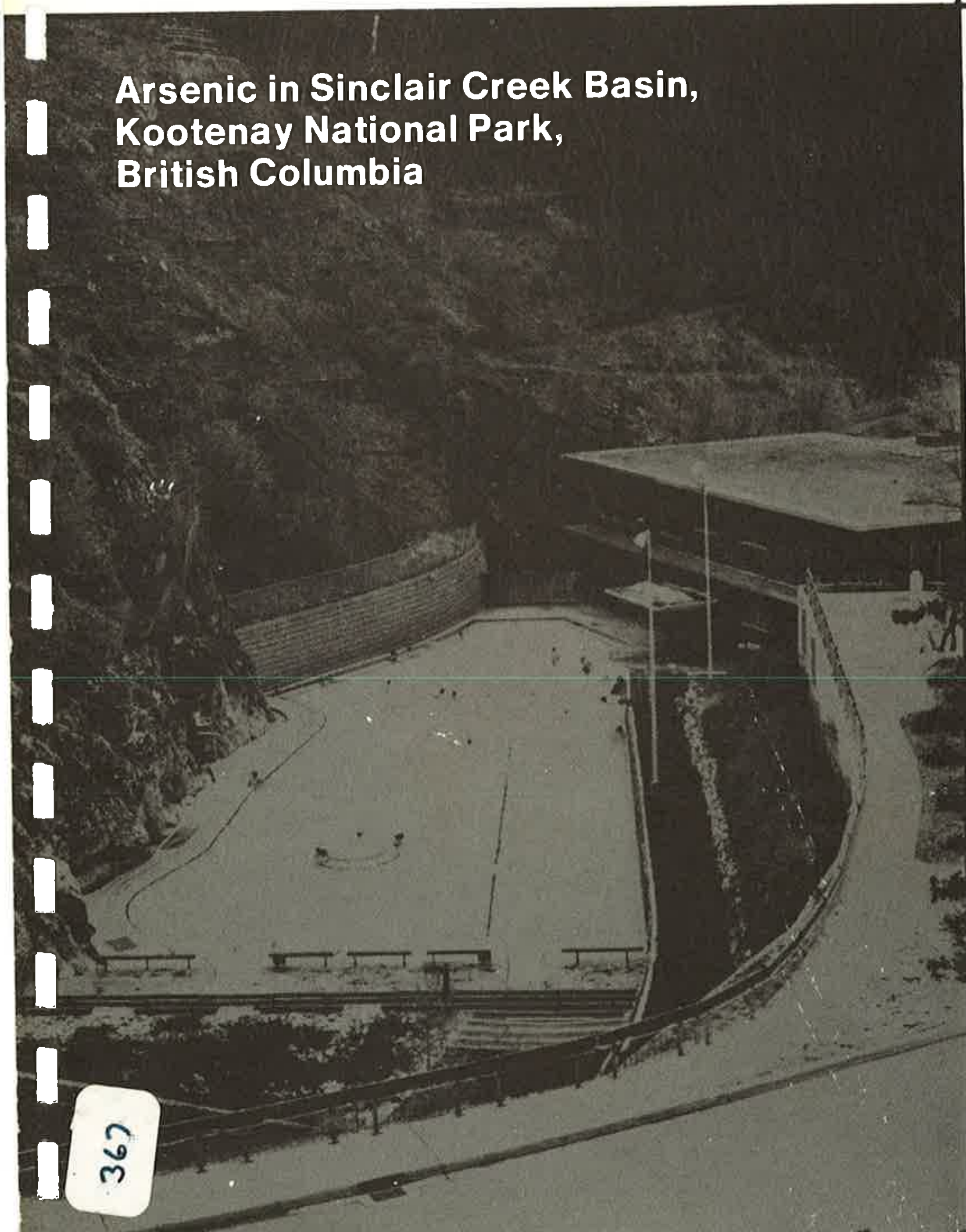
Environment Canada
Environmental Management

Environnement Canada
Gestion de l'environnement

Inland Waters Directorate
Western and Northern Region

Arsenic in Sinclair Creek Basin, Kootenay National Park, British Columbia



Wm. D. Gummer and
H. O. Block

WATER QUALITY BRANCH

JUNE 1979

WQB-79-2

Fisheries and Environment Canada
Environmental Management

Pêches et Environnement Canada
Gestion de l'Environnement

1979 07 19

Your file Votre référence

Our file Notre référence 7570-1

Mr. W.J. Turnbull
Regional Director
Parks Canada
Department of Environment
134 - 11th Avenue S.W.
Calgary, Alberta

Dear Mr. Turnbull:

I am pleased to submit 15 copies of a report titled "Arsenic in Sinclair Creek Basin, Kootenay National Park, B.C.". This report concludes our understanding of your letter of July 9, 1975 to Mr. Gummer whereby Parks Canada provided $5,000.00 to Inland Waters Directorate to carry out this study.

Briefly, the study concludes that while the John McKay Creek drinking water supply is not contaminated with arsenic, the Radium hot springs and other springs along Sinclair Creek in the vicinity of the Red Wall Fault, and Sinclair Creek below the hot springs do exceed acceptable arsenic levels for drinking waters. Because of the apparently limited and/or short term consumption made of the contaminated waters, we are of the opinion that these waters pose no danger to human health. It is however recommended that the Canyon Campground operator be advised to relocate his wells outside the influence of Sinclair Creek.

The report provides a brief geological description of the study area and discusses the temporal and spatial variability of arsenic levels in the Sinclair Creek Basin. A brief and general overview of the chemical quality of the hot springs and the surface waters in the Basin is also included.

.../2

Since Parks Canada partially funded the study and in keeping with the Environmental Management Service - Parks Canada Agreement, we would appreciate receiving your approval to publish this report in the Water Quality Branch interpretive report series.

Yours sincerely,

K. W. Reid
Chief
Water Quality Branch
Western & Northern Region
1st Floor, Motherwell Building
1901 Victoria Avenue
Regina, Saskatchewan
S4P 3R4

encl.

c.c. D.A. Davis
Regional Director
Inland Waters Directorate
Western & Northern Region

A R S E N I C
IN
SINCLAIR CREEK BASIN, KOOTENAY NATIONAL PARK, BRITISH COLUMBIA

BY

WM. D. GUMMER, H. O. BLOCK

JUNE, 1979

ABSTRACT

Routine monitoring in early 1975 revealed higher than expected concentrations of arsenic in Sinclair Creek of Kootenay National Park, British Columbia. Follow-up surveys found that the Radium Hot Springs contained about 0.5 mg/l arsenic.

Upon the request of Parks Canada, the Water Quality Branch undertook a ten month study to investigate the prevalence and abundance of arsenic in the waters of Sinclair Creek Basin. Arsenic was determined to be ubiquitous in the waters of the basin with maximum levels (up to 0.8 mg/l) recorded in diffused groundwater sources and in the hot springs serving the Radium Hot Springs Aquacourt (up to 0.3 mg/l).

John McKay Creek which is the drinking water supply for the townsite of Radium and the Aquacourt, contained levels of arsenic well below the acceptable limit of 0.01 mg/l of the Canadian Drinking Water Standards. The drinking water for Canyon Campground, on the otherhand, was found to contain arsenic at levels in excess of 0.025 mg/l. The high levels of arsenic in the hot and cold pools at the Aquacourt are not considered to present a health concern.

RESUME

Au commencement de l'année 1975 un arpentage routine a révélée une concentration élevé d'arsenic dans le crique Sinclair qu'est situé dans le parc national Kootenay au Colombie Britannique. Une investigation plus intensive a trouvée que les Radium Hot Springs contient de l'arsenic au concentration de 0.5 mg/l.

Sur la requête de Parc Canada, la Direction de la Qualité d'Eau entrepris une étude durée de dix mois avec le but de déterminer la prédominance et l'abondance d'arsenic dans les eaux du basin du crique Sinclair. L'arsenic est présent partout dans le basin avec les maximum concentration étant trouver dans des sources répandues (jusqu'à 0.8 mg/l) et dans les sources chaudes qui serve le Radium Hot Springs Aquacourt (jusqu'à 0.3 mg/l).

Les niveaux d'arsenic dans le crique John McKay, qui serve comme source d'eau potable pour le village de Radium et pour l'Aquacourt, était bien en aval de la limite acceptable de 0.01 mg/l présentée dans Canadian Drinking Water Standards. Dans l'eau potable du Canyon Campground, les niveaux d'arsenic était en excès de 0.025 mg/l. Les niveaux élevés d'arsenic dans les piscines chaudes et froides de l'Aquacourt ne sont pas considérés comme hasard à la santé.

TABLE OF CONTENTS

Page

ABSTRACT. i

RESUME. ii

LIST OF FIGURES v

LIST OF TABLES. vi

I INTRODUCTION 1

STUDY OBJECTIVES. 2
SCOPE OF STUDY. 2

II STUDY AREA 2

SETTING 2
GEOLOGICAL OVERVIEW 3
HYDROLOGY AND GEOMORPHOLOGY 5
WATER USES. 9
THE NATURAL OCCURRENCE OF ARSENIC 9

III METHODS. 12

SAMPLE ANALYSIS 12
SAMPLE COLLECTION 13
SAMPLING LOCATIONS AND SAMPLING FREQUENCY 14
DATA INTERPRETATION 14

IV RESULTS AND DISCUSSION 15

SPATIAL DISTRIBUTION OF ARSENIC IN SINCLAIR CREEK 15

Intensive Surveys. 16
Monthly Sampling 18

TEMPORAL VARIATIONS OF ARSENIC IN SINCLAIR CREEK. 22
RELATIONSHIP OF ARSENIC TO OTHER PARAMETERS 25
HOT SPRINGS POOLS CHEMICAL QUALITY. 29
GENERAL CHEMISTRY OF SINCLAIR CREEK AND TRIBUTARIES 35
IMPLICATIONS OF ARSENIC IN SINCLAIR CREEK BASIN 40

V CONCLUSIONS AND RECOMMENDATIONS. 45

CONCLUSIONS 45
RECOMMENDATIONS 48

ACKNOWLEDGEMENTS. 50

REFERENCES. 51

LIST OF FIGURES

Page

1. Sinclair Creek Study Area 4
2. Profile of Sinclair Creek 6
3. Schematic of Flow Regime of Radium Hot Springs Aquacourt. . . 8
4. Spatial Distribution of Arsenic in Sinclair Creek (Mean Levels during Period June 1975 to March 1976) 21
5. Correlation of Arsenic with Time (a) Sinclair Creek (b) Radium Hot Springs (r is correlation coefficient, α=0.05 and NS is nonsignificant correlation). 23
6. Variabilities and Differences in (a) Temperature (b) Specific Conductance (c) Sulfate, and (d) Chlorides of the Radium Hot Springs Cold Pool Outflow and Hot Pool Inflow and Outflow . . 31
7. Variabilities and Differences in (a)Calcium (b) Silica (c) pH and (d) Fluoride of the Radium Hot Springs Cold Pool Outflow and Hot Pool Inflow and Outflow 32
8. Spatial Distribution of Major Ions in Sinclair Creek as Illustrated by Mean Levels for the Period June 1975 to March 1976. Units are in mg/l unless Otherwise Shown 37
9. Temporal Variation of Specific Conductance in Sinclair Creek 45 m. above Sinclair Canyon 38
10. Spatial Comparison of Temperature in Sinclair Creek 39

I INTRODUCTION

In 1975, an inventory study of the quality of surface waters in Kootenay National Park commenced. The study was funded by Parks Canada of the Department of Indian and Northern Affairs and the Water Quality Branch of the Department of Fisheries and Environment. The first data for Sinclair Creek at Canyon Campground revealed dissolved arsenic concentrations of 0.085 milligrams/liter (mg/l) which are high for mountain surface waters.

A follow-up survey confirmed the original findings, and showed arsenic to be ubiquitous in the Sinclair Creek Basin. The highest concentrations were observed in the hot springs that supply the Radium Hot Springs Aquacourt.

The Canadian Drinking Water Standards (National Health and Welfare, 1968) recommend an acceptable arsenic concentration of 0.01 mg/l for drinking water. Since waters within the basin are utilized for drinking and recreational purposes and were shown to exceed this limit, it was necessary to quantify the existing level of arsenic. A study was undertaken during the period June 1975 to March 1976. In addition, a special survey was conducted in July 1977 to further quantify the arsenic level in local groundwater discharges. This report presents the findings of the work carried out in the Basin and puts the arsenic situation into perspective.

Columbia (Figure 1). Elevations in the basin range from 2591 m above sea level (a.s.l.) to less than 762 m a.s.l. For its size, the basin supports a relatively large tourist trade. There are two major developments in the basin, the largest being Radium townsite located near the junction of Provincial Highways 93 and 95 and Radium Hot Springs development the second largest development in Kootenay National Park. The Radium Hot Springs is the center of year round activity serving thousands of visitors annually. Motels, campgrounds, service stations and other services and a park work compound are also located in the basin.

GEOLOGICAL OVERVIEW

Sinclair Creek Basin is situated primarily in the Western Ranges sub-province described by Henderson (1954). The Brisco Range and Stanford Range of the Rocky Mountain System transverse the basin north to south making up about ninety percent of the basin. The western extremity of the basin lies in the Rocky Mountain trench in the valley of the Columbia River and is terraced up to about 910 m above sea level (a.s.l.).

In the Rocky Mountain trench are outcrops of the Windermere series and of the Paleozoic formations (Walker, 1926). The principal exposures are of the Quaternary era (Pleistocene to Recent Period) consisting of till, gravel, sand, silt and alluvium.

The Stanford Range, within the basin, is divided into two fault blocks by the Redwall fault. To the east of the Redwall fault in the headwaters of the basin, the fault block is characterized by upright, asymmetrical anticlines and to the westward side by longitudinal and obliquely trending folds dissected by numerous less distinguishing faults. The rocks range in age from late Precambrian to Middle Devonian and consist of limestones, limey shales, black shales, quartzites, argillites, slates, conglomerates and rock gypsum (Henderson, 1954).

The Brisco Range is characterized by tightly folded, crumpled and faulted rocks most of which are of the Ordovician and Silurian ages. Sinclair Creek cuts one of these fault blocks revealing at the eastern base of the block, Cambrian limestone of the Jubilee Formation, and at its western end, an outcrop of Middle Devonian limestone of the Harrogate Formation (MacKay, 1952). The Lardeau Map (east half) of Reesor (1973) show the rocks of the Brisco Range are primarily dolomitic limestone, quartzite, sandstone, upper massive dolomite, lower laminated dolomite and shales.

Perhaps the most striking geological feature of the basin is the Redwall fault. The fault is characterized by a red-oxide stained breccia zone which outcrops at various places within the basin. It brings together Jubilee and Beaverfoot strata representing a vertical displacement of several thousand feet. The fault extends through the entire Stanford Range and northward into the Brisco Range. Vertical walls of the fault can be observed where Sinclair Canyon has been cut through the fault zone of steep resistant dolomites of the Beaverfoot formation and into the limestones of the McKay Formation (Price, 1972).

HYDROLOGY AND GEOMORPHOLOGY

Sinclair Creek originates near Sinclair Pass and flows in a westerly direction confluencing the Columbia River about two miles west of Radium Townsite (Figure 1). Typical of mountain streams, Sinclair Creek is

The Lower Reach extends a distance of about 3 km and traverses the flood plain of the Columbia River. Sinclair Creek is wider in this reach and flows with a reduced velocity.

Because of the rapid drop in elevation, Sinclair Creek is swift flowing and turbulent. Flows are highly variable from season to season and reflect rate of snowmelt and precipitation levels. During June when run-off is generally greatest in the basin, the hydrograph correspondingly peaks. The mean daily flow for June is 3.4 m^3/s (Water Survey of Canada, 1975). Other than short term peaks following prolonged rainstorms, the hydrograph falls off rapidly after spring run-off to a monthly mean (as determined for the period August to March) of about 0.43 m^3/s (Water Survey of Canada, 1975).

Springs are influenced by snowmelt as evidenced by colder temperatures, increased discharge and better spring water quality during the spring period. Van Everdingen (1972) has further suggested that the hydrometric-water quality regimes of the hot springs are affected by movements in the surrounding brecciated rocks. For example, he suggests that the Alaska earthquake of March 27, 1964 may have resulted in the colder temperatures and the distinct reddish-brown hot spring waters.

Three major tributaries McKay Creek, Kimpton Creek and Redstreak Creek are estimated to constitute on the average approximately 25, 25 and 10 percent, respectively, of the Sinclair Creek main stem flow. The two latter creeks still have their natural flow regimes, whereas, flows in McKay Creek have been altered by the construction of a small dam adjacent to the water treatment plant.

WATER USES

The water in Sinclair Creek Basin is primarily limited to domestic and recreational use. The importance of basin waters as fish habitat is unclear, although a limited number of trout have been successfully stocked behind the dam on John McKay Creek.

The major developments in the basin, hotels and the Aquacourt, receive their drinking water from the John McKay Creek water treatment facilities. During periods of extreme low flow in John McKay Creek, water from Sinclair Creek may be used to supplement water supply demand.

Canyon Campground, located about 5 km below the Aquacourt and just outside the Park derives its drinking water from two water wells located adjacent to Sinclair Creek. There is reason to believe that seepage from Sinclair Creek feeds these two wells, therefore emphasizing the need to clearly define any arsenic problem that may exist in the waters originating from within the Park.

Spring water is no doubt an attractive drinking water source for hikers and campers. However, to what extent such use is made of springs is impossible to quantify.

THE NATURAL OCCURRENCE OF ARSENIC

Arsenic is twentieth in natural abundance among the elements of the earth's crust. The terrestrial abundance of arsenic is of the order of 3 parts per million (Boyle and Jonasson, 1973). Arsenic bearing minerals are widely occurring, the most common being those combined with sulphur, iron or nickel eg. realgar (As_2S_2), mispickel (FeAsS) and nickel glance (NiAsS).

The arsenic content of surface waters and groundwaters is dependent on the abundance of the element in host rocks or enclosed sulfides and on anthropogenic sources. In Sinclair Creek Basin, arsenic in the water is derived solely from the weathering of natural arsenic bearing formations because atmospheric contribution is considered negligible. The arsenic concentration in fresh waters of western Canada are summarized in Table 2. Concentrations of arsenic in springs and thermal waters are shown in Table 3.

Table 2. Arsenic Levels in Fresh Waters

Water Body	No. Samples	Arsenic (mg/1)	
		Range	Average
Red River, Manitoba	18	0.0006-0.018	0.004
Souris River, Manitoba	46	0.0017-0.028	0.006
Qu'Appelle River, Saskatchewan	23	0.0029-0.019	0.009
North Saskatchewan River, Sask.	44	<.001-0.0017	<0.001
South Saskatchewan River, Sask.	45	<.0005-0.0009	<0.0001
Poplar River, Saskatchewan	14	0.0011-0.027	0.008
Churchill River, Manitoba	34	<.0005-0.0006	<0.0005
Bow River, Alberta	12	<.0005-0.0011	<0.0006

Table 4. Parameters Measured During the Ten Month Arsenic Monitoring Study

Sampling Frequency	
Monthly	Bi-Monthly
temperature	chloride
specific conductance	alkalinity
pH	sulphates
arsenic	silica
iron (extractable)	calcium
manganese (extractable)	magnesium
antimony	sodium
sulphates	potassium
	copper (extractable)
	fluorides

*All chemical constituents are reported as dissolved except where indicated

SAMPLE COLLECTION

Samples for all dissolved parameters were collected in two-liter polyethylene bottles, put in coolers and immediately transported to the Calgary laboratory. Upon receipt at the laboratory, the samples were immediately filtered for the dissolved parameters.

Samples (one liter polyethylene bottle) for extractable iron, antimony, manganese and copper were treated immediately after collection with concentrated nitric acid at a rate of 2 ml /liter of sample.

All stream samples were collected by wading to mid stream and hand-dipping the appropriate bottle to a depth of about six inches below the water surface (Water Quality Branch, 1973).

format to facilitate interpretation. The summary format consists of statistics such as percentiles and standard deviations. Graphical presentations are used to describe spatial and temporal variations.

A posteri one way analysis of variance using the Modified Least Significant Difference Method (Nie, 1975) of grouping sub-populations were used to help define the spatial differences. This method is exact for unequal group sizes. A correlation analysis was used to examine the relationships of arsenic concentrations to other parameters.

IV RESULTS AND DISCUSSION

SPATIAL DISTRIBUTION OF ARSENIC IN SINCLAIR CREEK

Results from the earlier surveys conducted in Sinclair Creek Basin during the period January to April 1975 have been reported previously (Water Quality Branch, 1975). The results of the April 1975 survey indicated that traces of arsenic were present throughout the watershed. The April data also show that arsenic concentrations in the waters of Sinclair Creek increase significantly in two reaches of the Creek. In the reach between Kimpton Creek and John McKay Creek, single samples show the concentration increased from 0.0072 to 0.052 mg/l, while in the reach between the hot springs and Sinclair Canyon, it increased from 0.040 to 0.085 mg/l.

The two fold increase in the lower reach is attributable to the discharge from the hot springs which have arsenic concentrations in the order of 0.3 to 0.4 mg/l. The six fold increase in the upper reach suggests yet another source.

Table 6. Arsenic Levels in Sinclair Creek Basin - May 13, 1975 Survey

Map Location	Location	Arsenic Concentration (mg/l)
1	Sinclair Creek at Sinclair Pass	0.0007
2	Sinclair Creek opposite picnic site above Kimpton Creek	0.009
3	Kimpton Creek near mouth	0.0019
4	Sinclair Creek below Kimpton Creek (2.9 km above work compound)	0.003
5	Inflow to Sinclair Creek 0.3 km below Kimpton Creek (midway between turnaround point on highway and site #4)	0.030
6	Sinclair Creek approximately 0.6 km below Kimpton Creek (opposite turnaround point on highway)	0.014
7	Sinclair Creek approximately 2.0 km above work compound	0.014
8	Sinclair Creek approximately 1.6 km above work compound	0.017
9	Sinclair Creek at first highway crossing above Redstreak Creek	0.017
10	Sinclair Creek approximately 23 m above Redstreak Creek	0.017
11	Redstreak Creek at mouth	0.0057
12	Sinclair Creek approximately 180 m below Redstreak Creek	0.018
13	Inflow to Sinclair Creek approximately 275 m above John McKay Creek	0.0006
14	Sinclair Creek above John McKay Creek	0.016
15	John MacKay Creek near mouth	0.0013
16	Sinclair Creek above Hot Springs	0.014
17	Hot Springs - hot pool inflow	0.26
18	Hot Springs - hot pool outflow	0.26
19	Hot Springs - cold pool outflow	0.25
20	Sinclair Creek 45 m above Sinclair Canyon	0.023
21	Sinclair Creek at Canyon Campground	0.029
22	Domestic water supply at Canyon Campground (upper well)	0.032
23	Domestic water supply at Canyon Campground (lower well)	0.026

Table 7. Arsenic Levels in Sinclair Creek Basin - July 4, 1977 Survey

	Time (hrs)	Conductivity (μs/cm)	Temp (°C)	Approx. Flow* (l/sec)	Arsenic (ppm)	Remarks (Field Observations)
1. Sinclair Creek above John Mackay Creek	1130	240	5		0.0078	
2. Redstreak Creek at mouth	1200			75-190	0.0056	Flow in Sinclair Creek above Redstreak Creek is approximately 75 to 190 l/sec.
3. Sinclair Creek above Redstreak	1205		7.0		0.010	
4. Local inflow north side of Sinclair Creek approx. 180 m above Redstreak Creek	1220		6.0	3.8	0.016	It is difficult to say whether this flow was groundwater or seepage from creek.
5. Local inflow to Sinclair Creek approx. 0.4 km above Redstreak Creek	1235		6.0	-	0.010	Water is suspected to be from Sinclair Creek
6. Sinclair Creek at 1st Road Crossing above Redstreak Creek	1240		6.5	-	0.011	
7. Groundwater discharge north bank Sinclair Creek approx. 91 m below turnaround point on Hwy	-		8.0	20	0.023	Slight sulphur odour was present
8. Groundwater discharge north bank Sinclair Creek approx. 64 m below turnaround point	1335		8.0	-	0.021	
9. Sinclair Creek below falls by turnaround point	1340		6.5	-	0.0093	Many small channels of groundwater were observed discharging.
10. Sinclair Creek below Kimpton Creek	1400		6.0	-	0.0022	Kimpton Creek was about 40% of Sinclair Creek flow
11. Culvert discharge approx. 360 m below Kimpton Creek	1410		11.0	8	0.840	
12. Groundwater discharge approx. 400 m below Kimpton Creek	1420		8	10-50	0.025	
13. Spring water from weeping wall approx. 70 m above turnaround point	1430		-	2-20	0.140	A large number of trickles made it difficult to estimate quantity
14. Spring water in ditch below weeping wall	1435		12.5	2-10	0.240	
15. Groundwater, north bank Sinclair Creek approx. 27 m above falls at turnaround point	1445		8.5	10-50	0.23	

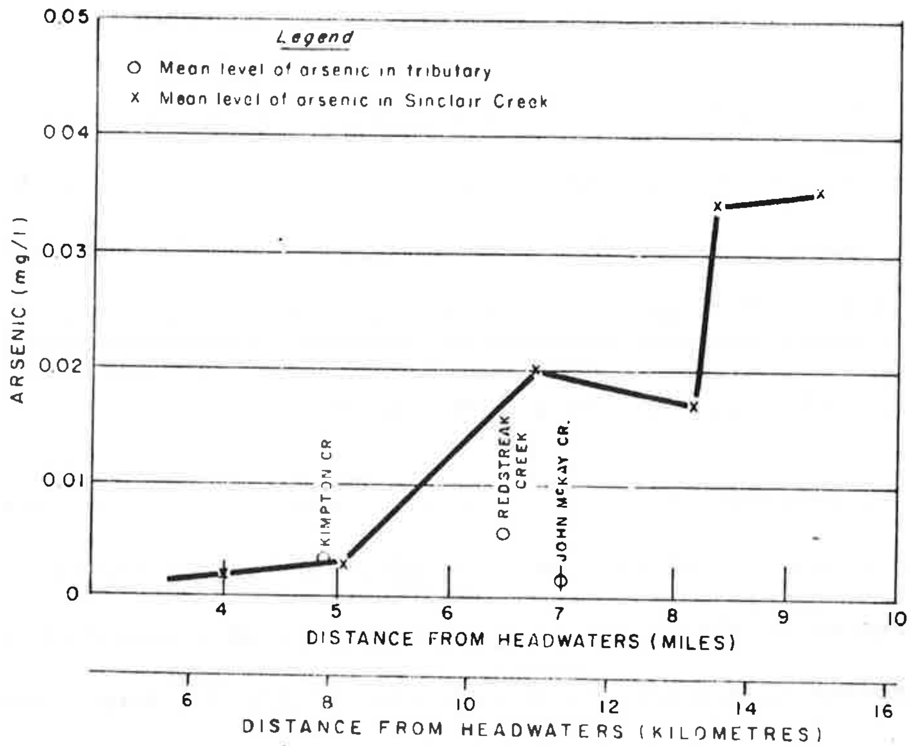
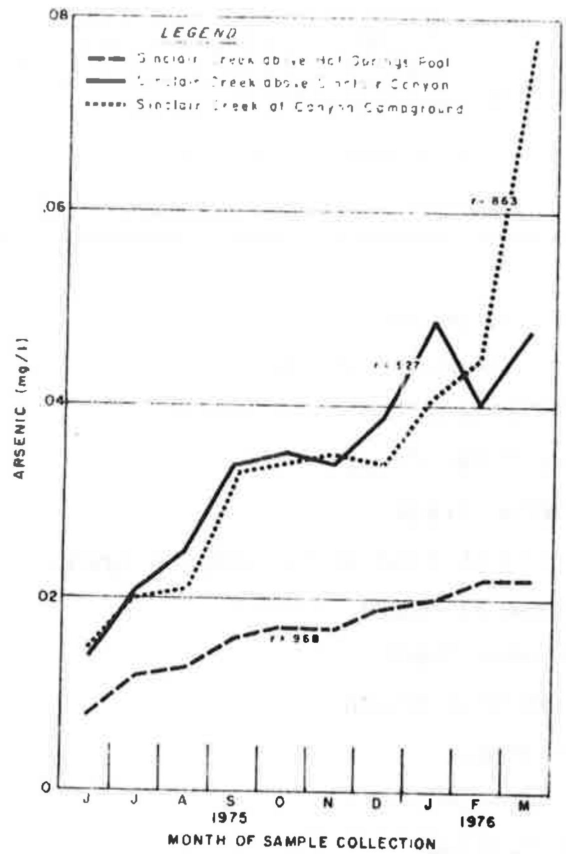


Figure 4. Spatial Distribution of Arsenic in Sinclair Creek (Mean Levels during Period June 1975 to March 1976)

The results of the *a posteriori* contracts used to determine differences are shown in Table 8. Although this method created five groupings of the monthly data which are not mutually exclusive, it does point out general trends. The headwaters reach tends to be different from the reach between Kimpton and McKay Creeks and the reach below the hot springs tends to stand alone as does the hot springs themselves. The MLSD was performed over the entire period of record June 1975 to March 1976. During this time, flow decreased from a normal spring high to a normal summer and winter low. Also, arsenic levels tended to increase during this period (the temporal aspects are discussed later). The large range and variability of arsenic concentrations explains why the groupings in the upper reaches of Sinclair Creek overlap.

This study and the July 1977 survey confirm groundwater discharges below Kimpton Creek as having levels of arsenic sufficiently high to account for the six to ten fold increase in concentrations observed in the

(a)



(b)

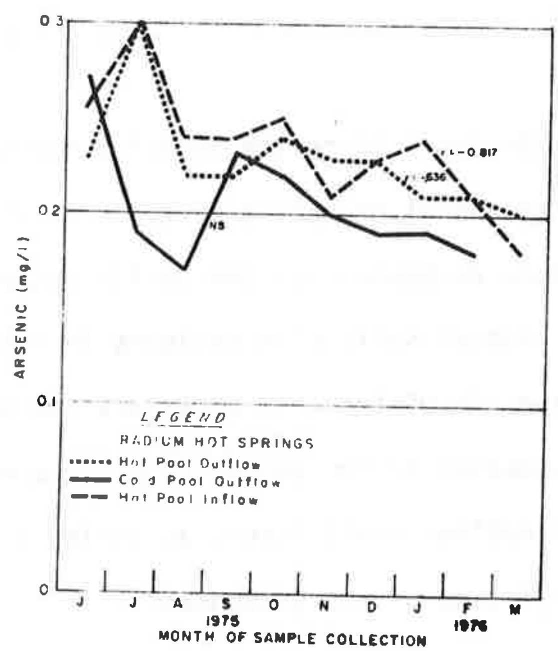


Figure 5. Correlation of Arsenic with Time
(a) Sinclair Creek (b) Radium Hot Springs
(r is correlation coefficient, α=0.05 and
NS is nonsignificant correlation)

reproducible annually, it will be seen in the next section that any significant direct association between time and arsenic concentrations is removed when one considers the association between arsenic and flow.

The decreasing arsenic concentration in the hot springs over the study period is contrary to what was observed at the Sinclair Creek sampling sites. An explanation for the temporal variation of arsenic concentrations in the Aquacourt Hot Springs cannot be given at this time. However, it is likely that deep internal circulation rates, discharge volume, temperature and mineral composition, contribute to the variation. As will be seen in the next section, fluoride levels follow the same general cyclic pattern as for arsenic, whereas, calcium levels to which arsenic is negatively correlated ($r=-0.88$, $\alpha=0.05$), increases as arsenic decreases. Temperature had a subtle increase over this same period and this is further discussed later.

RELATIONSHIP OF ARSENIC TO OTHER PARAMETERS

Arsenic in Sinclair Creek is strongly associated with many parameters (Table 10). It must be understood that the presence of correlation between two sets of data does not necessarily mean that causation is present even though the correlation is excellent. In fact, most of the chemical parameters which individually show cyclic variations, will in all probability when related to each other, have significant correlations. Furthermore, although causation may be present, the cause is not necessarily the sole cause.

The abundance of arsenic in Sinclair Creek surface waters is attributed to natural processes and the surrounding ore bodies. Much of the variability in arsenic concentrations is attributed to the temporal variability in flow. Significant correlations of those parameters with the log of flow are shown in Table 11. If we assume that there is a cause-effect relationship between the log transformed flow data and arsenic levels then the following can be said: the square of the correlation coefficient expressed as a percentage, approximates the degree the independent variable (log flow) affects the dependent variable (arsenic). For example, consulting Table 11 it is concluded that the variance associated with the log transformed flow data *could* account for 91% (0.956 x 0.956 x 100) of the variance in arsenic concentration at the site, Sinclair Creek above Canyon Campground. Sinclair Creek at Canyon Campground correlates -0.731, and therefore, flow accounts possibly for only 53% of the variance. An inspection of the scattergram for the two variables revealed that the low correlation at the campground site was due to one point which corresponded to an arsenic concentration of 0.078 mg/l which is much greater than other values reported for this site. Excluding this point results in a correlation coefficient of -0.953, nearly identical to that calculated for the site above Sinclair Canyon (Table 12). This simple exercise shows how correlations may be fortuitous.

Recalling the discussion in the preceeding Section, arsenic levels were shown to correlate well with time at most sites. However, flow is believed to be the more likely cause for arsenic level variability. Recalculating the correlation of arsenic concentration with study time as well as with the other parameters after controlling for the effects

Table 13. Significant Correlations of Various Parameters with Arsenic Controlling for the Effects of the Log of Flow (α=0.05)

Parameter	Sinclair Creek at Canyon Campground	Sinclair Creek above Sinclair Canyon
Julian	0.704	Not Significant
Field Conductivity	0.789	for any parameters
Lab Conductivity	0.988	identified.
Sulphate	0.989	

The high arsenic value of 0.078 mg/l on March 3, 1976 if discounted and removed from the calculations, destroys the remaining significant associations shown in Table 13, except for the log of flow.

To summarize this section, arsenic is strongly correlated to most parameters having cyclic patterns. This does not necessarily mean a dependency of arsenic on any one or more of these parameters. By correcting for variability attributed to the log of flow, these strong correlations disappear.

HOT SPRINGS POOLS CHEMICAL QUALITY

The quality of Radium Hot Springs waters has been previously reported (Van Everdingen 1972, Elworthy 1926). The data collected during this study are listed in Appendix A and statistical summaries of the data can be found in Appendix B. Table 14 summaries the quality of the hot springs pool inflow and outflow and the cold pool outflow.

Upon reaching the earth's surface, the hot springs undergo changes in chemical equilibrium and chemical quality due to factors such as evaporation, oxygenation, agitation, atmospheric contact, and so on. It is therefore expected that the hot pool outflow will differ somewhat in

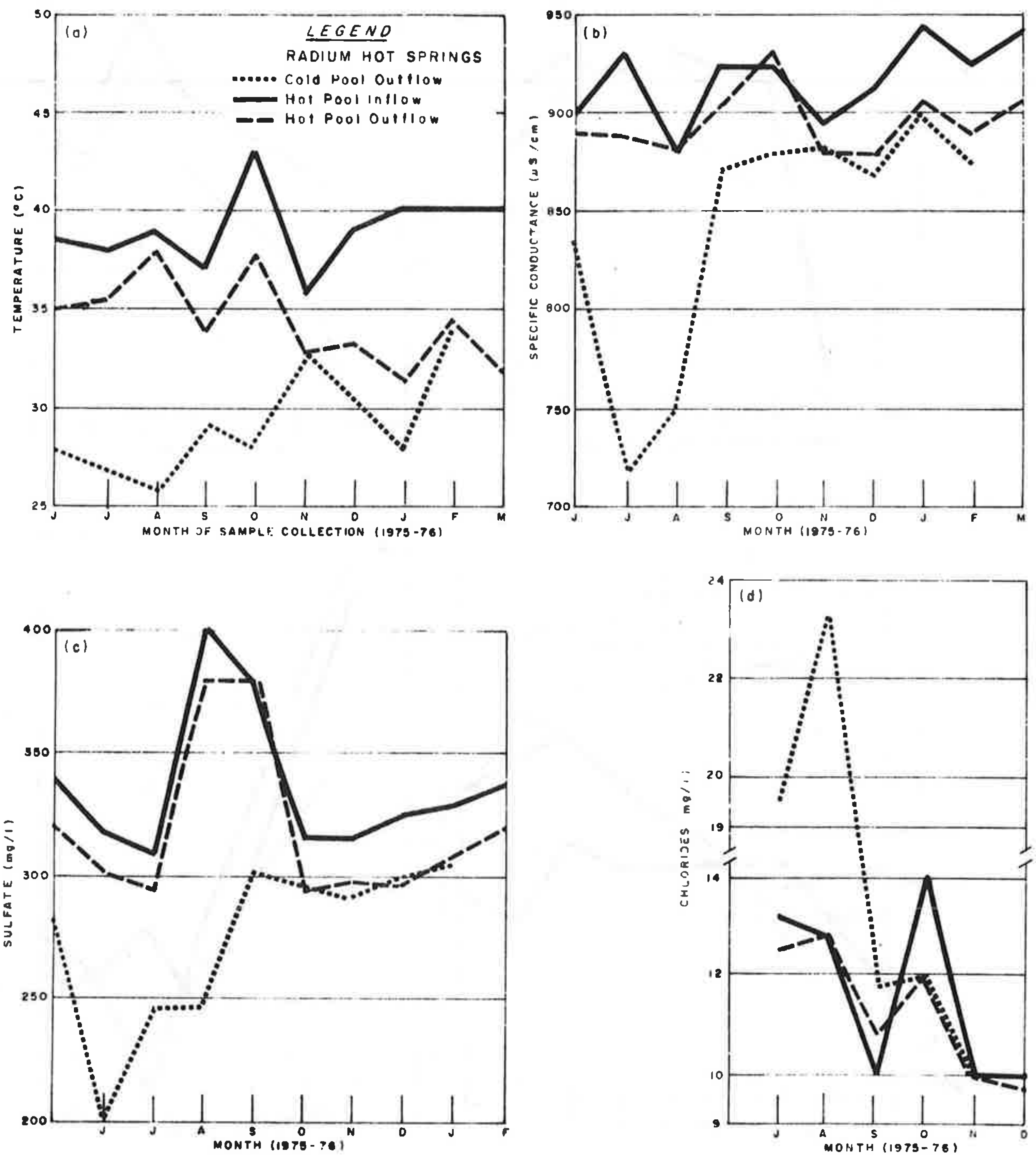


Figure 6. Variabilities and Differences in (a) Temperature (b) Specific Conductance (c) Sulfate, and (d) Chlorides of the Radium Hot Springs Cold Pool Outflow and Hot Pool Inflow and Outflow

Assuming that the hot springs pool inflow sampling site is reflective of the quality of the hot springs themselves, these springs are slightly acidic with a median pH of 6.9. During this study, temperatures ranged between 35.5 and 43°C. The hot pool outflow was slightly acidic during the summer months and slightly alkaline during the winter months. Temperatures ranged between 31.5 and 38°C being generally 3°C lower than the temperature of the springs as they emerged from the ground to the hot pool. The hot springs inflow temperature appears to be lowest in the summer and highest in the winter.

The practice of adding colder domestic water to lower the temperature of the hot spring waters for the cold pool, is routinely carried out. This practice no doubt accounts for the temperature of the cold pool differing by as much as 13°C from the hot pool during the month of August.

These figures also show how the quality of the cold pool outflow differs from the hot pool inflow and outflow qualities. The increase in pH may be attributed in part to a loss of carbon dioxide from the water in the hot pool.

The flow regime of the Aquacourt is schematically shown in Figure 3.

Dissolved solids variations are reflected by the variations in specific conductance (Figure 6). As would be expected, the hot pool inflow and outflow dissolved solids content varied in a similar manner. The fact that the hot pool outflow conductance is for the most part less than the conductance of the hot pool inflow, suggests that the ionic characteristics of the hot springs change when brought into contact with the atmosphere.

During the high tourist period of July to October, chlorides were substantially higher in the cold pool than in the hot pool (Figure 6).

Natural levels of metals in the Radium hot springs are low. No detectable occurrences of antimony were recorded. In the hot springs pool inflow, iron and manganese were detected on one occasion only while copper was detected on two occasions. The hot spring pool outflow on the otherhand had six and three positive detections in eight samples for iron and manganese, respectively. Copper was above the analytical detection limit for all but one sample. The explanation for the differences in inflow and outflow metal quality may be attributed to the piping used to convey the waters as well as possibly the paint used in the pool.

The mean arsenic concentration of the hot pool inflow was nearly identical to the mean concentration in the hot pool outflow. There was however, a difference of 0.04 mg/l between the mean concentration in the hot and cold pools. During July and August arsenic levels in the cold pool outflow are substantially different from both the hot pool inflow and outflow concentrations (Figure 5). While part of this difference may be due to the variability inherent in the analytical method, it may also reflect the circulation regime and temperature control of the pools.

The data collected during this study show that the chemical quality of the springs have not deviated significantly from the quality previously described by Van Everdingen (1972).

GENERAL CHEMISTRY OF SINCLAIR CREEK AND TRIBUTARIES

The general chemistry of Sinclair Creek and its major tributaries is summarized in Table 15. Detailed data and statistical summaries of the data are found in Appendices A and B. The data show that the

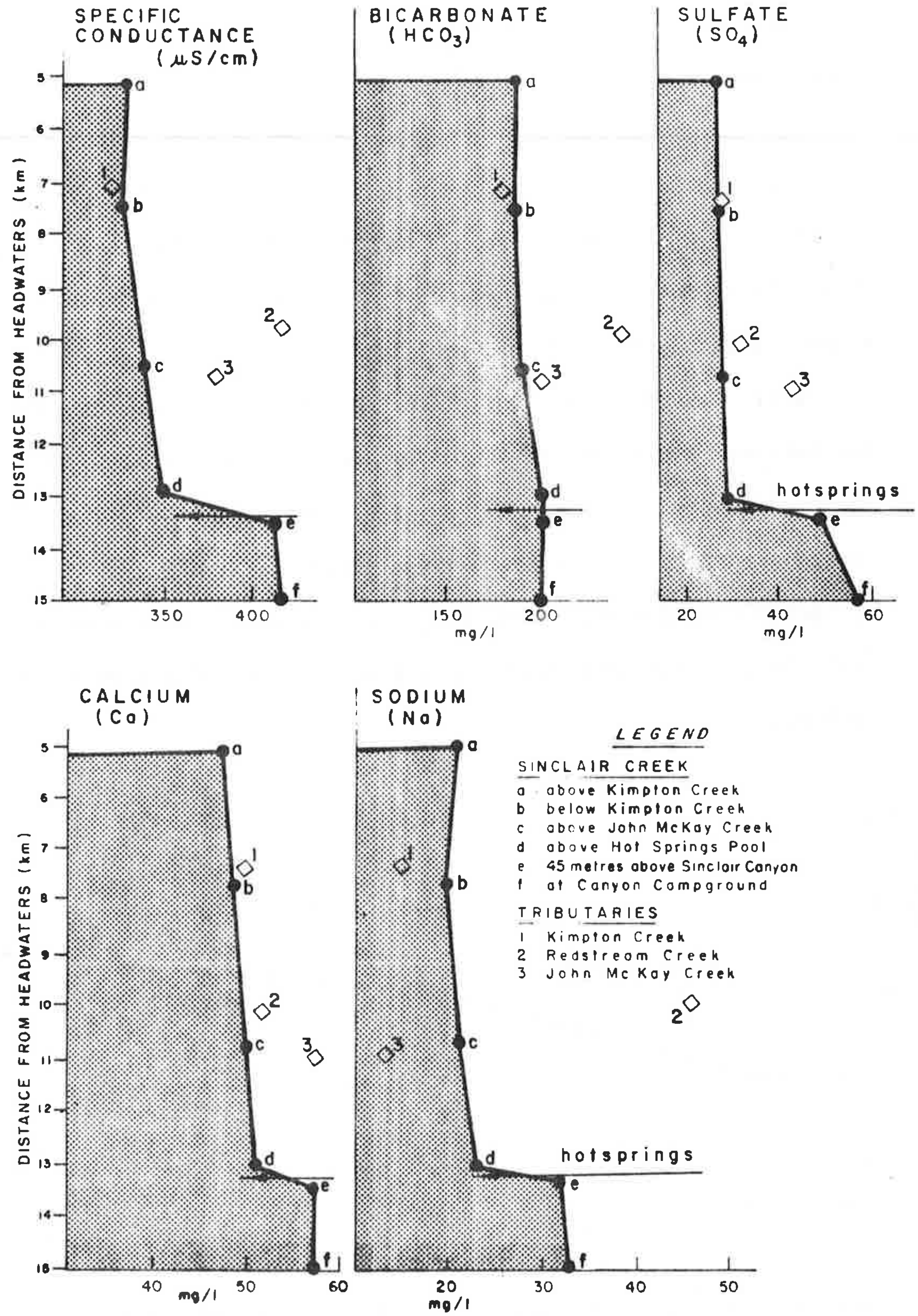


Figure 8. Spatial Distribution of Major Ions in Sinclair Creek as Illustrated by Mean Levels for the Period June 1975 to March 1976. Units are in mg/l Unless Otherwise Shown.

The temperature variability at most sites on Sinclair Creek is typical of mountain surface waters. As Figure 10 shows, the temperature of Sinclair Creek above Sinclair Canyon reflects the addition of hot spring waters.

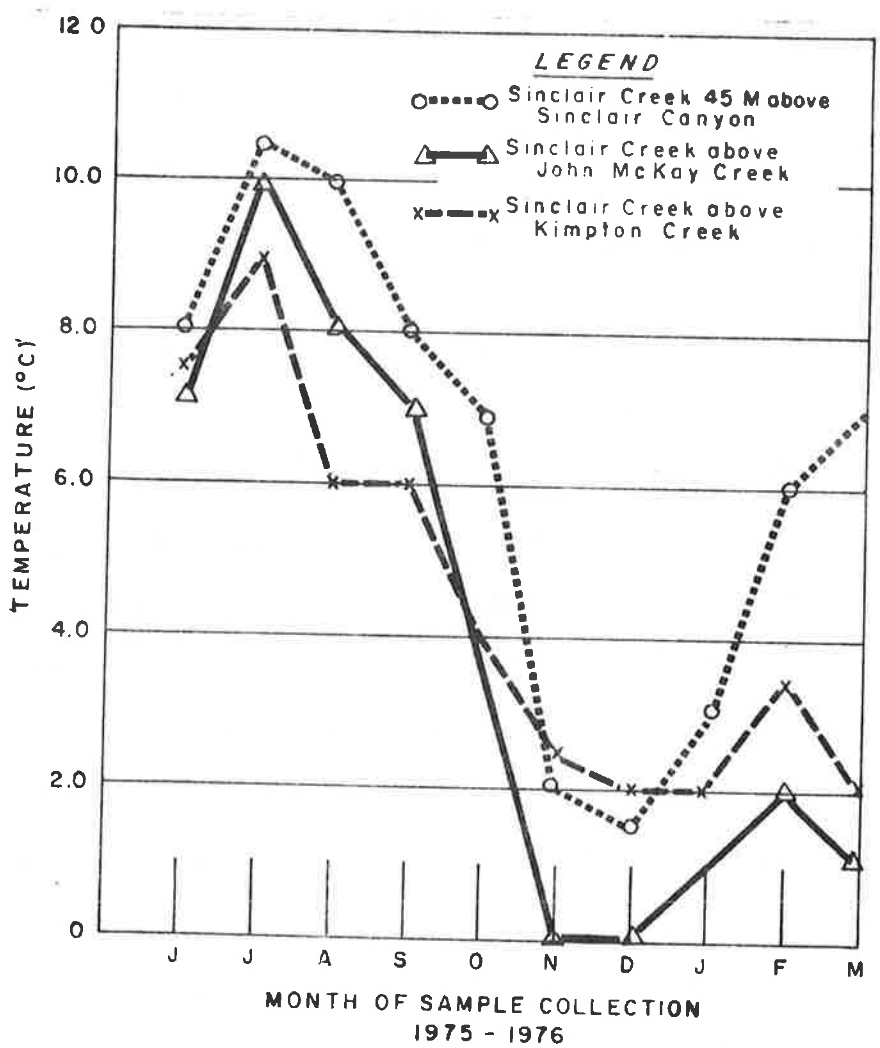


Figure 10. Spatial Comparison of Temperature in Sinclair Creek

consumption of drinking water having arsenic concentrations of 0.05 to 0.25 mg/l has been without ill effect (McKee and Wolfe, 1963).

Arsenic is absorbed from the gastrointestinal and respiratory systems. Symptoms of chronic arsenic poisoning are fatigue and loss of energy; more severe exposure leads to kidney degeneration, liver cirrhosis, hyperpigmentation and/or dermatitis of the skin (U.S. Environmental Protection Agency, 1976).

The lag time from the beginning of injestion to onset of lesions due to chronic arsenic poisoning is very long, 24 to 50 years (S. W. Reeder, Fisheries and Environment Canada, personal communication).

Permissible arsenic levels in drinking water have been addressed by many. In 1968, the World Health Organization established a permissible limit of 0.2 mg/l; the U.S. Environmental Protection Agency (1977) recommends 0.05 mg/l for domestic water supplies; the Canadian Drinking Water Standards (Health and Welfare, 1968) recommend a maximum permissible limit of 0.05 mg/l for drinking water purposes and an acceptable limit of 0.01 mg/l; and, the National Academy of Sciences (1974) recommends a maximum level of 0.1 mg/l total arsenic; the Alberta Department of Environment recommends a surface water objective of 0.01 mg/l (Alberta Environment, 1977).

Hullinjer (1975) states that the accumulation of arsenic even at low intake levels, can result in the appearances of chronic effects on the body and severe poisoning can occur from the intake of as little as 100 mg/l. He goes on to say that concentrations in most waters suitable for drinking do not ordinarily exceed 0.010 mg/l arsenic.

pose no real human health threat providing usage is seasonal or periodic. Long term-year-round usage may pose a health problem. There is some speculation that the operator of Canyon Campground may use the arsenic rich well water year round. This needs to be verified and the appropriate steps taken to advise the operator of the potential danger of drinking the contaminated well water over the long term.

The July survey of 1977 did locate a groundwater source possessing an arsenic concentration of 0.840 mg/l. Since people foster the idea that clear water is drinkable water, it would be good management to inform all Park visitors that natural impurities do exist and that whenever possible potable water from Park facilities should be utilized for consumption purposes.

It is not within the scope of this study to report on the structure of the biological community of Sinclair Creek. It is worth noting that arsenic has been reported to be quite toxic to microorganisms and lower aquatic organisms (NRC, 1977). It could be that the high arsenic concentrations present in Sinclair Creek since the birth of the hot springs thousands of years ago, are not at sufficiently high levels to affect the aquatic organisms. On the other hand, the long term effects of exposure to sublethal concentrations maybe as important as direct lethality, in that such exposure may limit development, growth, reproduction, metabolism or other physiologic processes (NRC, 1977). If arsenic in the lower reaches of Sinclair Creek, is sufficiently high to affect aquatic life, the species presently inhabiting Sinclair Creek have probably developed physiological adaptations to the arsenic rich environment.

V CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

Based on data from the ten month study, intensive surveys and regular monitoring, the following conclusions are drawn:

Arsenic is present in both surface water and groundwater throughout the Sinclair Creek Basin.

In the reach of Sinclair Creek above Redstreak Creek, arsenic concentrations are typically less than 0.005 mg/l. Between the confluence of Sinclair Creek with Kimpton Creek and the hot springs, groundwater inflow high in arsenic increases the arsenic levels in Sinclair Creek from a mean of 0.003 mg/l to 0.020 mg/l. Below the hot springs discharge from the Radium Aquacourt, the mean arsenic level in Sinclair Creek is about 0.035 mg/l. The three main tributaries in the basin, John McKay, Redstreak and Kimpton Creeks have mean arsenic levels of 0.001, 0.005 and 0.003 mg/l, respectively.

The inflow to the Radium Aquacourt hot pool has a mean arsenic concentration of 0.24 mg/l. The hot pool outflow and cold pool outflow have a mean arsenic level slightly lower than this, 0.23 and 0.20 mg/l, respectively. Local groundwater discharges contain arsenic at levels as high as 0.84 mg/l.

correlations. However, when correcting for the arsenic variability attributed to the log transformed flow, virtually all the strong correlations of arsenic to the other parameters disappear.

Arsenic levels in the hot springs were generally found to not correlate well with most of the other physical and chemical parameters measured.

The hot pool outflow arsenic levels correlate only with fluoride levels (r=0.926). The hot pool inflow arsenic levels correlate only with calcium and hardness, r=-0.882 and -0.874, respectively.

No other statistically significant correlations are evident from the data obtained.

John McKay Creek, the drinking water supply for Radium townsite and for the Aquacourt, is not contaminated with arsenic.

Arsenic concentrations in John McKay Creek varied between 0.0007 and 0.0013 mg/l with a median level of 0.0011 mg/l.

The Radium hot springs and the pools at the Aquacourt contain arsenic concentrations in excess of permissible concentrations for drinking water.

Since neither the spring nor the pool waters are intentionally consumed in large quantities there is likely no human health problem attributed to the high arsenic levels.

It is recommended that Park visitors be advised that mountain waters contain natural impurities and that Park-approved drinking water supplies be used whenever possible.

REFERENCES

Alberta Environment. 1977. Surface Water Quality Objectives. Edmonton.

Aston, S.R., I. Thornton, J.S. Webb, B.L. Milford and J.B. Purves. 1975. Arsenic in stream sediments and waters of South West England. Sci. Total Environ. 4: 347-358.

Baird, D.M. 1964. Kootenay National Park - Wild mountains and great valleys. Geol. Survey of Canada, Misc. Rept. 9, 94p.

Bean, Elwood L. 1974. Potable water quality goals. Journal AWWA. April.

Elworthy, R.T. 1918. Mineral Springs of Canada, Dept. of Mines, Bulletin No. 20, 173 p.

Goulden, P.D. and Deta Brooksbank. 1974. Automated Atomic Absorption Determination of Arsenic, Antimony and Selenium in Natural Waters, Analytical Chemistry, Vol. 46, P 1431-1436.

Health and Welfare Canada (1968). Canadian Drinking Water Standards and Objectives. Prepared by Joint Committee on Drinking Water Standards of Advisory Committee on Public Health Engineering and the Canadian Public Health Association, Ottawa.

Henderson, G.G.L. 1954. Geology of the Stanford Range of the Rocky Mountains. B.C. Dept. Mines, Bull. 35, 84p.

Hullinjer, David L. 1975. A study of heavy metals in Illinois impoundments. Journal AQQA. October.

Inland Waters Directorate. 1974. Analytical Methods Manual. Environment Canada.

Jackson, Robert and Jack W. Grainge. 1975. Arsenic and cancer. Can. med. Assoc. J. 113 (5); 396-401.

MacKay, B.R. 1952. Geology of the National Parks of Canada in the Rockies and Selkirks, Canadian Geog. Journal, Vol. 44, No.4, p.170-176.

McKee, J.E. and H.W. Wolfe. 1963. Water Quality Criteria. The Resources Agency of California, State Water Resources Control Board. Publication No. 3-A. Second Edition.

National Academy of Sciences. 1974. Water Quality Criteria 1972. Ecological Research Series, EPS-R3-73-033. Washington, D.C.

National Research Countil, 1977. Arsenic. National Academy of Sciences. Washington, D.C.

Nie, N.H. 1975. Statistical Package for the Social Sciences, 2nd Edition. Version SPSSH-Release 6.02.

APPENDIX A
DETAILED WATER QUALITY DATA

STATION 00BC08NA0004 LATITUDE 50D 37M 50S LONGITUDE 116D 4M 10S

SINCLAIR CREEK AT CANYON CAMPGROUND, BRITISH COLUMBIA

SAMPLE DATE D	M	Y	TIME MST H	M	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51302P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L
23	6	75	13	20	0.015				L.010
15	7	75	08	11	0.020	L.04	0.011		L.010
18	8	75	10	16	0.021	0.09	L.010		L.010
23	9	75	13	11	0.033	L.04	L.010		L.010
6	10	75	10	02	0.034	L.04	L.010		L.010
19	11	75	11	25	0.035	0.04	0.018		L.010
16	12	75	12	45	0.034	L.04	L.010	L.010	
15	1	76	10	42	0.041	0.04	0.025	L.010	
24	2	76	13	52	0.043	L.04	L.010	L.010	
16	3	76	12	40	0.078	0.05	L.010	L.010	

SAMPLE DATE D	M	Y	TIME MST H	M	02061S TEMP. WATER DEG.C.	02041S SPECIFIC CONDUCTANCE USIE/CM	10301S PH PH UNITS	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L
23	6	75	13	20	10.0	340	8.2	8.2	296	20.
15	7	75	08	11	11.0			8.2	328	25.
18	8	75	10	16	9.	420	8.4	8.3	353	37.
23	9	75	13	11	8.	500		8.3	400	51.
6	10	75	10	02	7.	460		8.4	402	52.
19	11	75	11	25	1.0		8.3	8.2	430	60.
16	12	75	12	45	1.0	344	8.3	8.2	428	58.
15	1	76	10	42	2.	377	8.2	8.2	451	67.
24	2	76	13	52	6.0	410	8.2	8.5	456	75.
16	3	76	12	40	7.	620		8.5	570	126.

SAMPLE DATE D	M	Y	TIME MST H	M	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
15	7	75	08	11	2.1	0.6	51.8	15.8	194.4
18	8	75	10	16	2.8	0.8	54.0	17.6	207.3
6	10	75	10	02	3.3	0.8	52.1	18.6	206.7
19	11	75	11	25	3.6	1.0	62.1	20.7	240.3
16	12	75	12	45	4.2	0.8	59.6	20.2	232.0
15	1	76	10	42	3.9	0.9	61.4	21.3	241.0

SAMPLE DATE D	M	Y	TIME MST H	M	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
15	7	75	08	11	1.4	145.	177	5.6	0.08	0.001
18	8	75	10	16	1.9	160.	188	7.0		0.003
6	10	75	10	02	2.7	167.	199	8.8	L.05	L.001
19	11	75	11	25	3.2	173.	211	9.4	L.05	L.001
16	12	75	12	45	3.8	169.	206	8.6	0.05	L.001
15	1	76	10	42	2.7	172.	203	9.4	0.06	L.001

STATION 00BC08NA0012 LATTITUDE 50D 38M 12S LONGITUNE 116D 1M 31S

SINCLATR CREEK ABOVE HOT SPRING POOLS

SAMPLE DATE D	M	Y	TIME MST H	M	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51302P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L
23	6	75	11	35	0.0080				L.010
15	7	75	09	30	0.012	L.04	L.010		L.010
18	8	75	10	59	0.013	0.10	L.010		L.010
23	9	75	14	48	0.016	L.04	L.010		L.010
7	10	75	10	34	0.017	L.04	L.010		L.010
19	11	75	12	30	0.017	L.04	L.010		L.010
17	12	75	11	05	0.019	L.04	L.010	L.010	
15	1	76	11	22	0.020	0.05	L.010	L.010	
24	2	76	14	15	0.022	L.04	L.010	L.010	
16	3	76	13	27	0.022	L.04	L.010	L.010	

SAMPLE DATE D	M	Y	TIME MST H	M	02061S TEMP WATER DEG.C.	02041S SPECIFIC CONDUCTANCE USIE/CM	10301S PH PH UNITS	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L
23	6	75	11	35	7.0	320	8.2	8.0	279	14.3
15	7	75	09	30	9.5			8.1	300	17.0
18	8	75	10	59	8.	390	8.4	8.4	316	26.
23	9	75	14	48	7.	420		8.3	356	33.
7	10	75	10	34	5.	400		8.4	359	30.
19	11	75	12	30	1.5			8.2	367	31.
17	12	75	11	05	1.0	247	8.2	8.2	375	32.
15	1	76	11	22	0.5	287	8.4	8.1	377	34.
24	2	76	14	15	3.0	333	8.1	8.4	378	36.
16	3	76	13	27	2.	430	8.3	8.4	388	39.

SAMPLE DATE D	M	Y	TIME MST H	M	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
15	7	75	09	30	1.6	0.6	47.0	14.7	177.9
18	8	75	10	59	2.0	0.8	49.0	16.5	190.3
7	10	75	10	34	2.4	0.8	50.8	19.0	205.1
19	11	75	12	30	3.5	0.6	52.0	18.9	207.7
17	12	75	11	05	2.8	0.6	52.7	19.2	210.6
15	1	76	11	22	2.4	0.7	53.0	19.4	212.2

SAMPLE DATE D	M	Y	TIME MST H	M	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
15	7	75	09	30	0.9	142.	173	4.6	0.08	L.001
18	8	75	10	59	1.3	159.	193	5.5		0.002
7	10	75	10	34	1.7	167.	201	6.0	L.05	L.001
19	11	75	12	30	2.6	169.	206	6.6	L.05	L.001
17	12	75	11	05	2.5	170.	207	5.9	L.05	0.001
15	1	76	11	22	1.5	172.	206	6.8	0.06	L.001

STATION 00BC08NA0014 LATITUDE 50D 38M 25S LONGITUDE 116D 0M 43S

SINCLAIR CREEK ABOVE JOHN MCKAY CREEK

SAMPLE DATE D	M	Y	TIME MST H	M	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51102P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L
23	6	75	11	10	0.0080				L.010
15	7	75	10	00	0.013	0.25	0.062		L.010
18	8	75	11	17	0.015	L.04	L.010		L.010
23	9	75	15	02	0.022	L.04	L.010		L.010
7	10	75	10	45	0.020	L.04	L.010		L.010
19	11	75	12	45	0.021	L.04	L.010		L.010
17	12	75	11	15	0.023	L.04	L.010	L.010	
15	1	76	11	32	0.025	0.06	L.010	L.010	
24	2	76	14	30	0.029	L.04	L.010	L.010	
16	3	76	13	38	0.028	L.04	L.010	L.010	

SAMPLE DATE D	M	Y	TIME MST H	M	020618 TEMP. WATER DEG.C.	020418 SPECIFIC CONDUCTANCE USIE/CM	103018 PH PH UNITS	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L
23	6	75	11	10	7.0	300	8.2	8.0	266	13.6
15	7	75	10	00	10.0			8.1	294	16.4
18	8	75	11	17	8.	380	8.1	8.3	307	24.
23	9	75	15	02	7.	395		8.3	344	30.
7	10	75	10	45	4.			8.3	350	30.
19	11	75	12	45	0.		8.0	8.2	353	29.
17	12	75	11	15	0.	255	8.4	8.2	354	30.
15	1	76	11	32	1.	283	8.3	7.8	367	37.
24	2	76	14	30	2.0	292	8.2	8.4	364	33.
16	3	76	13	38	1.	380		8.5	377	36.

SAMPLE DATE D	M	Y	TIME MST H	M	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
15	7	75	10	00	1.4	0.5	46.5	14.0	173.7
18	8	75	11	17	1.8	0.8	48.1	16.0	186.0
7	10	75	10	45	2.2	0.7	50.8	18.2	201.8
19	11	75	12	45	2.3	0.7	50.0	17.9	198.5
17	12	75	11	15	2.6	0.6	51.7	18.3	204.4
15	1	76	11	32	2.4	0.6	51.7	18.5	205.3

SAMPLE DATE D	M	Y	TIME MST H	M	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
15	7	75	10	00	1.0	139.	169	4.5	0.07	0.001
18	8	75	11	17	1.0	155.	183	5.3		0.003
7	10	75	10	45	1.5	160.	195	6.2	L.05	L.001
19	11	75	12	45	1.7	164.	200	6.2	L.05	L.001
17	12	75	11	15	1.8	167.	204	5.7	L.05	L.001
15	1	76	11	32	1.3	161.	196	6.2	L.05	L.001

STATION 00BC08NA0016 LATITUDE 50D 38M 45S LONGITUDE 115D 58M 30S

SINCLAIR CREEK BELOW KIMPTON CREEK (APPROXIMATELY 1.8 MILES ABOVE WORK COMPOUND)

SAMPLE DATE D	M	Y	TIME MST H	M	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51302P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L
23	6	75	10	20	0.0013				L.010
15	7	75	10	00	0.0022	L.04	L.010		L.010
18	8	75	11	47	0.0027	L.04	0.010		L.010
23	9	75	15	16	0.0032	L.04	L.010		L.010
7	10	75	11	03	0.0041	L.04	L.010		L.010
19	11	75	13	00	0.0040	L.04	L.010		L.010
17	12	75	11	35	0.0031	L.04	L.010	L.010	
15	1	76	11	50	0.0032	L.04	L.010	L.010	
24	2	76	14	40	0.0039	L.04	L.010	L.010	
16	3	76	14	05	0.0042	L.04	L.010	L.010	

SAMPLE DATE D	M	Y	TIME MST H	M	02061S TEMP. WATER DEG.C.	02041S SPECIFIC CONDUCTANCE USIE/CM	10301S PH PH UNITS	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L
23	6	75	10	20	5.5	285	8.2	7.9	261	13.3
15	7	75	10	00	8.5			8.1	266	15.3
18	8	75	11	47	6.	390	8.3	8.2	302	24.
23	9	75	15	16	6.	395		8.2	334	30.
7	10	75	11	03	4.			8.2	339	28.
19	11	75	13	00	1.0		8.2	8.1	342	28.
17	12	75	11	35	1.0	256	8.4	8.2	350	29.
15	1	76	11	50	2.	283	8.3	8.1	357	31.
24	2	76	14	40	2.5	287	8.2	8.3	354	32.
16	3	76	14	05	2.	405		8.3	368	35.

SAMPLE DATE D	M	Y	TIME MST H	M	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
15	7	75	10	00	1.4	0.4	45.9	13.3	169.4
18	8	75	11	47	1.8	0.6	47.0	14.6	177.5
7	10	75	11	03	2.0	0.8	43.8	15.1	171.5
19	11	75	13	00	2.0	0.6	50.1	16.1	191.4
17	12	75	11	35	2.5	0.6	51.8	16.8	198.5
15	1	76	11	50	2.1	0.5	51.2	17.0	197.8

SAMPLE DATE D	M	Y	TIME MST H	M	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
15	7	75	10	00	0.7	136.	166	4.3	0.06	L.001
18	8	75	11	47	0.8	149.	182	5.2		0.003
7	10	75	11	03	1.0	155.	189	6.2	L.05	0.001
19	11	75	13	00	1.0	157.	191	6.0	L.05	L.001
17	12	75	11	35	1.0	160.	195	5.5	L.05	L.001
15	1	76	11	50	1.0	161.	196	5.8	L.05	L.001

STATION 00BC08NA0018 LATITUDE 50D 39M 42S LONGITUDE 115D 57M 36S

SINCLAIR CREEK OPPOSITE PICNIC SITE ABOVE KIMPTON CREEK

SAMPLE DATE D	M	Y	TIME MST H	M	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51302P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L
23	6	75	10	00	L.0005				L.010
15	7	75	10	25	0.0007	L.04	0.012		L.010
18	8	75	12	09	0.0006	L.04	L.010		L.010
23	9	75	15	30	0.0010	L.04	L.010		L.010
7	10	75	11	15	0.0012	L.04	L.010		L.010
19	11	75	13	20	0.0031	0.21	0.066		L.010
17	12	75	11	45	0.0025	L.04	L.010	L.010	
15	1	76	12	00	0.0008	L.04	L.010	L.010	
24	2	76	15	00	0.0034	L.04	L.010	L.010	
16	3	76	14	18	0.0007	L.04	L.010	L.010	

SAMPLE DATE D	M	Y	TIME MST H	M	02061S TEMP. WATER DEG.C.	02041S SPECIFIC CONDUCTANCE USIE/CM	10301S PH PH UNITS	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L
23	6	75	10	00	7.5	275	8.4	7.9	246	10.
15	7	75	10	25	9.0			8.0	270	12.9
18	8	75	12	09	6.	380	8.3	8.2	299	22.
23	9	75	15	30	6.	390		8.2	334	28.
7	10	75	11	15	4.			8.3	337	25.
19	11	75	13	20	2.5		8.1	8.1	345	28.
17	12	75	11	45	2.0	266	8.4	8.2	348	28.
15	1	76	12	00	2.	309	8.3	8.1	370	37.
24	2	76	15	00	3.5	296	8.3	8.3	356	32.
16	3	76	14	18	2.	440		8.4	399	46.

SAMPLE DATE D	M	Y	TIME MST H	M	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
15	7	75	10	25	1.4	0.3	43.2	12.5	159.3
18	8	75	12	09	1.9	0.4	46.0	14.3	173.7
7	10	75	11	15	2.2	0.5	45.1	15.6	176.8
19	11	75	13	20	2.3	0.6	48.9	17.6	194.6
17	12	75	11	45	2.6	0.7	49.8	17.3	195.6
15	1	76	12	00	2.2	0.5	52.7	18.1	206.1

SAMPLE DATE D	M	Y	TIME MST H	M	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
15	7	75	10	25	0.6	130.	158	4.0	0.06	L.001
18	8	75	12	09	0.9	147.	179	5.0		0.003
7	10	75	11	15	1.6	156.	190	5.8	L.05	L.001
19	11	75	13	20	1.7	159.	194	6.2	L.05	0.002
17	12	75	11	45	2.0	162.	197	5.4	L.05	L.001
15	1	76	12	00	1.8	164.	194	5.6	L.05	L.001

STATION 11BC08NA0002 LATITUDE 50D 38M 3S LONGITUDE 116D 2M 28S

RADIUM HOT SPRINGS - COLD POOL OUTFLOW

SAMPLE DATE D	M	Y	TIME MST H	M	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51302P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L
23	6	75	11	55	0.27				L.010
15	7	75	09	05	0.19	L.04	L.010		L.010
18	8	75	12	43	0.17	0.04	L.010		L.010
23	9	75	14	02	0.23	L.04	L.010		L.010
6	10	75	09	27	0.22	L.04	L.010		L.010
19	11	75	12	15	0.20	0.17	L.010		L.010
17	12	75	10	45	0.19	0.30	0.010	L.010	
15	1	76	11	16	0.19	0.14	0.021	L.010	
24	2	76	13	12	0.18	1.1	0.025	L.010	

SAMPLE DATE D	M	Y	TIME MST H	M	02061S TEMP. WATER DEG.C.	02041S SPECIFIC CONDUCTANCE USIE/CM	10301S PH PH UNITS	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L
23	6	75	11	55	28.0	950	6.9	7.3	834	280.
15	7	75	09	05	27.0			7.3	718	195.
18	8	75	12	43	26.	900	6.8	7.4	749	244.
23	9	75	14	02	29.	990		7.4	872	245.
6	10	75	09	27	28.	975		7.7	878	300.
19	11	75	12	15	33.0		7.2	7.5	882	295.
17	12	75	10	45	30.5	730	7.4	7.7	869	290.
15	1	76	11	16	28.0	770	7.5	7.7	898	298.
24	2	76	13	12	34.0	1025	7.1	7.6	876	305.

SAMPLE DATE D	M	Y	TIME MST H	M	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
15	7	75	09	05	9.3	2.2	102.	28.7	372.9
18	8	75	12	43	11.6	2.6	120.0	29.6	421.5
6	10	75	09	27	13.5	2.6	139.	36.0	495.3
19	11	75	12	15	13.5	2.8	139.	34.0	487.1
17	12	75	10	45	13.8	2.8	143.	36.0	505.3
15	1	76	11	16	13.5	2.5	131.	35.0	471.2

SAMPLE DATE D	M	Y	TIME MST H	M	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
15	7	75	09	05	19.5	145.	177	23.0	0.25	0.002
18	8	75	12	03	23.3	153.	187	30.0		0.006
6	10	75	09	27	11.8	168.	205	34.2	0.14	0.001
19	11	75	12	15	12.0	170.	207	40.0	0.10	0.001
17	12	75	10	45	10.0	171.	208	34.6	0.13	0.002
15	1	76	11	16	9.7	170.	207	36.2	0.14	L.001

APPENDIX B
WATER QUALITY DATA SUMMARY

STATION 00BC08NA0004 LAT. 50D 37M 50S LONG. 116D 4M 10S

SINCLAIR CREEK AT CANYON CAMPGROUND, BRITISH COLUMBIA

	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51302P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L	02061S TEMP. WATER DEG.C.	02041S SPECIFIC CONDUCTANCE USIE/CM	10301S PH PH UNITS
SAMPLES	10	9	9	4	6	10	8	6
LOW	0.015	L.04	L.01	L.010	L.010	1.0	340	8.2
HIGH	0.078	0.09	0.03	L.010	L.010	11.0	620	8.4
AVERAGE	0.035	0.05	0.01			6.2	434	
STD.DEV.	0.018	0.02	0.01			3.7	93	
PERCNTI 10TH	0.018	L.04	L.01			1.0		
25TH	0.021	L.04	L.01	L.010	L.010	2.	361	8.2
MEDIAN 50TH	0.034	L.04	L.01	L.010	L.010	7.	417	8.3
75TH	0.041	0.04	0.01	L.010	L.010	9.	480	8.3
90TH	0.061	0.09	0.03			10.5		
BACKUP CODES								

	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
SAMPLES	10	10	10	6	6	6	6	6
LOW	8.2	296	20.	2.1	0.6	51.8	15.8	194.4
HIGH	8.5	570	126.	4.5	1.0	62.1	21.3	241.0
AVERAGE		411	57.	3.3	0.8	56.8	19.0	220.3
STD.DEV.		77	30.	0.8	0.1	4.7	2.1	20.[illegible]
PERCNTI 10TH	8.2	312	23.					
25TH	8.2	355	37.	2.8	0.8	52.1	17.6	206.7
MEDIAN 50TH	8.3	416	55.	3.4	0.8	56.8	19.8	210.7
75TH	8.4	451	67.	3.9	0.9	61.4	20.7	240.3
90TH	8.5	513	101.					
BACKUP CODES								

	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
SAMPLES	6	6	6	6	5	6
LOW	1.4	145.	177	5.6	L.05	L.001
HIGH	3.8	173.	211	9.4	0.08	0.003
AVERAGE	2.6	160.	197	8.1	0.06	0.001
STD.DEV.	0.9	11.	13	1.5	0.01	0.001
PERCNTI 10TH						
25TH	1.9	160.	188	7.0	L.05	L.001
MEDIAN 50TH	2.7	168.	201	8.7	0.05	L.001
75TH	3.2	172.	206	9.4	0.06	0.001
90TH						
BACKUP CODES						

STATION 00BC08NA0012 LAT. 50D 38M 12S LONG. 116D 1M 31S

SINCLAIR CREEK ABOVE HOT SPRING POOLS

	33104L ARSENIC DISSOLVED	26304P IRON EXTRBLE.	25304P MANGANESE EXTRBLE.	51302P ANTIMONY EXTRBLE.	51102L ANTIMONY DISSOLVED	02061S TEMP. WATER	02041S SPECIFIC CONDUCTANCE	10301S PH
	AS MG/L	FE MG/L	MN MG/L	SB MG/L	SB MG/L	DEG.C.	USIE/CM	PH UNITS
SAMPLES	10	9	9	4	6	10	8	6
LOW	0.0080	L.04	L.01	L.010	L.010	0.5	247	8.1
HIGH	0.022	0.10	L.01	L.010	L.010	9.5	430	8.4
AVERAGE	0.017	0.05				4.5	353	
STD.DEV.	0.005	0.02				3.3	67	
PERCNT: 10TH	0.010	L.04	L.01			0.8		
25TH	0.013	L.04	L.01	L.010	L.010	1.5	304	8.2
MEDIAN 50TH	0.017	L.04	L.01	L.010	L.010	4.0	362	8.3
75TH	0.020	L.04	L.01	L.010	L.010	7.0	410	8.4
90TH	0.022	0.10	L.01			9.0		
BACKUP CODES								

	10301L PH	02041L SPECIFIC CONDUCTANCE	16306L SULPHATE DISSOLVED	11103L SODIUM DISSOLVED	19103L POTASSIUM DISSOLVED	20103L CALCIUM DISSOLVED	12102L MAGNESIUM DISSOLVED	10602L HARDNESS TOTAL (CALCD.) CACO3
	PH UNITS	USIE/CM	SO4 MG/L	NA MG/L	K MG/L	CA MG/L	MG MG/L	MG/L
SAMPLES	10	10	10	6	6	6	6	6
LOW	8.0	279	14.3	1.6	0.6	47.0	14.7	177.9
HIGH	8.4	388	39.	2.8	0.8	53.0	19.4	212.2
AVERAGE		350	29.	2.3	0.7	50.8	18.0	200.6
STD.DEV.		38	8.	0.4	0.1	2.3	1.9	13.6
PERCNT: 10TH	8.1	290	14.1					
25TH	8.1	316	26.	2.0	0.6	49.0	16.5	190.3
MEDIAN 50TH	8.3	363	32.	2.4	0.7	51.4	19.0	206.4
75TH	8.4	377	34.	2.5	0.8	52.7	19.2	210.6
90TH	8.4	383	38.					
BACKUP CODES								

	17206L CHLORIDE DISSOLVED	10101L ALKALINITY TOTAL	06201L BICARBONT. (CALCD.)	14102L SILICA REACTIVE	09105L FLUORIDE DISSOLVED	29305P COPPER EXTRBLE.
	CL MG/L	CACO3 MG/L	HCO3 MG/L	SIO2 MG/L	F MG/L	CU MG/L
SAMPLES	6	6	6	6	5	6
LOW	0.9	142.	173	4.6	L.05	L.001
HIGH	2.6	172.	207	6.8	0.08	0.002
AVERAGE	1.8	163.	198	5.9	0.06	0.001
STD.DEV.	0.7	11.	13	0.8	0.01	0.000
PERCNT: 10TH						
25TH	1.3	159.	193	5.5	L.05	L.001
MEDIAN 50TH	1.6	168.	204	6.0	L.05	L.001
75TH	2.5	170.	206	6.6	0.06	0.001
90TH						
BACKUP CODES						

STATION 00BC08NA0014 LAT. 50D 38M 25S LONG. 116D 0M 43S

SINCLAIR CREEK ABOVE JOHN MCKAY CREEK

	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51302P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L	02061S TEMP. WATER DEG.C.	02041S SPECIFIC CONDUCTANCE USIE/CM	10301S PH PH UNITS
SAMPLES	10	9	9	4	6	10	7	6
LOW	0.0080	L.04	L.01	L.010	L.010	0.	255	8.[illegible]
HIGH	0.029	0.25	0.06	L.010	L.010	10.0	395	8.4
AVERAGE	0.020	0.07	0.02			4.0	326	
STD.DEV.	0.007	0.07	0.02			3.7	57	
PERCNT: 10TH	0.011	L.04	L.01			0.		
25TH	0.015	L.04	L.01	L.010	L.010	1.	283	8.1
MEDIAN 50TH	0.022	L.04	L.01	L.010	L.010	3.	300	8.2
75TH	0.025	L.04	L.01	L.010	L.010	7.	360	8.[illegible]
90TH	0.029	0.25	0.06			9.		
BACKUP CODES								

	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
SAMPLES	10	10	10	6	6	6	6	6
LOW	7.8	266	13.6	1.4	0.5	46.5	14.0	173.7
HIGH	8.5	377	37.	2.6	0.8	51.7	18.5	205.3
AVERAGE		338	28.	2.1	0.7	49.8	17.2	195.0
STD.DEV.		36	8.	0.4	0.1	2.1	1.8	12.6
PERCNT: 10TH	7.9	280	15.0					
25TH	8.1	302	24.	1.8	0.6	48.1	16.0	186.0
MEDIAN 50TH	8.3	352	30.	2.2	0.7	50.4	18.1	200.2
75TH	8.3	364	35.	2.4	0.7	51.7	18.3	204.0
90TH	8.5	372	37.					
BACKUP CODES								

	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
SAMPLES	6	6	6	6	5	6
LOW	1.0	139.	169	4.5	L.05	L.001
HIGH	1.8	167.	204	6.2	0.07	0.003
AVERAGE	1.4	158.	191	5.7	0.05	0.001
STD.DEV.	0.3	10.	13	0.7	0.01	0.001
PERCNT: 10TH						
25TH	1.0	155.	183	5.3	L.05	L.001
MEDIAN 50TH	1.4	161.	196	6.0	L.05	L.001
75TH	1.7	164.	200	6.2	L.05	0.001
90TH						
BACKUP CODES						

STATION 00BC08NA0016 LAT. 50D 38M 45S LONG. 115D 58M 30S

SINCLAIR CREEK BELOW KIMPTON CREEK (APPROXIMATELY 1.8 MILES ABOVE WORK COMPOUND)

	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51302P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L	02061S TEMP. WATER DEG.C.	02041S SPECIFIC CONDUCTANCE USIE/CM	10301S PH PH UNITS
SAMPLES	10	9	9	4	6	10	7	6
LOW	0.0013	L.04	L.01	L.010	L.010	1.0	256	8.2
HIGH	0.0042	L.04	0.01	L.010	L.010	8.5	405	8.4
AVERAGE	0.0032		0.01			3.9	329	
STD.DEV.	0.0009		0.00			2.6	65	
PERCNT: 10TH	0.0018	L.04	L.01			1.0		
25TH	0.0027	L.04	L.01	L.010	L.010	2.	263	8.2
MEDIAN 50TH	0.0032	L.04	L.01	L.010	L.010	3.	287	8.3
75TH	0.0040	L.04	L.01	L.010	L.010	6.	395	8.3
90TH	0.0042	L.04	0.01			7.		
BACKUP CODES								

	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
SAMPLES	10	10	10	6	6	6	6	6
LOW	7.9	261	13.3	1.4	0.4	43.8	13.3	169.4
HIGH	8.3	368	35.	2.5	0.8	51.8	17.0	198.5
AVERAGE		320	27.	2.0	0.6	48.3	15.5	184.4
STD.DEV.		35	7.	0.4	0.1	3.2	1.4	13.2
PERCNT: 10TH	8.0	274	14.3					
25TH	8.1	302	20.	1.8	0.5	45.9	14.6	171.5
MEDIAN 50TH	8.2	341	29.	2.0	0.6	48.6	15.6	184.5
75TH	8.2	354	31.	2.1	0.6	51.2	16.8	197.8
90TH	8.3	363	34.					
BACKUP CODES								

	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
SAMPLES	6	6	6	6	5	6
LOW	0.7	136.	166	4.3	L.05	L.001
HIGH	1.4	161.	196	6.2	0.06	0.003
AVERAGE	1.0	153.	187	5.5	0.05	0.001
STD.DEV.	0.2	9.	11	0.7	0.00	0.001
PERCNT: 10TH						
25TH	0.8	149.	182	5.2	L.05	L.001
MEDIAN 50TH	1.0	156.	190	5.7	L.05	L.001
75TH	1.0	160.	195	6.0	L.05	0.001
90TH						
BACKUP CODES						

STATION 00BC08NA0018 LAT. 50D 39M 42S LONG. 115D 57M 36S

SINCLAIR CREEK OPPOSITE PICNIC SITE ABOVE KIMPTON CREEK

	33104L ARSENIC DISSOLVED	26304P IRON EXTRBLE.	25304P MANGANESE EXTRBLE.	51302P ANTIMONY EXTRBLE.	51102L ANTIMONY DISSOLVED	02061S TEMP WATER	02041S SPECIFIC CONDUCTANCE	10301S PH
	AS MG/L	FE MG/L	MN MG/L	SB MG/L	SB MG/L	DEG.C.	USIE/CM	PH UNITS
SAMPLES	10	9	9	4	6	10	7	6
LOW	L.0005	L.04	L.01	L.010	L.010	2.	266	8.1
HIGH	0.0034	0.21	0.07	L.010	L.010	9.0	440	8.4
AVERAGE	0.0014	0.06	0.02			4.5	337	
STD.DEV.	0.0011	0.06	0.02			2.5	67	
PERCNT: 10TH	0.0006	L.04	L.01			2.		
25TH	0.0007	L.04	L.01	L.010	L.010	2.	275	8.3
MEDIAN 50TH	0.0009	L.04	L.01	L.010	L.010	4.	309	8.3
75TH	0.0025	L.04	L.01	L.010	L.010	6.	390	8.4
90TH	0.0033	0.21	0.07			8.3		
BACKUP CODES								

	10301L PH	02041L SPECIFIC CONDUCTANCE	16306L SULPHATE DISSOLVED	11103L SODIUM DISSOLVED	19103L POTASSIUM DISSOLVED	20103L CALCIUM DISSOLVED	12102L MAGNESIUM DISSOLVED	10602L HARDNESS TOTAL (CALCD.) CACO3
	PH UNITS	USIE/CM	SO4 MG/L	NA MG/L	K MG/L	CA MG/L	MG MG/L	MG/L
SAMPLES	10	10	10	6	6	6	6	6
LOW	7.9	246	10.	1.4	0.3	43.2	12.5	159.3
HIGH	8.4	399	46.	2.6	0.7	52.7	18.1	206.1
AVERAGE		331	27.	2.1	0.5	47.6	15.9	184.6
STD.DEV.		47	11.	0.4	0.1	3.5	2.2	17.3
PERCNT: 10TH	8.0	258	11.					
25TH	8.1	299	22.	1.9	0.4	45.1	14.3	173.7
MEDIAN 50TH	8.2	341	28.	2.2	0.5	47.5	16.5	185.7
75TH	8.3	356	32.	2.3	0.6	48.8	17.6	195.6
90TH	8.4	389	42.					
BACKUP CODES								

	17206L CHLORIDE DISSOLVED	10101L ALKALINITY TOTAL	06201L BICARBONT. (CALCD.)	14102L SILICA REACTIVE	09105L FLUORIDE DISSOLVED	29305P COPPER EXTRBLE.
	CL MG/L	CACO3 MG/L	HCO3 MG/L	SIO2 MG/L	F MG/L	CU MG/L
SAMPLES	6	6	6	6	5	6
LOW	0.6	130.	158	4.0	L.05	L.001
HIGH	2.0	164.	197	6.2	0.06	0.003
AVERAGE	1.4	153.	185	5.3	0.05	0.001
STD.DEV.	0.6	13.	15	0.8	0.00	0.001
PERCNT: 10TH						
25TH	0.9	147.	179	5.0	L.05	L.001
MEDIAN 50TH	1.7	158.	192	5.5	L.05	L.001
75TH	1.8	162.	194	5.8	L.05	0.002
90TH						
BACKUP CODES						

STATION 11BC08NA0002 LAT. 50D 38M 3S LONG. 116D 2M 28S

RADIUM HOT SPRINGS - COLD POOL OUTFLOW

	33104L ARSENIC DISSOLVED AS MG/L	26304P IRON EXTRBLE. FE MG/L	25304P MANGANESE EXTRBLE. MN MG/L	51302P ANTIMONY EXTRBLE. SB MG/L	51102L ANTIMONY DISSOLVED SB MG/L	02061S TEMP. WATER DEG.C.	02041S SPECIFIC CONDUCTANCE USIE/CM	10301S PH PH UNITS
SAMPLES	9	8	8	3	6	8	7	6
LOW	0.17	L.04	L.01	L.010	L.010	26.	730	6.8
HIGH	0.27	1.1	0.03	L.010	L.010	34.0	1025	7.5
AVERAGE	0.20	0.2	0.01			29.3	906	
STD.DEV.	0.03	0.4	0.01			2.7	114	
PERCNT: 10TH	0.17					26.		
25TH	0.19	L.04	L.01		L.010	28.	770	6.9
MEDIAN 50TH	0.19	0.09	L.01	L.010	L.010	28.0	950	7.2
75TH	0.22	0.24	0.02		L.010	30.5	990	7.4
90TH	0.27					34.0		
BACKUP CODES								

	10301L PH PH UNITS	02041L SPECIFIC CONDUCTANCE USIE/CM	16306L SULPHATE DISSOLVED SO4 MG/L	11103L SODIUM DISSOLVED NA MG/L	19103L POTASSIUM DISSOLVED K MG/L	20103L CALCIUM DISSOLVED CA MG/L	12102L MAGNESIUM DISSOLVED MG MG/L	10602L HARDNESS TOTAL (CALCD.) CACO3 MG/L
SAMPLES	9	9	9	6	6	6	6	6
LOW	7.3	718	195.	9.3	2.2	102.	28.7	372.9
HIGH	7.7	898	305.	13.8	2.8	143.	36.0	505.3
AVERAGE		842	272.	12.5	2.6	129.	33.2	458.9
STD.DEV.		64	37.	1.8	0.2	16.	3.2	51.4
PERCNT: 10TH	7.3	718	195.					
25TH	7.4	830	245.	11.6	2.5	120.0	29.6	421.5
MEDIAN 50TH	7.5	872	290.	13.5	2.6	135.	34.5	478.2
75TH	7.7	878	298.	13.5	2.8	139.	36.0	495.3
90TH	7.7	898	305.					
BACKUP CODES								

	17206L CHLORIDE DISSOLVED CL MG/L	10101L ALKALINITY TOTAL CACO3 MG/L	06201L BICARBONT. (CALCD.) HCO3 MG/L	14102L SILICA REACTIVE SIO2 MG/L	09105L FLUORIDE DISSOLVED F MG/L	29305P COPPER EXTRBLE. CU MG/L
SAMPLES	6	6	6	6	5	6
LOW	9.7	145.	177	23.0	0.10	L.001
HIGH	23.3	171.	208	40.0	0.25	0.006
AVERAGE	14.4	163.	199	33.0	0.15	0.002
STD.DEV.	5.6	11.	13	5.9	0.06	0.002
PERCNT: 10TH						
25TH	10.0	153.	187	30.0	0.13	0.001
MEDIAN 50TH	11.9	169.	206	34.4	0.14	0.002
75TH	19.5	170.	207	36.2	0.14	0.002
90TH						
BACKUP CODES						