MINISTRY OF ENVIRONMENT
PROVINCE OF BRITISH COLUMBIA

# WATER QUALITY ASSESSMENT AND OBJECTIVES OKANAGAN AREA TRIBUTARIES TO OKANAGAN LAKE NEAR KELOWNA

**(Kelowna, Brandt's and Mission Creeks)**

TECHNICAL APPENDIX

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# TABLE OF CONTENTS

## TABLE OF CONTENTS (Continued)

# LIST OF TABLES

# LIST OF FIGURES

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To these people we express our thanks.

# 1. INTRODUCTION

## 1.1 BACKGROUND

The British Columbia Ministry of Environment is preparing water quality assessments and objectives in priority water basins in British Columbia. This report describes the water quality within certain selected tributaries to the central portion of Okanagan Lake on its east shore near Kelowna (Figure 1). Presented in this report are data collected to April 1988. The objectives are being prepared as part of a fisheries management plan for tributaries to Okanagan Lake.

Four additional reports evaluating water quality in other selected tributaries to Okanagan Lake are in preparation. One report deals with Peachland, Trepanier, Westbank, Lambly, Faulkner, and Powers creeks; a second deals with Lower Vernon, Equesis and Deep creeks; a third deals with Eneas, Trout, and Prairie creeks; while the fourth deals with Penticton and Naramata creeks.

In addition, a water quality assessment of turbidity and suspended solids concentrations in Hydraulic Creek, a tributary to Mission Creek, is being undertaken[20].

## 1.2 PROVISIONAL WATER QUALITY OBJECTIVES - BASIC PHILOSOPHY

Water quality objectives are established in British Columbia for water bodies on a site-specific basis[1]. The objective can be a physical, chemical or biological characteristic of water, biota or sediment, which will protect the most sensitive designated water use at a specific location with an adequate degree of safety[1]. The objectives are aimed at protecting the most sensitive designated water use with due regard to ambient water quality, aquatic life, waste discharges and socio-economic factors[1].

Water quality objectives are based upon approved or working water quality criteria which are characteristics of water, biota, or sediment [1] that must not be exceeded to prevent specified detrimental effects from occurring to a water use[1]. The working criteria upon which many of the proposed provisional objectives are based come from the literature, and are referenced in the following chapters. The B.C. Ministry of Environment is in the process of developing approved criteria for water quality characteristics throughout British Columbia, to form part of the basis for permanent objectives.

As a general rule, objectives are only set in water bodies where man-made influences threaten a designated water use, either now or in the future. Provisional objectives are proposed in this report, and are to be reviewed as more monitoring information becomes available and as the Ministry of Environment establishes more approved water quality criteria.

The provisional objectives take into account the use of the water to be protected and the existing water quality. They allow for changes from background which can be tolerated, or for upgrading which may be required. Any change from background which is allowed indicates that some waste assimilative capacity can be used while still maintaining a good margin of safety to protect designated water uses. In cases of water quality degradation, objectives will set a goal for corrective measures.

The objectives do not apply to initial dilution zones of effluents. These zones in rivers are defined as extending up to 100 m downstream from a discharge, and occupying no more than 50 percent of the width of the river, from its bed to the surface. In lakes, initial dilution zones are defined as extending up to 100 m horizontally in all directions from the discharge, but not to exceed 25% of the width of the water body.

In cases where there are many effluents discharged, there could be some concern about the additive effect of dilution zones in which water quality objectives may be exceeded. Permits issued pursuant to the Waste Management Act control effluent quality which in turn determine the extent of initial dilution zones and the severity of conditions within them. In practice, small volume discharges or discharges with low levels of contaminants will require mixing zones much smaller than the maximum dilution zone allowed. The concentrations of contaminants permitted in effluents are such that levels in the dilution zones will not be acutely toxic to aquatic life or create objectionable or nuisance conditions. Processes such as chemical changes, precipitation, adsorption and microbiological action, as well as dilution, take place in these zones to ensure that water quality objectives will be met at their border.

## 1.3 DESCRIPTION OF WATERSHEDS

### 1.3.1 MISSION CREEK

Mission Creek enters Okanagan Lake from the east, on the south side of Kelowna (Figure 3). Its headwaters are at Mission Lake, approximately 67 km upstream from Okanagan Lake. From Mission Lake, Mission Creek descends at an average slope of 22 m/km. About 6 km upstream from the mouth of Mission Creek, a man-made diversion from Kelowna (Mill) Creek enters Mission Creek.

Anthropogenic activity along Mission Creek is generally downstream from the confluence of Joe Rich Creek, since there are no developed all weather roads upstream from this point. Joe Rich Creek joins Mission Creek from the south, at about mid-length.

A description of logging and agricultural activities is in Chapter 5.

### 1.3.2 KELOWNA (MILL) CREEK

Kelowna (Mill) Creek enters Okanagan Lake from the east, just south from the bridge which spans Okanagan Lake to Westside (Figure 2). Its headwaters are at Postill Lake, approximately 31 km upstream from Okanagan Lake. From Postill Lake, Kelowna Creek descends at an average slope of 33 m/km.

Anthropogenic activity along Kelowna Creek is generally downstream from the south end of Ellison Lake, since there are no developed all-weather roads upstream from this point. A description of logging and agricultural activities is in Chapter 5.

### 1.3.3 BRANDT'S CREEK

Brandt's Creek enters Okanagan Lake from the east, just north from the bridge which spans Okanagan Lake to Westside (Figure 2). It is considerably shorter than the other two creeks. Almost the entire watershed is within the City of Kelowna's political boundaries.

# 2. HYDROLOGY

Flows for creeks discussed in this technical appendix are regulated, so that frequency analysis cannot be performed. It is also difficult to discuss flow regimes; however, natural flows would likely have seen freshet occur during spring with snowmelt and with flows typically diminishing during the hot summer months.

## 2.1 MISSION CREEK

Mission Creek is regulated by a dam at the outlet of Mission Lake. It has a tributary area of over 810 $km^2$. Seven-day low flows at Station 08NM116 near the mouth for those years with a complete data set (n=20), have ranged from 0.194 $m^3/s$ (October 1973) to 1.05 $m^3/s$ (January 1982), with a mean 7-day low flow of 0.60 $m^3/s$. Low flows generally occur between December and February, although they have occurred in most months of the year, except May and June.

A more limited data base exists for flows on Mission Creek at Station 08NM233 located above the confluence of Pearson Creek, where there is a drainage area of 233 $km^2$. Seven-day low flows, for those years with a complete data set (n=5), have ranged from 0.125 $m^3/s$ (January 1980) to 0.299 $m^3/s$ (February 1981), with a mean 7-day low flow of 0.217 $m^3/s$. Low flows occurred between November and March.

Complete flow records exist for both Stations 08NM116 and 08NM233 only for the period 1978 to 1982. Low flows were as follows:

| | 7-day low flows ($m^3/s$) | |
|---|---|---|
| | 08NM233 | 08NM116 |
| 1978 | 0.240 (Jan) | 0.686 (Jan) |
| 1979 | 0.192 (Nov) | 0.437 (Sept) |
| 1980 | 0.125 (Jan) | 0.655 (Jan) |
| 1981 | 0.299 (Feb) | 0.885 (Sept) |
| 1982 | 0.201 (Mar) | 1.050 (Jan) |

These data indicate that the large drainage area downstream from Pearson Creek contributes significant flows which can alter the timing of low flows.

## 2.2 KELOWNA CREEK

Kelowna (Mill) Creek has a tributary area of over 220 $km^2$. Seven-day low flows at Station 08NM053 near Kelowna, for those years with a complete data set (n=19), have ranged from 0.136 $m^3/s$ (August 1973) to 0.295 $m^3/s$ (January 1982), with a mean 7-day low flow of 0.199 $m^3/s$. Low flows generally occur between July and August (n=11) or less frequently between January and February (n=5).

A more limited data base exists for flows on Kelowna Creek at Station 08NM117 located near the Kelowna Airport, with a drainage area of 162 $km^2$. Seven-day low flows, for years with a complete data set (n=3), have ranged from 0.067 $m^3/s$ (July 1971) to 0.105 $m^3/s$ (April 1972), with a mean flow of 0.084 $m^3/s$.

Complete flow records exist for both Stations 08NM053 and 08NM117 for only the period 1971 to 1973. Low flows (7-day) were as follows:

| | 7-day low flows ($m^3/s$) | |
|---|---|---|
| | 08NM117 | 08NM053 |
| 1971 | 0.067 (July) | 0.210 (July) |
| 1972 | 0.105 (April) | 0.214 (August) |
| 1973 | 0.080 (August) | 0.136 (August) |

These data seem to suggest that the drainage area downstream from Rutland (35.8% increase) can contribute at least a 70% increase (based on flows in 1973) in seven-day low flows.

## 2.3 BRANDT'S CREEK

Flows were measured in Brandt's Creek at Station 08NM152 in 1972, 1973, and 1975. Seven day low flows were 0.012 $m^3/s$, 0.034 $m^3/s$, and 0.023 $m^3/s$, respectively for a mean 7-day low flow of 0.023 $m^3/s$. Low flows appear to occur in the summer from June to August. Brandt's Creek is a very small local creek which flows through the Kelowna industrial area.

# 3. WATER USES

## 3.1 MISSION CREEK

The Ministry of Environment has ranked tributary streams to Okanagan Lake which support spawning populations of kokanee and/or rainbow trout on the basis of suitable and available habitat, present use, present and projected conflicts, and land status. Mission Creek was the most important of all tributaries in this ranking process. Salmon do not use the tributaries to Okanagan Lake for spawning, since they generally do not go upstream from Skaha Lake.

There are 195 licensed withdrawals from Mission Creek, with consumption as follows:

Domestic Use*: 93.2 $m^3/d$
Irrigation : 235 $dam^3/a$

* Includes stock watering and drinking water supplies.

## 3.2 KELOWNA CREEK

In its evaluation of tributaries suitable for kokanee and/or rainbow trout, Kelowna Creek was ranked as 4 of 18.

There are 72 licensed water withdrawals from Kelowna Creek, with consumption rates as follows:

| | | |
|---|---|---|
| Waterworks | : | 518 516 $dam^3/a$ |
| Domestic Use | : | 22.73 $m^3/d$ |
| Irrigation Use | : | 13 857 $dam^3/a$ |
| Cooling | : | 309.1 $m^3/d$ |

## 3.3 BRANDT'S CREEK

Brandt's Creek was not on the list of ranked tributaries to Okanagan Lake for rainbow trout and/or kokanee spawning, and is considered to have no fisheries potential[17]. The creek would be used by any wildlife in the area.

There is one licensed water withdrawal on Brandt's Creek for 11.7 $dam^3/a$ for irrigation purposes.

# 4. PERMITTED WASTE DISCHARGES

Permitted waste discharges can be located on Figure 2 by their permit number. They exist only in the Kelowna Creek and Brandt's Creek drainages.

## 4.1 REGIONAL DISTRICT OF CENTRAL OKANAGAN (PE 5752)

The Regional District has a carwash facility about 750 m to the west of highway 97 opposite the Kelowna Airport. Kelowna Creek flows through the Kelowna Airport.

Stormwater and washwater are discharged to two exfiltration ponds. Permit PE 5752 allows the discharge of a maximum of 70 $m^3$/d, although a January 1988 application for permit amendment requests an increase in the maximum discharge rate to 3 600 $m^3$/month (i.e., 120 $m^3$/d). There are no monitoring data for this operation.

Due to the nature of the discharge, in a dry climate, well removed from Kelowna Creek, it is not expected that this discharge will impact Kelowna Creek.

## 4.2 CITY OF KELOWNA TRADEWASTE TREATMENT FACILITY (PE 1434)

The Tradewaste Treatment facility treats wastewater from Sun-Rype Products Ltd. and Calona Wines Ltd. in an activated sludge plant consisting of an aeration basin, two clarifiers, centrifuge flow/load equalization basin, and influent screens. Permit PE 1434 allows the discharge of an average 2 650 $m^3$/d to Brandt's Creek with the following maximum concentrations: $BOD_5$, 20 mg/L; suspended solids, 35 mg/L; total nitrogen, 6 mg/L; and total phosphorus, 2 mg/L.

Data for effluent quality from February 1985 to October 1988 are in Table 1. The following were the number of excursions above permitted levels: $BOD_5$, 6 of 28 values; suspended solids, 7 of 28 values; total nitrogen, 9 of 28 values; and total phosphorus, 12 of 28 values. The maximum recorded value for each of these characteristics in the period 1985 to 1988 was 145 mg/L $BOD_5$, 1 040 mg/L suspended solids, 33.6 mg/L total Kjeldahl nitrogen, and 13.6 mg/L total phosphorus.

Improvements were made to the plant during 1988. Data collected by the City of Kelowna in 1988 and 1989 indicate that the overall plant performance is considerably better than in previous years[23].

The impact of this discharge on Brandt's Creek was evaluated in the same time period at two sites, approximately 100 m upstream and downstream from the discharge point. The data are not included in this report. Going in a downstream direction, decreases were measured on 25 of 29 occasions for pH, while increases were measured for turbidity on 21 of 29 occasions (decreases on 5 of 29), increases for ammonia on 12 of 29 occasions (decreases on 6 of 29), increases for nitrate on 13 of 29 occasions (decreases on 15 of 29), increases for nitrite on 14 of 29 occasions (decreases on 9 of 29), and increases for total phosphorus on all 29 occasions. For total phosphorus, the upstream mean value of 0.159 mg/L could not be compared to the downstream mean value of 0.473 mg/L by using the Students "t" test since the "F"-test procedure indicated that the data bases were significantly different (P=0.05). This in itself indicates that the discharge is likely having a significant effect on phosphorus values in Brandt's Creek. Similarly, mean values for the following (upstream mean value appears first) could not be compared using the student's "t" test: ammonia-N (0.024 mg/L and 0.088 mg/L), nitrate/nitrite-N (0.48 mg/L and 0.88 mg/L) and nitrite-N (0.011 mg/L and 0.024 mg/L). However, results with the "F" test again suggest a significant impact for these variables.

There was no significant increase going from upstream to downstream (F-test, Student's t-test: P=0.05) for turbidity.

An evaluation of water quality of Brandt's Creek and whether water quality criteria are achieved to protect designated water uses, is found in Section 6.3.

# 5. NON-POINT SOURCE DISCHARGES

The nature of non-point source discharges affecting the three creeks is significantly different. Along most of its length in the lower reaches, Mission Creek is affected by agricultural sources. It is also affected in its lower reaches by sources on Kelowna Creek upstream from the Kelowna (Mill) Creek diversion. Kelowna Creek is affected by agricultural runoff and the Kelowna Airport in its upstream reaches and urban runoff in its lower reaches. Brandt's Creek is affected by urban runoff in its lower reach and agricultural runoff in its upper reach.

## 5.1 MISSION CREEK

Mission Creek and its tributaries in the headwaters would be affected by considerable logging which has occurred there in recent years. Approximately 2 000 ha was harvested in upper Mission Creek between 1984 and 1987, approximately 300 ha near Pearson Creek since 1987, about 600 ha near Belgo Creek since 1986, and about 300 ha in the Daves/Cardinal Creek area[16] since 1986. Strips of trees were maintained along each of these water courses, the width of the strips depending on topographic considerations[16]. The Hydraulic Creek watershed has had considerable logging[20].

In the lower reaches of Mission Creek, inland from Okanagan Lake for a distance of about 10 km, agricultural activity predominates. In an attempt to determine if agricultural activity could affect Mission Creek, statistics on the number of cattle registered with the Beef Assurance Program of the B.C. Ministry of Agriculture and Fisheries were examined. The estimates for nutrient coefficients proposed by Bangay[13] were used to determine potential loadings. These were 7.92 kg P and 68 kg N per animal per year for cows, 0.22 kg P and 1.81 kg N per animal per year for calves, and 3.2 kg P and 39.9 kg N per animal per year for yearlings.

Ministry of Agriculture and Fisheries data indicate a minimum of 511 yearlings and 40 calves in the Mission Creek watershed, concentrated near the mouth (Figure 3). The waste from these cattle could result in a potential yearly loading of 1 654 kg P and 20 460 kg N. Precipitation records for a meteorological station operated near the mouth of Mission Creek indicate that although precipitation is heaviest in December and January (nearly 40 mm), there is between 20 and 30 mm of precipitation in every other month

except March (17.6 mm) and April (18.1 mm)[14]. Therefore for the purpose of this assessment, the following assumptions will be made:

(1) all of the phosphorus and nitrogen generated reach Mission Creek, and

(2) the nutrients are transported at an even rate throughout the year.

Using a mean 7-day low flow of 0.60 $m^3/s$ (Section 2.1), the following maximum increases in concentrations in Mission Creek from cattle are predicted:

Potential Increase in Nutrient Concentrations (mg/L)
Due to Agricultural Wastes

| | |
|---|---|
| Nitrogen | 1.08 mg/L |
| Phosphorus | 0.087 mg/L |

These potential increases would be reduced at greater creek flows but increased at lower flows. Although they depict a "worst-case" scenario and likely over-estimate the loading to the creek for this number of cattle, it must be remembered that all cattle in the watershed are not necessarily registered with the Beef Assurance Program since it is a voluntary program. As well, operations with less than 20 head are not eligible for the program.

Ambient water quality data cited in Section 6.1.3 indicate that these calculations do not overstate the actual values which have been measured in the past. The maximum values recorded were 0.9 mg/L total nitrogen and 0.14 mg/L total phosphorus at Site 0500046 (Table 3).

## 5.2 KELOWNA CREEK

Kelowna Creek was logged extensively in the 1970's; however, recent logging of approximately 100 ha on the north side of the creek occurred in 1988[16].

Cattle are located along the middle reach of Kelowna Creek (Figure 2). Using the procedure outlined in Section 5.1 for agricultural impacts from cattle, and the fact that there are 180 yearlings and 497 calves registered under the Beef Assurance Program which may impact Kelowna Creek, the potential loading from cattle is 689 kg P and 8 082 kg N. Based on the average 7-day low flow of 0.084 $m^3/s$ (Section 2.2) in Kelowna Creek, the following maximum potential increases in concentrations in Kelowna Creek from cattle are predicted:

Potential Increase in Nutrient Concentrations (mg/L)
Due to Agricultural Wastes

| | |
|---|---|
| Nitrogen | 3.05 mg/L |
| Phosphorus | 0.26 mg/L |

Data on maximum ambient concentrations found at Site 0500039 (Table 7) indicate that these calculated values are not overstated. The maximum values were 3.45 mg/L total nitrogen and 0.623 mg/L total phosphorus.

Swain [15] reported on contaminant levels in stormwater runoff from a residential catchment area in Vancouver. The discharge occurred through a 610 mm diameter pipe. The City of Kelowna has indicated that there are 30 stormwater outfalls into Kelowna Creek, ranging in size from 100 mm to 1067 mm diameter, with a total pipe discharge area (at the mouth of Kelowna Creek) approximately 24 times larger than at the Vancouver site. If it is assumed that the slope of the pipes in Kelowna averages the 0.6% slope in Vancouver, then the discharge volume into Kelowna Creek would be 24 times greater than that from the one Vancouver catchment.

However, significant differences exist in precipitation quantities between Kelowna and Vancouver, with the latter receiving 3.35 times the precipitation volume[14] on a yearly basis. During the period that Swain's data[15] were collected, this increased to 4.6 times. Thus, the loadings from Kelowna storm sewers will actually be only 5.2 times greater (24÷4.6) than from the 12.95 ha Vancouver catchment. This results in the following net loadings from stormwater to Kelowna Creek:

| | Estimated Loadings (kg/d) To Kelowna Creek | Estimated Increases (mg/L) |
|---|---|---|
| Aluminum | 0.52 | 0.072 |
| Copper | 0.047 | 0.006 |
| Lead | 0.088 | 0.012 |
| Zinc | 0.172 | 0.024 |
| Total Nitrogen | 1.352 | 0.19 |
| Total Phosphorus | 0.192 | 0.026 |
| Suspended Solids | 26.6 | 3.67 |

These estimated increases have easily been exceeded by maximum ambient concentrations measured at Site 0500039 at the mouth (Table 7). The effect on water uses is discussed in Section 6.2. The City of Kelowna will be investigating urban runoff quality during Stage 2 of its Master Drainage Plan.

## 5.3 BRANDT'S CREEK

There are 22 stormwater outfalls into Brandt's Creek, ranging in size from 62 mm diameter to 1 066 mm diameter. Their discharge volume is 11.6 times that from the Vancouver area, but with adjustments made for precipitation volumes, the loadings are 2.5 times (11.6÷4.6) greater than from the 12.95 ha Vancouver catchment. This results in the following net loadings and increase in concentrations in Brandt's Creek based on a 7-day low mean flow of 0.023 $m^3/s$:

| | Estimated Loadings (kg/d) To Brandt's Creek | Estimated Increases (mg/L) |
|---|---|---|
| Aluminum | 0.25 | 0.13 |
| Copper | 0.0225 | 0.011 |
| Lead | 0.425 | 0.021 |
| Zinc | 0.0825 | 0.042 |
| Total Nitrogen | 1.65 | 0.33 |
| Total Phosphorus | 0.0925 | 0.047 |
| Suspended Solids | 12.8 | 6.4 |

These predicted increases are exceeded by maximum ambient concentrations measured at Site 0500009 at the mouth (Table 9). The effect on water uses is discussed in Section 6.3.

# 6. AMBIENT WATER QUALITY AND PROPOSED PROVISIONAL WATER QUALITY OBJECTIVES

## 6.1 MISSION CREEK

Flow from Kelowna (Mill) Creek can be diverted to Mission Creek. This could mean that water quality objectives required in Kelowna (Mill) Creek due to upstream concerns may also be required in Mission Creek, even though similar concerns do not exist in the Mission Creek watershed. A water quality assessment and objectives document for Hydraulic Creek, a tributary to Mission Creek, is being prepared[20], and will be presented in a separate report.

Water quality data collected at Site 0500045 east from Kelowna and upstream from the Kelowna (Mill) Creek diversion are summarized in Table 2, while those collected at Site 0500046 near the mouth are in Table 3. Data were collected at a frequency of about two to three times per year in the period 1972 to 1982. There is a need to obtain more up-to-date data on Mission Creek so that present conditions can be determined.

Designated water uses are for aquatic life, wildlife, recreation, drinking water, livestock watering, and irrigation.

### 6.1.1 pH AND ALKALINITY

The pH in Mission Creek ranged from 6.6 to 9.1 at Site 0500046 (Table 3), although it ranged between 7.5 and 8.4 (Table 2) further upstream. Water quality criteria for pH are that it should be in the range from 6.5 to 8.5 for aesthetics of drinking water[2] and 6.5 to 9.0 to protect aquatic life[3]. At Site 0500046, 10 of 53 measurements exceeded the upper criteria limit of 8.5, but only 1 of 53 values exceeded the upper limit of 9.0. Thus, aquatic life are afforded protection in Mission Creek from the effects of pH. There are no inputs into Mission Creek which would affect pH; however, a water quality objective is proposed to protect the aquatic life from the adverse effects of ammonia at higher pH values. The objective is that the pH in Mission Creek should be between 6.5 and 9.0, in all areas of Mission Creek, except in initial dilution zones of effluents. These excluded zones extend 100 m downstream from a discharge and not more than 50% across the width of the water body.

Alkalinity values ranged from 17 mg/L to 178 mg/L at Site 0500046 (Table 3). These concentrations reflect the fact that Mission Creek has a low sensitivity to acidic inputs[4], although 2 of 29 values indicated that Mission Creek had moderate sensitivity to acidic inputs.

Alkalinity values at Site 0500045 ranged from 27 mg/L to 108 mg/L (Table 2), values which indicate that Mission Creek at this point has low sensitivity to acidic inputs[4].

The application of the F-test indicated that the variability of alkalinity data between Sites 0500045 and 0500046 was significantly different (P=0.05). This in itself indicates that the data bases are not comparable, which implies a significant difference.

### 6.1.2 HARDNESS AND METALS

The average hardness of Mission Creek was 73.7 mg/L at Site 0500045 (Table 2) and 101.1 mg/L at Site 0500046 (Table 3). Water hardness values between 80 mg/L and 100 mg/L are considered desirable for drinking water supplies[2]. Three of 33 measurements at Site 0500046 were in excess of the 200 mg/L criterion which indicates a poor water supply[2].

The application of the F-test indicated that the variability of the hardness data was significantly different (P=0.05) between the two sites.

The average water hardness is used to determine appropriate water quality criteria for certain metals to protect aquatic life for a 30-day period. For "screening" purposes, criteria will be based on a minimum hardness of 70 mg/L. Based on this hardness, copper concentrations[5] should not exceed an average of 0.003 mg/L nor a maximum of 0.009 mg/L, while lead concentrations[6] should be less than an average of 0.005 mg/L and a maximum of 0.052 mg/L. Two of 12 dissolved copper values (both recorded in 1972) at Site 0500046 exceeded the maximum criterion of 0.009 mg/L. The criteria for lead and the average copper criterion were met.

All other criteria for the other metals listed in Tables 2 and 3 were achieved, except for 1 of 16 dissolved zinc values (1972 value of 0.06 mg/L) at Site 0500046, which exceeded the criterion of 0.03 mg/L for a maximum concentration[3].

### 6.1.3 NUTRIENTS

The maximum ammonia-nitrogen concentration of 0.07 mg/L was well below the criteria listed in Tables 4 and 5 to protect aquatic life[7]. However, since cattle wastes (Section 5.1) can enter Mission Creek, a water quality objective is proposed for ammonia-nitrogen. The objective is that the maximum and average concentrations should not exceed values listed in Tables 4 and 5. These objectives apply along Mission Creek, except in the initial dilution zones of effluents, described in Section 6.1.1.

The application of the F-test to the data sets for Sites 0500045 and 0500046 indicated that the ammonia data had significant variability (P=0.05) between sites.

All nitrite-nitrogen concentrations have been <0.005 mg/L in Mission Creek (Tables 2 and 3), which is lower than the criteria[7] for nitrite (Table 6). However, incompletely oxidized ammonia can be converted to nitrite. For this reason, a provisional water quality objective is proposed for nitrite-nitrogen. The objective is that the average and maximum concentrations should not exceed the values listed in Table 6. The objective applies along Mission Creek, except in initial dilution zones of effluents, described in Section 6.1.1.

The maximum nitrate or nitrate/nitrite-nitrogen concentration was 0.78 mg/L at Site 0500045 (Table 2), well below the most stringent criterion of 10 mg/L[7] to protect drinking water supplies. Although ammonia which is in animal wastes can enter Mission Creek, its conversion to nitrate would not likely result in a concern for nitrate concentrations. Therefore, a water quality objective is not proposed for nitrate.

The application of the F-test to determine the variability of the nitrate/nitrite data for Sites 0500045 and 0500046 indicated that the variability was not significant (P=0.05), and that when mean values were subjected to the Student's t-test, there was no significant difference.

Dissolved and total phosphorus concentrations were high enough to cause algal growths, if phosphorus is the limiting factor and assuming other factors such as turbidity, stream velocity, or available substrate are not. Only with measurements of periphyton chlorophyll-a will the effect of phosphorus become evident.

The water quality objective for total phosphorus in Okanagan Lake is a maximum of 0.01 mg/L at spring overturn[21]. The average concentrations of 0.019 mg/L and 0.03 mg/L at Sites 0500045 (Table 2) and 0500046 (Table 3), respectively, would require minimum dilutions in Okanagan Lake of 1.9:1 and 3.0:1 to meet this objective.

The application of the F-test to the data sets for total phosphorus at Sites 0500045 and 0500046 indicated that there was significant variability (P=0.05) in the data between the two sites.

In Mission Creek, the growth of periphyton chlorophyll-a must be controlled so that aquatic life is not impeded. The B.C. criterion to protect aquatic life is a maximum 100 mg/m$^2$ on natural substrate[8]. Therefore, this is the proposed provisional water quality objective for periphyton chlorophyll-a. This objective does not apply in the initial dilution zones of effluents, described in Section 6.1.1. The maximum concentration is actually the mean of five randomly collected samples from natural substrate on the same day.

### 6.1.4 DISSOLVED OXYGEN

Dissolved oxygen concentrations ranged from 8.7 mg/L to 13.9 mg/L at Site 0500045 (Table 2) and from 8.2 mg/L to 13.8 mg/L at Site 0500046 (Table 3). Application of the F-test indicated there was no significant difference in the variability (P=0.05) in the data between the two sites and that when tested with the Student's t-test, there was no significant difference (P=0.05) between the mean values at the two sites.

There are no approved British Columbia criteria for dissolved oxygen. The following is the rationale to derive working water quality criteria for dissolved oxygen to be used in this document.

The CCREM[3] has developed criteria for dissolved oxygen, based on EPA criteria[9]. The criteria are based on warm-water and cold-water biota being present in a system. Cold-water systems were defined as any with at least one salmonid present. In British Columbia, this definition covers virtually the entire Province.

The EPA[9] had based its criteria, and discussed its findings, on the basis of salmonids and non-salmonids. Table 3-7 in CCREM (page 3-14) is from EPA[9]. The EPA[9] indicated that there was no impairment at 11.0 mg/L when embryo larvae were present or 8.0 mg/L for other life stages, and slight impairment at 9.0 mg/L and 6.0 mg/L, respectively. The EPA[9] based its criteria (accepted by CCREM) on the slight impairment levels, and then added 0.5 mg/L to arrive at the criteria. In British Columbia, we are fortunate enough to generally have high quality waters, and there is no need to accept the slight impairment level. Therefore, the criteria which will be used for dissolved oxygen in this document will be based on salmonids and should provide for no impairment (i.e., 8.0 mg/L and 11.0 mg/L minima).

The criterion of 8.0 mg/L was achieved on all occasions at both sites. The 11.0 mg/L criterion, applicable when embryo larvae are present, was usually not achieved between April and October. Since cattle wastes can enter Mission Creek (Section 5.1), with the potential to reduce oxygen concentrations, a provisional water quality objective is proposed for dissolved oxygen. The objective is that the minimum dissolved oxygen concentration should not be less than 8.0 mg/L for all life stages except when embryo and larvae are present, at which time the minimum concentration should be 11.0 mg/L. The objective applies along Mission Creek, except in the initial dilution zones of effluents, described in Section 6.1.1.

The difference in variability of percent saturation data between Sites 0500045 and 0500046 was significant (F-test: P=0.05). Values ranged from 75.9% to 111.1% at Site 0500045 (Table 2) and from 66.1% to 141.6% at Site 0500046 (Table 3).

The wider range of percent saturation values at Site 0500046 compared to Site 0500045 is possibly a result of algal growths in the creek near the mouth. These wider ranges of percent saturation values could stress aquatic life, and make them more susceptible to other stresses.

### 6.1.5 SOLIDS

Dissolved solids have been as high as 160 mg/L at Site 0500045 (Table 2) and 244 mg/L at Site 0500046 (Table 3). Both values were lower than the criteria of 500 mg/L for the protection of drinking water aesthetics[2] and irrigation water supplies[3]. The

variability between the data sets at both sites (F-test) and the difference between mean values (Student's t-test) were found to not be significant (P=0.05).

The average suspended solids concentration was about 17 mg/L at both Sites 0500045 and 0500046 (Tables 2 and 3). Application of the F-test to examine the variability of the data sets between the two sites indicated that variability was significantly (P=0.05) different.

Suspended solids measurements indicate concentrations of materials which can damage membranes of fish gills or cause siltation of spawning beds. Turbidity measures the transmission of light through water.

Turbidity has been measured to values as high as 45 NTU at Site 0500046 (Table 3). The average turbidity was 2.9 NTU at Site 0500045 and 6.8 NTU at Site 0500046.

The maximum acceptable concentration for turbidity in drinking water is 1 NTU, although 5 NTU may be permitted if it can be demonstrated that disinfection is not compromised[2]. The aesthetic objective for drinking water is 5 NTU[2]. Eight of 26 turbidity values at Site 0500046 and 3 of 15 turbidity measurements at Site 0500045 were in excess of 5 NTU. Thus water treatment to remove turbidity in addition to disinfection would be required to use this water as a drinking water supply.

### 6.1.6 BACTERIOLOGICAL QUALITY

Fecal coliform concentrations were only measured twice at Site 0500045 (<2 and 5 MPN/100 mL) and on eight occasions at Site 0500046 (<2 - 170 MPN/ 100 mL). Since 1 of the total of 10 measurements exceeded the criterion of <100 MPN/100 mL as a 90th percentile value[10], the water could require disinfection and partial treatment prior to use as a drinking water supply. More data are needed to confirm this conclusion.

The B.C. criteria[10] to protect drinking water supplies which are provided partial treatment are that 90th percentile values should not exceed 100/100 mL Escherichia coli, 25/100 mL enterococci, nor 100/100 mL fecal coliforms. These are the proposed water quality objectives for Mission Creek. The 90th percentile values are based on a minimum of 5 weekly samples in 30 days.

## 6.2 KELOWNA CREEK

Kelowna (Mill) Creek has been sampled at two sites: Site 0500039 near its mouth and Site 0500038 upstream from Kelowna. The data are summarized in Tables 7 and 8, respectively. Most of the samples were collected in the period from 1969 to 1973, so that caution must be used in dealing with these data. There is a great need to improve the data base on Kelowna Creek so that present conditions can be evaluated. Regardless, these historic data will be evaluated and water quality objectives proposed on the basis of historic inputs to the creek.

Designated water uses are for aquatic life, wildlife, drinking water, livestock watering, and irrigation.

### 6.2.1 pH AND ALKALINITY

The pH in Kelowna Creek has ranged from 7.3 to 9.1 at Site 0500038 (Table 8) and 7.8 to 9.1 at Site 0500039 (Table 7). Water quality criteria for pH are that it should be in the range from 6.5 to 8.5 for aesthetics of drinking water[2] and 6.5 to 9.0 for the protection of aquatic life[3]. Both the limits of 8.5 and 9.0 were exceeded by only 1 of 14 values at Site 0500038 and 1 of 47 values at Site 0500039.

There are no known inputs into Kelowna Creek which would affect pH; however, a water quality objective is proposed to aid in protecting aquatic life from adverse effects of ammonia which may enter the creek with animal wastes and be a concern at high pH values. The objective is that the pH in Kelowna Creek should be in the range from 6.5 to 8.5 in all areas of Kelowna Creek except in the initial dilution zones of effluents, described in Section 6.1.1.

Alkalinity concentrations ranged from 41 to 211 mg/L at Site 0500038 (Table 8) and from 57.4 to 258 mg/L at Site 0500039 at the mouth (Table 7). Thus Kelowna Creek has a low sensitivity to acidic inputs[4].

The application of the F-test (P=0.05) indicated that the variability in alkalinity data at Sites 0500038 and 0500039 was not significantly different. The application of the Student's t-test (P=0.05) to the mean values indicated a significant difference existed

between mean values at the two sites (i.e., alkalinity increases significantly in a downstream direction).

### 6.2.2 HARDNESS AND METALS

The average hardness of Kelowna Creek was 191 mg/L at Site 0500038 and 210 mg/L at Site 0500039. Water hardness values in excess of 200 mg/L indicate a poor drinking water supply[2]. Fifteen of 19 values at Site 0500038 exceeded the 200 mg/L criterion while 24 of 33 values at Site 0500039 exceeded it.

The application of the F-test (P=0.05) indicated that the variability of the hardness data was not significantly different. The application of the Student's t-test (P=0.05) to the mean values indicated no statistically significant difference between mean values at the two sites.

The average water hardness is used to determine appropriate water quality criteria for certain metals to protect aquatic life for a 30-day period. Based on an average hardness of 190 mg/L for screening purposes, copper concentrations[5] should not exceed 0.008 mg/L as an average value or 0.020 mg/L as a maximum value. Lead concentrations[6] should not exceed 0.011 mg/L as an average value nor 0.185 mg/L as a maximum value.

Average and maximum criteria for total copper (0.008 mg/L and 0.020 mg/L, respectively) were exceeded by 7 of 13 and 2 of 22 determinate dissolved values, respectively, at Site 0500038 and 2 of 13 and 1 of 13 determinate dissolved values, respectively, at Site 0500039. Determinate values were those either above varying detection limits, or with values cited as being less than detection limits which were, themselves, less than a criterion. In Section 5.2, it was estimated that stormwater could increase copper concentrations by 0.006 mg/L, which implies that some control of stormwater may be needed if the objective is to be achieved. For this reason, a water quality objective is proposed for Kelowna Creek. The objective is that the maximum total copper concentration should not exceed the value given by formula (1) for the appropriate hardness while the average should not exceed the value given by formula (2) for the average hardness. The formulas are as follows:

Maximum (μg/L) Total Copper = [0.094(hardness)+2] .....(1)
Average*(μg/L) Total Copper ≤ [0.04(average hardness)] .....(2)

Where hardness is reported as mg/L $CaC0_3$

*For hardness values ≤50 mg/L, the 30-day average total copper should not exceed 2 μg/L.

When total copper values upstream at Site 0500038 exceed these proposed objectives, there should not be a statistically significant (P=0.05) increase in downstream levels over those levels measured at Site 0500038. The objectives apply in all areas of Kelowna Creek, except in initial dilution zones of effluents, described in Section 6.1.1.

The B.C. Ministry of Environment normally samples five times in a thirty-day period to check achievement of water quality objectives. At this sampling effort, it has been shown that even a 20% increase which could be present due to analytical or sampling precision would be very restrictive statistically, and that only with data sets approaching 30 samples in 30 days would a 20% increase approximate a statistical difference[24]. Therefore, with these limitations in mind, a statistically significant increase for the purpose of verifying achievement of objectives will be one measured at a downstream site which exceeds 20%.

For total lead, the average and maximum criteria (0.011 mg/L and 0.185 mg/L respectively) were exceeded by 2 of 18 and zero of 18 determinate dissolved values at Site 0500038, and 4 of 19 and 1 of 19 determinate dissolved values at Site 0500039.

In Section 5.2, it was estimated that stormwater discharges into Kelowna Creek could increase lead concentrations by 0.012 mg/L. Most of the historical data for lead were collected prior to 1973, so that it is difficult to determine if lead values are being affected by stormwater. Regardless, a water quality objective is proposed to protect aquatic life from excess amounts of lead. The objective is that the maximum total lead concentration in any sample should not exceed the value determined by equation (3) which follows, while the thirty-day average of at least five samples should not exceed the value determined by equation (4) which follows. At times when the objective is exceeded at Site 0500038, downstream levels below a discharge or series of discharges should not increase by more than 20%. The objectives apply along Kelowna Creek, except in initial dilution zones of effluents, described in Section 6.1.1.

The maximum total lead concentration in any sample using the corresponding hardness concentration (mg/L $CaC0_3$) should not exceed:

Maximum (µg/L) total lead ≤ exp (1.273 ln(hardness)-1.460).....(3)

In addition, 80% of the values should be less than or equal to the 30-day average concentration. The 30-day average total lead concentration in any sample using the corresponding average hardness concentration (mg/L $CaC0_3$) should not exceed:

Average (µg/L) total lead ≤3.31 + exp(1.273 ln (average hardness)-4.705) .....(4)

An alert level of 0.8 µg/g (wet-weight) has been suggested[6] for edible fish tissues. This is proposed as a water quality objective for aquatic life in Kelowna Creek. The objective applies to fish caught at any location in Kelowna Creek, including initial dilution zones of effluents.

Criteria for total iron of 0.3 mg/L[3] and total manganese of 0.1 mg/L[12] to protect aquatic life were exceeded by 5 of 16 and 5 of 22 dissolved values, respectively, at Site 0500038 and 6 of 21 and 11 of 24 dissolved values respectively at Site 0500039. The drinking water criterion for iron is the same as for protection of aquatic life. For manganese, the drinking water criterion is 0.05 mg/L, which was exceeded by 15 of 22 dissolved values at Site 0500038 and by 19 of 24 dissolved values at Site 0500039.

The one dissolved aluminum value exceeded the criterion of 0.1 mg/L as a maximum[1] at Site 0500039. Aluminum was estimated to be increased by stormwater runoff to as high as 0.072 mg/L. For this reason, a water quality objective is proposed for dissolved aluminum. The objective is that the dissolved aluminum concentration in any sample should not exceed 0.1 mg/L, unless values measured upstream from a discharge or series of discharges exceed this level. In such cases, the maximum increase should not exceed 20% of the upstream value. The objective applies to Kelowna Creek, except in initial dilution zones of effluents.

Two mercury concentrations (of 8) were detected at Site 0500039 near the mouth in the early 1970's. The maximum value of 0.00019 mg/L exceeded the B.C. criterion to protect aquatic life of 0.0001 mg/L[22] . More data for mercury should be collected in

order to determine if these measured values were artifacts of sampling, or whether a real concern exists.

The criterion for total zinc of a maximum of 0.03 mg/L[3] was exceeded by 6 of 22 dissolved values at Site 0500038 and 5 of 23 dissolved values at Site 0500039. Stormwater was estimated to have the potential to increase zinc concentrations by 0.024 mg/L. For this reason, a water quality objective is proposed for total zinc in Kelowna Creek. The objective, which applies in all areas except initial dilution zones of effluents described in Section 6.1.1, is that total zinc should not exceed 0.03 mg/L in any sample. When values upstream from a discharge or series of discharges exceed the proposed objective, downstream values should not increase by more than 20%. This increase is not statistically significant.

### 6.2.3 NUTRIENTS

The maximum ammonia-nitrogen concentration of 1.51 mg/L recorded at Site 0500039 at the mouth would have exceeded the maximum permitted (Table 5) value if the coincident pH and temperature values were 9.0 and 23°C, respectively. The actual coincident pH measurement in June 1983 was 8.4, but the temperature could only be estimated from historic June data to be about 13°C. At a pH of 8.4, all water temperatures up to and including 20°C would result in this ammonia concentration being below the maximum permitted (Table 5), although above the average ammonia value (Table 4).

Applying the F-test (P=0.05) indicated a significant degree of variability for the ammonia data between Sites 0500038 and 0500039. Since cattle wastes can enter Kelowna Creek and cause increases in ammonia concentrations, a provisional water quality objective is proposed for ammonia nitrogen. The objective is that the maximum and average concentrations should not exceed values listed in Tables 4 and 5. The objectives apply along the lengths of Kelowna Creek, except in initial dilution zones of effluents, described in Section 6.1.1.

Nitrite-nitrogen values were as high as 0.02 mg/L at Site 0500038 and 0.052 mg/L at Site 0500039. Both these were below the most restrictive criteria for nitrite of a maximum of 0.06 mg/L (Table 6) at chloride concentrations of <2 mg/L. For the maximum nitrite of 0.052 mg/L at Site 0500039 to meet the average criteria concentration of 0.06 mg/L, 6 mg/L of chloride would have to be present. Such chloride concentrations

are often present at Site 0500039. The paired chloride data at Site 0500039 for the June 1983 sample when 0.052 mg/L nitrite was measured were not available. The variability of nitrite data between Sites 0500038 and 0500039 was significant (F-test: P=0.05).

Since high nitrite values have been measured in Kelowna Creek and since incompletely oxidized ammonia (from cattle wastes) can be converted to nitrite, a provisional water quality objective is proposed for nitrite-nitrogen. The objective is that the average and maximum concentrations should not exceed values listed in Table 6. The objective applies along the length of Kelowna Creek, except in initial dilution zones of effluents, described in Section 6.1.1.

The maximum nitrate or nitrate/nitrite-nitrogen concentration was 2.26 mg/L at Site 0500039 (Table 7). This is well below the most stringent criterion of 10 mg/L[7] to protect drinking water supplies. Oxidation of ammonia to nitrate would not likely raise nitrate concentrations to levels of concern. The application of the F-test to determine the variability of both nitrate and nitrate/nitrite data for Sites 0500038 and 0500039 determined that the variability of the data sets was statistically significant (P=0.05).

Dissolved and total phosphorus concentrations were high enough to cause algal growths, if phosphorus is the limiting factor and assuming other factors such as turbidity, stream velocity, or available substrate are not. Only with measurements of periphyton chlorophyll-a will the effect of phosphorus become evident.

The water quality objective for total phosphorus in Okanagan Lake[21] is a maximum of 0.01 mg/L at spring overturn. The average concentrations of 0.113 mg/L at Site 0500039 (Table 7) near the mouth and 0.110 mg/L at Site 0500038 (Table 8) would require dilutions of above 11:1 in Okanagan Lake to meet this objective.

The application of the F-test to the data sets for total phosphorus at Sites 0500038 and 0500039 indicated that there was no significant variability (P=0.05) in the data between the two sites. In comparing mean values with the Student's t-test (P=0.05), these were determined to be statistically similar.

In Kelowna Creek, the growth of periphyton chlorophyll-a must be controlled so that aquatic life is not impeded. The B.C. criterion[8] to protect aquatic life is a maximum 100 mg/m$^2$ on natural substrate. This is the proposed provisional water quality objective

for periphyton chlorophyll-a. The maximum concentration is actually the mean of five randomly collected samples from natural substrate on the same day. The objective does not apply in the initial dilution zones of effluents, described in Section 6.1.1.

### 6.2.4 DISSOLVED OXYGEN

Dissolved oxygen concentrations ranged from 7.6 to 13.2 mg/L at Site 0500038 and from 7.6 to 14.8 mg/L at Site 0500039. Application of the F-test (P=0.05) indicated that there was no significant difference in the variability of the data sets for dissolved oxygen at these two sites. As well, the Student's t-test indicated (P=0.05) that there was no significant difference between the mean values at the two sites.

In Section 6.1.4, the rationale was provided for water quality criteria for dissolved oxygen of 8.0 mg/L as a minimum at all times except when embryo or larvae were present. At those times, the minimum value should be 11.0 mg/L. The criterion of 8.0 mg/L has not been achieved at all times at either site: only 1 value at each site (of 17 at Site 0500038 and of 25 at Site 0500039) was slightly less than the criterion for a minimum. The mean values of 10.6 mg/L and 11.6 mg/L, which were not significantly different, could be considered as achieving the more restrictive criterion for the presence of embryo larvae.

Since cattle wastes can enter Kelowna Creek, with the potential to reduce oxygen concentrations, a provisional water quality objective is proposed for dissolved oxygen. The objective is that the minimum dissolved oxygen concentration should not be less than 8.0 mg/L for all life stages except when embryo or larvae are present, at which time the minimum concentration should be 11.0 mg/L. The objective applies along Kelowna Creek, except in the initial dilution zones of effluents, described in Section 6.1.1.

The difference in the variability of percent saturation values at the two sites was not significant (F-test: P=0.05); however, the difference in the mean values was significant (Student's t-test: P=0.05). Percent saturation values were as low as 72% at Site 0500038 (Table 8) and as high as 140.3% at Site 0500039 (Table 7). Such large ranges of percent saturation can indicate that aquatic life is potentially stressed, (even with adequate oxygen supplies) and more susceptible on such occasions to other stress factors. Such ranges of percent saturation values can result from algal growths.

### 6.2.5 SOLIDS

Dissolved solids have been as high as 437 mg/L at Site 0500039 (Table 7) near the mouth and 318 mg/L at Site 0500038 (Table 8) further upstream. Water quality criteria are a maximum concentration of 500 mg/L to protect aesthetics of drinking water supplies[2] and for irrigation[3].

The difference in the variability of the data sets for the two sites was determined to not be significant when the F-test (P=0.05) was applied. When the Student's t-test (P=0.05) was applied to the mean values for each site, these were determined to be significantly different.

Suspended solids concentrations varied significantly (F-test: P = 0.05) between Sites 0500038 (Table 8) and 0500039 (Table 7). The mean concentrations were 51.4 mg/L at Site 0500038 and 22.5 mg/L at Site 0500039.

Suspended solids concentrations provide information on potential damage to membranes of fish gills or on siltation of spawning beds. Turbidity measures the transmission of light through water.

Turbidity levels as high as 70 NTU have been measured at Site 0500038 and to as high as 92 NTU at Site 0500039. The variability of the turbidity data between the two sites was not significant (F-test: P=0.05) and the difference between the mean values was also not significant (Student's t-test: P=0.05).

The maximum acceptable concentration for turbidity in drinking water is 1 NTU, although 5 NTU may be permitted if it can be demonstrated that disinfection is not compromised. The aesthetic objective for drinking water is 5 NTU[2]. Five of seven turbidity measurements at Site 0500038 and 13 of 24 values at Site 0500039 were in excess of 5 NTU. Thus, some water treatment in addition to disinfection would be required to use Kelowna Creek as a drinking water supply.

### 6.2.6 BACTERIOLOGICAL QUALITY

Fecal coliform values were considerably higher at Site 0500039, where the median value was 540 MPN/100 mL (Table 7), than at Site 0500038. The median value of

20 MPN/100 mL at Site 0500038 (Table 8) was lower than the minimum recorded value at Site 0500039. Since the 90th percentile value for the total data set would be in excess of 100 MPN/100 mL, the water would require disinfection and partial treatment prior to use as a drinking water supply.

The B.C. criteria[10] to protect drinking water supplies which are provided partial treatment are that 90th percentile values should not exceed 100/100 mL Escherichia coli, 25/100 mL enterococci, nor 100/100 mL fecal coliforms. These are the proposed water quality objectives for Kelowna Creek.

## 6.3 BRANDT'S CREEK

Data for Brandt's Creek are in Table 9. The data were collected at Site 0500009 in the period 1985 to 1988, and therefore represent recent conditions in the creek. The only designated water uses for Brandt's Creek are for the protection of irrigation water supplies and wildlife. The flow in Brandt's Creek (Chapter 2) is about one-tenth that in Kelowna Creek and one-thirtieth that in Mission Creek, based upon mean 7-day flows. Therefore, concentrations in Brandt's Creek would have to be significantly higher than in the other two creeks to even contribute an equal loading to Okanagan Lake.

### 6.3.1 pH

The pH in Brandt's Creek ranged from 7.5 to 8.6 at Site 0500009. This is well within the range of 4.5 to 9.0 to protect irrigation water supplies[18].

### 6.3.2 HARDNESS AND METALS

Hardness values ranged from 259 to 745 mg/L, and would help ameliorate toxic effects of any metals present.

The B.C. criterion[11] to protect irrigation water supplies is a maximum 5 mg/L total aluminum. Values at Site 0500009 ranged from 0.04 to 4.88 mg/L (mean 0.89 mg/L). Therefore, the criterion was always achieved. The potential increase in aluminum concentrations due to stormwater was 0.13 mg/L (Section 5.3). No water quality objective is proposed for aluminum since stormwater is unlikely to be entering Brandt's Creek when irrigation water is being withdrawn.

Contributions of other metals from stormwater (Section 5.3) were not estimated to be of a significant enough nature relative to ambient water quality conditions or criteria to require that water quality objectives be proposed. All data were less than the criteria for total metals for irrigation supplies, as follows: chromium 0.1 mg/L[3]; copper, 0.2 mg/L[5]; iron, 20 mg/L[3]; manganese, 10 mg/L[3]; molybdenum, 0.05 mg/L[19]; nickel, 0.2 mg/L[6]; and zinc, 1.0 mg/L[3].

### 6.3.3 NUTRIENTS

Nutrient levels are not a concern from an irrigation standpoint[7,8]. High nutrient levels are beneficial in irrigation water.

### 6.3.4 DISSOLVED OXYGEN AND OXYGEN-CONSUMING MATERIALS

There are no criteria for dissolved oxygen concentrations in irrigation water supplies. No ambient data on dissolved oxygen were collected. Although $BOD_5$ values were generally not detectable (<10 mg/L), some measurable values did occur (12 mg/L on February 7, 1985, 65 mg/L on October 16, 1985, and 52 mg/L on October 27, 1985).

### 6.3.5 SOLIDS

There are no water quality criteria for irrigation supplies for either turbidity or suspended solids. However, there are criteria for dissolved solids (specific conductivity) concentrations to prevent salt build-up on soils[3]. The criteria have been developed for crops which are not tolerant (<700 µS/cm), slightly tolerant (<1 200 µS/cm), moderately tolerant (<2 200 µS/cm), tolerant (<3 600 µS/cm) and very tolerant (<5 000 µS/cm).

Data for specific conductivity in Brandt's Creek have ranged from 690 to 2 190 µS/cm (mean, 1 263 µS/cm). Thus, as a general rule, the water is not satisfactory for irrigation of low tolerance plants such as beans, carrots, strawberries or raspberries. Specific conductivity values in the May to August period were normally below the 1 200 µS/cm level for plants with slight tolerance. These levels would permit fruit, berries, and several vegetables, field crops, and forages to be grown[3] with little concern.

Stormwater could carry residual salts applied to roads during the winter period, into Brandt's Creek. Therefore, a water quality objective is proposed for dissolved solids in Brandt's Creek. The objective is that during the May through August irrigation period, the specific conductivity should be less then 1 200 µS/cm. The objective applies to discrete samples collected outside the initial dilution zones of effluents, described in Section 6.1.1.

### 6.3.6 BACTERIOLOGICAL QUALITY

Fecal coliform concentrations were from 0 to 1 650/100 mL, with a median of 14/100 mL. Only 1 of 8 values exceeded the criteria of ≤1 000/100 mL geometric mean for general irrigation, while 2 of 8 exceeded the criterion of ≤200/100 mL for crops eaten raw[10].

Stormwater can increase fecal coliform concentrations. Major modifications would be required to the stormwater collection system if it had to be treated to assure bacteriological conditions in Brandt's Creek met irrigation standards. Therefore it is recommended that in place of proposing water quality objectives at this time, a study of fecal coliform concentrations in Brandt's Creek be undertaken to determine if there is a concern during irrigation season.

A major waterfront hotel/resort complex is planned for the mouth of Brandt's Creek[23]. Public swimming areas will be in close proximity to this complex, requiring that bacteriological quality in Brandt's Creek will have to improve over existing conditions if criteria for swimming are to be achieved in Okanagan Lake near the creek.

# 7. MONITORING PROGRAM

Due to the lack of recent data for both Mission and Kelowna creeks, it is recommended that monitoring to check water quality objectives be undertaken in two periods: January to March, and June to August. Five samples should be collected in a 30-day period at each of two sites on both water bodies. A sample from the Kelowna (Mill) Creek Diversion should also be collected each time if it is in operation.

On Brandt's Creek, a study of fecal coliforms and other bacteriological indicators should be undertaken at a site near the mouth during irrigation season. This can coincide with the work on Kelowna and Mission creeks, with specific conductivity measurements made at the same time to check achievement of the objective. Monitoring bacteriological conditions in Okanagan Lake near its confluence with Brandt's Creek should also be undertaken.

The exact monitoring program undertaken will depend upon available resources.

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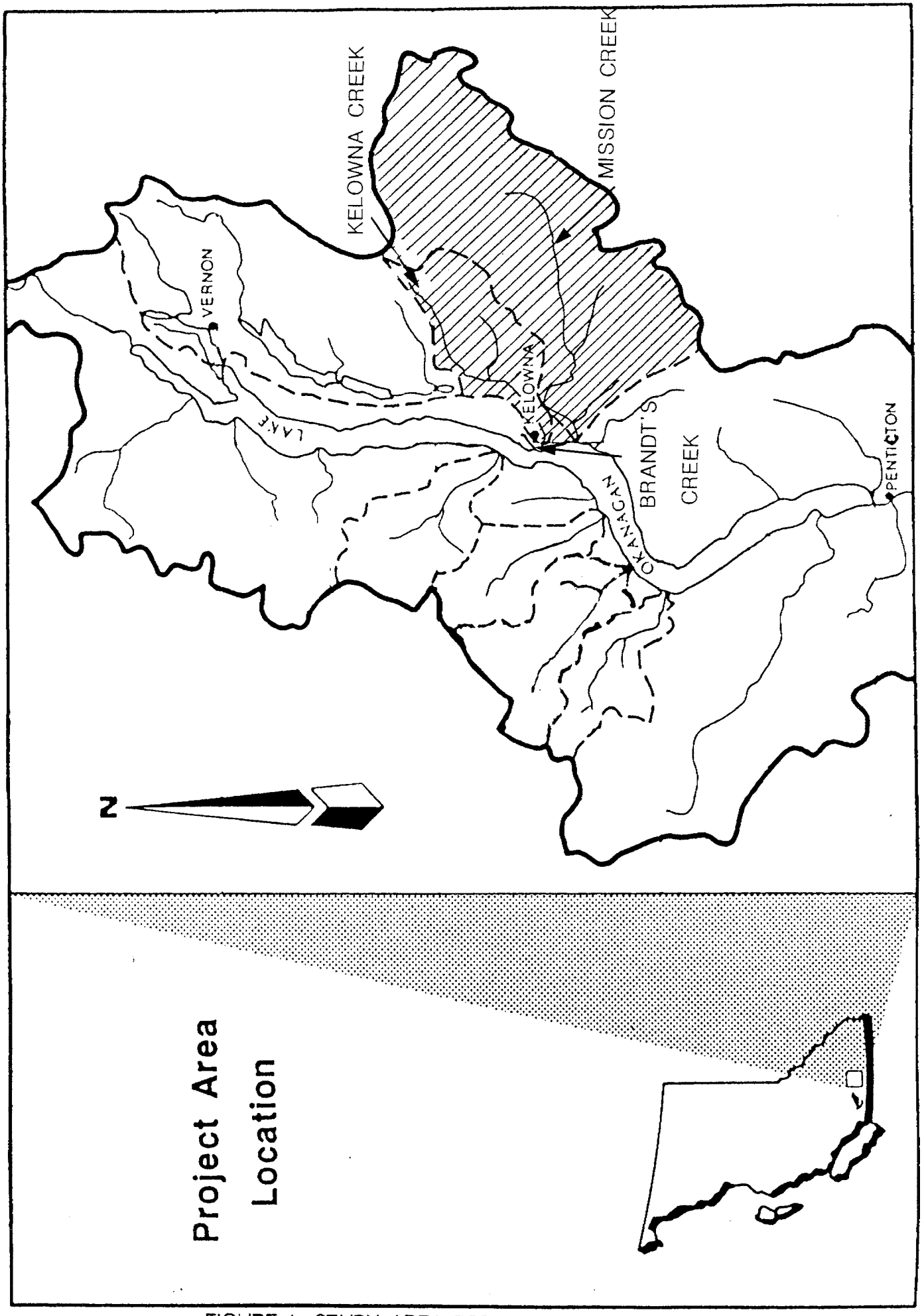


FIGURE 1 : STUDY AREA FOR THIS ASSESSMENT

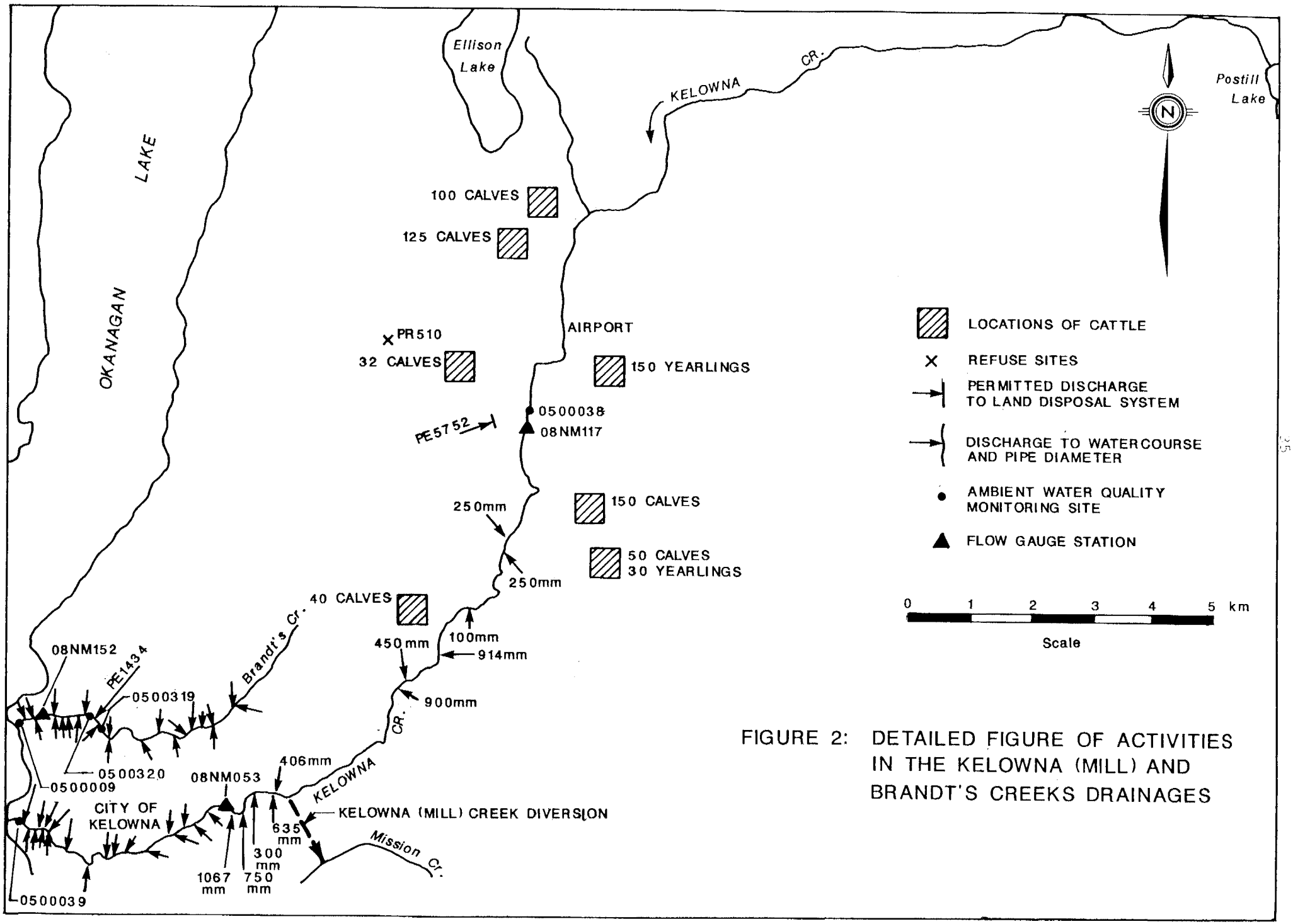


FIGURE 2: DETAILED FIGURE OF ACTIVITIES IN THE KELOWNA (MILL) AND BRANDT'S CREEKS DRAINAGES

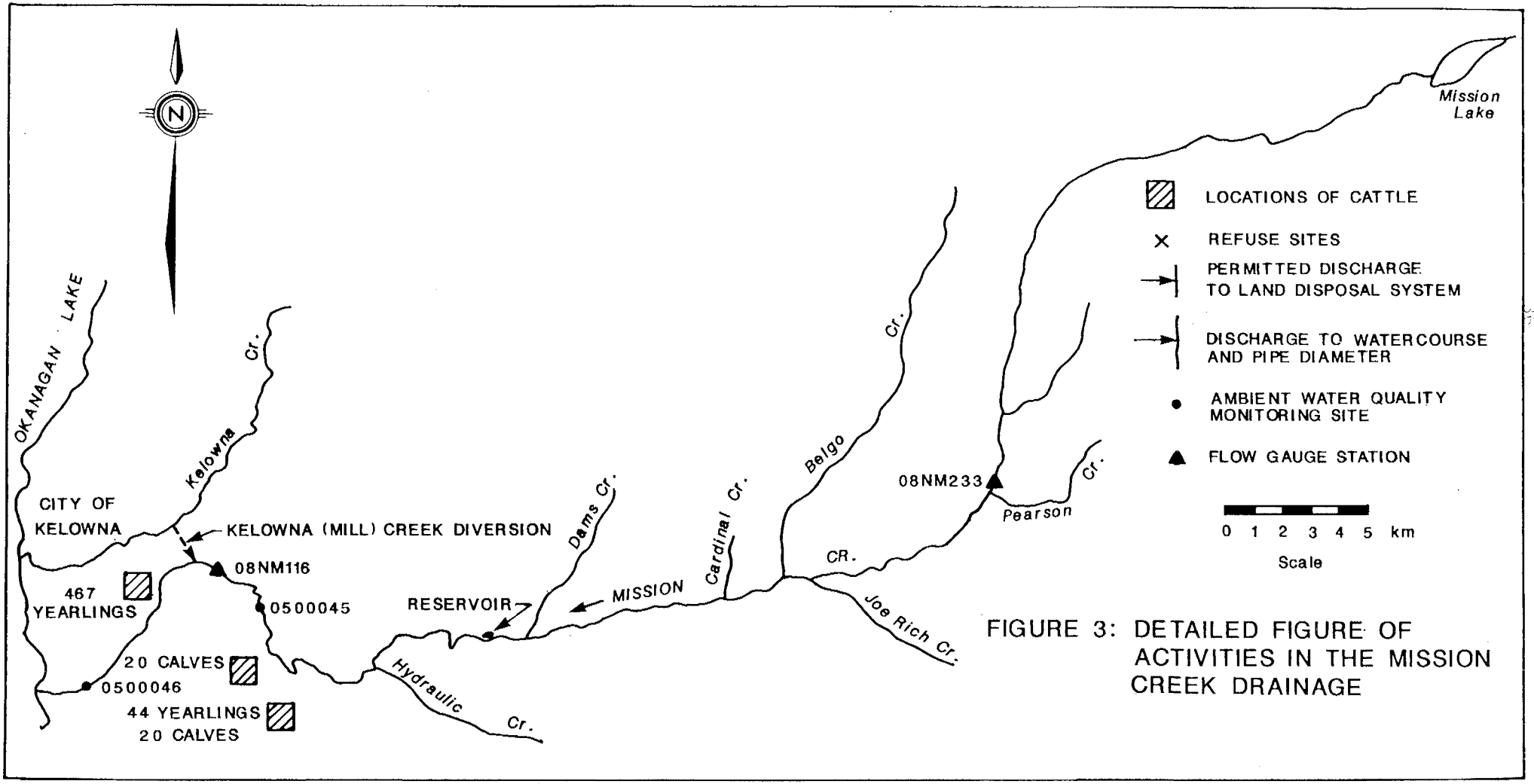


FIGURE 3: DETAILED FIGURE OF ACTIVITIES IN THE MISSION CREEK DRAINAGE

**TABLE 1**
**EFFLUENT QUALITY DATA SUMMARY**
**KELOWNA TRADE WASTEWATER TREATMENT PLANT (PE 1434)**

| CHARACTERISTIC | NUMBER OF VALUES | VALUES* MAXIMUM | MINIMUM | MEAN | STANDARD DEVIATION |
|---|---|---|---|---|---|
| Coliforms-Fecal | 5 | 16 | 2 | 9+ | - |
| -Escherechia | 5 | 10 | 2 | 6+ | - |
| Streptococci | 4 | 1340 | 16 | 38.5+ | - |
| Nitrogen | | | | | |
| -Ammonia | 28 | 8.55 | <0.005 | 0.87 | 1.83 |
| -Kjeldahl | 28 | 33.6 | 0.67 | 5.06 | 6.98 |
| -Nitrite | 28 | 0.345 | <0.005 | 0.051 | 0.085 |
| -Nitrate/ Nitrite | 28 | 22.4 | <0.02 | 3.19 | 5.88 |
| Oxygen-BOD | 11 | 145 | <10 | 22.6 | 29 |
| pH | 28 | 7.8 | 6.4 | 7.3+ | - |
| Phosphorus | | | | | |
| -Ortho Diss | 28 | 5.27 | <0.003 | 1.13 | 1.66 |
| -Total Diss | 28 | 5.68 | 0.009 | 1.28 | 1.75 |
| -Total | 28 | 13.6 | 0.02 | 2.51 | 2.85 |
| Solids-Suspended | 28 | 1040 | 2 | 675 | 194 |
| Specific Conductivity | 28 | 675 | 385 | 495 | 61 |
| Turbidity | 1 | 2.9 | - | - | - |

PERIOD OF RECORD : 1985-1988

\+ Median Value

*All values are as mg/L except:
1) Coliforms and Streptococci as No/100mL
2) pH
3) Specific Conductivity as uS/cm
4) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

**TABLE 2**
**AMBIENT WATER QUALITY DATA SUMMARY**
**SITE 0500045:MISSION CREEK AT EAST KELOWNA ROAD**

| CHARACTERISTIC | NUMBER OF VALUES | VALUES* MAXIMUM | MINIMUM | MEAN | STANDARD DEVIATION |
|---|---|---|---|---|---|
| Alkalinity | 19 | 108 | 27.1 | 68.2 | 27.7 |
| Carbon-Organic | 16 | 14 | 3 | 6.06 | 3.30 |
| Chloride | 18 | 2.3 | 0.5 | 1.12 | 0.49 |
| Coliforms-Fecal | 2 | 5 | <2 | - | - |
| Colour | 12 | 40 | 5 | 19.6 | 13.4 |
| Hardness-Total | 21 | 149 | 22.6 | 73.7 | 37.4 |
| -Calcium(Ca) | 21 | 37.2 | 6.3 | 19.4 | 9.4 |
| -Magnesium(Mg) | 19 | 13 | 1.68 | 6.29 | 3.49 |
| Metals (Dissolved) | | | | | |
| -Boron | 3 | <0.1 | <0.1 | <0.1 | - |
| -Cadmium | 6 | 0.0006 | <0.0001 | <0.0005+ | - |
| -Chromium | 6 | <0.005 | <0.005 | <0.005 | - |
| -Copper | 6 | 0.005 | <0.001 | 0.002 | 0.0015 |
| -Iron | 12 | 0.2 | 0.05 | 0.10 | 0.04 |
| -Lead | 6 | <0.003 | <0.001 | 0.001+ | - |
| -Manganese | 6 | 0.03 | <0.01 | <0.02+ | - |
| -Mercury(Tot) | 7 | <0.00005 | <0.00005 | <0.00005 | - |
| -Nickel | 5 | <0.01 | <0.01 | <0.01 | - |
| -Zinc | 6 | 0.03 | <0.005 | 0.011 | 0.010 |
| Nitrogen | | | | | |
| -Ammonia | 12 | 0.025 | 0.006 | 0.011 | 0.006 |
| -Kjeldahl | 19 | 0.63 | 0.05 | 0.20 | 0.16 |
| -Nitrate | 10 | 0.78 | 0.03 | 0.19 | 0.22 |
| -Nitrite | 13 | <0.005 | <0.005 | <0.005 | - |
| -Nitrate/ Nitrite | 13 | 0.39 | 0.02 | 0.19 | 0.15 |
| -Organic | 16 | 0.62 | 0.05 | 0.21 | 0.13 |
| -Total | 22 | 0.96 | 0.11 | 0.40 | 0.22 |
| Oxygen-Dissolved | 22 | 13.9 | 8.7 | 11.7 | 1.45 |
| -% Saturation | 16 | 111.1 | 75.9 | 99.5 | 8.66 |
| pH | 26 | 8.4 | 7.5 | 7.95+ | - |
| Phosphorus | | | | | |
| -Ortho Diss | 9 | 0.006 | <0.003 | <0.003+ | - |
| -Total Diss | 7 | 0.02 | 0.006 | 0.010 | 0.005 |
| -Total | 23 | 0.055 | 0.009 | 0.019 | 0.012 |
| Potassium | 19 | 3 | 0.6 | 1.17 | 0.53 |
| Sodium | 19 | 10.3 | 1.8 | 6.27 | 2.57 |
| Solids-Dissolved | 4 | 160 | 80 | 125 | 36.6 |
| -Suspended | 20 | 27 | <1 | 17 | 7.2 |
| -Total | 19 | 212 | 68 | 121.4 | 42.9 |
| Specific Conductivity | 25 | 346 | 50 | 174 | 80.8 |
| Sulphate | 19 | 24.1 | <5 | 12.2 | 6.28 |
| Temperature | 22 | 18 | 1 | 7.5 | 5.1 |
| Turbidity | 15 | 7.9 | 0.6 | 2.94 | 2.29 |

PERIOD OF RECORD : 1972-1981 + Median Value

*All values are as mg/L except:
1) Coliforms as MPN/100mL 2) Colour as true colour units
3) pH
4) Specific Conductivity as uS/cm
5) Temperature as °C 6) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

**TABLE 3**
**AMBIENT WATER QUALITY DATA SUMMARY**
**SITE 0500046:MISSION CREEK AT LAKESHORE ROAD**

| CHARACTERISTIC | NUMBER OF VALUES | VALUES* MAXIMUM | MINIMUM | MEAN | STANDARD DEVIATION |
|---|---|---|---|---|---|
| Alkalinity | 29 | 178 | 17 | 90.8 | 45.9 |
| Carbon-Organic | 22 | 15 | 3 | 7.4 | 3.58 |
| Chloride | 23 | 3.1 | 0.5 | 1.39 | 0.64 |
| Coliforms-Fecal | 8 | 170 | <2 | 33+ | - |
| Colour | 18 | 65 | 5 | 20.3 | 16.1 |
| Hardness-Total | 33 | 232 | 16 | 101.1 | 62.2 |
| -Calcium(Ca) | 34 | 52.4 | 4.6 | 25.1 | 14.5 |
| -Magnesium(Mg) | 32 | 23 | 1.1 | 9.43 | 6.44 |
| Metals (Dissolved) | | | | | |
| -Aluminum | 1 | 0.03 | - | - | - |
| -Boron | 4 | <0.1 | <0.01 | <0.1+ | - |
| -Cadmium | 14 | 0.0004 | <0.0001 | - | - |
| -Chromium | 10 | <0.005 | <0.005 | <0.005 | - |
| -Copper | 12 | 0.017 | <0.001 | 0.002+ | - |
| -Iron | 22 | 0.21 | <0.04 | 0.11 | 0.054 |
| -Lead | 11 | 0.006 | <0.001 | <0.001+ | - |
| -Manganese | 17 | 0.04 | <0.01 | 0.02 | 0.012 |
| -Mercury(Tot) | 11 | 0.00005 | <0.00005 | <0.00005+ | - |
| -Molybdenum | 5 | 0.01 | 0.0006 | 0.0044 | 0.005 |
| -Nickel | 11 | <0.05 | <0.01 | <0.01 | - |
| -Zinc | 16 | 0.06 | <0.005 | 0.012 | 0.014 |
| Nitrogen | | | | | |
| -Ammonia | 8 | 0.07 | <0.01 | 0.026 | 0.021 |
| -Kjeldahl | 26 | 0.36 | 0.11 | 0.23 | 0.06 |
| -Nitrate | 7 | 0.46 | 0.03 | 0.18 | 0.18 |
| -Nitrite | 21 | <0.005 | <0.005 | <0.005 | <0.005 |
| -Nitrate/ Nitrite | 18 | 0.67 | <0.02 | 0.21 | 0.21 |
| -Organic | 25 | 0.4 | 0.12 | 0.24 | 0.063 |
| -Total | 32 | 0.9 | 0.11 | 0.44 | 0.20 |
| Oxygen-Dissolved | 32 | 13.8 | 8.2 | 11.6 | 1.45 |
| -% Saturation | 26 | 141.6 | 66.1 | 102.8 | 16.2 |
| pH | 53 | 9.1 | 6.6 | 8.2+ | - |
| Phosphorus | | | | | |
| -Ortho Diss | 13 | 0.013 | <0.003 | 0.007 | 0.003 |
| -Total Diss | 11 | 0.021 | 0.005 | 0.012 | 0.004 |
| -Total | 34 | 0.14 | 0.008 | 0.030 | 0.025 |
| Potassium | 26 | 2.4 | 0.4 | 1.4 | 0.53 |
| Sodium | 26 | 18.5 | 1.2 | 8.59 | 4.51 |
| Solids-Dissolved | 8 | 244 | 52 | 152.5 | 73.3 |
| -Suspended | 28 | 137 | 1 | 16.6 | 29.1 |
| -Total | 25 | 336 | 70 | 192 | 76.8 |
| Specific Conductivity | 56 | 498 | <50 | 238 | 132.1 |
| Sulphate | 25 | 90.6 | <5 | 31.7 | 22.0 |
| Temperature | 34 | 19 | 0.5 | 8.6 | 5.2 |
| Turbidity | 26 | 45 | 0.6 | 6.8 | 11.4 |

PERIOD OF RECORD : 1969-1982 + Median Value

*All values are as mg/L except:
1) Coliforms as MPN/100mL 2) Colour as true colour units
3) pH
4) Specific Conductivity as uS/cm
5) Temperature as °C 6) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

**TABLE 4**
**AVERAGE 30-DAY CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)**

| pH | Temp. 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.5 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 | 1.90 | 1.88 | 1.86 | 1.84 |
| 6.6 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 | 1.90 | 1.88 | 1.86 | 1.84 |
| 6.7 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 | 1.90 | 1.88 | 1.86 | 1.84 |
| 6.8 | 2.08 | 2.05 | 2.02 | 1.99 | 1.96 | 1.94 | 1.92 | 1.90 | 1.88 | 1.86 | 1.84 |
| 6.9 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 | 1.90 | 1.88 | 1.86 | 1.84 |
| 7.0 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 | 1.90 | 1.88 | 1.86 | 1.84 |
| 7.1 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.94 | 1.92 | 1.90 | 1.88 | 1.86 | 1.84 |
| 7.2 | 2.08 | 2.05 | 2.02 | 1.99 | 1.96 | 1.95 | 1.92 | 1.90 | 1.88 | 1.86 | 1.85 |
| 7.3 | 2.08 | 2.05 | 2.02 | 1.99 | 1.97 | 1.95 | 1.92 | 1.90 | 1.88 | 1.86 | 1.85 |
| 7.4 | 2.08 | 2.05 | 2.02 | 2.00 | 1.97 | 1.95 | 1.92 | 1.90 | 1.88 | 1.87 | 1.85 |
| 7.5 | 2.08 | 2.05 | 2.02 | 2.00 | 1.97 | 1.95 | 1.93 | 1.91 | 1.88 | 1.87 | 1.85 |
| 7.6 | 2.09 | 2.05 | 2.03 | 2.00 | 1.97 | 1.95 | 1.93 | 1.91 | 1.89 | 1.87 | 1.85 |
| 7.7 | 2.09 | 2.05 | 2.03 | 2.00 | 1.98 | 1.95 | 1.93 | 1.91 | 1.89 | 1.87 | 1.86 |
| 7.8 | 1.78 | 1.75 | 1.73 | 1.71 | 1.69 | 1.67 | 1.65 | 1.63 | 1.62 | 1.60 | 1.59 |
| 7.9 | 1.50 | 1.48 | 1.46 | 1.44 | 1.43 | 1.41 | 1.39 | 1.38 | 1.36 | 1.35 | 1.34 |
| 8.0 | 1.26 | 1.24 | 1.23 | 1.21 | 1.20 | 1.18 | 1.17 | 1.16 | 1.15 | 1.14 | 1.13 |
| 8.1 | 1.00 | .989 | .976 | .963 | .952 | .942 | .932 | .922 | .914 | .906 | .899 |
| 8.2 | .799 | .788 | .777 | .768 | .759 | .751 | .743 | .736 | .730 | .724 | .718 |
| 8.3 | .636 | .628 | .620 | .613 | .606 | .599 | .594 | .588 | .583 | .579 | .575 |
| 8.4 | .508 | .501 | .495 | .489 | .484 | .479 | .475 | .471 | .467 | .464 | .461 |
| 8.5 | .405 | .400 | .396 | .381 | .387 | .384 | .380 | .377 | .375 | .372 | .370 |
| 8.6 | .324 | .320 | .317 | .313 | .310 | .308 | .305 | .303 | .301 | .300 | .298 |
| 8.7 | .260 | .257 | .254 | .251 | .249 | .247 | .246 | .244 | .243 | .242 | .241 |
| 8.8 | .208 | .206 | .204 | .202 | .201 | .200 | .198 | .197 | .197 | .196 | .196 |
| 8.9 | .168 | .166 | .165 | .163 | .162 | .161 | .161 | .160 | .160 | .160 | .160 |
| 9.0 | .135 | .134 | .133 | .132 | .132 | .131 | .131 | .131 | .131 | .131 | .131 |

| | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 18.0 | 19.0 | 20.0 |
|---|---|---|---|---|---|---|---|---|---|---|
| 6.5 | 1.82 | 1.81 | 1.80 | 1.78 | 1.77 | 1.64 | 1.52 | 1.41 | 1.31 | 1.22 |
| 6.6 | 1.82 | 1.81 | 1.80 | 1.78 | 1.77 | 1.64 | 1.52 | 1.41 | 1.31 | 1.22 |
| 6.7 | 1.83 | 1.81 | 1.80 | 1.78 | 1.77 | 1.64 | 1.52 | 1.41 | 1.31 | 1.22 |
| 6.8 | 1.83 | 1.81 | 1.80 | 1.78 | 1.77 | 1.64 | 1.52 | 1.42 | 1.32 | 1.22 |
| 6.9 | 1.82 | 1.81 | 1.80 | 1.78 | 1.77 | 1.64 | 1.53 | 1.42 | 1.32 | 1.22 |
| 7.0 | 1.83 | 1.81 | 1.80 | 1.79 | 1.77 | 1.64 | 1.53 | 1.42 | 1.32 | 1.22 |
| 7.1 | 1.83 | 1.81 | 1.80 | 1.79 | 1.77 | 1.65 | 1.53 | 1.42 | 1.32 | 1.23 |
| 7.2 | 1.83 | 1.81 | 1.80 | 1.79 | 1.78 | 1.65 | 1.53 | 1.42 | 1.32 | 1.23 |
| 7.3 | 1.83 | 1.82 | 1.80 | 1.79 | 1.78 | 1.65 | 1.53 | 1.42 | 1.32 | 1.23 |
| 7.4 | 1.83 | 1.82 | 1.80 | 1.79 | 1.78 | 1.65 | 1.53 | 1.42 | 1.32 | 1.23 |
| 7.5 | 1.83 | 1.82 | 1.81 | 1.80 | 1.78 | 1.66 | 1.54 | 1.43 | 1.33 | 1.23 |
| 7.6 | 1.84 | 1.82 | 1.81 | 1.80 | 1.78 | 1.66 | 1.54 | 1.43 | 1.33 | 1.24 |
| 7.7 | 1.84 | 1.83 | 1.81 | 1.80 | 1.78 | 1.66 | 1.54 | 1.44 | 1.34 | 1.24 |
| 7.8 | 1.57 | 1.56 | 1.55 | 1.54 | 1.53 | 1.42 | 1.32 | 1.23 | 1.14 | 1.07 |
| 7.9 | 1.33 | 1.32 | 1.31 | 1.31 | 1.30 | 1.21 | 1.12 | 1.04 | .970 | .904 |

| | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 18.0 | 19.0 | 20.0 |
|---|---|---|---|---|---|---|---|---|---|---|
| 8.0 | 1.12 | 1.11 | 1.10 | 1.10 | 1.09 | 1.02 | .944 | .878 | .818 | .762 |
| 8.1 | .893 | .887 | .882 | .878 | .874 | .812 | .756 | .704 | .655 | .611 |
| 8.2 | .714 | .709 | .706 | .703 | .700 | .651 | .606 | .565 | .527 | .491 |
| 8.3 | .571 | .568 | .566 | .564 | .562 | .523 | .487 | .455 | .424 | .396 |
| 8.4 | .458 | .456 | .455 | .453 | .452 | .421 | .393 | .367 | .343 | .321 |
| 8.5 | .369 | .367 | .366 | .366 | .365 | .341 | .318 | .298 | .278 | .261 |
| 8.6 | .297 | .297 | .296 | .296 | .296 | .277 | .259 | .242 | .227 | .213 |
| 8.7 | .241 | .240 | .240 | .241 | .241 | .226 | .212 | .198 | .186 | .175 |
| 8.8 | .196 | .196 | .196 | .197 | .198 | .185 | .174 | .164 | .154 | .145 |
| 8.9 | .160 | .161 | .161 | .162 | .163 | .153 | .144 | .136 | .128 | .121 |
| 9.0 | .132 | .132 | .133 | .134 | .135 | .128 | .121 | .114 | .108 | .102 |

-the average of the measured values must be less than the average of the corresponding individual values in this Table .
-each measured value is compared to the corresponding individual values in this Table . No more than one in five of the measured values can be greater than one-and-a-half times the corresponding values in this Table .

**TABLE 5**
**MAXIMUM CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)**

| pH | Temp. 0.0 | 1.0 | 2.0 | 3.0 | 4.0 | 5.0 | 6.0 | 7.0 | 8.0 | 9.0 | 10.0 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.5 | 27.7 | 28.3 | 27.9 | 27.5 | 27.2 | 26.8 | 26.5 | 26.2 | 26.0 | 25.7 | 25.5 |
| 6.6 | 27.9 | 27.5 | 27.2 | 26.8 | 26.4 | 26.1 | 25.8 | 25.5 | 25.2 | 25.0 | 24.7 |
| 6.7 | 26.9 | 26.5 | 26.2 | 25.9 | 25.5 | 25.2 | 24.9 | 24.6 | 24.4 | 24.1 | 23.9 |
| 6.8 | 25.8 | 25.5 | 25.1 | 24.8 | 24.5 | 24.2 | 23.9 | 23.6 | 23.4 | 23.1 | 22.9 |
| 6.9 | 24.6 | 24.2 | 23.9 | 23.6 | 23.3 | 23.0 | 22.7 | 22.5 | 22.2 | 22.0 | 21.8 |
| 7.0 | 23.2 | 22.8 | 22.5 | 22.2 | 21.9 | 21.6 | 21.4 | 21.1 | 20.9 | 20.7 | 20.5 |
| 7.1 | 21.6 | 21.3 | 20.9 | 20.7 | 20.4 | 20.2 | 19.9 | 19.7 | 19.5 | 19.3 | 19.1 |
| 7.2 | 19.9 | 19.6 | 19.3 | 19.0 | 18.8 | 18.6 | 18.3 | 18.1 | 17.9 | 17.8 | 17.6 |
| 7.3 | 18.1 | 17.8 | 17.5 | 17.3 | 17.1 | 16.9 | 16.7 | 16.5 | 16.3 | 16.2 | 16.0 |
| 7.4 | 16.2 | 16.0 | 15.7 | 15.5 | 15.3 | 15.2 | 15.0 | 14.8 | 14.7 | 14.5 | 14.4 |
| 7.5 | 14.4 | 14.1 | 14.0 | 13.8 | 13.6 | 13.4 | 13.3 | 13.1 | 13.0 | 12.9 | 12.7 |
| 7.6 | 12.6 | 12.4 | 12.2 | 12.0 | 11.9 | 11.7 | 11.6 | 11.5 | 11.4 | 11.3 | 11.2 |
| 7.7 | 10.8 | 10.7 | 10.5 | 10.4 | 10.3 | 10.1 | 10.0 | 9.92 | 9.83 | 9.73 | 9.65 |
| 7.8 | 9.26 | 9.12 | 8.98 | 8.88 | 8.77 | 8.67 | 8.57 | 8.48 | 8.40 | 8.32 | 8.25 |
| 7.9 | 7.82 | 7.71 | 7.60 | 7.51 | 7.42 | 7.33 | 7.25 | 7.17 | 7.10 | 7.04 | 6.98 |
| 8.0 | 6.55 | 6.46 | 6.37 | 6.29 | 6.22 | 6.14 | 6.08 | 6.02 | 5.96 | 5.91 | 5.86 |
| 8.1 | 5.21 | 5.14 | 5.07 | 5.01 | 4.95 | 4.90 | 4.84 | 4.80 | 4.75 | 4.71 | 4.67 |
| 8.2 | 4.15 | 4.09 | 4.04 | 3.99 | 3.95 | 3.90 | 3.86 | 3.83 | 3.80 | 3.76 | 3.74 |
| 8.3 | 3.31 | 3.27 | 3.22 | 3.19 | 3.15 | 3.12 | 3.09 | 3.06 | 3.03 | 3.01 | 2.99 |
| 8.4 | 2.64 | 2.61 | 2.57 | 2.54 | 2.52 | 2.49 | 2.47 | 2.45 | 2.43 | 2.41 | 2.40 |
| 8.5 | 2.11 | 2.08 | 2.06 | 2.03 | 2.01 | 1.99 | 1.98 | 1.96 | 1.95 | 1.94 | 1.93 |
| 8.6 | 1.69 | 1.67 | 1.65 | 1.63 | 1.61 | 1.60 | 1.59 | 1.58 | 1.57 | 1.56 | 1.55 |
| 8.7 | 1.35 | 1.33 | 1.32 | 1.31 | 1.30 | 1.29 | 1.28 | 1.27 | 1.26 | 1.26 | 1.25 |
| 8.8 | 1.08 | 1.07 | 1.06 | 1.05 | 1.04 | 1.04 | 1.03 | 1.03 | 1.02 | 1.02 | 1.02 |
| 8.9 | .871 | .863 | .856 | .849 | .844 | .839 | .836 | .833 | .832 | .831 | .831 |
| 9.0 | .703 | .697 | .692 | .683 | .685 | .682 | .681 | .681 | .680 | .681 | .682 |

| pH | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 18.0 | 19.0 | 20.0 |
|---|---|---|---|---|---|---|---|---|---|---|
| 6.5 | 25.2 | 25.0 | 24.8 | 24.6 | 24.5 | 24.3 | 24.2 | 24.0 | 23.9 | 23.8 |
| 6.6 | 24.5 | 24.3 | 24.1 | 23.9 | 23.8 | 23.6 | 23.5 | 23.3 | 23.3 | 23.2 |
| 6.7 | 23.7 | 23.5 | 23.3 | 23.1 | 23.0 | 22.8 | 22.7 | 22.6 | 22.5 | 22.4 |
| 6.8 | 22.7 | 22.5 | 22.3 | 22.2 | 22.0 | 21.9 | 21.8 | 21.7 | 21.6 | 21.5 |
| 6.9 | 21.6 | 21.4 | 21.3 | 21.1 | 21.0 | 20.8 | 20.7 | 20.6 | 20.5 | 20.4 |
| 7.0 | 20.3 | 20.2 | 20.0 | 19.9 | 19.7 | 19.6 | 19.5 | 19.4 | 19.3 | 19.2 |
| 7.1 | 18.9 | 18.8 | 18.7 | 18.5 | 18.4 | 18.3 | 18.2 | 18.1 | 18.0 | 17.9 |
| 7.2 | 17.4 | 17.3 | 17.2 | 17.1 | 16.9 | 16.8 | 16.8 | 16.7 | 16.6 | 16.5 |
| 7.3 | 15.9 | 15.7 | 15.6 | 15.5 | 15.4 | 15.3 | 15.2 | 15.2 | 15.1 | 15.1 |
| 7.4 | 14.2 | 14.1 | 14.0 | 13.9 | 13.9 | 13.8 | 13.7 | 13.6 | 13.6 | 13.5 |
| 7.5 | 12.6 | 12.5 | 12.4 | 12.4 | 12.3 | 12.2 | 12.2 | 12.1 | 12.1 | 12.0 |
| 7.6 | 11.1 | 11.0 | 10.9 | 10.8 | 10.8 | 10.7 | 10.7 | 10.6 | 10.6 | 10.5 |
| 7.7 | 9.57 | 9.50 | 9.43 | 9.37 | 9.31 | 9.26 | 9.22 | 9.81 | 9.15 | 9.12 |
| 7.8 | 8.18 | 8.12 | 8.07 | 8.02 | 7.97 | 7.93 | 7.90 | 7.87 | 7.84 | 7.82 |
| 7.9 | 6.92 | 6.88 | 6.83 | 6.79 | 6.75 | 6.72 | 6.69 | 6.67 | 6.65 | 6.64 |

| | 11.0 | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 | 17.0 | 18.0 | 19.0 | 20.0 |
|---|---|---|---|---|---|---|---|---|---|---|
| 8.0 | 5.81 | 5.78 | 5.74 | 5.71 | 5.68 | 5.66 | 5.64 | 5.62 | 5.61 | 5.60 |
| 8.1 | 4.64 | 4.61 | 4.59 | 4.56 | 4.54 | 4.53 | 4.51 | 4.50 | 4.49 | 4.49 |
| 8.2 | 3.71 | 3.69 | 3.67 | 3.65 | 3.64 | 3.63 | 3.62 | 3.61 | 3.61 | 3.61 |
| 8.3 | 2.97 | 2.96 | 2.94 | 2.93 | 2.92 | 2.92 | 2.91 | 2.91 | 2.91 | 2.91 |
| 8.4 | 2.38 | 2.37 | 2.36 | 2.36 | 2.35 | 2.35 | 2.35 | 2.35 | 2.35 | 2.36 |
| 8.5 | 1.92 | 1.91 | 1.91 | 1.90 | 1.90 | 1.90 | 1.90 | 1.90 | 1.91 | 1.92 |
| 8.6 | 1.55 | 1.54 | 1.54 | 1.54 | 1.54 | 1.54 | 1.55 | 1.55 | 1.56 | 1.57 |
| 8.7 | 1.25 | 1.25 | 1.25 | 1.25 | 1.25 | 1.26 | 1.26 | 1.27 | 1.28 | 1.29 |
| 8.8 | 1.02 | 1.02 | 1.02 | 1.02 | 1.03 | 1.03 | 1.04 | 1.05 | 1.06 | 1.07 |
| 8.9 | .832 | .834 | .838 | .842 | .847 | .853 | .861 | .870 | .880 | .891 |
| 9.0 | .684 | .688 | .692 | .698 | .704 | .711 | .720 | .729 | .740 | .752 |

**TABLE 6**

**CRITERIA FOR NITRITE FOR PROTECTION OF FRESHWATER AQUATIC LIFE**

| Concentration (mg/L) | | |
|---|---|---|
| Chloride | Maximum Nitrite | Average Nitrite |
| <2 | 0.06 | 0.02 |
| 2-4 | 0.12 | 0.04 |
| 4-6 | 0.18 | 0.06 |
| 6-8 | 0.24 | 0.08 |
| 8-10 | 0.30 | 0.10 |
| >10 | 0.60 | 0.20 |

NOTE: The 30-d average chloride concentration should be used to determine the appropriate 30-d average nitrite concentration .

**TABLE 7**
**AMBIENT WATER QUALITY DATA SUMMARY**
**SITE 0500039:KELOWNA CREEK AT MOUTH**

| CHARACTERISTIC | NUMBER OF VALUES | VALUES* MAXIMUM | MINIMUM | MEAN | STANDARD DEVIATION |
|---|---|---|---|---|---|
| Alkalinity | 39 | 258 | 57.4 | 208.6 | 48.7 |
| Carbon-Organic | 21 | 24 | <1 | 9.8 | 6.9 |
| Chloride | 26 | 21.1 | 1.1 | 10.4 | 3.8 |
| Coliforms-Fecal | 8 | >2400 | 33 | 540+ | - |
| Colour | 18 | 90 | 5 | 21.9 | 25.5 |
| Hardness-Total | 33 | 272 | 58.3 | 210.4 | 61.9 |
| -Calcium(Ca) | 45 | 72 | 15.5 | 53.6 | 14.3 |
| -Magnesium(Mg) | 33 | 23.7 | 4.6 | 18.7 | 5.24 |
| Metals (Dissolved) | | | | | |
| -Aluminum | 1 | 0.21 | - | - | - |
| -Boron | 10 | 0.1 | <0.01 | 0.073 | 0.033 |
| -Cadmium | 6 | 0.0007 | <0.0001 | 0.0004 | 0.0003 |
| -Chromium | 8 | <0.005 | <0.005 | <0.005 | - |
| -Copper | 16 | 0.036 | 0 | 0.008 | 0.010 |
| -Iron | 21 | 0.46 | <0.04 | 0.185 | 0.150 |
| -Lead | 20 | 0.27 | 0 | 0.021 | 0.059 |
| -Manganese | 24 | 0.24 | 0.01 | 0.103 | 0.056 |
| -Mercury(Tot) | 8 | 0.00019 | <0.00005 | <0.00005+ | - |
| -Nickel | 7 | 0.01 | <0.01 | <0.01 | - |
| -Zinc | 23 | 0.3 | 0 | 0.042 | 0.070 |
| Nitrogen | | | | | |
| -Ammonia | 19 | 1.51 | <0.005 | 0.119 | 0.338 |
| -Kjeldahl | 33 | 2.46 | 0.17 | 0.58 | 0.41 |
| -Nitrate | 10 | 2.18 | 0.07 | 0.90 | 0.68 |
| -Nitrite | 22 | 0.052 | <0.005 | 0.015 | 0.011 |
| -Nitrate/ Nitrite | 27 | 2.26 | 0.25 | 1.49 | 0.68 |
| -Organic | 36 | 1.22 | 0.02 | 0.39 | 0.32 |
| -Total | 38 | 3.45 | 0.19 | 1.83 | 0.79 |
| Oxygen-Dissolved | 25 | 14.8 | 7.6 | 11.6 | 1.9 |
| -% Saturation | 20 | 140.3 | 79.6 | 100.9 | 12.8 |
| pH | 47 | 9.1 | 7.8 | 8.3+ | - |
| Phosphorus | | | | | |
| -Ortho Diss | 11 | 0.058 | 0.027 | 0.043 | 0.010 |
| -Total Diss | 12 | 0.549 | 0.038 | 0.089 | 0.145 |
| -Total | 48 | 0.623 | 0 | 0.113 | 0.112 |
| Potassium | 39 | 5.1 | 0.4 | 3.5 | 0.83 |
| Sodium | 27 | 34.8 | 9.5 | 26.9 | 6.96 |
| Solids-Dissolved | 22 | 437 | 126 | 320.5 | 69.7 |
| -Suspended | 28 | 138 | 1 | 22.5 | 36.6 |
| -Total | 45 | 526 | 232 | 348 | 52.7 |
| Specific Conductivity | 50 | 890 | 140 | 521.3 | 136.5 |
| Sulphate | 38 | 75.3 | 16.2 | 48.5 | 11.4 |
| Temperature | 46 | 21 | 2 | 10.5 | 5.7 |
| Turbidity | 24 | 92 | 1 | 14.4 | 21.2 |

PERIOD OF RECORD : 1969-1983

+ Median Value

*All values are as mg/L except:
1) Coliforms as MPN/100mL
2) Colour as true colour units
3) Oxygen- Saturation as %
4) pH
5) Specific Conductivity as uS/cm
6) Temperature as °C
7) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

**TABLE 8**
**AMBIENT WATER QUALITY DATA SUMMARY**
**SITE 0500038:KELOWNA CREEK AT WESTMILLS**

| CHARACTERISTIC | NUMBER OF VALUES | VALUES* MAXIMUM | MINIMUM | MEAN | STANDARD DEVIATION |
|---|---|---|---|---|---|
| Alkalinity | 26 | 211 | 41 | 174.7 | 52.7 |
| Carbon-Organic | 9 | 27 | 2 | 10.4 | 7. |
| Chloride | 10 | 5.1 | 1 | 2.8 | 1.07 |
| Coliforms-Fecal | 3 | 110 | <20 | 20+ | - |
| Colour | 13 | 100 | <5 | 28.1 | 33.8 |
| Hardness-Total | 19 | 235 | 51.6 | 191.1 | 57.9 |
| -Calcium(Ca) | 27 | 67.5 | 14 | 55.1 | 16.1 |
| -Magnesium(Mg) | 10 | 143.8 | 5.7 | 18.0 | - |
| Metals (Dissolved) | | | | | |
| -Boron | 3 | 0.2 | <0.1 | 0.13 | 0.058 |
| -Cadmium | 3 | 0.0001 | <0.0001 | <0.0001+ | - |
| -Chromium | 4 | <0.005 | <0.005 | <0.005 | - |
| -Copper | 22 | 0.04 | 0.0 | 0.014 | 0.011 |
| -Iron | 16 | 29 | <0.04 | 2.01 | 7.2 |
| -Lead | 19 | 0.035 | 0.0 | 0.007 | 0.008 |
| -Manganese | 22 | 0.25 | 0.02 | 0.087 | 0.066 |
| -Mercury(Tot) | 3 | <0.00005 | <0.00005 | <0.00005 | - |
| -Nickel | 4 | <0.01 | <0.01 | <0.01 | - |
| -Zinc | 22 | 0.16 | 0.0 | 0.037 | 0.041 |
| Nitrogen | | | | | |
| -Ammonia | 23 | 0.38 | 0.0 | 0.07 | 0.09 |
| -Kjeldahl | 6 | 2 | 0.2 | 0.64 | 0.69 |
| -Nitrate | 19 | 1.04 | 0.04 | 0.20 | 0.23 |
| -Nitrite | 14 | 0.02 | <0.005 | 0.009 | 0.004 |
| -Nitrate/ Nitrite | 7 | 0.59 | 0.04 | 0.32 | 0.20 |
| -Organic | 23 | 0.64 | 0.01 | 0.23 | 0.17 |
| -Total | 20 | 2.47 | 0.22 | 0.68 | 0.55 |
| Oxygen-Dissolved | 17 | 13.2 | 7.6 | 10.6 | 1.6 |
| -% Saturation | 17 | 133.7 | 72.0 | 97.3 | 13.5 |
| pH | 14 | 9.1 | 7.3 | 8.0+ | - |
| Phosphorus | | | | | |
| -Ortho Diss | 4 | 0.055 | 0.027 | 0.047 | 0.013 |
| -Total | 28 | 0.585 | 0.0 | 0.110 | 0.103 |
| Potassium | 28 | 5.1 | 1 | 2.92 | 0.86 |
| Sodium | 10 | 18.5 | 6.1 | 14.1 | 3.94 |
| Solids-Dissolved | 20 | 318 | 122 | 272.1 | 62.4 |
| -Suspended | 13 | 347 | 4.4 | 51.4 | 94.8 |
| -Total | 34 | 798 | 156 | 328 | 120.2 |
| Specific Conductivity | 24 | 590 | 104 | 425.5 | 120.9 |
| Sulphate | 23 | 62 | 12.2 | 41.7 | 13.3 |
| Temperature | 33 | 23 | 1 | 10.4 | 5.1 |
| Turbidity | 7 | 70 | 3.5 | 15.1 | 24.3 |

PERIOD OF RECORD : 1969-1982

+ Median Value

*All values are as mg/L except:
1) Coliforms as MPN/100mL
2) Colour as true colour units
3) pH
4) Oxygen-% Saturation as %
5) Specific Conductivity as uS/cm
6) Temperature as °C
7) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM

**TABLE 9**
**AMBIENT WATER QUALITY DATA SUMMARY**
**SITE 0500009 : BRANDTS CREEK AT MOUTH**

| CHARACTERISTIC | NUMBER OF VALUES | VALUES* MAXIMUM | MINIMUM | MEAN | STANDARD DEVIATION |
|---|---|---|---|---|---|
| Coliforms-Fecal | 8 | 1650 | 0 | 14+ | - |
| Hardness | | | | | |
| -Calcium(Ca) | 28 | 103 | 45.3 | 67.3 | 14.6 |
| -Magnesium(Mg) | 28 | 119 | 32.3 | 60.5 | 21.4 |
| Metals (Total) | | | | | |
| -Aluminum | 21 | 4.88 | 0.04 | 0.89 | 1.02 |
| -Cadmium | 28 | 0.01 | <0.01 | <0.01+ | - |
| -Chromium | 28 | 0.03 | <0.01 | <0.01+ | - |
| -Iron | 28 | 7.1 | 0.05 | 1.04 | 1.28 |
| -Lead | 28 | <0.1 | <0.1 | <0.1 | - |
| -Manganese | 28 | 0.48 | 0.03 | 0.17 | 0.10 |
| -Molybdenum | 28 | 0.04 | <0.01 | 0.02 | 0.009 |
| -Zinc | 28 | 0.1 | <0.01 | 0.02 | 0.018 |
| Nitrogen | | | | | |
| -Ammonia | 29 | 0.985 | <0.005 | 0.085 | 0.188 |
| -Kjeldahl | 29 | 4.05 | 0.42 | 1.10 | 0.78 |
| -Nitrite | 29 | 0.235 | <0.005 | 0.026 | 0.042 |
| -Nitrate/ Nitrite | 29 | 6.2 | <0.02 | 0.83 | 1.18 |
| Oxygen-BOD | 27 | 65 | <10 | <10+ | - |
| pH | 29 | 8.6 | 7.5 | 8.1+ | - |
| Phosphorus | | | | | |
| -Ortho Diss | 29 | 1.04 | <0.003 | 0.204 | 0.232 |
| -Total Diss | 29 | 1.09 | 0.015 | 0.23 | 0.24 |
| -Total | 29 | 1.75 | 0.094 | 0.402 | 0.365 |
| Specific Conductivity | 29 | 2190 | 690 | 1263 | 338 |
| Turbidity | 29 | 80 | 1.5 | 10.8 | 14.7 |

PERIOD OF RECORD : 1985-1988

+ Median Value

*All values are as mg/L except:
1) Coliforms as MPN/100mL
2) pH
3) Specific Conductivity as uS/cm
4) Turbidity as NTU

DATA SOURCE :B.C. MINISTRY OF ENVIRONMENT DATA RETRIEVAL SYSTEM