.0	108.2	129.7
GRANDFOR	12	100.0	141.2	100.0	53.0	89.7
HOPE	32	131.2	141.5	100.0	90.8	113.6
CASTLGAR	9	100.0	148.3	100.0	70.5	58.9
PR.RUPRT	52	104.4	170.2	100.0	138.3	89.0

APPENDIX 4,3

Mean age-standardized mortality rates per 100,000, for female stomach cancer in British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
HOWESD	48	148.9	33.2	100.0	17.5	135.6
GOLDEN	18	100.0	43.2	100.0	94.3	100.0
BURNSLK	55	100.0	46.7	100.0	49.8	64.1
LILLOET	29	100.0	50.5	100.0	53.3	100.0
GULF.IS	64	100.0	53.4	218.7	89.2	99.0
CARIBOU	27	100.0	53.6	100.0	113.0	36.3
NECHAKO	56	246.8	54.4	100.0	43.7	37.7
ARROWLK	10	100.0	54.7	100.0	100.0	40.3
SMITHERS	54	100.0	58.4	440.4	127.3	82.9
COQUITLM	43	19.7	58.8	100.0	71.8	52.8
C.COAST	49	100.0	58.8	812.2	31.0	80.2
W.VANC	45	88.2	66.9	81.1	135.5	106.6
PEACE.N	60	100.0	69.2	100.0	119.7	122.9
PEACE.S	59	52.5	69.8	100.0	68.6	97.6
COWICHAN	65	60.2	70.7	140.4	107.2	76.7
CRANBROO	2	225.3	73.9	100.0	88.3	177.4
CAMPBRIV	72	167.8	75.0	179.5	79.5	51.6
PRGEORGE	57	142.0	75.0	100.0	85.7	59.1
COURTENA	71	100.0	77.3	100.0	107.5	88.7
DELTA	37	47.9	77.8	82.5	72.0	134.9
PENTCTON	15	56.4	78.2	270.9	87.8	128.7
VERNON	22	52.0	78.8	255.1	102.2	50.3
NELSON	7	24.2	79.1	100.0	92.0	148.2
KANLOOPS	24	100.0	81.3	114.8	87.3	110.9
WINDERMR	4	364.7	82.0	100.0	129.9	56.4
SUMMERLD	77	62.0	82.0	225.1	144.5	100.3
N.W.M.	40	149.2	83.8	196.4	108.6	143.5
N.VANC	44	73.2	84.0	180.9	117.2	111.2
LANGLEY	35	232.8	84.5	139.3	87.7	43.5
SURREY	36	101.6	89.0	53.1	97.9	114.3
ABBTSFOR	34	130.0	92.0	117.4	85.7	73.6
CENT.OK	23	91.2	94.0	163.9	90.4	67.9
VICTORIA	61	115.7	94.8	92.8	106.5	94.7
BURNBY	41	89.8	98.7	104.4	84.9	91.4
ALBERNI	70	89.2	99.1	97.2	71.1	111.1
AGAS.HAR	76	100.0	100.0	100.0	77.9	154.0
VAN.IS.W	84	100.0	100.0	100.0	0.0	180.1
ARMSTRNG	21	100.0	100.0	100.0	132.5	63.3
N.THOMP	26	397.3	100.0	100.0	93.1	100.0
RICHMND	38	133.0	104.6	100.0	108.3	87.1
VANCOVR	39	127.6	106.8	89.1	104.9	109.5
CHILLWAK	33	68.8	108.3	49.4	92.7	120.3
TRAIL	11	108.2	109.3	354.6	84.3	93.2
MAPLERDG	42	58.3	109.6	141.5	104.9	125.7

APPENDIX 4,3
Female stomach cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
MERRITT	31	100.0	111.8	100.0	182.5	78.5
CRES.KAS	86	77.8	112.2	100.0	57.1	63.0
SAANICH	63	93.7	114.6	100.0	98.8	72.7
SHUSWAP	89	54.7	114.9	286.7	103.1	78.8
HOPE	32	100.0	115.1	100.0	106.9	39.9
SOOKE	62	100.0	123.2	106.3	75.6	84.1
SCARIBOU	30	100.0	125.5	100.0	114.8	85.5
NANAIMO	68	139.9	125.7	81.9	118.0	89.8
QUESNEL	28	100.0	127.9	100.0	50.9	65.7
RELSTOK	19	100.0	135.5	100.0	122.7	191.6
QUALICUM	69	100.0	143.4	100.0	133.8	105.0
PRINCTON	17	100.0	144.4	100.0	99.4	51.8
KEREMEOS	16	163.0	145.6	100.0	59.3	105.0
KITIMAT	80	223.9	146.6	100.0	99.4	124.5
COWICHL.	66	100.0	152.2	100.0	58.6	100.9
POWELLR	47	41.0	155.6	270.3	83.7	90.3
S.OKAN	14	100.0	160.8	163.5	110.5	123.0
KIMBRLY	3	100.0	169.7	100.0	118.9	25.9
KETTLE.V	13	100.0	171.2	813.7	90.0	79.5
FERNIE	1	292.2	177.1	250.7	88.6	255.6
CASTLGAR	9	100.0	179.0	220.8	88.6	63.2
GRANDFOR	12	76.0	199.9	100.0	55.8	147.5
TERRACE	88	100.0	205.7	100.0	117.9	46.6
SUNCOAST	46	127.4	207.1	149.5	77.6	150.8
MISSION	75	76.5	210.1	134.8	102.5	98.4
PR.RUPRT	52	60.8	231.2	195.2	137.5	132.0
QUEENCHA	50	368.4	250.2	100.0	130.1	112.5
VAN.IS.N	85	175.7	320.1	100.0	100.4	102.8

APPENDIX 5,3

Mean age-standardized mortality rates per 100,000, for male small intestine cancer in British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
N.VANC	44	123.8	86.0	31.4	111.7	114.1
CHILLWAK	33	51.6	110.0	51.1	86.8	99.8
KAMLOOPS	24	76.7	94.4	51.7	88.8	124.9
SURREY	36	80.0	95.2	70.9	93.8	96.9
COQUITLM	43	52.5	80.7	76.7	92.3	92.8
DELTA	37	91.1	104.6	81.1	92.2	96.7
VANCOUVR	39	132.1	112.7	83.7	113.9	116.3
SHUSWAP	89	54.0	98.4	86.0	69.4	93.7
NELSON	7	87.5	87.1	87.3	71.6	88.2
ALBERNI	70	98.9	101.6	90.4	80.2	85.5
CENT.OK	23	91.0	94.6	99.5	87.1	81.8
SCARIBOU	30	41.0	61.7	100.0	52.4	70.3
SMITHERS	54	326.3	117.1	100.0	112.1	93.3
ARROWLK	10	50.6	98.1	100.0	102.3	43.2
CRANBROO	2	44.3	100.2	100.0	118.6	114.5
FERNIE	1	56.2	133.1	100.0	50.6	133.7
TRAIL	11	190.2	103.3	100.0	99.6	103.3
HOWESD	48	340.1	83.9	100.0	37.8	145.7
MERRITT	31	49.3	85.4	100.0	64.0	171.4
PRGEORGE	57	110.7	120.6	100.0	106.5	63.1
REVLSTOK	19	161.4	60.8	100.0	114.5	121.9
NECHAKO	56	38.4	82.8	100.0	78.7	49.5
KETTLE.V	13	76.9	67.3	100.0	20.2	100.0
VAN.IS.N	85	38.1	65.2	100.0	68.8	32.4
CAMPBRIV	72	81.0	91.8	100.0	89.2	139.7
POWELLR	47	32.0	97.0	100.0	127.7	89.6
ARMSTRNG	21	81.9	80.1	100.0	41.6	35.5
CARIBOU	27	83.3	89.7	100.0	70.2	89.5
COWICHL.	66	106.1	80.0	100.0	122.7	45.3
RICHMND	38	120.8	109.5	100.0	118.8	109.0
QUEENCHA	50	379.0	80.5	100.0	71.8	100.0
COWICHAN	65	111.2	88.4	100.0	86.5	87.5
GOLDEN	18	151.6	32.6	100.0	116.9	32.3
PENTCTON	15	94.6	85.5	100.0	100.2	100.2
PR.RUPRT	52	104.4	170.2	100.0	138.3	89.0
SUMMERLD	77	26.4	97.1	100.0	80.5	79.8
SOOKE	62	96.7	74.4	100.0	102.2	101.1
CRES.KAS	86	97.0	68.9	100.0	80.8	65.7
COURTENA	71	75.8	70.0	100.0	71.4	111.2
KIMBRLY	3	98.0	113.3	100.0	110.9	70.8
QUALICUM	69	98.6	92.8	100.0	88.4	57.0
HOPE	32	131.2	141.5	100.0	90.8	113.6
C.COAST	49	100.0	51.6	100.0	20.9	100.0
GRANDFOR	12	100.0	141.2	100.0	53.0	89.7

APPENDIX 5,3
Male small intestine cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
TERRACE	88	144.8	135.2	100.0	108.2	129.7
CASTLGAR	9	100.0	148.3	100.0	70.5	58.9
WINDERMR	4	100.0	85.9	100.0	73.6	98.8
KITIMAT	80	100.0	83.5	100.0	84.6	138.8
N.THOMP	26	100.0	47.3	100.0	86.0	48.2
VAN.IS.W	84	100.0	100.0	100.0	100.0	156.4
LILLOET	29	100.0	53.0	100.0	125.1	52.8
ABBTSFOR	34	89.1	112.1	118.8	82.7	86.1
BURNBY	41	81.7	104.7	123.2	89.6	104.6
SUNCOAST	46	95.4	130.6	127.2	105.5	130.6
LANGLEY	35	124.9	89.7	130.9	97.1	114.4
S.OKAN	14	73.9	104.0	149.1	80.1	47.9
NANAIMO	68	84.4	114.8	165.6	92.5	108.4
N.W.M.	40	104.1	120.2	167.6	117.2	102.5
QUESNEL	28	97.2	94.9	175.1	89.2	95.9
GULF.IS	64	45.7	78.9	191.6	98.0	49.0
VERNON	22	56.4	107.5	192.2	95.6	58.5
VICTORIA	61	96.0	85.0	201.0	111.2	93.5
MAPLRDG	42	51.6	96.6	206.3	67.5	103.5
PEACE.N	60	100.0	57.4	207.9	53.3	88.7
MISSION	75	60.8	99.2	243.3	74.4	93.0
PEACE.S	59	72.4	132.9	264.6	84.3	54.8
W.VANC	45	108.7	75.1	281.1	119.1	108.8
SAANICH	63	110.1	58.4	344.7	89.7	86.8
KEREMEOS	16	53.5	104.7	435.5	123.4	46.6
AGAS.HAR	76	57.4	37.0	449.1	43.4	24.2
BURNSLK	55	121.3	92.2	456.9	47.2	26.4
PRINCTON	17	100.0	101.4	461.9	163.2	100.4

APPENDIX 6,3

Mean age-standardized mortality rates per 100,000, for female small intestine cancer in British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
CHILLWAK	33	68.8	108.3	49.4	92.7	120.3
SURREY	36	101.6	89.0	53.1	97.9	114.3
W.VANC	45	88.2	66.9	81.1	135.5	106.6
NANAIMO	68	139.9	125.7	81.9	118.0	89.8
DELTA	37	47.9	77.8	82.5	72.0	134.9
VANCOVR	39	127.6	106.8	89.1	104.9	109.5
VICTORIA	61	115.7	94.8	92.8	106.5	94.7
ALBERNI	70	89.2	99.1	97.2	71.1	111.1
PEACE.S	59	52.5	69.8	100.0	68.6	97.6
NELSON	7	24.2	79.1	100.0	92.0	148.2
ARMSTRNG	21	100.0	100.0	100.0	132.5	63.3
RELSTOK	19	100.0	135.5	100.0	122.7	191.6
MERRITT	31	100.0	111.8	100.0	182.5	78.5
HOPE	32	100.0	115.1	100.0	106.9	39.9
COQUITLM	43	19.7	58.8	100.0	71.8	52.8
KEREMEOS	16	163.0	145.6	100.0	59.3	105.0
N.THOMP	26	397.3	100.0	100.0	93.1	100.0
CRES.KAS	86	77.8	112.2	100.0	57.1	63.0
GRANDFOR	12	76.0	199.9	100.0	55.8	147.5
VAN.IS.W	84	100.0	100.0	100.0	0.0	180.1
AGAS.HAR	76	100.0	100.0	100.0	77.9	154.0
SAANICH	63	93.7	114.6	100.0	98.8	72.7
KITIMAT	80	223.9	146.6	100.0	99.4	124.5
RICHMND	38	133.0	104.6	100.0	108.3	87.1
BURNSLK	55	100.0	46.7	100.0	49.8	64.1
TERRACE	88	100.0	205.7	100.0	117.9	46.6
HOWESD	48	148.9	33.2	100.0	17.5	135.6
LILLOET	29	100.0	50.5	100.0	53.3	100.0
CARIBOU	27	100.0	53.6	100.0	113.0	36.3
QUEENCHA	50	368.4	250.2	100.0	130.1	112.5
ARROWLK	10	100.0	54.7	100.0	100.0	40.3
PEACE.N	60	100.0	69.2	100.0	119.7	122.9
VAN.IS.N	85	175.7	320.1	100.0	100.4	102.8
KIMBRLY	3	100.0	169.7	100.0	118.9	25.9
SCARIBOU	30	100.0	125.5	100.0	114.8	85.5
GOLDEN	18	100.0	43.2	100.0	94.3	100.0
WINDERMR	4	364.7	82.0	100.0	129.9	56.4
COURTENA	71	100.0	77.3	100.0	107.5	88.7
CRANBROO	2	225.3	73.9	100.0	88.3	177.4
NECHAKO	56	246.8	54.4	100.0	43.7	37.7
QUESNEL	28	100.0	127.9	100.0	50.9	65.7
PRGEORGE	57	142.0	75.0	100.0	85.7	59.1
QUALICUM	69	100.0	143.4	100.0	133.8	105.0
PRINCTON	17	100.0	144.4	100.0	99.4	51.8

APPENDIX 6,3

Female small intestine cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
COWICHL.	66	100.0	152.2	100.0	58.6	100.9
BURNBY	41	89.8	98.7	104.4	84.9	91.4
SOOKE	62	100.0	123.2	106.3	75.6	84.1
KANLOOPS	24	100.0	81.3	114.8	87.3	110.9
ABBTSFOR	34	130.0	92.0	117.4	85.7	73.6
MISSION	75	76.5	210.1	134.8	102.5	98.4
LANGLEY	35	232.8	84.5	139.3	87.7	43.5
COWICHAN	65	60.2	70.7	140.4	107.2	76.7
MAPLERDG	42	58.3	109.6	141.5	104.9	125.7
SUNCOAST	46	127.4	207.1	149.5	77.6	150.8
S.OKAN	14	100.0	160.8	163.5	110.5	123.0
CENT.OK	23	91.2	94.0	163.9	90.4	67.9
CAMPBRIV	72	167.8	75.0	179.5	79.5	51.6
N.VANC	44	73.2	84.0	180.9	117.2	111.2
PR.RUPRT	52	60.8	231.2	195.2	137.5	132.0
N.W.M.	40	149.2	83.8	196.4	108.6	143.5
GULF.IS	64	100.0	53.4	218.7	89.2	99.0
CASTLGAR	9	100.0	179.0	220.8	88.6	63.2
SUMMERLD	77	62.0	82.0	225.1	144.5	100.3
FERNIE	1	292.2	177.1	250.7	88.6	255.6
VERNON	22	52.0	78.8	255.1	102.2	50.3
POWELLR	47	41.0	155.6	270.3	83.7	90.3
PENTCTON	15	56.4	78.2	270.9	87.8	128.7
SHUSWAP	89	54.7	114.9	286.7	103.1	78.8
TRAIL	11	108.2	109.3	354.6	84.3	93.2
SMITHERS	54	100.0	58.4	440.4	127.3	82.9
C.COAST	49	100.0	58.8	812.2	31.0	80.2
KETTLE.V	13	100.0	171.2	813.7	90.0	79.5

APPENDIX 7,3

Mean age-standardized mortality rates per 100,000, for male colon cancer in British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
KETTLE.V	13	76.9	67.3	100.0	20.2	100.0
C.COAST	49	100.0	51.6	100.0	20.9	100.0
HOWESD	48	340.1	83.9	100.0	37.8	145.7
ARMSTRNG	21	81.9	80.1	100.0	41.6	35.5
AGAS.HAR	76	57.4	37.0	449.1	43.4	24.2
BURNSLK	55	121.3	92.2	456.9	47.2	26.4
FERNIE	1	56.2	133.1	100.0	50.6	133.7
SCARIBOU	30	41.0	61.7	100.0	52.4	70.3
GRANDFOR	12	100.0	141.2	100.0	53.0	89.7
PEACE.N	60	100.0	57.4	207.9	53.3	88.7
MERRITT	31	49.3	85.4	100.0	64.0	171.4
MAPLRDG	42	51.6	96.6	206.3	67.5	103.5
VAN.IS.N	85	38.1	65.2	100.0	68.8	32.4
SHUSWAP	89	54.0	98.4	86.0	69.4	93.7
CARIBOU	27	83.3	89.7	100.0	70.2	89.5
CASTLGAR	9	100.0	148.3	100.0	70.5	58.9
COURTENA	71	75.8	70.0	100.0	71.4	111.2
NELSON	7	87.5	87.1	87.3	71.6	88.2
QUEENCHA	50	379.0	80.5	100.0	71.8	100.0
WINDERMR	4	100.0	85.9	100.0	73.6	98.8
MISSION	75	60.8	99.2	243.3	74.4	93.0
NECHAKO	56	38.4	82.8	100.0	78.7	49.5
S.OKAN	14	73.9	104.0	149.1	80.1	47.9
ALBERNI	70	98.9	101.6	90.4	80.2	85.5
SUMMERLD	77	26.4	97.1	100.0	80.5	79.8
CRES.KAS	86	97.0	68.9	100.0	80.8	65.7
ABBTSFOR	34	89.1	112.1	118.8	82.7	86.1
PEACE.S	59	72.4	132.9	264.6	84.3	54.8
KITIMAT	80	100.0	83.5	100.0	84.6	138.8
N.THOMP	26	100.0	47.3	100.0	86.0	48.2
COWICHAN	65	111.2	88.4	100.0	86.5	87.5
CHILLWAK	33	51.6	110.0	51.1	86.8	99.8
CENT.OK	23	91.0	94.6	99.5	87.1	81.8
QUALICUM	69	98.6	92.8	100.0	88.4	57.0
KAMLOOPS	24	76.7	94.4	51.7	88.8	124.9
QUESNEL	28	97.2	94.9	175.1	89.2	95.9
CAMPBRIV	72	81.0	91.8	100.0	89.2	139.7
BURNBY	41	81.7	104.7	123.2	89.6	104.6
SAANICH	63	110.1	58.4	344.7	89.7	86.8
HOPE	32	131.2	141.5	100.0	90.8	113.6
DELTA	37	91.1	104.6	81.1	92.2	96.7
COQUITLM	43	52.5	80.7	76.7	92.3	92.8
NANAIMO	68	84.4	114.8	165.6	92.5	108.4
SURREY	36	80.0	95.2	70.9	93.8	96.9

APPENDIX 7,3

Male colon cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
VERNON	22	56.4	107.5	192.2	95.6	58.5
LANGLEY	35	124.9	89.7	130.9	97.1	114.4
GULF.IS	64	45.7	78.9	191.6	98.0	49.0
TRAIL	11	190.2	103.3	100.0	99.6	103.3
VAN.IS.W	84	100.0	100.0	100.0	100.0	156.4
PENTCTON	15	94.6	85.5	100.0	100.2	100.2
SOOKE	62	96.7	74.4	100.0	102.2	101.1
ARROWLK	10	50.6	98.1	100.0	102.3	43.2
SUNCOAST	46	95.4	130.6	127.2	105.5	130.6
PRGEORGE	57	110.7	120.6	100.0	106.5	63.1
TERRACE	88	144.8	135.2	100.0	108.2	129.7
KIMBRLY	3	98.0	113.3	100.0	110.9	70.8
VICTORIA	61	96.0	85.0	201.0	111.2	93.5
N.VANC	44	123.8	86.0	31.4	111.7	114.1
SMITHERS	54	326.3	117.1	100.0	112.1	93.3
VANCOUVR	39	132.1	112.7	83.7	113.9	116.3
REVLSTOK	19	161.4	60.8	100.0	114.5	121.9
GOLDEN	18	151.6	32.6	100.0	116.9	32.3
N.W.M.	40	104.1	120.2	167.6	117.2	102.5
CRANBROO	2	44.3	100.2	100.0	118.6	114.5
RICHMND	38	120.8	109.5	100.0	118.8	109.0
W.VANC	45	108.7	75.1	281.1	119.1	108.8
COWICHL.	66	106.1	80.0	100.0	122.7	45.3
KEREMEOS	16	53.5	104.7	435.5	123.4	46.6
LILLOET	29	100.0	53.0	100.0	125.1	52.8
POWELLR	47	32.0	97.0	100.0	127.7	89.6
PR.RUPRT	52	104.4	170.2	100.0	138.3	89.0
PRINCTON	17	100.0	101.4	461.9	163.2	100.4

APPENDIX 8,3

Mean age-standardized mortality rater per 100,000, for female colon cancer in British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
VAN.IS.W	84	100.0	100.0	100.0	0.0	180.1
HOWESD	48	148.9	33.2	100.0	17.5	135.6
C.COAST	49	100.0	58.8	812.2	31.0	80.2
NECHAKO	56	246.8	54.4	100.0	43.7	37.7
BURNSLK	55	100.0	46.7	100.0	49.8	64.1
QUESNEL	28	100.0	127.9	100.0	50.9	65.7
LILLOET	29	100.0	50.5	100.0	53.3	100.0
GRANDFOR	12	76.0	199.9	100.0	55.8	147.5
CRES.KAS	86	77.8	112.2	100.0	57.1	63.0
COWICHL.	66	100.0	152.2	100.0	58.6	100.9
KEREMEOS	16	163.0	145.6	100.0	59.3	105.0
PEACE.S	59	52.5	69.8	100.0	68.6	97.6
ALBERNI	70	89.2	99.1	97.2	71.1	111.1
COQUITLM	43	19.7	58.8	100.0	71.8	52.8
DELTA	37	47.9	77.8	82.5	72.0	134.9
SOOKE	62	100.0	123.2	106.3	75.6	84.1
SUNCOAST	46	127.4	207.1	149.5	77.6	150.8
AGAS.HAR	76	100.0	100.0	100.0	77.9	154.0
CAMPBRIV	72	167.8	75.0	179.5	79.5	51.6
POWELLR	47	41.0	155.6	270.3	83.7	90.3
TRAIL	11	108.2	109.3	354.6	84.3	93.2
BURNBY	41	89.8	98.7	104.4	84.9	91.4
PRGEORGE	57	142.0	75.0	100.0	85.7	59.1
ABBTSFOR	34	130.0	92.0	117.4	85.7	73.6
KANLOOPS	24	100.0	81.3	114.8	87.3	110.9
LANGLEY	35	232.8	84.5	139.3	87.7	43.5
PENTCTON	15	56.4	78.2	270.9	87.8	128.7
CRANBROO	2	225.3	73.9	100.0	88.3	177.4
CASTLGAR	9	100.0	179.0	220.8	88.6	63.2
FERNIE	1	292.2	177.1	250.7	88.6	255.6
GULF.IS	64	100.0	53.4	218.7	89.2	99.0
KETTLE.V	13	100.0	171.2	813.7	90.0	79.5
CENT.OK	23	91.2	94.0	163.9	90.4	67.9
NELSON	7	24.2	79.1	100.0	92.0	148.2
CHILLWAK	33	68.8	108.3	49.4	92.7	120.3
N.THOMP	26	397.3	100.0	100.0	93.1	100.0
GOLDEN	18	100.0	43.2	100.0	94.3	100.0
SURREY	36	101.6	89.0	53.1	97.9	114.3
SAANICH	63	93.7	114.6	100.0	98.8	72.7
PRINCTON	17	100.0	144.4	100.0	99.4	51.8
KITIMAT	80	223.9	146.6	100.0	99.4	124.5
ARROWLK	10	100.0	54.7	100.0	100.0	40.3
VAN.IS.N	85	175.7	320.1	100.0	100.4	102.8
VERNON	22	52.0	78.8	255.1	102.2	50.3

APPENDIX 8,3
Female colon cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
MISSION	75	76.5	210.1	134.8	102.5	98.4
SHUSWAP	89	54.7	114.9	286.7	103.1	78.8
MAPLERDG	42	58.3	109.6	141.5	104.9	125.7
VANCOVR	39	127.6	106.8	89.1	104.9	109.5
VICTORIA	61	115.7	94.8	92.8	106.5	94.7
HOPE	32	100.0	115.1	100.0	106.9	39.9
COWICHAN	65	60.2	70.7	140.4	107.2	76.7
COURTENA	71	100.0	77.3	100.0	107.5	88.7
RICHMND	38	133.0	104.6	100.0	108.3	87.1
N.W.M.	40	149.2	83.8	196.4	108.6	143.5
S.OKAN	14	100.0	160.8	163.5	110.5	123.0
CARIBOU	27	100.0	53.6	100.0	113.0	36.3
SCARIBOU	30	100.0	125.5	100.0	114.8	85.5
N.VANC	44	73.2	84.0	180.9	117.2	111.2
TERRACE	88	100.0	205.7	100.0	117.9	46.6
NANAIMO	68	139.9	125.7	81.9	118.0	89.8
KIMBRLY	3	100.0	169.7	100.0	118.9	25.9
PEACE.N	60	100.0	69.2	100.0	119.7	122.9
RELSTOK	19	100.0	135.5	100.0	122.7	191.6
SMITHERS	54	100.0	58.4	440.4	127.3	82.9
WINDERMR	4	364.7	82.0	100.0	129.9	56.4
QUEENCHA	50	368.4	250.2	100.0	130.1	112.5
ARMSTRNG	21	100.0	100.0	100.0	132.5	63.3
QUALICUM	69	100.0	143.4	100.0	133.8	105.0
W.VANC	45	88.2	66.9	81.1	135.5	106.6
PR.RUPRT	52	60.8	231.2	195.2	137.5	132.0
SUMMERLD	77	62.0	82.0	225.1	144.5	100.3
MERRITT	31	100.0	111.8	100.0	182.5	78.5

APPENDIX 9,3

Mean age-standardized mortality rates per 100,000, for male rectal cancer in British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
AGAS.HAR	76	57.4	37.0	449.1	43.4	24.2
BURNSLK	55	121.3	92.2	456.9	47.2	26.4
GOLDEN	18	151.6	32.6	100.0	116.9	32.3
VAN.IS.N	85	38.1	65.2	100.0	68.8	32.4
ARMSTRNG	21	81.9	80.1	100.0	41.6	35.5
ARROWLK	10	50.6	98.1	100.0	102.3	43.2
COWICHL.	66	106.1	80.0	100.0	122.7	45.3
KEREMEOS	16	53.5	104.7	435.5	123.4	46.6
S.OKAN	14	73.9	104.0	149.1	80.1	47.9
N.THOMP	26	100.0	47.3	100.0	86.0	48.2
GULF.IS	64	45.7	78.9	191.6	98.0	49.0
NECHAKO	56	38.4	82.8	100.0	78.7	49.5
LILLOET	29	100.0	53.0	100.0	125.1	52.8
PEACE.S	59	72.4	132.9	264.6	84.3	54.8
QUALICUM	69	98.6	92.8	100.0	88.4	57.0
VERNON	22	56.4	107.5	192.2	95.6	58.5
CASTLGAR	9	100.0	148.3	100.0	70.5	58.9
PRGEORGE	57	110.7	120.6	100.0	106.5	63.1
CRES.KAS	86	97.0	68.9	100.0	80.8	65.7
SCARIBOU	30	41.0	61.7	100.0	52.4	70.3
KIMBRLY	3	98.0	113.3	100.0	110.9	70.8
SUMMERLD	77	26.4	97.1	100.0	80.5	79.8
CENT.OK	23	91.0	94.6	99.5	87.1	81.8
ALBERNI	70	98.9	101.6	90.4	80.2	85.5
ABBTSFOR	34	89.1	112.1	118.8	82.7	86.1
SAANICH	63	110.1	58.4	344.7	89.7	86.8
COWICHAN	65	111.2	88.4	100.0	86.5	87.5
NELSON	7	87.5	87.1	87.3	71.6	88.2
PEACE.N	60	100.0	57.4	207.9	53.3	88.7
PR.RUPRT	52	104.4	170.2	100.0	138.3	89.0
CARIBOU	27	83.3	89.7	100.0	70.2	89.5
POWELLR	47	32.0	97.0	100.0	127.7	89.6
GRANDFOR	12	100.0	141.2	100.0	53.0	89.7
COQUITLM	43	52.5	80.7	76.7	92.3	92.8
MISSION	75	60.8	99.2	243.3	74.4	93.0
SMITHERS	54	326.3	117.1	100.0	112.1	93.3
VICTORIA	61	96.0	85.0	201.0	111.2	93.5
SHUSWAP	89	54.0	98.4	86.0	69.4	93.7
QUESNEL	28	97.2	94.9	175.1	89.2	95.9
DELTA	37	91.1	104.6	81.1	92.2	96.7
SURREY	36	80.0	95.2	70.9	93.8	96.9
WINDERMR	4	100.0	85.9	100.0	73.6	98.8
CHILLWAK	33	51.6	110.0	51.1	86.8	99.8
KETTLE.V	13	76.9	67.3	100.0	20.2	100.0

APPENDIX 9,3

Male rectal cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
C.COAST	49	100.0	51.6	100.0	20.9	100.0
QUEENCHA	50	379.0	80.5	100.0	71.8	100.0
PENTCTON	15	94.6	85.5	100.0	100.2	100.2
PRINCTON	17	100.0	101.4	461.9	163.2	100.4
SOOKE	62	96.7	74.4	100.0	102.2	101.1
N.W.M.	40	104.1	120.2	167.6	117.2	102.5
TRAIL	11	190.2	103.3	100.0	99.6	103.3
MAPLRDG	42	51.6	96.6	206.3	67.5	103.5
BURNBY	41	81.7	104.7	123.2	89.6	104.6
NANAIMO	68	84.4	114.8	165.6	92.5	108.4
W.VANC	45	108.7	75.1	281.1	119.1	108.8
RICHMND	38	120.8	109.5	100.0	118.8	109.0
COURTENA	71	75.8	70.0	100.0	71.4	111.2
HOPE	32	131.2	141.5	100.0	90.8	113.6
N.VANC	44	123.8	86.0	31.4	111.7	114.1
LANGLEY	35	124.9	89.7	130.9	97.1	114.4
CRANBROO	2	44.3	100.2	100.0	118.6	114.5
VANCOUVR	39	132.1	112.7	83.7	113.9	116.3
REVLSTOK	19	161.4	60.8	100.0	114.5	121.9
KAMLOOPS	24	76.7	94.4	51.7	88.8	124.9
TERRACE	88	144.8	135.2	100.0	108.2	129.7
SUNCOAST	46	95.4	130.6	127.2	105.5	130.6
FERNIE	1	56.2	133.1	100.0	50.6	133.7
KITIMAT	80	100.0	83.5	100.0	84.6	138.8
CAMPBRIV	72	81.0	91.8	100.0	89.2	139.7
HOWESD	48	340.1	83.9	100.0	37.8	145.7
VAN.IS.W	84	100.0	100.0	100.0	100.0	156.4
MERRITT	31	49.3	85.4	100.0	64.0	171.4

APPENDIX 10,3

Mean age-standardized mortality rates per 100,000, for female rectal cancer in British Columbia, years 1956-1978.

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
KIMBRLY	3	100.0	169.7	100.0	118.9	25.9
CARIBOU	27	100.0	53.6	100.0	113.0	36.3
NECHAKO	56	246.8	54.4	100.0	43.7	37.7
HOPE	32	100.0	115.1	100.0	106.9	39.9
ARROWLK	10	100.0	54.7	100.0	100.0	40.3
LANGLEY	35	232.8	84.5	139.3	87.7	43.5
TERRACE	88	100.0	205.7	100.0	117.9	46.6
VERNON	22	52.0	78.8	255.1	102.2	50.3
CAMPBRIV	72	167.8	75.0	179.5	79.5	51.6
PRINCTON	17	100.0	144.4	100.0	99.4	51.8
COQUITLM	43	19.7	58.8	100.0	71.8	52.8
WINDERMR	4	364.7	82.0	100.0	129.9	56.4
PRGEORGE	57	142.0	75.0	100.0	85.7	59.1
CRES.KAS	86	77.8	112.2	100.0	57.1	63.0
CASTLGAR	9	100.0	179.0	220.8	88.6	63.2
ARMSTRNG	21	100.0	100.0	100.0	132.5	63.3
BURNSLK	55	100.0	46.7	100.0	49.8	64.1
QUESNEL	28	100.0	127.9	100.0	50.9	65.7
CENT.OK	23	91.2	94.0	163.9	90.4	67.9
SAANICH	63	93.7	114.6	100.0	98.8	72.7
ABBTSFOR	34	130.0	92.0	117.4	85.7	73.6
COWICHAN	65	60.2	70.7	140.4	107.2	76.7
MERRITT	31	100.0	111.8	100.0	182.5	78.5
SHUSWAP	89	54.7	114.9	286.7	103.1	78.8
KETTLE.V	13	100.0	171.2	813.7	90.0	79.5
C.COAST	49	100.0	58.8	812.2	31.0	80.2
SMITHERS	54	100.0	58.4	440.4	127.3	82.9
SOOKE	62	100.0	123.2	106.3	75.6	84.1
SCARIBOU	30	100.0	125.5	100.0	114.8	85.5
RICHMND	38	133.0	104.6	100.0	108.3	87.1
COURTENA	71	100.0	77.3	100.0	107.5	88.7
NANAIMO	68	139.9	125.7	81.9	118.0	89.8
POWELLR	47	41.0	155.6	270.3	83.7	90.3
BURNBY	41	89.8	98.7	104.4	84.9	91.4
TRAIL	11	108.2	109.3	354.6	84.3	93.2
VICTORIA	61	115.7	94.8	92.8	106.5	94.7
PEACE.S	59	52.5	69.8	100.0	68.6	97.6
MISSION	75	76.5	210.1	134.8	102.5	98.4
GULF.IS	64	100.0	53.4	218.7	89.2	99.0
N.THOMP	26	397.3	100.0	100.0	93.1	100.0
LILLOET	29	100.0	50.5	100.0	53.3	100.0
GOLDEN	18	100.0	43.2	100.0	94.3	100.0
SUMMERLD	77	62.0	82.0	225.1	144.5	100.3
COWICHL.	66	100.0	152.2	100.0	58.6	100.9

APPENDIX 10,3

Female rectal cancer continued

School District	District Number	Esophageal	Stomach	Small Intestine	Colon	Rectal
VAN.IS.N	85	175.7	320.1	100.0	100.4	102.8
QUALICUM	69	100.0	143.4	100.0	133.8	105.0
KEREMEOS	16	163.0	145.6	100.0	59.3	105.0
W.VANC	45	88.2	66.9	81.1	135.5	106.6
VANCOVR	39	127.6	106.8	89.1	104.9	109.5
KANLOOPS	24	100.0	81.3	114.8	87.3	110.9
ALBERNI	70	89.2	99.1	97.2	71.1	111.1
N.VANC	44	73.2	84.0	180.9	117.2	111.2
QUEENCHA	50	368.4	250.2	100.0	130.1	112.5
SURREY	36	101.6	89.0	53.1	97.9	114.3
CHILLWAK	33	68.8	108.3	49.4	92.7	120.3
PEACE.N	60	100.0	69.2	100.0	119.7	122.9
S.OKAN	14	100.0	160.8	163.5	110.5	123.0
KITIMAT	80	223.9	146.6	100.0	99.4	124.5
MAPLERDG	42	58.3	109.6	141.5	104.9	125.7
PENTCTON	15	56.4	78.2	270.9	87.8	128.7
PR.RUPRT	52	60.8	231.2	195.2	137.5	132.0
DELTA	37	47.9	77.8	82.5	72.0	134.9
HOWESD	48	148.9	33.2	100.0	17.5	135.6
N.W.M.	40	149.2	83.8	196.4	108.6	143.5
GRANDFOR	12	76.0	199.9	100.0	55.8	147.5
NELSON	7	24.2	79.1	100.0	92.0	148.2
SUNCOAST	46	127.4	207.1	149.5	77.6	150.8
AGAS.HAR	76	100.0	100.0	100.0	77.9	154.0
CRANBROO	2	225.3	73.9	100.0	88.3	177.4
VAN.IS.W	84	100.0	100.0	100.0	0.0	180.1
RELSTOK	19	100.0	135.5	100.0	122.7	191.6
FERNIE	1	292.2	177.1	250.7	88.6	255.6

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WATER QUALITY AND DIGESTIVE CANCER IN CANADA,

WITH EMPHASIS ON BRITISH COLUMBIA

Author [redacted]

IAN H. NORIE

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