CANADA - BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

TASK 139

(Part Thereof)

Influence of Septic Tank Effluent on Receiving Water Nutrient Gain from Groundwater

by

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N O T I C E

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S U M M A R Y

Septic tank and related ground discharge of sewage can contribute to nutrient loadings in the surface waters of the Okanagan Basin. Transport of these nutrients involves downward movement through unsaturated soils to the water table, and then horizontal movement with the groundwater to a surface water course. In order to estimate the influence of this nutrient source on the basin, it was necessary to do three things:

a) determine the number and relative density of septic tanks throughout the basin;
b) assess the parameters that affect the vertical movement of nutrients through unsaturated soil. The two most important parameters were considered to be soil type and depth to water table;
c) determine the proximity of septic tanks to surface waters, and estimate the nutrient loadings that actually reach the mainstem lakes and the tributary streams, respectively.

The enumeration of septic tanks was accomplished by a combination of utilizing land use maps prepared by the various regional governments and direct field counting of residences.

The travel of nutrients through unsaturated soil was investigated with the help of a pilot-scale experiment in which simulated tile-field disposal of septic tank effluent was carried out over a six-month period of time. Three parallel units were used, each one containing a soil from an area of the valley which has a large number of septic tanks.

To aid the estimation of nutrient transport within the groundwater zone, all septic tank enumeration was split into categories of: less than 500 feet distant from surface waters in sub-basins that drain directly to mainstem lakes and rivers; less than 500 feet distant from surface waters in sub-basins than drain to tributary streams; and greater than 500 feet distant from surface waters in direct drainage sub-basins and tributary sub-basins, respectively.

As a result of this work, the basin-wide loadings were found to be as follows:

	Applied to Soil	Reaching Groundwater	Reaching Receiving Waters
Total Kjeldahl Nitrogen.	497,000 lb/yr	20,000 lb/yr	11,500 lb/yr
Nitrate Nitrogen........	negligible	108,000 lb/yr	87,600 lb/yr
Total Phosphorous.......	137,000 lb/yr	31,800 lb/yr	18,800 lb/yr
Dissolved Ortho-Phosphorous........	104,000 lb/yr	24,500 lb/yr	15,000 lb/yr

Of the amounts of nutrients that are shown to finally reach surface waters, the fractions that enter the mainstem lakes or rivers directly are estimated to be 70% for all four nutrient forms considered.

By far the least accurate part of the study was the estimations of the amounts of septic tank nutrients transported by the groundwater to lakes or streams. If the management alternatives for the basin are found to be sensitive to the calculated septic tank figures, then more work should be undertaken before any final decisions are made.

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SECTION 1

INTRODUCTION

PURPOSE

In order to suggest methods by which the input of major nutrients to the receiving waters of the Okanagan Valley can be controlled, it is first necessary to know how much nutrients are originating from various sources which are capable of being controlled. Septic tank effluent as dispersed via tile fields certainly contains sufficient quantities of nutrients (when considered collectively throughout the study area) to potentially be a major contributor of nutrients. The project discussed in this report was implemented to accomplish two main purposes: firstly, to determine the total amounts of major nutrients which are contained in the septic tank effluents of the Valley; and secondly, to estimate how much of these loadings actually reach the receiving waters via groundwater.

GENERAL PROCEDURE

The determination of total amounts of major nutrients present in septic tank effluents required that a septic tank count of the entire valley be carried out. This survey was carried out by getting as much information as possible from maps in the various District and Municipal offices, with a considerable amount of field counting being required to fill in the blanks and check the validity of the available maps. The nutrient content of septic tank effluent was estimated by analyzing the effluent of a "representative" septic tank, and by calculating the per capita nutrient contents of the raw sewage entering the Vernon and Penticton sewage treatment plants.

Estimating the amount of applied nutrients that finally get into the surface waters of the valley involves the considerations of many parameters, the most important of these probably being: depth of unsaturated soil above the water table; soil characteristics; and proximity of tile fields to surface waters. Adequate understanding of the vertical movement of nutrients through unsaturated soils and the horizontal movement through saturated soils had to be obtained so that the effects of the above-mentioned parameters could be reasonably estimated. Furthermore, mapping of the Okanagan Valley drainage basin relative to major soil types, and depth to groundwater, had to be undertaken in order for the final calculations to be carried out. This latter information was actually gathered by that portion of the Task 139 group investigating nutrient inputs to groundwater from agricultural practices, and details of the procedures involved can be found in the report entitled "Estimate of Nutrient Contributions to Receiving Waters from Agricultural Sources via Groundwater Transport".

SECTION II

GEOGRAPHICAL DISTRIBUTION OF NUTRIENTS FROM SEPTIC TANK EFFLUENTS

ENUMERATION OF SEPTIC TANKS

Tha amount of septic tank effluent being applied to the ground in the Okanagan Valley drainage basin has been approximated by obtaining a count of residential, commercial, and tourist-oriented establishments that dispose of liquid effluent in this manner. A substantial portion of this data was available from land use maps in Municipal and Regional offices throughout the Valley. There was, however, a considerable amount of direct field counting of residences required to ensure that reliable data was available for all the potentially important areas of the Valley. The only regions not investigated were the hinterlands of the basin where concentrations of septic tanks are low, and the distances to groundwater or surface water are large. It was decided that the potential input of nutrients from these regions is so small that the work involved in collecting the data was unwarranted.

Data obtained from the existing land use maps and from the field enumeration was transposed onto transparent overlays of the Valley. These overlays were primarily at a scale of 1" = 1000 feet, with a few being at a scale of 1" = 1320 feet. Boundaries of the various drainage sub-basins were plotted on the overlays, as well as the positions of lakes, rivers and streams of the Okanagan basin. There overlays were designed to be used in conjunctions with base maps of the Valley which show water table elevations and soil types.

Simultaneous examinations of the maps will allow estimates to be made of the percentages of applied nutrients that reach the receiving waters.

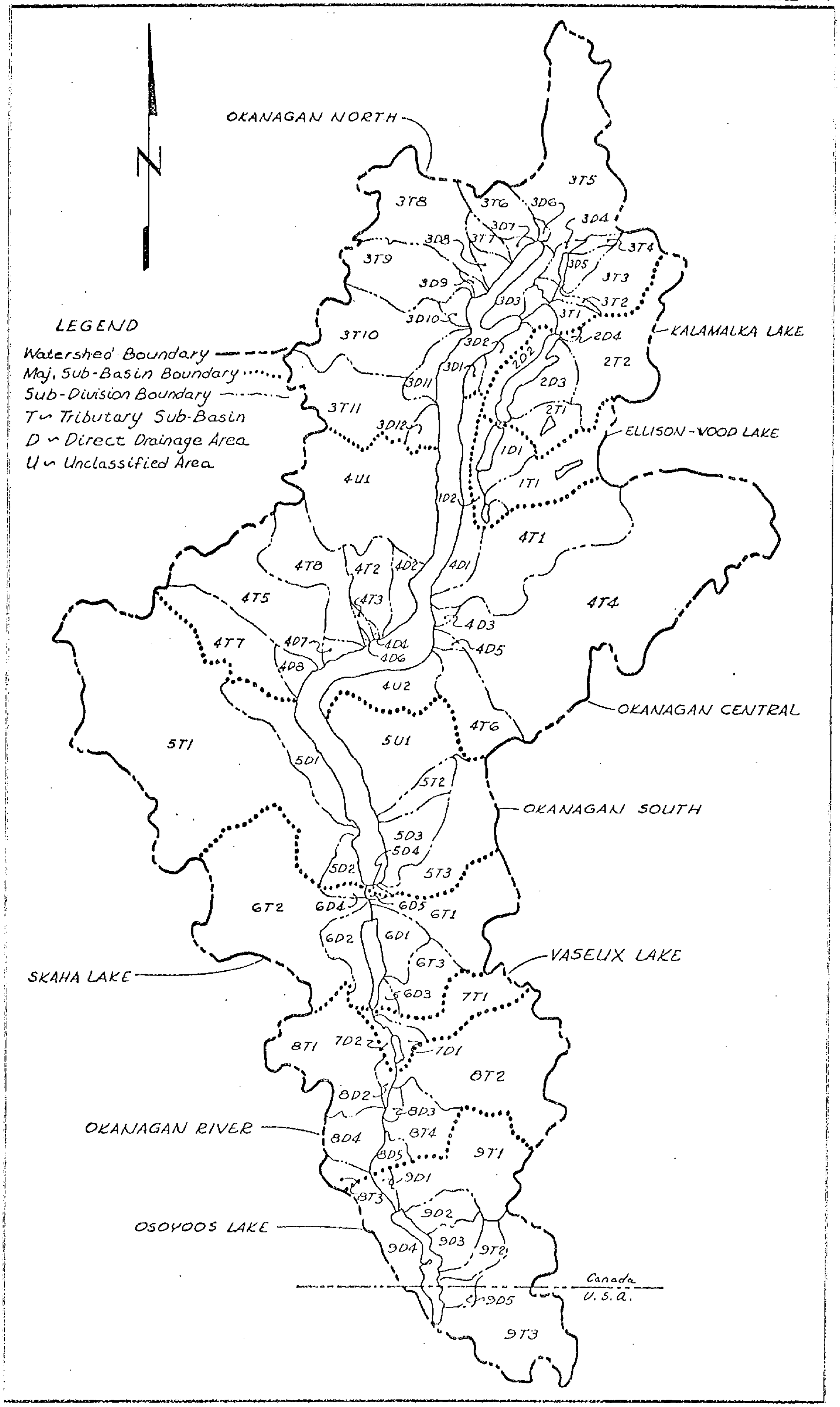
Table 2 shows a summary of the number of "equivalent single family units" that are serviced by septic tanks in each of the sub-basins, with the locations of the sub-basins being indicated on Figure 1. An "equivalent single family unit" can be defined as that concentration of activity that produces the same nutrient loading to the soil as an average single family residence. A ten-unit apartment building would therefore be considered to be 10 equivalent single family units, whereas a ten-unit motel or a ten-unit campsite would be somewhat less in effect. Some of these conversion factors have been somewhat arbitrarily assigned, but the effect on the study conclusions of any possible error in the conversion factors is considered minimal.

NUTRIENT LOADINGS PER UNIT

When dealing with the nutrient content of domestic sewage, it is essential that information for local conditions be obtained. Published data for other parts of North America are not acceptable, primarily because the different laws respecting additives in detergents can have a marked effect on nutrient content in sewage. The nitrogen and phosphorous content of Okanagan sewage was calculated in three ways: from analysis of septic tank effluent originating from a family-type apartment near Vernon; from long-term analyses available on effluent from the Vernon sewage treatment plant; and from available analyses of raw sewage at the Penticton sewage treatment plant.

FIG. I

DRAINAGE BASINS & SUB-BASINS IN OKANAGAN VALLEY.



The apartment building chosen has eleven units with a total of 28 residents during the period of this study. Since each suite has its own laundry facilities, and since garbage grinders are not being used, it is considered to be representative of average dwelling units in the Okanagan Valley. The results of some thirty analyses of the septic tank effluent during 1972 gave rise to the following average concentrations:

Total Kjeldahl Nitrogen (asN) = 32 mg/l (this was well over 99% of all nitrogen forms present)

Total phosphorous (asP) = 7.8 mg/l

Dissolved ortho phosphorous (asP) = 6.8 mg/l

Dircct measurment of the amount of sewage leaving the septic tank was not undertaken, but water consumption rates in the apartment building were found to be 37 Imperial gallons per capita per day from December 1971 to February 1972. Table I shows the results of calculations based on this flow rate, and the winter season concentrations of nutrients, which were higher than the averages given above (TKN = 38 mg/l; Total P = 9.2 mg/l; and Dissolved ortho P = 8.1 mg/l).

Nitrogen and phosphorous data for Vernon sewage is limited to that present in the sewage treatment plant effluent. However, the slight loss in nutrients as the sewage passes through the treatment plant will probably more or less compensate for the nutrients that get into the sewage from non-residential sources in Vernon. Knowing the average daily flow through the plant, and the sewered population in the City, the per capita contributions shown in Table I were calculated.

Data prepared by others[1] indicates that the total average amount of nutrients entering the Penticton plant each day is 420 lb. of total phosphorous (as phosphate). With a known sewered population of 16,000, the per capita values shown in Table 2 were derived.

TABLE 1

Per Capita Contributions of Nutrients

	Apartment Building 37 Igpcpd	Vernon STP	Penticton STP	From Zanoni and Rutkowski[2]	Design Value Used in Study
Total N	.014 lb/day	.021 lb/day	.026 lb/day	.0202	.020 lb/day
Total P	.0035 lb/day	.0061 lb/day	.0062 lb/day	.0082	.0055 lb/day
Diss. Ortho P	.0030 lb/day	.0052 lb/day	--------	.0040	.0042 lb/day

TOTAL NUTRIENT LOADINGS

Available data on population of the Okanagan Valley indicates that the average number of residents per single family dwelling is about 3.5. Using this factor and the data in Table I, septic tank counts were converted into nutrient loadings for each of the sub-basins. These loadings are summarized in Table 2.

The 1971 census data for the Okanagan Valley indicates that the total basin population is 113,500. A combination of census data and flow data from the various sewage treatment plants reveals that the sewered

TABLE 2

SUMMARY OF NUTRIENT LOADINGS FROM SEPTIC TANKS

Sub-basin Number (see Fig. I)	Equiv. Single Family Units (SFU)		Population		TKN lb./yr.		Total P lb./yr.		Diss. Ortho P lb./yr.		Nitrate N lb./yr.
	<500' from water	>500' from water	<500'	>500'	<500'	>500'	<500'	>500'	<500'	>500'	<500' >500'
1D1	88	199	308	697	2050	4610	620	1400	470	1070	
1D2	453	390	1586	1366	10550	9050	3190	2740	2430	2100	
1T1	0	2	0	7	0	50	0	10	0	10	
Σ					12600	13710	3810	4150	2900	3180	negligible
2D2	102	112	357	392	2370	2600	720	790	550	600	
2D3	51	99	179	347	1190	2300	360	700	280	530	
2D4	68	33	238	115	1580	760	480	230	370	180	
2T1	78	24	273	84	1810	560	550	170	420	130	
2T2	295	314	1033	1099	6840	7380	2070	2210	1580	1690	
Σ					13790	13600	4180	4100	3200	3130	negligible
3D2	250	46	875	161	5800	1070	1760	330	1340	250	
3D3	113	11	396	39	2630	260	800	80	610	60	
3D4	15	22	53	77	350	510	110	160	80	120	
3D5	18	120	63	420	420	2790	130	840	100	640	
3D6	0	3	0	11	0	70	0	20	0	20	
3D7	0	59	0	207	0	1390	0	420	0	320	
3T1	231	530	809	1855	5470	12280	1620	3720	1240	2840	
3T2	51	207	179	725	1190	4810	360	1460	280	1110	
3T3	130	335	455	1173	3020	7770	920	2360	700	1800	
3T4	0	42	0	147	0	980	0	300	0	230	
3T5	40	442	140	1547	930	10270	280	3100	210	2370	
3T6	0	12	0	42	0	280	0	90	0	70	
Σ					19810	42480	5980	12880	4560	9830	negligible
4D1	201	30	704	105	4680	700	1420	210	1080	160	
4D2	257	430	899	1505	5960	9990	1810	3020	1380	2300	
4D3	499	386	1747	1351	11600	8960	3510	2710	2680	2070	
4D4	227	42	795	147	5270	980	1600	300	1220	230	
4D5	285	289	998	1012	6600	6700	2000	2030	1530	1550	
4D6	26	58	91	203	600	1340	180	410	140	310	
4D7	61	148	214	518	1420	3430	430	1040	330	790	
4D8	414	49	1449	172	9600	1140	2910	350	2220	2670	
4T1	108	2423	378	8481	2510	56100	760	17000	580	12980	
4T2	10	15	35	53	230	350	70	110	50	80	
4T3	6	138	21	483	140	3200	40	970	30	740	
4T4	260	501	910	1754	6030	11560	1830	3520	1400	2760	
4T5	61	0	214	0	1410	0	430	0	330	0	
4T6	215	78	753	273	4990	1810	1520	550	1160	420	
4T8	25	121	88	424	580	2810	180	860	140	660	
4U2	128	91	448	319	2970	2110	900	640	690	490	
Σ					54590	111180	19590	33920	14960	28210	negligible
5D1	421	1646	1474	5761	9770	38200	2970	11550	1880	8820	
5D2	72	63	252	221	1670	1460	510	440	390	340	
5D3	105	197	368	689	2440	4560	740	1290	560	980	
5T1	29	269	102	942	680	6240	210	1900	160	1450	
5T4	87	27	304	95	2020	630	610	190	470	150	
5T5	25	5	88	18	580	120	180	40	140	30	
5U1	169	22	592	77	3920	520	1090	160	830	120	
Σ					21080	51730	6310	15570	4430	11890	negligible
6D1	43	180	151	630	1000	4180	300	1270	230	920	
6D2	150	182	525	637	3480	4210	1060	1280	810	980	
6D3	151	151	529	529	3500	3500	1070	1070	820	820	
6T1	29	76	102	266	680	1760	210	540	160	410	
6T3	8	0	28	0	190	0	60	0	50	0	
Σ					8850	13650	2700	4160	2070	3130	negligible
7D1	54	11	189	39	1250	260	380	80	290	60	
7D2	1	3	4	11	30	70	10	20	10	20	
7T1	67	115	235	403	1560	2670	470	810	360	620	
Σ					2840	3000	860	910	660	700	negligible
8D2	31	37	109	130	720	860	220	260	170	200	
8D3	115	64	403	224	2690	1480	810	450	620	340	
8D4	113	439	396	1537	2620	10180	800	3090	610	2360	
8T1	46	28	161	98	1070	650	320	200	240	150	
8T2	13	76	46	266	300	1760	90	540	70	410	
8T3	7	10	25	35	170	230	50	70	40	50	
8T4	1	1	4	4	30	30	10	10	10	10	
Σ					7600	15160	2300	4620	1760	3520	negligible
9D1	28	30	98	105	650	700	200	210	150	160	
9D3	146	155	512	543	3390	3600	1030	1100	790	840	
9D4	436	689	1526	2413	10100	16000	3060	4840	2340	3690	
9T1	1	1	4	4	30	30	10	10	10	10	
9T2	6	5	21	18	140	120	40	40	30	30	
Σ					14310	20450	4340	6200	3320	4730	negligible

population of the valley amounts to about 51,000, leaving some 62,500 people serviced by septic tanks. This latter figure includes the sewered areas of Rutland and Osoyoos. They are included under septic tank areas, however, because ground disposal of effluent is practised in both cases, and hence should be taken into account as potential contributors to nutrients in groundwater.

The total equivalent septic tank population shown on Table 2 amounts to some 68,000. This compares very favourably with the census figure of 62,500, especially when it is realized that the count of 68,000 people includes the equivalent average annual tourist population that contributes to septic tank discharges.

SECTION III

EFFECT OF SOIL TYPE ON NUTRIENT MOVEMENT THROUGH UNSATURATED SOIL

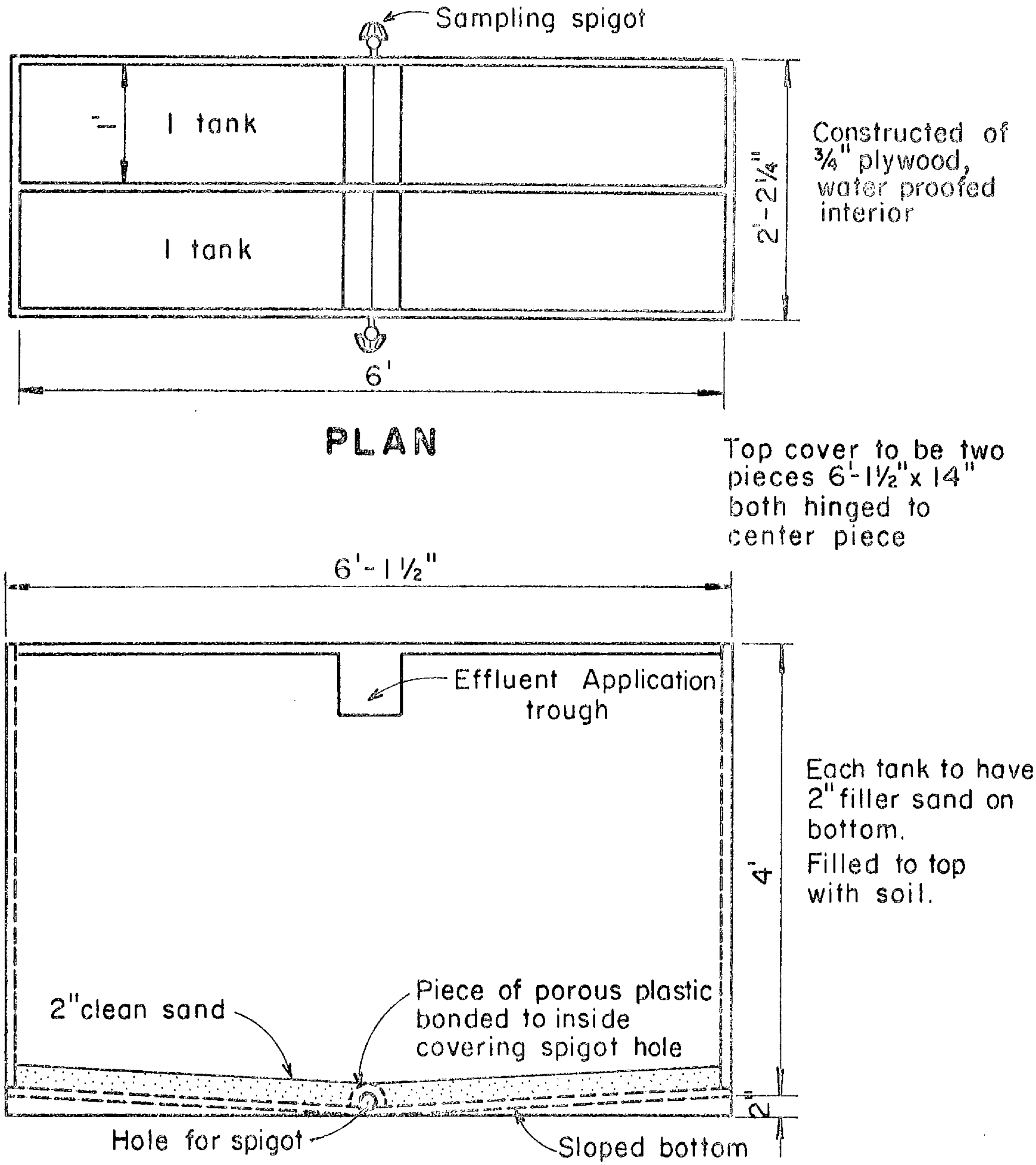
In order to estimate the amount of nutrients which move vertically through the unsaturated soil column from the point of application of the septic tank effluent to the groundwater table, some pilot scale experimentation was necessary. With the help of the District Office of the Soils Division of the Provincial Department of Agriculture, three soils typical of conditions in areas of the Valley where septic tanks are common were chosen for testing.

DESCRIPTION OF TEST FACILITY

With the cooperation of the City of Vernon, an addition to the storage building at the Vernon sewage treatment plant was constructed to house the lysimeter units. These units were constructed to simulate four one-foot lengths of septic tank tile fields (see Figure II). Each of the four boxes so constructed were water proofed with coal-tar epoxy approved for use in potable water systems. In addition to the entire assembly being inside a building, hinged covers were attached to each lysimeter tank, thus reducing the evaporation losses as much as possible, and hence approximating natural conditions in a tile field. The sloping bottoms were lined with two to three inches of clean uniformly graded sand (0.15 mm. average diamater), so that water which percolated down through the soil could flow to the collection spigot without significant disruption of the

FIG. II

SEPTIC TANK LYSIMETER DESIGN



ELEVATION

stream lines in the soil itself. It would thus simulate an extensive tile field in which the flow is downward toward a free groundwater surface. One of the lysimeter tanks was constructed with leachate collection trays and spigots at three elevations, to enable the rate of movement of impurity "fronts" to be determined.

The soils selected to be placed in the lysimeter tanks were a loamy sand from Pine Grove Estates in Kelowna, a silty loam from the Coldstream Creek area, and a relatively clean sand from lower Summerland. The loamy sand was placed in tanks #1 and #2 (with number 2 having collection trays and spigots at three levels), the silty loam was placed in tank #3, and the sand in tank #4. Descriptions of the sites from which the soils were obtained are included as Appendix I.

APPLICATION WATER

Septic tank effluent from Kalavista Terrace apartments was applied to the four lysimeter tanks on a daily basis. The daily application rate was that recommended in the Provincial Department of Health regulations, and was determined by in-situ permeability tests on the three soils as outlined in those same regulations. The actual application rates were as follows:

Lysimeter Tank # 1 .... 2.75 I.gal/week

Lysimeter Tank # 2 .... 2.75 I.gal/week

Lysimeter Tank # 3 .... 2.2 I.gal/week (1.1 I.gal/week prior to June 6)

Lysimeter Tank # 4 ....16.3 I.gal/week

The quality of the application water was determined on approximately a weekly basis during the course of the study (April 1 to October 31, 1972). Parameters measured were coliforms (total and fecal), nitrogen and phosphorous content, plus some ten other chemical entities for use in other studies. The results of these analyses are reported in a late sub-section of this report.

LEACHATE CHARACTERISTICS

All application water which leached through the soil to the sand layer was collected in hard plastic containers. The volume collected between application times was measured and recorded, so that water loss from leakage, evaporation, etc. would be known. Over the course of the study, the amount of lost water was no more than 20% of the amount applied (see Table 3).

The leachate quality parameters that are of concern to this study are coliform bacteria (as an indicator of bacterial contamination), nitrogen forms, and phosphorous forms. Generally, the other impurities in household septic tank effluents are a function of the water supply source, and not of the use to which the water has been put before release to the septic tanks.

Coliform analyses (both total and fecal) were performed on the septic tank effluent and on the lysimeter tank leachates at relatively constant intervals during the period of study. The number of analyses performed ranged from a low of 21 for the lower sampling spigot of lysimeter tank #2, to a high of 50 for the septic tank effluent (application

TABLE 3

QUANTITIES OF APPLICATION & LEACHATE LIQUID

Lysimeter No.	Period of Application	Month of Reward	Amount of Application Water (Imp. gal.)	Leachate Collected (Imp.gal.)
1	April 5, 1972 to Oct. 26, 1972	April 1972	8.4	5.3
		May 1972	11.5	9.2
		June 1972	12.1	11.5
		July 1972	11.0	11.0
		Aug. 1972	12.1	10.7
		Sept. 1972	11.5	9.8
		Oct. 1972	9.3	9.2
		Σ	75.9	66.7
2	May 1, 1972 to Oct. 26, 1972	May 1972	12.1	3.5
		June 1972	12.1	10.9
		July 1972	11.0	11.2
		Aug. 1972	12.1	11.7
		Sept. 1972	11.5	9.2
		Oct. 1972	9.3	8.0
		Σ	68.1	54.5
3	May 1, 1972 to Oct. 26, 1972	May 1972	4.8	4.7
		June 1972	9.0	5.7
		July 1972	8.3	7.4
		Aug. 1972	9.7	7.3
		Sept. 1972	9.2	7.2
		Oct. 1972	7.5	6.1
		Σ	49.0	38.4
4	May 1, 1972 to Oct. 26, 1972	May 1972	64.3	54.8
		June 1972	73.5	70.8
		July 1972	66.9	66.5
		Aug. 1972	73.5	67.3
		Sept. 1972	70.2	65.7
		Oct. 1972	56.9	57.6
		Σ	405.3	382.7

liquid). All coliform analyses were performed by the Provincial Laboratory of the Public Health in Vancouver, and procedures used were that laboratory's standard multiple tube fermentation technique.

The application liquid was found to have an average total coliform count of something greater than 2,400,000 bacteria per 100 ml., while the average fecal coliform count was in excess of 1,000,000 bacteria per 100 ml. No more difinitive numbers are possible because of the high percentage of tests in which all tubes incubated were found to be positive in gas production.

Efficiencies of the three selected soil types in removing coliform organisms can be seen by referring to Figures III, IV, V, VI, and VII. Because of the rather wild day to day fluctuations in coliform concentrations of the individual samples, it was decided to calculate "moving averages[3] for plotting on the figures listed above. The use of this technique smooths out the many sudden fluctuations, and allows the more important long term trends to be easily observed. Three things are readily apparent from the plotted graphs:

i) the removal efficiences of both total and fecal coliforms is in excess of 99.7 % for all three soil types;

ii) the finer textured soil in lysimeter #3 is consistently better than the coarser soils in its ability to remove coliforms;

iii) the trends in all four lysimeters is toward an increase in leachate coliforms content with time.

FIG. III
COLIFORM CONCENTRATIONS IN LEACHATE FROM LYSIMETER #1.

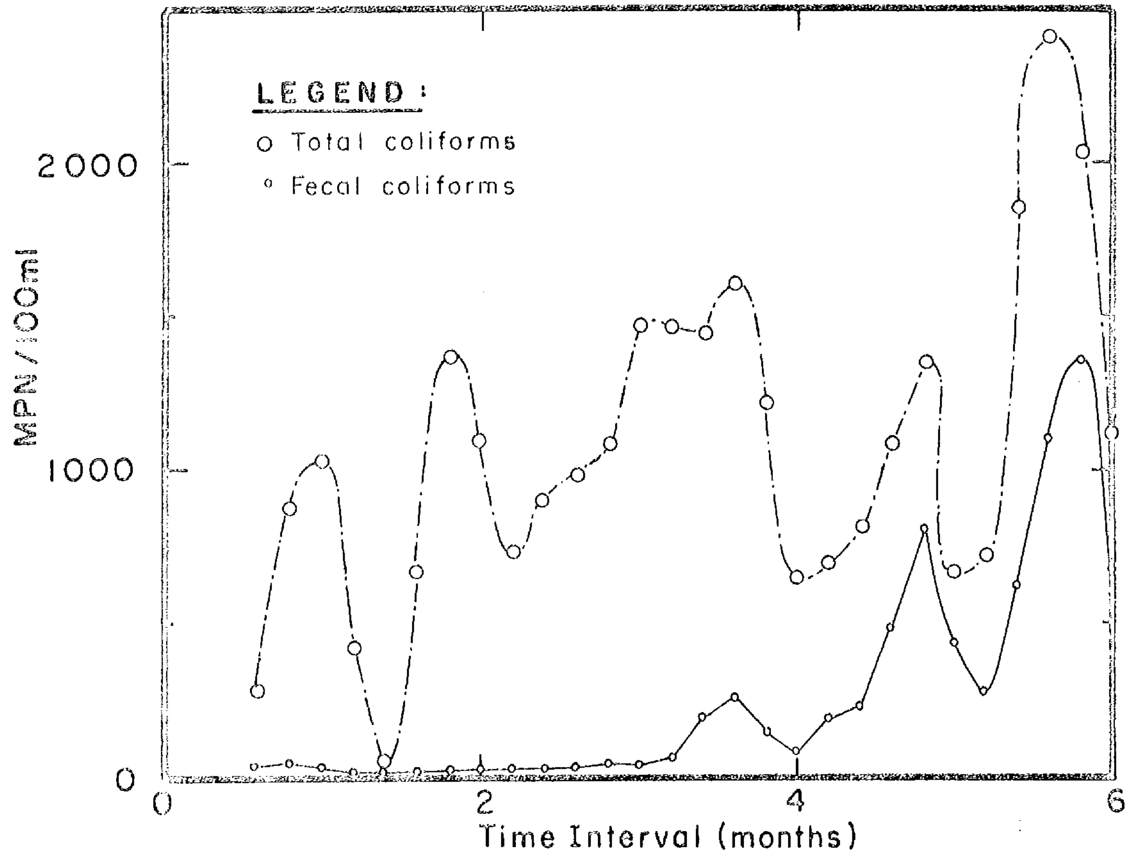


FIG. IV
COLIFORM CONCENTRATIONS IN INTERMEDIATE LEACHATE FROM LYSIMETER #2 .

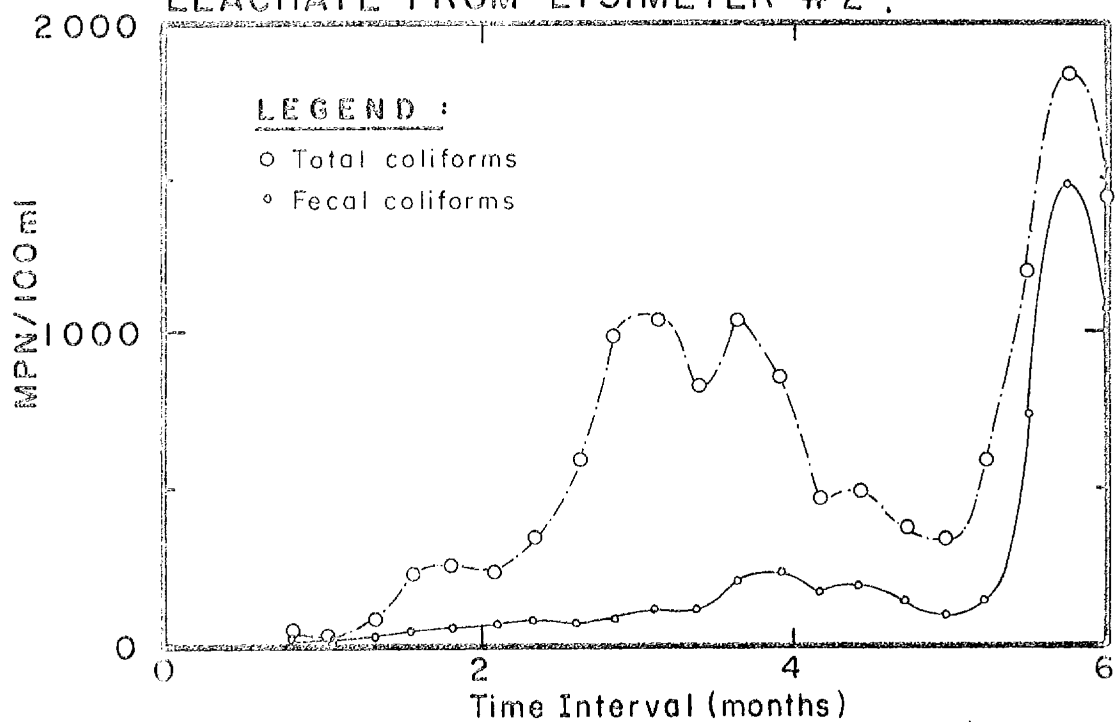


FIG. V

COLIFORM CONCENTRATIONS IN LEACHATE FROM LYSIMETER # 2.

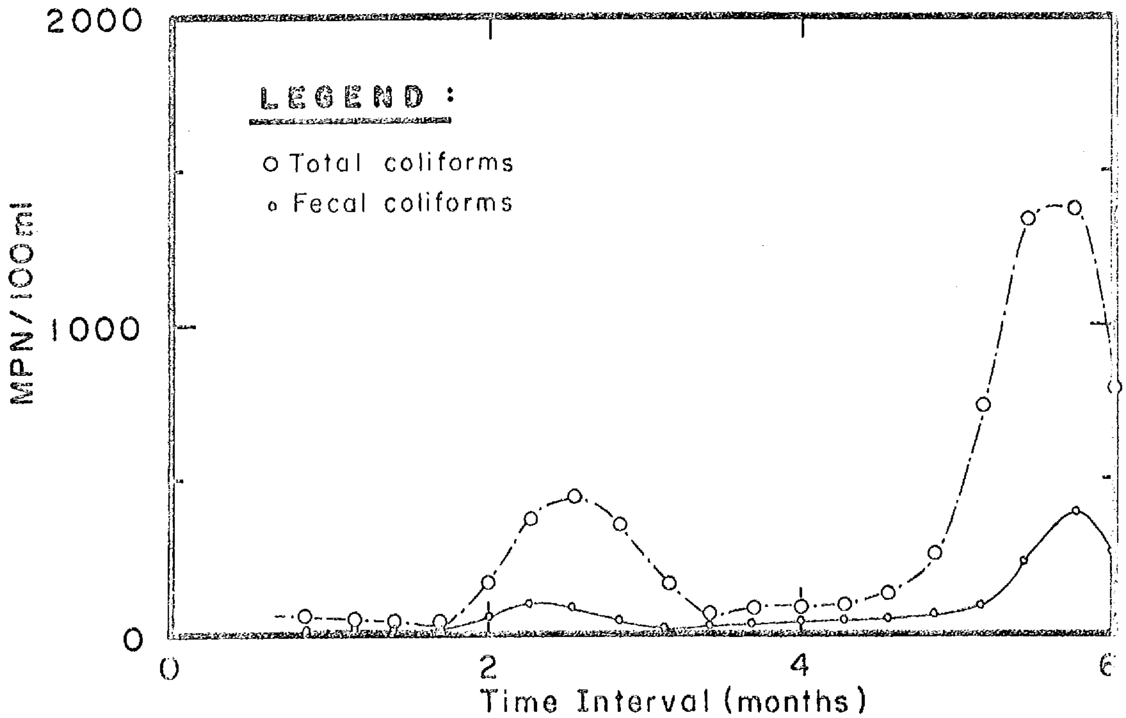


FIG. VI

COLIFORM CONCENTRATIONS IN LEACHATE FROM LYSIMETER # 3.

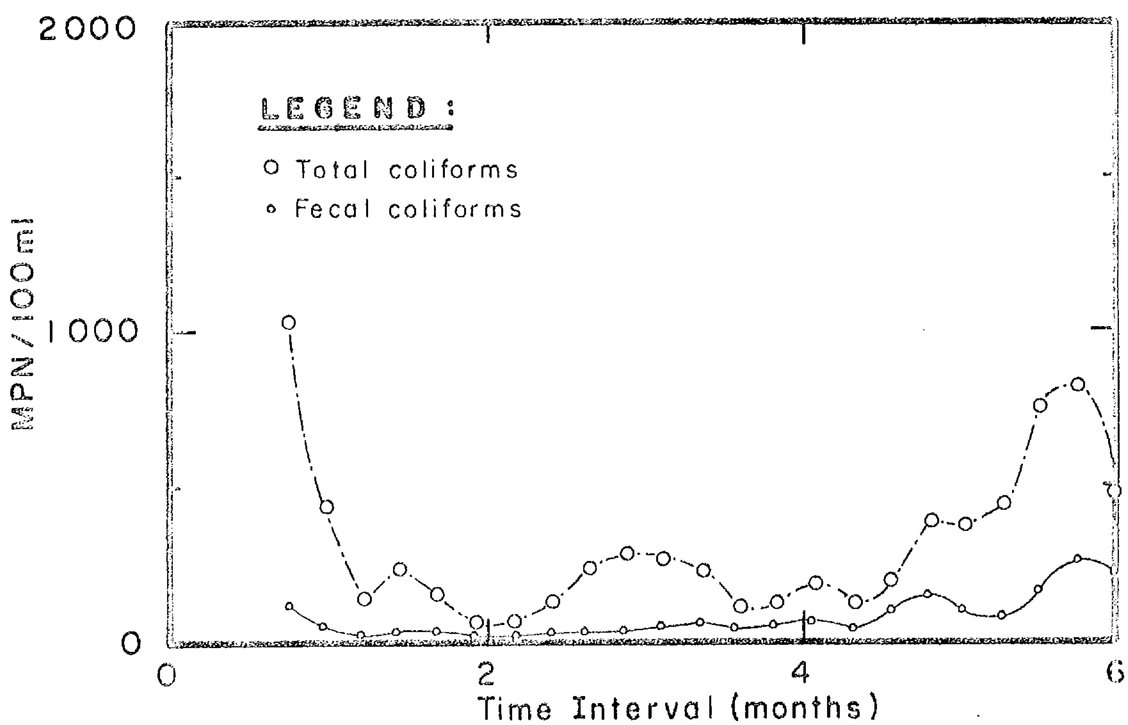
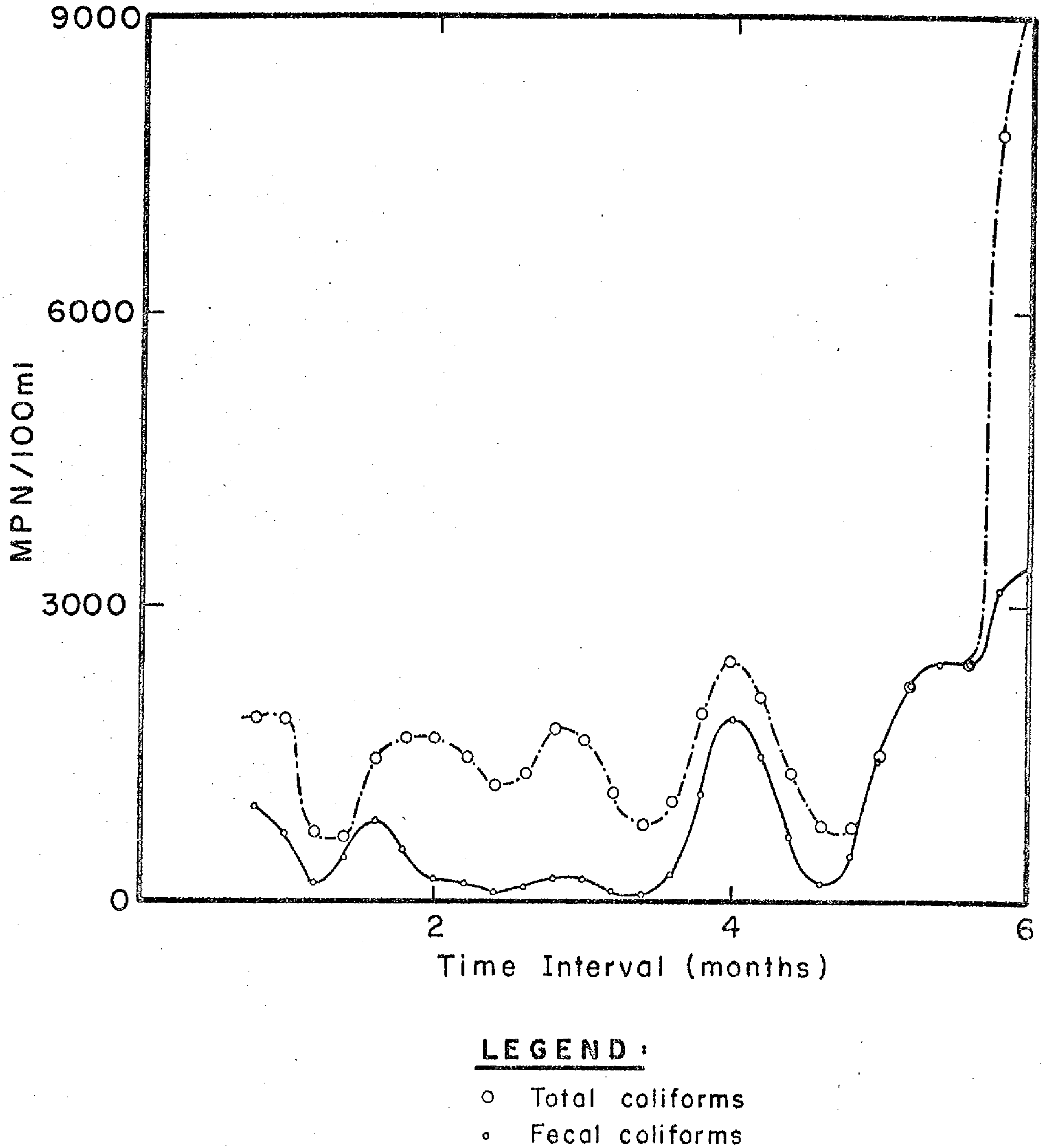


FIG. VII
COLIFORM CONCENTRATIONS
IN LEACHATE FROM LYSIMETER #4.



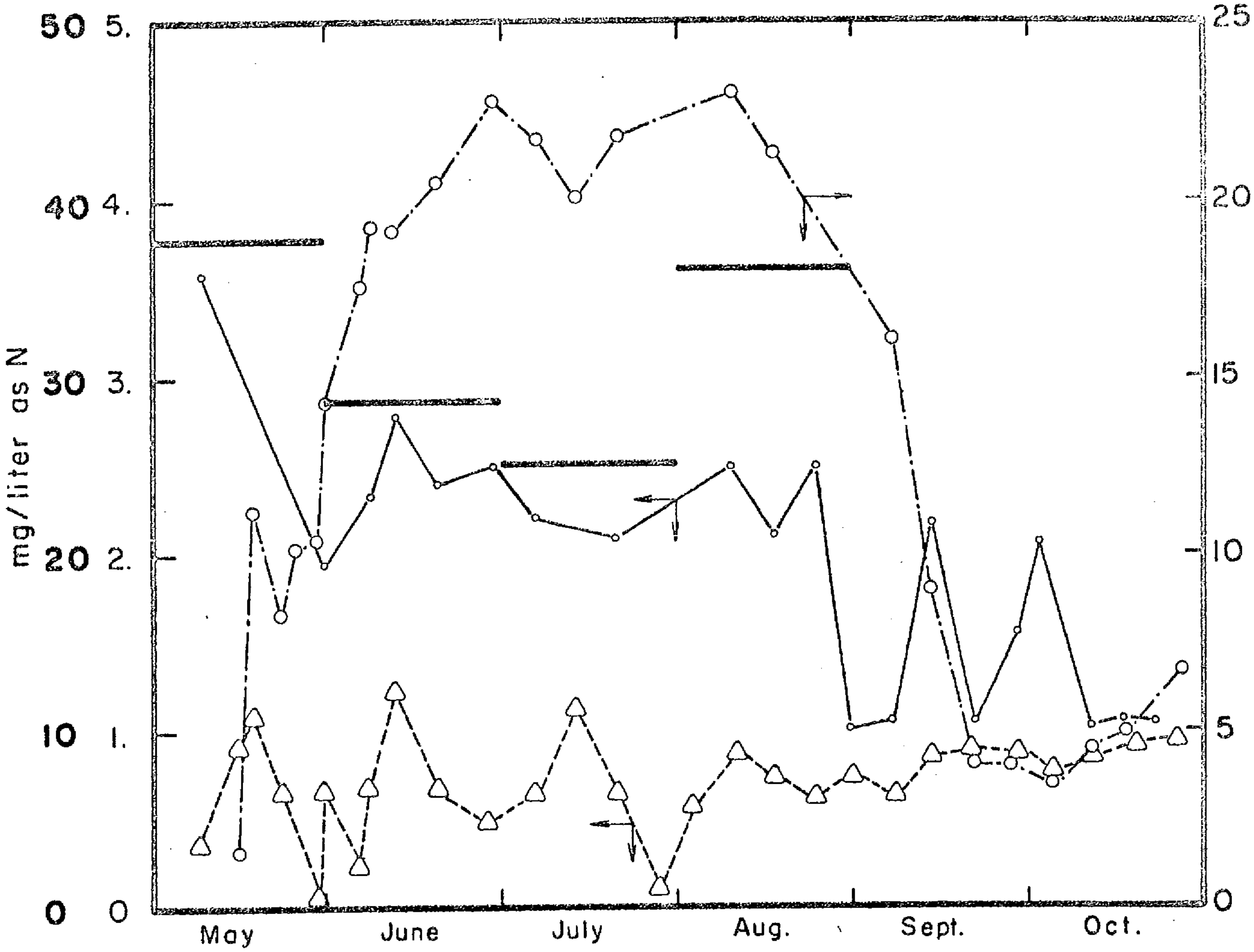
The fecal coliform results indicate that somewhere between 300 and 3000 organisms per 100 ml. (depending upon soil texture) can get through four feet of soil after some six months of operation. The more long-term effects have not been studied here. However, work done elsewhere[(4)] indicates that application concentrations of up to 2 x 10^8 coliforms/100 ml. will be reduced to values less than 1000 coliforms/100 ml. in a sandy-loam type of soil. If it can be assumed that fecal coliform levels in the leachate would remain relatively constant with time, then it follows that, from the bacterial contamination point of view, only areas that have a very high water table will experience conditions of questionable bacterial quality in the groundwater. In this study, we are concerned with the ultimate effect of septic tanks on surface waters. Even if the efficiency of soil filtration does decrease with time, the ultimate effect on surface waters should be small indeed. The water containing the coliforms has to travel horizontally to the receiving water after it percolates down to the water table, and in so doing will have its coliform count reduced still further due to filtration. It is possible, and in fact probable that some of the areas of the Valley with large numbers of septic tanks and high water tables will have undesirably high coliform concentrations in the local groundwater. More will be known about this as the results from the Provincial Kalamalka-Wood Lake Basin Study are compiled.

Nutrient analyses on the septic tank effluent and on the lysimeter leachates were limited to the following: ammonia nitrogen; nitrate nitrogen; nitrite nitrogen; organic nitrogen, dissolved ortho phosphate; and total phosphorous. As expected, the nitrogen in the septic tank effluent was limited almost entirely to ammonia and organic forms. When the average values of the forty-five samples were calculated, it was found that less than ½% of the nitrogen was in the nitrate and nitrite forms. Phosphorous analyses showed that dissolved ortho phosphate accounted for about 90% of the total phosphorous present in the septic tank effluent. It was apparent from the data that there was a temporal fluctuation in concentrations of all nutrient forms, and hence monthly averages were calculated, and are shown on Figures VIII, IX, X, and XI. Speculation as to why this fluctuation is occurring is difficult, but it is interesting to note that, with the exception of the trivial nitrate levels, the nutrient concentrations drop off during the two main summer months.

Leachate analyses performed over the six months of testing (May 1 to October 30, 1972) showed concentrations of total Kjeldahl nitrogen, nitrate nitrogen, total phosphorous, and dissolved ortho phosphorous indicated on the attached graphs. The TKN data indicates that the two finer soils were fairly effective in removing TKN, with these removal efficiencies remaining constant for the life of the project. The reason for the silt being less effective than the loamy sand (93% vs. 98% removal) is obscure, but it may be attributable to a nitrification-dentrification process in the loamy sand that could not be set up in the silty loam due to the presence of only a very small aerobic zone at the surface. The sand exhibited odd TKN characteristics when considered in isolation, but when nitrate data is observed simultaneously, the reasons

FIG. VIII

TKN CONCENTRATIONS IN LEACHATE FROM LYSIMETERS.

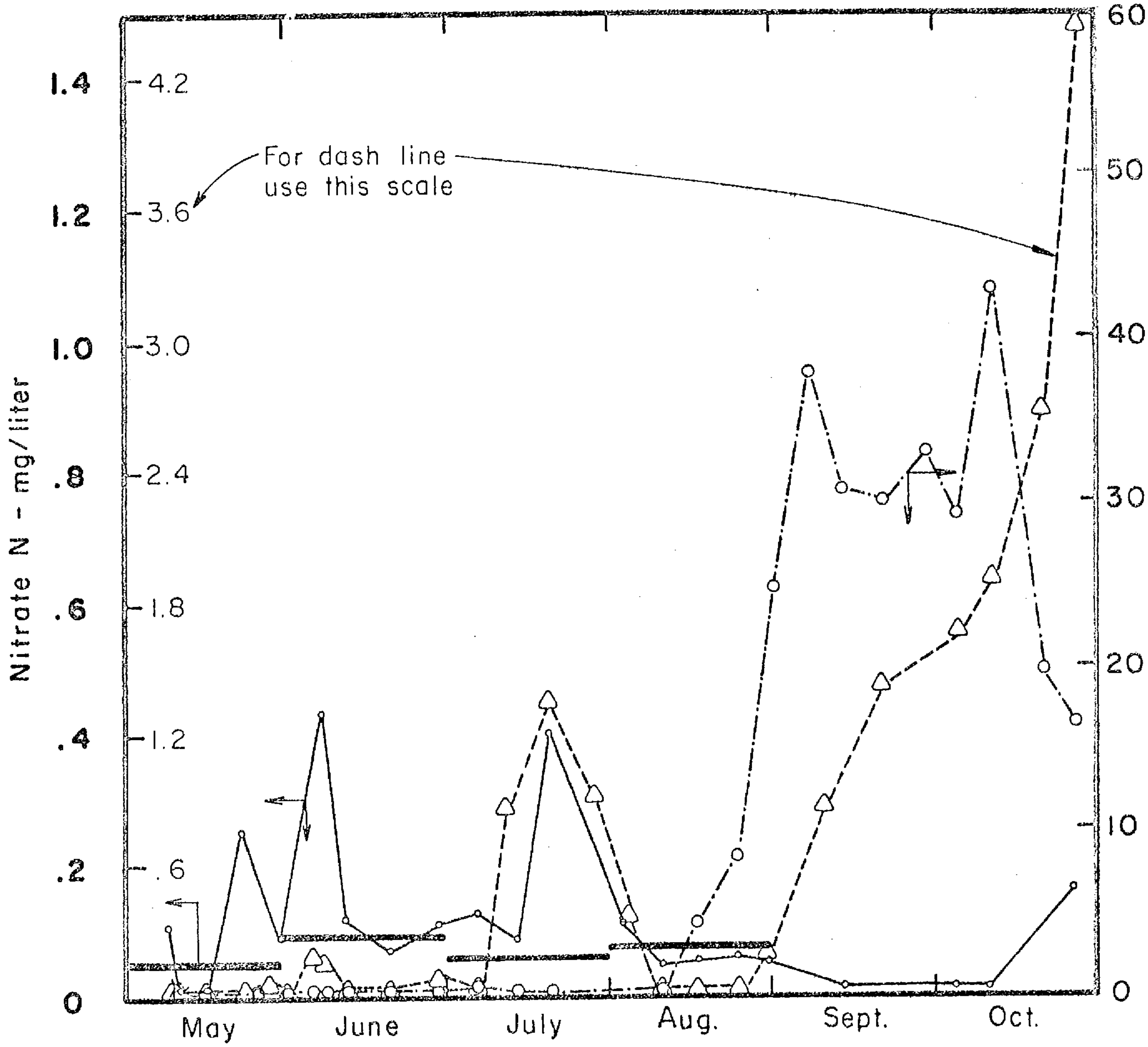


LEGEND:

- ∘ Silty loam
- △ Loamy sand
- ○ Coarse sand
- ▬ Monthly average concentration applied

FIG. IX

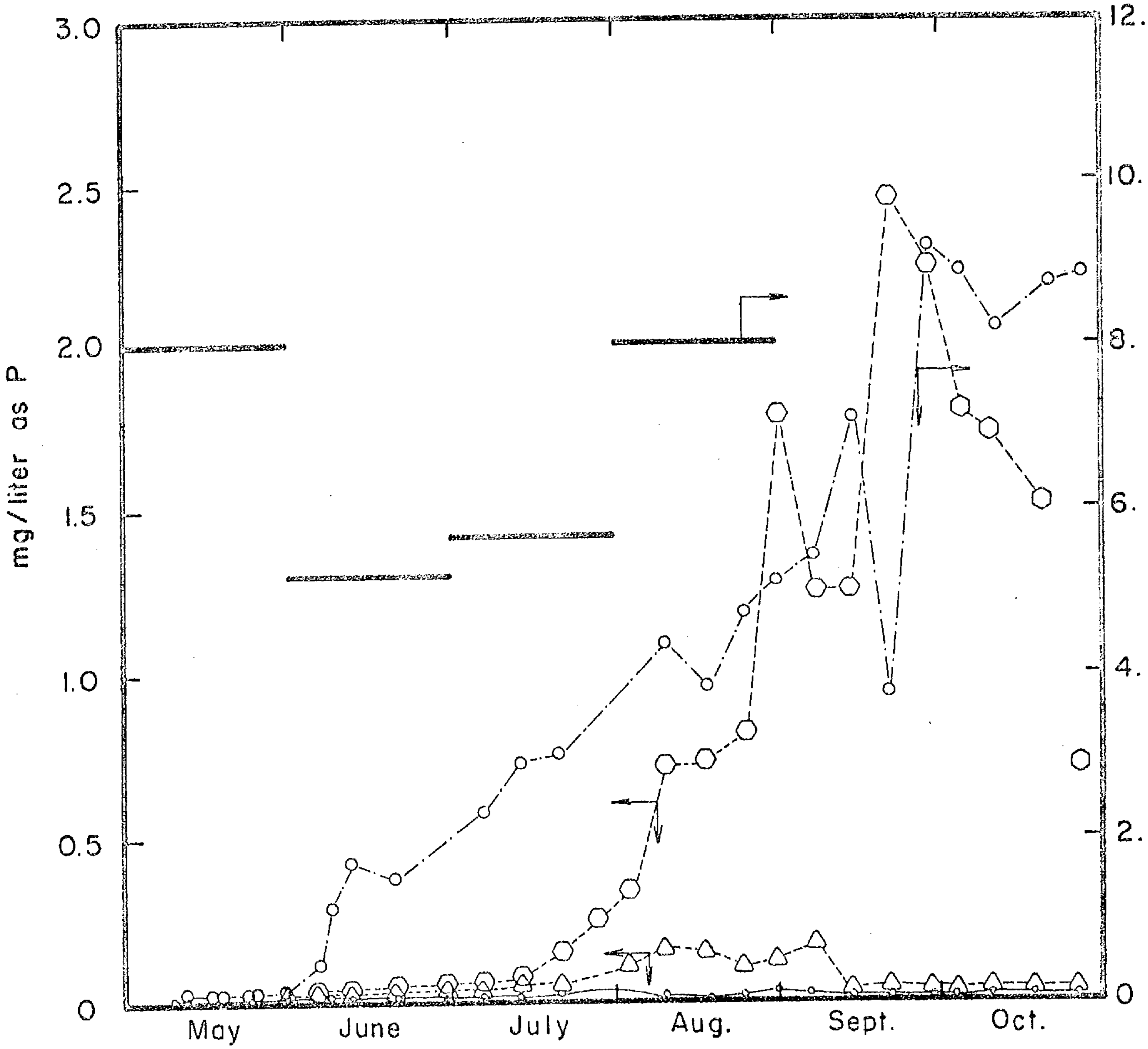
NITRATE NITROGEN CONCENTRATIONS IN LEACHATE FROM LYSIMETERS.



LEGEND:

- ∘ Silty loam
- △ Loamy sand
- ○ Coarse sand
- ▬ Monthly average concentration applied

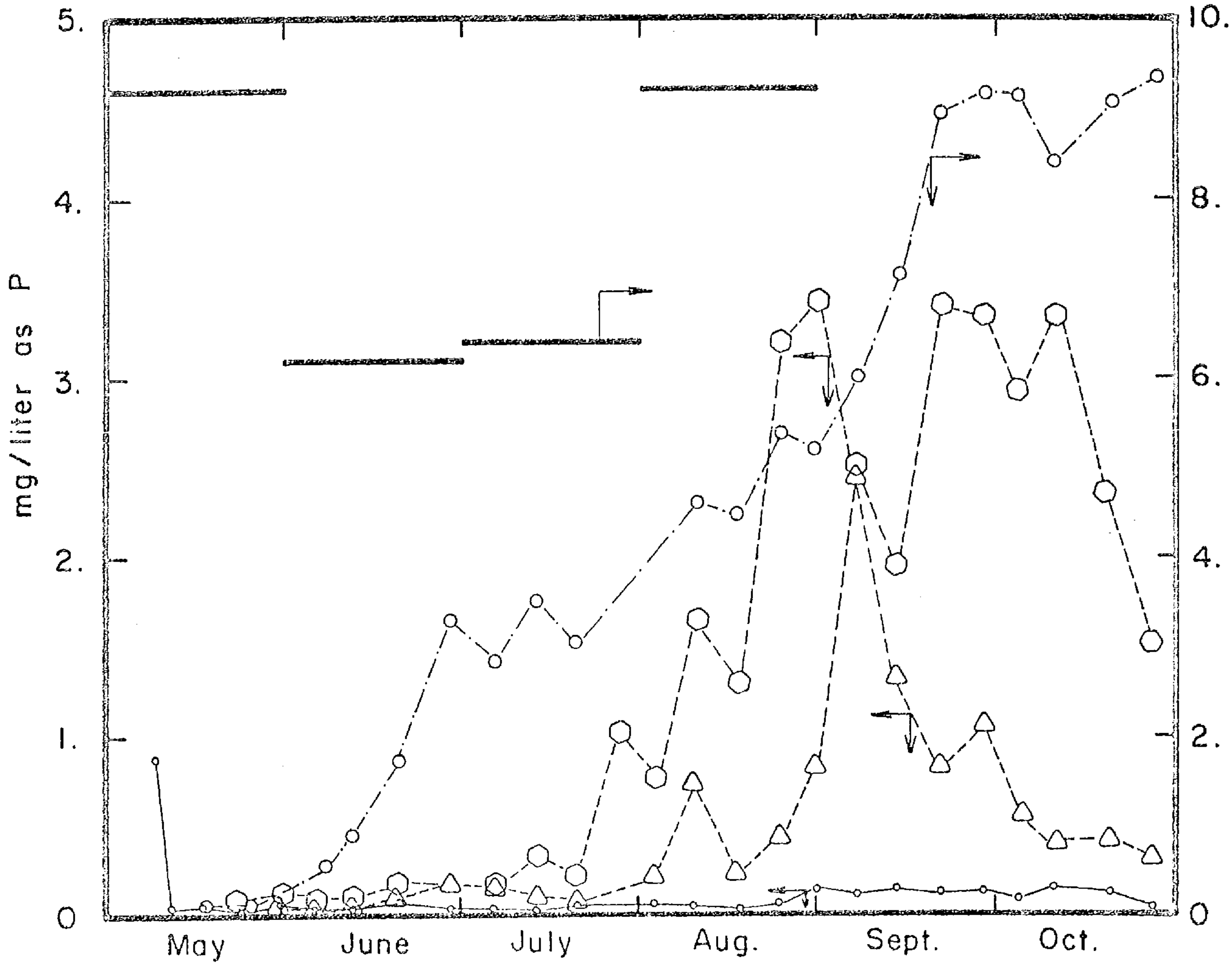
FIG. X
DISSOLVED ORTHO-P CONCENTRATIONS IN LEACHATE FROM LYSIMETERS.



LEGEND:

- ∘ Silty loam
- △ Loamy sand (4'deep)
- ⬡ Loamy sand (2½'deep)
- ○ Coarse sand
- ▬ Monthly average concentration applied

FIG. XI
TOTAL PHOSPHOROUS CONCENTRATIONS IN LEACHATE FROM LYSIMETERS.



LEGEND:

- ∘ Silty loam
- △ Loamy sand (4'deep)
- ⬡ Loamy sand (2½'deep)
- ○ Coarse sand
- ▬ Monthly average concentration applied

for the TKN trend becomes obvious: (1) TKN concentration rises very quickly, as the sand has very little capacity to adsorb it; (2) as nitrifying bacteria establish themselves in the easily maintained aerobic zone of the sand, the TKN concentration falls off at the same time as the resulting NO_3^- level rises. By the time four months have elapsed, the NO_3^- levels have reached almost 90% of the application loads of TKN.

Nitrate concentrations in the leachate from the loamy sand were beginning to rise toward the end of the six months, indicating that nitrification was proceeding without a totally compensating dentrification process at greater depth. In the silty-loam, no appreciable NO_3^- was observable at any time, indicating that either all TKN was being adsorbed as TKN, or if any nitrification was occurring, it was being completely denitrified again as the water moved through the deeper soil.

Total phosphorous and dissolved ortho phosphorous concentrations in the leachate were more easily explainable, with total breakthrough of both occurring in the four foot depth of sand during the test period. In the loamy sand, breakthrough of both total and ortho P at the 2½ foot depth began to occur after three months (35% breakthrough after five months), while no breakthrough was apparent after five months at the four foot depth. The leachate from the silt loam had no appreciable concentration of phosphorous in it after the five months of testing.

SECTION IV

AMOUNTS OF NUTRIENTS REACHING GROUNDWATER

To estimate the amounts of the various nutrient forms that actually travel from the loading sites to the groundwater table, it is necessary to consider the types of soil involved at the loading sites, and the depths of unsaturated soil above groundwater. Both of these factors may substantially affect the fraction of nutrient loading that reaches the groundwater. A matrix can then be established that shows the superimposed effects of these two parameters.

EFFECT OF SOIL TYPE

As a result of the tile field simulation studies at Vernon, it was possible to estimate the concentrations of nutrients leaching through some 4 feet of the three tested soil types. Some ideas of the rate of movement of the nutrient fronts through the soil was also obtainable, although no definite rates in terms of feet per year could be established. The results summarized in Figures VIII to IX were used to estimate multiplying factors to convert septic tank loadings into leachate quantities for 4 feet of soil depth. These factors are shown in Table 4.

The nitrate nitrogen factors shown in Table 4 must be used in conjunction with TKN loadings. The data from the tests indicated that no nitrate nitrogen was present in the septic tank effluent, and hence the nitrate levels found in the leachate must be due to nitrification that has occurred in the soil.

TABLE 4

Fraction of Nutrient Loadings Appearing in Leachate from Soil Columns

Nutrient	Silty Loam (Coldstream)	Loamy Sand (Kelowna)	Sand (Summerland)
Total Kjeldahl Nitrogen	0.05	0.03	0.15
Nitrate Nitrogen*	0.01	0.06	0.85
Total Phosphorous	0.02	0.4	1
Dissolved Ortho-Phosphorous	0.02	0.4	1

* multiplying factors for nitrate nitrogen are to be applied to TKN loadings

At present time, there is no conclusive explanation of why the loamy sand allowed less TKN to pass through than the silty loam did, but a possible reason might be that the loamy sand allowed considerably more nitrification to occur, with a subsequent denitrification occurring in the lower levels of the soil. The silty loam, on the other hand, could conceivably contain such a small aerobic zone that little nitrification occurred, but some TKN was still able to pass through.

All of the factors shown in Table 4 are based on the more or less steady-state conditions that were evident after six months of testing. The question of how long each of the soils would continue to adsorb the nutrients in difficult to answer. It is obvious that the Summerland sand was exhausted of its adsorptive capacity within 3 or 4 months, while the Kelowna loamy-sand was showing a partial breakthrough of phosphorous after about four months at a depth of 2½ feet (see Figures X & XI). The factors that were derived for Table 4 are intended to be indicative of conditions that might prevail in a septic tank tile field area that has been in existence at least two years. The factors may be considerably higher where loadings have been applied for periods well in excess of two years.

To make use of soil categorization maps that had already been prepared for the agricultural inputs aspects of Task 139, it was necessary to change the factors shown in Table 4 to conform with the soil types used on the categorization maps. These three soil types were loosely termed fine, medium, and coarse. According to detailed soils maps, none of the three soils that had been chosen for the septic tank field experiment were indicative of the fine soils of the Okanagan Basin. Both the loamy-sand and the sand fell in the coarse category, while the silty-loam is classified as medium. An estimate therefore had to be made for loading fractions reaching groundwater for fine soils, and this is shown in Table 5.

TABLE 5

MULTIPLYING FACTORS FOR DEFINED SOIL TYPES
(fraction reaching groundwater)

Depth to Groundwater \ Soil Type	F	M	C
	Total Phosphorous		
0'-6' (S)	.01	.03	1.0
6'-30' (I)	.005	.015	0.7
30' + (D)	.002	.007	0.3
	Dissolved Ortho-Phosphorous		
0'-6' (S)	.01	.03	1.0
6'-30' (I)	.005	.015	0.7
30' + (D)	.002	.007	0.3
	Total Kjeldahl Nitrogen		
0'-6' (S)	.02	.04	.15
6'-30' (I)	.01	.02	.10
30' + (D)	.005	.008	.07
	Nitrate Nitrogen (xTKN loading)		
0'-6' (S)	.01	.05	.85
6'-30' (I)	.01	.03	.7
30' + (D)	.01	.01	.5

EFFECT OF SOIL DEPTH

For purposes of this study, the areas of the Okanagan Basin that contain septic tanks were categorized according to depth of soil to groundwater. This was accomplished by overlaying transparencies showing septic tank areas onto base maps showing existing wells. The Groundwater Division of the Provincial Water Resources Service then supplied the necessary well data cards so that water table elevations could be plotted in three depth ranges; shallow (0'-6'); intermediate (6'-30'); and deep (<30'). These three categories were deemed sufficient to adequately estimate the total input of nutrients to groundwater. For the shallow depth areas, the field experiments provide factors for estimating fractions of loading reaching groundwater. The intermediate depth factors are still estimable from the field experiments, and although the factors for the deep category may be substantially in error, there is only a very small percentage of the septic tanks in the basin that are located in such areas.

Table 5 is a summary of factors for converting source nutrient loadings to groundwater contributions for the three chosen soil depth categories. It should be noted that, as was the case in Table 4, the nitrate nitrogen factors are to be used in conjunction with the TKN loadings.

GROUNDWATER CONTRIBUTIONS

Map transparencies of the Okanagan Basin have been prepared which show septic tank numbers and densities within each of the drainage sub-basins shown on Figure 1. When these transparencies, plus the transparencies which show soil types, are superimposed over the base maps that indicate depths to groundwater, it is possible to determine quite closely the number of septic tanks in each combination of soil type and depth to groundwater. Table 6 summarizes the information so obtained. The term single family unit (SFU) was used so that all establishments using septic tanks for disposal of sewage could be considered in the same terms. Conversion estimates for motels, for instance, were made on the basis of the number of rental units contained, and the percentage of time occupied.

To determine the nutrient contributions of septic tanks to groundwater, the loadings shown in Table 2 were multiplied by the fractions of SFU's in each category of soil type and depth to groundwater shown in Table 6, and that result was subsequently multiplied by the appropriate multiplying factor in Table 5. The results of these calculations are summarized in Tables 7, 8, 9, and 10.

It is interesting to note that by far the majority of the septic tanks are located in the coarse or intermediate soil areas, and in the shallow or medium depth to groundwater areas. The choosing of coarse soils for developments that utilize septic tanks for sewage disposal has historically been recommended to avoid potential public health problems. However, Table 5 shows that such soils are much less desirable than the fine soils when the problem of nutrient transport is considered. Because most of the development is located in the main valley near water bodies, the depth to groundwater is not great, and hence a greater percentage of nutrient loadings reach that groundwater than would be the case in higher areas of the basin.

TABLE 6

EQUIVALENT SINGLE FAMILY UNITS (S.F.U.'S) RELATED TO SOIL TYPES AND DEPTH TO GROUND WATER

Soil Type	Depth to Groundwater
F = Fine	S = Shallow (0 - 6')
M = Medium	I = Intermediate (6' - 30')
C = Coarse	D = Deep (> 30')

Sub-Basin	No. of Equiv. S.F.U.'s	No. of Equiv. SFU's in each combination of Soil Type and depth to Ground Water								
		CS	CI	CD	MS	MI	MD	FS	FI	FD
3T5	482	59	94	12	8	117	9	6	156	21
3T6	12				7			5		
3D6	3					3				
3D3	124					36			88	
3D4	37				2			34	1	
3D7	59		28			6			25	
3T4	42	8							28	6
3D5	138	37	10		10	18		15	40	8
3T3	465	24	27	20	45	265	30	30	21	3
3T1	761	2	30		51	313	10		208	147
3T2	258					110	40		108	
3D2	296	130	34	106		11		5	5	5
Σ Basin 3	2677	260	223	138	123	879	89	95	680	190
2D4	101					101				
2T2	609	15	20		30	298	2		244	
2D3	150					67			83	
2D2	214		205			9				
2T1	102		30			10	14		48	
Σ Basin 2	1176	15	255	0	30	485	16	0	375	0
1D1	287				87	14		70	116	
1D2	843		233		103	120	10	109	229	39
1T1	2					2				
Σ Basin 1	1132	0	233	0	190	136	10	179	345	39
4D1	231		30						201	
4T1	2531		8		174	2152		50	144	3
4D3	885		167			4			714	
4T4	761	30	176			484		35	36	
4T3	144		10			20		20	94	
4D6	84							17	67	
4T8	146					112		5	29	
4D7	209				7	196		3	3	
4T5	61					61				
4D8	463					463				
4D4	269				75	75		63	56	
4T2	25				15	10				
4D2	687				250	249		94	94	
4U2	219		36		62	62		29	30	
4D5	574		499			75				
4T6	293	10	226	57						
Σ Basin 4	7582	40	1152	57	583	3963	0	316	1468	3
5D1	2067		808			1257			2	
5T1	298		197			101				
5D2	135					135				
5D3	302		97			205				
5U1	191					191				
5T4	114		10			104				
5T5	30		30							
Σ Basin 5	3137	0	1142	0	0	1993	0	0	2	0
6T3	8					8				
6D3	302					302				
6D1	223		54			169				
6D2	332		320			12				
6T1	105		105							
Σ Basin 6	970	0	479	0	0	491	0	0	0	0
7D2	4		4							
7D1	65		41	1	16	7				
7T1	182	27	16		60	32	47			
Σ Basin 7	251	27	61	1	76	39	47	0	0	0
8D4	552	5	322	10	57	153			5	
8D2	68		2		2	64				
8T4	2		2							
8T2	89		89							
8D3	179	49	114		6	10				
8T1	74		24		17	31	2			
8T3	17		11						6	
Σ Basin 8	981	54	564	10	82	258	2	0	11	0
9D1	58	2	42				3		11	
9D4	1125	160	760	148	10	46			1	
9T2	11	5	4	2						
9D3	301	72	229							
9T1	2		2							
Σ Basin 9	1497	239	1037	150	10	46	3	0	12	0

TABLE 7

AMOUNT OF TKN REACHING GROUNDWATER

Sub-Basin	TKN Loading (lb./yr.)	Amount of TKN Reaching Groundwater for Each Combination of Soil Type and Depth to Groundwater (loading)x(fraction of SFU's in each category[Table 7])x(multiplying factor[Table 6])									
		CS	CI	CD	MS	MI	MD	FS	FI	FD	Total
1	26,310	0	541	0	177	63	2	83	80	5	951
2	27,390	52	594	0	28	226	3	0	87	0	990
3	62,290	907	519	225	114	409	17	44	158	22	2,415
4	175,770	139	2,671	92	541	1,837	0	147	340	0	5,767
5	72,810	0	2,650	0	0	925	0	0	0	0	3,575
6	22,500	0	1,111	0	0	228	0	0	0	0	1,339
7	5,840	94	142	2	71	18	9	0	0	0	336
8	22,790	188	1,310	16	76	120	0	0	3	0	1,713
9	34,760	832	2,408	244	9	21	1	0	3	0	3,518
											Σ = 20,604

TABLE 8

AMOUNT OF NITRATE N REACHING GROUNDWATER

Sub-Basin	TKN Loading (lb/yr)	Amount of Nitrate reaching groundwater for each combination of SOIL TYPE and DEPTH TO GROUNDWATER (Loading) x (fraction of SFU_s in each categ. (Table 7) x (mult. factor (Table 6)									
		CS	CI	CD	MS	MI	MD	FS	FI	FD	TOTAL
1	26,310	0	3,787	0	221	95	3	42	80	10	4,238
2	27,390	295	4,158	0	35	339	4	0	87	0	4,918
3	62,290	5,140	3,633	1,607	143	614	21	22	158	44	11,382
4	175,770	788	18,697	657	676	2,756	0	74	340	0	23,988
5	72,810	0	18,550	0	0	1,388	0	0	0	0	19,938
6	22,500	0	7,777	0	0	342	0	0	0	0	8,119
7	5,840	533	994	14	89	27	11	0	0	0	1,668
8	22,790	1,065	9,170	114	95	180	0	0	3	0	10,627
9	34,760	4,715	16,856	1,743	11	32	1	0	3	0	23,361

Σ = 108,239

TABLE 9

AMOUNT OF TOTAL P REACHING GROUNDWATER

Sub-Basin	Total P Loading lb/yr	Amount of Total P reaching groundwater for each combination of SOIL TYPE AND DEPTH TO GROUNDWATER (loading) x (fraction of S.F.U. in each cat.(Table 7) x (mult.factor(Table 6)									
		CS	CI	CD	MS	MI	MD	FS	FI	FD	TOTAL
1	7,960	0	1,147	0	40	14	0	13	12	1	1,227
2	8,280	106	1,257	0	6	51	1	0	13	0	1,434
3	18,860	1,831	1,100	292	26	93	4	7	24	3	3,380
4	53,410	282	5,681	120	123	419	0	22	52	0	6,699
5	21,880	0	5,576	0	0	209	0	0	0	0	5,785
6	6,860	0	2,371	0	0	52	0	0	0	0	2,423
7	1,770	190	301	2	16	4	2	0	0	0	515
8	6,920	381	2,785	21	17	27	0	0	0	0	3,231
9	10,540	1,683	5,111	317	2	5	0	0	0	0	7,118
									Σ	=	31,812

TABLE 10

AMOUNT OF DISSOLVED ORTHO P REACHING GROUNDWATER

Sub-Basin	Total Ortho P Loading lb/yr	Amount of Dissolved Ortho P reaching groundwater for each combination of SOIL TYPE AND DEPTH TO GROUNDWATER (loading) x (S.F.U. fraction in each cat.(Table 7) x (mult.factor(Table 6)									
		CS	CI	CD	MS	MI	MD	FS	FI	FD	TOTAL
1	6,080	0	876	0	31	11	0	10	9	0	937
2	6,330	81	961	0	5	39	1	0	10	0	1,097
3	14,390	1,398	839	223	20	71	3	5	18	2	2,579
4	43,170	228	4,591	97	100	338	0	18	42	0	5,414
5	16,320	0	4,159	0	0	156	0	0	0	0	4,315
6	5,200	0	1,797	0	0	39	0	0	0	0	1,836
7	1,360	146	231	2	12	3	2	0	0	0	396
8	5,280	291	2,125	16	13	21	0	0	0	0	2,466
9	8,050	1,285	3,903	242	2	4	0	0	0	0	5,436
									Σ	=	24,476

In summary, the estimates of additions of nutrients to groundwater from septic tanks over the entire basins are as follows:

Total Kjeldahl Nitrogen................ 20,600 lb/yr.

Nitrate Nitrogen......................108,000 lb/yr.

Total Phosphorous...................... 31,800 lb/yr.

Dissolved Ortho-Phosphorous............ 24,500 lb/yr.

SECTION V

AMOUNTS OF NUTRIENTS REACHING SURFACE WATERS VIA GROUNDWATER

The estimations of nutrient transport via groundwater to the surface waters of the Okanagan Basin can be considered approximate at best. To provide relatively accurate estimates would require the establishment of well-fields in areas of high septic tank density so that the increase in nutrient content of the groundwater can be measured as it passes under the septic tank area. Some data on this will be forthcoming from the Provincial Kalamalka-Wood Lake Basin Study, but the information will not be available until the summer of 1973.

Analysis of the data in Table 2 permits the major sub-basin loadings to be categorized according to whether they are applied on land that drains directly to the mainstem lakes and rivers or on land that drains to tributary streams, and also according to whether they are applied to land less than or more than 500 feet from surface water courses. These calculations are summarized in Table 11.

By combining the data from Table 11 with that from Tables 7 to 10, the amounts of nutrients reaching groundwater in each of the categories of Table 11 can be calculated. A summary of these calculations is contained in Table 12.

TABLE 11

FRACTIONS OF NUTRIENT LOADINGS APPLIED TO AREAS
THAT DRAIN DIRECTLY TO MAINSTEM LAKES AND RIVERS

Sub-Basin (see Fig.I)	% of Loading Applied to Direct Drainage Areas		% of Loading Applied to Tributary Drainage Areas	
	<500'from surface water	>500'from surface water	<500'from surface water	>500'from surface water
1	48	52	0	0
2	19	21	32	28
3	15	10	17	58
4	26	19	11	44
5	19	61	10	10
6	35	53	4	8
7	22	6	27	45
8	26	55	7	12
9	41	58	0.5	0.5

TABLE 12

NUTRIENT CONTRIBUTIONS TO GROUNDWATER IN AREAS THAT DRAIN DIRECTLY TO MAINSTEM LAKES AND RIVERS

Sub-Basin	TKN (lb/yr.)				Nitrate N (lb/yr.)				Total P (lb/yr.)				Diss. Ortho P (lb/yr.)			
	Direct Drainage Area		Tributary Drainage Area		DDA		TDA		DDA		TDA		DDA		TDA	
	<500'	>→500'	<500'	>→500'	<500'	>→500'	<500'	>500'	<500'	>500'	<500'	>500'	<500'	>500'	<500'	>500'
1	455	495	0	0	2030	2200	0	0	590	640	0	0	450	485	0	0
2	190	210	310	280	935	1030	1570	1375	270	300	460	400	205	230	350	305
3	360	240	410	1400	1705	1140	1935	6600	505	340	575	1960	385	260	440	1490
4	1500	1095	635	2540	6235	4555	2640	10550	1740	1270	735	2945	1325	965	560	2245
5	680	2180	360	360	3790	12160	2000	2000	1100	3530	580	580	840	2690	440	440
6	470	710	55	110	2840	4300	325	650	850	1285	95	195	645	980	70	150
7	75	20	90	150	370	100	450	750	115	30	140	230	90	25	105	175
8	445	940	120	205	2765	5845	745	1275	840	1775	225	390	540	1350	170	295
9	1440	2035	20	20	9575	13540	115	115	2915	4125	35	35	2220	3140	25	25

In order to determine the amounts of nutrients actually reaching surface waters via groundwater, three assumptions have been made:

i) 100% of all nutrients that reach groundwater within 500 feet of a surface water course will find their way to that surface water;

ii) 70% of nitrate N that reaches groundwater farther than 500 feet from a surface water course will find its way to that water course; and

iii) 30% of the other nutrient forms that reach groundwater farther than 500 feet from a surface water course will find their way to that water course.

None of these three numbers are specifically defensible. However, the 100% and the 70% figures are probably not substantially in error, due to the short distance involved in the former case, and the chemical inactivity of nitrate in the latter case (although denitrification activity could alter this). The third assumption is strictly a guess, and may in fact range from 0% to something in excess of 50% for different sections of the basin, depending upon what percentage of the groundwater actually reaches a surface water course and upon the adsorptive capacity of the saturated soil. The data in Table 13 is simply a conversion of the figures in Table 12 to anticipated surface water course loadings (using the above mentioned assumptions).

The amounts of nutrients shown under the heading "Direct Drainage Area" in Table 13 are in effect estimates of septic tank nutrients that reach the mainstem lakes and rivers directly. The amounts shown under the heading "Tributary Drainage Area" are estimates of septic tank nutrients that at least conceivably reach their final destination via groundwater and surface streams. Thus, these loadings have at least theoretically already been taken into account by the stream monitoring program.

TABLE 13

NUTRIENT LOADINGS REACHING SURFACE WATERS IN THE MAJOR SUB-BASINS OF THE OKANAGAN VALLEY

Sub-Basin	TKN(lb/yr.)		Nitrate N(lb/yr.)		Total P(lb/yr)		Diss. Ortho P(lb/yr)	
	Direct Drainage Area	Tributary Drainage Area	DDA	TDA	DDA	TDA	DDA	TDA
1	605	0	3570	0	850	0	640	0
2	255	395	1655	2530	390	620	300	470
3	430	830	2505	6555	660	1360	500	1040
4	1830	1395	9425	10020	2250	1910	1710	1450
5	1335	470	12300	3400	2510	810	1910	620
6	685	90	5850	780	1360	170	1040	130
7	80	135	440	975	125	230	95	175
8	725	180	6855	1640	1550	380	1180	290
9	2050	30	18950	195	4560	50	3470	40
Σ	7995	3525	61550	26095	13255	5530	10845	4215

SECTION VI

CONCLUSIONS AND RECOMMENDATIONS

As a result of the studies carried out on septic tanks in the Okanagan Valley, the following general conclusions have been reached:

1. Nutrient loadings from septic tanks in the whole Okanagan Basin amounted to 497,000 lb/yr. of Total Kjeldahl Nitrogen, 137,000 lb/yr. of Total Phosphorous, and 104,000 lb/yr. of Dissolved Ortho-Phosphorous.

2. The amounts of nutrients travelling through the unsaturated soil and thus reaching the groundwater were calculated to be 20,000 lb/yr. of Total Kjeldahl Nitrogen, 108,000 lb/yr. of Nitrate (from denitrification of TKN), 31,800 lb/yr. of Total Phosphorous, and 24,500 lb/yr. of Dissolved Ortho-Phosphorous.

3. The amounts of nutrients that are estimated to be transported by the groundwater to surface waters are as follows:

	to mainstem lakes	to tributary streams
TKN	8,000 lb/yr	3,520 lb/yr.
Nitrate N	61,500 lb/yr	26,100 lb/yr.
Total P	13,250 lb/yr	5,530 lb/yr.
Diss.Ortho P	10,850 lb/yr	4,220 lb/yr.

There is a significant number of assumptions inherent in the calculations of the quantities listed above, as discussed in previous sections of the report. This is especially true of calculations required to arrive at the figure given in conclusion number 3 above. However, it is known that the boundaries of these values lie between 0 lb/yr. and the number shown in conclusion 2 above. If it is found that the amounts of nutrients reaching the lake system are critical to the solution of the water quality problems in the Okanagan, then it is recommended that more work be done so that the figures quoted in Table 13 can be adequately verified. This work should involve the following:

1. Continuation of the septic tank leaching studies at Vernon to ascertain better average concentration of nutrients in the leachate waters after percolation through different soils;

2. A more detailed approach to the effects of soil type on the transport of nutrients from the source to the groundwater;

3. A few field experiments using well-points to allow actual samples of groundwater to be gathered upstream and downstream of septic tank areas in the Okanagan Valley.

Furthermore, if it appears that septic tank leachate may be responsible for localized surface water quality problems, it is recommended that well-points be installed in these locations before any corrective actions are taken. By so doing, the impact of the corrective action can be realistically monitored, and the results used to plan corrective actions in other problem areas.

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APPENDIX I

CHARACTERISTICS OF SOILS USED IN SEPTIC TANK TILE FIELD SIMULATION STUDY

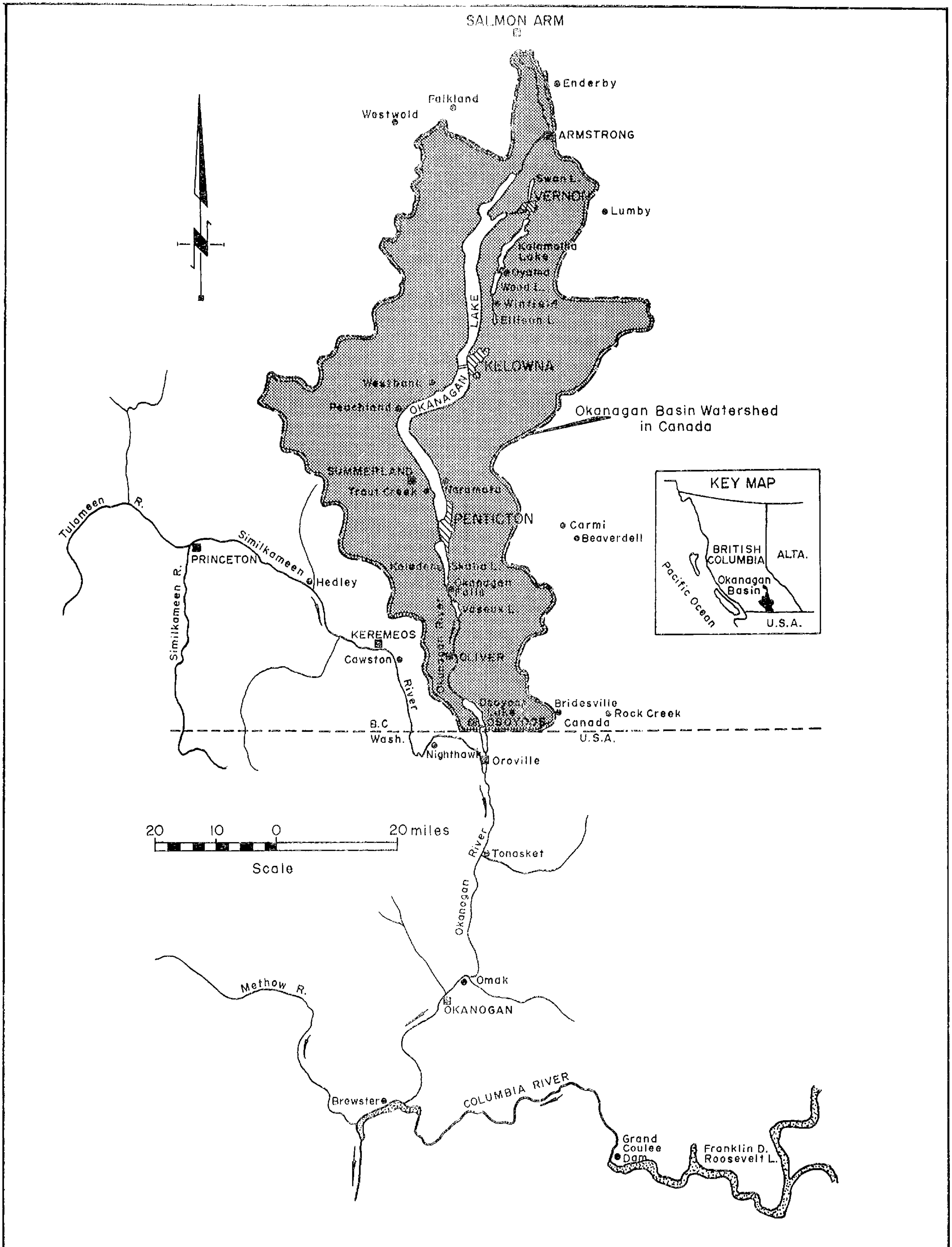
LOAMY SAND - from Pine Grove Estates near Kelowna

Horizon	Description
Ap 0-10"	- loamy sand, cultivated horizon
C_1 10-18"	- loamy sand containing occasional pieces of gravel - somewhat compact
C_2 18-26"	- coarse, loose sand
Cgj_1 26"-40"	- sandy loam & loamy sand - moderate, medium subangular blocky structure - weakly mottled indicating that the watertable sometimes rises into this horizon
Cgj_2 40"-52"+	- loose fine sand and fine loamy sand - weakly mottled

The materials from 26" downward are reasonably similar textured and should be suitable for your lysimeter work.

SILTY LOAM - from flats next to Coldstream Creek

Horizon	Description
Ah 0- 6"	- loamy sand or sand, probably younger than the remainder of the soil profile and deposited by more recent flooding
IIAh 6-12"	- weakly calcareous



OKANAGAN DRAINAGE BASIN IN CANADA