POLLUTION PREVENTION PROGRAM

MINISTRY OF ENVIRONMENT, LANDS, AND PARKS

PROVINCE OF BRITISH COLUMBIA

WATER QUALITY ASSESSMENT

AND OBJECTIVES FOR

KEREMEOS CREEK WATERSHED

OKANAGAN AREA

OVERVIEW

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SUMMARY

THIS DOCUMENT is one in a series that presents ambient water quality objectives for British Columbia. It has two parts: this overview, which is available as a separate document—and the full report. This overview provides general information about water quality in the Keremeos Creek watershed. It is intended for both technical readers and for readers who may not be familiar with the process of setting water quality objectives. It includes tables listing water quality objectives and recommended monitoring. The main report presents the details of the water quality assessment for these waterbodies, and forms the basis of the recommendations and objectives presented in this overview.

Water quality objectives are recommended to protect aquatic life, wildlife, irrigation water supplies, livestock watering, and drinking water supplies in Keremeos Creek, South Keremeos Creek, Cedar Creek and Olalla Creek.

There are a variety of human activities in the watershed which could degrade water quality. Increases in chloride in upper portions of the creek were caused by a gravel pit operation. Activities near Apex Mountain Resort were found to increase nutrients and sediments in upper portions of Keremeos Creek. Agricultural activities in the lower section of Keremeos Creek were found to increase nutrients and fecal coliform bacteria in the creek. More specific studies would be required to determine the impact of timber harvest on water quality. As the data used in this report is limited, additional sampling would be required to more fully document the nature of these effects and to determine attainment of the water quality objectives specified for the protection of the most sensitive water use.

PREFACE

Purpose of Water Quality Objectives

WATER QUALITY OBJECTIVES are prepared for specific bodies of fresh, estuarine and coastal marine surface waters of British Columbia as part of the Ministry of Environment, Lands and Parks' mandate to manage water quality. Objectives are prepared only for those waterbodies and water quality characteristics that may be affected by human activity now or in the near future.

How Objectives Are Determined

WATER QUALITY OBJECTIVES are based the BC approved and working guidelines (guideline) as well as national water quality guidelines.[1] Water quality guidelines are safe limits of the physical, chemical, or biological characteristics of water, biota (plant and animal life) or sediment which protect water use. Objectives are established in British Columbia for waterbodies on a site-specific basis. They are derived from the guideline by considering local water quality, water uses, water movement, waste discharges, and socio-economic factors.

Water quality objectives are set to protect the most sensitive designated water use at a specific location. A designated water use is one that is protected in a given location and is one of the following:

- raw drinking water, public water supply, and food processing
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics
- industrial water supplies

Each objective for a location may be based on the protection of a different water use, depending on the uses that are most sensitive to the physical, chemical, or biological characteristics affecting that waterbody.

[1] The process for establishing water quality objectives is outlined more fully in *Preparing Water Quality Objectives in British Columbia*. Copies of this document are available from the Water Quality Branch, Environmental Protection Department.

How Objectives Are Used

WATER QUALITY OBJECTIVES routinely provide policy direction for resource managers for the protection of water uses in specific waterbodies. Objectives guide the evaluation of water quality, the issuing of permits, licences and orders, and the management of fisheries and the province's land base. They also provide a reference against which the state of water quality in a particular waterbody can be checked, and help to determine whether basin-wide water quality studies should be initiated. Water quality objectives are also a standard for assessing the Ministry's performance in protecting water uses. While water quality objectives have no legal standing and are not directly, objectives do become legally enforceable when included as a requirement of a permit, licence, order, or regulation, such as the Forest Practices Code Act, Water Act regulations or Waste Management Act regulations.

Objectives and Monitoring

WATER QUALITY OBJECTIVES are established to protect all uses which may take place in a waterbody. Monitoring (sometimes called sampling) is undertaken to determine if all the designated water uses are being protected. The monitoring usually takes place at a critical time when a water quality specialist has determined that the water quality objectives may not be met. It is assumed that if all designated water uses are protected at the critical time, then they also will be protected at other times when the threat is less. The monitoring usually takes place during a five week period, which allows the specialists to measure the worst, as well as the average condition in the water. For some waterbodies, the monitoring period and frequency may vary, depending upon the nature of the problem, severity of threats to designated water uses, and the way the objectives are expressed (i.e., mean value, maximum value).

INTRODUCTION

THIS REPORT assesses water quality of Keremeos Creek and its main tributaries: South Keremeos Creek, Cedar Creek , and Olalla Creek (Figure 1). Although Keremeos Creek has been sampled historically near its confluence with the Similkameen River, much of the data presented in this report was gathered between November 1994 and July of 1997.

Keremeos Creek and its tributaries are licenced for domestic and irrigation water supply. These creeks also provide fish rearing habitat and contain resident populations of trout and a variety of other fish species, but census information and access are limited.

A ski resort in the headwaters of Keremeos Creek, as well as agriculture, forestry and road maintenance operations, all influence the water quality of these creeks to varying degrees.

This document summarizes the BC Environment water quality data available for the watershed up to July 1997 and proposes water quality objectives for a number of parameters that may be affected by human activities noted above. These objectives are proposed to protect all water uses in Keremeos, South Keremeos, Cedar and Olalla creeks. FRBC funded monitoring since 1997 may be used to determine water quality objectives attainment and will be reported at a later date.

KEREMEOS CREEK- A WATERSHED PROFILE

Hydrology

THE FLOWS in Keremeos Creek are monitored but not regulated. In upper and lower Keremeos Creek, high flows occur during the spring runoff, with flows decreasing so that the lowest flows are experienced during the summer months. Keremeos Creek has a drainage area of 250 km^2 at the mouth of the creek. Olalla Creek has a drainage area of 27 km^2, while South Keremeos Creek has a drainage area of 7 km^2 and Cedar Creek of 15 km^2.

Mean seven-day low flows in Keremeos Creek were recorded at Olalla in the range of 0.212 to 0.216 m^3/s between July and September. An annual average freshet flow of 2.5 m^3/s is observed during May and June in Keremeos Creek at Olalla.

Water Uses

As of 1997, consumptive water uses include domestic withdrawals totalling: 668 m^3/d on Keremeos Creek, 12m^3/d Cedar Creek, and 150 m^3/d on Olalla Creek. Keremeos Creek drainage above the Gunbarrel intake (Apex Water Utility), and Olalla Creek above the Olalla intake (not in use), are Community Watersheds under the Forest Practices Code at the time this report was prepared. Irrigation use includes: 1724 dam^3/a in Keremeos Creek, 272 dam^3/a on Cedar Creek and 193dam^3/a on Olalla Creek. Although the fishery value of Keremeos Creek is low due to limited access, it is rated highly as a rainbow trout producer for the Similkameen River. Similarly, while the fishery is considered low in both Cedar and Olalla creeks, these systems may be important rearing habitat for fish in Keremeos Creek and the Similkameen River. Rainbow and eastern brook trout, peamouth chub, carp, largescale suckers, redside shiners, squawfish, and chiselmouth are known to reside in Keremeos Creek. Rainbow trout have been observed in Keremeos Creek near the Apex Resort (D. Shanner, pers. comm. 2000). Yellow perch are reported to be in Ford Lake (near Keremeos Creeks first crossing of Green Mountain Road) and may be in Keremeos Creek.

In South Keremeos Creek, rainbow trout and eastern brook trout are known to exist in the creek below Green Mountain Road as the gradient and a culvert under Green Mountain Road present a barrier to fish migration. While the fishery is considered of low value in South Keremeos Creek, it may serve as important rearing habitat for fish residing in waters downstream.

Cedar and Olalla creeks both are known to contain eastern brook and rainbow trout.

The designated water uses for Keremeos Creek, and Cedar Creek are aquatic life, wildlife, irrigation, livestock watering and drinking water supplies. The designated water uses for South Keremeos Creek are aquatic life, wildlife, and livestock watering. The designated water uses for Olalla Creek are aquatic life, wildlife, irrigation, livestock watering, and drinking water supplies.

WATER QUALITY ASSESSMENT AND OBJECTIVES

Water Quality Assessments

Keremeos Creek

THERE ARE FEW permitted refuse sites or wastewater discharges present in the Keremeos Creek watershed. No direct discharge of wastewater to Keremeos Creek has been permitted. The largest discharge under permit (BC Environment) in the Keremeos Creek watershed is from Apex Mountain Resort. This discharge of secondary-treated effluent occurs to infiltration ponds approximately 220 m east of upper Keremeos Creek. Upper Keremeos Creek water quality monitoring conducted during this study (November 1994 - July 1997) near Apex Mountain Resort has shown slight increases in nitrogen and phosphorus concentrations in Keremeos Creek near this discharge. Additional creek and groundwater sampling is needed to definitively determine the source of these nutrients and to ascertain what impact the sewage discharge may have on the creek. Although chloride enters Keremeos Creek near its headwaters from a gravel pit operation, no water use is compromised to date. Sediments enter upper Keremeos Creek from road run off, a gravel pit operation, and the ski runs and parking lot at the Apex Resort area. Although non-filterable residue (suspended sediment) levels in Keremeos Creek have decreased since erosion control measures were implemented by Apex Mountain Resort in 1995, further monitoring is required to ensure the works continue to be effective.

Permitted waste discharges to ground within portions of the lower Keremeos Creek watershed are from a mobile home park septic system near Keremeos, and a small-volume discharge from a fruit packing plant in Cawston to a ground disposal system. There is also a permitted refuse site located near Keremeos. Given the small size and distance of these discharges from Keremeos Creek, it is unlikely that these sites have a measurable impact on Keremeos Creek.

Approximately 1900 head of cattle, 400 with creek access, in the lower Keremeos Creek area in the winter of 1994/1995, caused elevated fecal coliform bacteria counts and increased ammonia nitrogen concentrations. Due to the elevated fecal coliform bacteria levels, lower Keremeos Creek should not be used for drinking water without at least disinfection and partial treatment.

The portion of Keremeos Creek above the Apex Water Utility is a Community Watershed under the *Forest Practices Code of British Columbia Act*. As such, forest fertilization, use of pesticides, harvesting, range use and haul roads must be carried out in a way that achieves the water quality objectives established by the Ministry of Environment Lands and Parks for those watersheds. No logging has been proposed for the Community Watershed portion of Keremeos Creek, however logging is planned for 2000 and 2001 in other parts of the drainage.

Recreational activities in Kermeos Creek watershed may include hiking, mountain biking, motorcycle, ATV and four wheel drive useage.

Although historic mining activity is recorded for the Keremeos Creek watershed, none presently occurs. Metals, including zinc, copper, and lead, were not found in lower Keremeos Creek at concentrations greater than the provincial guidelines. Chromium is occassionally elevated and should be examined further, along with other metals, should mining activity resume in the watershed.

Maximum concentrations of ammonia, nitrite, and nitrate were below guidelines for all water uses of Keremeos Creek. Phosphorus concentrations may be high enough to cause excessive algal growths if phosphorus is the limiting factor. Dissolved oxygen concentrations appear to be adequate to protect aquatic life, but further measurements are required to confirm this. Water temperature increases in lower Keremeos Creek due to the loss of streamside shade, and may exceed the optimal temperature regime for salmonids.

South Keremeos Creek

In spite of the mineral development potential of the South Keremeos Creek drainage no mining has occurred. Chromium, copper, zinc and lead were at or below the B.C. approved and working water quality guideline to protect aquatic life. Further metals sampling would be required if mining were proposed for the drainage. Maximum concentrations of ammonia, nitrite, and nitrate were all below guidelines. Cattle grazing occurs in the South Keremeos Creek drainage. Logging has occurred in this drainage in the past, and is expected to resume in 2002. Turbidity and non-filterable residue concentrations in South Keremeos Creek are relatively low.

Cedar Creek

Cedar Creek is used for domestic drinking water without treatment. Cattle grazing occurs in the Cedar Creek drainage. Some logging activity has occurred in the past, and harvest plans have been set for 2002. Cedar Creek is relatively free of turbidity and with the exception of fecal coliform levels, all other parameters easily met the provincial guidelines to protect the most sensitive water use. Fecal bacteria counts would require that at least disinfection be applied to the water before consumption.

Olalla Creek

The Olalla water utility does not presently use Olalla Creek for domestic consumption, but private domestic licences are in effect on Olalla Creek. Logging and mining have occurred historically in the Olalla watershed, and cattle grazing and logging presently occur in the watershed. The water of Olalla Creek is relatively free of turbidity and, with the exception of fecal coliform bacteria, all parameters met the provincial guidelines for the most sensitive water use. Fecal bacteria counts would require at least disinfection be applied to the water before consumption.

Water Quality Objectives

WATER QUALITY OBJECTIVES proposed for upper and lower portions of Keremeos Creek, South Keremeos Creek, Cedar Creek, and Olalla Creek are summarized in Table 1. The objectives are based on the B.C. approved and working guidelines for water quality, on known uses of the water resource, the limited available ambient water quality data, waste discharges, water uses, and stream flows. The objectives are proposed to ensure that point and non-point source contamination are not preventing designated water uses from taking place. Objectives may be modified or added as found necessary due to knowledge of new water uses, new discharges which cause impacts on the creeks, receiving new data from water monitoring programs, or newly established water quality guidelines for other characteristics of concern.

The designated water uses for Keremeos Creek and Cedar Creek include: aquatic life, wildlife, irrigation, livestock watering, and drinking water supplies. Water quality objectives are proposed for microbiological indicators, filterable and non-filterable residues, turbidity, ammonia, nitrite, nitrite/nitrate, pH, dissolved oxygen, dissolved chloride, and chlorophyll-a (Table 1). An objective for water temperature is proposed for Keremeos Creek.

The designated water uses for South Keremeos Creek include: aquatic life, wildlife, and livestock watering. Water quality objectives are proposed for microbiological indicators, turbidity, filterable and non-filterable residues, ammonia, nitrite, nitrite/nitrate, pH, dissolved oxygen, chlorophyll-a.

The designated water uses for Olalla Creek include: aquatic life, drinking water, wildlife, livestock watering, and irrigation. Water quality objectives are proposed for microbiological indicators, turbidity, filterable and non-filterable residues, ammonia, nitrite, nitrite/nitrate, pH, dissolved oxygen, dissolved chloride, chlorophyll-a.

Monitoring Recommendations

Water quality objectives have been proposed for a number of water quality characteristics. Generally, these should be checked under worst-case flow conditions. For parameters such as fecal coliform bacteria, the worst-case conditions occur during the late winter or early spring when low elevation snow melt occurs and agricultural impacts are potentially high. Sampling in the watershed during freshet flows will be required to describe worst case conditions due to sediment loading and turbidity.

Sampling for ammonia nitrogen, dissolved oxygen and temperature are important measurements in the summer when water flows are low and solar radiation high. To check attainment of average or percentile values, a minimum of five samples should be collected in a thirty-day period. For the purposes of checking attainment of the bacteriological objectives, use of the ninetieth percentile is recommended in situations where non-attainment occurs using five samples. Interpolation of the ninetieth percentile value from a graphical presentation of the 5 values can be carried out, however ten sampling dates is recommended. A proposed monitoring scheme is presented in Table 2; however, the water quality monitoring program undertaken may vary, depending on available resources.

Operational monitoring of forestry operations is important to ensure the Forest Practices Code requirements are met and water quality protected. Monitoring the effectiveness of the sediment control measures implemented at the Apex Mountain Resort is necessary to ensure adequate performance of the works installed. Sediment source surveys and riparian assessments, as recommended in the level one IWAP, may need to be conducted, should non-filterable residue and turbidity levels impair water use.

Periodic inspection of farming operations are conducted during low elevation snow melt to ensure the Code of Agricultural Practice for Waste Management in BC is being followed.

Protecting water quality is contingent on an adequate flow of water under normal conditions to sustain fish and aquatic life of the creeks. Minimum flow requirements to protect aquatic life need to be determined and a process of monitoring the adequacy of the flow targets established to provide adequate environmental protection of these water resources.

Lastly, perhaps the two most important initiatives necessary to protect water quality in the watershed are retaining and replanting streamside shade trees, and stream stewardship. Without local initiatives to make people and communities feel connected to and responsible for the water course, protection of this resource is not complete.

Report Prepared by:

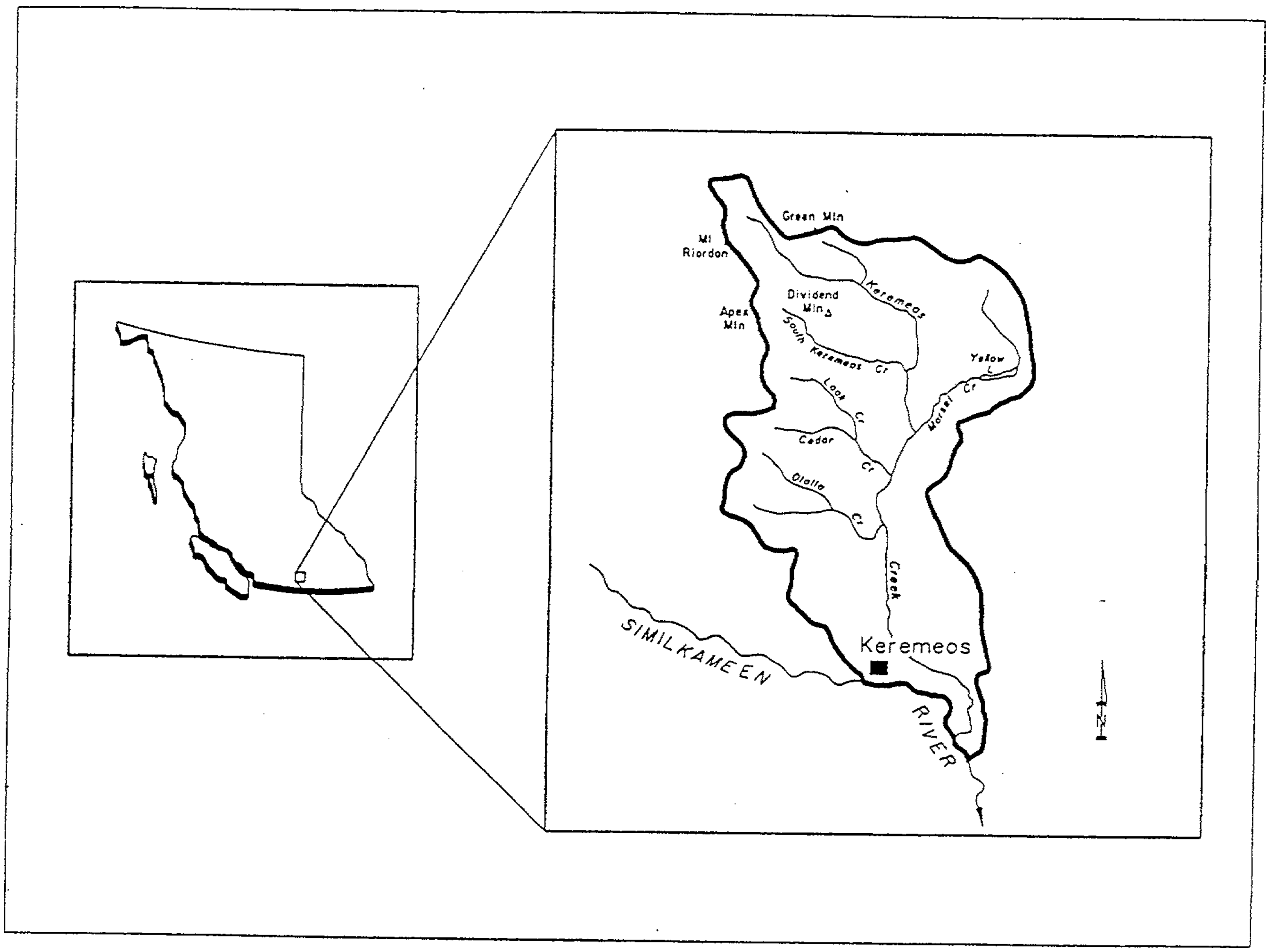
E.V. Jensen[2] R.P. Bio and B. Dean[3]

[2] Pollution Prevention Program, Ministry of Environment, Lands and Parks, Penticton BC

[3] Dean Associated Environmental Services, Summerland BC

FIGURE 1

LOCATION OF KEREMEOS CREEK WATERSHED



WATER QUALITY OBJECTIVES AND MONITORING TABLES

THE FOLLOWING TABLES provide a summary of the objectives data and monitoring recommendations.

To protect water uses in a waterbody, objectives specify a range of values for characteristics (variables) that may affect these uses. These values are maximum, mean, and/or minimum values that are not to be exceeded.

Some readers may be unfamiliar with terms such as: maximum concentration, 30-day average concentration, or 90th percentile. Maximum concentration means that a value for a specific variable should not be exceeded; 30-day average concentration means that a value should not be exceeded during a period of 30 days, when five or more samples are collected at approximately equal time intervals. The term 90th percentile indicates that 9 out of 10 values should be less than a particular value.

To determine if objectives for non-filterable residue or turbidity have been exceeded, ideally, for short-term (acute) exposures, hourly samples taken over a 24-hour period are preferred to demonstrate the continuity of an event. Initially, less frequent monitoring may be appropriate to determine the need for more extensive monitoring. For long-term (chronic) exposures daily samples taken over a 30-day period are preferred, but also may initially be checked by less frequent monitoring. Obviously, the statistical reliability of the data is increased as the frequency of monitoring is increased.

TABLE 1

SUMMARY OF WATER QUALITY OBJECTIVES PROPOSED FOR KEREMEOS CREEK WATERSHED

	KEREMEOS CREEK	OLALLA CREEK& CEDAR CREEK	SOUTH KEREMEOS CREEK
DESIGNATED WATER USES	Aquatic life, wildlife, drinking water with partial treatment, livestock watering, irrigation	Aquatic life, wildlife, livestock watering, irrigation and drinking water with disinfection	Aquatic life, wildlife,livestock watering
Characteristics			
Fecal coliforms[1]	≤ 10 CFU/100ml (90[th] percentile) at the Gunbarrel Intake and long term objective in lower Keremeos Cr. <100 CFU/100ml (90th percentile) for areas downstream of Gunbarrel Intake as a interim objective in lower Keremeos Cr.	≤ 10 CFU/100ml (90[th] percentile)	≤ 200 CFU/100ml (90[th] percentile)
Non-Filterable Residue[2]	Clear Flow: <10 mg/L at Gunbarrel Intake site Downstream of intake: 25 mg/L increase in 24 hr or 5 mg/L in 30 days Turbid Flow: 10 mg/L increase if 25-100 mg/L or 10% maximum increase if upstream ≥ 100 mg/L; interim 150 mg/L maximum at Triple Chair site.	Clear Flow: 25 mg/L increase in 24 hr or 5 mg/L in 30 days Turbid Flow: 5 NTU increase when background 5-50 NTU; 10 % increase when background > 50 NTU	Clear Flow: 25 mg/L increase in 24 hr or 5 mg/L in 30 days Turbid Flow: 5 NTU increase when background 5-50 NTU; 10 % increase when background > 50 NTU
Turbidity[2]	Clear Flow: 2.5 NTU average /5 NTU max. at Gunbarrel Intake. Downstream of Gunbarrel Intake during 8NTU increase over 24 hrs or 2NTU over 30 days Turbid Flow: 8-50 NTU:5 NTU increase 10% maximum increase when upstream > 50 NTU	Clear Flow: 1NTU increase when background < 5NTU Turbid Flow: 8-50 NTU: 5 NTU increase 10% maximum increase when upstream > 50 NTU)	Clear Flow: 8NTU increase over 24 hrs or 2NTU over 30 days Turbid Flow: 8-50 NTU: 5 NTU increase 10% maximum increase when upstream > 50 NTU)
Ammonia Nitrogen	See Tables 3 and 4	See Tables 3 and 4	See Tables 3 and 4
Nitrite Nitrogen	See Table 5	See Table 5	See Table 5
Nitrite/Nitrate Nitrogen	10 mg/L maximum	10 mg/L maximum	100 mg/L maximum ≤ 40 mg/L average
PH	6.5–8.5	6.5–8.5	6.5–9.0
Dissolved Oxygen	8.0 mg/L minimum 11.0 mg/L when salmonid embryos and larvae present	8.0 mg/L minimum 11.0 mg/L when salmonid embryos and larvae present	8.0 mg/L minimum 11.0 mg/L when salmonid embryos and larvae present
Chlorophyll-a[3]	50 mg/m²	50 mg/m²	50 mg/m²
Filterable Residue	500 mg/L (lower Keremeos Cr.)	500 mg/L	20% increase downstream
Dissolved Chloride	100 mg/L	N/A	NA
Temperature	Keremeos Creek max 17.0 °C weekly average[4]		

Note: The objectives apply to discrete samples from all parts of Keremeos and South Keremeos Creek (specified in Table 1) except for initial dilution zones which are provisionally defined as extending up to 100 metres downstream from a discharge, and occupying no more than 50% of the stream width around a discharge point, from the bed of the stream to the surface. Initial dilution zones may be adjusted for Keremeos Creek using site specific information at the time of permiting a waste discharge.

1 The average is calculated from at least 5 samples in a 30 day period. Ten samples are required for 90th percentiles
2 The increase (in mg/L or NTU) is over levels measured at a site upstream for a discharge or series of discharges and as close to them as possible and applies to downstream values.
3 The maximum is based on the average calculated from at least five randomly located samples from natural substrates at each site on any sampling date.
4 The weekly average shall be calculated from 5 samples collected in the afternoon at downstream locations

TABLE 2

RECOMMENDED WATER QUALITY MONITORING FOR KEREMEOS CREEK WATERSHED

	UPPER KEREMEOS	*Frequency*	*Date*	*n*	*Parameters*
	BASE FLOW SAMPLING				
E221390	Keremeos Cr. at Base of Triple Chair	Five	July	30	True Color
E221387	Keremeos Cr. at XC Bridge u/s Apex STP	times	to		pH
E221386	Keremeos Cr. u/s Gunbarrel	(weekly)	April		Non-Filterable Residue
E221413	Keremeos Cr. North Fork u/s R.V. Parking Lot	in 30 days			Turbidity
E221384	Keremeos Cr. West Fork u/s Apex Parking Lot				Ammonia Nitrogen
					Nitrite/Nitrate Nitrogen
					Nitrite Nitrogen
					Dissolved Chloride
					Chlorophyll-a
					MF fecal bacteria
					Temperature
					Dissolved Oxygen
	FRESHET SAMPLING				
E221389	Keremeos Cr. at Road. to Dividend Mtn.	Five	May	30	Non-Filterable Residue
E221390	Keremeos Cr. at Base of Triple Chair	times	to		Turbidity
E221387	Keremeos Cr. at XC Bridge u/s Apex STP	(weekly)	July		
E221386	Keremeos Cr. u/s Gunbarrel	in 30 days			
E221413	Keremeos Cr. North Fork u/s R.V. Parking Lot				
E221384	Keremeos Cr. West Fork u/s Apex Parking Lot				
	LOWER KEREMEOS	*Frequency*	*Date*	*n*	*Parameters*
	BASE FLOW SAMPLING				
0500757	Keremeos Cr. at Cawston	Five	July	15	pH
E221340	Keremeos Cr. at Olalla u/s Olalla Cr.	times	to		Specific Conductance
E221339	Keremeos Cr. at Hwy 3A	(weekly)	April		Non-Filterable Residue
E221341	Keremeos Cr. at Keremeos	in 30 days			Filterable Residue
E221391	South Keremeos Creek				Turbidity
E221525	Cedar Creek u/s Hwy 3A				Ammonia Nitrogen
E221526	Olalla Cr. at Olalla				Nitrite/Nitrate Nitrogen
					Nitrite Nitrogen
					Chlorophyll-a
					MF fecal bacteria
					Temperature
					Dissolved Oxygen
	FRESHET SAMPLING				
0500757	Keremeos Cr. at Cawston	Five	May	15	Non Filterable Res
E221340	Kermeos Cr. at Olalla u/s Olalla Cr.	times	to		Turbidity
E221339	Keremeos Cr. at Hwy 3A	(weekly)	July		
E221391	South Keremeos Cr.				
E221525	Cedar Cr. u/s Hwy 3A				
E221526	Olalla Cr. at Olalla				

MINISTRY OF ENVIRONMENT, LANDS AND PARKS
PROVINCE OF BRITISH COLUMBIA

KEREMEOS WATERSHED WATER QUALITY ASSESSMENT AND OBJECTIVES

TECHNICAL APPENDIX

Vic Jensen, B.Sc., RPBio
Environmental Section
Pollution Prevention Program
Ministry of Environment, Lands and Parks
Penticton, B.C.

Brian Dean
Dean Associated Environmental Services
Summerland, B.C.

DATE

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1.0 INTRODUCTION

1.1 BACKGROUND

The British Columbia Ministry of Environment, Lands, and Parks (hereafter referred to as B.C. Environment) prepares water quality assessments and objectives for priority water basins in British Columbia. This report describes and assesses water quality of Keremeos Creek and its main tributaries: South Keremeos Creek, Cedar Creek , and Olalla Creek (Figure 1). Although Keremeos Creek has been occassionally sampled in the past near its confluence with the Similkameen River, much of the data presented in this report was gathered between November 1994 and July of 1997.

Keremeos Creek and its tributaries are licenced for domestic and irrigation supply. These creeks also provide fish rearing habitat and contain resident populations of trout and a variety of other fish species, but census information and access are limited. A ski resort in the headwaters of Keremeos Creek, as well as agriculture, forestry and road maintenance all influence the water quality of these creeks to varying degrees. Olalla and Keremeos Creeks upstream of the community water intakes are designated as Community Watersheds under the *Forest Practices Code of British Columbia Act.* As such forest fertilization, use of pesticides, harvesting, range use and haul roads, must be carried out in a way that achieves the water quality objectives established by the Ministry of Environment Lands and Parks for those watersheds.

This document summarizes the BC Environment water quality data available for the watershed up to July 1997 and proposes water quality objectives for a number of parameters that may be affected by human activities. FRBC funded moniting since 1997 may be used to determine objectives attainment. These objectives are proposed to protect all water uses in Keremeos, Olalla, Cedar and South Keremeos creeks.

1.2 WATER QUALITY OBJECTIVES - BASIC PHILOSOPHY

Water quality objectives are established in British Columbia for water bodies on a site-specific basis. 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. The objectives are set at a level which should protect the most sensitive designated water use with due regard for ambient water quality, aquatic life, waste discharges and socio-economic factors.

Water quality objectives are based upon the provincial approved and working water quality guidelines (criteria) (Nagpal et.al. 1998) and Canadian Council of Ministers of the Environment (CCME) water quality guidelines (Anon. 1998) which are characteristics of water, biota, or sediment that must not be exceeded to prevent specified detrimental effects from occurring to a water use. The working guidelines upon which many of the proposed provisional objectives are based come from the literature, and are referenced in the following sections. B.C. Environment is in the process of developing approved guidelines 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 may threaten a designated water use, either now or in the near future. The reason for this is that objectives will only be set for water bodies where resource management is required to protect existing water quality or where remediation is required and sufficiently practical to improve in water quality. As well, promulgating water quality objectives where there is an uncertain possibility of future human influences would lead to a large number of objectives for variables which may not be important in the long term, and would lead to an expectation that those variables would be measured at some frequency through time to determine attainment of the objectives. This could lead to an unrealistic belief that the waters were being protected, albeit by dated objectives.

The objectives proposed in this report take into account the use of the water to be protected and the existing water quality. They allow for increases over background which can be tolerated, or for upgrading water quality which may be required. Any increase over 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. However, all reasonable efforts should be exercised to maintain conditions superior to the objectives. These objectives are to be reviewed as more monitoring information becomes available and as B.C. Environment establishes more approved water quality guidelines.

Water quality objectives do not apply to the initial dilution zones of effluents. These zones may be site specific but in rivers are normally 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. Direct discharges to smaller streams such as those described in this report require specific studies to determine an appropriate initial dilution zone. As no direct discharge of a permitted waste occurs to these creeks, no initial dilution zones have been set.

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 KEREMEOS CREEK

Keremeos Creek originates in the mountains at the south end of the Thompson Plateau, east of Penticton (Figure 1). Keremeos Creek descends from its headwaters at the base of Mt. Riordan and Beaconsfield Mountain at a slope of 0.075 metre (m) per m for 14 km in the upper reaches (upper Keremeos Cr) until it subsides to an average of 0.008 m per m for 26 km (lower Keremeos Cr) until it reaches the Similkameen River. For the purpose of better describing Keremeos Creek in this document, the creek is sometimes divided geographically into upper and lower Keremeos Creek with the boundary being the uppermost or first crossing of Green Mountain Road. These are not gazetted names but are used only to describe different sections of the creek. Keremeos Creek has a catchment area of approximately 250 km^2 (Hrasko, 1995) at the mouth of the creek. Road access to the creek is limited in the upper 9.7 km section from Dividend Mountain to Green Mountain Road. The creek then follows Green Mountain Road and then Highway 3A to Keremeos. From Keremeos the creek flows in a southeast direction to Cawston where it turns west and enters the Similkameen River. Tributaries to Keremeos Creek include Rock Oven Pass Creek, Klohtelt Creek, South Keremeos Creek , Cedar Creek, Olalla Creek, Shuttle Creek, Armstrong Creek, and Marsel Creek. Marsel Creek flows intermittently from its source at the outflow pipe at the dam on Yellow Lake.

1.3.2 SOUTH KEREMEOS CREEK

South Keremeos Creek (topographical map Penticton 82 E/5) enters Keremeos Creek from the west, approximately 3 km south of the point where Keremeos Creek first crosses Green Mountain Road (Figure 1). The creek desends from its headwaters at a slope of 0.19 m per m for 5.1 km before it joins Keremeos Creek. South Keremeos Creek has a catchment area of 7 km^2 at the mouth of the creek and flows primarily from the south east slope of Dividend Mountain and the south west slope of Apex Mountain. One fork of South Keremeos Creek is fed from two small unnamed lakes.

1.3.3 CEDAR CREEK

Cedar Creek (topographical map Penticton 82 E/5) enters Keremeos Creek from the west approximately 4 km north of Olalla (Figure 1). The creek descends from its headwaters at a slope of 0.19 m per m for 7.2 km before it joins Keremeos Creek. Cedar Creek has a catchment area of 15 km^2 at the mouth of the creek and flows primarily from the south eastern slopes approximately 6 km south of Dividend Mountain. The main tributary of Cedar Creek is Loak Creek which flows from the northwest into Cedar Creek approximately 3 km upstream from the mouth. The slope of Loak Creek is 0.16 m per m for its length of 5 km. Loak Creek has a catchment area of 5.5 km^2 at the confluence with Cedar Creek. Cedar Creek at the confluence with Loak Creek has a catchment area of 6 km^2. Road access to Cedar Creek is limited and is obtained using the Cedar Creek Forest road which runs through the Cedar Creek Ranch north of Olalla.

1.3.4 OLALLA CREEK

Olalla Creek (topographical map, Penticton 82 E/5) enters Keremeos Creek from the west through Olalla (Figure 1). It is a steep sloping creek, with a gradient of 0.16 m per m along its length of 8.4 km. It is surrounded along most of its length by forest cover and grassland. At its mouth, Olalla Creek has a drainage area of 27 km^2 (Obedkoff, 1995). It is publically accessible by Olalla Creek Forest service road which travels along much of Olalla Creek.

2.0 HYDROLOGY

2.1 KEREMEOS CREEK

Flows in Keremeos Creek have been monitored near Olalla (Figure 7, 8) at Environment Canada stations 08NL010 from 1919 to 1972 and more recently at 08NL045 (Water Survey of Canada, 1988). The monitoring site was moved approximately 100 m south following flood damage in 1972 and the site is now located at the Crowbar Ranch bridge at the end of 12th St. in Olalla (Skinner, pers.comm. 1995). The highest monthly average flow recorded at Olalla during freshet was 7.25 m^3/s, recorded in 1972. The highest maximum daily flow was recorded at 22 m^3/s in 1948. The average monthly flows during freshet were 2.18 m^3/s in May and 2.85 m^3/s in June. The seven-day mean low flow in Keremeos Creek at Olalla using exisiting Water Survey of Canada site 08NL045 is 0.074 m^3/s over a 25 year return period (D.Gooding, pers. comm. 1997). The mean annual flow at 08NL045 is 0.7m^3/s. Ten percent of the mean annual flow (ie. 0.07m^3/s) has been suggested as a generic minumum requirement for fisheries protection (D. Smith, pers. comm. 1996).

The upper section of the creek has been occasionally monitored by BC Environment Water Management Division, using sites near Apex Mountain Resort (close to sites E221385 North Fork Above Road and E221387 U/S STP @ XC Bridge). BC Environment flow estimates are based on the hydrology of the area and measurements taken in November 1994. Upper Keremeos Creek mean seven-day low flow were estimated at the upstream site (North Fork Above Road) as 0.001m^3/s and 0.004 m^3/s for the site at the XC Bridge.

2.2 SOUTH KEREMEOS CREEK

There are no flow data available for South Keremeos Creek.

2.3 CEDAR CREEK

There are no flow data available for Cedar Creek.

2.4 OLALLA CREEK

The flows in Olalla Creek were monitored during the ice-free period (April through September) by Environment Canada at Olalla (station 08NL011) from 1919 to 1921. The maximum daily flow recorded for Olalla Creek was 1.53 m^3/s (May 20, 1921); the minimum flow of 0.02 m^3/s occured April 1, 1920. The month of April had the lowest average flow of 0.041m^3/s. The average flows for May and June were 0.44 m^3/s and 0.57m^3/s respectively (Environment Canada, 1988).

3.0 WATER USES

3.1 KEREMEOS CREEK

3.1.1 WATER LICENCES

There are 38 water licences for consumptive use on Keremeos Creek (Figure 2). Domestic withdrawals total 668 m^3/d and irrigation totals 1724 dam^3/a. The largest withdrawals in the upper and lower sections are the Apex Water Utility and the Keremeos Irrigation District respectively. The Apex Water Utility uses chlorination prior to distribution. The Keremeos Irrigation District does not use water directly from the creek but rather uses wells close to the creek (R. Johnston, pers.comm.2000). Livestock watering occurs in the section of Keremeos Creek between Green Mountain Road and the Similkameen River, with approximately 400 cattle allowed direct access to the creek. Forestry grazing licences in the upper section also allow cattle access to the creek for water.

3.1.2 FISH

Keremeos Creek is known to contain rainbow trout and eastern brook trout from the Similkameen River to the headwaters and near Ford Lake, respectively. Keremeos Creek is thought to contain a wide variety of other fish species which include:

- mountain whitefish
- northern squawfish
- peamouth chub
- northern mountain sucker
- bridgeslip sucker
- redside shiner
- longnose dace
- sculpin (various species)
- kokanee
- yellow perch

All stream fish populations are totally supported by natural recruitment. Tributary streams to the Similkameen River are suspected to be important contributors to the river's rainbow trout production. Keremeos Creek supports a small recreational fishery, with public access being the limiting factor on angling effort (S. Matthews, pers. comm.1996).

3.1.3 DESIGNATED WATER USES

The water uses for upper and lower Keremeos Creek are designated as: drinking water, livestock, irrigation, wildlife and the protection of aquatic life. Primary contact recreation uses of Keremeos Creek are believed to be limited.

3.2 SOUTH KEREMEOS CREEK

3.2.1 WATER LICENCES

There are no water licences for irrigation or domestic water supplies on South Keremeos Creek. In the headwaters of South Keremeos Creek, there are five springs which are licenced for stock watering at 4.55 m^3/d each. These springs are used as watering stations and it is unknown what impacts this use may have on South Keremeos Creek.

3.2.2 FISH

South Keremeos Creek contains both rainbow and brook trout at the mouth and in the lower sections of the creek (Johnson, 1994). Due to the steep gradient and a large vertical drop from the culvert under Green Mountain Road it is unlikely portions of South Keremeos Creek above the road presently serve as a spawning area for fish from the Similkameen River.

3.2.3 DESIGNATED WATER USES

The water uses for South Keremeos Creek are designated for: protection of aquatic life, wildlife and livestock watering.

3.3 CEDAR CREEK

3.3.1 WATER LICENCES

There are six water licences for consumptive use on Cedar Creek. The licences are for the withdrawal of 272 dam^3/a for irrigation water supply and 12 m^3 /d for domestic use (calculated from B.C. Environment Water Licensing System, report generated December 9, 1997).

3.3.2 FISH

Cedar Creek is known to contain brook trout and rainbow trout. Perhaps due to demand on the water flow during the summer months from irrigation and domestic sources or natural low flow, there was no water flowing in the creek at highway 3A on August 25, 1994, when a fish survey was conducted (Johnson, 1994). The water was flowing approximately 1 km west of the highway where it was dammed in two places and diverted for consumptive purposes (Johnson, 1994).

3.3.3 DESIGNATED USES

The water uses for Cedar Creek are designated for: aquatic life, wildlife, drinking water, livestock, and irrigation.

3.4 OLALLA CREEK

3.4.1 WATER LICENCES

There are 32 water licences for consumptive use on Olalla Creek (Figure 2). The licences are for the withdrawal of 193 dam^3/a for irrigation water supplies and 150 m^3/d for domestic use (calculated from B.C. Environment Water Licencing System, report generated December 9, 1997). The Olalla water utility until recently used Olalla Creek water without chlorination and had been on a boil water advisory for the past nine years. The Olalla water utility now uses groundwater but licences for domestic use on Olalla Creek are still in effect (R.Johnston, pers. comm. 2000).

3.4.2 FISH

Olalla Creek contains brook and rainbow trout in the lower reaches of the creek (Johnson, 1994). Due to a reservoir structure and steep slope it is unlikely that fish are plentiful in the upper reaches of the creek.

3.4.3 DESIGNATED USES

The water uses for Olalla Creek are designated for: drinking water, irrigation, livestock watering, aquatic life and wildlife.

4.0 PERMITTED WASTE DISCHARGES

4.1 KEREMEOS CREEK

4.1.1 APEX MOUNTAIN RESORTS LTD. (PE 6017)

Apex Mountain Resort Ltd. operates a ski resort located in the headwaters of Keremeos Creek. The operation uses an aerated lagoon system to treat municipal effluent. Waste Management Permit, PE 6017, authorizes the discharge of a maximum of 636 m^3/d and an average of ≤ 427 m^3/d of secondary-treated municipal effluent at a frequency of approximately 3 to 4 times per year to three infiltration basins located approximately 220 m east, and 57 m higher in elevation, than Keremeos Creek (Figure 3). Wastewater undergoes aeration in two ponds prior to discharge and infiltration to the surrounding ground. The infiltration lagoons have a surface area of 139 m^2. The effluent quality is permitted to have a maximum biochemical oxygen demand of 45 mg/L and total suspended solids of 60 mg/L.

Up to January 20, 1998 Apex Mountain (PE 6017) effluent quality and flows had not exceeded permit limits (R. Gunoff, pers. comm. 1998). There is no direct discharge permitted to the creek and the permitee is required to monitor effluent quality during discharge, and groundwater well levels and groundwater quality at 3 wells (Figure 5) following a discharge. Some of the wells were dry during the 1994 - 1995 ski season, and new wells were installed in August 1995 to improve knowledge of groundwater movement and quality. Groundwater levels on August 23, 1995 were approximately 15 m to 30 m below the infiltration basins (Golder, 1995). Golder Associates concluded that two separate aquifer systems are present at the Apex infiltration basin site. Effluent entering the upper aquifer is estimated to take approximately 781 days to travel from the infiltration basins to Keremeos Creek. Although the lower aquifer could not be characterized with the information available, Golder Associates did establish that in the estimated effluent flow path, Keremeos Creek was perched at least 1.5 m above groundwater.

Sampling of Keremeos Creek, during and following effluent discharge events in 1995, did not show any impact of the discharge on the creek (Golder, 1995). BC Environment monitoring of Keremeos Creek upstream and downstream of the discharge area from November 1994 to July 1997 (Figure 13) found increases in nitrate downstream in the creek, which were not matched by similar increases in chloride or ammonia. Nitrate could arise from natural sources, animal wastes, fertilizer applied to ski runs, or sewage tailwater. The trend in chloride observed at downstream locations, is inconsistent with nitrate increases, if sewage tailwater was the primary source of nitrate (Figure 12). Nitrate in Keremeos Creek decreases to background levels before reaching Green Mountain Road.

4.1.2 SAGEWOOD MOBILE HOME PARK (PE 13256)

The Sagewood Mobile Home Park near Olalla, operates a septic tank system consisting of 14 residential-sized septic tanks and drainfields to accommodate 40 mobile homes. The creek is approximately 200 metres from the drain field (Figure 4).

Waste Management permit PE 13256 allows the discharge of an average of 45.5 m^3/d of domestic or typical septic tank effluent to ground. Given the distance to the creek this discharge is expected to have little effect on Keremeos Creek.

4.1.3 REGIONAL DISTRICT OF OKANAGAN - SIMILKAMEEN (PR 3291)

The Regional District Okanagan Similkameen operates a landfill 1.6 km north of Keremeos and approximately 1.6 km west of Keremeos Creek. Groundwater levels below the landfill are estimated at between 36 and 40 m. Due to the distance from Keremeos Creek and depth to water table, it is unlikely that this operation affects Keremeos Creek.

4.1.4 WILD WEST ORGANIC HARVEST CO-OPERATIVE (PE 4395)

This company operates a cold storage facility for locally grown fruit. The facilities are located approximately 1 km from Keremeos Creek near Cawston. Permit PE 4395 allows the discharge of 393 m^3/d of uncontaminated water from refrigeration units and a fruit washing operation. The wastewater is discharged to ground using an exfiltration trench. Due to the distance from the creek and the nature of the discharge, it is unlikely that this operation has any impact on Keremeos Creek.

4.1.5 POTENTIAL MINERAL DEVELOPMENT

There is potential for the development of mineral resources in the area as shown by the known locations of certain types of ore in Figure 6. However, no mineral development occurs at present.

4.2 SOUTH KEREMEOS CREEK

There were no discharges to South Keremeos Creek under permit with BC Environment when this report was written and although there is potential for the development of mineral resources in the area as shown on Figure 6, none occurs at present.

4.3 CEDAR CREEK

There are no discharges to Cedar Creek under permit with BC Environment. There is the potential for development of mineral resources (copper, gold, silver and lead) in the area as indicated in Figure 6; however, no mining activity occurs at the present time.

4.4 OLALLA CREEK

There are no discharges to Olalla Creek under permit with BC Environment. There is potential for mineral resource development in the Olalla watershed (Figure 6). Objectives for metals in Olalla Creek will not be proposed as no mining occurs at the present time.

In the Olalla Creek drainage area there are a few abandoned mine sites, notably the Golconda and Olalla Mines which historically produced gold ore. Given that Olalla Creek may serve as a domestic water supply and historic mining activity has occurred, it is recommended that some limited water quality sampling occur to determine current metal levels.

5.0 NON-POINT SOURCE DISCHARGES

5.1 KEREMEOS CREEK

Anthropogenic activities which may currently cause non-point source contamination of Keremeos Creek include: ski resort development, motorized and non-motorized recreation, cattle grazing, logging, road maintenance and gravel pit operations.

Apex Mountain Resort Ltd. currently covers a 470 ha area, of which 260 ha is cleared for skiing (pers. comm. Wood,1995). Increased sediment loading to the creek can occur during rapid snowmelt from the ski resort development. Storm drainage systems which are used to collect surface water from semi or non porous surfaces may also influence water quality of the creek. Storm drainage from within the base area enters the creek from the Apex parking lot as well as from the area near the Beaconsfield Lodge. Sediment control works were constructed in 1995 to control and reduce sediment losses from the ski area to the creek.

Ministry of Forests licences to the Cedar Creek Ranch and Lawrence Ranch allow cattle grazing in the headwaters of Keremeos Creek. Approximately 104 mature cattle graze in the area from May 1 to October 31 (J.Pethybridge, pers.comm. 2000).

Logging in the upper Keremeos Creek watershed may be a factor to consider in the future, but the schedule of harvest as of November 1997 does not indicate timber harvest through to year 2002 for areas within the Community Watershed portion of Keremeos Creek above the Gunbarrel Intake. Timber harvest plans in 1997 showed approximately 214 hectares in Shuttle Creek subdrainage targeted for 1999; 57 hectares in 2000, in areas north of Yellow Lake; and 33 hectares of clear cut and 442 hectares of partial cutting in 2001 in the area of Keremeos Creek upstream of the confluence with South Keremeos Creek. A level one Interior Watershed Assessment Procedure (IWAP) in 1996 indicated upper Keremeos Creek and South Keremeos Creek could be negatively impacted by roads and clear cuts. It was recommended that sediment source surveys should be completed, roads should be deactivated , the ECA reduced and no additional roads constructed in sensitive areas (EVS, 1996).

Traffic and road maintenence may be a source of non-point source contamination to Keremeos Creek. Apart from the passenger vehicles using the road, transport vehicles haul fuels and equipment to the Apex Resort, trucks transport reagents to the Homestake Canada Ltd. Nickel Plate Mine. The road is regularly sanded during the winter using a gravel/salt mixture. The gravel and salt mix is stored at a gravel pit just west of Rock Oven Pass, approximatly 200 m from the north fork of Keremeos Creek. Elevated chloride and suspended solids levels have been noted in the north fork of Keremeos Creek and are attributable to the operation of the gravel pit. An average chloride concentration increase of 16.2 mg/L (based on fifteen measurements) was noted over the duration of the study (1995-1997), downstream of the gravel pit

(Figure 12). Approximately 100 tonnes of salt (contained in road sand at 2.5%) have been stored in the pit during the winter months (Hubbard, pers. comm. 1995). A site assessment and recommendations for site remediation were made (Punshan, 1995) and implemented in 1996. Installation of sedimentation ponds, and removal of raw salt storage pile have reduced sediment and salt delivery to Keremeos Creek (Dean, 1996). Chloride levels in Keremeos Creek decrease with distance downstream and are near background levels by the time the creek reaches Highway 3A.

Non-point sources of contamination which may affect lower reaches of the creek include agriculture, septic systems, logging, road salt, road maintenance and land disturbance. Contributions from non-point sources higher in the system can potentially affect water quality in the lower sections of the creek.

In an effort to determine lower Keremeos Creek use by agriculture, each cattle operation was visited in August 1995 to inventory cattle usage through the year. Cattle operations near Keremeos Creek use creek water for livestock watering more extensively during the winter than in the spring and summer when the majority of cattle are grazing on open range land. Approximately 1900 cattle overwintered along lower Keremeos Creek in 1994. While best management practices for cattle ranching are being demonstrated by many of the ranchers, approximately 400 cattle are allowed direct access to the creek for watering purposes. The high number of cattle with direct access to Keremeos Creek poses a significant potential source of nutrient and bacterial contamination to the creek. Although significant amounts of nutrients from cattle manure will be retained in the soil, some enter the groundwater, and may eventually reach Keremeos Creek.

Considerable creek channelization has occurred to lower Keremeos Creek. Historically lower Keremeos Creek would have meandered through stable riparian habitat. Land clearing and use of the flood plain for agriculture has over the years removed extensive areas of streamside vegetation of shrubs and trees. This has decreased stream bank stability, and reduced thermal protection and wildlife habitat. Flooding in 1972 and 1974 led to creek dredging and bank stabilization on lower Keremeos Creek (Talbot. 1977).

Pesticides from agricultural operations located near the creek may also affect water quality. However, sediment sampling, conducted approximately 200 m downstream from site 0500757 in Keremeos Creek at Cawston on July 28, 1993, revealed the presence of only pp-DDE at the concentration of 0.02 mg/g, which is a level considered to be background for sediment (D.McBeth, pers.comm. 1994). The sample was subjected to a total scan of 112 pesticides at Zenon Environmental Laboratories in Richmond.

5.2 SOUTH KEREMEOS CREEK

Cattle grazing occurs seasonally in the South Keremeos Creek watershed. No water licences have been issued for irrigation purposes; however, there are five livestock watering tanks in place in the South Keremeos Creek watershed (Water Management Branch Maps). The tanks provide water for 120 cattle (Cedar Creek Ranch) from May 1 to October 31. Logging roads in the area were established during the early 1970s. Approximately 58 hectares are planned to be logged in 2002. Given the mineral development potential of the area, some exploration may be occuring. The impact of this activity on South Keremeos Creek water quality is unknown.

5.3 CEDAR CREEK

There are six water licences on Cedar Creek for irrigation purposes. Range licences issued by Ministry of Forests to the Cedar Creek Ranch and the Lewis Ranch allow approximately 250 cattle access to the watershed from May 1 to October 14 (J. Pethybridge, pers.comm. 2000); seven water troughs are located throughout the watershed to provide drinking water to cattle. Roadways in the area were established during logging in the early 1970s and remnants of a lumber milling operation are present along side the road. Just under half the road network is within 100 metres of the creek, with a total of 17 stream crossings. The level one IWAP recommended sediment source surveys, road rehabilitation near the creek, minimization of stream crossings and protection of sensitive areas (EVS. 1996). Approximately 26 hectares of logging in Cedar Creek and 28 hectares of logging in Loak Creek, a major tributary to Cedar Creek, is scheduled for prior to 2003 (B. Harris. pers. comm.1997). Given the mineral development potential of the area, some exploration may be occuring. The impact of these activities on Cedar Creek water quality is unknown.

5.4 OLALLA CREEK

A minimal amount of agricultural activity occurs in the Olalla Creek watershed, as implied by the fact that there are few water licences which have been issued for irrigation purposes. Roadways in the area were established during logging in the early 1970's. The logged area in the Olalla Creek watershed is currently at an equivalent clearcut area of 2.2%. Approximately 15.3 km of roads were to be developed in 1997; and 13.5 hectares and 92.4 hectares may be logged in 1999 and 2002 respectively (Maxnuk. pers. comm.1997). Due to the steep slope of the area and the use of the creek as a drinking water supply, road building and timber harvest could affect water quality. Just over half the road network is within 100 metres of the creek, with a total of 45 stream crossings. The level one IWAP recommended sediment source surveys, road rehabilitation near the creek, minimization of stream crossings and protection of sensitive areas (EVS. 1996). The Lewis Ranch grazes approximately 84 mature cattle in the watershed from May 1 to October 30 (J. Pethybridge, pers.comm. 2000). As mentioned earlier in this report, no mining currently occurs in the watershed, although historic operations may continue to affect water quality. It is unknown if mineral exploration is presently occuring or affecting Olalla Creek water quality.

6.0 AMBIENT WATER QUALITY AND PROPOSED WATER QUALITY OBJECTIVES

Analytical techniques for many water quality variables have generally improved during the 1980's and 1990's compared to the analytical techniques which were used in earlier decades. As well, the level of quality control and quality assurance of data has received more emphasis, with greater awareness that sample handling both in the laboratory and in the field can introduce problems of contamination. During the sampling period reported here, numerous blank and split samples were submitted to Zenon Environmental Laboratories (1994-1995) and Pacific Environmental Science Centre (1996) for analysis, and these results are summarized in Table 28. The results indicate there were no large systematic errors, and acceptable precision of the results were obtained during the period of time this study was conducted.

In the sections which follow, results of water quality monitoring will be discussed. Although some historic data for Keremeos Creek near its confluence with the Similkameen River was available, most of the data in this report was collected during periods of base and freshet flow between November 1994 and July 1997. Analyzing agencies included Zenon Environmental (1994-1995), Pacific Environmental Science Centre (1996-1997), and Caro Environmental Services (1997). Sampling from April 30, 1997 to June 11, 1997 on portions of Keremeos Creek was carried out by FNOSEPS under an FRBC operational inventory project (Caro Environmental Services, 1997). All the data collected, up to July 31, 1997, have been summarized in Tables 6 to 30. The locations of the water quality sampling sites are shown on Figures 3 and 4. Due to infrequent samping, Rock Oven Pass Creek, Spring d/s Apex STP, and Marsel Creek are not discussed in the following sections, however data for these drainages can be found in Tables 25-27 respectively.

6.1 KEREMEOS CREEK

Data for upper Keremeos Creek above Green Mountain Road and at or near Apex Mountain Resort Ltd. are summarized in Tables 6 through 16. In general, the water quality of upper Keremeos Creek (at Gunbarrel intake and North Fork above road) are above land disturbances and are pristine. Every effort must be made to ensure water quality of these upper reaches of Keremeos Creek remain pristine. As Keremeos Creek moves through the Apex ski resort area and past road ways, the watercourse picks up sediments, nutrients and bacteria. The parameters of concern in this area are related to the operation of the ski resort, road maintenance, cattle grazing, and include: pH, nutrients, periphyton chlorophyll-a, dissolved oxygen, chloride, residues (sediments) and turbidity, and coliform bacteria.

Data for lower Keremeos Creek between Green Mountain Road and the Similkameen River are summarized in Tables 17 to 21. The parameters of concern in this area are related to agricultural operations, road construction and maintenance, upstream watershed disturbances (logging, resort development and potential mining). The parameters are: pH, nutrients, periphyton, dissolved oxygen, residues, metals and coliform bacteria.

6.1.1 PH AND ALKALINITY

The alkalinity of Keremoes creek, even near its headwaters (E221386; 11.3-23.1 mg/L), suggests the creek has only moderate sensitivity to acidic inputs. The pH of upper Keremeos Creek is almost neutral, with a range of values from 6.5 to 7.8 (Tables 6-16) and meets provincial guidelines for protection of drinking water (6.5-8.5) and freshwater aquatic life (6.5-9.0) (McKean et al, 1991).

As the water moves downslope, more ions are dissolved in the water and the pH of lower Keremeos Creek becomes more basic, with a range of pH values from 7.1 to 8.5. Alkalinity also increases with a mean concentration of 71.5 mg/L (Tables 17-21). This water would be considered as having a low sensitivity to acidic inputs (Nagpal et. al., 1995). In order to protect drinking water supplies and aquatic life, a water quality objective is proposed for pH in lower Keremeos Creek. The objective is that the pH range should be between 6.5 pH and 8.5. The proposed objective applies to discrete samples collected from outside the initial dilution zones of effluents, described in Section 1.2.

6.1.2 HARDNESS AND METALS

Neither hardness nor metal concentrations were measured in upper Keremeos Creek during the sampling period described in this document. Although there is potential for mineral development in upper Keremeos Creek (copper, zinc, silver and gold), water quality objectives will not be proposed for metals at this time. It is recommended that these parameters be monitored periodically but the setting of objectives be postponed until such time as development is proposed.

Minerals shown to be of potential for exploration and development in lower portions of Keremeos Creek include: copper, lead, zinc, silver and gold. Athough there is no active mining in the lower portion of Keremeos Creek aquatic life values are high; consequently, a limited amount of metals data was collected during recent sampling. Metals objectives are not being proposed nor sampling proposed at this time. However, as this information is available, the data was compared to BCMoELP metals guidelines (Nagpal et. al., 1995) to determine present water quality status.

The hardness in lower Keremeos Creek ranged from 55.8 mg/L to 198 mg/L and averaged 126 mg/L (Tables 17-21). In general, metals become less toxic to aquatic life with increasing water hardness. To determine the maximum allowable level of metals in lower Keremeos Creek, a conservative approach has been chosen using the lowest hardness concentration of 55.8 mg/L recorded in lower Keremeos Creek (E221338 First Crossing Green Mountain Road). However, to determine the average acceptable level for each metal the average hardness of 126 mg/L was used.

Chromium in lower Keremeos was on average less than provincial guideline of 0.02 mg/L to protect aquatic life. During low flow winter conditions (1994/95) higher values of 0.046 mg/L, and 0.027 mg/L were found at the Green Moutain Road site and u/s Olalla Creek. All other values were at or below the 0.002 mg/L detection limit. Further testing under varying flow conditions would be needed to determine baseline levels of chromium in Keremeos Creek.

The water quality guidelines for copper were determined by the following formula (Nagpal et. al., 1995):

$$\text{Maximum Total Copper (mg/L)} = [0.094(\text{hardness})+2]/1000$$
$$\text{Average Total Copper (mg/L)} \leq [0.04(\text{average hardness})]/1000$$

Where: hardness is reported as mg/L $CaCO_3$

For lower Keremeos Creek, the water quality objective for copper would be a maximum of 0.007 mg/L, and an average concentration of ≤0.005 mg/L. These levels would protect freshwater aquatic life in lower Keremeos Creek. All measured total copper concentrations in lower Keremeos Creek were below this maximum guideline (Tables 17-21). The guideline for the mean concentration could not be evaluated since the guideline requires that an average be calculated using a minimum of five samples collected in a thirty-day period.

The maximum and 30-day average total lead concentrations in any sample using the appropriate hardness concentration (55.8 and 126 mg/L $CaCO_3$, respectively) should not exceed a value as defined by the following formulas (Nagpal et. al., 1995):

$$\text{Maximum Total Lead (mg/L)} = (\exp^{(1.273\ \ln(\text{hardness})\ -\ 1.460)})/1000$$
$$\text{Average Total Lead (mg/L)} \leq (3.31 + \exp^{(1.273\ \ln(\text{average hardness})\ -\ 4.705)})/1000$$

Where: exp= 2.7182818

For lower Keremeos Creek this equates to a maximum concentration of 0.04 mg/L. All lead concentrations in lower Keremeos Creek were below detection limit of 0.003 mg/L.

Using the average hardness of 126 mg/L for lower Keremeos Creek, this calculation equates to an average acceptable concentration of ≤0.01 mg/L lead. In addition, it is recommended that 80% of the values should be ≤1.5x the allowable 30-day average concentration or approximately 0.007 mg/L at a hardness of 126 mg/L. As all lead values were below detection limit at all sites (Tables 17-21) aquatic life should be protected at the present lead levels. To properly evaluate the average concentration a minimum of five samples should be collected in a thirty-day period. An alert level of 0.0008 mg/g (wet-weight) has been suggested for edible fish tissues, but no data have been collected.

Provincial guidelines specify maximum total zinc levels should be less than 0.03 mg/L to protect aquatic life (Nagpal et. al., 1995). Effects have been noted on algae at 0.014 mg/L (Nagpal et. al., 1995). During the recent sampling the maximum concentration of 0.040 mg/L was found at Green Mountain Road, and upstream of Olalla and Keremeos (Tables 17, 19 and 20). Further monitoring would be required to establish whether the zinc is routinely in excess of the water guidelines at these sites.

6.1.3 NUTRIENTS

Ammonia nitrogen, arising from the incomplete oxidation of nitrogenous organic matter, can be toxic to aquatic life. Only traces of ammonia are normally present in the freshwater environment. In upper Keremeos Creek the only significant potential source of ammonia would be the Apex Mountain Resort STP discharge, animal wastes, or perhaps fertilizers high in ammonia or ammonium salts. The maximum ammonia concentration of 0.033 mg/L for sites on upper Keremeos Creek (Figure 10) was well below the maximum and average guidelines concentrations at all expected temperatures and pH values encountered (Tables 3 and 4), as indicated by Nordin and Pommen (1986). All ammonia nitrogen levels measured in lower portions of Keremeos Creek, including the maximum concentration of 2.7 mg/L (at Cawston, Table 21) were below the guidelines to safeguard aquatic life from acute toxic effects as indicated by Table 3. The maximum concentration of 2.7 mg/L occurred in the late winter of 1995 during a period of lower elevation snow melt and was coincident with high fecal coliform counts and high colour. This high level of ammonia could have been due to manure entering lower Keremeos Creek from the cattle being wintered near the creek since similar increases were not evident at the same time in upper Keremeos Creek. In order to protect aquatic life a water quality objective is proposed for total ammonia concentrations in Keremeos Creek. The objective is that the maximum concentration should not exceed concentrations listed in Table 3, and average concentrations should not exceed concentrations shown in Table 4. It is anticipated that the number of livestock near the creek are much reduced in the summer, at a time when elevated water temperatures could contribute to ammonia toxicity to aquatic life. It is proposed that sampling be carried out, using a minimum of five samples collected in a thirty-day period, to confirm that the proposed objectives are achieved.

Excessive levels of nitrite and nitrate nitrogen are harmful to aquatic life and human health respectively. The maximum nitrite concentration of 0.027 mg/L, at the chloride concentration of 21.4 mg/L, found in upper Keremeos Creek at the base of the Quad chair, was well below the levels set for the protection of aquatic life in Table 5. Nitrite concentrations averaged 0.008 mg/L with a maximum value of 0.061 mg/L (at Keremeos, Table 20). These are below guidelines at the associated chloride concentrations (Table 5) to protect aquatic life. The maximum nitrate or nitrate plus nitrite concentration of 0.41 mg/L, encountered in upper Keremeos Creek (at the base of the Triple Chair), was well below the maximum concentration of 10 mg/L to protect drinking water supplies. The maximum nitrate/nitrite concentration in lower Keremeos Creek was 0.78 mg/L (Upstream Gristmill), well below the guideline for the maximum concentration of 10 mg/L to protect drinking water supplies. Since nitrite can form in the creek under ice cover with the incomplete oxidation of ammonia, a water quality objective is proposed for nitrite concentrations in Keremeos Creek for the protection of aquatic life. The objective is that the maximum and average concentrations should not exceed concentrations listed in Table 5. As well, to ensure drinking water supplies are protected when ammonia oxidation is complete a water quality objective is proposed for nitrate. The nitrate objective is a maximum level of 10 mg/L. The objectives do not apply to discrete samples collected in the initial dilution zones of effluents, described in Section 1.2.

Even if phosphorus were the nutrient limiting algal growths, other factors such as turbidity, stream velocity, or substrate availability are also important factors limiting algal growth. There is no B.C. guideline for phosphorus to protect aquatic life in streams. The maximum total phosphorus concentration (0.660 mg/L) in upper Keremeos Creek was recorded at West Fork u/s Apex Parking Lot (Table 10). Total phosphorus concentrations in lower Keremeos Creek averaged 0.036 mg/L (Tables 17 to 21) and peaked at 0.556 mg/L (January 12, 1995 at Upstream Gristmill). Only with measurements of periphyton chlorophyll-a will it be possible to ascertain if algal growths are of concern. A water quality objective is proposed for periphyton chlorophyll-a concentrations in order to protect aquatic life and recreational use of Keremeos Creek. The objective is that the chlorophyll-a concentration should not exceed a concentration of 50 mg/m^2 as an average of five randomly collected samples from outside the initial dilution zone, described in Section 1.2.

6.1.4 DISSOLVED OXYGEN AND TEMPERATURE

Adequate amounts of dissolved oxygen (D.O.) must be available for fish and other aquatic organisms to survive. Dissolved oxygen concentrations vary with demand from decomposition of organic and inorganic matter; its solubility is inversely related to temperature; and inputs limited to photosynthetic activity and physical mixing. BCMoELP working guidelines for D.O. are based on EPA guideline (U.S. EPA,1986). The guideline 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 had based its guideline, and discussed its findings, on the basis of salmonids and non-salmonids (CCME. 1987). The EPA indicated that there was no impairment at 11.0 mg/L dissolved oxygen when embryo or 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 based its guideline (accepted by CCME) on the slight impairment levels, and then added 0.5 mg/L to arrive at the guideline. In British Columbia, we are fortunate enough to generally have high quality waters, and there is no need to accept the slight impairment level.

Dissolved oxygen concentrations were not measured in upper Keremeos Creek during the study period (November 1994-July 1997).

Dissolved oxygen concentrations in lower Keremeos Creek during July 1997 (Tables 17 to 21) ranged from 14.2 mg/L, to 9.2 mg/L and averaged 11.5 mg/L. The average percent saturation in lower Keremeos Creek was 101%, based on elevation and field temperatures at each site. These are above all guideline to protect aquatic life. The objective which will be proposed for dissolved oxygen in

Keremeos Creek will be based on salmonid embryos and invertebrate larval stages and should provide for no impairment. A minimum of 11 mg/L should be present in the water column and 8 mg/L in the gravels when embryo or larval stages are present. At other times of the year a minimum of 8 mg/L should be present in the water. The objectives apply to in-situ measurements or to discrete samples collected from outside the initial dilution zone, described in Section 1.2.

Maintaining the natural temperature regime of streams is vital to safe guard the normal life cycles of aquatic life. Small increases in temperature can alter life cycle timing of aquatic life, shift algal species compositions from thin mats of diatoms to thick filamentous growths of green algae and cyanobacteria species, and alter the abundances of fish species from cool water fish such as salmonids to those better able to tolerate a wider temperature range. Large increases in temperature can increase the toxicity of ammonia nitrogen and other contaminants, reduce oxygen availability, and increase the risk of fish diseases. Once the temperature exceed species-specific maximum tolerance levels, mortality occurs. Keremeos Creek water temperature data for summer low flow conditions are limited. On July 6, 1982, the creek at Cawston was 13°C. In the third week of August 1994, temperatures of 9-10.5°C were recorded in Keremeos Creek along Green Mountain Rd. and 17°C at the Grist Mill Bridge in Keremeos. Five temperature surveys were conducted on lower Keremeos Creek, from June 10 to July 31, 1997. By mid summer the water temperature increased from 11.0°C at the Hwy 3A site to 17.0°C at Cawston. Groundwater inputs may moderate temperature increases caused by direct solar radiation where shading by streamside vegetation is lost. The provincial guidelines specify 18-19 C as a maximum weekly average for protection of adults and juveniles of aquatic life (Nagpal, 1995). For rainbow trout specifically, the temperature range maximums should be 8-10°C during spawning (spring), 13-15°C for embryo survival (until early July), and 22-24°C for adults (Nagpal. 1995). Given that salmonid juveniles are resident in Keremeos Creek throughout the summer and that land clearing can increase stream temperatures, a maximum weekly average temperature of 17°C is proposed as the short term water quality objective. This reflects the present temperture regime and recommends no further increase in water temperature due to loss of streamside shade or water withdrawals exacerbating low flows. To enhance salmonid survival in Keremeos Creek, a maximum weekly average temperature of 15°C is proposed as the long term water quality objective. Restoring streamside vegetation along lower Keremeos Creek will be necessary to achieve this objective.

6.1.5 RESIDUES AND TURBIDITY

Filterable residues (dissolved solids) in Keremeos Creek increase in upper sections largely due to chloride entering from the highways gravel pit (Figure 18). In the upper portion of Keremeos Creek a maximum filterable residue concentration of 212 mg/L was reported at the Triple Chair station. In lower sections of the creek, alkaline soils and groundwater add calcium, magnesium, potassium, sulphur and sodium. The maximum filterable residue concentration in lower Keremeos Creek was 284 mg/L (January 12, 1995 at Upstream Grist Mill). All values were below the guideline of a maximum of 500 mg/L to protect aesthetics of drinking water supplies and irrigation (Nagpal et. al., 1995). Therefore, the water quality objectives proposed for filterable residue in Keremeos Creek will be based on the protection of drinking water and irrigation, and will allow for a maximum concentration of 500 mg/L filterable residue.

Non-filterable residue or suspended solids are particles light enough to be carried in suspension by stream flow. Non-filterable residue may enter Keremeos Creek from soil erosion from land clearing, ski hill operation, motorized and non-motorized recreation, logging and road building, cattle access to the creek and natural processes. Excessive levels of non-filterable residue (NFR) can inflict damage to the membranes of fish gills or cause siltation and smothering of spawning beds and benthic aquatic life. NFR concentrations in the headwaters above road and ski area impacts averaged 4 - 6 mg/L (Tables 6,8). As the community watershed portion of Keremeos Creek above the Gunbarrel Intake is relatively free of NFR (avg: 6 mg/L; max 19 mg/L) every effort should be made to guard against any increase. Therefore, provided this does not compromise the turbidity objective at the Gunbarrel Intake, the objective proposed for NFR in Keremeos Creek at the Gunbarrel Intake will be based on the historic data. As the present watershed is essentially without disturbance and present water use unaffected by present NFR levels, it is proposed that the average level of NFR should not exceed 10 mg/L. Individual sample levels above 20 mg/L should be investigated to determine the cause of these events.

Data for NFR in other portions of Keremeos Creek (Figure 16) indicate that inputs occur near the Apex Mountain Resort and to a lesser extent at locations further downstream. These inputs from roadways occur most notably during freshet on the west fork between the main reservoir and the parking lot (1995,1996), and from ski runs on the main stem between the Quad and Dividend sites (1995) (Table 29 Figure 17). Sediment control measures undertaken by the Ministry of Highways (Dean, 1996) and the Apex Ski Resort (Golder, 1995) have reduced NFR levels in upper Keremeos Creek, even though run-off in 1997 was above average. Average NFR levels at the Triple Chair site decreased from 399 mg/L in 1995, to 92 mg/L in 1996, and 82 mg/L in 1997. Further monitoring is required to determine the success of these sediment control activities. Non-filterable residue in lower Keremeos Creek during freshet ranged from <4 mg/L to 546 mg/L (average 46 mg/L) and is indicative of the sediment transport that occurs during snow melt and storm events (Table 29, Figure 17). The long term objective proposed for NFR in Keremeos Creek (below the Gunbarrel Intake) will follow the B.C. guidelines for the protection of aquatic life which allow an increase of 25 mg/L for 24 hours or 5 mg/L for 30 days during clear flows (<25 mg/L); a change of 10 mg/L over background when NFR is 25 to 100 mg/L; or a 10% increase from background when background levels are greater than 100 mg/L (Caux and Moore, 1997). Interim objectives for freshet conditions in upper Keremeos Creek are proposed as 150 mg/L maximum at the Triple Chair. Futher monitoring will be necessary to determine whether the sediment control measures are adequate and whether the long term objective is an appropriate management target.

Turbidity measures the transmission of light through water and is usually proportional to NFR. High levels of turbidity affect aquatic biological communities and also necessitate increased levels of disinfection for potable water. The community watershed portion of Keremeos Creek above the Gunbarrel Intake (Table 6) is normally low in turbidity (avg: 1.3; max: 4.8 NTU) as is the north fork of Keremeos Creek (Table 8) upstream of roads and the ski area (avg: 0.4; max: 0.7 NTU). During low flow, turbidity in lower Keremeos Creek has been as high as 21.0 NTU (July 31, 1997 at Cawston) but averaged 1.5 NTU. During snow melt turbidity increases in upper Keremeos Creek above the Apex Mountain Resort on the west fork and below the ski runs (Table 30, Figure 15). As with NFR response to sediment control measures, maximum turbidity at the Triple Chair site decreased from 32 NTU in 1995 to 10.2 NTU and 19.2 NTU in 1996 and 1997 respectively. During the 1995, 1996, and 1997 freshet periods, turbidity in lower Keremeos Creek ranged from 0.3 to 52 NTU (average 5.8 NTU, Table 30, Figure 15).

In the cases where the water is used for human consumption excessive turbidity reduces the potability of drinking water. Accordingly the BC guidelines for turbidity to protect aquatic life and drinking water supplies, allow for a maximum increase of 1 NTU when background concentrations are less than 5 NTU (Caux and Moore, 1997). As drinking water diversion occurs only near the source of the west fork of Keremeos Creek the water quality objectives proposed during freshet for turbidity at the Gunbarrel Intake will be based on the protection of drinking water and should restrict the average turbidity to 2.5 NTU and a maximum of 5 NTU. As roads, logging, land clearing and cattle could increase erosion and turbidity the long term objectives proposed for turbidity for the remainder of Keremeos Creek are based on the protection of aquatic life and allow for a increase of 8 NTU in 24 hours or 2 NTU over 30 days during clear flows (NFR< 25 mg/L); a change of 5 NTU when background values are 8-50 NTU;or a maximum of a 10% increase or less where turbidity is normally greater than 50 NTU. The objectives apply to the all portions of Keremeos Creek, except in the initial dilution zones of effluents, described in Section 1.2. Futher sampling would be required to determine whether the proposed objective is adequately protective or achievable.

6.1.6 MICROBIOLOGICAL INDICATORS

Fecal coliform bacteria concentrations in upper Keremeos Creek have been as high as 12 CFU/100 mL (at the Dividend site, Table 16) during the study period. No fecal coliform bacteria were found at the Gunbarrel Intake (Table 6). The B.C. guideline to protect drinking water used with only disinfection as treatment, is for the fecal coliform concentration as a 90th percentile to be less than 10 CFU/100 mL. This is the proposed water quality objective for Keremeos Creek at the Gunbarrel Intake. To determine if the guideline for the 90th percentile concentration is achieved, a minimum of ten samples need to be collected in a thirty-day period.

Fecal coliform counts in lower Keremeos Creek were as high as >2400 CFU/100 mL at Cawston on October 8, 1980 (Figure 9). The geometric mean of the fecal coliform counts for all lower Keremeos

Creek sites from November 23, 1994 to July 31, 1997 is 21.5 CFU/100mL. Domestic water if taken from Keremeos Creek during run-off periods is likely to receive at least partial treatment to reduce solids and bacteria prior to consumption. Recognizing that Keremeos Creek, during low flow periods, is normally relatively free of coliform bacteria, it is appropriate to propose a long term water quality objective for fecal coliform bacteria in lower Keremeos Creek: as a 90^{th} percentile of less than 10 CFU/100mL with sampling a minimum of ten times within 30 days. While more information is gathered to characterize water quality impacts, it is appropriate to set a short term objective for fecal coliform bacteria. B.C. guideline to protect raw drinking water used with partial treatment requires the 90^{th} percentile concentration (ten samples within 30 days) to be $\leq$ 100 CFU/100 mL. As failing septic tanks or cattle access to the creek can cause fecal contamination, the interim water quality objective for fecal coliform bacteria proposed for lower Keremeos Creek is a 90^{th} percentile of less than 100 CFU/100mL with sampling a minimum of ten times within 30 days. The objectives apply to Keremeos Creek downstream of the Gunbarrel Intake.

6.1.7 CHLORIDE

Chloride concentrations in upper Keremeos Creek ranged from 0.3 to 48.0 mg/L with an average concentration of 14.1 mg/L (Figure 12). Chloride concentrations in lower Keremeos Creek ranged from <0.5 mg/L to 23.8 mg/L and averaged 5.0 mg/L. The BC water quality guideline for chloride allows a maximum acceptable concentration of 100 mg/L for irrigation and 250 mg/L drinking water (Nagpal et. al.,1995). No guidelines exist for the protection of aquatic life. For the protection of irrigation supplies in Keremeos Creek a water quality objective is proposed for chloride. The proposed objective allows a maximum acceptable concentration of 100 mg/L chloride in lower Keremeos Creek in any discrete sample collected outside the initial dilution zone, described in Section 1.2.

6.2 SOUTH KEREMEOS CREEK

Data for South Keremeos Creek (E221391) for the site just upstream of Green Mountain Road are summarized in Table 22. The data in Table 22 represent water quality conditions for the period from November 1994 to June 1996. Designated water uses for South Keremeos Creek are: livestock watering, wildlife, and aquatic life. The parameters of concern in this area are related to agricultural operations (cattle grazing), timber harvest, road maintenance, and mining include: pH, nutrients, periphyton, dissolved oxygen, solids, metals and bacteria.

6.2.1 PH AND ALKALINITY

The average pH in South Keremeos Creek was 7.5 and ranged from 7.1 to 7.9. The BC guidelines for pH to protect aquatic life are that the pH should be in the range from 6.5 to 9.0, while guidelines to protect livestock watering supplies are that the pH should be in the range from 5.0 to 9.5 (Nagpal et. al., 1995). The pH guidelines for drinking water supplies are for aesthetic objectives, and pH values outside this range do not necessarily preclude the raw water source for a drinking water supply. The data tend to indicate that the pH of South Keremeos Creek is within the range defined for the protection of livestock water supplies and protection of aquatic life. In order to protect aquatic life, a water quality objective proposed for pH is the range from 6.5 to 9.0. When upstream values exceed 9.0 no statistically significant increase in pH should occur.

On the basis of seven measurements, South Keremeos Creek, with a mean alkalinity of 38.8 mg/L has a low sensitivity to acidic inputs (Nagpal et. al., 1995).

6.2.2 HARDNESS AND METALS

South Keremeos Creek is of moderate water hardness ranging from 28.4 mg/L to 70.7 mg/L and averaged 59.9 mg/L (Table 22). In general, metals become less toxic with increasing water hardness. Accordingly, the maximum and average metal guidelines are calculated below, using the lowest hardness (28.4 mg/L) and the average hardness (59.9 mg/L), respectively. Minerals shown to be of potential for exploration and development in South Keremeos Creek include: copper, lead, zinc, silver and gold. While no mineral development is proposed for the drainage area, the limited data for metals are compared below to BC Environment Water Quality Guidelines. Water quality objectives however will not be proposed, nor further metals sampling conducted until mineral development is proposed in the area.

Total chromium in South Keremeos Creek averaged 0.006 mg/L which is less than the provincial guideline of 0.02 mg/L; four values were less than 0.002 mg/L and one value was 0.022 mg/L (Table 22).

In South Keremeos Creek, one of five total copper measurements was at the detection limit of 0.002 mg/L; the remaining four values were below the detection limit, thus the guidelines for the average concentration for the protection of aquatic life was met (0.002 mg/L).

Using the lowest hardness for South Keremeos Creek (28.4 mg/L), the calculated maximum acceptable lead concentration is 0.016 mg/L. All lead concentrations measured in South Keremeos Creek on five occasions were below the detection limit of 0.003 mg/L and below the guideline. The calculated allowable 30-day average total lead is 0.005 mg/L, and all total lead values met this guideline. The proper application of this average guideline requires that a minimum of five samples be collected in a thirty-day period, which has not been done to date.

Zinc concentrations according to the BC Environement water quality guidelines (tentative) should be less than 0.03 mg/L for the protection of aquatic life (Nagpal et. al., 1995). One total zinc value (of five measured) in South Keremeos Creek was 0.03 mg/L (January 19, 1995) with the remaining values being between 0.03 mg/L and the 0.01 mg/L detection limit. Effects on algae have been noted at 0.014 mg/L zinc (Nagpal et. al., 1995).

6.2.3 NUTRIENTS

Ammonia nitrogen was not detected in the eleven samples from South Keremeos Creek during the period reported in this study. However, as animal wastes can generate ammonia, a water quality objective is proposed for total ammonia concentrations in South Keremeos Creek in order to protect aquatic life. The objective is that the maximum concentration not exceed concentrations listed in Table 3, and average concentrations not exceed concentrations shown in Table 4. The objectives are proposed for the protection of aquatic life and apply to discrete samples collected outside the initial dilution zone of point sources, described in Section 1.2

Even using the highest measured nitrite concentration of 0.019 mg/L (February 16, 1995) and the lowest chloride concentration of 0.2 mg/L in South Keremeos Creek (Table 22), the nitrite concentration in the creek did not approach the guideline maximum of 0.06 mg/L (Table 5) allowed to protect aquatic life. Although excessive nitrite nitrogen levels are unlikely, proper evaluation of the mean concentration objective requires that a minimum of five samples be collected in a thirty-day period. Since incomplete oxidation of ammonia can result in the formation of nitrite, and since ammonia is associated with animal wastes which can enter South Keremeos Creek, a provisional water quality objective is proposed for nitrite. The objective is that the maximum and mean nitrite concentrations should not exceed those values listed in Table 5. The objectives apply to the entire length of South Keremeos Creek except for the initial dilution zones, described in Section 1.2

The maximum nitrate or nitrate/nitrite concentration was 0.18 mg/L (Table 22), well below the maximum concentration of 100 mg/L to protect livestock water supplies. Since ammonia which may enter the creek through animal waste can be converted to nitrate, a provisional water quality objective is proposed for nitrate plus nitrite in South Keremeos Creek. The objective is that the maximum nitrate plus nitrite concentration not exceed 100 mg/L while the average concentration should not exceed 40 mg/L. The maximum objective protects livestock watering activity while the average objective is designed to protect aquatic life. The objectives, which do not apply to the initial dilution zones (Section 1.2), should be reviewed if Keremeos Creek water use is compromised due to reduced water quality in South Keremeos Creek.

Total phosphorus concentrations (n=10) averaged 0.004 mg/L (Table 22) and had a maximum concentration of 0.009 mg/L on May 24, 1995. Total phosphorus levels were probably not high enough to cause excessive algal growths. However, only with measurements of periphyton chlorophyll-a will it be possible to tell if algal growths are of concern. The approved and working guidelines for the protection of recreational use of streams from excessive algae is 50 mg/m^2 chlorophyll-a (Nagpal et. al., 1995). There is no proposed phosphorus guideline for streams; therefore a water quality objective is proposed so that the average of five periphyton chlorophyll-a concentrations be less than 50 mg/m^2 in South Keremeos Creek. The objective protects aquatic life and recreational use and applies to the average of five naturally-growing periphytic algae samples collected from natural substrate at one site on the same day (Nagpal et. al., 1995).

6.2.4 DISSOLVED OXYGEN AND TEMPERATURE

Dissolved oxygen, measured only once in South Keremeos Creek on November 23,1994, was 14.0 mg/L (101 % saturation). Since oxygen-consuming substances can enter South Keremeos Creek from animal wastes, logging or mining activity, a water quality objective is proposed for dissolved oxygen. The objective is that the minimum dissolved oxygen concentrations in the water column should not be lower than 11.0 mg/L when salmonid embryo are present, and no lower than 8.0 mg/L at all other times. The objectives apply to the entire length of South Keremeos Creek excluding the initial dilution zones of effluents, described in Section 1.2. Data for water temperature during the summer low flow conditions is limited to one record (9 C) in August of 1994. Due to the limited temperature data no objective will be proposed for water temperature.

6.2.5 RESIDUES AND TURBIDITY

The maximum filterable residue (dissolved solids) concentration in South Keremeos Creek was 150 mg/L on January 19, 1995, and averaged 90 mg/L (Table 22). Both the maximum and average values were below the guideline maximum of 1000 mg/L to protect the most sensitive water use (livestock water supplies) (Nagpal et. al., 1995). However, it is proposed that no more than a 20% increase in filterable residue be allowed downstream of an area of impact on South Keremeos Creek, providing the water quality of Keremeos Creek is not compromised as a result.

Non-filterable residue (suspended solids) concentrations measured in South Keremeos Creek from November 1994 to June 1996, during low or clear flows, were all below the detection limit of 4 mg/L (Table 22) and within approved guidelines for the protection of aquatic life (Caux and Moore, 1997). As timber harvesting, cattle grazing or mining could increase non-filterable residue in Sourth Keremeos Creek, a water quality objective is proposed for non-filterable residue in South Keremeos Creek, based on the protection of aquatic life. The proposed objective is an induced concentration of 10 mg/L non-filterable residue when the background is less than between 25 and100 mg/L; 25 mg/L increase in 24 hours or 5 mg/L increase over 30 days when background values are < 25 mg/L.

Freshet data for South Keremeos Creek indicate that non-filterable residue levels in the creek are influenced during snow melt and rain storm events, with the average of ten measurements being 10.3 mg/L and the maximum being 38 mg/L (May 24, 1995). Should further monitoring indicate turbid flows > 100 mg/L, a water quality objective for the protection of aquatic life, shall allow an induced non-filterable residue concentration of 10% over background. The objectives apply to the entire length of South Keremeos Creek.

Mean turbidity concentrations in South Keremeos Creek ranged from 0.2 to 0.5 NTU during periods of low flow. The average freshet turbidity concentration was 0.7 NTU. The B.C. guidelines to protect aquatic life from turbidity allow for an increase of 8 NTU in 24 hours or 2 NTU over 30 days during clear flows (NFR< 25 mg/L); a change of 5 NTU when background values are 8-50 NTU;or a maximum of a 10% increase or less where turbidity is normally greater than 50 NTU. As existing conditions appear to meet the guidelines these are proposed as the water quality objectives for turbidity providing Keremeos Creek water quality is not compromised.

6.2.6 MICROBIOLOGICAL INDICATORS

The median and maximum fecal coliform counts of eleven samples taken from South Keremeos Creek were 0 CFU/100 mL and 5 CFU/100 mL, respectively. The B.C. guidelines to protect livestock watering supplies are that values should not exceed 200 CFU/100 mL. This is the proposed water quality objective for South Keremeos Creek providing water quality objectives set for Keremeos Creek water quality are not compromised.

6.3 CEDAR CREEK

Data for Cedar Creek (E221525) are summarized in Table 23 for a site near the mouth of the creek just upstream from the highway. Established water uses for Cedar Creek are: drinking water, livestock watering, wildlife, and aquatic life. The parameters of concern in this area are related to agricultural operations (cattle grazing), mineral exploration, logging, road maintenance and include: pH, nutrients, periphyton, metals, dissolved oxygen, solids, bacteria and low flows.

6.3.1 PH AND ALKALINITY

The average pH in Cedar Creek was 7.3 and ranged from 7.0 to 7.7. The BC guidelines for pH to protect drinking water are that the pH should be in the range from 6.5 to 8.5, while guidelines to protect livestock watering supplies are that the pH should be in the range from 5.0 to 9.5 (Nagpal et. al., 1995). In order to protect drinking water, the water quality objective proposed for pH is the range from 6.5 to 8.5.

On the basis five measurements, Cedar Creek, with a mean alkalinity of 45.2 mg/L has a low sensitivity to acidic inputs (Nagpal et. al., 1995).

6.3.2 HARDNESS AND METALS

No data exists to describe water hardess or metals in Cedar Creek. No objectives will be proposed until mineral exploration or development are proposed in this drainage.

6.3.3 NUTRIENTS

Ammonia nitrogen was not detected in 6 samples from Cedar Creek during the period reported in this study. However, as animal wastes can generate ammonia, a water quality objective is proposed for total ammonia concentrations in Cedar Creek in order to protect aquatic life. The objective is that the maximum concentration not exceed concentrations listed in Table 3, and average concentrations not exceed concentrations shown in Table 4.

Nitrite nitrogen was detected in only one (0.005 mg/L) of eight samples and was well below the guideline of 0.06 mg/L (Table 5) allowed to protect aquatic life. Since incomplete oxidation of ammonia can result in the formation of nitrite, and since ammonia is associated with animal wastes which can enter Cedar Creek, a provisional water quality objective is proposed for nitrite. The objective is that the maximum and mean nitrite concentrations should not exceed those values listed in Table 5.

The maximum nitrate or nitrate/nitrite concentration was 0.02 mg/L (Table 23), well below the maximum concentration of 10 mg/L to protect human health. Since ammonia which may enter the creek through animal waste can be converted to nitrate, a provisional water quality objective is proposed for nitrate plus nitrite in Cedar Creek. The objective is that the maximum nitrate plus nitrite concentration not exceed 10 mg/L.

Total phosphorus concentrations averaged 0.004 mg/L (Table 23) and had a maximum concentration of 0.008 mg/L on May 24, 1995. Total phosphorus levels were probably not high enough to cause excessive algal growths. However, only with measurement of periphyton chlorophyll-a will it be possible to tell if algal growths are of concern. The approved and working guidelines for the protection of recreational use of streams from excessive algae is 50 mg/m^2 chlorophyll-a (Nagpal et. al., 1995). There is no proposed phosphorus guideline for streams; therefore the water quality objective proposed is that the average of five periphyton chlorophyll-a concentrations be less than 50 mg/m^2 in Cedar Creek. The objective protects aquatic life and recreational use, and applies to the average of five naturally-growing periphytic algae samples collected from natural substrate at one site on the same day (Nagpal et. al., 1995).

6.3.4 DISSOLVED OXYGEN AND TEMPERATURE

No dissolved oxygen information is available for Cedar Creek. However since oxygen-consuming substances can enter Cedar Creek from animal wastes, logging or mining activity, a water quality objective is proposed for dissolved oxygen. The objective is that the minimum dissolved oxygen concentrations in the water column should not be lower than 11.0 mg/L when salmonid embryo are present, and no lower than 8.0 mg/L at all other times. The objectives apply to the entire length of Cedar Creek excluding the initial dilution zones of effluents, described in Section 1.2.

Temperature data for Cedar Creek during summer low flow conditions is limited to one date in August 1994 (R. Johnston. 1994). The water temperature was 11.5 °C. Of note is that no water was flowing at Highway 3A. One kilometre upstream of the highway two dams diverted approximately three quarters of the stream flow for domestic and irrigation use. Rainbow and brook trout were present in the pools behind the dams. Due to the limited data, no objective will be proposed for water temperature.

6.3.5 RESIDUES AND TURBIDITY

The maximum filterable residue (dissolved solids) concentration in Cedar Creek was 164 mg/L on March 16, 1995, and averaged 85 mg/L (Table 23). Both the maximum and average values were below the guideline of a maximum of 500 mg/L to protect drinking water supplies (Nagpal et. al., 1995). Therefore, the water quality objectives proposed for filterable residue in Cedar Creek will be based on the protection of drinking water, allowing for a maximum concentration of 500 mg/L filterable residue, providing the water quality of Keremeos Creek is not compromised as a result.

Non-filterable residue levels in Cedar Creek are influenced during snow melt and storm events, with the average of nine measurements being 7 mg/L and the maximum being 20 mg/L (June 3, 1996). As logging, cattle grazing or mining could increase non-filterable residue in Cedar Creek, the water quality objectives to protect aquatic life will follow the provincial guidelines which allow an increase of 25 mg/L for 24 hours or 5 mg/L for 30 days during clear flows (<25 mg/L); a change of 10 mg/L over background when NFR is 25 to 100 mg/L; or a 10% increase from background during turbid flows when background levels are greater than 100 mg/L (Caux and Moore, 1997). The objectives apply to the entire length of Cedar Creek.

Turbidity concentrations in Cedar Creek ranged from <0.1 to 7 NTU and averaged 1.2 NTU. As logging, cattle grazing or mining could increase turbidity in Cedar Creek, an objective is proposed to protect drinking water. The objective proposed is a maximum increase of 1 NTU for background levels less than 5 NTU, an increase of 5 NTU when background conditions are less than 50 NTU, or an increase of 10 % when background is greater than 50 NTU.

6.3.6 MICROBIOLOGICAL INDICATORS

The 90th percentile and maximum fecal coliform counts of six samples taken from Cedar Creek were 41.5 CFU/100 mL and 68 CFU/100 mL, respectively. Domestic water is used without treatment from Cedar Creek (W. Carter. pers. comm.). Recognizing that Cedar Creek is normally relatively free of turbidity, but does periodically contain fecal bacteria which is typical of surface waters, it is appropriate to propose that the water quality objective for fecal coliform bacteria in Cedar Creek should be a 90th percentile of less than 10 CFU/100mL. This presumes that at least some form of disinfection should be used on an uncontrolled surface water supply.

6.4 OLALLA CREEK

Data for Olalla Creek (E221526) are summarized in Table 24. This site is near the mouth of the creek just downstream from the Olalla Campground. Although the creek is no longer used by the town of Olalla as a drinking water source, Olalla Creek is still licenced for domestic use. Established water uses for Olalla Creek are: drinking water, livestock watering, wildlife, and aquatic life. The parameters of concern in this area are related to logging, agricultural operations (cattle grazing), mineral exploration, include: pH, nutrients, periphyton, metals dissolved oxygen, solids and bacteria.

6.4.1 PH AND ALKALINITY

The average pH in Olalla Creek was 7.8 and ranged from 7.3 to 8.2. The BC guidelines for pH to protect drinking water are that the pH should be in the range from 6.5 to 8.5. The data tend to indicate that the pH of Olalla Creek is within the range defined for the protection of drinking water. In order to protect aquatic life, the water quality objective proposed for pH is a range from 6.5 to 8.5.

Olalla Creek, with a mean alkalinity of 66.0 mg/L (n=5), has a low sensitivity to acidic inputs (Nagpal et. al., 1995).

6.4.2 HARDNESS AND METALS

No data exists to describe the water hardness of Olalla Creek. The metals data for Olalla Creek is very limited (Table 24). No objectives will be proposed until mineral exploration or development are proposed in this drainage.

6.4.3 NUTRIENTS

Ammonia nitrogen was detected at levels near the detection limit, in 2 of 7 samples from Olalla Creek during the period reported in this study. As septic tank leachate and animal wastes can generate ammonia, a water quality objective is proposed for total ammonia concentrations in Olalla Creek in order to protect aquatic life. The objective is that the maximum concentration not exceed concentrations listed in Table 3, and average concentrations not exceed concentrations shown in Table 4.

Nitrite nitrogen was detected in only one (0.005 mg/L) of eight samples and was well below the guideline of 0.06 mg/L (Table 5) set to protect aquatic life. Since incomplete oxidation of ammonia can result in the formation of nitrite, and since ammonia is associated with animal wastes which can enter Olalla Creek, a provisional water quality objective is proposed for nitrite to protect aquatic life.

The objective is that the maximum and mean nitrite concentrations should not exceed those values listed in Table 5.

The maximum nitrate or nitrate/nitrite concentration of 0.02 mg/L (Table 24), was well below the maximum concentration of 10 mg/L to protect human health. As ammonia entering the creek from animal waste can be converted to nitrate, or nitrate may enter the creek directly from mining activity, a provisional water quality objective is proposed for nitrate plus nitrite in Olalla Creek. The objective is that the maximum nitrate plus nitrite concentration not exceed 10 mg/L.

Total phosphorus concentrations averaged 0.004 mg/L (Table 24) and had a maximum concentration of 0.008 mg/L on May 24, 1995. Total phosphorus levels were probably not high enough to cause excessive algal growths. However, only with measurements of periphyton chlorophyll-a will it be possible to tell if algal growths are of concern. The approved and working guidelines for the protection of recreational use of streams from excessive algae is 50 mg/m^2 chlorophyll-a (Nagpal et. al., 1995). There is no proposed phosphorus guideline for streams; therefore the water quality objective proposed is that the average of five periphyton chlorophyll-a concentrations be less than 50 mg/m^2 in Olalla Creek. The objective protects aquatic life and recreational use, and applies to the average of five naturally-growing periphytic algae samples collected from natural substrate at one site on the same day (Nagpal et. al., 1995).

6.4.4 DISSOLVED OXYGEN

No dissolved oxygen information is available for Olalla Creek. However since oxygen-consuming substances can enter Olalla Creek from animal wastes, logging or mining activity, a water quality objective is proposed for dissolved oxygen. The objective is that the minimum dissolved oxygen concentrations in the water column should not be lower than 11.0 mg/L when salmonid embryos are present, and no lower than 8.0 mg/L at all other times.

Temperature data for Olalla Creek during summer low flow conditions is limited to one date in August, 1994 (R. Johnston. 1994). The water temperature was 18°C in a pool at Main Street. Due to the limited data, no objective will be proposed for water temperature.

6.4.5 RESIDUES AND TURBIDITY

The maximum filterable residue (dissolved solids) concentration in Olalla Creek was 178 mg/L on March 16, 1995, and averaged 105 mg/L (Table 24). Both the maximum and average values were below the guideline maximum of 500 mg/L to protect drinking water supplies (Nagpal et. al., 1995). Therefore, the water quality objectives proposed for filterable residue in Olalla Creek will be based on the protection of drinking water, allowing for a maximum concentration of 500 mg/L filterable residue.

Non-filterable residue levels in Olalla Creek are influenced during snow melt and storm events, with the average of nine measurements being 9 mg/L and the maximum being 56 mg/L (June 3, 1996). As logging, cattle grazing or mining could increase non-filterable residue in Olalla Creek the water quality objectives to protect aquatic life will follow the provincial guidelines which allow an increase of 25 mg/L for 24 hours or 5 mg/L for 30 days during clear flows (<25 mg/L); a change of 10 mg/L over background when NFR is 25 to 100 mg/L; or a 10% increase from background during turbid flows when background levels are greater than 100 mg/L (Caux and Moore, 1997). The objectives apply to the entire length of Olalla Creek.

Turbidity concentrations in Olalla Creek ranged from 0.1 to 7.2 NTU and averaged 2 NTU. As logging, cattle grazing or mining could increase turbidity in Olalla Creek, an objective is proposed to protect drinking water. The objective proposed is a maximum increase of 1 NTU for background levels less than 5 NTU, an increase of 5 NTU when background conditions are less than 50 NTU, or an increase of 10 % when the background concentration is greater than 50 NTU.

6.4.6 MICROBIOLOGICAL INDICATORS

The 90th percentile and maximum fecal coliform counts of 12 samples taken from Olalla Creek were 9.4 CFU/100 mL and 12 CFU/100 mL, respectively. Recognizing that Olalla Creek is normally relatively free of turbidity, but does periodically contain fecal bacteria which is typical of surface waters, it is proposed that the water quality objective for fecal coliform bacteria in Olalla Creek should be a 90th percentile of less than 10 CFU/100mL. This presumes that at least some form of disinfection should be used on an uncontrolled surface water supply.

7.0 MONITORING RECOMMENDATIONS

Water quality objectives have been proposed for a number of water quality characteristics. Generally, these should be checked under worst-case flow conditions. For parameters such as fecal coliform bacteria, the worst-case conditions occur during the late winter or early spring when low elevation snow melt occurs and agricultural impacts are potentially high. Sampling in the watershed during freshet flows will be required to describe worst- case conditions due to sediment loading and turbidity. Sampling for ammonia nitrogen, dissolved oxygen and temperature are important measurements in the summer when water flows are low and solar radiation high. To check attainment of average or percentile values, a minimum of five samples should be collected in a thirty-day period. For the purposes of checking attainment of the bacteriological objectives, use of the ninetieth percentile is recommended in situations where non-attainment occurs using five samples. Interpolation of the ninetieth percentile value from a graphical presentation of the 5 values can be carried out, however ten sampling dates is recommended. A proposed monitoring scheme is presented in Table 2. However, the water quality monitoring program undertaken may vary, depending on available resources.

Operational monitoring of forestry operations is important to ensure the Forest Practices Code requirements are met and water quality protected. Monitoring the effectiveness of the sediment control measures implemented at the Apex Mountain Resort is necessary to ensure adequate performance of the works installed. Sediment source surveys and riparian assessments, as recommended in the level one IWAP, may need to be conducted, should non-filterable residue and turbidity levels impair water use. Ideally, a comprehensive survey of channel characteristics and biota of lower Keremeos Creek should be conducted to document physical and biological aspects of the stream. Such a survey would document sediment source areas, stream bed particle size (pebble counts), stream bed profile of pools and riffles (Thalweg profile) riparian vegetation type and density, presence of large woody debris, and fish and benthic invertebrate populations.

Periodic inspection of farming operations are conducted during low elevation snow melt to ensure the Code of Agricultural Practice for Waste Management in BC is being followed.

Protecting water quality is contingent on an adequate flow of water under normal conditions to sustain fish and aquatic life of the creek. Minimum flow requirements to protect aquatic life need to be determined and a process of monitoring the adequacy of the flow targets established to provide adequate environmental protection of these water resources.

Lastly, perhaps the two most important initiatives necessary to protect water quality in the lower watershed are retaining and replanting streamside shade trees, and initiating stream stewardship. Without local initiatives to make people and communities feel connected to and responsible for the water course, protection of this resource is not complete.

8.0 REFERENCES

American Fisheries Society. 1979.A Review of the EPA Red Book: Quality Guideline for Water.

Anon. 1987. Canadian Council of Ministers of the Environment. Canadian Water Quality Guidelines.

Anon. 1998. British Columbia water quality guidelines (guideline). 1998 edition. Water Quality Branch, Ministry Of Environment, Lands & Parks, Victoria, B.C.

Bangay, G. E. 1976. Livestock and poultry wastes in the Great Lakes Basin. Environmental concerns and management options. Appendix 3. Environment Canada, Inland Waters Directorate, Ontario Region, Water Planning and Management Branch. Burlington, Ontario.

Caux, P.-Y. and D.R.J. Moore. 1997. Ambient water quality guidelines (guideline) for turbidity, suspended and benthic sediments. Technical Appendix. Prepared by Cadmus Group Inc. and D.McDonald of MacDonald Environmental Sciences Ltd. For Water Management Branch, Ministry Of Environment, Lands & Parks, Victoria, B.C.

Dean, B. 1996. Keremeos Creek highways pit water quality assessment project. Report to Ministry of Transportation and Highways, Penticton B.C.

Environment Canada. 1988. Historical streamflow summary British Columbia 1986. Inland Waters Directorate, Water Resources Branch Water Survey of Canada. Ottawa Canada.

EVS Environment Consultants. 1996. Level one interim watershed assessment of Shingle and Keremeos creek watersheds. Report prepared for First Nations Okanagan Similkameen Environmental Protection Society, Penticton, B.C.

Golder Associates Ltd. 1995. Report on hydrogeological investigation and review of groundwater monitoring program, Apex Mountain Resorts Ltd. Penticton, B.C.

Golder Associates Ltd. 1995. Report on drainage, erosion and sediment control plan Apex Resort, Penticton, B.C.

Hrasko, R.J. 1995. Briefing report water supply and demand Apex Alpine Ski Resort. Reid Crowther and Partners Ltd. Kelowna, B.C.

Johnston, R. 1994. A General fish inventory of streams in the south Okanagan and Similkameen watersheds

McKean, C.1991.Ambient water quality guideline for pH. Water Quality Branch, Water Management Division, B.C. Ministry of Environment. Victoria, B.C.

Ministry of Environment Lands and Parks. 1986. Principles for preparing water quality objectives in British Columbia. Victoria, B.C.

Nagpal, N.K. 1987.Water quality criteria for lead. Resource Quality Section, Water Management Branch, Ministry of Environment and Parks. Victoria, B.C.

Nagpal, N.K., L. Pommen, and L. Swain,L. 1998. A compendium of working water quality guidelines for British Columbia. Water Quality Branch, B.C. Ministry of Environment, Lands and Parks.

Nordin, R.N. and L.W. Pommen. 1986. Water quality criteria for nitrogen (nitrate, nitrite, and ammonia). Resource Quality Section, Water Management Branch, Ministry of Environment and Parks. Victoria, B.C.

Nordin, R.N.1985.Water quality criteria for nutrients and algae. Resource Quality Section, Water Management Branch, Ministry of Environment. Victoria, B.C.

Punshon, J.A. 1995. Contaminated Site Investigation (Level 1), Keremeos Creek South Okanagan district Thompson-Okanagan region, Ministry of Transportation and Highways Geotechnical and Material Engineering Branch, Victoria, B.C.

Reid Crowther and Partners Ltd. 1996. Seven Peaks Baseline Environmental Audit. Prepared for the Ministry of Environment Lands and Parks, Penticton, B.C.

Singleton, H.J. 1987.Water quality criteria for copper. Resource Quality Section, Water Management Branch, Ministry of Environment and Parks. Victoria, B.C.

Singleton, H.J. 1985.Water quality criteria for particulate matter. Resource Quality Section, Water Management Branch, Ministry of Environment. Victoria, B.C.

Swain, L. 1995 Developing water quality objectives in British Columbia - A User's Guide, (draft3).

Talbot, R.J. 1977. Flooding and erosion upper Keremeos Creek. B.C. Ministry of Environment. Water Investigations Branch. Penticton, B.C.

Truelson, R. Ambient water quality criteria for dissolved oxygen. Water Quality Branch, Environmental Protection Department, B.C. Ministry of Environment. Victoria, B.C. Draft Document.

U.S. EPA. Ambient water quality criteria for dissolved oxygen. Criteria and Standards Division, U.S. Environmental Protection Agency. Washington, D.C. EPA 440/5-86-003. 1986.

Warrington, P.D. 1988.Water quality criteria for microbiological indicators. Resource Quality Section, Water Management Branch, Ministry of Environment and Parks. Victoria, B.C.

FIGURE 1

LOCATION OF KEREMEOS CREEK WATERSHED

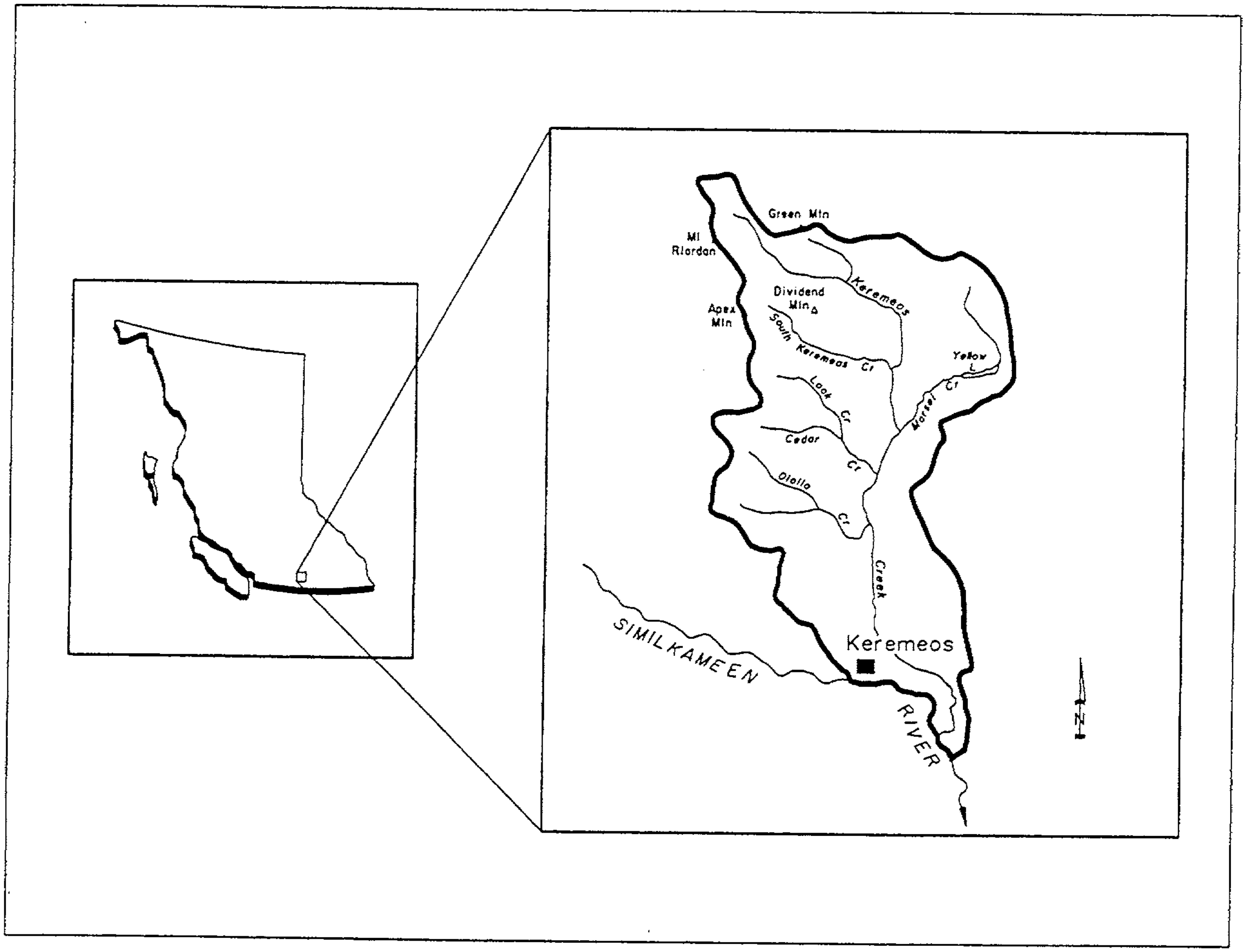


FIGURE 2

LOCATIONS OF LICENCED WATER WITHDRAWLS

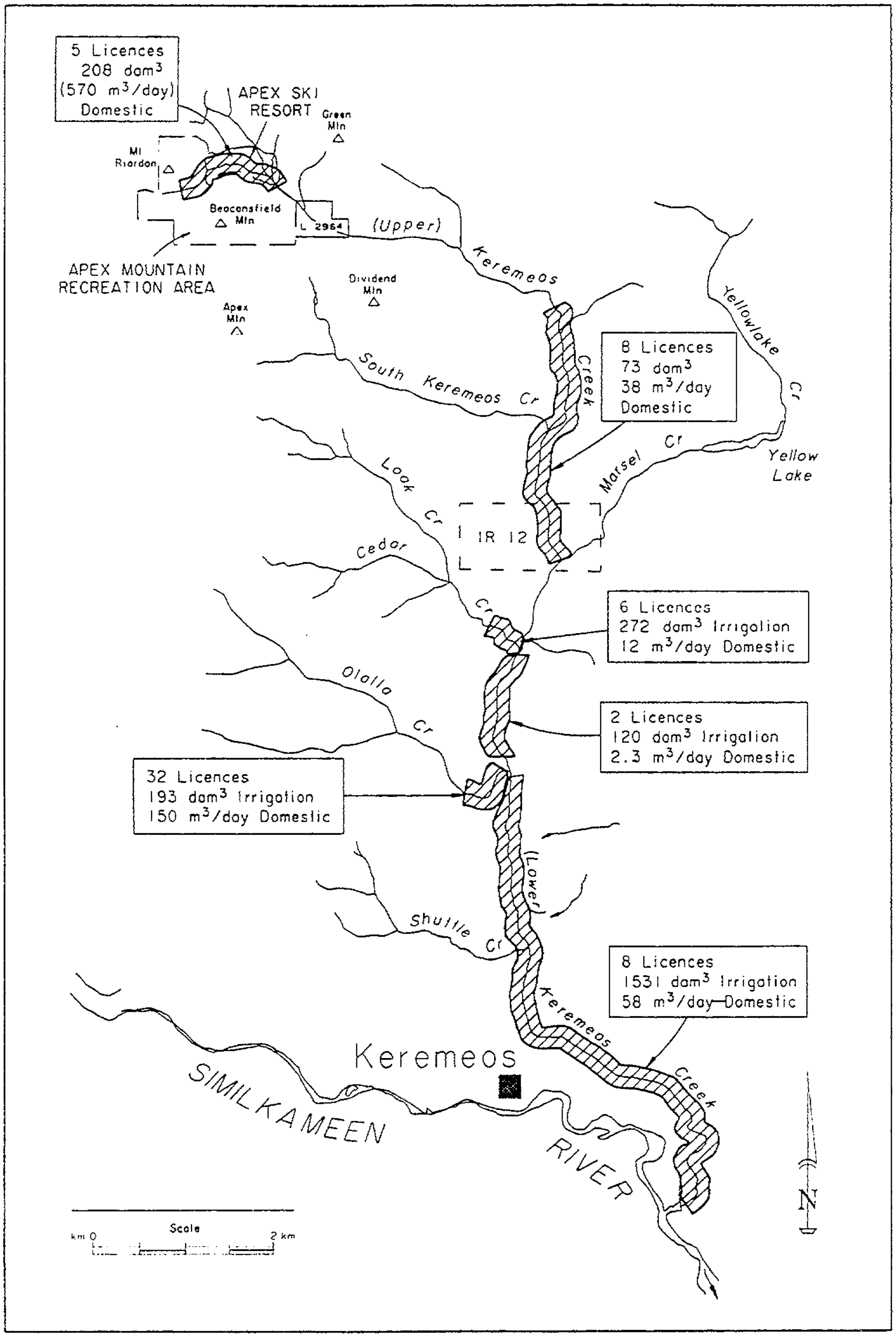


FIGURE 3

LOCATIONS OF WASTE MANAGEMENT PERMITS, AMBIENT WATER QUALITY MONITORING SITES AND FLOW MONITORING STATIONS ON UPPER KEREMEOS CREEK

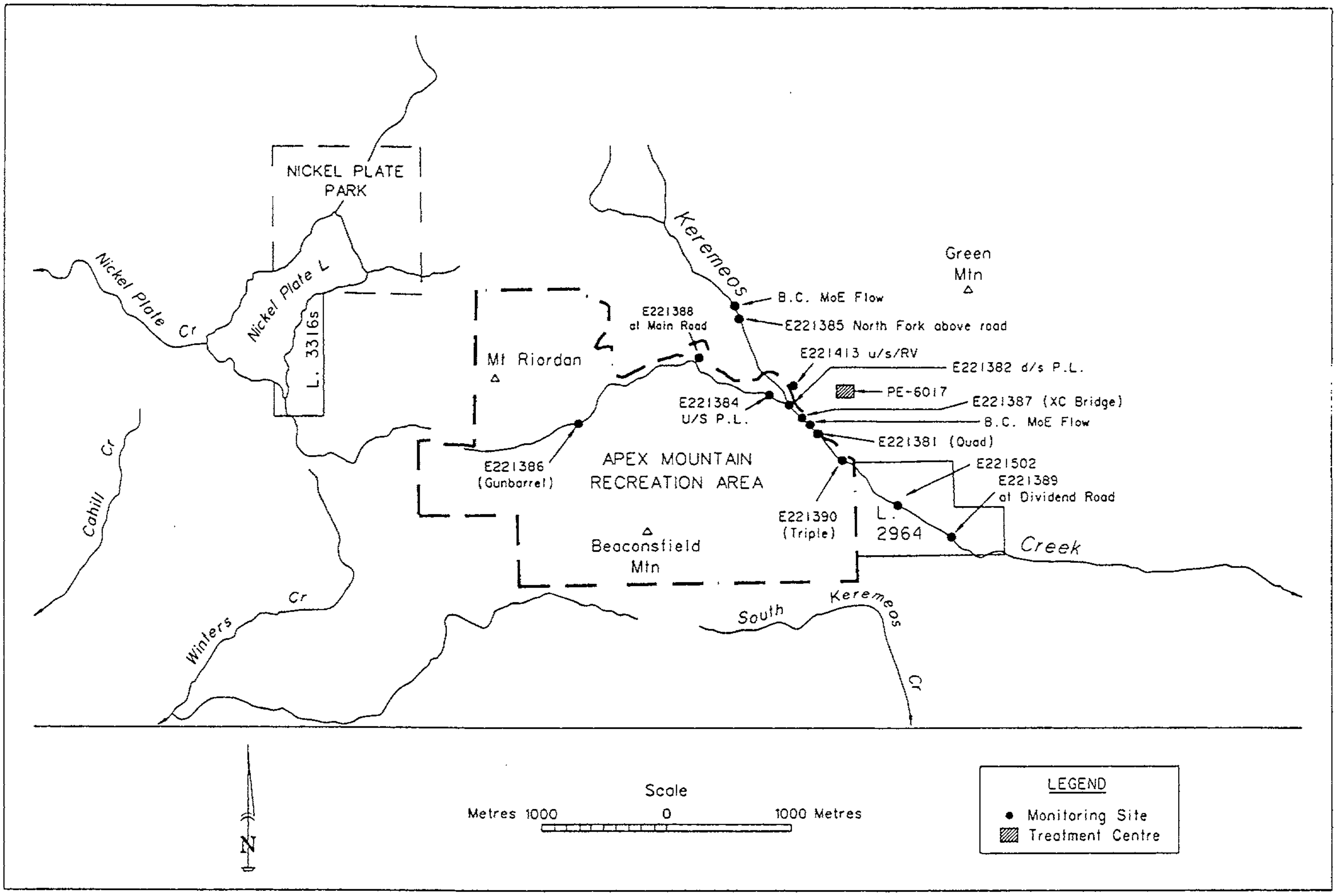


FIGURE 4

LOCATIONS OF WASTE MANAGEMENT PERMITS, AMBIENT WATER QUALITY MONITORING SITES AND FLOW MONITORING STATIONS ON LOWER KEREMEOS CREEK

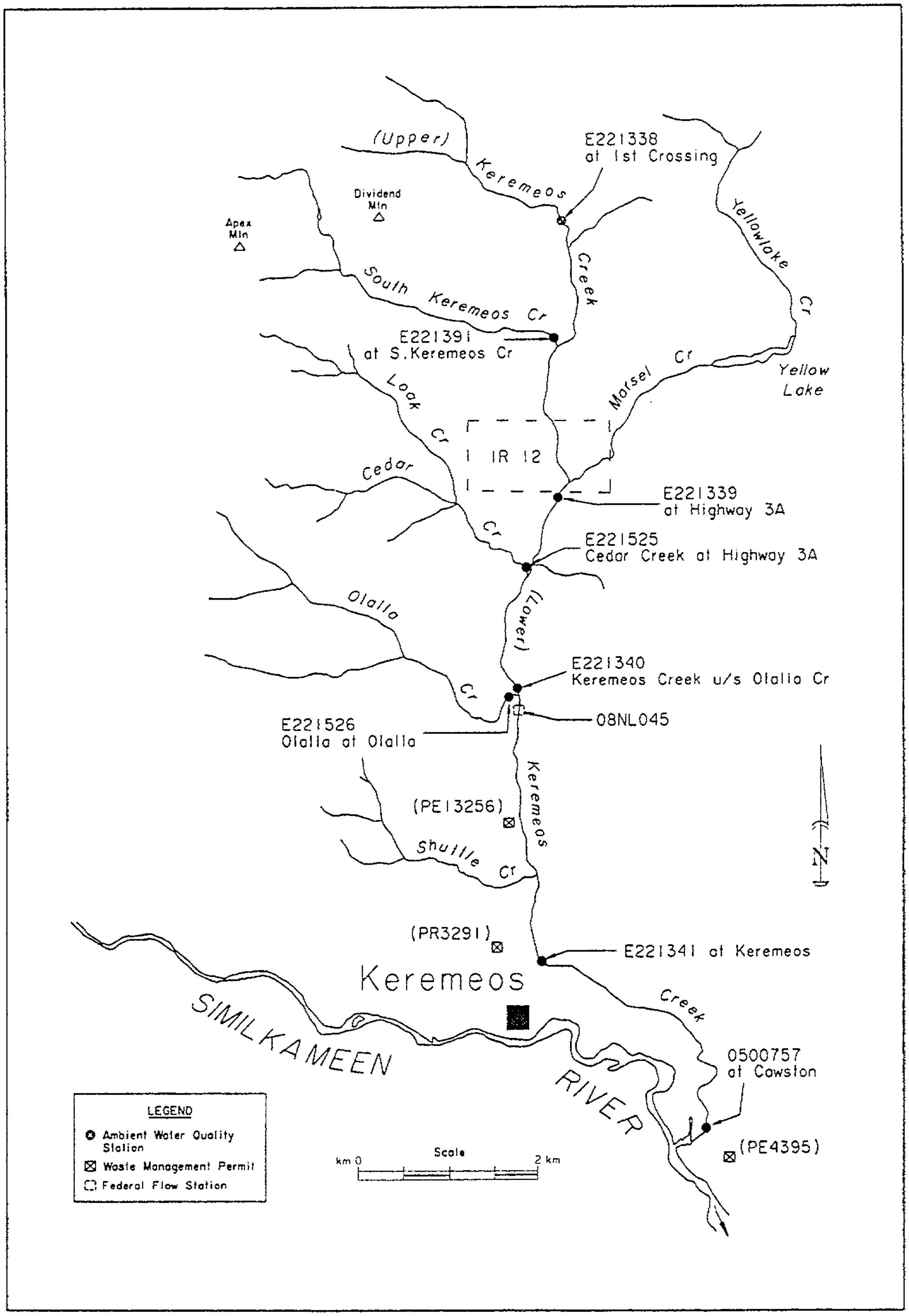


FIGURE 5

APEX MOUNTAIN RESORT GROUNDWATER MONITORING WELLS

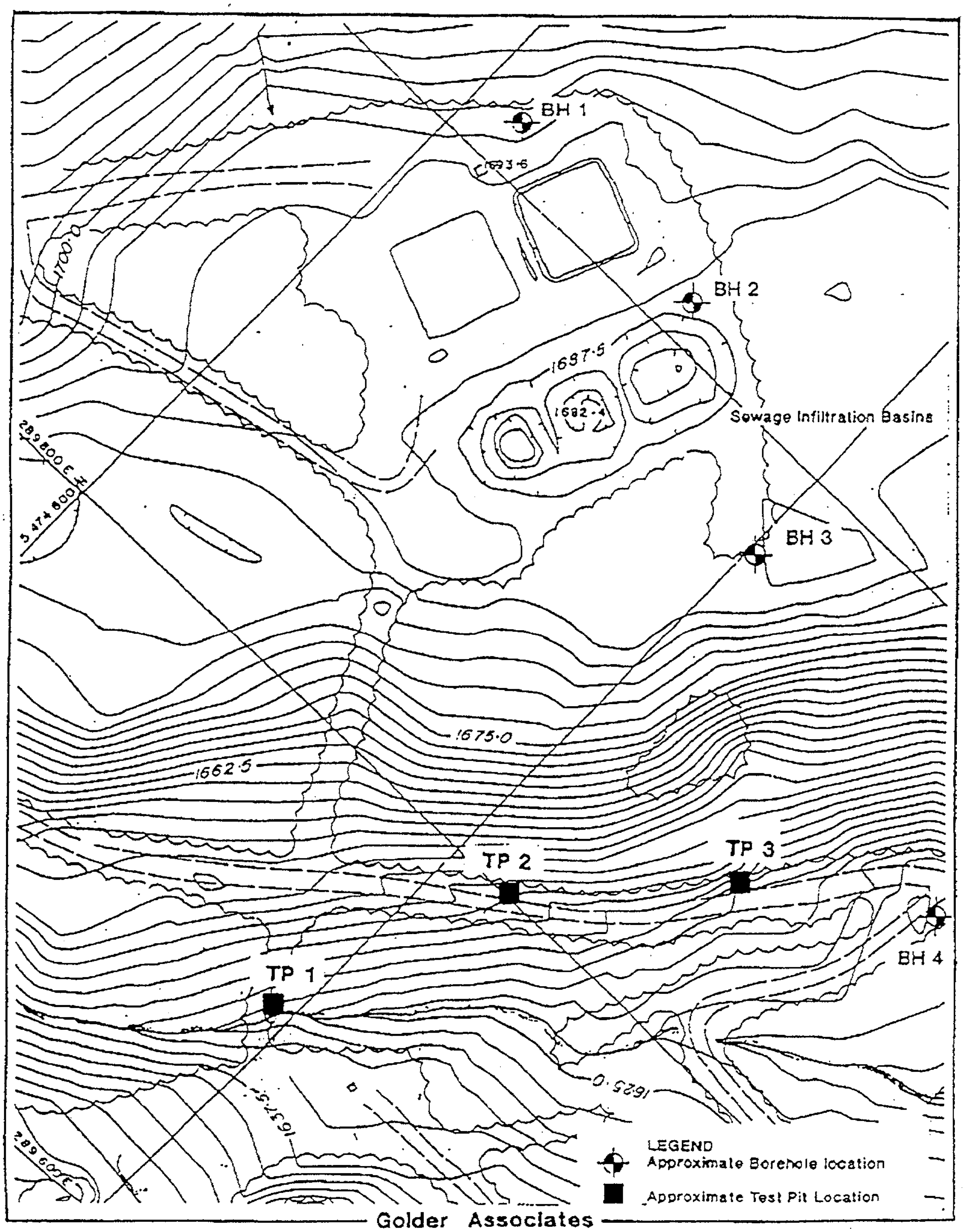


FIGURE 6

MINERAL POTENTIAL IN KEREMEOS CREEK WATERSHED

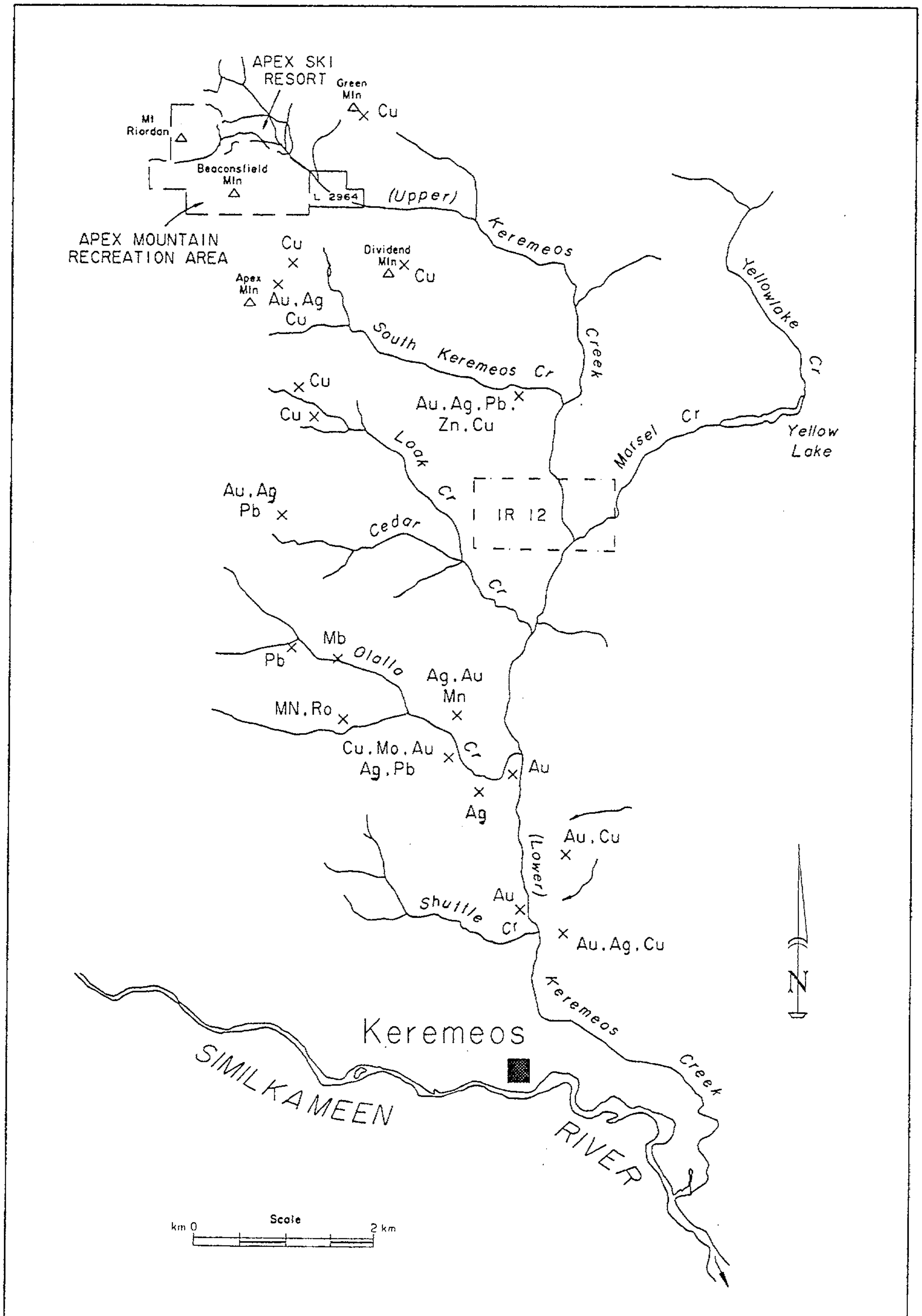
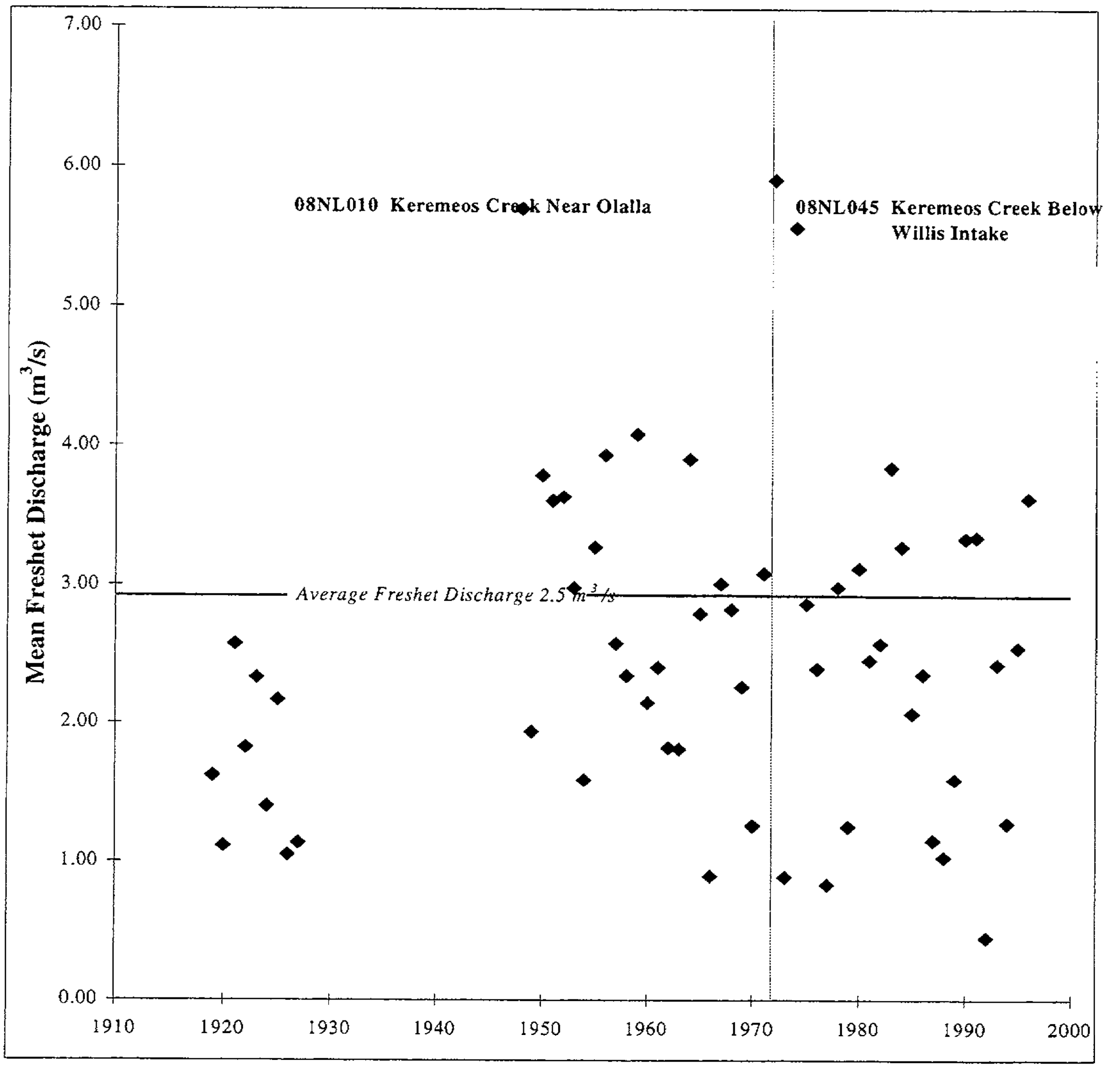


FIGURE 7

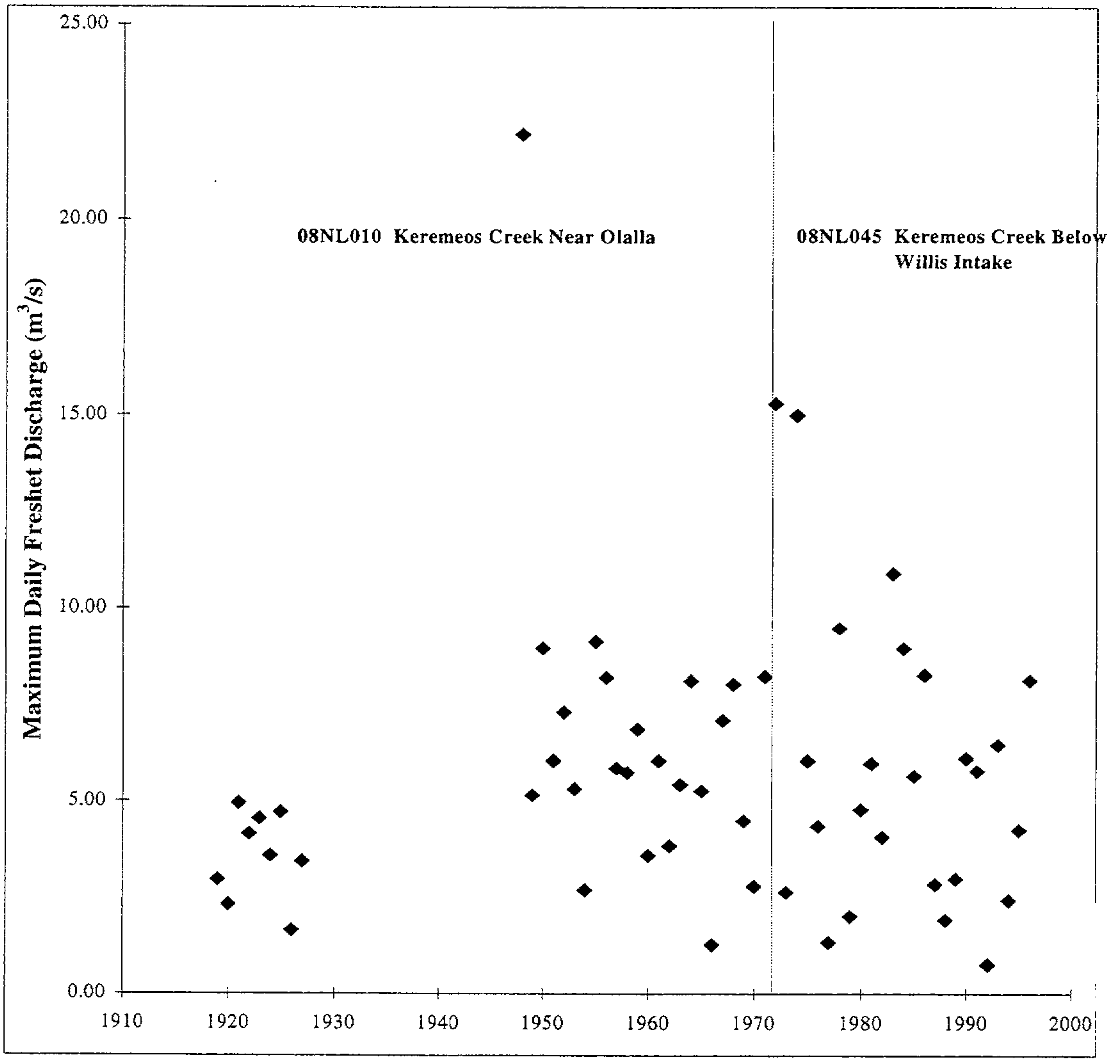
MEAN FRESHET DISCHARGE FOR KEREMEOS CREEK, MAY TO JUNE 1919-1996



Water Survey of Canada, 1998

FIGURE 8

MAXIMUM DAILY DISCHARGE FOR KEREMEOS CREEK, MAY TO JUNE 1919-1996



Water Survey of Canada, 1998

FIGURE 9

FECAL COLIFORM BACTERIA IN KEREMEOS CREEK WATERSHED, NOVEMBER 22, 1994 TO JULY 31, 1997

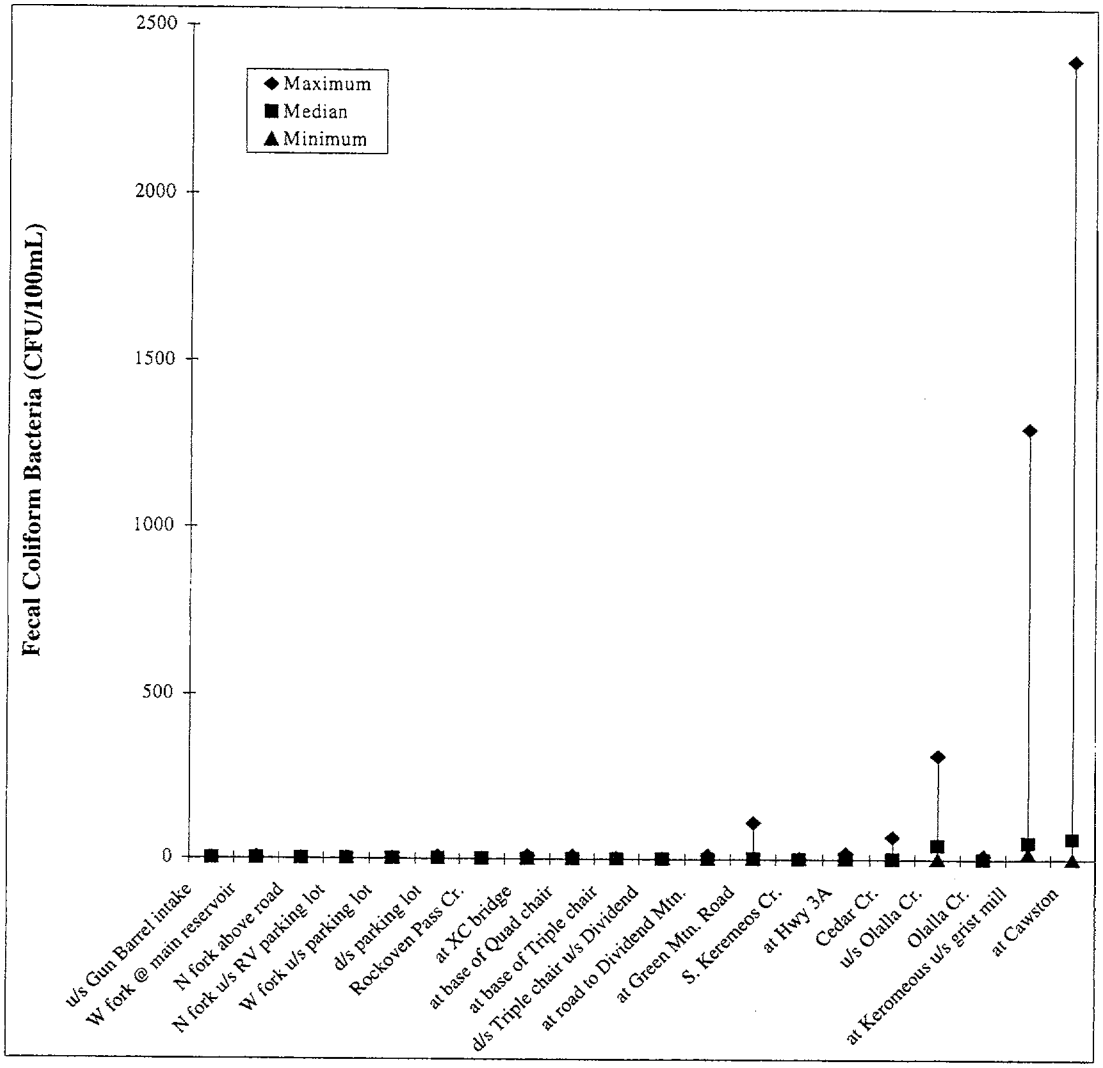


FIGURE 10

AMMONIA NITROGEN (LOG $_{10}$) CONCENTRATIONS IN KEREMEOS CREEK WATERSHED, NOVEMBER 22, 1994 TO JULY 31, 1997

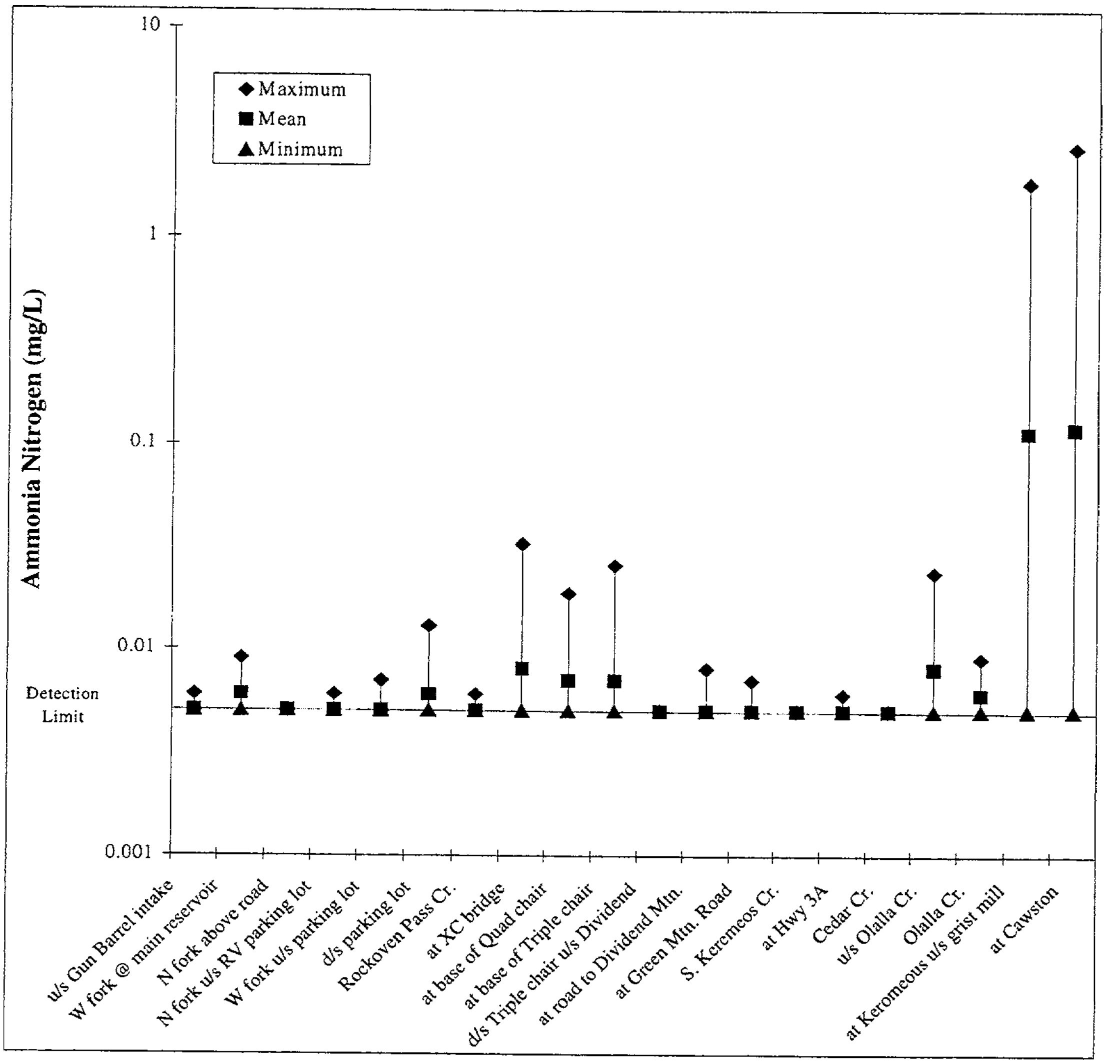


FIGURE 11

SPECIFIC CONDUCTANCE IN KEREMEOS CREEK WATERSHED, NOVEMBER 11, 1994 TO JULY 31, 1997

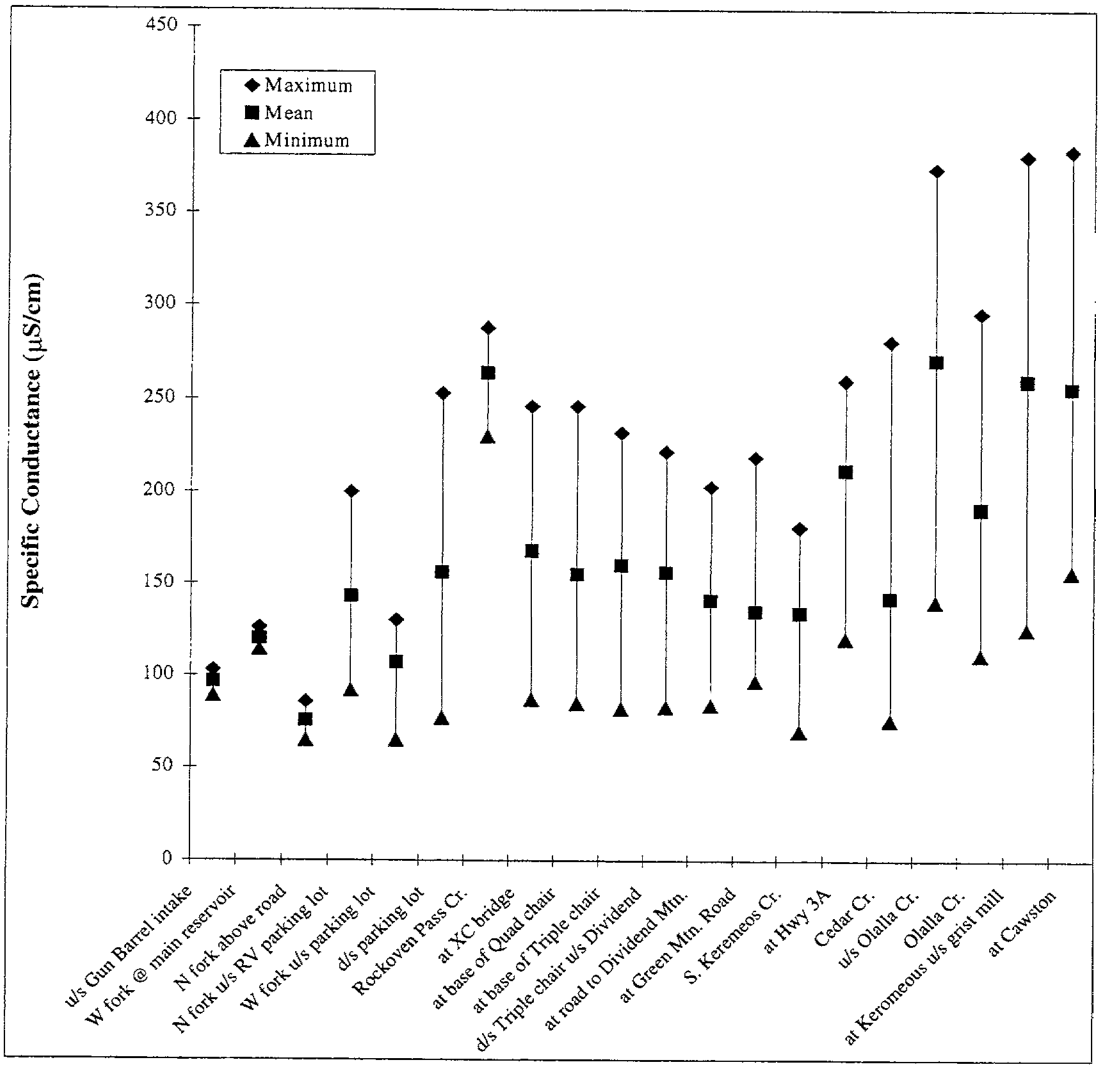


FIGURE 12

DISSOLVED CHLORIDE CONCENTRATIONS IN KEREMEOS CREEK WATERSHED, NOVEMBER 22, 1994 TO JULY 4, 1997

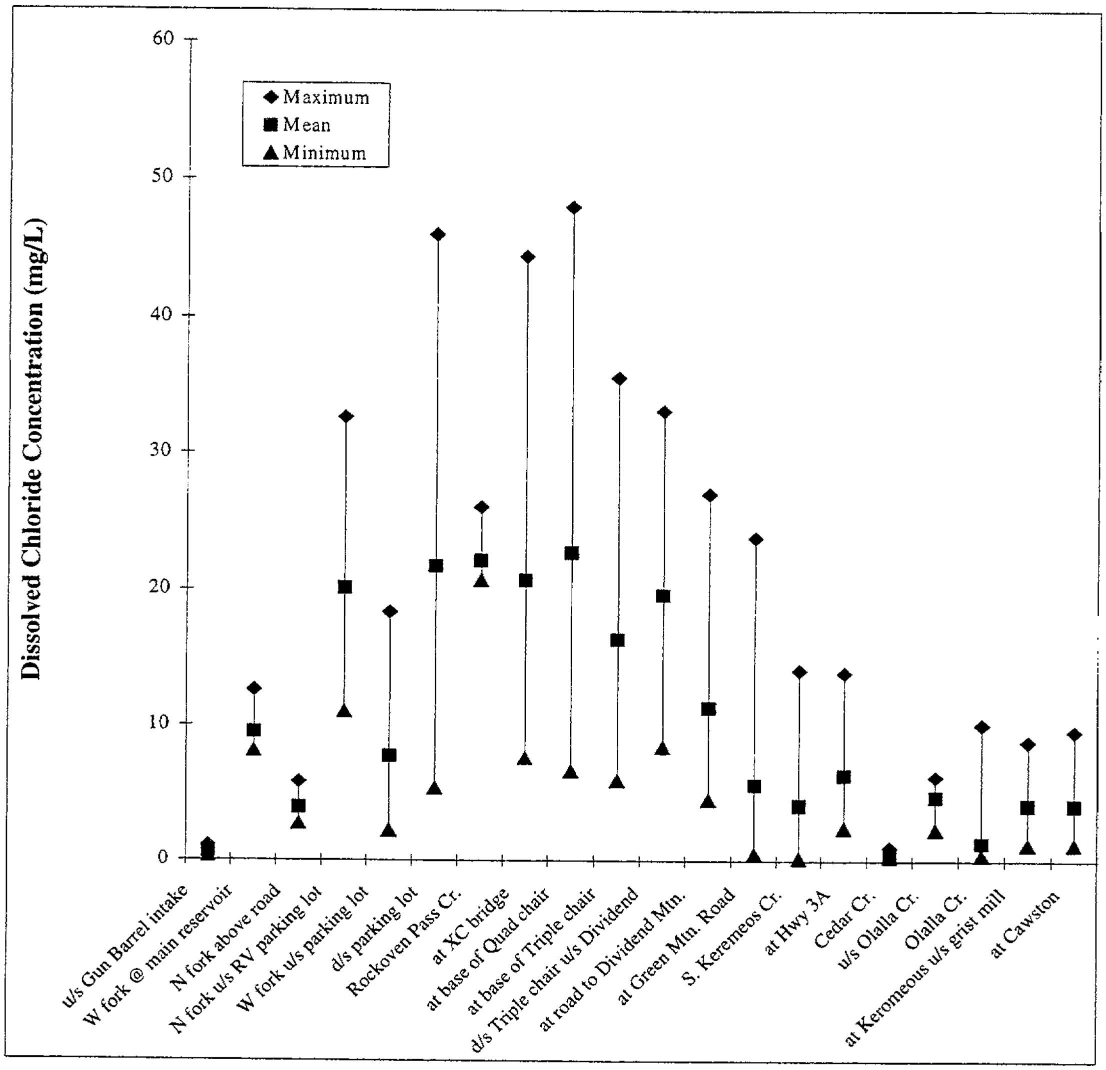


FIGURE 13

NITRITE/NITRATE CONCENTRATIONS IN KEREMEOS CREEK WATERSHED, NOVEMBER 22, 1994 TO JULY 31, 1997

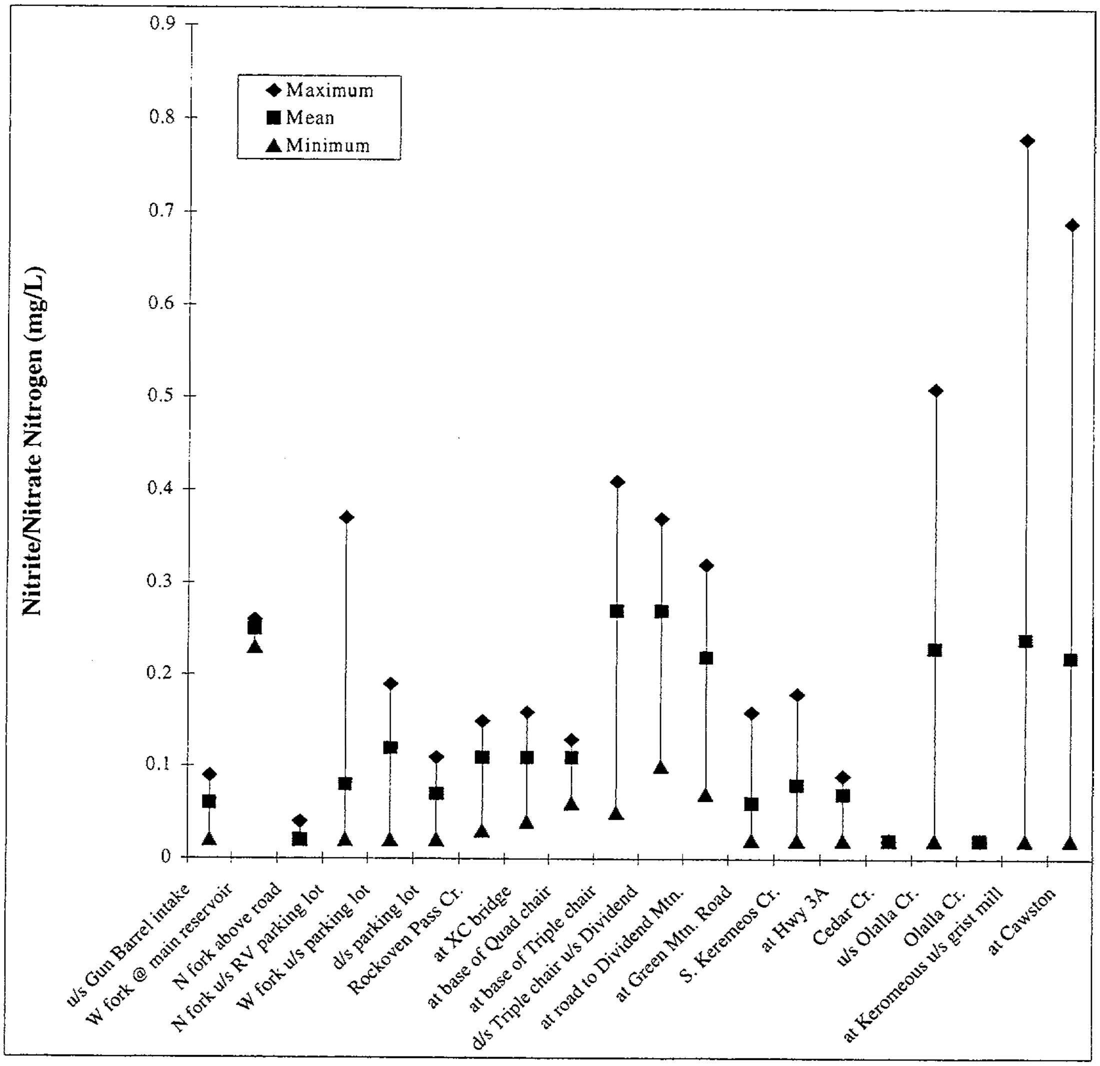


FIGURE 14

TURBIDITY IN KEREMEOS CREEK WATERSHED, NOVEMBER 11, 1994 TO JULY 31, 1997

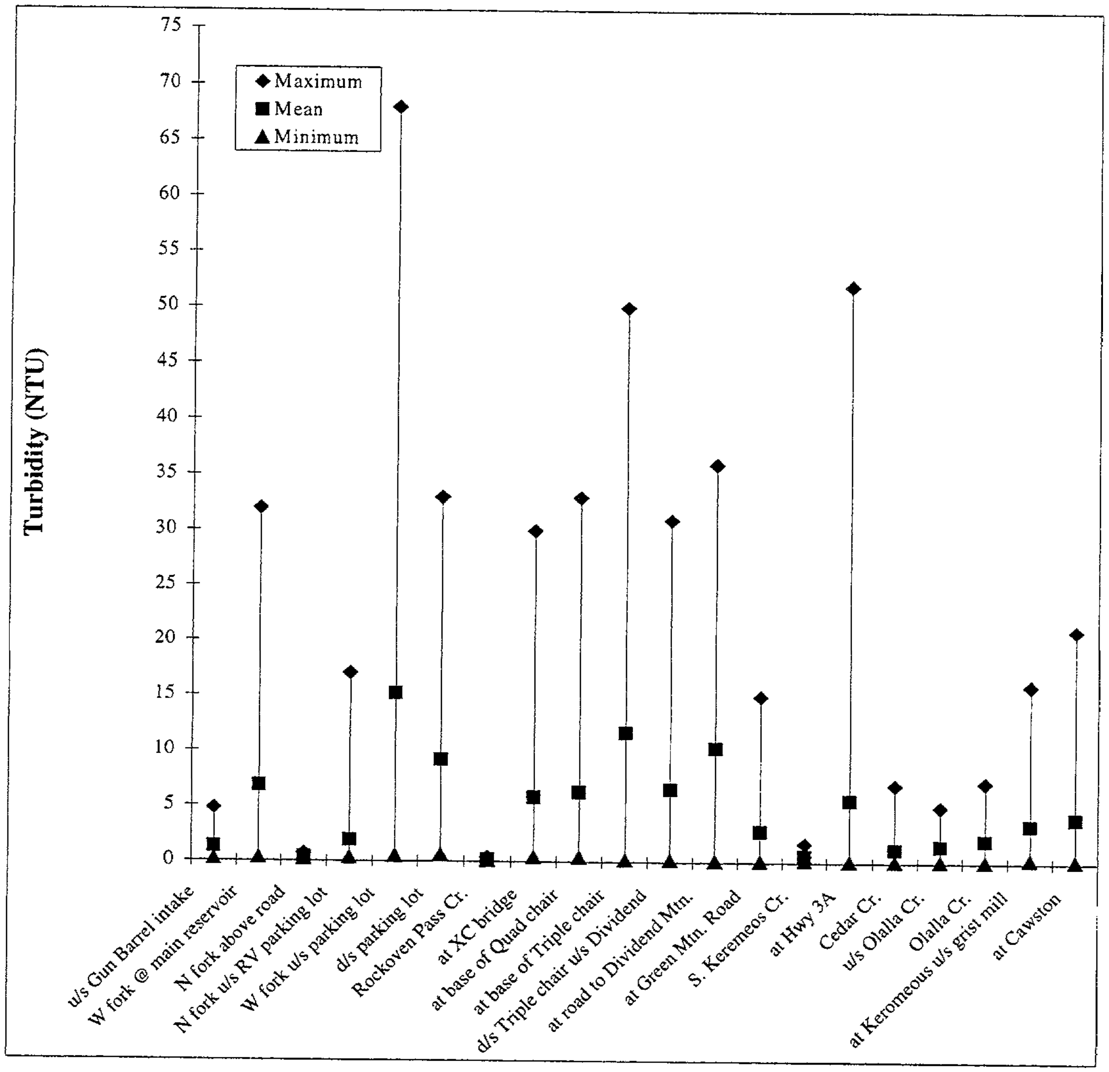


FIGURE 15

TURBIDITY IN KEREMEOS CREEK WATERSHED DURING FRESHET, MAY TO JUNE 1995-97

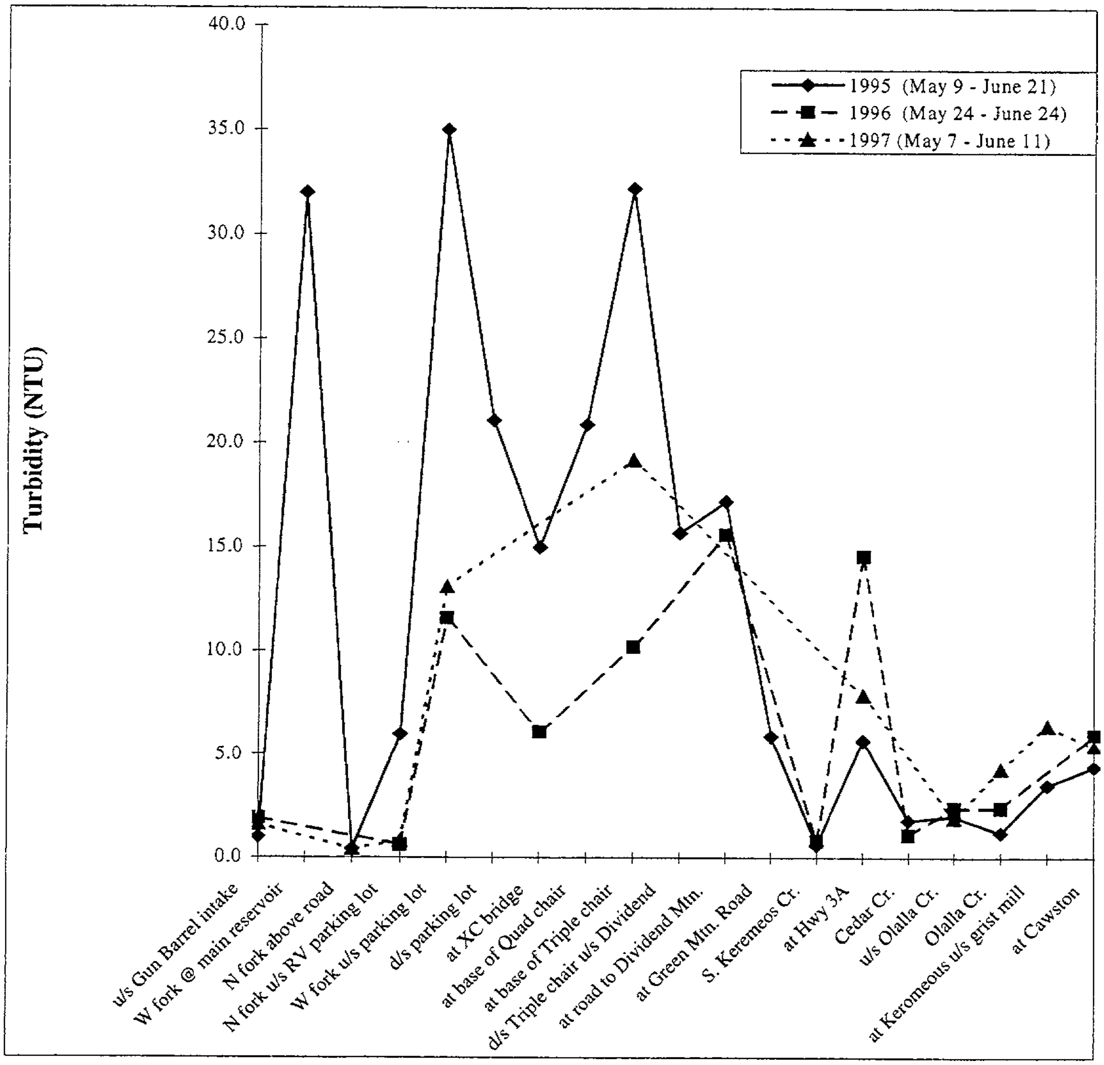


FIGURE 16

NON FILTERABLE RESIDUE IN KEREMEOS CREEK WATERSHED, DECEMBER 14, 1994 TO JUNE 11, 1997

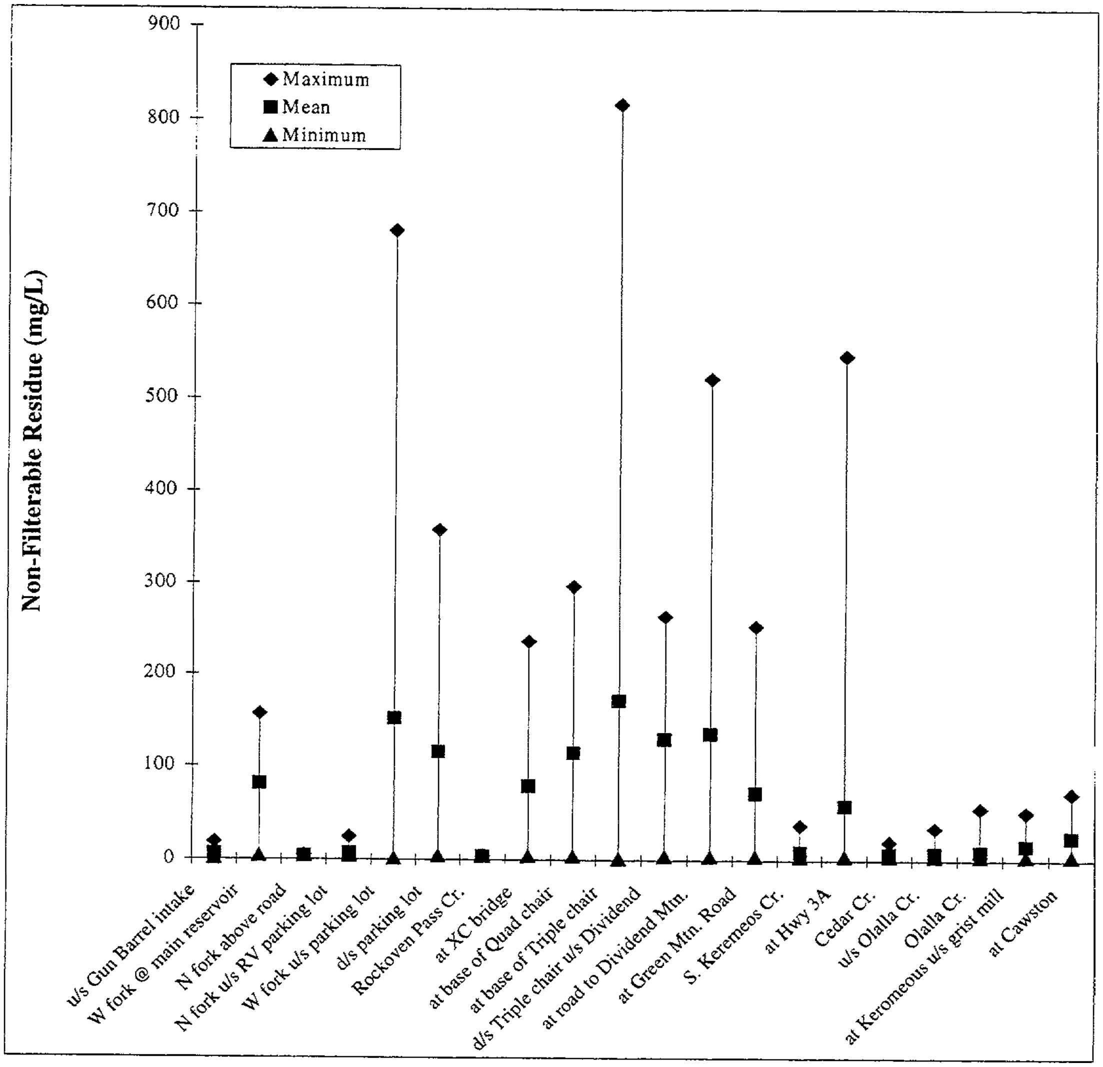


FIGURE 17

NON-FILTERABLE RESIDUE IN KEREMEOS CREEK WATERSHED DURING FRESHET, MAY TO JUNE 1995-97

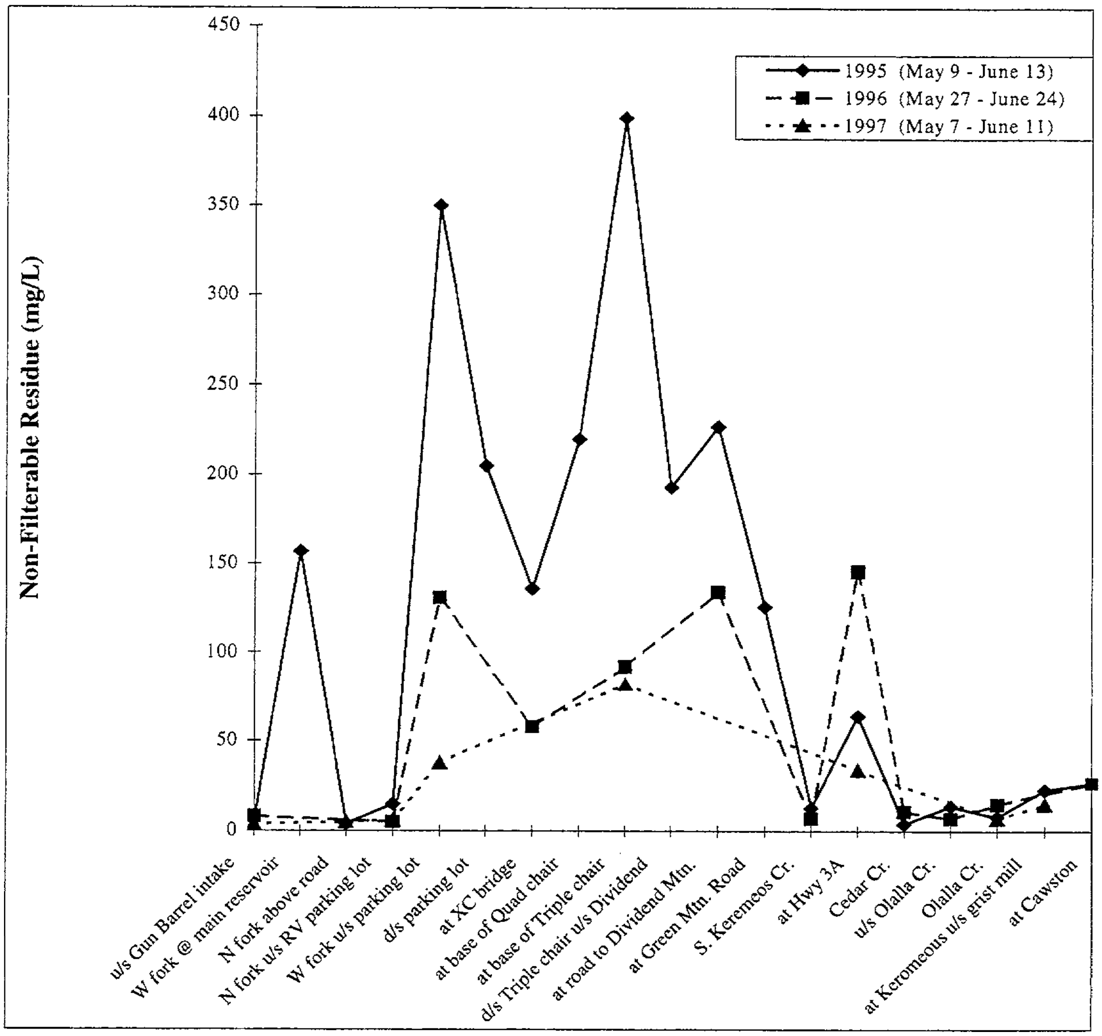


FIGURE 18

FILTERABLE RESIDUE IN KEREMEOS CREEK WATERSHED, DECEMBER 14, 1994 TO JULY 4, 1997

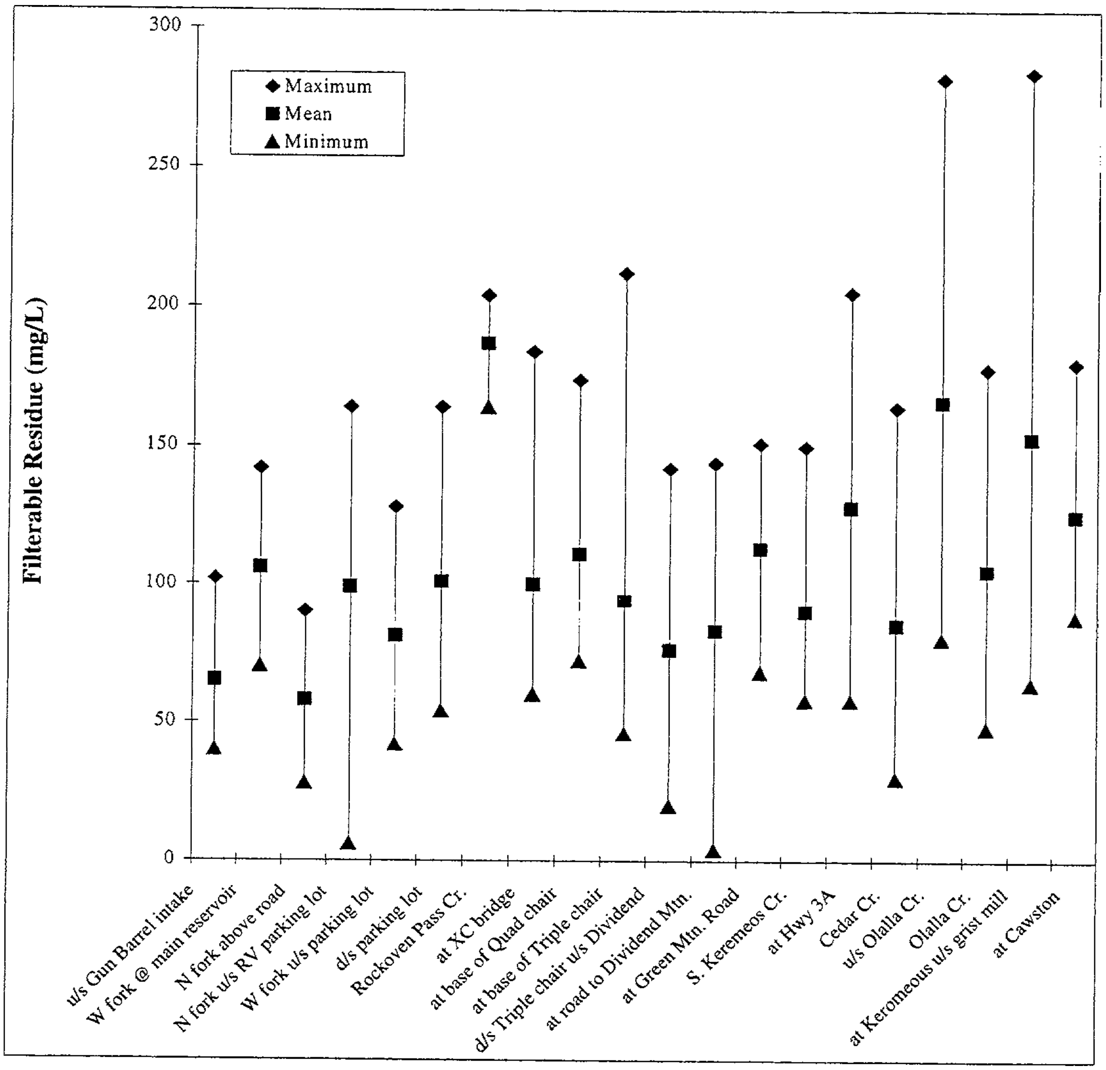


TABLE 1

SUMMARY OF WATER QUALITY OBJECTIVES PROPOSED FOR KEREMEOS CREEK WATERSHED

	KEREMEOS CREEK	OLALLA CREEK& CEDAR CREEK	SOUTH KEREMEOS CREEK
DESIGNATED WATER USES	Aquatic life, wildlife, drinking water with partial treatment, livestock watering, irrigation	Aquatic life, wildlife, livestock watering, irrigation and drinking water with disinfection	Aquatic life, wildlife,livestock watering
Characteristics			
Fecal coliforms[1]	≤ 10 CFU/100ml (90th percentile) at the Gunbarrel Intake and long term objective in lower Keremeos Cr. <100 CFU/100ml (90th percentile) for areas downstream of Gunbarrel Intake as a interim objective in lower Keremeos Cr.	≤ 10 CFU/100ml (90th percentile)	≤ 200 CFU/100ml (90th percentile)
Non-Filterable Residue[2]	Clear Flow: <10 mg/L at Gunbarrel Intake site Downstream of intake: 25 mg/L increase in 24 hr or 5 mg/L in 30 days Turbid Flow: 10 mg/L increase if 25-100 mg/L or 10% maximum increase if upstream ≥ 100 mg/L; interim 150 mg/L maximum at Triple Chair site.	Clear Flow: 25 mg/L increase in 24 hr or 5 mg/L in 30 days Turbid Flow: 5 NTU increase when background 5-50 NTU; 10 % increase when background > 50 NTU	Clear Flow: 25 mg/L increase in 24 hr or 5 mg/L in 30 days Turbid Flow: 5 NTU increase when background 5-50 NTU; 10 % increase when background > 50 NTU
Turbidity[2]	Clear Flow: 2.5 NTU average /5 NTU max. at Gunbarrel Intake. Downstream of Gunbarrel Intake during 8NTU increase over 24 hrs or 2NTU over 30 days Turbid Flow: 8-50 NTU:5 NTU increase 10% maximum increase when upstream > 50 NTU	Clear Flow: 1NTU increase when background < 5NTU Turbid Flow: 8-50 NTU: 5 NTU increase 10% maximum increase when upstream > 50 NTU)	Clear Flow: 8NTU increase over 24 hrs or 2NTU over 30 days Turbid Flow: 8-50 NTU: 5 NTU increase 10% maximum increase when upstream > 50 NTU)
Ammonia Nitrogen	See Tables 3 and 4	See Tables 3 and 4	See Tables 3 and 4
Nitrite Nitrogen	See Table 5	See Table 5	See Table 5
Nitrite/Nitrate Nitrogen	10 mg/L maximum	10 mg/L maximum	100 mg/L maximum ≤ 40 mg/L average
PH	6.5–8.5	6.5–8.5	6.5–9.0
Dissolved Oxygen	8.0 mg/L minimum 11.0 mg/L when salmonid embryos and larvae present	8.0 mg/L minimum 11.0 mg/L when salmonid embryos and larvae present	8.0 mg/L minimum 11.0 mg/L when salmonid embryos and larvae present
Chlorophyll-a[3]	50 mg/m^2	50 mg/m^2	50 mg/m^2
Filterable Residue	500 mg/L (lower Keremeos Cr.)	500 mg/L	20% increase downstream
Dissolved Chloride	100 mg/L	N/A	NA
Temperature	Keremeos Creek max 17.0 °C weekly average[4]		

Note: The objectives apply to discrete samples from all parts of Keremeos and South Keremeos Creek (specified in Table 1) except for initial dilution zones which are provisionally defined as extending up to 100 metres downstream from a discharge, and occupying no more than 50% of the stream width around a discharge point, from the bed of the stream to the surface. Initial dilution zones may be adjusted for Keremeos Creek using site specific information at the time of permiting a waste discharge.

1 The average is calculated from at least 5 samples in a 30 day period. Ten samples are required for 90th percentiles

2 The increase (in mg/L or NTU) is over levels measured at a site upstream for a discharge or series of discharges and as close to them as possible and applies to downstream values.

3 The maximum is based on the average calculated from at least five randomly located samples from natural substrates at each site on any sampling date.

4 The weekly average shall be calculated from 5 samples collected in the afternoon at downstream locations

TABLE 2

RECOMMENDED WATER QUALITY MONITORING FOR KEREMEOS CREEK WATERSHED

	UPPER KEREMEOS	*Frequency*	*Date*	*n*	*Parameters*
	BASE FLOW SAMPLING				
E221390	Keremeos Cr. at Base of Triple Chair	Five	July	30	True Color
E221387	Keremeos Cr. at XC Bridge u/s Apex STP	times	to		pH
E221386	Keremeos Cr. u/s Gunbarrel	(weekly)	April		Non-Filterable Residue
E221413	Keremeos Cr. North Fork u/s R.V. Parking Lot	in 30 days			Turbidity
E221384	Keremeos Cr. West Fork u/s Apex Parking Lot				Ammonia Nitrogen
					Nitrite/Nitrate Nitrogen
					Nitrite Nitrogen
					Dissolved Chloride
					Chlorophyll-a
					MF fecal bacteria
					Temperature
					Dissolved Oxygen
	FRESHET SAMPLING				
E221389	Keremeos Cr. at Road. to Dividend Mtn.	Five	May	30	Non-Filterable Residue
E221390	Keremeos Cr. at Base of Triple Chair	times	to		Turbidity
E221387	Keremeos Cr. at XC Bridge u/s Apex STP	(weekly)	July		
E221386	Keremeos Cr. u/s Gunbarrel	in 30 days			
E221413	Keremeos Cr. North Fork u/s R.V. Parking Lot				
E221384	Keremeos Cr. West Fork u/s Apex Parking Lot				
	LOWER KEREMEOS	***Frequency***	***Date***	***n***	***Parameters***
	BASE FLOW SAMPLING				
0500757	Keremeos Cr. at Cawston	Five	July	15	pH
E221340	Keremeos Cr. at Olalla u/s Olalla Cr.	times	to		Specific Conductance
E221339	Keremeos Cr. at Hwy 3A	(weekly)	April		Non-Filterable Residue
E221341	Keremeos Cr. at Keremeos	in 30 days			Filterable Residue
E221391	South Keremeos Creek				Turbidity
E221525	Cedar Creek u/s Hwy 3A				Ammonia Nitrogen
E221526	Olalla Cr. at Olalla				Nitrite/Nitrate Nitrogen
					Nitrite Nitrogen
					Chlorophyll-a
					MF fecal bacteria
					Temperature
					Dissolved Oxygen
	FRESHET SAMPLING				
O500757	Keremeos Cr. at Cawston	Five	May	15	Non Filterable Res
E221340	Kermeos Cr. at Olalla u/s Olalla Cr.	times	to		Turbidity
E221339	Keremeos Cr. at Hwy 3A	(weekly)	July		
E221391	South Keremeos Cr.				
E221525	Cedar Cr. u/s Hwy 3A				
E221526	Olalla Cr. at Olalla				

TABLE 3

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

	TEMPERATURE										
pH	*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	0.871	0.863	0.856	0.849	0.844	0.839	0.836	0.833	0.832	0.831	0.831
9.0	0.703	0.697	0.692	0.688	0.685	0.682	0.681	0.681	0.680	0.681	0.682

	TEMPERATURE									
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	24.6	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
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	0.832	0.834	0.838	0.842	0.847	0.853	0.861	0.870	0.880	0.891
9.0	0.684	0.688	0.692	0.698	0.704	0.711	0.720	0.729	0.740	0.752

TABLE 4

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

	TEMPERATURE										
pH	*0.0*	*1.0*	*2.0*	*3.0*	*4.0*	*5.0*	*6.0*	*7.0*	*8.0*	*9.0*	*10.0*
6.5-7.1	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	0.989	0.976	0.963	0.952	0.942	0.932	0.922	0.914	0.906	0.899
8.2	0.799	0.788	0.777	0.768	0.759	0.751	0.743	0.736	0.730	0.724	0.718
8.3	0.636	0.628	0.620	0.613	0.606	0.599	0.594	0.588	0.583	0.579	0.575
8.4	0.508	0.501	0.495	0.489	0.484	0.479	0.475	0.471	0.467	0.464	0.461
8.5	0.405	0.400	0.396	0.381	0.387	0.384	0.380	0.377	0.375	0.372	0.370
8.6	0.324	0.320	0.317	0.313	0.310	0.308	0.305	0.303	0.301	0.300	0.298
8.7	0.260	0.257	0.254	0.251	0.249	0.247	0.246	0.244	0.243	0.242	0.241
8.8	0.208	0.206	0.204	0.202	0.201	0.200	0.198	0.197	0.197	0.196	0.196
8.9	0.168	0.166	0.165	0.163	0.162	0.161	0.131	0.131	0.131	0.131	0.131

	TEMPERATURE									
pH	*11.0*	*12.0*	*13.0*	*14.0*	*15.0*	*16.0*	*17.0*	*18.0*	*19.0*	*20.0*
6.5-7.7	1.82	1.81	1.80	1.78	1.77	1.64	1.52	1.41	1.31	1.22
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	0.970	0.904
8.0	1.12	1.11	1.10	1.10	1.09	1.02	0.944	0.878	0.818	0.762
8.1	0.893	0.887	0.882	0.878	0.874	0.812	0.756	0.704	0.655	0.611
8.2	0.714	0.709	0.706	0.703	0.700	0.651	0.606	0.565	0.527	0.491
8.3	0.571	0.568	0.566	0.564	0.562	0.523	0.487	0.455	0.424	0.396
8.4	0.458	0.456	0.455	0.453	0.452	0.421	0.393	0.367	0.343	0.321
8.5	0.369	0.367	0.366	0.366	0.365	0.341	0.318	0.298	0.278	0.261
8.6	0.297	0.297	0.296	0.296	0.296	0.277	0.259	0.242	0.227	0.213
8.7	0.241	0.240	0.240	0.241	0.241	0.226	0.212	0.198	0.186	0.175
8.8	0.196	0.196	0.196	0.197	0.198	0.185	0.174	0.164	0.154	0.145
8.9	0.160	0.161	0.161	0.162	0.163	0.153	0.144	0.136	0.128	0.121
9.0	0.132	0.132	0.133	0.134	0.135	0.128	0.121	0.114	0.108	0.102

- the average of the measured values must be less than the average of the corresponding individual values in Table 4
- each measured value is compared to the corresponding individual values in Table 4
- no more than one in five of the measured values can be greater than 1½ times the corresponding objective values in Table 4

TABLE 5

MAXIMUM AND 30-DAY AVERAGE NITRITE NITROGEN CONCENTRATIONS FOR PROTECTION OF AQUATIC LIFE

Maximum Nitrite Nitrogen Concentration (mg/L)	*Dissolved Chloride Concentration (mg/L)*	*30-d Average Nitrite Nitrogen Concentration[1] (mg/L)*
0.06	<2	0.02
0.12	2-4	0.04
0.18	4-6	0.06
0.24	6-8	0.08
0.30	8-10	0.10
0.60	>10	0.20

[1] the 30-d average dissolved chloride concentration should be used to determine the appropriate 30-d average nitrite objective

TABLE 6

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK WEST FORK AT GUNBARREL INTAKE (SITE E221386) FOR THE PERIOD NOVEMBER 22, 1994 TO JULY 4, 1997

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	3	5	5	5	0
pH	5	7.6	6.8	7.1	0.3
Specific Conductance	4	103	89	97	6
Non-Filterable Residue	13	19	<1	6	4
Filterable Residue	12	102	40	65	21
Turbidity	16	4.8	0.2	1.3	1.3
Total Alkalinity pH 4.5	2	23.1	11.3	17.2	8.3
Kjeldahl Nitrogen	4	0.06	<0.04	0.05	0.01
Ammonia Nitrogen	5	0.006	<0.005	0.005	0.001
Nitrite/Nitrate Nitrogen	5	0.09	<0.02	0.06	0.03
Nitrite Nitrogen	5	0.018	<0.005	0.010	0.007
Total Dissolved Phosphorus	4	<0.003	<0.003	<0.003	0
Total Phosphorus	5	0.014	<0.003	0.005	0.005
Dissolved Chloride	14	1.1	0.3	0.6	0.3
Dissolved Sodium	4	2.51	2.35	2.39	0.08
Dissolved Sulfate	1	18.6	18.6	18.6	0
Fecal Coliform Bacteria	4	0	0	0 (median)	0.0

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (µS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 7

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK WEST FORK AT MAIN RESERVOIR (SITE E221388) FOR THE PERIOD NOVEMBER 22, 1994 TO MAY 17, 1995

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	3	5	<5	5	0
pH	4	7.5	7.1	7.3	0.2
Specific Conductance	4	126	114	120	6
Non-Filterable Residue	2	157	<4	81	108
Filterable Residue	2	142	70	106	51
Turbidity	5	32.0	0.3	6.8	14.1
Total Alkalinity pH 4.5	1	34.5	34.5	34.5	0
Kjeldahl Nitrogen	4	0.12	<0.04	0.07	0.04
Ammonia Nitrogen	4	0.009	<0.005	0.006	0.002
Nitrite/Nitrate Nitrogen	4	0.26	0.23	0.25	0.01
Nitrite Nitrogen	4	0.021	<0.005	0.009	0.008
Total Dissolved Phosphorus	4	0.006	<0.003	0.004	0.002
Total Phosphorus	4	<0.003	<0.003	<0.003	0
Dissolved Chloride	4	12.6	8.1	9.5	2.1
Dissolved Sodium	4	3.41	3.30	3.37	0.05
Dissolved Sulfate	1	9.3	9.3	9.3	0
Fecal Coliform Bacteria	4	4	0	0 (median)	2.0

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (µS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 8

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK NORTH FORK ABOVE ROAD (SITE E221385) FOR THE PERIOD NOVEMBER 22, 1994 TO JUNE 11, 1997

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	3	5	<5	5	0
pH	8	7.5	6.5	7.0	0.4
Specific Conductance	9	86	65	76	9
Non-Filterable Residue	11	5	<4	4	1
Filterable Residue	8	90	28	58	19
Turbidity	13	0.7	0.2	0.4	0.2
Total Alkalinity pH 4.5	5	25.4	18.4	21.6	3.3
Kjeldahl Nitrogen	4	0.06	<0.04	0.05	0.01
Ammonia Nitrogen	7	<0.005	<0.005	<0.005	0
Nitrite/Nitrate Nitrogen	7	0.04	<0.02	0.02	0.01
Nitrite Nitrogen	7	<0.005	<0.005	<0.005	0
Total Dissolved Phosphorus	4	<0.003	<0.003	<0.003	0
Total Phosphorus	6	0.005	<0.003	0.003	0.001
Dissolved Chloride	11	5.8	2.7	3.9	0.9
Dissolved Sodium	4	2.33	2.11	2.19	0.10
Dissolved Sulfate	2	9.6	8.5	9.1	0.8
Fecal Coliform Bacteria	4	1	0	0 (median)	0.5

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 9

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK NORTH FORK UPSTREAM APEX RV PARKING LOT (SITE E221413) FOR THE PERIOD DECEMBER 14, 1994 TO JUNE 11, 1997

	NO. OF	VALUES			
CHARACTERISTIC	VALUES	MAXIMUM	MINIMUM	MEAN	ST DEV
True Color	5	5	<5	5	0
pH	7	7.6	6.8	7.3	0.3
Specific Conductance	10	200	92	143	44
Non-Filterable Residue	18	25	<4	7	6
Filterable Residue	14	164	6	99	43
Turbidity	18	17.0	0.3	1.9	3.9
Kjeldahl Nitrogen	5	0.08	<0.04	0.06	0.02
Ammonia Nitrogen	6	0.006	<0.005	0.005	0
Nitrite/Nitrate Nitrogen	6	0.37	<0.02	0.08	0.14
Nitrite Nitrogen	6	<0.005	<0.005	<0.005	0
Total Dissolved Phosphorus	5	0.003	<0.003	<0.003	0
Total Phosphorus	5	<0.003	<0.003	<0.003	0
Dissolved Chloride	15	32.6	11.0	20.1	8.6
Dissolved Sodium	5	12.80	11.80	12.44	0.42
Fecal Coliform Bacteria	4	0	0	0 (median)	0.0

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 10

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK WEST FORK UPSTREAM APEX PARKING LOT (SITE E221384) FOR THE PERIOD DECEMBER 7, 1994 TO JUNE 11, 1997

	NO. OF	VALUES			
CHARACTERISTIC	VALUES	MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	5	5	<5	5	0
pH	10	7.6	6.7	7.1	0.3
Specific Conductance	9	130	65	107	26
Non-Filterable Residue	20	681	1	152	200
Filterable Residue	19	128	42	81	26
Turbidity	22	68.0	0.5	15.2	18.6
Total Alkalinity pH 4.5	6	37.5	18.1	25.6	8.3
Kjeldahl Nitrogen	5	0.12	<0.04	0.07	0.03
Ammonia Nitrogen	9	0.007	<0.005	0.005	0.001
Nitrite/Nitrate Nitrogen	9	0.19	0.02	0.12	0.06
Nitrite Nitrogen	9	<0.005	<0.005	<0.005	0
Total Dissolved Phosphorus	6	<0.003	<0.003	<0.003	0
Total Phosphorus	8	0.660	<0.003	0.119	0.237
Dissolved Chloride	18	18.3	2.2	7.7	5.0
Dissolved Sodium	6	3.55	3.14	3.39	0.18
Fecal Coliform Bacteria	6	2	0	0 (median)	0.8

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 11

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK DOWNSTREAM APEX PARKING LOT (SITE E221382) FOR THE PERIOD DECEMBER 7, 1994 TO JUNE 21, 1995

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	5	5	<5	5	0
pH	10	7.4	6.8	7.2	0.2
Specific Conductance	9	253	77	156	49
Non-Filterable Residue	8	358	<4	116	142
Filterable Residue	8	164	54	101	42
Turbidity	10	33.0	0.6	9.2	13.0
Total Alkalinity pH 4.5	3	29.7	18.6	22.6	6.2
Kjeldahl Nitrogen	7	0.37	<0.04	0.11	0.12
Ammonia Nitrogen	10	0.013	<0.005	0.006	0.003
Nitrite/Nitrate Nitrogen	10	0.11	<0.02	0.07	0.03
Nitrite Nitrogen	10	0.025	<0.005	0.007	0.006
Total Dissolved Phosphorus	6	0.007	<0.003	0.004	0.002
Total Phosphorus	9	0.108	<0.003	0.021	0.034
Dissolved Chloride	10	46.0	5.3	21.7	11.9
Dissolved Sodium	6	10.50	8.42	9.29	0.73
Fecal Coliform Bacteria	7	7	0	1 (median)	2.9

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 12

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK AT CROSS COUNTRY BRIDGE UPSTREAM APEX SEWAGE TREATMENT CENTRE (SITE E221387) FOR THE PERIOD NOVEMBER 22, 1994 TO JUNE 24, 1996

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	7	5	<5	5	0
pH	13	7.6	6.8	7.3	0.3
Specific Conductance	12	246	87	168	43
Non-Filterable Residue	14	236	<4	79	76
Filterable Residue	13	184	60	100	36
Turbidity	22	30.0	0.4	5.8	7.9
Total Alkalinity pH 4.5	5	33.7	20.5	25.8	7.0
Kjeldahl Nitrogen	9	0.12	<0.04	0.06	0.02
Ammonia Nitrogen	13	0.033	<0.005	0.008	0.008
Nitrite/Nitrate Nitrogen	14	0.16	0.04	0.11	0.03
Nitrite Nitrogen	14	0.017	<0.005	0.006	0.003
Total Dissolved Phosphorus	9	0.004	<0.003	0.003	0
Total Phosphorus	13	0.058	<0.003	0.007	0.015
Dissolved Chloride	19	44.4	7.6	20.7	9.0
Dissolved Sodium	9	8.24	7.36	7.82	0.34
Dissolved Sulfate	1	10.5	10.5	10.5	0
Fecal Coliform Bacteria	8	10	0	0 (median)	3.3

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 13

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS AT BASE OF QUAD CHAIR (SITE E221381) FOR THE PERIOD NOVEMBER 22, 1994 TO JUNE 13, 1995

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	5	5	<5	5	0
pH	9	7.8	6.8	7.3	0.3
Specific Conductance	9	246	85	155	49
Non-Filterable Residue	6	297	<4	115	138
Filterable Residue	6	174	72	111	39
Turbidity	11	33.0	0.4	6.3	12.0
Total Alkalinity pH 4.5	3	35.6	22.8	27.1	7.4
Kjeldahl Nitrogen	6	0.11	<0.04	0.08	0.03
Ammonia Nitrogen	8	0.019	<0.005	0.007	0.005
Nitrite/Nitrate Nitrogen	10	0.13	0.06	0.11	0.02
Nitrite Nitrogen	10	0.027	<0.005	0.009	0.008
Total Dissolved Phosphorus	6	0.005	<0.003	0.003	0.001
Total Phosphorus	9	0.007	<0.003	0.004	0.001
Dissolved Chloride	11	48.0	6.6	22.7	10.6
Dissolved Sodium	6	8.50	7.07	7.57	0.52
Fecal Coliform Bacteria	8	10	0	0 (median)	4.0

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 14

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK AT BASE OF TRIPLE CHAIR (SITE E221390) FOR THE PERIOD NOVEMBER 22, 1994 TO JUNE 4, 1997

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	8	5	<5	5	0
pH	14	7.7	6.7	7.3	0.3
Specific Conductance	13	232	82	160	43
Non-Filterable Residue	19	817	<1	172	208
Filterable Residue	18	212	46	94	46
Turbidity	27	50.0	0.2	11.7	14.9
Total Alkalinity pH 4.5	5	59.1	21.8	32.9	16.1
Kjeldahl Nitrogen	10	0.13	<0.04	0.07	0.03
Ammonia Nitrogen	14	0.026	<0.005	0.007	0.006
Nitrite/Nitrate Nitrogen	15	0.41	0.05	0.27	0.09
Nitrite Nitrogen	15	0.017	<0.005	0.006	0.003
Total Dissolved Phosphorus	10	0.006	<0.003	0.003	0.001
Total Phosphorus	14	0.151	<0.003	0.014	0.040
Dissolved Chloride	25	35.6	5.9	16.3	7.7
Dissolved Sodium	10	7.23	6.34	6.77	0.29
Dissolved Sulfate	2	10.5	9.6	10.1	0.6
Fecal Coliform Bacteria	8	5	0	1 (median)	1.7

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 15

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK DOWNSTREAM TRIPLE CHAIR UPSTREAM DIVIDEND (SITE E221502) FOR THE PERIOD NOVEMBER 22, 1994 TO JUNE 13, 1995

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
pH	3	7.8	6.8	7.2	0.6
Specific Conductance	3	222	83	156	70
Non-Filterable Residue	3	264	<4	130	130
Filterable Residue	3	142	20	76	62
Turbidity	5	31.0	0.2	6.6	13.7
Ammonia Nitrogen	3	<0.005	<0.005	<0.005	0
Nitrite/Nitrate Nitrogen	5	0.37	0.10	0.27	0.10
Nitrite Nitrogen	5	0.014	<0.005	0.007	0.004
Total Phosphorus	4	0.004	<0.003	0.003	0.001
Dissolved Chloride	5	33.1	8.4	19.6	9.0
Fecal Coliform Bacteria	3	1	0	1 (median)	0.6

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 16

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK AT ROAD TO DIVIDEND MTN. (SITE E221389) FOR THE PERIOD NOVEMBER 22, 1994 TO JUNE 24, 1996

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	5	5	<5	5	0
pH	11	7.7	6.9	7.3	0.3
Specific Conductance	9	203	84	141	36
Non-Filterable Residue	17	522	<4	136	145
Filterable Residue	16	144	<4	83	33
Turbidity	21	36.0	<0.1	10.3	12.4
Total Alkalinity pH 4.5	5	39.1	23.2	28.3	6.7
Kjeldahl Nitrogen	6	0.12	<0.04	0.06	0.03
Ammonia Nitrogen	9	0.008	<0.005	0.005	0.001
Nitrite/Nitrate Nitrogen	11	0.32	0.07	0.22	0.07
Nitrite Nitrogen	11	0.009	<0.005	0.005	0.001
Total Dissolved Phosphorus	6	0.005	<0.003	0.003	0.001
Total Phosphorus	10	0.081	<0.003	0.011	0.025
Dissolved Chloride	19	27.0	4.5	11.3	5.9
Dissolved Sodium	6	5.84	5.19	5.55	0.27
Dissolved Sulfate	1	8.9	8.9	8.9	0
Fecal Coliform Bacteria	6	12	0	0 (median)	4.2

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (µS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 17

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK AT FIRST CROSSING GREEN MOUNTAIN ROAD (SITE E221338) FOR THE PERIOD NOVEMBER 23, 1994 TO JUNE 13, 1995

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Dissolved Oxygen	1	13.7	13.7	13.7	0
True Color	5	5	<5	<5	0
pH	11	7.8	7.1	7.4	0.3
Specific Conductance	10	219	97	135	38
Non-Filterable Residue	9	253	<4	72	88
Filterable Residue	9	151	68	113	31
Turbidity	11	15.0	<0.1	2.8	4.6
Hardness	5	67.5	55.8	61.4	4.6
Total Alkalinity pH 4.5	7	54.3	28.0	38.3	10.2
Kjeldahl Nitrogen	5	0.09	<0.04	0.07	0.03
Ammonia Nitrogen	11	0.007	<0.005	0.005	0.001
Nitrite/Nitrate Nitrogen	12	0.16	<0.02	0.06	0.05
Nitrite Nitrogen	12	0.018	<0.005	0.006	0.004
Total Dissolved Phosphorus	5	<0.003	<0.003	<0.003	0
Total Phosphorus	10	0.073	<0.003	0.020	0.030
Dissolved Chloride	12	23.8	<0.5	5.6	6.8
Dissolved Sodium	5	5.42	1.98	2.69	1.53
Dissolved Sulfate	1	17.4	17.4	17.4	0
Total Aluminum	5	<0.06	<0.06	<0.06	0
Total Antimony	5	<0.02	<0.02	<0.02	0
Total Arsenic	5	0.0023	<0.0005	0.0009	0.0008
Total Boron	5	0.07	<0.04	0.05	0.01
Total Barium	5	0.029	0.009	0.013	0.009
Total Beryllium	5	<0.001	<0.001	<0.001	0
Total Bismuth	5	<0.02	<0.02	<0.02	0
Total Calcium	5	22.10	19.10	20.76	1.27
Total Cadmium	5	<0.0001	<0.0001	<0.0001	0
Total Cobalt	5	<0.004	<0.004	<0.004	0
Total Chromium	5	0.046	<0.002	0.011	0.020
Total Copper	5	<0.002	<0.002	<0.002	0
Total Iron	5	0.22	<0.05	0.08	0.08
Total Lead	5	<0.003	<0.003	<0.003	0
Total Magnesium	5	3.00	1.98	2.33	0.40
Total Manganese	5	0.004	<0.002	0.003	0.001
Total Molybdenum	5	<0.004	<0.004	<0.004	0
Total Nickel	5	0.03	<0.01	0.01	0.01
Total Potassium	5	1.4	1.0	1.2	0.1
Total Selenium	5	<0.03	<0.03	<0.03	0
Total Silicon	5	6.6	5.5	6.0	0.4
Total Silver	5	<0.03	<0.03	<0.03	0
Total Sodium	5	5.3	1.9	2.7	1.5
Total Sulphur	5	5.5	3.8	4.3	0.7
Total Tin	5	<0.02	<0.02	<0.02	0
Total Strontium	5	0.062	0.049	0.055	0.005
Total Tellurium	5	<0.02	<0.02	<0.02	0
Total Titanium	5	<0.003	<0.003	<0.003	0
Total Thallium	5	<0.03	<0.03	<0.03	0
Total Vanadium	5	<0.003	<0.003	<0.003	0
Total Zinc	5	0.04	<0.01	0.02	0.01
Total Zirconium	5	<0.003	<0.003	<0.003	0
Fecal Coliform Bacteria	12	110	0	65(90%)	35.1
Total Coliform Bacteria	6	130	1	17(median)	58.0

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL & TOTAL COLIFORM BACTERIA (CFU/100mL); fecal coliform mean as 90^{th} percentile value

TABLE 18

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS AT HWY 3A (SITE E221339) FOR THE PERIOD NOVEMBER 23, 1994 TO JULY 31, 1997

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Dissolved Oxygen	7	12.4	10.4	11.4	0.7
True Color	8	5	<5	<5	0
pH	14	8.0	7.2	7.7	0.3
Specific Conductance	19	260	120	212	48
Non-Filterable Residue	21	546	<4	59	115
Filterable Residue	26	205	58	128	35
Turbidity	28	52.0	0.1	5.6	9.9
Hardness	1	121	121	121	0
Total Alkalinity pH 4.5	7	87.8	39.7	60.9	22.5
Kjeldahl Nitrogen	8	0.13	<0.04	0.08	0.03
Ammonia Nitrogen	21	0.006	<0.005	<0.005	0
Nitrite/Nitrate Nitrogen	20	0.09	0.02	0.07	0.02
Nitrite Nitrogen	14	0.009	<0.005	0.006	0.001
Total Dissolved Phosphorus	8	0.006	<0.003	0.004	0.001
Total Phosphorus	13	0.065	<0.003	0.015	0.021
Dissolved Chloride	25	13.9	2.4	6.3	2.7
Dissolved Sodium	8	5.22	4.45	4.84	0.37
Dissolved Sulfate	1	31.7	31.7	31.7	0
Total Aluminum	1	<0.06	<0.06	<0.06	0
Total Antimony	1	<0.02	<0.02	<0.02	0
Total Arsenic	1	0.0005	0.0005	0.0005	0
Total Boron	1	0.07	0.07	0.07	0
Total Barium	1	0.028	0.028	0.028	0
Total Beryllium	1	<0.001	<0.001	<0.001	0
Total Bismuth	1	<0.02	<0.02	<0.02	0
Total Calcium	1	39.3	39.3	39.3	0
Total Cadmium	1	<0.0001	<0.0001	<0.0001	0
Total Cobalt	1	<0.004	<0.004	<0.004	0
Total Chromium	1	0.002	0.002	0.002	0
Total Copper	1	<0.002	<0.002	<0.002	0
Total Iron	1	<0.05	<0.05	<0.05	0
Total Lead	1	<0.003	<0.003	<0.003	0
Total Magnesium	1	5.58	5.58	5.58	0
Total Manganese	1	<0.002	<0.002	<0.002	0
Total Molybdenum	1	<0.004	<0.004	<0.004	0
Total Nickel	1	<0.01	<0.01	<0.01	0
Total Potassium	1	1.7	1.7	1.7	0
Total Selenium	1	<0.03	<0.03	<0.03	0
Total Silicon	1	6.55	6.55	6.55	0
Total Silver	1	<0.03	<0.03	<0.03	0
Total Sodium	1	4.6	4.6	4.6	0
Total Sulphur	1	10.3	10.3	10.3	0
Total Tin	1	<0.02	<0.02	<0.02	0
Total Strontium	1	0.13	0.13	0.13	0
Total Tellurium	1	<0.02	<0.02	<0.02	0
Total Titanium	1	<0.003	<0.003	<0.003	0
Total Thallium	1	<0.03	<0.03	<0.03	0
Total Vanadium	1	<0.003	<0.003	<0.003	0
Total Zinc	1	<0.01	<0.01	<0.01	0
Total Zirconium	1	<0.003	<0.003	<0.003	0
Fecal Coliform Bacteria	17	18	0	10.2(90th)	5.0
Total Coliform Bacteria	6	21	3	12(median)	8.0

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL & TOTAL COLIFORM BACTERIA (CFU/100mL); fecal coliform mean is the 90th percentile.

TABLE 19

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS UPSTREAM OLALLA CREEK (SITE E221340) FOR THE PERIOD NOVEMBER 23, 1994 TO JULY 31, 1997

	NO. OF	VALUES			
CHARACTERISTIC	VALUES	MAXIMUM	MINIMUM	MEAN	STD DEV
Dissolved Oxygen	7	14.2	9.8	11.5	1.5
True Color	8	5	<5	<5	0
pH	14	8.1	7.1	7.8	0.3
Specific Conductance	19	374	140	271	76
Non-Filterable Residue	16	35	<4	8	8
Filterable Residue	21	282	80	166	66
Turbidity	24	5.0	<0.1	1.5	1.2
Hardness	4	198	155	181	20
Total Alkalinity pH 4.5	7	140.0	44.9	79.5	41.6
Kjeldahl Nitrogen	8	0.24	0.08	0.15	0.07
Ammonia Nitrogen	20	0.024	<0.005	0.008	0.005
Nitrite/Nitrate Nitrogen	21	0.51	0.02	0.23	0.20
Nitrite Nitrogen	15	0.037	<0.005	0.008	0.008
Total Dissolved Phosphorus	8	0.030	0.004	0.013	0.011
Total Phosphorus	13	0.057	<0.003	0.018	0.017
Dissolved Chloride	20	6.2	2.3	4.7	1.2
Dissolved Sodium	8	9.32	8.92	9.11	0.15
Dissolved Sulfate	1	41.4	41.4	41.4	0
Total Aluminum	4	<0.06	<0.06	<0.06	0
Total Antimony	4	<0.02	<0.02	<0.02	0
Total Arsenic	4	0.0010	<0.0005	0.0008	0.0002
Total Boron	4	0.09	<0.04	0.05	0.03
Total Barium	4	0.034	0.029	0.032	0.002
Total Beryllium	4	<0.001	<0.001	<0.001	0
Total Bismuth	4	<0.02	<0.02	<0.02	0
Total Calcium	4	60.20	46.60	55.00	6.51
Total Cadmium	4	<0.0001	<0.0001	<0.0001	0
Total Cobalt	4	<0.004	<0.004	<0.004	0
Total Chromium	4	0.027	<0.002	0.009	0.012
Total Copper	4	<0.002	<0.002	<0.002	0
Total Iron	4	0.16	<0.05	0.10	0.06
Total Lead	4	<0.003	<0.003	<0.003	0
Total Magnesium	4	11.58	9.36	10.42	1.06
Total Manganese	4	0.014	0.007	0.010	0.003
Total Molybdenum	4	<0.004	<0.004	<0.004	0
Total Nickel	4	<0.01	<0.01	<0.01	0
Total Potassium	4	2.8	1.7	2.1	0.5
Total Selenium	4	<0.03	<0.03	<0.03	0
Total Silicon	4	7.21	6.33	6.85	0.38
Total Silver	4	<0.03	<0.03	<0.03	0
Total Sodium	4	10.4	8.8	9.4	0.8
Total Sulphur	4	15.8	12.9	14.2	1.4
Total Tin	4	<0.02	<0.02	<0.02	0
Total Strontium	4	0.385	0.309	0.345	0.037
Total Tellurium	4	<0.02	<0.02	<0.02	0
Total Titanium	4	0.003	<0.003	<0.003	0
Total Thallium	4	<0.03	<0.03	<0.03	0
Total Vanadium	4	<0.003	<0.003	<0.003	0
Total Zinc	4	0.04	<0.01	0.03	0.01
Total Zirconium	4	<0.003	<0.003	<0.003	0
Fecal Coliform Bacteria	16	316	<1	133(90th)	81.9
Total Coliform Bacteria	5	1100	4	60(median)	471.4

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (µS/cm)
- TURBIDITY (NTU)
- FECAL & TOTAL COLIFORM BACTERIA (CFU/100mL); fecal coliform mean is the 90th percentile value.

TABLE 20

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK AT KEREMEOS UPSTREAM GRIST MILL (SITE E221341) FOR THE PERIOD NOVEMBER 23, 1994 TO JULY 31, 1997

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Dissolved Oxygen	6	14.0	10.2	11.4	1.3
True Color	5	60	<5	16	25
pH	11	8.3	7.2	7.8	0.37
Specific Conductance	16	381	125	260	84
Non-Filterable Residue	13	52	<4	16	15
Filterable Residue	19	284	64	153	54
Turbidity	21	16.0	0.3	3.4	3.5
Hardness	1	170	170	170	0
Total Alkalinity pH 4.5	7	139.0	48.0	83.1	39.3
Kjeldahl Nitrogen	5	5.74	0.07	1.26	2.51
Ammonia Nitrogen	17	1.830	<0.005	0.114	0.442
Nitrite/Nitrate Nitrogen	18	0.78	<0.02	0.24	0.22
Nitrite Nitrogen	12	0.061	<0.005	0.012	0.016
Total Dissolved Phosphorus	5	0.463	<0.003	0.100	0.203
Total Phosphorus	9	0.556	0.003	0.084	0.179
Dissolved Chloride	17	8.8	1.2	4.1	1.6
Dissolved Sodium	5	8.65	7.38	8.19	0.48
Dissolved Sulfate	1	40.1	40.1	40.1	0
Total Aluminum	1	<0.06	<0.06	<0.06	0
Total Antimony	1	<0.02	<0.02	<0.02	0
Total Arsenic	1	0.0009	0.0009	0.0009	0
Total Boron	1	0.09	0.09	0.09	0
Total Barium	1	0.034	0.034	0.034	0
Total Beryllium	1	<0.001	<0.001	<0.001	0
Total Bismuth	1	<0.02	<0.02	<0.02	0
Total Calcium	1	52.30	52.30	52.30	0
Total Cadmium	1	<0.0001	<0.0001	<0.0001	0
Total Cobalt	1	<0.004	<0.004	<0.004	0
Total Chromium	1	0.003	0.003	0.003	0
Total Copper	1	0.005	0.005	0.005	0
Total Iron	1	0.09	0.09	0.09	0
Total Lead	1	<0.003	<0.003	<0.003	0
Total Magnesium	1	9.51	9.51	9.51	0
Total Manganese	1	0.006	0.006	0.006	0
Total Molybdenum	1	<0.004	<0.004	<0.004	0
Total Nickel	1	<0.01	<0.01	<0.01	0
Total Potassium	1	2.0	2.0	2.0	0
Total Selenium	1	<0.03	<0.03	<0.03	0
Total Silicon	1	6.5	6.5	6.5	0
Total Silver	1	<0.03	<0.03	<0.03	0
Total Sodium	1	8.2	8.2	8.2	0
Total Sulphur	1	12.6	12.6	12.6	0
Total Tin	1	<0.02	<0.02	<0.02	0
Total Strontium	1	0.289	0.289	0.289	0
Total Tellurium	1	<0.02	<0.02	<0.02	0
Total Titanium	1	<0.003	<0.003	<0.003	0
Total Thallium	1	<0.03	<0.03	<0.03	0
Total Vanadium	1	<0.003	<0.003	<0.003	0
Total Zinc	1	0.04	0.04	0.04	0
Total Zirconium	1	<0.003	<0.003	<0.003	0
Fecal Coliform Bacteria	18	1300	<1	341(90th)	313
Total Coliform Bacteria	6	1500	28	169(median)	569.5

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL & TOTAL COLIFORM BACTERIA (CFU/100mL); fecal coliform mean is 90th percentile value.

TABLE 21

AMBIENT WATER QUALITY DATA SUMMARY FOR KEREMEOS CREEK AT CAWSTON (SITE 0500757) FOR THE PERIOD APRIL 24, 1980 TO JULY 31, 1997

	NO. OF	VALUES			
CHARACTERISTIC	VALUES	MAXIMUM	MINIMUM	MEAN	STD DEV
Dissolved Oxygen	6	14.0	9.2	11.1	1.6
True Color	9	60	<5	12	18
pH	18	8.5	7.2	7.9	0.4
Specific Conductance	23	384	156	256	82
Non-Filterable Residue	15	72	4	25	16
Filterable Residue	19	180	88	125	32
Turbidity	32	21.0	0.2	4.0	4.3
Hardness	5	192	72	140	46
Total Alkalinity pH 4.5	11	152.0	48.6	87.0	39.8
Kjeldahl Nitrogen	11	6.51	0.04	0.75	1.91
Ammonia Nitrogen	24	2.700	<0.005	0.119	0.550
Nitrite/Nitrate Nitrogen	26	0.69	<0.02	0.22	0.19
Nitrite Nitrogen	20	0.043	<0.005	0.009	0.010
Total Dissolved Phosphorus	10	0.348	<0.003	0.045	0.107
Total Phosphorus	17	0.464	<0.003	0.051	0.110
Dissolved Chloride	23	9.6	1.2	4.1	1.7
Dissolved Sodium	7	9.11	5.00	7.99	1.42
Dissolved Sulfate	3	41.2	32.6	38.3	5.0
Total Aluminum	2	<0.06	<0.06	<0.06	0
Total Antimony	2	<0.02	<0.02	<0.02	0
Total Arsenic	2	0.0017	0.0008	0.0013	0.0006
Total Boron	2	0.07	<0.04	0.06	0.02
Total Barium	2	0.038	0.033	0.036	0.004
Total Beryllium	2	<0.001	<0.001	<0.001	0
Total Bismuth	2	<0.02	<0.02	<0.02	0
Total Calcium	2	59.00	51.20	55.10	5.52
Total Cadmium	2	<0.0001	<0.0001	<0.0001	0
Total Cobalt	2	<0.004	<0.004	<0.004	0
Total Chromium	2	0.002	0.002	0.002	0
Total Copper	3	0.005	<0.002	0.003	0.002
Total Iron	3	0.88	<0.05	0.33	0.50
Total Lead	3	<0.003	0.001	0.002	0.001
Total Magnesium	3	10.90	7.84	9.35	1.53
Total Manganese	3	0.030	<0.002	0.011	0.016
Total Molybdenum	2	<0.004	<0.004	<0.004	0
Total Nickel	3	<0.01	<0.01	<0.01	0
Total Potassium	2	2.4	2.1	2.3	0.21
Total Selenium	2	<0.03	<0.03	<0.03	0
Total Silicon	2	7.52	6.15	6.84	0.97
Total Silver	2	<0.03	<0.03	<0.03	0
Total Sodium	2	8.9	8.2	8.6	0.5
Total Sulphur	2	14.6	12.3	13.5	1.6
Total Tin	2	<0.02	<0.02	<0.02	0
Total Strontium	2	0.331	0.281	0.306	0.035
Total Tellurium	2	<0.02	<0.02	<0.02	0
Total Titanium	2	<0.003	<0.003	<0.003	0
Total Thallium	2	<0.03	<0.03	<0.03	0
Total Vanadium	2	<0.003	<0.003	<0.003	0
Total Zinc	2	<0.01	<0.005	0.008	0.003
Total Zirconium	2	<0.003	<0.003	<0.003	0
Fecal Coliform Bacteria	23	>2400	1	384(90th)	512
Total Coliform Bacteria	8	>2400	20	215(median)	827.6

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL & TOTAL COLIFORM BACTERIA (CFU/100mL); fecal coliform mean is 90^{th} percentile value.

TABLE 22

AMBIENT WATER QUALITY DATA SUMMARY FOR SOUTH KEREMEOS CREEK (SITE E221391) FOR THE PERIOD NOVEMBER 23, 1994 TO JUNE 24, 1996

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Dissolved Oxygen	1	14.0	14.0	14.0	0
True Color	5	5	<5	<5	0
pH	11	7.9	7.1	7.5	0.3
Specific Conductance	10	181	70	134	46
Non-Filterable Residue	14	38	<4	9	9
Filterable Residue	13	150	58	90	27
Turbidity	16	1.7	0.2	0.6	0.4
Hardness	5	71	28	60	18
Total Alkalinity pH 4.5	7	57.4	25.1	38.8	13.2
Kjeldahl Nitrogen	5	0.13	<0.04	0.07	0.04
Ammonia Nitrogen	11	<0.005	<0.005	<0.005	0
Nitrite/Nitrate Nitrogen	12	0.18	<0.02	0.08	0.07
Nitrite Nitrogen	12	0.019	<0.005	0.006	0.004
Total Dissolved Phosphorous	5	0.006	<0.003	0.004	0.001
Total Phosphorous	10	0.009	<0.003	0.004	0.002
Dissolved Chloride	16	14.1	0.2	4.1	5.3
Dissolved Sodium	5	5.23	2.04	4.31	1.29
Dissolved Sulfate	1	12.0	12.0	12.0	0
Total Aluminum	5	<0.06	<0.06	<0.06	0
Total Antimony	5	<0.02	<0.02	<0.02	0
Total Arsenic	5	0.001	<0.0005	0.0007	0.0002
Total Boron	5	0.1	<0.04	0.05	0.03
Total Barium	5	0.032	0.005	0.023	0.011
Total Beryllium	5	<0.001	<0.001	<0.001	0
Total Bismuth	5	<0.02	<0.02	<0.02	0
Total Calcium	5	22.70	9.61	19.56	5.60
Total Cadmium	5	<0.001	<0.0001	0.0003	0.0004
Total Cobalt	5	<0.004	<0.004	<0.004	0
Total Chromium	5	0.022	<0.002	0.006	0.009
Total Copper	5	0.002	<0.002	<0.002	0
Total Iron	5	0.16	<0.05	0.09	0.06
Total Lead	5	<0.003	<0.003	<0.003	0
Total Magnesium	5	3.40	1.07	2.67	0.93
Total Manganese	5	0.006	<0.002	0.004	0.002
Total Molybdenum	5	<0.004	<0.004	<0.004	0
Total Nickel	5	<0.01	<0.01	<0.01	0
Total Potassium	5	1.6	0.7	1.2	0.4
Total Selenium	5	<0.03	<0.03	<0.03	0
Total Silicon	5	6.9	3.0	5.8	1.6
Total Silver	5	<0.03	<0.03	<0.03	0
Total Sodium	5	5.1	1.7	4.3	1.4
Total Sulphur	5	6.4	1.9	5.3	1.9
Total Tin	5	<0.02	<0.02	<0.02	0
Total Strontium	5	0.062	0.025	0.054	0.016
Total Tellurium	5	<0.02	<0.02	<0.02	0
Total Titanium	5	<0.003	<0.003	<0.003	0
Total Thallium	5	<0.03	<0.03	<0.03	0
Total Vanadium	5	<0.003	<0.003	<0.003	0
Total Zinc	5	0.03	<0.01	0.02	0.01
Total Zirconium	5	<0.003	<0.003	<0.003	0
Fecal Coliform Bacteria	12	5	0	0(median)	1.4
Total Coliform Bacteria	6	10	0	0.5(median)	3.9

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (µS/cm)
- TURBIDITY (NTU)
- FECAL & TOTAL COLIFORM BACTERIA (CFU/100mL)

TABLE 23

AMBIENT WATER QUALITY DATA SUMMARY FOR CEDAR CREEK AT HWY 3A (SITE E221525) FOR THE PERIOD FEBRUARY 16, 1995 TO JULY 2, 1996

	NO. OF	VALUES			
CHARACTERISTIC	VALUES	MAXIMUM	MINIMUM	MEAN	STD DEV
pH	6	7.7	7.0	7.3	0.3
Specific Conductance	6	281	76	142	81
Non-Filterable Residue	9	20	<4	7	6
Filterable Residue	8	164	30	85	42
Turbidity	11	7.0	<0.1	1.2	2.0
Total Alkalinity pH 4.5	5	87.3	30.0	45.2	23.9
Ammonia Nitrogen	6	<0.005	<0.005	<0.005	0
Nitrite/Nitrate Nitrogen	7	0.02	<0.02	<0.02	0
Nitrite Nitrogen	8	0.005	<0.005	<0.005	0
Total Phosphorus	6	<0.05	<0.003	0.012	0.019
Dissolved Chloride	12	1.0	0.3	0.5	0.2
Fecal Coliform Bacteria	6	68	0	41.5 (90th)	26.7
Total Coliform Bacteria	3	57	4	19 (median)	27.3

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL & TOTAL COLIFORM BACTERIA (CFU/100mL); fecal coliform mean is 90th percentile value.

TABLE 24

AMBIENT WATER QUALITY DATA SUMMARY FOR OLALLA CREEK AT OLALLA (SITE E221526) FOR THE PERIOD FEBRUARY 16, 1995 TO JUNE 4, 1997

	NO. OF	VALUES			
CHARACTERISTIC	VALUES	MAXIMUM	MINIMUM	MEAN	STD DEV
pH	7	8.2	7.3	7.8	0.4
Specific Conductance	6	296	111	191	85
Non-Filterable Residue	18	56	<4	9	12
Filterable Residue	13	178	48	105	37
Turbidity	17	7.2	0.1	2.0	2.1
Total Alkalinity pH 4.5	5	98.5	50.5	66.0	19.1
Ammonia Nitrogen	7	0.009	<0.005	0.006	0.002
Nitrite/Nitrate Nitrogen	8	0.02	<0.02	<0.02	0
Nitrite Nitrogen	10	0.005	<0.005	<0.005	0
Total Phosphorus	8	<0.05	<0.003	0.016	0.021
Dissolved Chloride	16	10.1	0.4	1.3	2.4
Total Copper	3	<0.01	<0.01	<0.01	0
Total Lead	3	0.001	<0.001	0.001	0
Total Zinc	3	0.02	<0.01	0.01	0.01
Fecal Coliform Bacteria	12	12	0	9.4 (median)	3.9
Total Coliform Bacteria	4	20	2	6 (median)	8.3

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL & TOTAL COLIFORM BACTERIA (CFU/100mL)

TABLE 25

AMBIENT WATER QUALITY DATA SUMMARY FOR ROCK OVEN PASS CREEK (SITE E221383) FOR THE PERIOD NOVEMBER 22, 1994 TO JUNE 21, 1995

	NO. OF	VALUES			
CHARACTERISTIC	VALUES	MAXIMUM	MINIMUM	MEAN	STD DEV
True Color	4	5	<5	5	0
pH	6	7.8	7.6	7.7	0.1
Specific Conductance	6	288	230	264	22
Non-Filterable Residue	3	4	<4	<4	0
Filterable Residue	3	204	164	187	21
Turbidity	6	0.4	<0.1	0.2	0.1
Total Alkalinity pH 4.5	1	67.6	67.6	67.6	0
Kjeldahl Nitrogen	6	0.14	<0.04	0.06	0.04
Ammonia Nitrogen	6	0.006	<0.005	0.005	0
Nitrite/Nitrate Nitrogen	6	0.15	0.03	0.11	0.04
Nitrite Nitrogen	6	0.01	<0.005	0.006	0
Total Dissolved Phosphorus	5	0.006	<0.003	0.004	0.001
Total Phosphorus	6	<0.003	<0.003	<0.003	0
Dissolved Chloride	6	26.0	20.7	22.1	2.0
Dissolved Sodium	5	3.0	2.7	2.8	0.1
Fecal Coliform Bacteria	5	0	0	0 (median)	0.0

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 26

AMBIENT WATER QUALITY DATA SUMMARY FOR THE SPRING AT APEX DOWNSTREAM APEX STP (SITE E221503) FOR THE PERIOD JANUARY 26, 1995 TO JUNE 13, 1995

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
pH	3	7.2	6.6	6.9	0.3
Specific Conductance	3	170	156	162	7
Turbidity	4	0.7	<0.1	0.3	0.3
Total Alkalinity pH 4.5	1	49.4	49.4	49.4	0
Kjeldahl Nitrogen	1	<0.04	<0.04	<0.04	0
Ammonia Nitrogen	3	<0.005	<0.005	<0.005	0
Nitrite/Nitrate Nitrogen	5	3.33	1.07	1.86	0.90
Nitrite Nitrogen	5	0.005	<0.005	<0.005	0
Total Dissolved Phosphorous	1	<0.003	<0.003	<0.003	0
Total Phosphorous	4	0.003	<0.003	<0.003	0
Dissolved Chloride	5	7.1	4.9	5.9	1.0
Dissolved Sodium	2	4.90	3.93	4.42	0.69
Dissolved Sulfate	1	12.2	12.2	12.2	0
Total Aluminum	1	<0.06	<0.06	<0.06	0
Total Antimony	1	<0.02	<0.02	<0.02	0
Total Arsenic	1	<0.04	<0.04	<0.04	0
Total Boron	1	<0.04	<0.04	<0.04	0
Total Barium	1	0.022	0.022	0.022	0
Total Beryllium	1	<0.001	<0.001	<0.001	0
Total Bismuth	1	<0.02	<0.02	<0.02	0
Total Calcium	1	21.90	21.90	21.90	0
Total Cadmium	1	<0.002	<0.002	<0.002	0
Total Cobalt	1	<0.004	<0.004	<0.004	0
Total Chromium	1	<0.002	<0.002	<0.002	0
Total Copper	1	<0.002	<0.002	<0.002	0
Total Iron	1	<0.05	<0.05	<0.05	0
Total Lead	1	<0.03	<0.03	<0.03	0
Total Magnesium	1	3.36	3.36	3.36	0
Total Manganese	1	<0.002	<0.002	<0.002	0
Total Molybdenum	1	<0.004	<0.004	<0.004	0
Total Nickel	1	<0.01	<0.01	<0.01	0
Total Potassium	1	2.0	2.0	2.0	0
Total Selenium	1	<0.03	<0.03	<0.03	0
Total Silicon	1	7.9	7.9	7.9	0
Total Silver	1	<0.03	<0.03	<0.03	0
Total Sodium	1	4.6	4.6	4.6	0
Total Sulphur	1	4.1	4.1	4.1	0
Total Tin	1	<0.02	<0.02	<0.02	0
Total Strontium	1	0.058	0.058	0.058	0
Total Tellurium	1	<0.02	<0.02	<0.02	0
Total Titanium	1	<0.003	<0.003	<0.003	0
Total Thallium	1	<0.03	<0.03	<0.03	0
Total Vanadium	1	<0.003	<0.003	<0.003	0
Total Zinc	1	0.05	0.05	0.05	0
Total Zirconium	1	<0.003	<0.003	<0.003	0
Biological Oxygen Demand	1	<6	<6	<6	0
Fecal Coliform Bacteria	3	0	0	0 (median)	0

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (µS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 27

AMBIENT WATER QUALITY DATA SUMMARY FOR MARSEL CREEK AT GREEN MOUNTAIN ROAD (SITE E221972) FOR THE PERIOD JANUARY 12, 1995 TO MAY 24, 1995

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
pH	3	8.5	8.3	8.4	0.1
Specific Conductance	3	824	682	749	71
Non-Filterable Residue	1	<4	<4	<4	0
Filterable Residue	1	486	486	486	0
Turbidity	2	3.5	3.5	3.5	0
Hardness	1	261.0	261.0	261.0	0
Total Alkalinity pH 4.5	1	266.0	266.0	266.0	0
Kjeldahl Nitrogen	1	0.29	0.29	0.29	0
Ammonia Nitrogen	3	<0.005	<0.005	<0.005	0
Nitrite/Nitrate Nitrogen	3	0.32	0.03	0.15	0.15
Nitrite Nitrogen	3	0.005	<0.005	<0.005	0
Total Dissolved Phosphorous	1	0.114	0.114	0.114	0
Total Phosphorous	3	0.147	0.113	0.127	0.018
Dissolved Chloride	3	96.0	58.2	75.7	19.1
Dissolved Sodium	1	64.50	64.50	64.50	0
Total Aluminum	1	<0.06	<0.06	<0.06	0
Total Antimony	1	<0.02	<0.02	<0.02	0
Total Arsenic	1	<0.04	<0.04	<0.04	0
Total Boron	1	0.05	0.05	0.05	0
Total Barium	1	0.032	0.032	0.032	0
Total Beryllium	1	<0.001	<0.001	<0.001	0
Total Bismuth	1	<0.02	<0.02	<0.02	0
Total Calcium	1	68.90	68.90	68.90	0
Total Cadmium	1	<0.002	<0.002	<0.002	0
Total Cobalt	1	<0.004	<0.004	<0.004	0
Total Chromium	1	<0.002	<0.002	<0.002	0
Total Copper	1	0.005	0.005	0.005	0
Total Iron	1	0.22	0.22	0.22	0
Total Lead	1	<0.03	<0.03	<0.03	0
Total Magnesium	1	21.50	21.50	21.50	0
Total Manganese	1	0.009	0.009	0.009	0
Total Molybdenum	1	<0.004	<0.004	<0.004	0
Total Nickel	1	<0.01	<0.01	<0.01	0
Total Potassium	1	1.8	1.8	1.8	0
Total Selenium	1	<0.03	<0.03	<0.03	0
Total Silicon	1	11.1	11.1	11.1	0
Total Silver	1	<0.03	<0.03	<0.03	0
Total Sodium	1	61.9	61.9	61.9	0
Total Sulphur	1	11.4	11.4	11.4	0
Total Tin	1	<0.02	<0.02	<0.02	0
Total Strontium	1	1.640	1.640	1.640	0
Total Tellurium	1	<0.02	<0.02	<0.02	0
Total Titanium	1	0.009	0.009	0.009	0
Total Thallium	1	<0.03	<0.03	<0.03	0
Total Vanadium	1	<0.003	<0.003	<0.003	0
Total Zinc	1	0.01	0.01	0.01	0
Total Zirconium	1	<0.003	<0.003	<0.003	0
Fecal Coliform Bacteria	3	12	2	3(median)	5.5
Total Coliform Bacteria	2	15	7	11(median)	5.7

VALUES ARE AS mg/L EXCEPT:

- TRUE COLOR (color units)
- pH (relative units)
- SPECIFIC CONDUCTANCE (μS/cm)
- TURBIDITY (NTU)
- FECAL COLIFORM BACTERIA (CFU/100mL)

TABLE 28

SUMMARY OF QUALITY ASSURANCE DATA

ANALYSIS OF DEIONIZED WATER SHIPPED TO ZENON ENVIRONMENTAL LABORATORY

CHARACTERISTIC	MINIMUM DETECTABLE LEVEL	NO. OF VALUES	MAXIMUM	MINIMUM	MEAN	STD DEV
pH	0.1	4	7.7	6.3	7.2	0.62
Specific Conductance	1	4	2	1	1.25	0.5
Turbidity	0.1	4	0.1	0.1	0.1	0
Ammonia Nitrogen	0.005	4	0.005	0.005	0.005	0
Nitrate/Nitrite Nitrogen	0.02	6	0.02	0.02	0.02	0
Nitrate Nitrogen		6	0.02	0.02	0.02	0
Nitrite Nitrogen		6	0.005	0.005	0.005	0
Total Phosphorus	0.003	6	0.003	0.003	0.003	0
Dissolved Chloride	0.5	6	0.5	0.5	0.5	0

ANALYSIS OF SPLIT SAMPLES SHIPPED TO ZENON ENVIRONMENTAL LABORATORIES AND PACIFIC ENVIRONMENTAL SCIENCE CENTRE

PARAMETER	NO. OF VALUES	AVERAGE DIFFERENCE	MAXIMUM DIFFERENCE	STD DEV
pH	17	0.1	0.2	0.1
Specific Conductance	17	9	69	17
Non-Filterable Residue	13	2	15	4
Filterable Residue	12	12	39	12
Turbidity	21	0.9	14.0	3.0
Kjeldahl Nitrogen	15	0.02	0.07	0.02
Ammonia Nitrogen	17	0.001	0.012	0.003
Nitrite/Nitrate Nitrogen	18	0.01	0.05	0.01
Nitrite Nitrogen	19	0.001	0.011	0.003
Total Dissolved Phosphorous	15	0.001	0.005	0.001
Total Phosphorous	19	0.002	0.009	0.003
Dissolved Chloride	22	0.6	7.2	1.6

TABLE 29

KEREMEOS CREEK WATERSHED NON-FILTERABLE RESIDUE (mg/l) FRESHET DATA, MAY TO JUNE 1995, 1996, 1997

SAMPLING LOCATION	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
u/s Gunbarrel intake	11	19	<1	6	5
W fork @ main reservoir	1	157	157	157	0
N fork above road	9	5	<4	4	1
N fork u/s RV parking lot	13	25	<5	8	6
W fork u/s parking lot	20	798	1	182	247
d/s parking lot	4	358	43	205	155
at XC bridge	11	236	25	99	74
at base of Quad chair	3	297	84	220	118
at base of Triple chair	16	817	<1	204	213
d/s Triple chair u/s Dividend	2	264	121	193	101
at road to Dividend Mtn.	13	522	20	177	143
at Green Mtn. Rd	5	253	40	126	85
at Hwy 3A	15	546	18	81	131
u/s Olalla Cr.	10	35	<4	11	9
at Keremeos u/s grist mill	10	52	7	19	15
at Cawston	14	72	4	26	17
S Keremeos Cr.	10	38	<4	10	10
Cedar Cr.	7	20	<4	8	6
Olalla Cr.	14	56	4	11	14
Rockoven Pass Cr.	1	4	4	4	0

TABLE 30

KEREMEOS CREEK WATERSHED TURBIDITY (NTU) FRESHET DATA MAY TO JUNE 1995, 1996, 1997

SAMPLING LOCATION	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
u/s Gunbarrel intake	11	4.8	0.4	1.6	1.4
W fork @ main reservoir	1	32.0	32.0	32.0	0
N fork above road	9	0.7	0.3	0.4	0.2
N fork u/s RV parking lot	13	17.0	0.3	2.3	4.6
W fork u/s parking lot	16	68.0	2.0	20.3	19.5
d/s parking lot	4	33.0	1.2	21.1	13.9
at XC bridge	11	30.0	1.5	10.7	8.8
at base of Quad chair	3	33.0	1.6	20.9	16.9
at base of Triple chair	15	50.0	1.9	20.5	15.1
d/s Triple chair u/s Dividend	2	31.0	0.4	15.7	21.6
at road to Dividend Mtn.	13	36.0	0.4	16.3	12.4
at Green Mtn. Rd	5	15.0	0.7	5.9	5.6
at Hwy 3A	16	52.0	2.4	9.3	12.0
u/s Olalla Cr.	10	5.0	0.3	2.2	1.3
at Keremeos u/s grist mill	11	16.0	0.3	5.0	4.1
at Cawston	15	9.4	2.0	5.1	2.2
S Keremeos Cr.	10	1.7	0.2	0.7	0.5
Cedar Creek	9	7.0	0.2	1.5	2.2
Olalla Cr.	14	7.2	0.4	2.4	2.1
Rockoven Pass Cr.	1	0.2	0.2	0.2	0
Spring at Apex	1	<0.1	<0.1	<0.1	0

GLOSSARY OF TERMS

Absorption	The incorporation of a substance into the body of another (cf sorption).
Acute toxicity	A pronounced effect (severe biological harm or death) produced in an organism by a substance or mixture of substances within a short period of time (usually 96 hours or less) after exposure.
Adsorption	The attachment of a substance on the surface of another (cf. sorption).
Aerobic	Denotes the presence of gaseous or dissolved oxygen (cf. anaerobic).
Algae	A group of simple chlorophyll-containing lower plants, mostly aquatic although most are microscopic, some forms reach extremely large size.
Algal bloom	A bloom of algae occurs when their growth is so rapid that they become numerous enough to colour a body of water.
Ambient	Refers to conditions in the surrounding environment.
Anadromous	Ascending from the sea to freshwater for spawning at certain seasons.
Anaerobic	Denotes the absence of gaseous or dissolved oxygen.
Anthropogenic	Relates to, or involves, the impact of man.
Benthic organinism (Benthos)	Any organism that lives in or near the bottom of a water body or the sediment thereof.
Bioaccumulation	The uptake, retention, and concentration above background levels of environmental substances by an organism from its environment.
Bioassay	Quantitative estimation of biologically active substances by the amount of their actions in standardized conditions on living organisms.
Biota	Living organisms including bacteria, plants, and animals.
Buffer	A compound or solution capable of resisting a change in pH.
Chlorophyll-a	Green pigment found in all plants except fungi and a few flowering plants which is essential for photosynthesis.
Chronic toxicity	A long-term toxic effect produced in an organism by a substance or mixture of substances (e.g. toxin).
Contaminant	A substance that infects or degrades its surroundings by contact or association.
Dam^3/a	(Decameters cubed per annum) unit of volume usually associated with irrigation or large volumes of water.
Designated water use	A water use that is to be protected at a specific location.
Diffuser	A structure composed of several components, placed at the end of an outfall pipe, which is designed to spread the effluent widely so as to improve dilution.

Disinfection	The process of destroying microorganisms in water by the application of a chemical agent (disinfectant) such as chlorine.
Dissolved metals	Metals in solution in a liquid which pass through a filter are assumed for environmental purposes to be dissolved.
Eutrophication	The process of increasing the nutrient content of natural waters, so that biomass productivity is increased.
Geometric mean	The n^{th} root of the product of "n" observations.
Habitat	A place with a particular kind of environment inhabited by organisms.
Heavy metals	Metallic elements of high molecular weight (e.g., copper, lead, etc.) typically with specific gravities greater than 5.
Initial dilution	Areas adjacent to a waste water discharge wherein Water Quality zone objectives (except those in fish) do not apply.
Invertebrate	Organism without a backbone.
Larvae	The pre-adult form in which some animals hatch from the egg.
MDC	The minimum concentration detectable with analytical method.
Median	A value in an ordered set of values below and above which there is an equal number of values.
Micrograms per Litre (ug/L)	A concentration unit of chemical constituents in solution, the weight of one thousandth of one milligram of solute (substance) per unit volume of solvent (water).
Milligrams per Litre (mg/L)	A concentration unit of chemical constituents in solution; the weight of one milligram of solute (substance) per unit volume of solvent (water).
Nutrient	Substance (element or compound) necessary for the growth and development of plants and animals.
Organic	Organic chemicals which commonly are toxic, persistent, and mobile in contaminant the environment.
pH	Negative of the logarithm (base 10) of the hydrogen ion concentration. Quantitative expression for acidity or alkalinity of solution. Scale ranges from 0 to 14, pH 7 is neutral; less than 7 is acidic; greater than 7 is alkaline.
Riparian	Riparian areas are the lands beside streams, rivers, wetlands and other surface water bodies. These areas provide a diversity of plant species, reduce erosion of stream banks, provide shade and protection from solar radiation and provide an important food supply for fish and wildlife.
Salmonid	Fish of the family Salmonidae;. including trout, salmon, and char.

Secondary sewage	Includes primary treatment and provides conditions for the treatment biological oxidation of organic wastes.
Sorption	A general term for the process of absorption and adsorption. It is often used to denote the occurrence of both.
Sublethal	Involves an effect below the level that causes death.
Total Metal	A measure of metals in the dissolved state and those sorbed to particulate matter in suspension.
Toxic	Pertaining to, due to, or of the nature of, a poison,thus toxicity the quality of being poisonous.
Water Quality Criteria	Numerical value(s) for a physical, chemical, or biological characteristic of water, biota, or sediment which must not be exceeded to prevent specified detrimental effects from occurring to water use.
Water Quality Guideline	Numerical concentration or narrative statement recommended to support and maintain a designated water use.
Water Quality Objective	A Water Quality Criterion or Guideline adapted to protect the most sensitive designated water use at a specific location with an adequate degree of safety, taking local circumstances into account.