WATER QUALITY BRANCH
WATER MANAGEMENT DIVISION
MINISTRY OF ENVIRONMENT, LANDS AND PARKS

Water Quality Assessment and Objectives for Tributaries to Okanagan Lake Near Vernon

(Lower Vernon, Equesis and Deep Creeks)

Okanagan Area

Prepared pursuant to Section 2(e) of the
Environment Management Act, 1981

Approved: Jan 14/94 — Date   J. C. Kalan — Assistant Deputy Minister

Canadian Cataloguing in Publication Data
Swain, L. G. (Leslie Grant), 1950-
Water quality assessment and objectives for tributaries to Okanagan Lake near Vernon (Lower Vernon, Equesis and Deep Creeks) Okanagan area

"Report prepared by: L.G. Swain."--P. 12.
"Prepared pursuant to Section 2(e) of the Environment Management Act, 1981."
Consists of two parts: An overview and a report, of which the overview is also available as a separate document. Cf. P. 3.
ISBN 0-7726-2017-2

1. Water quality - British Columbia - Okanagan Valley. I. BC Environment. Water Quality Branch. II. Title.

TD227.B7S84 1993 363.73'942'097115 C94-960035-0

SUMMARY

THIS DOCUMENT is one in a series that presents ambient water quality objectives for British Columbia. It has two parts: an overview—which is available as a separate document—and the report. The overview provides general information about water quality in the three tributaries to Okanagan Lake: lower Vernon, Deep, and Equesis creeks. 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 required 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 the overview.

Salmonid species are present in lower Vernon, Deep, and Equesis creeks, and the water quality objectives in this report are to form part of a fisheries management plan for tributaries to Okanagan Lake.

Most water contamination comes from the City of Armstrong sewage discharge into Deep Creek, non-point source discharges to Deep Creek and lower Vernon Creek, and possible groundwater contamination in some areas from irrigation with treated sewage. The City of Armstrong began a program of spray irrigation of treated sewage in the Spring of 1993, so that discharges to the creek should now only take place during periods of high precipitation.

Water quality objectives are recommended to protect aquatic life, wildlife, irrigation water supplies, and drinking water supplies in Deep Creek and lower Vernon Creek. Water quality objectives were not set for Equesis Creek since there were no known anthropogenic inputs which could impact ambient water quality significantly.

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 future.

How Objectives Are Determined

WATER QUALITY OBJECTIVES are based on scientific guidelines called water quality criteria.* Water quality criteria 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 criteria 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

* 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, Water Management Division.

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.

How Objectives Are Used

WATER QUALITY OBJECTIVES have no legal standing at this time and are not directly enforced. However, they do 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, licenses 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.

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

Lower Vernon, Deep, and Equesis creeks are tributaries to Okanagan Lake on the east, north, and west shores, respectively, and enter the lake near the City of Vernon (see Figure 1). The purpose of this report was to determine the need for and develop water quality objectives in these waterbodies for use by Environment Managers, including the development of a fisheries management plan for tributaries to Okanagan Lake. Water quality objectives were not set for Equesis Creek.

TRIBUTARIES TO OKANAGAN LAKE NEAR VERNON-PROFILE

Hydrology

The flows in Equesis and Deep creeks are regulated. In lower Vernon Creek, high flows occur during the Spring runoff, with flows decreasing so that the lowest flows are experienced during the winter months. Equesis Creek has a drainage area of 199 km^2 at the mouth of the creek, Deep Creek has a drainage area of 306 km^2, while lower Vernon Creek has a drainage area between Kalamalka and Okanagan lakes of 179 km^2.

Seven-day low flows have ranged from 0.031 to 0.356 m^3/s in the summer and from 0.034 to 0.402 m^3/s in the winter in Equesis Creek, from 0.027 to 0.261 m^3/s in Deep Creek (usually in August), and from 0.071 to 0.562 m^3/s in lower Vernon Creek. All these flows were recorded at sites in the waterbodies located near their confluence with Okanagan Lake. Return periods could not be calculated for these low flows due to incomplete data bases.

Water Uses

Water uses in all three creeks are similar. Consumptive water uses include domestic water supply withdrawals (9.1 m^3/d on Equesis Creek, 11.4 m^3/d on Deep Creek, and 48 m^3/d on lower Vernon Creek) and irrigation water supply withdrawals (3 867 dam^3/a on Equesis Creek, 1 710 dam^3/a on Deep Creek, and 1 432 dam^3/a on lower Vernon Creek). Fisheries values are considered to be moderate on Equesis Creek, low in Deep Creek, and moderate to high in lower Vernon Creek.

Equesis Creek has a large quantity of accessible habitat which would allow for habitat enhancement. Kokanee cannot access the creek beyond the first 2.6 km due to a dam. Larger rainbow trout can pass this dam, but are blocked by a second dam 3.7 km from the lake. The first 5.6 km of Equesis Creek are on reserve lands of First Nations people, and complete information on fish usage in this area is not available.

In Deep Creek, kokanee have not been documented as being present, and there are no real opportunities to enhance salmonid production in the lower creek. Coarse fish are plentiful in the creek below Armstrong, although there is potential to improve rainbow trout production above Armstrong.

In lower Vernon Creek, rainbow trout, kokanee, peamouth chub, carp, largescale suckers, redside shiners, squawfish, and chiselmouth are known to reside. In addition, juvenile lake trout may be using the creek as a downstream migration corridor since lake trout are beginning to be caught in Okanagan Lake (which has never been stocked with this species). The dam at the end of Kalamalka Lake prevents all species from migrating from Okanagan Lake into Kalamalka Lake. A number of enhancement projects have been undertaken by numerous groups which have improved fish access, habitat potentials, and fish populations.

Waste Discharges

There are no permitted refuse sites or waste water discharges into the Equesis Creek watershed. The most significant discharge to Deep Creek until November 1992 was from the Armstrong sewage treatment plant. This discharge has been shown to increase the concentration of nutrients and decrease dissolved oxygen concentrations. The City of Armstrong completed a Waste Water Management Plan in 1988 which recommended that the treated waste water be used as a source of irrigation water in the neighbouring municipality of Spallumcheen. This began in the Spring of 1993.

Other permitted waste discharges within the Deep Creek watershed are the discharge of cooling water from a cheddar cheese manufacturing plant into Deep Creek, and a small-volume discharge from a rendering plant into a seepage pit. This latter operation also has a permitted refuse site.

In the lower Vernon Creek watershed, there are three permitted waste discharges. Two are located near a tributary to lower Vernon Creek, BX Creek, while the Vernon Sewage Treatment Plant is located adjacent to lower Vernon Creek. The treated effluent from the City of Vernon is spray-irrigated on adjacent properties, although an effluent outfall into Okanagan Lake has been built so that waste water can be discharged to the lake (with chemical phosphorus removal) in extremely wet years. It is apparent that the irrigation is causing some nutrients to increase in the ground water at some sites. The City of Vernon Recreation complex discharges cooling water to BX Creek, while a ready-mix cement operation discharges truck wash water to an exfiltration pit.

Non-point sources are also impacting water quality, especially in Deep Creek. A two-year study conducted in 1987 and 1988 on Deep Creek showed that there was an increase of over 4 kg phosphorus per kilometre at sites upstream from Armstrong, presumably due to non-point sources. Downstream from Armstrong (and downstream from Otter Lake), the increase was 105 kg/km. Otter Lake seems to act as a reservoir for nutrients, storing them during low flow periods, and releasing them during high flows. As such, the loadings to Okanagan Lake are concentrated during the high runoff period of the year. Similar impacts likely would be apparent for nitrogen compounds and possibly bacteria concentrations if these phosphorus loadings originated from cattle wastes. It is suspected that phosphorus loadings could originate from several sources, including breakthrough from manure applications due to over-application, and peat oxidation in the upper creek valley.

WATER QUALITY ASSESSMENT AND OBJECTIVES

Water Quality Assessment

Equesis Creek is well-buffered to acidic inputs, while having moderate hardness. All metal concentrations in Equesis Creek were usually below the B.C. approved or working water quality criteria. Nitrogen compounds were usually low, although phosphorus concentrations were high enough to cause excessive algal growths if phosphorus is the limiting factor. Dissolved oxygen concentrations were usually high enough to achieve all water quality criteria, although some more restrictive criteria aimed at protecting aquatic life when embryos are present were not always achieved in July or September, periods when embryos are likely not present.

Deep Creek is well-buffered to acidic inputs, and has a moderate amount of hardness to ameliorate the toxicity of some metals. A number of metals occasionally have had concentrations which exceed B.C. approved or working water quality criteria to protect aquatic life. These metals included aluminum, iron, manganese, and lead. There are no known sources of metals to Deep Creek other than possibly stormwater runoff from Armstrong and alum which was used at the City of Armstrong for phosphorus removal. Maximum concentrations of ammonia, nitrite, and nitrate were all below criteria. Phosphorus concentrations were high enough to cause excessive algal growth if phosphorus is the limiting factor. Dissolved oxygen concentrations in Deep Creek were occasionally below criteria to protect aquatic life. Dissolved solids concentrations in Deep Creek can on occasion exceed water quality criteria to protect aesthetics of drinking water supplies.

Lower Vernon Creek is also considered to be well-buffered to acidic inputs, and to have moderate water hardness. Metals, which occasionally were at concentrations greater than the criteria, were aluminum, iron, and lead. The only known sources of metals to lower Vernon Creek are storm water runoff. Maximum concentrations of ammonia, nitrite, and nitrate were all below criteria. Phosphorus concentrations were high enough to cause excessive algal growths if phosphorus is the limiting factor. Dissolved oxygen concentrations infrequently were below criteria to protect aquatic life.

Water Quality Objectives

Water quality objectives proposed for Deep and lower Vernon creeks are summarized in Table 1. No objectives are proposed for Equesis Creek since there are no problems in the creek which can be attributed to present or foreseen anthropogenic activities. It is believed that the water uses in Equesis Creek are protected at present. The objectives for Deep and lower Vernon creeks are based on B.C. approved and working criteria for water quality and on available data on ambient water quality, waste discharges, water uses, and stream flows. The objectives will be modified as necessary by new data from receiving water monitoring programs, or should the Ministry establish water quality criteria for all the characteristics of concern.

Water quality objectives have no legal standing and would not be directly enforced. The objectives can be considered as policy guidelines for resource managers to protect water uses in the specified waterbodies. They will guide the evaluation of water quality, the issuing of permits, licenses, and orders, and the management of the fisheries and of the Province's land base. They will also provide a reference against which the state of water quality in a particular waterbody can be checked, and serve to make decisions on whether to initiate basin-wide water quality studies.

Depending on the circumstances, water quality objectives may already be met in a waterbody, or may describe water quality conditions which can be met in the future. To limit the scope of the work, objectives are only being prepared for waterbodies and for water quality characteristics which may be affected by man's activity now and in the foreseeable future.

Designated water uses for all three waterbodies are for the protection of aquatic life, wildlife, irrigation, livestock watering, and drinking water supplies.

Water quality objectives which are based on approved B.C. water quality criteria are proposed for microbiological indicators, turbidity, suspended solids, ammonia, nitrite, nitrate, pH, and periphyton chlorophyll-*a* (to reflect the impacts from nutrients, especially phosphorus). The objectives are required to ensure that inputs from non-point source discharges and from the Armstrong and Vernon sewage treatment plants do not impair water uses. An objective is proposed for pH as a range of values. The upper value will control the formation of toxic quantities of ammonia. Dissolved oxygen levels proposed for the waterbodies are based on the Canadian Water Quality Guidelines, but are more restrictive.

Monitoring Recommendations

We recommend that monitoring be carried out for at least three years to check whether the objectives are being achieved. The extent of the monitoring after that will depend on results, as well as on regional priorities and available funding. A recommended monitoring design is included as Table 5.

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LOCATION AND MONITORING SITES MAPS

FIGURE 1

LOCATION MAP

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 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, 90th percentile, and not applicable (NA). 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 a particular variable. Not applicable (NA) means that water uses are not threatened for that particular variable.

TABLE 1
WATER QUALITY OBJECTIVES FOR DEEP CREEK AND LOWER VERNON CREEK

Waterbodies	**Deep Creek**	**Lower Vernon Creek**
Designated Water Uses	aquatic life, wildlife, drinking water (partial treatment), livestock, irrigation	
Characteristics		
Fecal coliforms[1]	≤ 100/cL 90th percentile	
Escherichia coli[1]	≤ 100/cL 90th percentile	
Enterococci[1]	≤ 25/cL 90th percentile	
Suspended solids[2]	10 mg/L maximum increase (upstream < 100 mg/L) 10% maximum increase (upstream > 100 mg/L)	
Turbidity[2]	5 NTU maximum increase (upstream < 50 NTU) 10% maximum increase (upstream > 50 NTU)	
Total ammonia-N	*See* Tables 2 and 3	
Nitrite-N	*See* Table 4	
Nitrate-N + Nitrite-N	10 mg/L maximum	
Periphyton chlorophyll-*a*[3]	100 mg/m^2 maximum	
pH[4]	6.5–9.0	not applicable
Dissolved oxygen	8.0 mg/L minimum 11.0 mg/L when salmonid embryos and larvae present (November–April)	

Note: The objectives apply to discrete samples from all parts of lower Vernon Creek between Kalamalka Lake and Okanagan Lake, along BX Creek between Swan Lake and its confluence with lower Vernon Creek, and along the entire length of Deep Creek, except from initial dilution zones of effluents. These excluded initial dilution zones are defined as extending up to 100 metres downstream from a discharge, and occupying no more than 50% of the stream width around the discharge point, from the bed of the stream to the surface.

[1]The average and the 90th percentiles are calculated from at least five weekly samples in a period of thirty days. For values recorded as less than the detection limit, the detection limit itself should be used in calculating the statistic. The 90th percentile can be extrapolated by graphical methods when fewer than ten samples are collected.

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

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

[4]Measurements may be made in-situ, but must be confirmed in the laboratory if the objective is not achieved.

TABLE 2
MAXIMUM CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

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

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 3
AVERAGE 30-DAY CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5-7.1	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

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 3.
- each measured value is compared to the corresponding individual values in Table 3. No more than one in five of the measured values can be greater than one-and-a-half times the corresponding objective values in Table 3.

TABLE 4
MAXIMUM AND 30-DAY AVERAGE NITRITE (N) CONCENTRATIONS TO PROTECT AQUATIC LIFE

Chloride Concentration (mg/L)	Maximum Nitrite–N Concentration (mg/L)	30-Day Average Nitrite–N Concentration* (mg/L)
<2	0.06	0.02
2-4	0.12	0.04
4-6	0.18	0.06
6-8	0.24	0.08
8-10	0.30	0.10
>10	0.60	0.20

*The 30-day average chloride concentration should be used to determine the appropriate 30-day average nitrite objective.

TABLE 5
RECOMMENDED WATER QUALITY MONITORING FOR DEEP CREEK AND VERNON CREEK

Site Number	Location	Frequency	Date	No.	Variables
0500020 0500258 0500768 0500089 0500091	Deep C near mouth Deep C u/s Armstrong Cheese Deep C @ Larkin Rd Vernon C @ outlet from Kalamalka Lake Vernon C @ mouth Okanagan Lake	5 times weekly in 30 days	July–Sept	25	Dissolved oxygen Temperature MF fecal Enterococci NH3–N NO3–N NO2–N Chloride Suspended solids
0500091 0500020	Vernon C @ mouth Okanagan Lake Deep C near mouth	once : 6 reps	July–Sept	2	Periphyton chlorophyll-*a*

MINISTRY OF ENVIRONMENT, LANDS, AND PARKS
PROVINCE OF BRITISH COLUMBIA

WATER QUALITY ASSESSMENT AND OBJECTIVES FOR TRIBUTARIES TO OKANAGAN LAKE NEAR VERNON (Lower Vernon, Deep, and Equesis Creeks) OKANAGAN AREA

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Water Quality Branch
Water Management Division

JANUARY 1994

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ACKNOWLEDGMENTS

Input to this report came from many valued individuals. Mr. Don Reksten of the Water Management Division in Victoria provided the data on seven-day low flows reported in Chapter 2. Mr. Bruce Shepherd with the Recreational Fisheries Management Program prepared information on the fisheries use and the importance of each of the water bodies to the Okanagan fishery. Mr. Ian Lundman, a Co-op student from Okanagan College working for the Water Management Division in Victoria, summarized water consumption information for the water bodies. Mr. Tim Forty with Environmental Protection in Penticton provided information on the status of Waste Water Management Plans, while Mr. Ron Townson of Environmental Protection in Penticton provided data graphs for non-point sources to Deep Creek. Dr. Rick Nordin of Water Management Division in Victoria and Mr. Peter Wright of Water Management in Vernon provided information on the storm sewer systems draining into BX and Lower Vernon creeks.

This report was reviewed and comments provided by Messrs. R. Rocchini and L. Pommen of Water Quality Branch, Mr. Norm Clarkson of the North Okanagan Health Unit, Dr. Barry Willoughby of the Ministry of Health, Mr. Vic Jensen of Environmental Protection (Penticton), Mr. Ron Townson of the Okanagan Water Quality Control Project, Mr. Bruce Shepherd of the Fisheries Management Program, and Dr. Wendy Mason of the Contaminated Sites and Toxicology Section of the Environmental Protection Division.

To these people we express our thanks.

1. INTRODUCTION

1.1 BACKGROUND

The British Columbia Ministry of Environment, Lands, and Parks (hereafter referred to as the B.C. Ministry of Environment) is preparing water quality assessments and objectives in priority water basins in British Columbia. This report describes the water quality within certain selected tributaries to the central portion of Okanagan Lake on its east shore near Kelowna (Figure 1.1). Presented in this report are data collected to December 1990. The objectives are being prepared as part of a fisheries management plan for tributaries to Okanagan Lake.

Four additional reports evaluating water quality in other selected tributaries to Okanagan Lake are in preparation. One report deals with Peachland, Trepanier, Westbank, Lambly, Faulkner, and Powers creeks; a second deals with Mission, Kelowna, and Brandt's creeks; a third deals with Eneas, Trout, and Prairie creeks; while the fourth deals with Penticton and Naramata 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 aimed at protecting the most sensitive designated water use with due regard to ambient water quality, aquatic life, waste discharges and socio-economic factors[1.1].

Water quality objectives are based upon approved or working water quality criteria which are characteristics of water, biota, or sediment that must not be exceeded to prevent specified detrimental effects from occurring to a water use[1.1]. The working criteria upon which many of the proposed provisional objectives are based come from the literature, and are referenced in the following chapters. The B.C. Ministry of Environment is in the process of developing approved criteria for water quality characteristics throughout British Columbia, to form part of the basis for permanent objectives.

As a general rule, objectives are only set in water bodies where man-made influences threaten a designated water use, either now or in the future. The reasons for this are that objectives will only be placed in water bodies where remediation efforts can lead to an improvement in water quality. As well, promulgating water quality objectives where there is an uncertain possibility of future man-made 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 feeling that the waters were being protected , albeit by dated objectives. Provisional objectives are proposed in this report, and are to be reviewed as more monitoring information becomes available and as the B.C. Ministry of Environment establishes more approved water quality criteria.

The provisional objectives take into account the use of the water to be protected and the existing water quality. They allow for 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.

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

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

1.3 DESCRIPTION OF WATERSHEDS

1.3.1 EQUESIS CREEK

Equesis Creek enters Okanagan Lake from the west, opposite the City of Vernon (Figure 1.2). It descends from its headwaters at a slope of about 1.22 m per m for a distance of about 1.5 km, prior to changing slope to a gentler 0.09 m per m on average until it reaches Okanagan Lake. Equesis Creek has a drainage area of 199 km^2 at the mouth of the creek.

There is limited road access to the creek beyond the Westside Road, which is within about 1.5 km from the shore of Okanagan Lake.

1.3.2 DEEP CREEK

Deep Creek enters Okanagan Lake from the north end (Figure 1.2). It is a gently sloping creek, with a slope of only about 0.003 m per m along its length. It is surrounded along most of its length by agricultural operations. At the mouth, it has a drainage area of 306 km^2. It is generally accessible by road along its entire length.

1.3.3 LOWER VERNON CREEK

For the purpose of this water quality assessment, Lower Vernon Creek is deemed to be that creek section from its exit from the north end of Kalamalka Lake, flowing northward for two kilometres, and then eastward for another two kilometres, prior to flowing south-westerly through Vernon and entering Okanagan Lake, almost immediately due west from where it exits Kalamalka Lake (Figure 1.2). In the section of Vernon Creek where it flows westerly, it is joined by BX Creek, which carries flows from the north from Swan Lake.

Lower Vernon Creek has an average gradient of 0.027 m per m in its descent between the two lakes. Although Lower Vernon Creek has a total tributary area of 751 km^2, it has a tributary area associated with that section of creek between Kalamalka and Okanagan lakes of only 179 km^2.

2. HYDROLOGY

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

2.1 EQUESIS CREEK

The flows in Equesis Creek are regulated. Low flows on Equesis Creek were measured at Station 08NM161 near the mouth (Figure 2.1) and occurred both during the summer periods and the winter. Summer seven-day low flows which occurred usually in August for nine years between 1970 and 1982 ranged from 0.031 to 0.356 m^3/s, with a mean flow of 0.162 m^3/s. Seven-day low flows during the winter period ranged from 0.034 to 0.402 m^3/s, with a mean seven-day low flow of 0.146 m^3/s.

In an un-regulated tributary (Ewer Creek) to Equesis Creek, natural seven-day low flows occurred for nine of fourteen years during the winter period. It is likely that the flows in Equesis Creek prior to regulation would have followed a similar pattern.

2.2 DEEP CREEK

The flow regime of Deep Creek is regulated. Flows have been measured at two stations, 08NM119 at Armstrong in the periods from 1951 to 1963 and 1974 to 1982, and at a station near the mouth (08NM153) from 1969 to 1975 (Figure 2.1).

Seven-day low flows usually are recorded during August. At station 08NM119, seven-day low flows were from 0.001 to 0.052 m^3/s, with a mean seven-day low flow of 0.017 m^3/s. At station 08NM153 near the mouth, low flows have ranged from 0.027 to 0.261 m^3/s, with a mean low flow of 0.131 m^3/s.

2.3 LOWER VERNON CREEK

The flows in lower Vernon Creek have been measured at station 08NM065 at the exit from Kalamalka Lake, and at station 08NM160 near the mouth at Okanagan Lake. The data referred to in this section were collected in the periods from 1959 to 1989 (31 years) and from 1969 to 1989 (19 years), respectively.

Seven-day low flows ranged from 0.000 to 0.150 m^3/s (mean seven-day low flow of 0.046 m^3/s) at station 08NM065, and from 0.071 to 0.562 m^3/s (mean seven-day low flow of 0.285 m^3/s) at station 08NM160.

3. WATER USES

The Ministry of Environment, Lands, and Parks has ranked tributary streams to Okanagan Lake which support spawning populations of kokanee and/or rainbow trout on the basis of suitable and available habitat, present use, present and projected conflicts, and land status. Salmon do not use the tributaries to Okanagan Lake for spawning, since they generally do not go upstream from Skaha Lake.

3.1 EQUESIS CREEK

There are four water licenses for consumptive use on Equesis Creek. These are for irrigation water supplies for 925 dam^3/a.

In overview, fisheries values in Equesis Creek would be considered as moderate. Wightman and Taylor [3.1] ranked Equesis Creek as the third highest for major enhancement activity due to the quantity of accessible habitat and the favourable discharge regime. Kokanee cannot access the creek beyond the first 2.6 km due to the presence of a dam. Larger rainbow trout can probably pass this dam, but a second dam at the 3.7 km point blocks even these fish.

There is an additional 18.5 km reach upstream from the second dam to Little Pinaus Lake, all of which is capable of supporting rainbow trout. In fact, rainbow trout from the lake have used this reach and returned to the lake (2 000 observed in 1987). Pinaus and Little Pinaus lakes have been known to support redside shiners, sculpins, peamouth chub, and squawfish.

The first 5.6 km of Equesis Creek are on reserve lands of the Okanagan Indian Band. Complete information on the fish usage in this area is not available due to the past reluctance of the Band to allow outsiders access to the creek until their concern regarding mercury concentrations in the kokanee relative to human consumption is resolved. In order to begin to address this concern, it is recommended that the Ministry, with the permission of the Band, collect at least ten samples of kokanee muscle from different individual kokanee and have these samples tested for the presence of mercury.

In 1992, a project sponsored by the Westbank Indian Council, in partnership with the Okanagan Indian Band, resulted in kokanee spawners in Equesis Creek to be enumerated for the first time in over twenty years. The 1992 results showed that about 2 500 kokanee returned to spawn in Equesis Creek.

The B.C. Ministry of Environment completed a water supply study for Equesis Creek in 1983 (3.3) which was to be revised during 1993.

3.2 DEEP CREEK

There are 32 water licenses for irrigation and domestic water supplies on Deep Creek. There are three licenses for domestic use of 11.4 m^3/d and 29 for irrigation water supplies for 1 710 dam^3/a.

In overview, sports fish values in Deep Creek would be considered as low. The presence of kokanee has never been documented in this creek, although there is an historical anecdote that kokanee have spawned just below Otter Lake. Pinsent et. al. (3.2) estimated the annual number of harvestable-size trout at 110 for Deep Creek. Wightman and Taylor (3.1) reported no real opportunities for improving salmonid production for the lower reaches of Deep Creek, although there is some potential for improving the resident rainbow trout population in the reaches upstream from Armstrong. Below Armstrong, the stream is silted and slow-moving, and non-salmonid fish are presumed to be plentiful and worthy of water quality protection. The lower reaches of Deep Creek below Armstrong are therefore not considered as aquatic habitat for present or future sportfish production.

3.3 LOWER VERNON CREEK

There are 16 water licenses for consumptive use on Lower Vernon Creek. The licences are for the withdrawal of 1 432 dam^3/a for irrigation water supplies and 48 m^3/d for domestic use.

In overview, fisheries values in Lower Vernon Creek would be considered as high to moderate. Species of fish known to be in Lower Vernon Creek include rainbow trout, kokanee, peamouth chub, carp, largescale suckers, redside shiners, squawfish, and chiselmouth. In addition, juvenile lake trout may be using this creek as a downstream migration corridor since lake trout are beginning to be caught in Okanagan Lake which has never been stocked with this species. Interestingly, lake trout were stocked in Kalamalka Lake in the early 1970's. Since lake trout could have a very detrimental effect on the kokanee of Okanagan Lake(by predation), the presence of lake trout is not considered desirable. The dam at the end of Kalamalka Lake prevents all species from migrating upstream from Okanagan Lake to Kalamalka Lake.

The number of kokanee spawning in Lower Vernon Creek has improved yearly during the 1980's (except 1987) as shown below:

Year	No. of Kokanee	Year	No. of Kokanee
1983	14	1984	130
1985	540	1986	522
1987	354	1988	940
1989	1 023	1990	1 799
1991	900	1992	700

The increases in kokanee may be related in large part to the release in 1987 of about 179 000 1986-brood kokanee fry to Lower Vernon Creek. The reduced returns of kokanee to lower Vernon Creek in the 1990 to 1992 period follow trends also apparent for Penticton, Naramata, and Eneas creeks.

A number of enhancement projects by numerous groups have been undertaken in Lower Vernon Creek, including the relieving of culvert obstructions and debris removal, bank erosion control, and the installation of spawning gravel platforms at a number of points. These efforts are improving fish access and habitat potentials, and fish populations, particularly kokanee, are projected to increase as a result.

4. PERMITTED WASTE DISCHARGES

Permitted waste discharges can be located on Figure 4.1 by their permit number. They exist only in the Deep Creek and Lower Vernon Creek drainages, but not in the Equesis Creek drainage.

4.1 DEEP CREEK WATERSHED

4.1.1 Fraser Valley Milk Producers Association (PE 310)

This company operates a cheddar cheese manufacturing plant located in the residential area of the City of Armstrong. It is located about 365 m southeast from Deep Creek, and produces cheese and butter. Process waste water in the form of floor and equipment exterior wash water is discharged to the City of Armstrong sanitary sewer, while cooling water from the plant is discharged to Deep Creek (PE 310). Skim whey and equipment interior wash water is disposed of by applying to gravel roads for dust control or to fields as a soil conditioner (PE 5434).

Waste Management Permit PE 310 allows the discharge of a maximum of 91 m^3/d of cooling water at a maximum temperature of 20^{o} C. There are no data related to this operation or its impact on Deep Creek. However, at the mean low flow of 0.017 m^3/s, the cooling water would be diluted a minimum of 16:1. The maximum change in creek temperatures would be only about 1^{o}C.

4.1.2 The City of Armstrong (PE 75)

The City of Armstrong operates a sewage treatment plant to process both domestic waste water and industrial effluent from the cheese plant located in Armstrong. Waste water was treated in aerated lagoons which were discharged into the creek. This practice was discontinued in November 1992.

The City of Armstrong completed a Waste Water Management Plan in early 1988. The Plan called for the construction of an effluent storage reservoir in the neighbouring water-short farming municipality of Spallumcheen, for irrigation by Spallumcheen farmers.

An effluent forcemain was to be built between the existing sewage treatment plant and the reservoir. Irrigation was to begin in the Spring of 1993.

The reservoir is designed for an average year in terms of precipitation. Thus, during a series of wet years, chemical tertiary treatment will be provided and excess effluent will be discharged to the creek. In a series of dry years, creek water will be pumped to the reservoir during freshet. During the Spring of 1993, there will be a trial discharge to the creek when the phosphorus removal equipment will be utilized. Discharge to the creek should only be necessary following a series of wet years when maximum irrigation is not possible.

Data for the effluent discharge for the period from 1985 to 1991 are summarized in Table 4.1. The data indicate that the effluent quality is generally typical for secondary-treatment with chlorination. Mean concentrations have been 26.1 mg/L ammonia, 0.15 mg/L nitrite, 18.4 mg/L BOD_5, 35 mg/L suspended solids, 3.38 mg/L ortho dissolved phosphorus, and 5.6 mg/L total phosphorus.

As part of a non-point source impact study undertaken in 1987 and 1988, phosphorus and nitrogen concentrations were measured upstream (noted as Longstaff site) and downstream from the sewage lagoons. Data for phosphorus concentrations measured during 1987 at the two sites are in Figures 4.2 and 4.3, respectively, while those for nitrogen concentrations are in Figures 4.4 and 4.5, respectively.

The data for phosphorus show that values downstream from the lagoons increased dramatically with the lower flows in the summer, with concentrations increasing from about 0.25 mg/L upstream to as high as about 3.0 mg/L downstream. The data for 1988, although not shown, were similar to those for 1987.

The impact from the lagoons during the summer low flows is also apparent for nitrogen concentrations. Of most concern is the high ammonia nitrogen concentrations measured downstream from the lagoons, to concentrations as high as 12.0 mg/L. As well, nitrite concentrations were as high as 3.0 mg/L. These concentrations exceed the B.C. criteria for the protection of aquatic life[6,6], as well as the criterion for nitrite in drinking water. At the Longstaff site, concentrations of both nitrite and ammonia were both well below these concentrations.

4.1.3 Fletcher Challenge Limited (PE 368, PR 5074)

This company operates a plywood mill about five kilometres south from Armstrong. Waste water originates from log block heating vat, boiler blowdown water, water softener backwash, and domestic septic tank effluent.

The waste water undergoes aeration prior to exfiltrating to the surrounding ground. Aeration takes place in two ponds operated in series, with a combined capacity in the ponds of about 1 900 m^3, with a minimum retention of about 16 days. The exfiltration lagoons have a surface area of about 1 800 m^2, and with a percolation rate from 1.2 to 3.9 minutes per centimetre.

Waste Management permit PE 368 allows the discharge of a maximum of 114 m^3/d at a pH from 6.5 to 8.5, and with maximum loadings of 14 kg/d each of BOD_5 and suspended solids. Data on file for this operation consisted of three sets collected in September 1985, June 1986, and October 1988. The pH values were 8.4, 8.3, and 7.9, respectively. The BOD_5 concentrations were 13 mg/L, 23 mg/L, and <10 mg/L, respectively, while the suspended solids concentrations were 46 mg/L, 95 mg/L, and 1 mg/L, respectively. The pH values were within the permit limits while it cannot be determined if the loadings of BOD_5 or suspended solids achieved the permit level. There were no data available on the effect of this discharge on Deep Creek; however, any impact likely would be minimal due to the distance to Deep Creek (Figure 4.1).

The sawmill at the operation also has a refuse site associated with it. Waste Management permit PR 5074 allows the discharge of 38.5 m^3/d of log yard refuse, gravel, and sand to the site. There are no data to indicate whether there is a problem with leachate from this refuse site.

4.1.4 McLeod's By-Products (1978) Ltd. (PE 2477, PR 6580)

This company began to operate a rendering plant operation approximately eight kilometres south from the City of Armstrong (Figure 4.1), east from Deep Creek, in 1961. The company retrieves various waste organics, primarily animal carcasses and wastes from slaughter houses. The wastes from the operation discussed in this assessment are wash water and small quantities of solid waste.

The waste water is treated using a filter press, gravity separator, septic tank, dissolved air flotation, and chemical coagulation. It is discharged to the ground through a seepage pit and tile field. Waste Management permit PE 2477 allows the discharge of 33 m^3/d of effluent to the ground.

Solid wastes are discharged to a landfill site. Permit PR 6580 allows the discharge of 700 kg/d refuse to the land in a trench and fill operation.

There are no data to indicate the effect of this operation on Deep Creek, but given that the effluent is discharged to the ground, well removed from Deep Creek, there would likely not be a significant impact. Traditionally, the impact from rendering plants are usually odour problems.

4.2 LOWER VERNON CREEK WATERSHED

4.2.1 City of Vernon Recreation Complex (PE 1974)

The City of Vernon operate a recreation complex consisting of a swimming pool, gymnasium, outdoor tennis court which is also used as a skating rink, and an ice arena. Waste water consists of compressor cooling water from the curling and skating ice plant. The brine for the ice plant is not wasted and the ammonia is in a closed-loop system. The cooling water discharge is untreated, and is combined with parking lot runoff prior to discharge to BX Creek, a tributary to Lower Vernon Creek (Figure 4.1). The creek is about three metres wide at the point of discharge.

Waste Management permit PE 1974 allows the discharge of an average of 35 m^3/d at a maximum temperature of 16 ^{o}C. Unpublished data indicate that flows in BX Creek range from 12 720 to 64 100 m^3/d. These flows would result in dilutions of the cooling water from about 360:1 to 1830:1.

There are no data for this discharge, but given the high dilution ratios, little effect should occur in BX Creek.

4.2.2 OK Ready-Mix Ltd. (PE 1983)

This company operates a ready-mix concrete operation in Vernon which is located about one-half kilometre to the east from BX Creek and one kilometre north from Lower Vernon Creek. Waste water consists of wash water from cleaning the six to nine trucks which are usually in operation at any time.

The wash water is discharged to an exfiltration pit (approximately 3m by 5m by 1.5 m), with about 35 m^3 of solids per month accumulating and being removed from the pit for use as landfill in Vernon every two to three months. Wash water entering the pit contains about 11 000 mg/L of suspended solids, at a pH of about 12.4. Water from the pit exfiltrates to the surrounding aquifer, while the solids settle out.

Waste Management permit PE 1983 allows the discharge of a maximum of 5.5 m^3/d of wash water to the settling pit. There are no data related to this operation; however, it is likely that the operation would not impact nearby creeks due to the small volume of the discharge and the distance to both BX and Lower Vernon creeks.

4.2.3 City of Vernon (PE 382)

The City of Vernon operates a sewage treatment plant consisting of a trickling filter secondary treatment plant, smoothing basins, a reservoir, three exfiltration basins (used only for one year due to major breakout of effluent), spray irrigation, and trickle irrigation facilities. The irrigation facilities are located both in the Kalamalka-Wood Lake basins and in the Lower Vernon Creek basin. Thus, the treated effluent has the potential to affect ground water quality and in turn, surface water quality, in both these basins. The water quality in the Kalamalka-Wood Lake basins is discussed in another water quality assessment report [4.1].

A Waste Water Management Plan was completed in the mid-1980's for the City of Vernon. The Plan called for the upgrading of the trickling filter plant to handle waste water generated from up to 40 000 people, the optimization of the existing effluent irrigation system, the installation of an effluent trunk main from the site of the existing sewage treatment plant to an advanced waste water treatment plant with chemical phosphorus removal facilities, and the construction of an effluent outfall into Okanagan Lake near the juncture of Vernon and Armstrong Arms. The construction of works was completed in 1989. The City of Vernon have recently applied to update their Liquid Waste Management Plan.

Waste Management permit PE 382 allows the discharge of an average of 13 638 m^3/d from the secondary treatment plant with a maximum 25 mg/L suspended solids and 26 mg/L BOD_5. Treated waste water has not normally been discharged to either Okanagan Lake or Lower Vernon Creek, but is used instead for irrigation. An exception to this took place in 1984 and 1985, when a discharge of treated waste water had to be made to Lower Vernon Creek due to high water levels in the storage reservoir.

A report on the effect of the discharge on Lower Vernon Creek and Okanagan lake was prepared (4.2). "The waste water altered several characteristics of Vernon Creek; there were increases in: nitrogen, phosphorus, specific conductance, and chloride. Despite high concentrations of ammonia nitrogen, there was no evidence of acute or chronic toxicity from the waste water. The discharge did not increase coliform numbers in Vernon Creek, but coliform numbers in Vernon Arm increased following the discharge in 1985 but not 1984."

"The discharge increased the nitrogen concentration in Vernon Arm. The discharge may have slightly increased phosphorus and phytoplankton of Vernon Arm, although the effect of the releases is confounded with the effect of diffuse sources on water quality in Vernon Arm. Phosphorus and phytoplankton increases in Vernon Arm were very slight, considerably less than during the period of continuous discharge to Vernon Creek before the City of Vernon began the spray irrigation program in 1977."(4.2)

"In both 1984 and 1985 the timing of the waste water release was determined by considerations other than the potential effect on water quality in Vernon Arm. In order to minimize algae growth in Vernon Arm, the best time for releasing waste water would have been mid-November to mid-January." (4.2)

The Ministry of Environment, Lands, and Parks monitor a number of ground water wells near the infiltration basin (used only for one year) and the irrigation plots (Figure 4.6). One site, located to the east from the sewage treatment plant (Site 0500708), was unaffected until July 1989. Until that time, nitrate/nitrite concentrations were below 1 mg/L. Since then, concentrations have been in excess of 1 mg/L and to as high as 4.22

mg/L, except for one sample in October 1989 (after irrigation) when the concentration was 0.33 mg/L.

For the same site, increases were seen for ortho dissolved phosphorus, from a pre-1989 maximum of 34 µg/L, to values as high as 107 µg/L, although normally in the 90 µg/L range.

Thus, it is apparent that the ground water concentrations of some variables are increased at some sites. However, the data also show the opposite at some wells, making it difficult to determine from a cursory examination of the data what is causing a general increase in nutrient concentrations. Any apparent effect on local waterbodies is also difficult to determine.

5. NON-POINT SOURCE DISCHARGES

The nature of non-point source discharges affecting the three creeks is significantly different. The creek affected the most by non-point source discharges is Deep Creek. This creek was the subject of an investigation by the Okanagan Water Quality Control Project of the Ministry of Environment, Lands, and Parks in 1987 and 1988. The results of that study are summarized below.

The investigation consisted of sampling on a weekly basis between February and November. Samples were collected at 14 sites along the length of Deep Creek (Figure 4.1), as well as at the mouths of selected tributaries. The purpose of the investigation was to determine if individual farms could be identified as contributing significant quantities of nutrients to the creek. It was found that generally, this could not be done [5.1].

When the phosphorus concentrations are compared for the furthest upstream point with a good data base (Grayston) and the furthest downstream site before the sewage lagoon discharge (Longstaff), it is apparent (Figure 5.1) that there is a considerable contribution, presumably from non-point sources, in the period of April and May 1987. It is estimated from the data in Figure 5.1 that a loading of over 420 kg of phosphorus came from non-point sources. This amounted to 4.2 kg/km for the 10 km of creek between the two sites.

The City of Armstrong adds a considerable quantity of phosphorus to Deep Creek, although much of this settles out downstream in Otter Lake from where it can be re-mobilized. Two sites were also monitored downstream from Otter Lake, at Larkin and Highway 97. For the same period (May-April 1987), it was estimated from Figure 5.2 that a loading of about 155 kg of phosphorus came from non-point sources in this reach. For the approximate 1.5 km reach, this equates to a contribution of about 105 kg/km.

Thus it is apparent that non-point sources add a considerable loading of phosphorus to Deep Creek and eventually to Okanagan Lake. Similar impacts may be apparent for nitrogen compounds and bacteria concentrations, depending upon the origin of these phosphorus loadings. These phosphorus loadings to Okanagan Lake are concentrated during the high runoff period of the year.

A minimal amount of agricultural activity occurs in the Equesis Creek watershed, as implied by the fact that there are only four water licences which have been issued for irrigation purposes.

Logging in the Deep Creek. Equesis Creek, and lower Vernon Creek watersheds is not a significant factor to consider.

6. AMBIENT WATER QUALITY AND PROPOSED WATER QUALITY OBJECTIVES

Generally speaking, analytical techniques for many variables have improved dramatically during the 1980'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.

In the sections which follow, all data collected for all variables have been summarized in the Tables; however, where inconsistencies appear in the data, these aforementioned factors will be taken into consideration in the discussion. The locations of the water quality sampling sites are shown on Figure 4.1.

6.1 EQUESIS CREEK

Data for Equesis Creek are summarized in Table 6.1 for Site 0500028 at Westside Road near the mouth of the creek. Designated water uses for Equesis Creek are for wildlife, irrigation, domestic water supplies, livestock watering, and protection of aquatic life.

6.1.1 pH and Alkalinity

The pH of Equesis Creek is basic, with a range of values from 7.3 to 8.9. Alkalinity values reflect the pH, with a mean concentration of 181.3 mg/L (Table 6.1). This water would be considered as having a low sensitivity to acidic inputs[6.1].

6.1.2 Hardness and Metals

The higher the water hardness, the less toxic to aquatic life will be any metals which may be present in the water column. The hardness in Equesis Creek ranged from 72.7 to 257 mg/L (Table 6.1), which indicates that the water is of moderate hardness. The lowest hardness value of 72.7 mg/L was used to determine appropriate water quality criteria for some metals.

For example, the water quality criteria for copper(6.2) are determined by the following formula:

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

Where hardness is reported as mg/L $CaCO_3$
*For hardness values ≤50 mg/L, the 30-day average total copper should not exceed 2 µg/L.

For Equesis Creek, the criteria would be for a maximum copper concentration of 9 µg/L and an average concentration of 3 µg/L. All measured dissolved and total copper concentrations in Equesis Creek were lower than the criterion for the maximum (Table 6.1). The criterion for the mean concentration could not be evaluated since the criterion requires that a minimum of five samples be collected in a thirty-day period.

The maximum total lead concentration(6.3) in any sample using the corresponding hardness concentration (mg/L $CaCO_3$) should not exceed:

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

For Equesis Creek, this equates to a maximum concentration of 54.4 µg/L. All lead concentrations in Equesis Creek were well below this criterion. In addition, 80% of the values should be less than or equal to the 30-day average concentration. The 30-day average total lead concentration in any sample(6.3) using the corresponding average hardness concentration (mg/L $CaCO_3$) should not exceed:

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

In Equesis Creek, this equates to an average concentration of 5.4 µg/L. The mean value in Table 6.1 was below this value. However, the criterion for the mean concentration should have been evaluated using a minimum of five samples collected in a thirty-day period.

An alert level for lead in edible fish tissues of 0.8 µg/g (wet-weight) has been suggested(6.3), but no fish tissue data are available for fish from Equesis Creek.

The criterion for cadmium is also dependent upon hardness. The maximum permitted cadmium concentration to protect aquatic life is 0.8 µg/L at hardness values between 60 and 120 mg/L (6.4). Only one of 14 values exceeded this criterion .

The criteria for iron to protect aesthetics of drinking water supplies and to protect aquatic life are that a maximum concentration of 0.3 mg/L should be present (6.4,6.7). One of 14 dissolved and one of five measurements as total exceeded this criterion.

The criterion for mercury is for a maximum of 0.10 µg/L to protect aquatic life (6.12). All values were less than this criterion (Table 6.1).

The criteria to protect aquatic life from excess nickel are related to hardness. The criterion to protect aquatic life is a maximum of 0.065 mg/L (6.4), at hardness values between 60 and 120 mg/L. One of 10 measurements exceeded this criterion (Table 6.1).

Zinc concentrations, according to working water quality criteria, should be less than 0.03 mg/L (6.4). One of the 19 dissolved and total concentrations exceeded this criterion. Effects have been noted for algae at 0.015 mg/L. Thus, the mean concentration exceeds concentrations shown to affect algae.

6.1.3 Nutrients

The maximum ammonia concentration of 0.57 mg/L was below all criteria for maximum concentrations at all temperatures and pH values indicated by Nordin and Pommen (6.6) and shown in Table 6.2, and below most average concentrations listed in Table 6.3. To determine if the criterion for the mean concentration is achieved, a minimum of five samples need to be collected in a thirty-day period, which hasn't been done, to-date. However, ammonia is not likely a problem in Equesis Creek.

Nitrite concentrations were all below detection (<0.005 mg/L) and thus below the criteria (6.6) in Table 6.4 to protect aquatic life. The maximum nitrate or nitrate/nitrite concentration was 0.48 mg/L, well below the maximum concentration of 10 mg/L to protect drinking water supplies (6.7).

Phosphorus concentrations (all forms) were high enough to likely cause excessive algal growths, if phosphorus is the limiting factor and assuming that other factors such as turbidity, stream velocity, or substrate availability are not. Only with measurements of periphyton chlorophyll-a will it be possible to tell if algal growths are of concern. The B.C. criterion to protect recreational use in lakes is a maximum concentration of 0.01 mg/L (6.8), while the mean total phosphorus concentration in Equesis Creek was 0.058 mg/L. Therefore, the concentrations in the creek may cause problems with algal growths in some areas of Equesis Creek.

6.1.4 Dissolved Oxygen

There are no approved British Columbia criteria for dissolved oxygen, although Truelson has recently completed a proposal in a draft report (6.16). The following is the rationale to derive working water quality criteria for dissolved oxygen to be used in this document.

The CCREM(6.4) has developed criteria for dissolved oxygen, based on EPA criteria(6.5). The criteria are based on warm-water and cold-water biota being present in a system. Cold-water systems were defined as any with at least one salmonid present. In British Columbia, this definition covers virtually the entire Province.

The EPA(6.5) had based its criteria, and discussed its findings, on the basis of salmonids and non-salmonids. Table 3-7 in CCREM (page 3-14) is from EPA(6.5). The EPA(6.5) indicated that there was no impairment at 11.0 mg/L dissolved oxygen when embryo larvae were present or 8.0 mg/L for other life stages, and slight impairment at 9.0 mg/L and 6.0 mg/L, respectively. The EPA(6.5) based its criteria (accepted by CCREM) on the slight impairment levels, and then added 0.5 mg/L to arrive at the criteria. In British Columbia, we are fortunate enough to generally have high quality waters, and there is no need to accept the slight impairment level. Therefore, the criteria which will be used for dissolved oxygen in this document will be based on salmonids and should provide for no impairment (i.e., 8.0 mg/L and 11.0 mg/L minima).

Dissolved oxygen concentrations ranged from 9.7 to 15.2 mg/L in Equesis Creek (Table 6.1). Therefore, the criterion of 8.0 mg/L was achieved on all occasions. The 11.0 mg/L criterion, applicable when embryo larvae are present, was not achieved for 5 of the 19 measurements, which usually occurred in July or September, when embryo and larvae are not usually present.

6.1.5 Solids and Turbidity

The maximum dissolved solids concentration of 326 mg/L was below the criterion of a maximum of 500 mg/L to protect aesthetics of drinking water supplies (6.7).

Suspended solids concentrations have ranged from 1 to 294 mg/L (Table 6.1), with an average concentration of 20 mg/L. Suspended solids concentrations indicate concentrations of material that can inflict damage to membranes of fish gills or siltation of spawning beds.

Turbidity has been as high as 21 NTU (Table 6.1), with three of 24 measurements being greater than 5 NTU. Turbidity measures the transmission of light through water. The B.C. criteria to protect aquatic life from turbidity are for a maximum increase of 5 NTU when background concentrations are less than 50 NTU, while to protect drinking water supplies which are to be used untreated, the maximum increase should be 1 NTU for background concentrations less than 5 NTU(6.9).

To protect aesthetics of drinking water supplies where there is no colour removal, colour should not exceed 15 units(6.4). The maximum colour value was 17 units (Table 6.1), which just exceeds (and was the only measured value to exceed) the criterion.

6.1.6 Microbiological Indicators

Fecal coliform concentrations have been as high as 350 MPN/100 mL (Table 6.1) in Equesis Creek. The B.C. criterion to protect primary contact recreation (which occurs in Okanagan Lake) is for the geometric mean fecal coliform concentration to be below 200/100 mL (6.10).

6.2 DEEP CREEK

Data for Deep Creek are summarized in Table 6.5 for Site 0500020 near the mouth of the creek, in Table 6.6 for Site 0500769 at highway 97, in Table 6.7 for Site 0500708 at Larkin Road, and in Table 6.8 for Site 0500258 upstream from Armstrong. The data in

Tables 6.5 and 6.8 represent water quality conditions for the period from about 1973 to 1990, while those data for the other two sites represent limited data for the period 1987 to 1989.

Designated water uses for Deep Creek are for the protection of drinking water, irrigation water supplies, livestock watering, wildlife, and aquatic life.

6.2.1 pH and Alkalinity

The median pH at both the upstream site and the site in Deep Creek near the mouth were virtually the same, pH 8.0 and pH 8.1, respectively. The short-term pH values for the other two sites were slightly higher, at pH 8.4 and pH 8.6. Criteria for pH to protect aquatic life are that the pH should be in the range from 6.5 to 9.0, while criteria to protect drinking water supplies are that the pH should be in the range from 6.5 to 8.5 [6.15]. The pH criteria 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.

At Site 0500258, 5 of 67 pH values were in excess of the pH 8.5 criterion, but all five values were measured prior to 1974. Eighteen of 31 values between 1987 and 1989 at Site 0500768, 9 of 31 values between 1987 and 1989 at Site 0500769, and 8 of 109 pH values at Site 0500020 at the mouth (only 4 values since 1973) exceeded the pH 8.5 criterion.

The data tend to indicate that the pH of Deep Creek is within the range defined for the protection of drinking water supplies. The B.C. criteria indicate that values outside the criteria may not be a problem from a public health perspective. In order to protect aquatic life, a water quality objective is proposed for pH. The objective is that the pH in Deep Creek should be in the range from 6.5 to 9.0. When upstream values exceed 9.0, no statistically significant increase in pH should occur, as defined in reference 6.16. The objective applies to discrete samples collected outside the initial dilution zones of effluent discharges. The initial dilution zones are defined as extending no further than 100 metres downstream from the discharge, and no further across the water body than 50% of its width, from the surface of the creek to its bed.

Deep Creek is well buffered to acidic inputs, with a mean alkalinity concentration increasing from 192 mg/L upstream from Armstrong, and increasing slightly to about 230 mg/L prior to entering Okanagan Lake. This means that the water is well buffered and has a low sensitivity to acidic inputs (6.1).

6.2.1 Hardness and Metals

The water hardness has important ramifications in determining the toxic properties of several metals, with water of higher hardness being less toxic to aquatic organisms than softer water with the same metal concentration. In Deep Creek, the mean water hardness ranged from 287.8 mg/L at Site 0500258 upstream from Armstrong to 324 mg/L at Site 0500020 at the mouth. For determining the criteria for different metals in Deep Creek, a conservative approach will be used and the appropriate level will be determined using the lowest hardness concentration of 141 mg/L recorded at Site 0500258 (Table 6.8). This water would be deemed to have moderate hardness.

The data for total aluminum at Site 0500258 were collected between 1984 and 1990, with a maximum value of 3.2 mg/L and a mean concentration of 0.78 mg/L (Table 6.8). At Site 0500020 near the mouth where the data were collected between 1982 and 1990, the maximum value was 2.0 mg/L and the mean value 0.50 mg/L (Table 6.5). The B.C. criteria for aluminum are as dissolved concentrations, so that direct comparison to the total concentrations is not possible. The criteria for aluminum are that the maximum concentration should not exceed 0.10 mg/L, and the mean concentration 0.05 mg/L (6.11). At Site 0200258, only 5 of 24 total values were less than the criterion for the maximum dissolved concentration, while 6 of 33 total values were less than the criterion for the maximum concentration. One source of aluminum to Deep Creek was alum from the sewage treatment plant; however, no objective will be proposed since this discharge has been discontinued.

The working water quality criterion to protect aquatic life from adverse effects of total cadmium is that the maximum concentration should not exceed 0.0013 mg/L in waters with hardness from 120 to 180 mg/L (6.4). Cadmium concentrations were reported only for Site 0500020, and 2 of 17 were higher than this criterion (Table 6.5). Therefore, there is little concern for the effects of cadmium on aquatic life in Deep Creek.

Working water quality criteria for chromium are a maximum of 0.002 mg/L to protect phytoplankton, and 0.02 mg/L to protect fish (6.4). At Site 0500258 upstream from Armstrong, all values were less than or equal to the criterion to protect fish, but the analytical detection limit was too high (0.005 mg/L) to determine if the criterion to protect phytoplankton was achieved. At Site 0500020 at the mouth of Deep Creek, all chromium concentrations were <0.005 mg/L and were therefore less than the criterion to protect fish, but the status with respect to phytoplankton is unknown. There are no known sources for chromium to Deep Creek.

The water quality criteria for copper[6.2] are determined by the following formulae:

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

Where hardness is reported as mg/L $CaC0_3$

For Deep Creek, the criteria would be for a maximum copper concentration of 15 μg/L and an average concentration of 5.6 μg/L. At Site 0500020 near the mouth, 1 of 14 dissolved values and 3 of 46 total values exceeded the criterion for the maximum. Four of 30 total measurements at Site 0500258, upstream from Armstrong (Table 6.8) also exceeded the criterion for the maximum concentration. Since the incidence of non-achievement of the criterion is about the same at both sites, and since there are no known anthropogenic sources of copper to Deep Creek, the values which exceed the criterion are likely natural fluctuations. The criterion for the mean concentration could not be evaluated since the criterion requires that a minimum of five samples be collected in a thirty-day period.

The criterion for iron to protect aesthetics of drinking water supplies and to protect aquatic life is a maximum concentration of 0.3 mg/L [6.4,6.7]. These criteria were exceeded by 23 of 31 total values at Site 0500258 and by 1 of 23 dissolved and 31 of 47 total values at Site 0500020. This is likely of little concern since the dissolved iron concentrations generally met the criterion, and particulate iron would not be of concern unless as an iron floc. There are no known sources of iron to Deep Creek.

The maximum total lead concentration[6.3] in any sample using the corresponding hardness concentration (141 mg/L $CaC0_3$) should not exceed:

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

For Deep Creek, this equates to a maximum concentration of 126.4 µg/L. All lead concentrations in Deep Creek at both Sites 0500258 and 0500020 were well below this criterion. In addition, 80% of the values should be less than or equal to the 30-day average concentration. The 30-day average total lead concentration in any sample(6.3) using the corresponding average hardness concentration (mg/L $CaCO_3$) should not exceed:

Average (µg/L) total lead $\leq 3.31 + \exp(1.273 \ln(\text{average hardness}) - 4.705)$ ......(4)

In Deep Creek, this equates to an average concentration of 8.2 µg/L. All detectable total lead values at Site 0500258 (Table 6.5) met this criterion, while at Site 0500020, 1 of 5 total values collected before 1982, and 2 of 15 dissolved values collected before 1982 (Table 6.8) were above this value. It should be noted that the phase-out of leaded gasoline since that time should result in lower lead concentrations in Deep Creek. As well, the proper application of this criterion for the average concentration requires that a minimum of five samples be collected in a thirty-day period. An alert level of 0.8 µg/g (wet-weight) has been suggested(6.3) for edible fish tissues, but no data have been collected.

One of 15 total mercury concentrations at Site 0500020 exceeded the criterion of a maximum 0.10 µg/L to protect aquatic life (6.12). It was not possible to determine how many values exceeded the criterion for the mean mercury concentration since most values were below detection (0.05 µg/L) which was higher than criterion of 0.02 µg/L (6.12).

The most restrictive criteria for manganese are for the protection of aesthetics of drinking water supplies, with a maximum concentration of 0.05 mg/L (6.7). Most of the total and dissolved values at both sites 0500258 and 0500020 exceeded this criterion. To protect aquatic life, working criteria range from 0.1 to 1.0 mg/L (6.13). All values at both the sites were within this range of criteria.

The mean molybdenum concentration was 0.02 mg/L at Site 0500020 near the mouth (Table 6.5), and the median concentration at Site 0500258 (Table 6.8) was <0.01 mg/L. B.C. criteria to protect irrigation water supplies from excess molybdenum (the most restrictive water use criteria) are a maximum of 0.05 mg/L and a mean concentration from 0.01 to 0.03 mg/L, depending on the Cu:Mo ratio (6.14). Only 1 of 31 values at Site 0500258 exceeded the criterion for the maximum value, while none at the other site did. Recent Cu:Mo ratios in Deep Creek usually have been less than 2:1; therefore, the mean molybdenum concentration for irrigation of forage crops should be ≤ 0.01 mg/L. This could be a problem at times.

All nickel concentrations at both Sites 0500258 and 0500020 were less than 0.05 mg/L. The criteria to protect aquatic life from excess nickel are related to hardness. The criterion to protect aquatic life when the hardness is between 120 and 180 mg/L is a maximum of 0.11 mg/L (6.4), which is considerably higher than the measured nickel concentrations.

Zinc concentrations according to working water quality criteria should be less than 0.03 mg/L (6.4). All 48 total values at Site 0500020 in Deep Creek at the mouth were ≤ 0.02 mg/L, although three of 18 dissolved zinc values prior to 1982 exceeded this criterion at the same site. Most of the total zinc values were recorded after 1981. At Site 0500258 upstream from Armstrong, two of 31 values exceeded the criterion, which in turn skewed the mean concentration.

6.2.3 Nutrients

Figure 6.1 shows the typical change in nitrogen concentrations in a downstream direction along Deep Creek during both high flow (March 18, 1987) and low flow (August 6, 1987) conditions. Of interest is the dampening effect of Otter Lake during high flow, as well as during low flow when the nitrogen concentrations are raised considerably by the discharge from the Armstrong lagoons.

The maximum ammonia concentration of 1.81 mg/L at Site 0500020 in Deep Creek at the mouth was below all criteria for maximum concentrations at all temperatures and for pH values below 8.6, as indicated by Nordin and Pommen (6.6) and shown in Table 6.2. For the average concentrations listed in Table 6.3, there would not be a problem below a pH of 7.8. Thus ammonia can be a problem in Deep Creek since the median pH value exceeds 7.8. Since animal wastes can generate ammonia, and ammonia would be present in any municipal discharges to Deep Creek, a water quality objective is proposed for total ammonia concentrations in Deep Creek. The objective is that the maximum concentration should not exceed concentrations listed in Table 6.2, and average concentrations should not exceed concentrations shown in Table 6.3. The objectives apply to discrete samples collected outside the initial dilution zone of effluents, described in Section 6.2.1.

Nitrite concentrations were as high as 0.087 mg/L at Site 0500020 (Table 6.5) near the mouth of Deep Creek, although the maximum concentration upstream from Armstrong was 0.053 mg/L (Table 6.8), and thus possibly higher than the criteria (6.6) in Table 6.4 to protect aquatic life. An examination of coincident nitrite and chloride concentrations since 1980 indicated only one case where the average criteria for nitrite was exceeded (although the maximum criterion was not exceeded). In August 1990 at Site 0500020 near the mouth, a nitrite concentration of 0.087 mg/L was measured when the chloride concentration was 5.8 mg/L. The appropriate nitrite criteria are a maximum of 0.06 mg/L as an average, and 0.18 mg/L as a maximum value.

Since incomplete oxidation of ammonia can result in the formation of nitrite, and since ammonia is associated with animal and human wastes which can enter Deep 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 6.2. The objective applies to discrete samples collected outside the initial dilution zones of effluents, described in Section 6.2.1.

The maximum nitrate or nitrate/nitrite concentration was 4.35 mg/L at Site 0500258 (Table 6.8), below the maximum concentration of 10 mg/L to protect drinking water supplies (6.7). Since ammonia which is discharged can be converted to nitrate, a provisional water quality objective is proposed for nitrate plus nitrite in Deep Creek. The objective is that the maximum nitrate plus nitrite concentration should not exceed 10.0 mg/L. The objective applies to discrete samples collected outside the initial dilution zones of effluents, described in Section 6.2.1.

Phosphorus concentrations (all forms) were high enough to likely cause excessive algal growths, if phosphorus is the limiting factor and assuming that other factors such as turbidity, stream velocity, or substrate availability are not. Only with measurements of periphyton chlorophyll-a will it be possible to tell if algal growths are of concern. The B.C. criterion to protect recreational use in lakes is a maximum phosphorus concentration of 0.01 mg/L (6.8). The mean concentration of total phosphorus entering Okanagan Lake at Site 0500020 is 0.349 mg/L (Table 6.5). Therefore, if there is any relationship between concentrations in the creek and those which cause problems in slow-moving lakes, excessive algal growths will likely be a concern in Deep Creek.

Figure 6.2.2 shows the typical change in phosphorus loading in a downstream direction during both high flow (March 18, 1987) and low flow (August 6, 1987) conditions. Of interest is the fact that the dampening effect of Otter Lake during high flow is not evident, and that a considerable increase in loading is apparent, likely due to re-suspension of organic material from Otter Lake since the discharge of sewage from Armstrong lagoons took place during both flow regimes.

In creeks and rivers where excess phosphorus can lead to excessive periphyton growths, the most direct means to measure adverse effects is with the measurement of periphyton chlorophyll-a. A water quality objective is therefore proposed for the protection of aquatic life. The provisional objective is that the maximum periphyton chlorophyll-a value should not exceed 100 mg/m^2(6.8). The objective applies outside the initial dilution zones of effluents, described in Section 6.2.1, and applies to the average of five periphyton samples collected from natural substrate at one site on the same day.

6.2.4 Dissolved Oxygen

A rationale was provided in Section 6.1.4 for the use of two dissolved oxygen criteria. The criteria which were used for dissolved oxygen in this document were based on salmonids being present and for the provision for no impairment (i.e., 8.0 mg/L minimum when embryo larvae are present and 11.0 mg/L minimum when all other life stages are present).

Dissolved oxygen concentrations were measured only at Sites 0500258 and 0500020, but not at the same time so that comparisons of the data are not possible. The few data collected at Site 0500258 were collected in August 1973, May 1974, August 1974, and October 1980. All values were greater than the 8.0 mg/L criterion for a minimum at Site 0500258, while 6 of 25 values at Site 0500020 were less than 8.0 mg/L, some to as low as 6.4 mg/L. Since oxygen-consuming substances can enter Deep Creek from animal and human wastes, a water quality objective is proposed for dissolved oxygen The objective is that the minimum dissolved oxygen concentration should not be lower than 11.0 mg/L when embryo and larvae are present, nor lower than 8.0 mg/L at all other times. The objective applies to measurements made outside the initial dilution zones of effluents, described in Section 6.2.1.

6.2.5 Solids and Turbidity

Mean concentrations of suspended solids were 30 mg/L at Site 0500258 upstream from Armstrong (Table 6.8), and 20 mg/L at Site 0500020 at the mouth (Table 6.5). Although the data for both sites were collected during the same time period from 1972 to 1980, there were approximately three times more data for Site 0500020, so that comparing the mean concentrations to each other is not appropriate.

B.C. criteria for suspended solids relate to the induced concentration of suspended solids downstream from a discharge or series of discharges. The criteria are that the maximum induced concentration can be 10 mg/L or 10% of the upstream concentration, whichever is greater [(6.9)]. Since there are discharges which can increase the concentration of suspended solids in Deep Creek, a provisional water quality objective is proposed. The objective is that the maximum induced concentration of suspended solids should be no greater than 10 mg/L or 10% of upstream concentrations, whichever is greater.

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

The maximum acceptable concentration for turbidity in drinking water is 1 NTU, although 5 NTU may be permitted if it can be demonstrated that disinfection is not compromised[(6.7)]. The aesthetic objective for drinking water is 5 NTU[(6.7)]. Twenty-seven of 51 turbidity values at Site 0500258 and 45 of 73 turbidity measurements at Site 0500020 were in excess of 5 NTU. Thus water treatment to remove turbidity in addition to disinfection would be required to use this water as a drinking water supply.

Mean turbidity concentrations in Deep Creek decreased from 14.5 NTU at Site 0500258 upstream from Armstrong, to 8.6 NTU at Site 0500020 at the mouth. The B.C. criteria to protect drinking water supplies from turbidity are for a maximum increase of 1 NTU for background levels less than 5 NTU, 5 NTU for background levels of 5 to 50 NTU, and 10 % of background when background is greater than 50 NTU [(6.9)]. The latter two criteria also protect aquatic life. These are the proposed provisional water quality objective for turbidity.

The criterion to protect drinking water supplies from dissolved solids is a maximum of 500 mg/L for aesthetics (6.7). To protect irrigation water supplies, the criteria range from 500 to 3 500 mg/L maximum depending on soil conditions and the crop (6.9). The level of 500 mg/L was exceeded by 12 of 40 values at Site 0500020 at the mouth (Table 6.5). Both dissolved solids values at Site 0500258 were below the 500 mg/L concentration.

The criterion to protect aesthetics of drinking water supplies from colour is a maximum of 15 colour units. This criterion was exceeded by 16 of 20 values at Site 0500020 and 9 of 12 values at Site 0500258. For drinking water, this water should receive colour removal.

6.2.6 Microbiological Indicators

The median fecal coliform concentration decreased from 195/100 mL at Site 0500258 to 49/100 mL at Site 0500020. The B.C. criteria(6.10) to protect drinking water supplies which are provided partial treatment are that 90th percentile values should not exceed 100/100 mL Escherichia coli, 25/100 mL enterococci, nor 100/100 mL fecal coliforms. These are the proposed water quality objectives for Deep Creek. The 90th percentile values are based on a minimum of 5 weekly samples in 30 days.

6.2 LOWER VERNON CREEK

Data for Lower Vernon Creek are summarized in Table 6.9 for Site 0500089 near the outlet of the creek from Kalamalka Lake and in Table 6.10 for Site 0500091 at the mouth of Okanagan Lake. The data in the tables represent water quality conditions for the period from about 1971 to 1989.

Designated water uses for Lower Vernon Creek are for the protection of drinking water, primary contact recreation, irrigation water supplies, livestock watering, wildlife, and aquatic life.

A water quality assessment of the remainder of the Vernon Creek watershed has been undertaken by Nordin et al (4.1).

6.3.1 pH and Alkalinity

The pH of Lower Vernon Creek was about the same at both sites, with a median pH of 8.3 as the creek leaves Kalamalka Lake, and decreasing to 8.1 as it entered Okanagan Lake. The maximum pH was 8.8 at Site 0500089 as the creek left Kalamalka Lake, and 8.5 as it enters Okanagan Lake at Site 0500091. Although the criteria for drinking water supplies is that the pH should be in the range from 6.5 to 8.5, natural variations outside this range will not likely be a concern from a human health perspective [6.15]. With mean alkalinity concentrations of 147 mg/L at Kalamalka Lake and 173 mg/L as it entered Okanagan Lake, Lower Vernon Creek would be considered to be well-buffered and would have a low sensitivity to acidic inputs [6.1].

6.3.2 Hardness and Metals

The mean water hardness increased from 164 mg/L at Site 0500089 (Table 6.9) as Lower Vernon Creek leaves Kalamalka Lake, to 225 mg/L at Site 0500091 (Table 6.10) just prior to entering Okanagan Lake.

The B.C. criteria to protect aquatic life from excess aluminum is a maximum concentration of 0.10 mg/L dissolved, and a 30-day average of 0.05 mg/L [6.11]. All total aluminum concentrations at Site 0500089 were below the maximum concentration, but 23 of 27 total aluminum values at Site 0500091 exceeded the 0.10 mg/L concentration. We cannot determine if the dissolved aluminum exceeded the criteria, but it is common in British Columbia for total aluminum to exceed the criteria levels[6.11]. There are no known anthropogenic sources of aluminum to Lower Vernon Creek.

The criteria to protect aquatic life from cadmium is a maximum concentration of 0.0013 mg/L for water hardness between 120 and 180 mg/L, and 0.0018 mg/L for water hardness greater than 180 mg/L [6.4]. Taking the actual average water hardness for each site into account, the data at both sites were all below the criterion of 0.0013 mg/L. Thus, cadmium is not a concern in Lower Vernon Creek.

A maximum concentration of 0.002 mg/L chromium prevents toxic effects to phytoplankton and zooplankton, while 0.020 mg/L protects fish [6.4]. The detection limit of 0.005 mg/L was too high to determine if the lower criterion was exceeded at Site 0500089; however, 3 of 28 detectable values at Site 0500091 were higher than the lower criterion. The criterion to protect fish was not exceeded at either site. More data with lower detection limits are required to determine if chromium is a concern in Lower Vernon Creek.

Water quality criteria for copper(6.2) are determined by the following formulae:

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

Where hardness is reported as mg/L $CaCO_3$
*For hardness values ≤50 mg/L, the 30-day average total copper should not exceed 2 µg/L.

For Lower Vernon Creek, the criteria would be for a maximum copper concentration of 16 µg/L and an average concentration of 6 µg/L at Site 0500089 and 17 µg/L and 6 µg/L, respectively at Site 0500091. These criteria, for the purpose of screening the data, were based on the lowest hardness value at each site. All measured dissolved values at both sites were less than the respective criteria values, while all but one total value at Site 0500091 were less than the criterion. That one total copper value of 0.02 mg/L had a paired hardness concentration of 375 mg/L. At that hardness value, the formulae above would result in a maximum permitted copper concentration of 37 µg/L, and a mean concentration of 15 µg/L. Therefore, the one value which appeared by screening to possibly exceed the criteria, in fact, was well below the permitted maximum when the coincident hardness concentration was taken into account.

The water quality criteria to protect drinking water supplies from aesthetic concerns related to iron (6.7) and to protect aquatic life (6.4) are the same at a maximum concentration of 0.3 mg/L. All values at Site 0500089 were less than or equal to this concentration, while at Site 0500091 at the mouth at Okanagan Lake, 25 of 34 values were in excess of 0.3 mg/L. This is probably not of concern since all the dissolved concentrations were less than the criterion, and particulate iron is not of concern unless it is as an iron precipitate floc.

The most restrictive water quality criterion for total mercury is for the protection of aquatic life, with a maximum of 0.1 µg/L (6.12). All values at Site 0500089 at the exit from Kalamalka Lake were below this criterion, while 2 of 14 values at Site 0500091 were in excess of this concentration. Mercury is one water quality variable where it has been determined that sample collection and handling techniques can alter results significantly. Since the two values in excess of the criterion were measured in 1973, it is possible that the values are artifacts of sampling. However, mercury seals were used for the old trickling filters at Vernon, and some losses of mercury were reported to have occurred. More sampling for mercury is recommended using up-to-date techniques.

All manganese values at both sites were below 0.05 mg/L, the most restrictive water quality criterion for the protection of aesthetics of drinking water supplies (6.7). As well, all molybdenum values at both sites were below 0.05 mg/L, the most restrictive water quality criterion for the protection of irrigation water supplies (6.14). In fact, the maximum value at either site was only 0.04 mg/L, and the mean value at each was less than 0.02 mg/L.

The maximum total lead concentration(6.3) in any sample using the corresponding hardness concentration (mg/L $CaC0_3$) should not exceed:

$$\text{Maximum } (\mu g/L) \text{ total lead} \leq \exp(1.273 \ln(\text{hardness}) - 1.460) \quad \ldots(3)$$

For Lower Vernon Creek, this equates to a maximum concentration of 135 µg/L. All lead concentrations in Lower Vernon Creek at both Sites 0500089 and 0500091 were below this concentration. In addition, 80% of the values should be less than or equal to the 30-day average concentration. The 30-day average total lead concentration in any sample(6.3) using the corresponding average hardness concentration (mg/L $CaC0_3$) should not exceed:

$$\text{Average } (\mu g/L) \text{ total lead} \leq 3.31 + \exp(1.273 \ln(\text{average hardness}) - 4.705) \quad \ldots\ldots(4)$$

In Lower Vernon Creek, this equates to an average concentration of 9 µg/L. All detectable lead values at Site 0500089 (Table 6.9) were below this criterion, while only 1 of 5 total values collected in 1977 and 1 of 13 dissolved values collected in 1972 (Table 6.10) were above this average concentration. It should be noted that the phase-out of leaded gasoline since that time should result in lower lead concentrations in Lower Vernon Creek. An alert level of 0.8 µg/g (wet-weight) has been suggested(6.3) for edible fish tissues. No fish have been tested from lower Vernon Creek for the presence of lead.

The water quality criterion to protect aquatic life from excess zinc concentrations is a maximum of 0.03 mg/L (6.4). All total concentrations at Sites 0500089 and 0500091 were below this concentration. For dissolved zinc concentrations measured on different days than the total values, 1 of 10 values (measured in 1972) at Site 0500089 and 2 of 14 values (both measured in 1972) at Site 0500091 were in excess of the criterion. Zinc concentrations are likely not a concern in Lower Vernon Creek.

6.3.3 Nutrients

The maximum ammonia concentration of 1.22 mg/L at Site 0500091 in Lower Vernon Creek at the mouth was below all criteria for maximum concentrations at all temperatures and for pH values below 8.7, as indicated by Nordin and Pommen (6.6) and shown in Table 6.2. For the average concentrations listed in Table 6.3, there would not be a problem below a pH of 7.9. Thus ammonia can be a problem in Lower Vernon Creek since the median pH exceeds 7.9. Since waste water from the City of Vernon can find its way to Lower Vernon Creek and potentially can generate ammonia, a water quality objective is proposed for total ammonia concentrations in Lower Vernon Creek. The objective is that the maximum concentration should not exceed concentrations listed in Table 6.2, and average concentrations should not exceed concentrations shown in Table 6.3. The objectives apply to discrete samples collected outside the initial dilution zone of effluents, described in Section 6.2.1.

Nitrite concentrations were as high as 0.229 mg/L at Site 0500091 (Table 6.10) near the mouth of Lower Vernon Creek, although the maximum concentration upstream at the exit from Kalamalka Lake was 0.011 mg/L (Table 6.9), and thus some values were possibly higher than the criteria (6.6) in Table 6.4 to protect aquatic life. An examination of coincident nitrite and chloride concentrations indicated no cases where the criteria for the maximum nitrite was exceeded, and since 1980, the most restrictive criteria for the mean nitrite concentration of 0.02 mg/L has not been exceeded.

Since incomplete oxidation of ammonia can result in the formation of nitrite, and since ammonia is associated with human wastes which can enter Lower Vernon 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 6.2. The objective applies to discrete samples collected outside the initial dilution zones of effluents, described in Section 6.2.1.

The maximum nitrate or nitrate/nitrite concentration was 2.4 mg/L at Site 0500091 (Table 6.10), below the maximum concentration of 10 mg/L to protect drinking water supplies (6.7). Since ammonia which is discharged can be converted to nitrate, a provisional water quality objective is proposed for nitrate plus nitrite in Lower Vernon Creek. The objective is that the maximum concentration of nitrate plus nitrite should not exceed 10.0 mg/L. The objective applies to discrete samples collected outside the initial dilution zones of effluents, described in Section 6.2.1.

Maximum dissolved and total phosphorus concentrations at Site 0500089 likely were high enough to cause excessive algal growths, if phosphorus is the limiting factor and assuming that other factors such as turbidity, stream velocity, or substrate availability are not. Only with measurements of periphyton chlorophyll-a will it be possible to tell if algal growths are of concern. The B.C. criterion to protect recreational use in lakes is a maximum concentration of 0.01 mg/L (6.8), and therefore algal growths may be a problem in lower Vernon Creek when phosphorus concentrations exceed this criterion.

In creeks and rivers where excess phosphorus can lead to excessive periphyton growths, the most direct means to measure adverse effects is with the measurement of periphyton chlorophyll-a. Since lower Vernon Creek enters Okanagan Lake at a bathing beach, it is desirable to maintain the aesthetic appeal of the water which is entering the lake. A water quality objective is therefore proposed for the protection of recreation and aesthetics. The provisional objective is that the maximum periphyton chlorophyll-a value should not exceed 50 mg/m^2. The objective applies outside the initial dilution zones of effluents, described in Section 6.2.1, and applies to the average of five periphyton samples collected from natural substrate at one site on the same day.

6.3.4 Dissolved Oxygen

A rationale was provided in Section 6.1.4 for the use of two dissolved oxygen criteria. The criteria which were used for dissolved oxygen in this document were based on salmonids being present and for the provision for no impairment (i.e., 8.0 mg/L minimum when embryo larvae are present and 11.0 mg/L minimum when all other life stages are present).

Dissolved oxygen concentrations ranged from 4.9 to 15.2 mg/L (mean concentration of 11 mg/L) at Site 0500089 at the outlet from Kalamalka Lake and from 7.8 to 13.8 mg/L (mean concentration of 10.6 mg/L) at Site 0500091 at its mouth at Okanagan lake. Only two of 50 values at Site 0500089 were less than the 8.0 mg/L criterion (July 1976 and March 1982), while two of 68 values at Site 0500091 were less than the 8.0 mg/L criterion (July 1975 and July 1980). At both sites, the 11.0 mg/L criterion was achieved from December to March.

Since oxygen-consuming substances can enter Lower Vernon Creek from human wastes, a water quality objective is proposed for dissolved oxygen The objective is that the minimum dissolved oxygen concentration should not be lower than 11.0 mg/L when embryo and larvae are present, nor lower than 8.0 mg/L at all other times. The objective applies to measurements made outside the initial dilution zones of effluents, described in Section 6.2.1.

6.3.5 Solids and Turbidity

Mean concentrations of suspended solids were 2 mg/L at Site 0500089 at Kalamalka Lake (Table 6.9), and 24 mg/L at Site 0500091 at the mouth (Table 6.10). The data for both sites were collected during the same time period from 1972 to 1980.

B.C. criteria for suspended solids relate to the induced concentration of suspended solids downstream from a discharge or series of discharges. The criteria are that the maximum induced concentration can be 10 mg/L or 10% of the upstream concentration, whichever is greater [6.9]. Since stormwater can increase the concentration of suspended solids in Lower Vernon Creek, a provisional water quality objective is proposed. The objective is that the maximum induced concentration can be 10 mg/L or 10% of the upstream concentration, whichever is greater.

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

The maximum acceptable concentration for turbidity in drinking water is 1 NTU, although 5 NTU may be permitted if it can be demonstrated that disinfection is not compromised[6.7]. The aesthetic objective for drinking water is 5 NTU[6.7]. None of the

97 turbidity values at Site 0500089 were in excess of 5 NTU; however, at Site 0500091, 33 of 69 values did. Thus water treatment to remove turbidity in addition to disinfection would be required to use this water as a drinking water supply except at the outlet from Kalamalka Lake.

Mean turbidity concentrations in Lower Vernon Creek increased from 1 NTU at Site 0500089 at Kalamalka Lake, to 7.2 NTU at Site 0500091 at the mouth. The B.C. criteria to protect drinking water supplies from turbidity are for a maximum increase of 1 NTU for background levels less than 5 NTU, 5 NTU for background levels of 5 to 50 NTU, and 10 % of background when background is greater than 50 NTU (6.9). The latter two criteria also protect aquatic life. These are the proposed provisional water quality objective for turbidity, since stormwater discharges can increase turbidity.

Criteria to protect drinking water supplies from dissolved solids is a maximum of 500 mg/L for aesthetics (6.7). To protect irrigation water supplies, the criteria range from 500 to 3500 mg/L maximum depending on soil conditions and the crop (6.9). The level of 500 mg/L was not exceeded at Site 0500089 at Kalamalka Lake (Table 6.9), but at Site 0500091, it was exceeded by only one of 16 values (December 1979).

6.3.6 Microbiological Indicators

The B.C. criteria(6.10) to protect drinking water supplies which are provided partial treatment are that 90th percentile values should not exceed 100/100 mL *Escherichia coli*, 25/100 mL enterococci, nor 100/100 mL fecal coliforms. Median fecal coliform concentrations were 6/100 mL at Site 0500089 and 235/100 mL at Site 0500091. *E. coli* were measured only at Site 0500089, where the median value was 29/100 mL.

An intensive study of bacteriological quality at the exit from Kalamalka Lake at Site 0500089 between July and October 1989 indicated that the 90th percentile values were 43.5 CFU/cL *E. coli* and 54.9 CFU/cL fecal coliform. Coincident data were not collected at Site 0500091.

Since treated human waste water can possibly make its way to Lower Vernon Creek, as well as stormwater discharges, a provisional water quality objective is proposed for microbiological indicators in Lower Vernon Creek. The objective is that 90th percentile values should not exceed 100/100 mL Escherichia coli, 25/100 mL enterococci, nor 100/100 mL fecal coliforms.

7. MONITORING PROGRAM

Water quality objectives have been proposed for a number of water quality characteristics. Generally, these should be checked in the summer when low flows would normally occur, so that "worst-case" conditions may occur.

To check attainment of average or percentile values, a minimum of five samples should be collected in a thirty-day period. When percentiles such as the ninetieth percentile are to be calculated, for the purpose of checking attainment of the objective, it will be deemed acceptable to interpolate the ninetieth percentile value from a graphical presentation of the data.

The exact monitoring program undertaken will depend upon available resources; however, a proposed monitoring scheme is presented in the following table.

PROPOSED WATER QUALITY MONITORING FOR DEEP CREEK AND VERNON CREEK

Site Number	Location	Frequency	Date	No.	Variables
0500020	Deep C near mouth	5 times weekly in 30 days	July–Sept	25	Dissolved oxygen
0500258	Deep C u/s Armstrong Cheese				Temperature MF fecal
0500768	Deep C @ Larkin Rd				Enterococci
0500089	Vernon C @ outlet from Kalamalka Lake				NH3–N NO3–N
0500091	Vernon C @ mouth Okanagan Lake				NO2–N Chloride Suspended solids
0500091	Vernon C @ mouth Okanagan Lake	once : 6 reps	July–Sept	2	Periphyton chlorophyll-*a*
0500020	Deep C near mouth				

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FIGURE 1.1 STUDY AREA FOR THIS ASSESSMENT

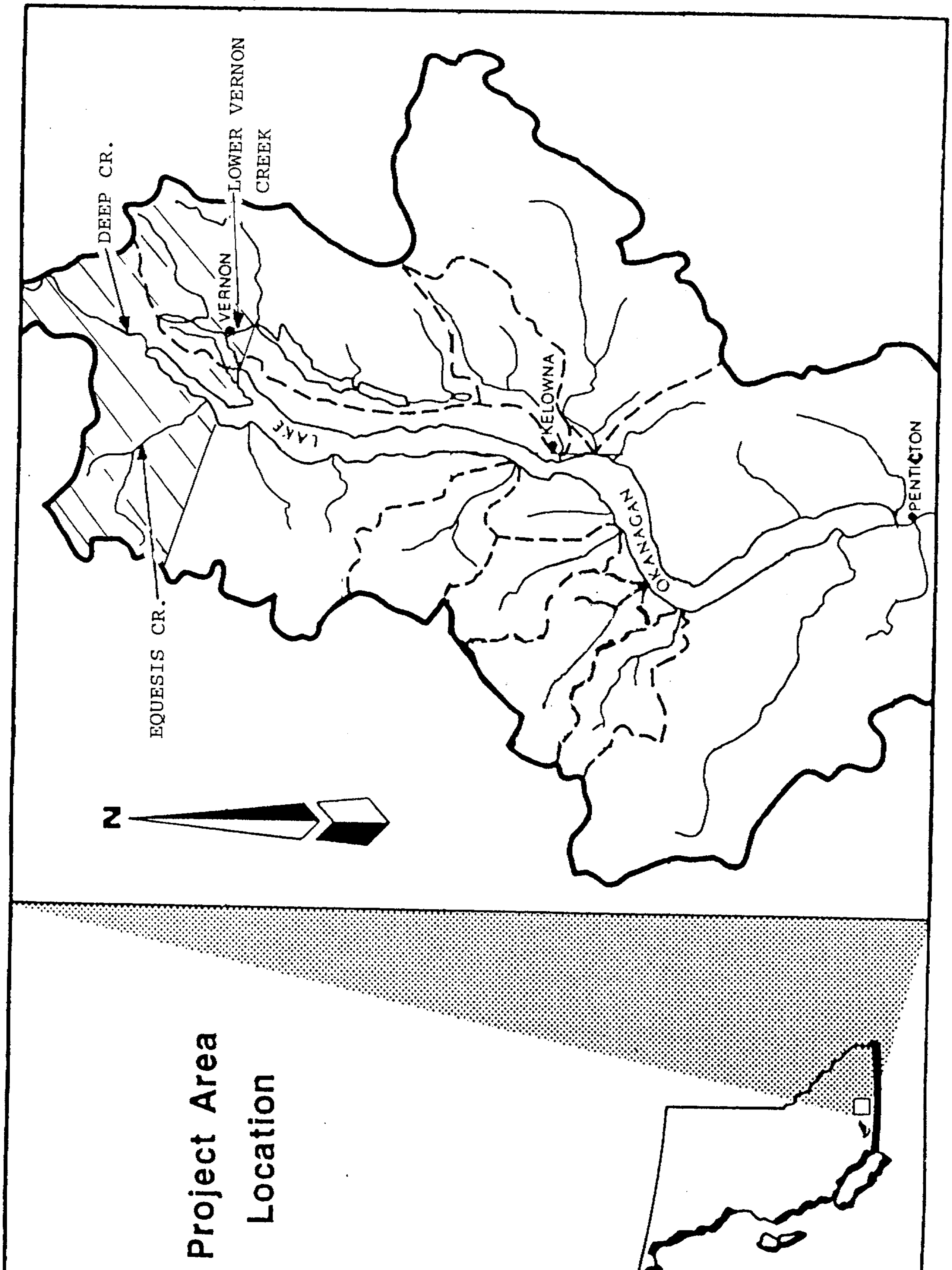


FIGURE 1.2 LOCATIONS OF LICENSED WATER WITHDRAWALS

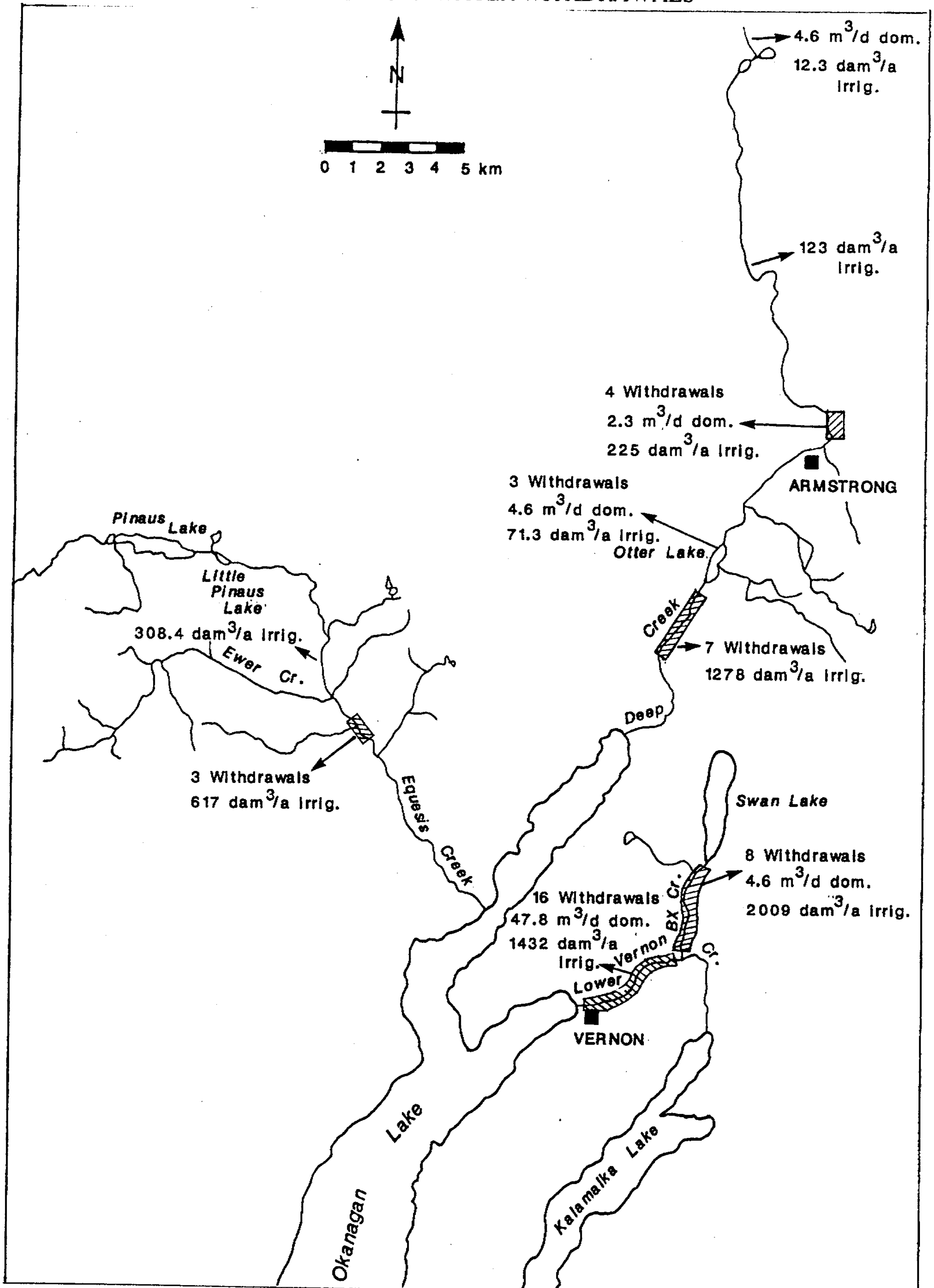


FIGURE 2.1 LOCATIONS OF FLOW GUAGES

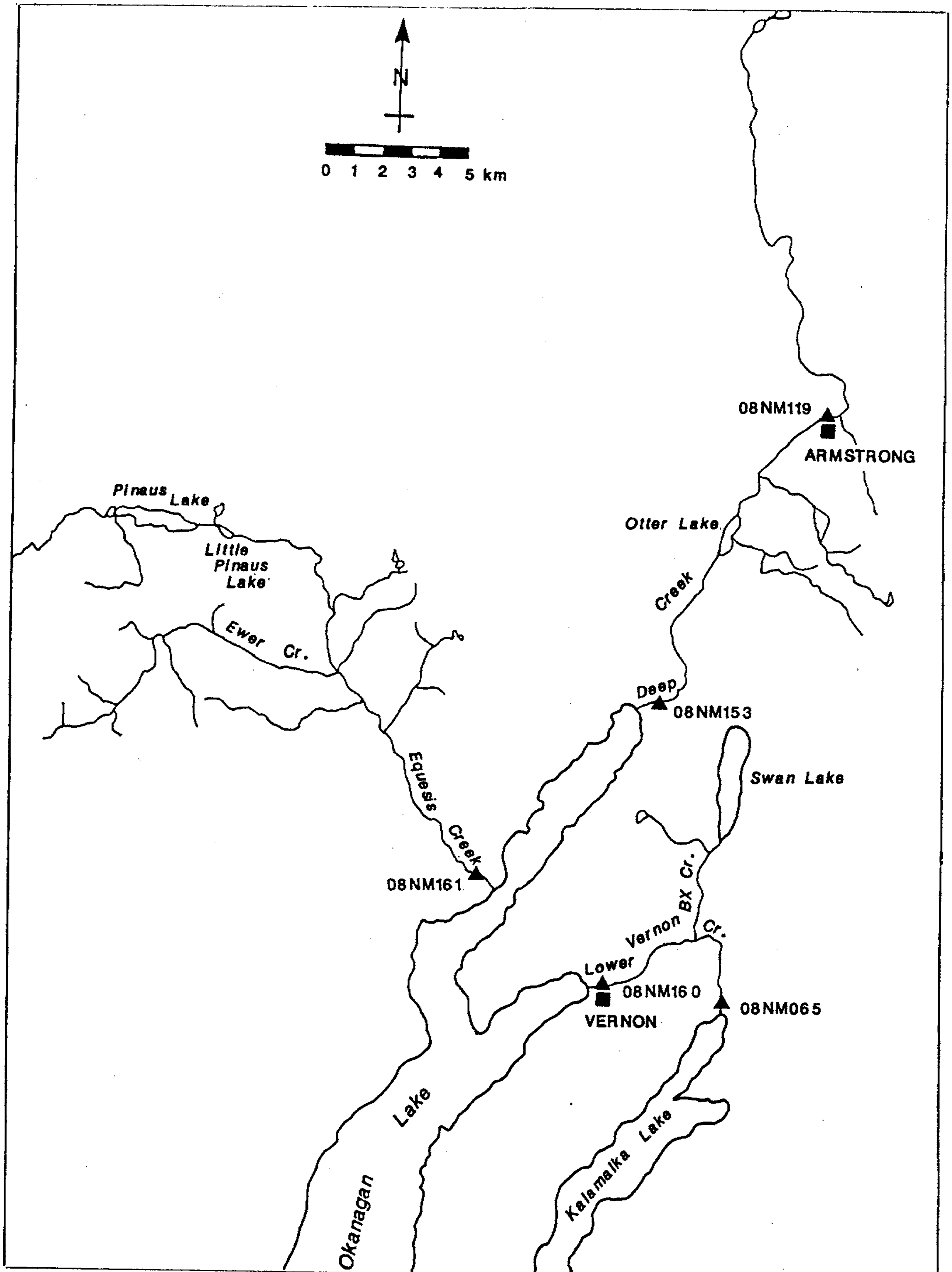


FIGURE 4.1 LOCATIONS OF WASTE MANAGEMENT PERMITS AND AMBIENT WATER QUALITY MONITORING SITES

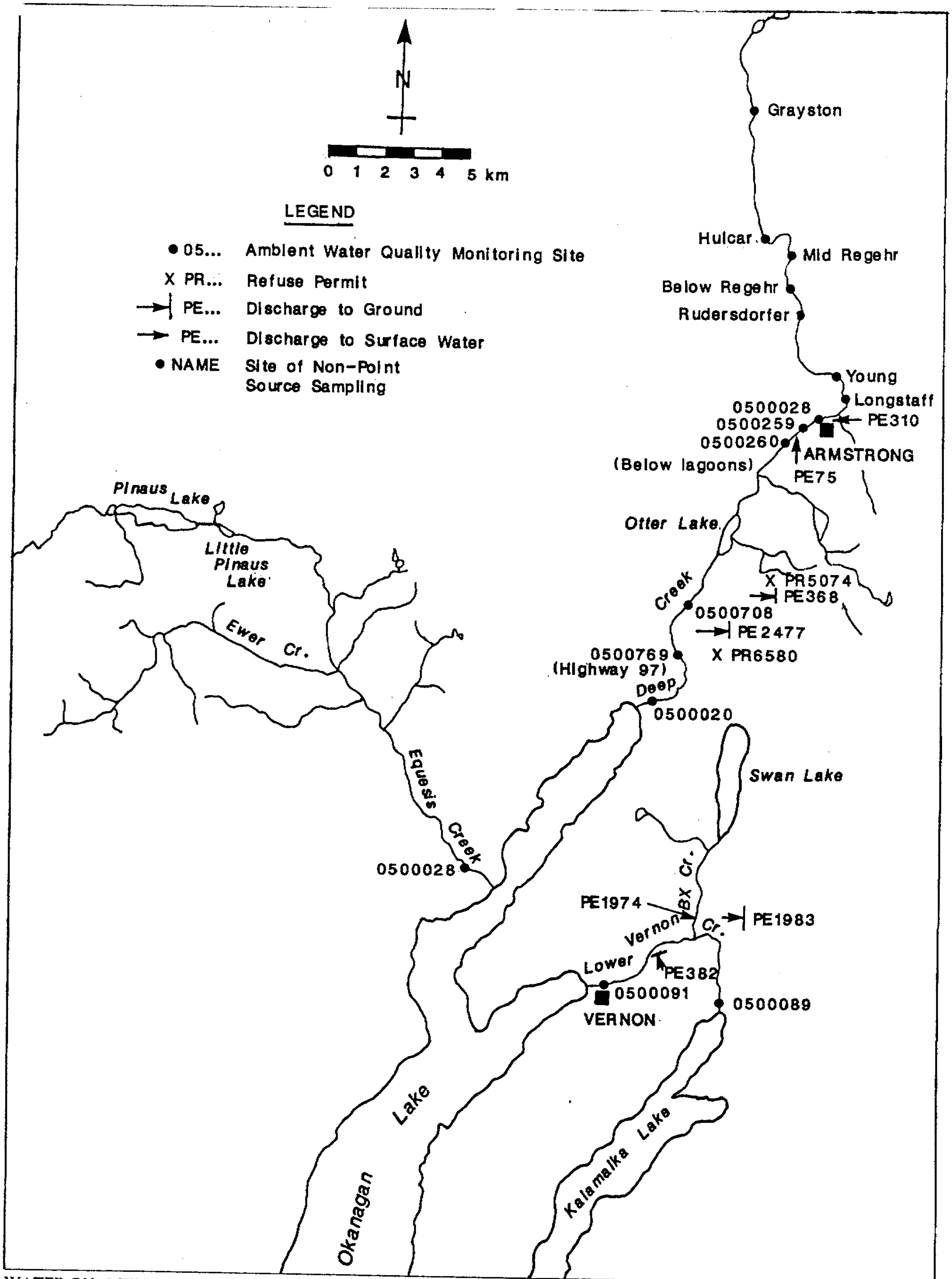


FIGURE 4.2 1987 PHOSPHORUS CONCENTRATIONS IN DEEP CREEK AT LONGSTAFF

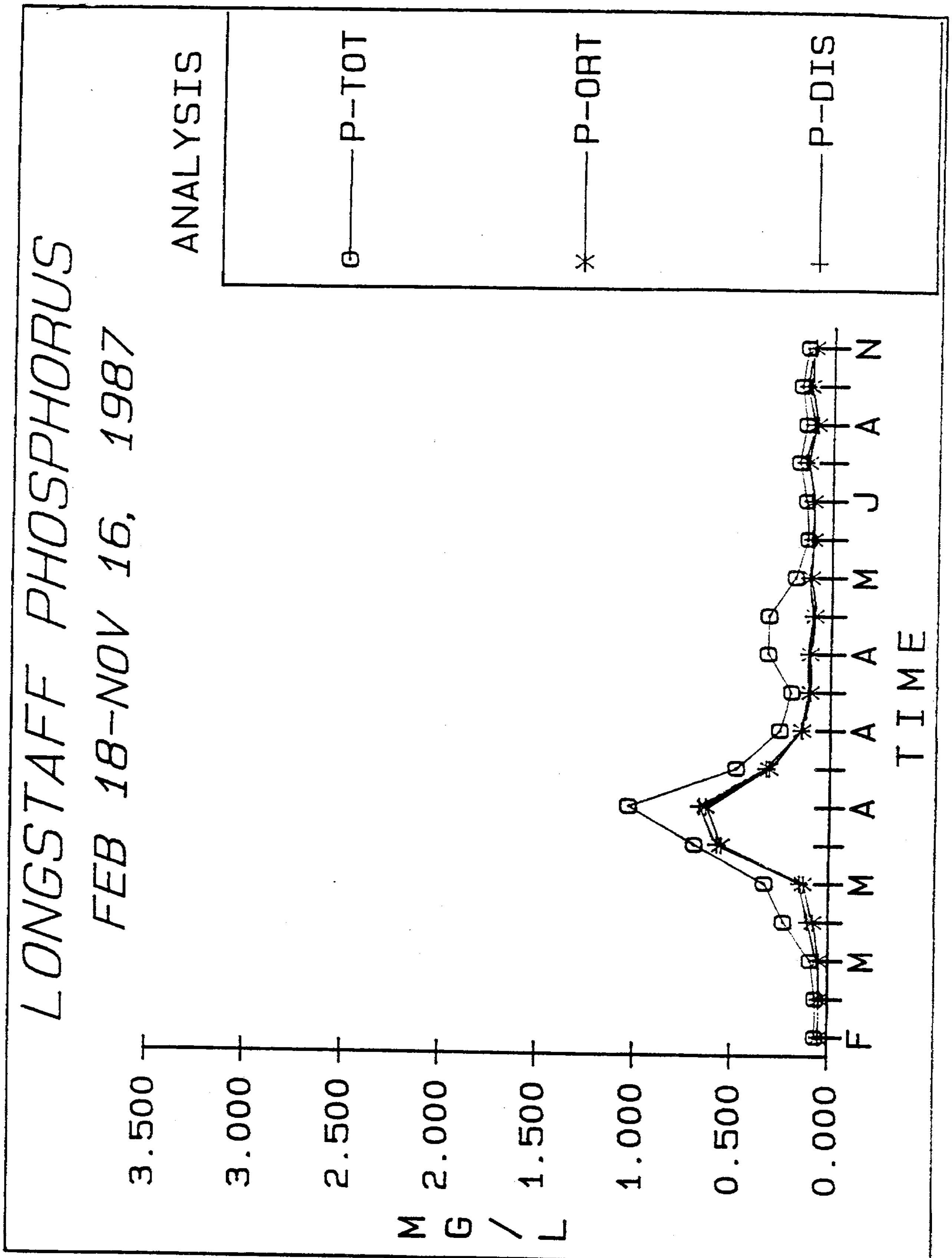


FIGURE 4.3 1987 PHOSPHORUS CONCENTRATIONS IN DEEP CREEK BELOW THE LAGOONS

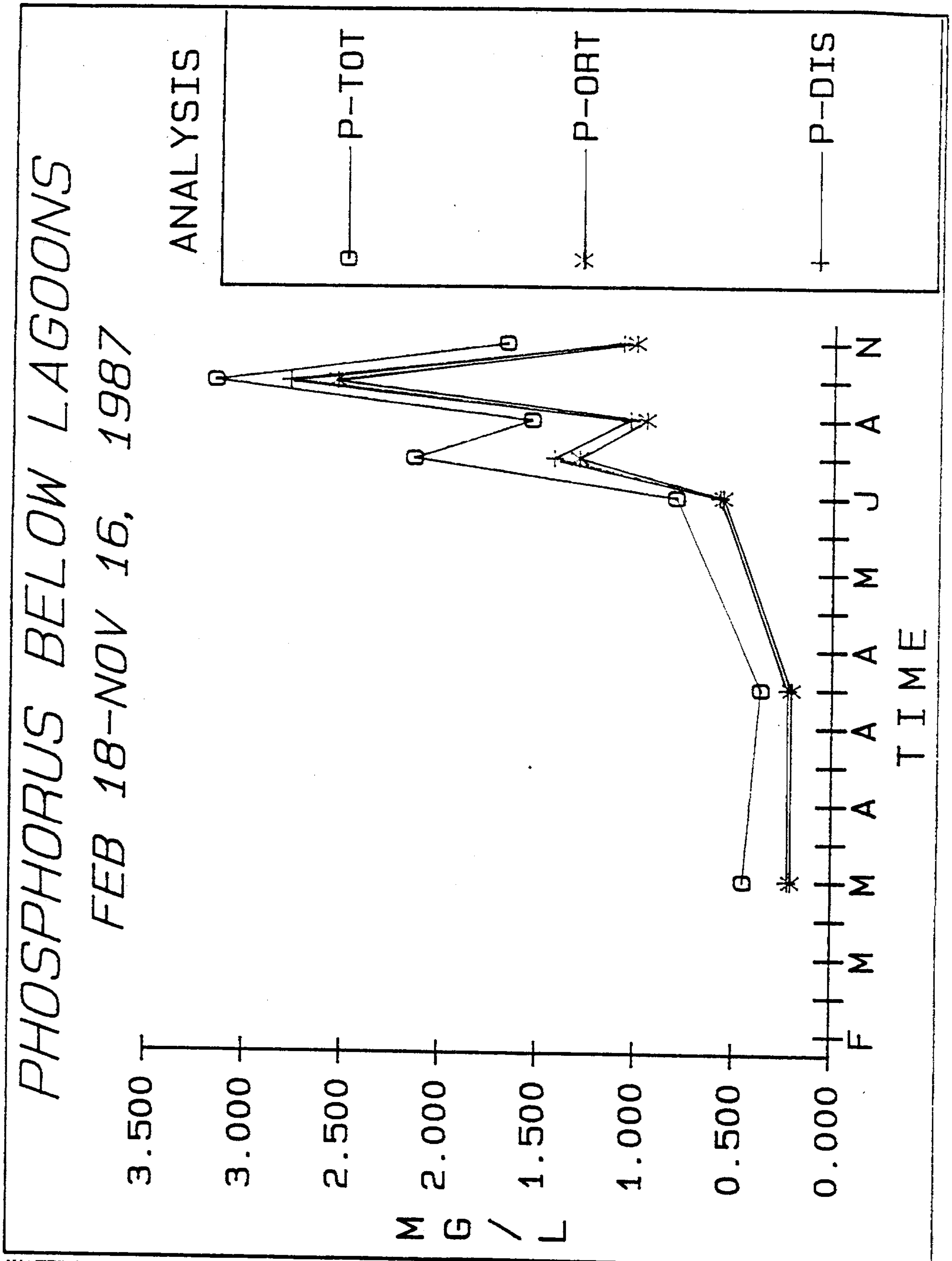


FIGURE 4.4 1987 NITROGEN CONCENTRATIONS IN DEEP CREEK AT LONGSTAFF

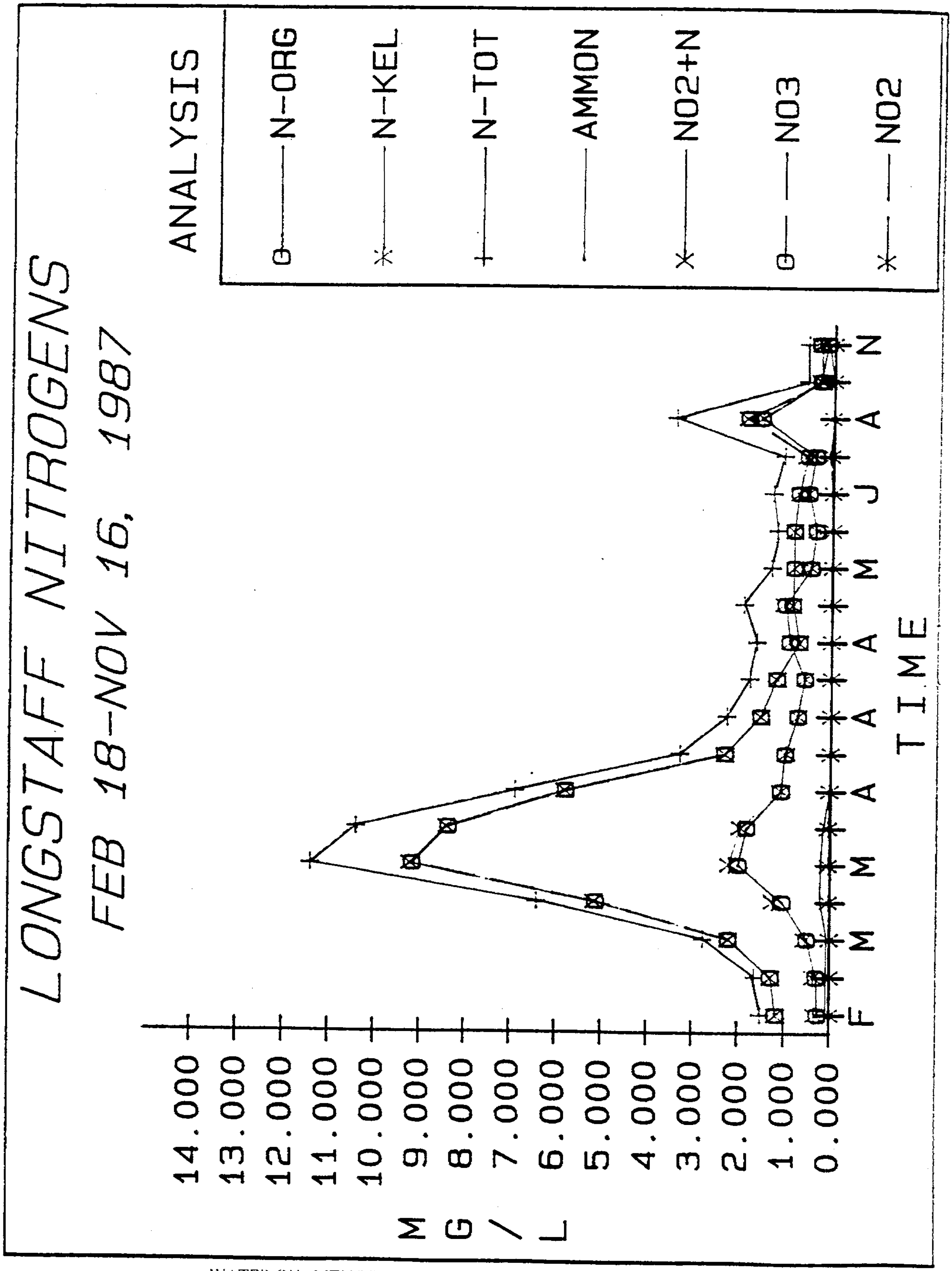


FIGURE 4.5 1987 NITROGEN CONCENTRATIONS IN DEEP CREEK BELOW THE LAGOONS

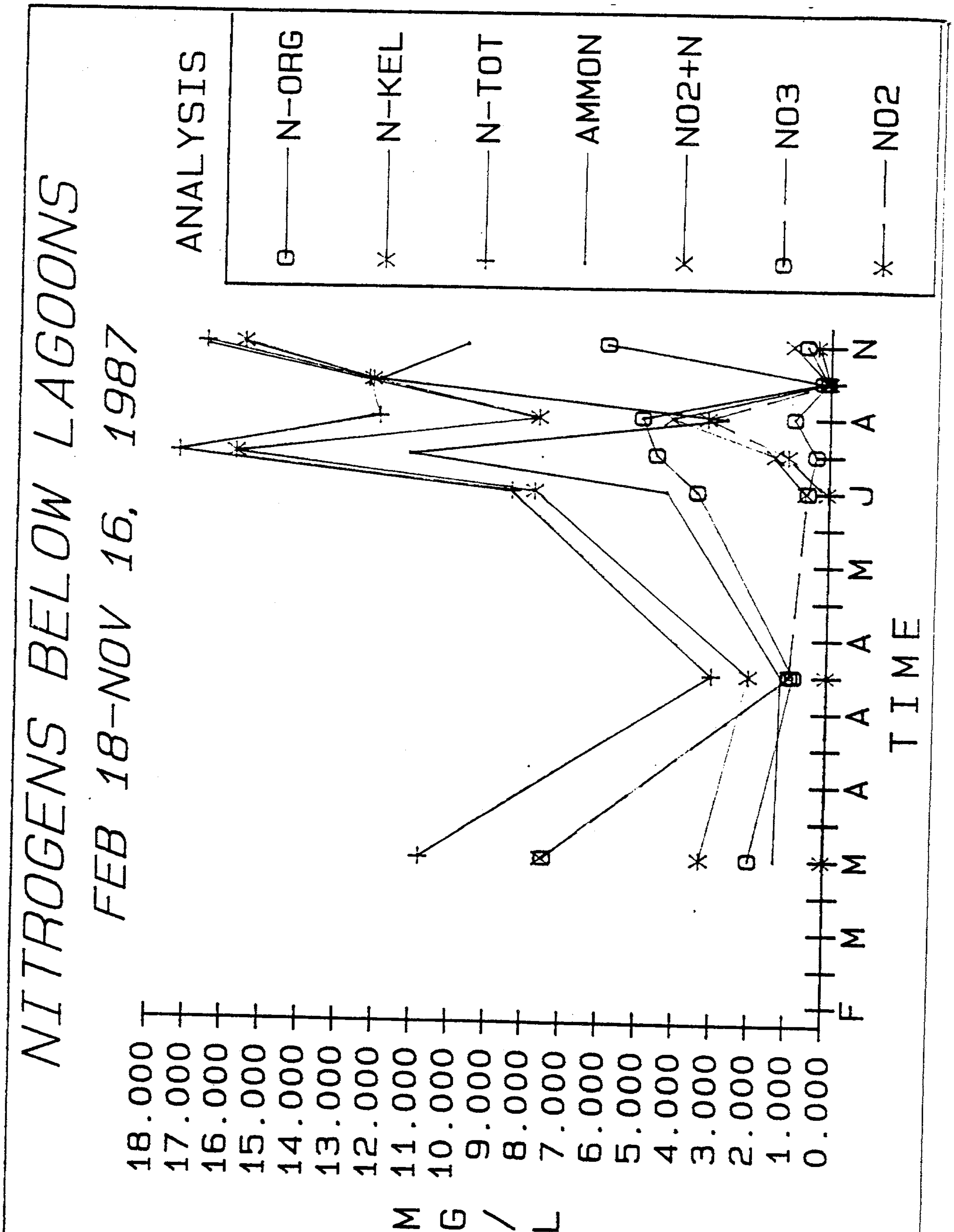


FIGURE 4.6 VERNON EFFLUENT IRRIGATION GROUND WATER MONITORING WELLS

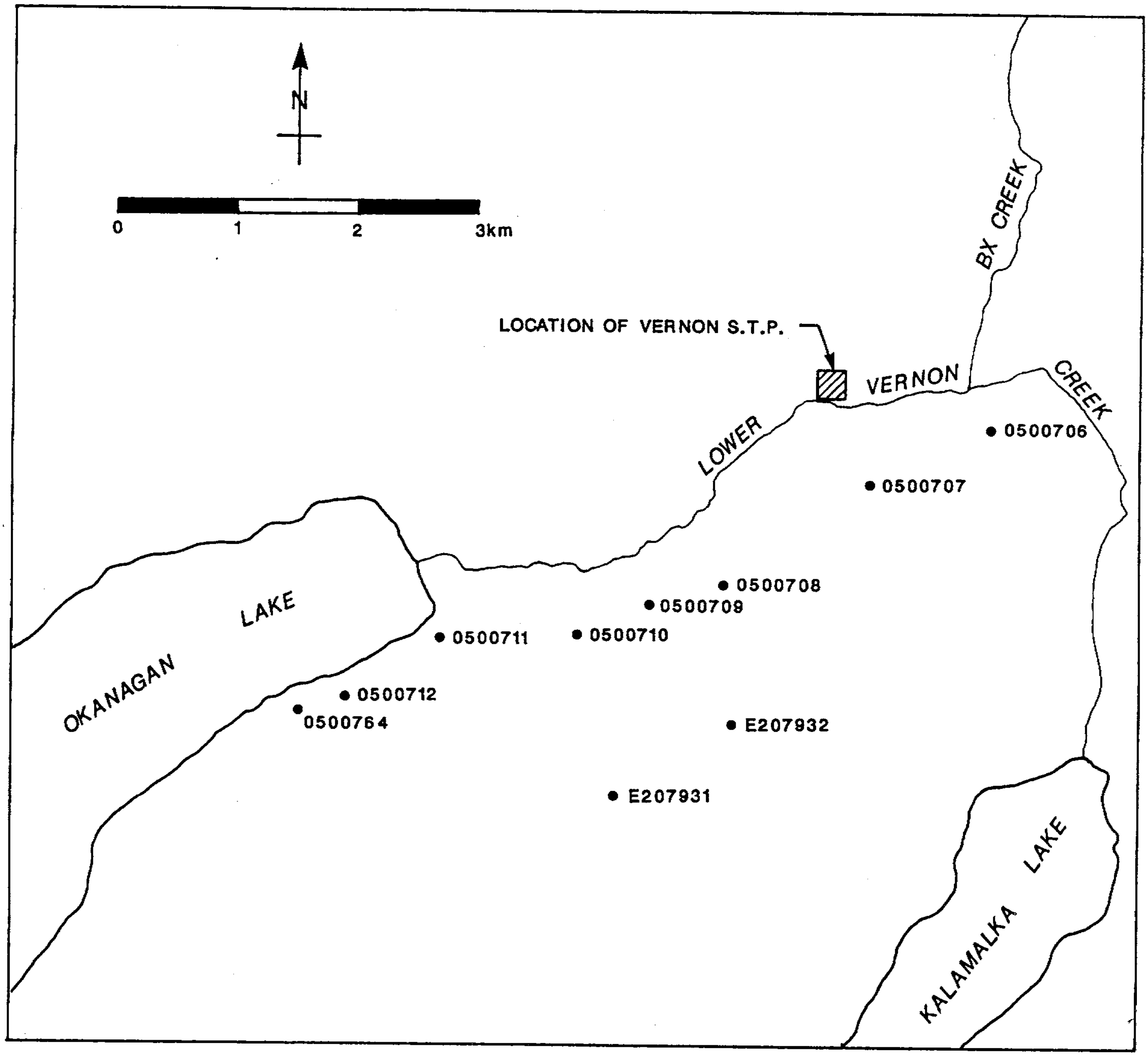


FIGURE 5.1 1987 PHOSPHORUS LOADINGS IN DEEP CREEK AT GRAYSTON AND LONGSTAFF

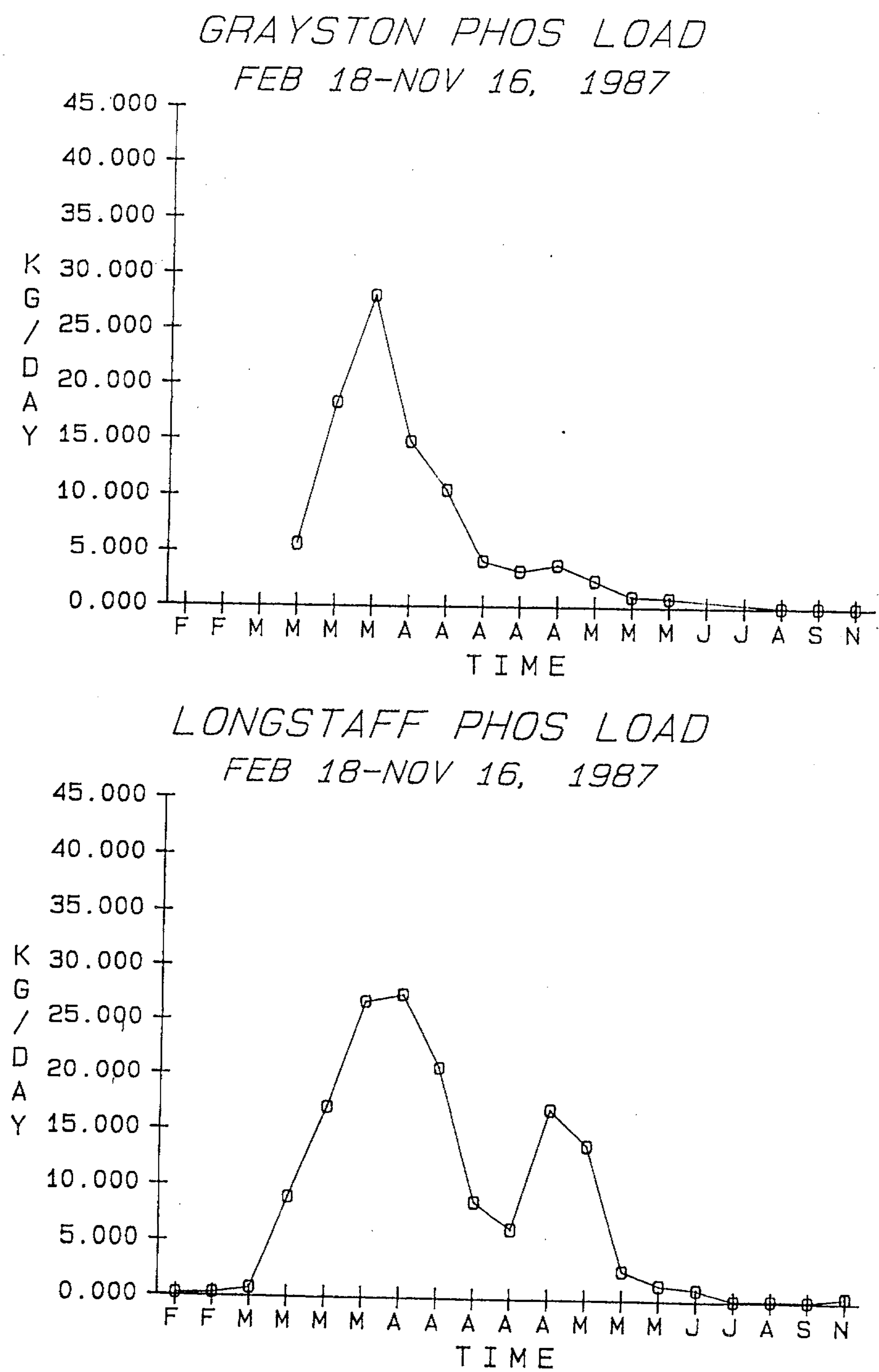
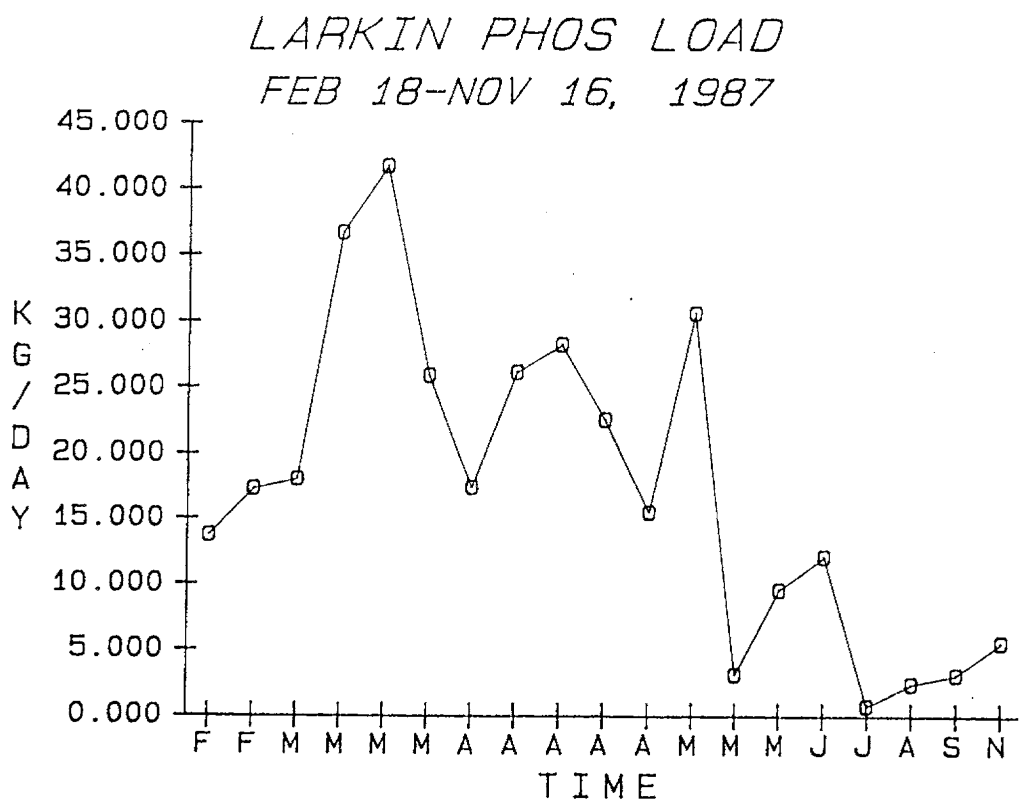


FIGURE 5.2 1987 PHOSPHORUS LOADINGS IN DEEP CREEK AT LARKIN AND HIGHWAY 97



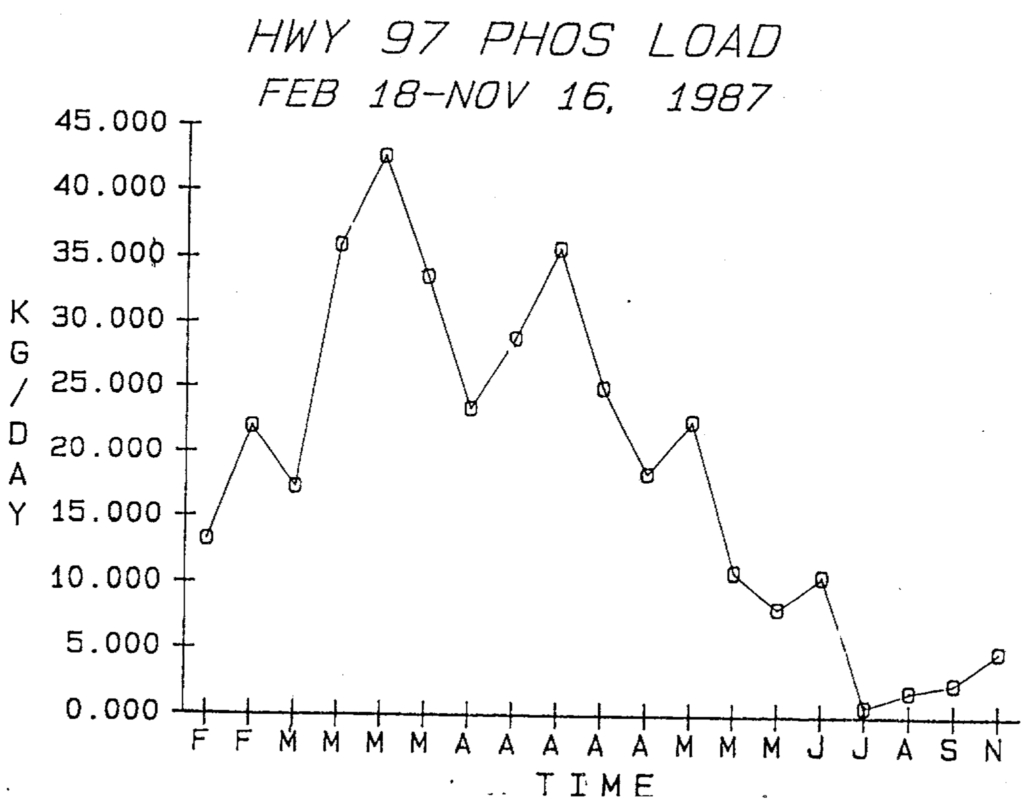
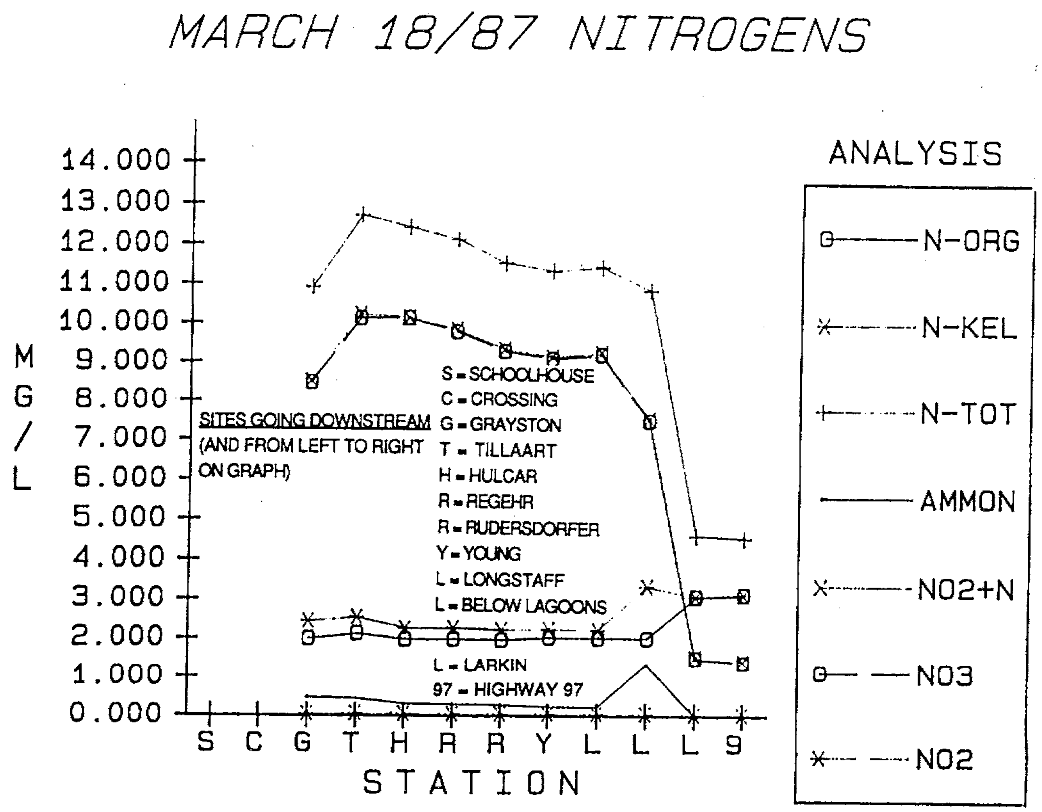


FIGURE 6.1 NITROGEN CONCENTRATIONS ALONG DEEP CREEK IN SPRING AND SUMMER



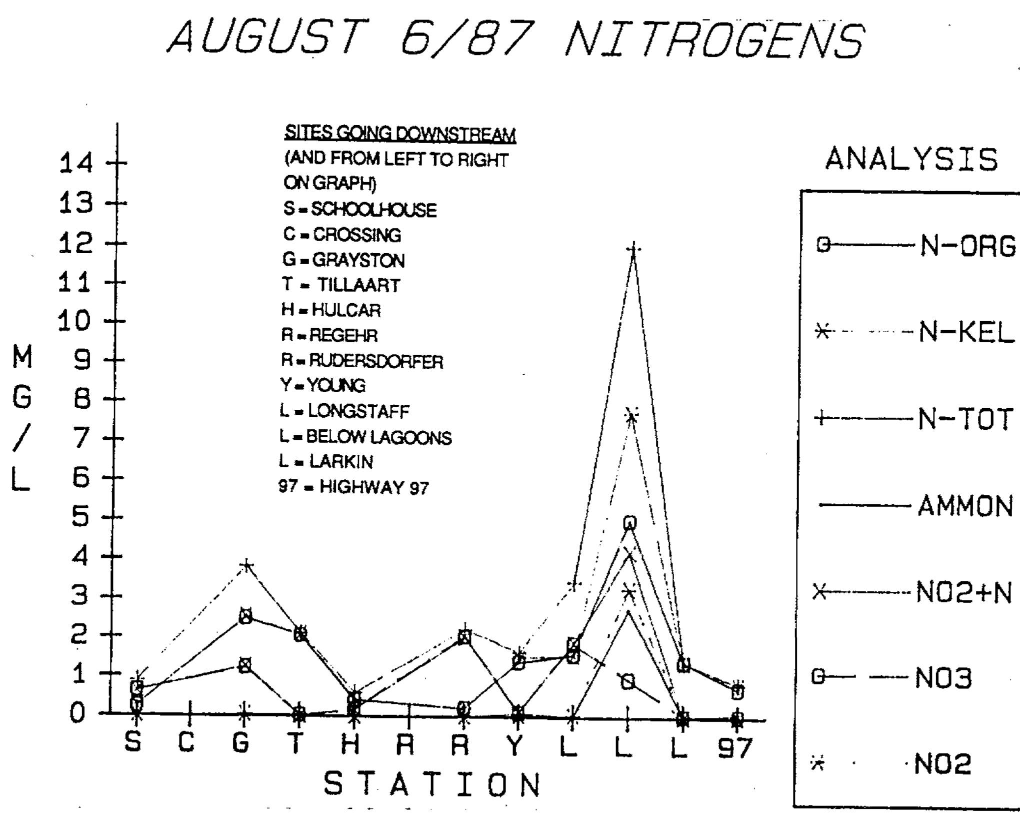
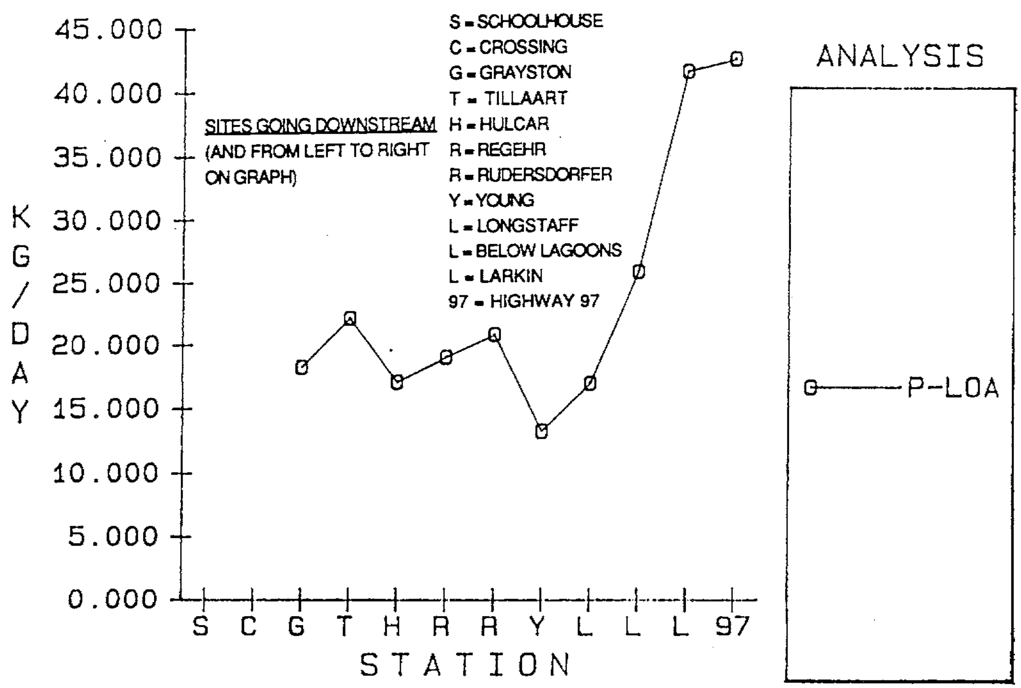


FIGURE 6.2 PHOSPHORUS LOADINGS ALONG DEEP CREEK IN SPRING AND SUMMER

MARCH 18/87 PHOS LOAD



AUGUST 6/87 PHOS LOAD

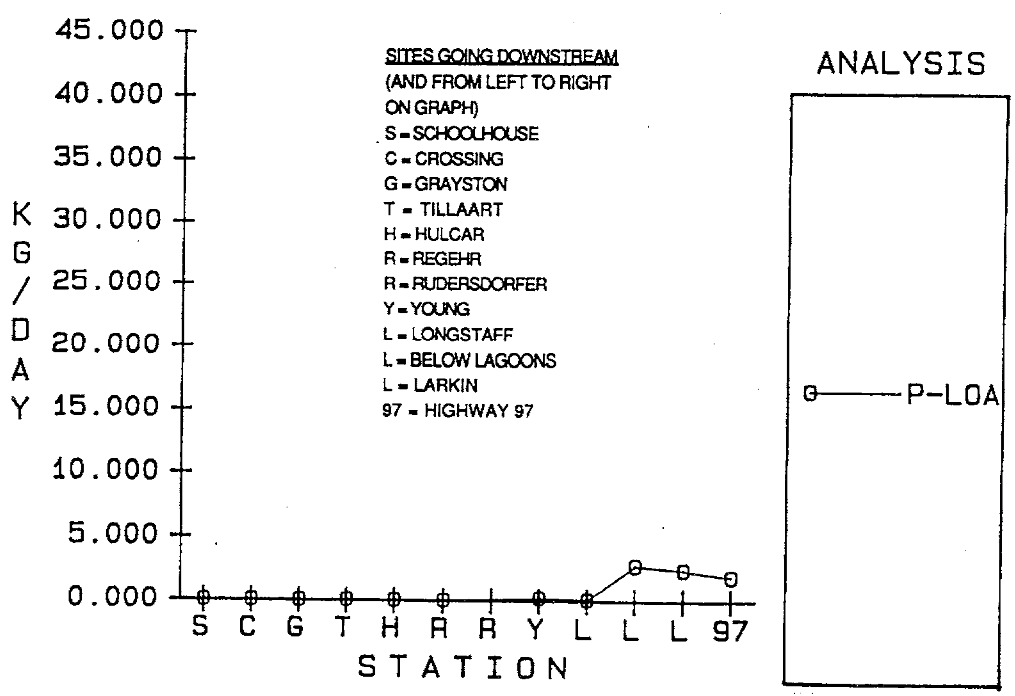


TABLE 4.1

EFFLUENT DATA SUMMARY FOR ARMSTRONG STP (PE 75) FOR THE PERIOD 1985 - 1991

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Chloride	27	54.3	37.3	44.1	4.58
Coliforms-fecal (CFU)	10	7600	<2	134+	-
-FECAL (MPN)	9	2300	11	79+	-
Hardness					
-calcium	25	65.8	40.8	52.5	7.3
-magnesium	25	18.6	5.94	11	3.2
Metals					
-aluminum(total)	19	4.91	0.06	1.88	1.55
-chromium(total)	25	0.01	<0.01	<0.01	-
-copper (total)	25	0.04	<0.01	<0.01	-
-iron (total)	25	0.59	0.11	0.30	0.10
-manganese (total)	25	0.09	0.04	0.06	0.01
-molybdenum(total)	25	0.02	<0.01	<0.01+	-
-lead (total)	25	<0.1	<0.1	<0.1	-
-nickel (total)	25	<0.05	<0.05	<0.05	-
-zinc (total)	25	0.32	<0.01	0.03	0.06
Nitrogen-ammonia	28	37.1	10.7	26.1	6.74
-nitrate/nitrite	28	1.82	0.02	0.30	0.38
-nitrite	28	0.91	0.01	0.15	0.21
-Kjeldahl	28	43.6	14.5	31.2	6.6
Oxygen-BOD5	28	77	<10	18.4	13.5
pH	28	8.2	7.1	7.4+	-
Phosphorus					
-ortho diss	27	6.52	1.32	3.38	1.39
-dissolved	28	7.14	1.44	3.6	1.4
-total	28	7.98	3.04	5.6	1.3
Solids-suspended	26	79	10	35	15.8
Specific Cond.	28	1000	720	840	66.6
Sulphate	27	114	52.5	88.3	16.5

+ Median Value
VALUES ARE AS mg/L EXCEPT:
1.)pH
2.)SPECIFIC CONDUCTIVITY AS µS/cm

TABLE 6.1

AMBIENT WATER QUALITY DATA SUMMARY FOR EQUESIS CREEK AT WESTSIDE ROAD (SITE 0500028) FOR THE PERIOD 1985 - 1991

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Alkalinity	25	219	68.3	181.3	36.9
Carbon-total org	21	18	<1	5	5
-inorganic	1	21	-	-	-
Chloride	19	1.4	0.5	0.8	0.19
Coliforms-fecal	9	350	<2	33+	-
Colour (TAC)	9	17	2	6.3	4.6
Hardness-total	27	257	72.7	193.8	44.9
-calcium	28	63	19.4	49.1	10.5
-magnesium	26	26	4	17.1	5.1
Metals					
-cadmium (d)	14	0.0019	<0.0001	0.0005	0.0005
-chromium (d)	11	<0.005	<0.005	<0.005	-
-copper (diss)	11	0.007	<0.001	0.003	0.002
-copper (total)	7	0.005	<0.001	0.002	0.001
-iron (diss)	17	0.7	<0.01	0.11	0.16
-iron (total)	5	2.1	<0.1	0.58	0.86
-lead (diss)	11	0.009	<0.001	0.003	0.002
-manganese (d)	14	<0.02	<0.01	<0.01+	-
-mercury (total)	12	0.00005	<0.00005	<0.00005+	-
-nickel (diss)	10	0.08	<0.01	<0.01+	-
-zinc (diss)	14	0.12	<0.005	0.016	0.031
-zinc (total)	5	0.026	<0.005	0.009	0.009
Nitrogen-ammonia	23	0.57	<0.005	0.033	0.117
-nitrate	11	0.23	0.014	0.114	0.072
-nitrate/nitrite	23	0.48	0.07	0.19	0.086
-nitrite	22	<0.005	<0.005	<0.005	-
-organic	32	1	<0.01	0.18	0.19
-Kjeldahl	25	2	<0.01	0.24	0.39
-total	31	0.78	0.13	0.33	0.13
Oxygen-dissolved	19	15.2	9.7	11.9	1.4
pH	46	8.9	7.3	8.3+	-

TABLE 6.1
CONTINUED

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Phosphorus-ortho	14	0.087	0.013	0.029	0.017
-dissolved	15	0.105	0.02	0.037	0.026
-total	33	0.289	0.023	0.058	0.053
Potassium	21	3.6	1.7	2.8	0.4
Sodium	24	10.5	4	8.5	1.85
Solids-total	23	426	180	264	51.4
-dissolved	12	326	138	268	55.7
-suspended	26	294	1	20	56.8
Specific Cond.	49	560	120	379	103
Sulphate	23	53	12.8	36.4	11.8
Temperature	26	13	1	7	3.3
Turbidity	24	21	0.5	2.9	4.5

VALUES ARE AS mg/L EXCEPT:
1) COLOUR AS TAC units
2.)COLIFORMS AS CFU/cL
3.)pH
4.)SPECIFIC CONDUCTIVITY AS µS/cm
5.)TEMPERATURE AS °C
6.)TURBIDITY AS NTU

+ Median Value

TABLE 6.2
MAXIMUM CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N) (Reference 6.6)

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

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 6.3
AVERAGE 30-DAY CONCENTRATION OF TOTAL AMMONIA NITROGEN FOR PROTECTION OF AQUATIC LIFE (mg/L-N) (Reference 6.6)

pH	Temp. 0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
6.5-7.1	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

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 6.3.
- each measured value is compared to the corresponding individual values in Table 6.3. No more than one in five of the measured values can be greater than one-and-a-half times the corresponding objective values in Table 6.3.

TABLE 6.4

MAXIMUM AND 30-d AVERAGE NITRITE (N) CONCENTRATIONS TO PROTECT AQUATIC LIFE (Reference 6.6)

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

*the 30-d average chloride concentration should be used to determine the appropriate 30-d average nitrite objective.

TABLE 6.5
AMBIENT WATER QUALITY DATA SUMMARY FOR DEEP CREEK NEAR THE MOUTH (SITE 0500020)

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Alkalinity	34	304	114	232.5	42.8
Carbon-total	33	27	<1	12.4	8.0
-inorganic	5	65	50	59.2	7.53
Chloride	59	12.4	2.7	5.7	2.2
Coliforms-fecal	44	1600	<2	49+	-
Colour (TAC)	20	64	9	24.4	12.8
Hardness-total	35	443	173	324	51.1
-calcium	46	106	40.4	77.9	12.4
-magnesium	45	48.3	10.9	29.1	7.9
Metals					
-aluminum(total)	33	2.0	<0.02	0.50	0.52
-cadmium (diss)	17	0.018	<0.0001	<0.0005+	-
-chromium(diss)	11	<0.005	<0.005	<0.005	-
-copper (diss)	14	0.02	<0.001	0.005	0.005
-copper (total)	46	0.03	<0.001	<0.01+	-
-lead (dissolved)	15	0.026	<0.001	<0.003+	-
-lead (total)	5	0.006	<0.001	0.0026	0.0023
-iron (diss)	23	0.4	0.04	0.13	0.08
-iron (total)	47	2.99	0.1	0.90	0.84
-lead (diss)	15	0.026	<0.001	<0.003+	-
-manganese(diss)	18	0.42	0.06	0.16	0.09
-manganese(total)	44	0.31	0.05	0.18	0.06
-mercury (total)	15	0.11	0.02	<0.05+	-
-molybdenum(total)	41	0.04	0.0025	0.02	0.01
-nickel (total)	41	<0.05	<0.01	<0.05+	-
-zinc (diss)	18	0.11	<0.005	0.021	0.026
-zinc (total)	48	0.02	<0.005	<0.01+	-
Nitrogen-ammonia	72	1.81	<0.005	0.40	0.47
-nitrate	15	0.91	<0.02	0.28	0.23
-nitrate/ nitrite	76	2.0	<0.02	0.28	0.35
-nitrite	73	0.087	<0.005	0.019	0.017
-organic	56	2.76	0.11	0.94	0.54
-Kjeldahl	81	3.31	0.17	1.38	0.71

Table 6.5 (Continued)

CHARACTERISTIC	NO. OF VALUES	MAXIMUM	MINIMUM	MEAN	STD DEV
Oxygen-dissolved	25	12.0	6.4	9.2	1.58
pH	109	9.1	6.8	8.1+	-
Phosphorus					
-ortho diss	18	0.645	0.04	0.30	0.16
-dissolved	60	0.493	0.007	0.203	0.123
-total	90	0.876	0.114	0.349	0.137
Potassium	31	8.8	3.7	7.0	1.2
Sodium	36	32.1	6.2	20.1	4.8
Solids-total	41	666	264	493	76.7
-dissolved	40	664	225	475	72.4
-suspended	43	127	2	20	24.7
Specific Cond.	117	918	325	676	109
Sulphate	62	35.5	8.1	23.7	7.4
Tannin and Lignin	9	1.7	0.4	0.97	0.46
Temperature	39	22	0.5	9.7	6.0
Turbidity	73	35	1	8.6	7.4

VALUES ARE AS mg/L EXCEPT:
1) COLOUR AS TAC units
2.)COLIFORMS AS CFU/cL
3.)MERCURY AS µg/L
4.)pH
5.)SPECIFIC CONDUCTIVITY AS µS/cm
6.)TEMPERATURE AS °C
7.)TURBIDITY AS NTU

+ Median Value

TABLE 6.6
AMBIENT WATER QUALITY DATA SUMMARY FOR DEEP CREEK AT HIGHWAY 97 (SITE 0500769) FOR THE PERIOD 1987-1989

CHARACTERISTIC	NO. OF VALUES	MAXIMUM	VALUES MINIMUM	MEAN	STD DEV
Nitrogen-ammonia	33	1.16	<0.005	0.131	0.304
-nitrate/ nitrite	33	1.42	<0.005	0.28	0.43
-nitrite	33	0.051	<0.005	0.014	0.014
-Kjeldahl	33	4.75	0.77	2.39	1.06
pH	31	9.0	7.9	8.4+	-
Phosphorus					
-ortho diss	33	0.184	<0.003	0.045	0.054
-dissolved	33	0.226	0.021	0.073	0.056
-total	34	0.705	0.138	0.340	0.132
Solids-suspended	32	269	5	80	67.9
Specific Cond.	32	770	490	663	71.3
Turbidity	34	72	3.7	22.3	15.6

VALUES ARE AS mg/L EXCEPT:
1.)pH
2.)SPECIFIC CONDUCTIVITY AS µS/cm
3.)TURBIDITY AS NTU

+ Median Value

TABLE 6.7
AMBIENT WATER QUALITY DATA SUMMARY FOR DEEP CREEK AT LARKIN ROAD (SITE 0500768) FOR THE PERIOD 1987-1989

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Nitrogen-ammonia	33	1.41	<0.005	0.154	0.37
-nitrate/ nitrite	33	2.9	<0.02	0.34	0.62
-nitrite	33	0.068	<0.005	0.016	0.019
-Kjeldahl	33	4.27	1.17	2.51	0.82
pH	31	9.1	7.9	8.6+	-
Phosphorus					
-ortho diss	33	0.214	0.003	0.046	0.064
-dissolved	33	0.257	0.021	0.076	0.069
-total	34	0.516	0.18	0.346	0.094
Solids-suspended	32	183	11	67	48.8
Specific Cond.	32	780	462	616	71.9
Turbidity	34	44	5.3	20	11.9

VALUES ARE AS mg/L EXCEPT:
1.)pH
2.)SPECIFIC CONDUCTIVITY AS µS/cm
3.)TURBIDITY AS NTU

+ Median Value

TABLE 6.8

AMBIENT WATER QUALITY DATA SUMMARY FOR DEEP CREEK UPSTREAM FROM DAIRYLAND (SITE 0500258) FOR THE PERIOD 1973-1990

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Alkalinity	3	247	107	192	74.7
Carbon-total	13	28	2	12.2	8.8
-inorganic	2	61	25	43	-
Chloride	41	35.3	2.5	10.3	8.3
Coliforms-fecal	43	81 000	<2	195+	-
Colour (TAC)	12	54	9	25.6	12.3
Hardness-total	33	371.3	141	287.8	59.1
-calcium	34	119	42.7	84.1	17.4
-magnesium	33	28.2	8.36	18.4	5.34
Metals					
-aluminum(total)	24	3.2	<0.02	0.78	0.98
-chromium (total)	32	0.02	<0.005	0.01	0.003
-copper (total)	30	0.04	<0.01	<0.01+	-
-iron (total)	31	12.1	0.09	1.71	2.58
-lead (total)	31	<0.1	<0.001	<0.1+	-
-manganese (total)	30	0.77	0.03	0.17	0.13
-molybdenum(total)	31	0.08	0.0064	<0.01	-
-nickel (total)	30	<0.05	<0.05	<0.05	-
-zinc (total)	31	0.46	<0.01	0.035	0.086
Nitrogen-ammonia	58	0.955	<0.005	0.137	0.207
-nitrate	8	0.54	0.13	0.29	0.13
-nitrate/ nitrite	55	4.35	0.11	0.87	0.80
-nitrite	61	0.053	<0.005	0.014	0.010
Oxygen-dissolved	7	13.9	9.1	11	1.8
pH	67	8.9	6.8	8.0+	-
Phosphorus					
-ortho diss	2	0.136	0.076	0.106	-
-dissolved	54	0.486	0.043	0.113	0.089
-total	63	0.756	0.057	0.186	0.152
Solids-total	13	452	334	416	35.5
-dissolved	2	422	262	342	-
-suspended	13	164	1	30	47.2
Specific Cond.	70	880	233	593	144

Table 6.8 (Continued)

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Sulphate	34	179	45.5	92.3	29
Temperature	14	20	1	11.6	6.2
Turbidity	51	148	1	14.5	23.4

VALUES ARE AS mg/L EXCEPT:
1) COLOUR AS TAC units
2.)COLIFORMS AS CFU/cL
3.)pH
4.)SPECIFIC CONDUCTIVITY AS µS/cm
5.)TEMPERATURE AS °C
6.)TURBIDITY AS NTU

+ Median Value

TABLE 6.9

AMBIENT WATER QUALITY DATA SUMMARY FOR VERNON CREEK AT OUTLET FROM KALAMALKA LAKE (SITE 0500089) FOR THE PERIOD 1971-1989

CHARACTERISTIC	NO. OF VALUES	VALUES MAXIMUM	MINIMUM	MEAN	STD DEV
Alkalinity	38	152	140	147.2	2.7
Carbon-total	22	10	<1	5.3	3.1
-inorganic	5	40	37	37.8	1.3
Chloride	36	4.4	1.4	2.2	0.6
Coliforms-fecal	56	570	2	6+	-
-E. Coli	56	543	2	28.6	83.7
-Streptococci	56	1230	2	9+	-
Colour (TAC)	4	4	<1	1.75	1.5
Hardness-total	26	172	149	164	5.5
-calcium	10	45	35.5	38.7	3.0
-magnesium	26	19.3	16	17.7	0.83
Metals					
-aluminum (total)	7	0.09	<0.02	<0.02+	-
-cadmium (diss)	9	0.0009	0.0001	0.0004	0.0003
-chromium (diss)	8	<0.005	<0.005	<0.005	-
-copper (diss)	10	0.01	<0.001	0.003	0.003
-iron (total)	10	0.3	0.04	0.128	0.090
-lead (diss)	10	0.005	<0.001	<0.001+	-
-manganese (diss)	10	<0.02	<0.01	<0.01+	-
-mercury (total)	12	0.07	<0.05	<0.05+	-
-molybdenum (total) 7	0.02	0.0074	0.012	0.005	
-zinc (diss)	10	0.13	<0.005	<0.005+	-
-zinc (total)	3	<0.005	<0.005	<0.005	
Nitrogen-ammonia	44	0.041	<0.005	0.008	0.007
-nitrate	13	0.09	<0.02	0.03	0.02
-nitrate/ nitrite	44	0.14	<0.02	0.05	0.03
-nitrite	29	0.011	<0.005	<0.005+	-
-organic	28	0.41	0.09	0.20	0.074
-Kjeldahl	50	0.42	0.13	0.22	0.057
Oxygen-dissolved	50	15.2	4.9	11	2.0
pH	97	8.8	7.5	8.3+	-