CHAPTER 15
Water Quality Evaluations

The planning objectives for water quality management in the Okanagan Basin, as outlined in Chapter 12, are two-fold:

1. To provide a raw water quality compatible with consumptive uses of water for domestic, municipal, agricultural, and industrial purposes, with primary emphasis on protecting the health of Okanagan residents.

2. To provide a water quality consistent with a high quality environment for protection of the ecology and for water based recreation and aesthetics, particularly in the main valley lakes.

While these objectives are similar, the criteria and methods for achieving the objectives differ. The first requires limiting chemical elements and bacterial content in raw water supplies to levels that are not injurious to the health of man, or plants. The second requires controlling the amount of nutrients in surface waters to limit biological productivity (aquatic plant and algal growth) to levels that are acceptable for recreational and aesthetic pursuits, and for protection of the natural environment.

This chapter reviews the existing quality of water in the basin, discusses the effect of continued economic growth on water quality to the year 2020, and examines alternative ways in which these planning objectives may be achieved.

15.1 REVIEW OF EXISTING CONDITIONS

The results of water quality and limnology studies under the Canada-British Columbia Okanagan Basin Agreement (Chapter 5 and 6) have provided the following findings on the existing (1971) quality of water in the basin:

1. Most streams in the basin have one or more constituents which exceed acceptable concentrations based on health standards for drinking water and other consumptive uses. These include color, turbidity, iron, manganese, phosphorus, nitrogen and coliform. Streams in which major quality problems are evident include Vernon, Coldstream, Deep, Westbank, Kelowna, and Brandt's Creek. The main valley lakes meet acceptable raw water quality standards for drinking purposes and most other consumptive uses with the exception of Wood Lake which exhibits a low oxygen concentration in the summer months, and high phosphorus levels throughout the year.

2. Nutrient enrichment, and resulting increases in aquatic plant and algal growth, has occurred in varying degrees in all of the main valley lakes

over the past 50 to 100 years. The major source of these nutrients has been identified as tributary streams and municipal outfalls, although other sources including septic tanks, agriculture, and soil erosion, also affect local shoreline areas. Wood Lake in particular has declined to the point that recreational and social benefits have been adversely affected.

3. Phosphorus has been identified as the nutrient which may most successfully be controlled to limit algal and aquatic plant growth. This finding was based on limnological studies, the fact that tecnological means are available to remove this nutrient through waste treatment processes, and the fact that limiting this nutrient has proved successful in the control of weed and algal growth in other lakes in North America. While the control of phosphorus through waste treatment processes is considered the most important single measure that can be implemented to enhance the quality of the main valley lakes, decreasing other sources of phosphorus and eventually other nutrients through the control of stream erosion, green belts, and other measures outlined herein must also be considered over the long term.

4. While the level of waste treatment in the Okanagan Basin is considered comparable to or better than that in all other parts of Canada, some major problems are still evident. The influx of tourists in the summer months overloads existing waste treatment facilities resulting in a decline in the efficiency of waste treatment when it is most required. Existing waste treatment plants do not include facilities for the removal of phosphorus, with the exception of Penticton (and to some extent Vernon) where such facilities were initiated in 1971.

Over 50% of the population of the Valley are serviced by septic tank installations, yet most soils, adjacent to the main valley takes where the bulk of this population is located have very limited suitability to remove nutrient loadings because of the coarse nature of the soils, and the shallow depth to groundwater.

One over-riding factor concerning the above findings and following evaluations, is the limited accuracy of some of the loading data, and the uncertainty involved in establishing phosphorus loading criteria for the main valley lakes because of their complex nature and the many factors that are difficult to quantify. Therefore white the basic objective of controlling phosphorus levels to acceptable assimilative capacities for each lake is considered a valid approach, the effect of implementing specific controls should be carefully monitored to ensure the desired results are being achieved.

15.2 PROJECTIONS OF WASTE LOADINGS

Future loadings of phosphorus to the main valley lakes have been estimated from present loading data, and from economic growth projections for the years 1980, 2000 and 2020 (Tables 15.1 to 15.6). Only the high and low projections are included to provide a range of potential future loadings, assuming a continuation of existing treatment policies. These tables also show the effect of various levels of phosphorus removal for the urban centers of Vernon, Kelowna, Penticton, and Oliver on total loadings from all sources.

Projections for municipal waste effluent discharged to the main valley lakes are based on a per capita loading of .008 pound of phosphorus per day (See Technical Supplement XI) and estimates of future populations for a low economic growth rate (Projection III) and a high economic growth rate (Projection II).

Industrial loadings are projected on the basis of dollar value and pounds or tons of output and have been broken down into the following categories for each of the four economic regions:

(1) Fruit and Vegetable Canners
(2) Wineries, Distilleries and Soft Drink Plants
(3) Sawmills and Plywood Mills
(4) Fruit Packers
(5) Ice Rinks and Fish Hatcheries

Projections for categories (1), (2), and (3) are on the basis of dollar values, category (4) is based on tons of product packed, while the loadings for category (5) are not assumed to change on the basis of current information.

The projection of waste loadings from storm sewers in the major centers of Vernon, Kelowna and Penticton is based on population increases.

Projected contributions from groundwater sources are based on the acreage of land under agricultural production for agricultural sources, and the projected rural population for septic tanks. Contributions from 'other' sources due to man's influence include such sources as: (1) fertilizers used in industrial operations such as airport runway de-icing; (2) household pets; (3) fertilizers used on lawns and gardens, and (4) ground discharge of industrial wastes. Projected contribution from these other sources, is based on factors similar to that of agricultural and septic tank sources.

No significant changes are expected to occur in the natural loadings from streams and groundwater, or in dustfall and precipitation loadings.

Part of the groundwater return flow from agriculture and septic tank sources returns to surface waters in streams and has been measured as tri-

TABLE 15.1

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO KALAMALKA LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality = 6600 to 8800 Pounds Total Phosphorus per Year.)

SOURCE \ PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980	PROJECTED LOADINGS FOR THE YEAR 2000		PROJECTED LOADINGS FOR THE YEAR 2020	
			Low Economic Growth (III)	High Economic Growth (II)	Low Economic Growth (III)	High Economic Growth (II)
1. TRIBUTARY STREAMS						
- Excluding Agriculture and Septic Tank Sources	3080	3080	3080	3080	3080	3080
- Agricultural Source Loadings to Streams *1	20	20	20	20	20	20
- Septic Tank Source Loadings to Streams *1	500	760	1220	1360	1580	2400
Sub-total - Tributary Streams	3600	3860	4320	4460	4680	5500
2. DUSTFALL AND PRECIPITATION	600	1600	1600	1600	1600	1600
3. INDUSTRIAL	-	-	-	-	-	-
4. GROUNDWATER						
- Agricultural Sources	20	20	20	20	20	20
- Septic Tank Sources	Range*2 440 to 940	1460	2300	2560	3000	4540
- Natural Sources	20	20	20	20	20	20
- Other	-	-	-	-	-	-
Sub-total Groundwater	980	1500	2340	2600	3040	4580
TOTAL - ALL SOURCES	5180	6960	8260	8660	9320	11680

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot study results.

TABLE 15.2

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO WOOD LAKE FROM EXTERNAL SOURCES (IN POUNDS)
(Loading Criteria for Acceptable Water Quality = 2000 to 3000 Pounds Total Phosphorus per Year.)

SOURCE \ PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980	PROJECTED LOADINGS FOR THE YEAR 2000		PROJECTED LOADINGS FOR THE YEAR 2020	
			Low Economic Growth (III)	High Economic Growth (II)	Low Economic Growth (III)	High Economic Growth (II)
1. TRIBUTARY STREAMS*[3]						
- Excluding Agriculture and Septic Tank Sources	800	800	800	800	800	800
- Agricultural Source Loadings to Streams *1	-	-	-	-	-	-
- Septic Tank Source Loadings to Streams *1	-	-	-	-	-	-
Subtotal - Tributary Streams	800	800	800	800	800	800
2. DUSTFALL AND PRECIPITATION	140	140	140	140	140	140
3. INDUSTRIAL	20	20	20	20	20	20
4. GROUNDWATER						
- Agricultural Sources	400	360	360	260	300	220
- Septic Tank Sources	Range*[2] 780 to 1660	3080	5900	6560	9120	13440
- Natural Sources	40	40	40	40	40	40
- Other	260	480	920	1000	1440	2100
Subtotal Groundwater	2360	3960	7220	7860	10900	15800
TOTAL - ALL SOURCES	3320	4920	8180	8820	11860	16760

*[1] Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*[2] Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot study results.

*[3] Includes inflow from Vernon Creek to Wood Lake

TABLE 15.3

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO OKANAGAN LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality = 135000 to 185000 Pounds Total Phosphorus Per Year)

PROJECTION / SOURCE	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980				PROJECTED LOADINGS FOR THE YEAR 2000								PROJECTED LOADINGS FOR THE YEAR 2020							
						Low Economic Growth (III)				High Economic Growth (II)				Low Economic Growth (III)				High Economic Growth (II)			
DEGREE OF PHOSPHORUS REMOVAL		1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%
1. TRIBUTARY STREAMS																					
- Excluding Agricultural and Septic Tank Sources	60500	60500				60500				60500				60500				60500			
- Agricultural Source Loadings to Streams *1	2820	3480				5000				4840				6460				6260			
- Septic Tank Source Loadings to Streams *1	4560	6720				10060				11380				12820				19040			
Sub-total - Tributary Streams	67880	70700				75560				76720				79780				85800			
2. MAIN VALLEY STREAM (Vernon Creek from Kalamalka Lake excluding Vernon S.T.P.)	1600	1600				1600				1600				1600				1600			
3. MUNICIPAL - 1971 Treatment - 30% Phosphorus Removal - 80% Phosphorus Removal - 90% Phosphorus Removal	82160	114940	102220	29200	14680	158800	140740	40200	20120	190440	168780	48220	24100	181520	160140	45740	22880	26940	237540	67860	33920
4. DUSTFALL AND PRECIPITATION	19600	19600				19600				19600				19600				19600			
5. INDUSTRIAL	1600	2720				4200				4100				5400				5060			
6. STORM SEWERS	600	780				1020				1180				1160				1720			
7. GROUNDWATER																					
- Agricultural Sources	520	500				520				400				520				380			
- Septic Tank Sources	Range*2 5360 to 11060	11960				17240				19460				20880				31200			
- Natural Sources	2060	2060				2060				2060				2060				2060			
- Other Sources	240	300				460				500				540				800			
Sub-total - Groundwater	13880	14820				20280				22420				24000				34440			
TOTAL - ALL SOURCES	187320	225160	212440	139420	124820	281060	263000	172460	142380	316060	294400	173840	149720	313060	291680	177280	154420	417460	385760	216080	182140

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot [illegible] results

TABLE 15.4

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO SKAHA LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality = 30000 to 40000 Pounds Total Phosphorus Per Year)

SOURCE / PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980			
DEGREE OF PHOSPHORUS REMOVAL		1971	30%	80%	90%
1. TRIBUTARY STREAMS					
- Excluding Agricultural and Septic Tank Sources	3640	3640			
- Agricultural Source Loadings to Streams *1	340	340			
- Septic Tank Source Loadings to Streams *1	220	300			
Subtotal - Tributary Streams	4200	4280			
2. MAIN VALLEY STREAM (Okanagan River from Okanagan Lake)	10600	10600			
3. MUNICIPAL - 1971 Treatment*3 - 30% Phosphorus Removal - 80% Phosphorus Removal - 90% Phosphorus Removal	28900	37120	49020	14000	7000
4. DUSTFALL AND PRECIPITATION	1660	1660			
5. INDUSTRIAL	140	260			
6. STORM SEWERS	100	120			
7. GROUNDWATER					
- Agricultural Sources	40	40			
- Septic Tank Sources	*2 1260 to 2600	3480			
- Natural Sources	160	160			
- Other Sources	60	120			
Subtotal - Groundwater	2860	3800			
TOTAL - ALL SOURCES	48460	57840	69740	34720	27720

SOURCE	PROJECTED LOADINGS FOR THE YEAR 2000: Low Economic Growth III				High Economic Growth II			
DEGREE OF PHOSPHORUS REMOVAL	1971	30%	80%	90%	1971	30%	80%	90%
1. TRIBUTARY STREAMS								
- Excluding Agricultural and Septic Tank Sources	3640				3640			
- Agricultural Source Loadings to Streams *1	340				340			
- Septic Tank Source Loadings to Streams *1	420				480			
Subtotal - Tributary Streams	4400				4460			
2. MAIN VALLEY STREAM (Okanagan River from Okanagan Lake)	10600				10600			
3. MUNICIPAL - 1971 Treatment*3 - 30% Phosphorus Removal - 80% Phosphorus Removal - 90% Phosphorus Removal	49280	65100	18600	9300	59020	77940	22280	11140
4. DUSTFALL AND PRECIPITATION	1660				1660			
5. INDUSTRIAL	320				300			
6. STORM SEWERS	160				200			
7. GROUNDWATER								
- Agricultural Sources	40				40			
- Septic Tank Sources	4780				5520			
- Natural Sources	160				160			
- Other Sources	120				120			
Subtotal - Groundwater	5100				5840			
TOTAL - ALL SOURCES	71520	87340	40840	31540	82080	101000	45340	34200

SOURCE	PROJECTED LOADINGS FOR THE YEAR 2020: Low Economic Growth III				High Economic Growth II			
DEGREE OF PHOSPHORUS REMOVAL	1971	30%	80%	90%	1971	30%	80%	90%
1. TRIBUTARY STREAMS								
- Excluding Agricultural and Septic Tank Sources	3640				3640			
- Agricultural Source Loadings to Streams *1	340				340			
- Septic Tank Source Loadings to Streams *1	480				720			
Subtotal - Tributary Streams	4460				4700			
2. MAIN VALLEY STREAM (Okanagan River from Okanagan Lake)	10600				10600			
3. MUNICIPAL - 1971 Treatment*3 - 30% Phosphorus Removal - 80% Phosphorus Removal - 90% Phosphorus Removal	54300	71720	20500	10240	80460	106280	30360	15180
4. DUSTFALL AND PRECIPITATION	1660				1660			
5. INDUSTRIAL	340				300			
6. STORM SEWERS	180				280			
7. GROUNDWATER								
- Agricultural Sources	40				40			
- Septic Tank Sources	5520				8280			
- Natural Sources	160				160			
- Other Sources	120				180			
Subtotal - Groundwater	5840				8660			
TOTAL - ALL SOURCES	77380	94800	43580	33320	106600	132480	56560	41380

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot study results

*3 Values based on 1972-73 Efficiency of Penticton Tertiary Treatment Unit

TABLE 15.5

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO VASEUX LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality = 17500 to 22000 Pounds of Total Phosphorus Per Year)

SOURCE \ PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980				PROJECTED LOADINGS FOR THE YEAR 2000								PROJECTED LOADINGS FOR THE YEAR 2020							
						Low Economic Growth III				High Economic Growth II				Low Economic Growth III				High Economic Growth II			
DEGREE OF PHOSPHORUS REMOVAL		1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%
1. TRIBUTARY STREAMS																					
- Excluding Agriculture and Septic Tank Sources	-	-				-				-				-				-			
- Agricultural Source Loadings to Streams *1	-	-				-				-				-				-			
- Septic Tank Source Loadings to Streams *1	260	380				640				720				840				1240			
Sub-total - Tributary Streams	260	380				640				720				840				1240			
2. MAIN VALLEY STREAM																					
- Okanagan River at Vaseux Lake - Base Loading	18800	18800				18800				18800				18800				18800			
3. EFFECT OF DEGREE OF TREATMENT AT PENTICTON ON BASE LOADING (Phosphorus Removal) - Present level of Treatment (1971) - 30% Removal - 80% Removal - 90% Removal		+8220	+20120	-1540	-2280	+19900	+35460	-1100	-2040	+30120	+49040	- 80	-1900	+25400	+42820	-880	-1940	+51560	+77380	+1460	-1400
4. DUSTFALL AND PRECIPITATION	40	40				40				40				40				40			
5. GROUNDWATER																					
- Agriculture Sources	20	20				20				20				20				20			
- Septic Tank Sources	*2 140-280	420				700				760				900				1300			
- Natural Sources	80	80				80				80				80				80			
- Other Sources	20	-				-				-				-				-			
Sub-total - Groundwater	400	520				800				860				1000				1400			
TOTAL - ALL SOURCES	19500	27950	39860	18200	17460	40180	55740	19180	18240	50540	69480	20340	18520	46080	63500	19800	18740	73040	98860	22940	20080

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot

TABLE 15.6

PRESENT AND PROJECTED LOADINGS OF TOTAL PHOSPHORUS TO OSOYOOS LAKE FROM EXTERNAL SOURCES (IN POUNDS)

(Loading Criteria for Acceptable Water Quality =
26000 to 37000 Pounds Total Phosphorus Per Year)

SOURCE / PROJECTION	ESTIMATED LOADINGS IN 1971 BASED ON 1969-71 DATA POUNDS	PROJECTED LOADINGS POUNDS 1980				PROJECTED LOADINGS FOR THE YEAR 2000								PROJECTED LOADINGS FOR THE YEAR 2020							
						Low Economic Growth (III)				High Economic Growth (II)				Low Economic Growth (III)				High Economic Growth (II)			
DEGREE OF PHOSPHORUS REMOVAL		1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%	1971	30%	80%	90%
1. TRIBUTARY STREAMS																					
- Excluding Agricultural and Septic Tank Sources	700	700				700				700				700				700			
- Agricultural Source Loadings to Streams *1	60	60				60				60				60				60			
- Septic Tank Source Loadings to Streams *1	40	60				60				80				80				100			
Subtotal - Tributary Streams	800	820				820				840				840				860			
2. MAIN VALLEY STREAM																					
- Base Loading of Okanagan River excluding Oliver S.T.P.	22140	22140				22140				22140				22140				22140			
3. EFFECT OF DEGREE OF TREATMENT AT PENTICTON ON BASE LOADING																					
- Present Level of Treatment - 30% Phosphorus Removal - 80% Phosphorus Removal - 90% Phosphorus Removal	-	+8220	+20120	-1540	-2280	+19900	+36200	-1100	-2040	+30120	+49040	- 80	-1900	+25400	+42820	-880	-1940	+51560	+77380	+1460	-1400
4. INCREMENTAL LOADING TO OKANAGAN RIVER ENROUTE	-	1480				2880				3460				3640				6440			
5. MUNICIPAL																					
- Loadings from Oliver Treatment Plant to Okanagan River and Osoyoos Lake - 1971 Treatment - 30% Phosphorus Removal - 80% Phosphorus Removal - 90% Phosphorus Removal	4060	4340	3580	1020	520	4600	3780	1080	540	5620	4620	1320	660	4600	3780	1080	540	6120	5040	1440	720
6. DUSTFALL AND PRECIPITATION	980	980				980				980				980				980			
7. INDUSTRIAL	200	300				380				360				420				360			
8. STORM SEWERS	-	-				-				-				-				-			
9. GROUNDWATER																					
- Agricultural Sources	520	540				500				480				520				500			
- Septic Tank Sources	Range*2 4160 - 8560	12240				16760				17860				17940				25660			
- Natural Sources	200	200				200				200				200				200			
- Other Sources	60	80				80				140				120				140			
Subtotal - Groundwater	9340	13060				17540				18660				18780				26500			
TOTAL - ALL SOURCES	37520	51340	62480	38260	37020	69240	84720	44720	43240	82180	100300	47680	45200	76800	93400	47000	45400	114960	139700	60180	56600

*1 Groundwater and surface runoff loadings which return to stream surface waters and were measured as tributary stream loadings.

*2 Estimated range of probable loadings from septic tanks. Maximum values based on per capita contribution of phosphorus from standard septic tank installations and have been used in all projections. Minimum values are based on short duration pilot butary stream loadings. Estimates of these contributions were therefore made and deducted from the tributary stream total to provide the figures shown under tributary streams in Tables 15.1 to 15.6.

The amount of phosphorus carry-over in Okanagan River between Skaha Lake and Osoyoos Lake has been estimated from the graph shown in Figure 15.1. The assumptions used in developing this graph are as follows:

(1) Depletion of phosphorus occurs with time, below the major source.

(2) The variables - stream flow, time, and distance are interchangeable.

(3) Under present conditions the river has assimilated total phosphorus and nitrogen to a minimum level. Any loading higher than present (1969-71) conditions is therefore represented by a parallel curve.

(4) Any loading less than the present one (1969-71) may be estimated by interpolation between the present and natural state curve.

(5) The minimal loading possible increases to a maximum of ten per cent under zero municipal input.

(6) The input from Okanagan Lake is relatively constant.

The carry-over values as calculated represent the change from present loadings that may occur with future increases or decreases in the amount of nutrient loading from the City of Penticton Sewage Treatment Plant. Negative values of carry-over therefore represent a decrease in the loadings to be expected from this source.

Projected nitrogen loadings have also been calculated and included in Technical Supplement IV.

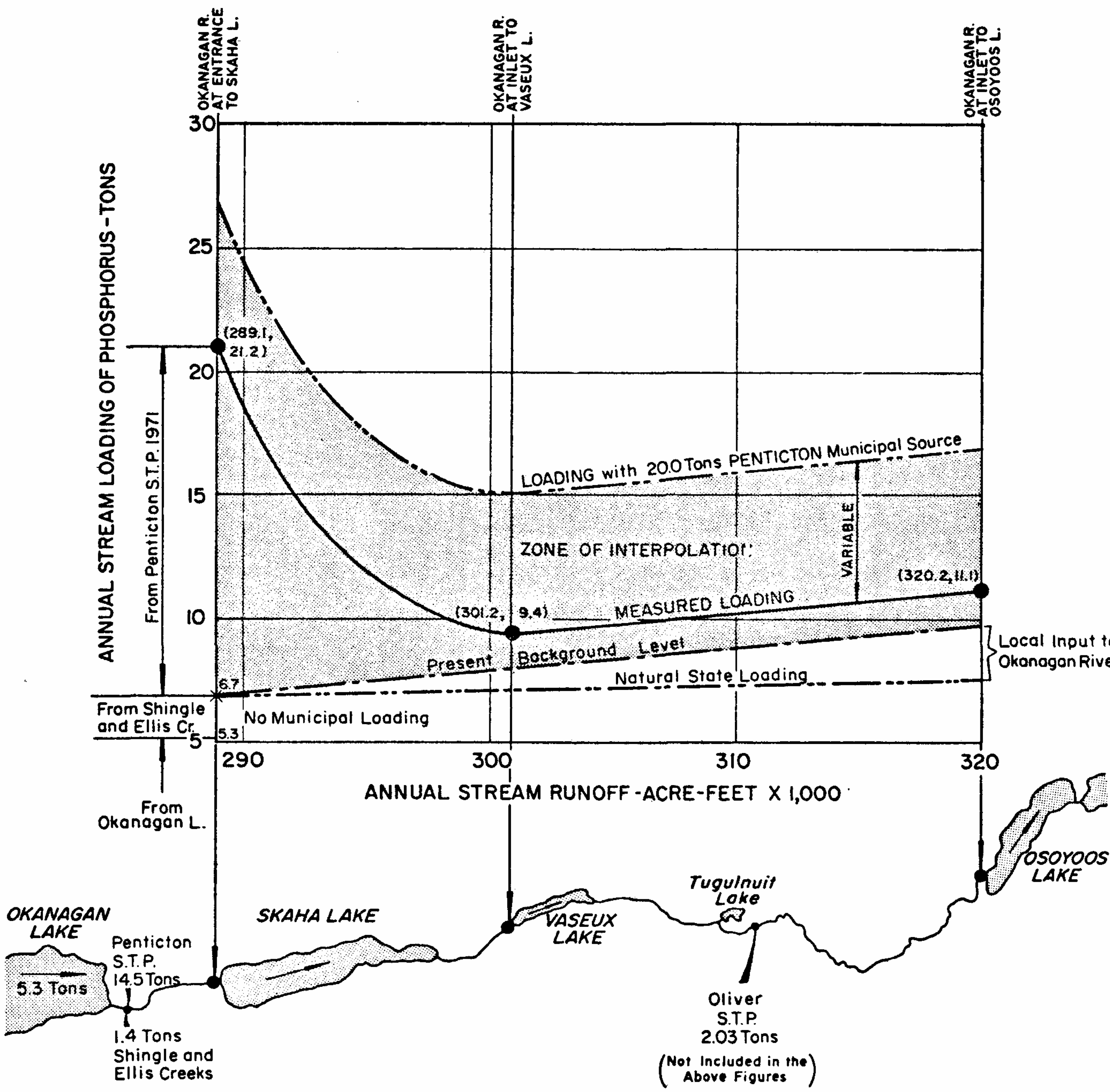
5.3 WATER QUALITY FOR CONSUMPTIVE USE

This analysis is primarily concerned with water quality alternatives to meet consumptive use objectives in tributary streams. The quality of the main valley lakes is either acceptable for consumptive use purposes, or can only be controlled through limiting pollutants entering the lakes from tributary streams and direct waste outfall discharges. The latter will be discussed under Section 15.4.

Because of the diffuse nature of most pollutants entering the streams, and the difficulty in controlling these, the evaluations for quality control in streams are highly subjective.

15.3.1 Rationale for Stream Water Quality Evaluations

The generally accepted allowable criteria for raw water sources was presented in Table 5.1, Chapter 5. Many streams are approaching or now exceed these criteria for specific quality parameters. Of most concern are those pollutants which are harmful to the health of man, or injurious to fish,



PHOSPHORUS CARRYOVER IN THE OKANAGAN RIVER SYSTEM

Figure 15.1

such as high coliform levels, and high nutrient levels. The origin of these pollutants is primarily from point sources in the developed areas of the basin including industrial and municipal waste discharges to streams and cattle feed-lots, riding stables, and poultry farms adjacent to streams. Soil erosion resulting from forestry and agricultural operations, particularly logging road construction, also contributes a significant amount of sediment containing nutrients to tributary streams. Because the amount of waste material that various streams can assimilate varies from creek to creek, from month to month, and from year to year, depending on the size of the sub-basin and the amount of available runoff, it is difficult if not impractical to establish general stream loading or effluent standards to meet acceptable criteria for stream water quality in the Okanagan Basin. Also, there are few streams in the basin that carry sufficient water on a year round basis to assimilate any waste products other than natural pollutants from the basin itself. Therefore the removal of all municipal and industrial discharges containing pollutants is required to achieve established water quality standards in most streams. However, where such waste discharges can be proved acceptable and free of pollutants, the additional water provided by such discharges is often beneficial, and should be encouraged. Community or regional treatment plants would be the most suitable in achieving the above objective particularly in respect to industrial outfalls.

Logging-road construction and land cultivation adjacent to streams are major sources of soil erosion from surface runoff. Eroded soils greatly increase the turbidity of water, and provide a base in lakebeds for rooted aquatic vegetation. They also contribute a substantial amount of nutrients and other chemical elements to the main valley lakes. Improved landuse management over a period of time may reduce such erosion, but continued monitoring and surveillance of stream water quality may also indicate the need for appropriate green belts (Strips of permanent vegetation) along the entire course of streams where logging and cultivation are practiced. Such green belts must be maintained to ensure their effectiveness in minimizing soil erosion and stream pollution.

The remaining increases in stream loadings are expected to come from forestry operations, diffuse agricultural sources, and septic tanks. No estimate of the future contribution from forestry operations has been made, but if there is no increase in the annual amount of timber harvested, there should be no significant increase in loading from this source to the basin as a whole. The tributaries affected, however, will depend on the areas being logged and the care taken to keep logging road and other construction away from streams.

Projections of phosphorus loadings from diffuse agricultural sources and septic tanks to tributary streams are included in Table 15.1 to 15.6. These show significant increases to the year 2020 for streams tributary to Okanagan Lake. Agricultural source tradings are expected to increase from 2800 pounds in 1971 to 6500 pounds per year in 2020. Septic tank loadings are expected to increase from 4500 in 1971 to 13,000 pounds per year in 2020 under a low economic growth rate, assuming no change in waste treatment policy. Projected phosphorus loadings from septic tank sources located near streams tributary to Kalamalka Lake are also expected to increase from 20 pounds in 1971 to 1600 pounds per year in 2020 under a low economic growth rate. Changes in source loadings to streams tributary to the other main valley lakes are estimated to be relatively mi nor.

Livestock may also contribute high levels of fecal coliform from feedlots and confined animal housing units. Future levels of coliform from these operations will be dependent on the numbers of livestock in a sub-basin, and farm management practices, but no projection has been made on this aspect.

One additional source of stream pollution which has not been estimated is the effect of the use of the headwater lakes for angling and recreation. The number of angler days on these lakes is expected to increase from 71,000 in 1971 to between 190,000 and 246,000 by 2020, which will greatly increase the opportunity for increased waste disposal and pollution of these waters. The headwaters of the basin have not been used extensively for other forms of recreation to date, but this may change as access improves and the population of the valley increases.

15.3.2 Alternatives (Stream Water Quality)

The continuation of present management practices for water quality in the tributary streams, while an option, would mean that most stream water would not be acceptable for consumptive use purposes without prior treatment. A continued decline in the existing quality should also be expected with economic growth over the next 50 years, resulting in more expensive treatment of these raw water sources with time if they are to be used for consumptive purposes.

The implementation of management policies to meet the objective of providing a water quality compatible with various consumptive uses, would require positive steps in the control waste discharges and land use practices. Alternatives considered include the following:

(a) Removal of Positive Waste Discharges

The removal of all direct municipal and industrial waste discharges causing pollution may be the only way in which the quality of many of the streams in their lower reaches can be improved to a level that will meet acceptable water quality standards. However, because the flow in the majority of streams during the greater part of the year is small, the return of unpolluted water from waste outfalls could help support fishery and other recreational uses. Waste treatment facilities that provide a high quality effluent should therefore be encouraged where such discharges can be proved acceptable and free of pollutants.

(b) Green Belts

The primary purpose of green belts is to prevent surface runoff, from urban and agricultural areas, reaching tributary streams directly. Green belts along the periphery of all tributary streams through developed areas could help reduce stream oxygen deficits and high coliform levels resulting from agricultural and urban developments. These green belts in the form of natural cover, grass, and trees, and elevated where necessary would ensure that all surface runoff waters pass through a soil column before reaching a stream. This would provide a filter and form of treatment for surface runoff from cattle feedlots, riding stables, poultry farms, and pastured grassland, etc. located near streams but outside of the green belt area. While this form of treatment would reduce coliform levels and oxygen deficits, the effect on nutrient loadings would be dependent on the soil type and cover crop and in most cases may be minimal.

Green strips between streams and logging roads would also reduce loadings from logging and other forestry operations in the headwaters of the basin. Streams on which these should be given special consideration are those that are important to the fishery resource including Mission, Vernon, Equesis and Trepanier Creeks.

(c) Agricultural and Watershed Management Practices

Certain land use practices in stream sub-basins may have a detrimental effect on stream water quality. In foresty operations these may include poor harvesting practices, forest fires, logging road construction adjacent to streams, erosion, and the application of chemicals for insect or growth control. Clear-cutting of forest areas causes accelerated nutrient loss to streams and effects the runoff by increasing the intensity of spring melt and storm runoff.

Logging methods which greatly disturb the soil cause increases in stream turbidity, nutrient concentrations, and sediment loads. Disturbance of stream banks and subsequent land slides caused by road construction expose soil to erosion and leaching.

Various agricultural practices affect stream quality through erosion or groundwater flow. Excess applications of fertilizers and manure, or application at the wrong time of the year, and excess irrigation can all result in increased nutrient loadings through groundwater return flows.

All of the above reflect management practices over which there is little direct control by governments. Education along with positive incentives for improving such landuse practices may be the only alternative for reducing loadings and improving stream quality in these management areas.

15.4 CONTROL OF AQUATIC PLANT AND ALGAL GROWTH IN THE MAIN VALLEY LAKES

Aquatic plant growth and algal blooms have become visually evident in parts of all the main valley lakes in recent years. These conditions will continue to worsen under existing waste management practices and will have an increasing detrimental effect on the enjoyment of these lakes from an economic, recreational and aesthetic viewpoint. The cause of this type of quality impairment has been identified as nutrient loadings in excess of that which the lake can assimilate, particularly those resulting from man-induced sources.

15.4.1 Rationale for Lake Water Quality Evaluations

To provide a basis for projecting the effect of nutrient loadings on each of the main valley lakes over the next 50 years, the maximum desirable concentration of phosphorus in each lake at spring overturn has been related to lake water quality and annual phosphorus loadings. This in turn, has provided tentative standards for the control of aquatic plant and algal growth in each of the lakes.

Reasons for the selection of phosphorus as the key nutrient in biological control were outlined in Chapter 6.

The 'assimilative capacity' of a lake may be defined as the percent of total energy intake required for the growth, respiration, and reproduction of plant life. This relationship may be expressed as:

$$\text{Assimilative Capacity} = \frac{\text{Nutrients required for plant growth, respiration and reproduction}/t}{\text{Total Nutrient Input}/t}$$

Where t - time in years

For each nutrient, trace element, and organic factor required for plant growth there is a relationship between supply and demand that can be expressed by the assimilative capacity. In Oligotrophic lakes, the nutrient supply is so low that the input limits plant populations and seasonal growth is balanced by loss. In these cases the input is equal to the amount required to sustain existing plant life and the assimilative capacity approaches 1. In eutrophic lakes, supplies of most nutrients are in excess of demand and values of the assimilative capacity are less than 1. In these cases, factors such as available light, competition, or predation often limit growth to a greater extent than available nutrient supply. Wood Lake is an excellent example of this condition where phosphorus is super-abundant and other nutrients, or the above mentioned controls, regulate plant populations before the external supply is exhausted. Unfortunately this type of control is not imposed until nuisance levels of algal blooms and weed growth have been reached.

By limiting annual loadings of phosphorus to a lake, to that which can be assimilated within an acceptable level of biological production, high water quality can be maintained and future quality predicted, based on annual loadings. This approach has been used in establishing acceptable loading criteria for each of the main valley lakes. Since each lake will respond differently to a given nutrient load because of differences in mean depth, water renewal rates and other factors, these loading criteria will vary from lake to lake.

Values were set so as to achieve, within limits, an optimum level of biological production for multiple water use without the occurrence of nuisance algal blooms and extensive aquatic plant growth (Figure 15.2). These criteria apply primarily to macro-sources of nutrients and the lake as a whole, rather than to localized micro-sources of nutrients.

The values selected were based on information gained over the period 1969 to 1972 including the following:

(1) Current average load of total phosphorus to each lake.

(2) Present mean concentration of total phosphorus and orthophosphorus at spring overturn.

(3) The sediment retention of phosphorus and internal loading where applicable,

(4) Average algal biomass based on chlorophyll a determinations,

(5) Average biomass of zoobenthos (bottom organisms) and Zooplankton (suspended or free floating organisms) in relation to (1) and (4) above.

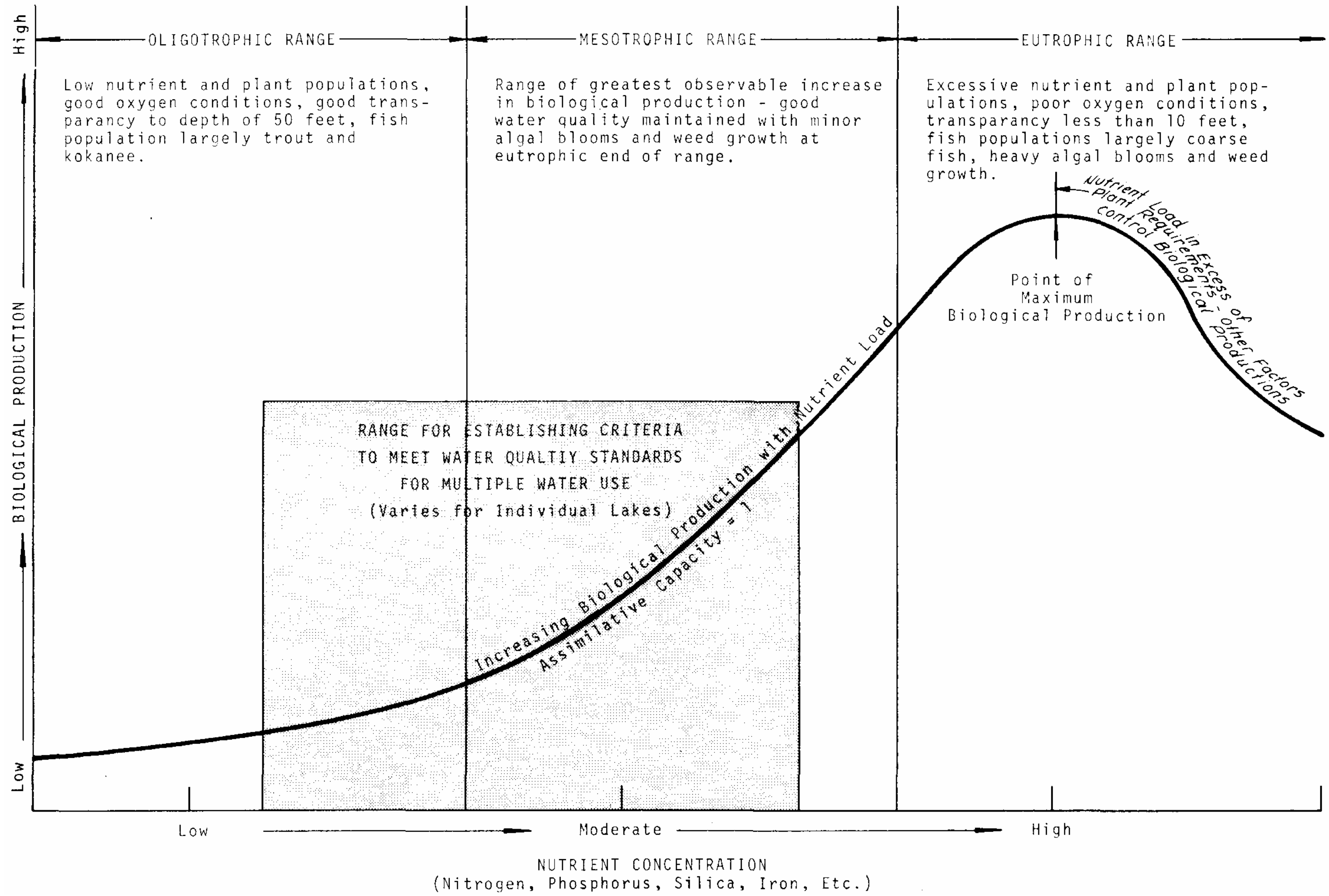
The present (1971) average concentrations of phosphorus at spring overturn, and suggested criteria for multiple water use are shown in Table 15.7. The rationale for establishing specific criteria for each of the main valley lakes is summarized below:

(a) Okanagan Lake

The acceptable range for phosphorus loading to Okanagan Lake has been established at 135,000 to 185,000 pounds per year. Because certain areas of the lake exhibit eutrophic characteristics while the main body of the lake is Oligotrophic, suggested maximum loadings to the north, central and south sections of the lake have also been computed. This separation was hot based on any natural state, but was introduced to facilitate water quality evaluations for this lake.

(i) North Basin

Acceptable limits for phosphorus loading to this basin were set at 55,000 to 75,000 pounds per year. These loadings are considered to be approximately equal to the ass imitative capacity of existing plant biomass in the central portion of the basin which still exhibits excellent water quality A loading of 66,000 pounds per year should be considered the maximum, recognizing that in any given year the load may reach 75,000 pounds due to uncontrollable sources of phosphorus. These values apply to the entire north basin and should not be



SCHEMATIC DRAWING OF RELATIONSHIP BETWEEN NUTRIENT LOADINGS AND BIOLOGICAL PRODUCTION, AND RANGE FOR SELECTING LOADING CRITERIA FOR MAIN VALLEY LAKES.

Figure 15.2

TABLE 15.7

TOTAL PHOSPHORUS CONCENTRATIONS AND LOADING CRITERIA - MAIN VALLEY LAKES

LAKE	AVERAGE CONCENTRATION OF TOTAL PHOSPHORUS AT SPRING OVERTURN 1971 — MICROGRAMS PER LITER		MAXIMUM DESIRABLE CONCENTRATION OF PHOSPHORUS AT SPRING OVERTURN FOR MULTIPLE WATER USE QUALITY STANDARDS — MICROGRAMS PER LITER		LOADING CRITERIA TO ACHIEVE DESIRABLE CONCENTRATIONS OF TOTAL PHOSPHORUS EQUALS (ASSIMILATIVE CAPACITY)	TROPHIC CHARACTER BASED ON NEW LOADING CRITERIA
	Average	Range	Average	Range	Pounds per year	
Wood Lake	104	83-125	20	10-30	2,000 - 3,000	Meso-Eutrophic
Kalamalka Lake	8	4-12	5	1-10	6,600 - 8,800	Oligotrophic
Okanagan Lake (as a Unit)	7	2-12	5	1-10	135,000 - 185,000	Oligotrophic
-North Basin	-	-	-	-	55,000 - 75,000	"
-Central Basin	-	-	-	-	55,000 - 75,000	"
-South Basin	-	-	-	-	25,000 - 35,000	"
Skaha Lake	24	15-32	12	10-15	30,000 - 40,000	Mesotrophic
Vaseux Lake					17,500 - 22,000	Eutrophic
Osoyoos Lake	12	10-15	10	5-15	26,000 - 37,000	"

confused with point source loadings to small regions which may exhibit local effects of nutrient enrichment. The shallow North and Vernon Arms will continue to exhibit some aquatic plant growth due to basin characteristics and continuing diffuse loadings from the Armstrong and Vernon areas respectively.

(ii) Central Basin

Criteria for the central basin are the same as for the north basin and the same comments apply. Localized problems are expected to continue along the Kelowna foreshore.

(iii) South Basin

Values for this basin have been set lower than the previous two basins so that this relatively large section of the Okanagan Lake can act as a buffer for lakes below. Positive point sources are few in this section of the lake and the very large volume of excellent quality water should protect Penticton beaches from any nuisance aquatic plant growths and insure a low nutrient discharge from Okanagan Lake to Skaha Lake. Any proposed point sources should be kept out of this basin to maintain a sizeable reservoir of good quality water between Kelowna and the lake outlet at Penticton. A loading of 35,000 pounds per year should be considered an absolute maximum, again recognizing that values below this will further insure the maintenance of good water quality.

(b) Skaha Lake

Acceptable limits for phosphorus loadings to Skaha Lake range from 30,000 to 40,000 pounds per year. These somewhat high values take into account the very short retention time of water in this lake (one year) and the excellent source of good quality water flowing into Skaha Lake from Okanagan Lake.

If values remain within these established limits, good water quality should be achieved. Sporadic algal blooms may continue to occur along with moderate aquatic plant growth on the eastern shoreline, however the annual occurrence of heavy blue-green blooms will be eliminated.

(c) Osoyoos Lake

Phosphorus loading limits established for this lake range from 26,000 to 37,000 pounds per year. These values allow for the very rapid water renewal rate (residence time) which prevents the accumulation of large amounts of nutrients. The maintenance of phosphorus loads below 37,000 pounds per year should prevent extensive algal blooms and control aquatic plant growth to within manageable limits. Osoyoos Lake is largely dependent on the quality of water in Skaha Lake and in Okanagan River, and improvement in the quality of these lake and river waters will also benefit Osoyoos Lake.

(d) Kalamalka Lake

Loading limits for Kalamalka range from 6,600 to 8,800 pounds per year. This is much lower than for the other lakes because of the small volume of inflow and the long retention time of water in this lake. Its calcium carbonate cycle may partially buffer it from nutrient overload, but any large increase in phosphorus loadings may cause this carbonate system to collapse. The lake is already an effective plankton producer as evidenced in bioassay studies and recent paleolimnological investigations. If phosphorus loadings can be curtailed to within these proposed limits, the lake should maintain its present excellent condition.

(e) Wood Lake

Acceptable loadings established for Wood Lake are 2,000 to 3,000 pounds of phosphorus per year. These annual rates are no doubt above historical values, but below present levels. If these limits are met, and a continual source of good quality water reaches this lake, the occurrence of annual blue-green algal problems should be eliminated, as well as the need for periodic aquatic plant harvest. The lake will continue to be a productive lake, but not in the sense of objectionable nuisance organism. Clarity and oxygen levels will be improved and fisheries enhanced if these criteria are met. Because of the existing high internal loading of phosphorus in this lake a significant decrease in phosphorus loadings will be required initially to effect any change in its condition. The lower loading criteria value of 2,000 pounds should therefore be used until a significant improvement in the quality of Wood Lake has been achieved.

The higher inflows and reduced retention time of water in this lake, due to industrial cooling water discharge, should speed the recovery of this lake, but will have no immediate effect on its quality.

(f) Vaseux Lake

Acceptable loadings for this lake range between 17,500 and 22,000 pounds of phosphorus per year. The achievement of these standards depends primarily on improving the quality of Skaha Lake and Okanagan River water. Extensive aquatic plant growth will always be an integral part of this lake, due to its shallowness and rich bottom sediments. This habitat is considered suitable for this lake as it has been established as a wildlife sanctuary.

15.4.2 Alternatives (Lake Water Quality)

As stated previously, the continuation of existing waste management practices will result in a continuing decline in the water quality of the main valley lakes from a recreation and aesthetic viewpoint.

Waste management alternatives reviewed in this report to meet the objective of a water quality consistent with a high quality environment are as follows:

(1) Waste Export from the Basin
(2) Outfall Discharge Locations
(3) Green Belts
(4) Flushing through Increased Flows
(5) Waste Treatment
- Phosphorus Removal
- Costs and Benefits of Phosphorus Removal
- Waste management

Discussion of the first four alternatives is subjective because of the difficulty in quantifying benefits and costs. The first is a direct alternative to waste treatment, while the latter three provide methods for improving water quality either alone or in combination with other alternatives.

The fifth alternative involving advanced waste treatment processes is considered the most important in terms of maintaining or improving water quality in the main valley lakes for recreation and aesthetic purposes. Discussions on this alternative include preliminary estimates of the cost and benefit of various levels of phosphorus removal, and waste management requirements.

(a) Waste Export from the Basin

This method of controlling nutrient input to the Main Valley Lakes would involve pumping treated effluent from municipal sewage treatment plants to a remote area of an adjacent drainage basin for disposal. Only the three major centers of Vernon, Kelowna and Penticton have been considered for a preliminary review of this concept. The proposal would require the construction of pumping stations and transporting pipelines for each municipal regions.

Disposal sites which could be used for the three centers are as follows:

- City of Vernon - 12 1/2 miles east near Spider Creek in the South Thompson River Drainage Basin; 580 feet above Vernon.
- City of Kelowna- 20 miles east near Hydraulic Lake in the Kettle River Drainage Basin. The elevation above Kelowna is 2950 feet.
- City of Penticton - 14 miles southwest near Green Mountain in the Similkameen River Drainage Basin. The elevation above Penticton is 1850 feet.

Preliminary cost estimates for simply transporting treated effluent from the urban treatment plants to the point of disposal, show these to be comparable to spray irrigation for phosphorus removal and about twice the cost of phosphorus removal by chemical precipitation.

Excluding the above cost comparison, major disadvantages associated with waste export are:

(i) The effect these discharges would have on the quality of water in adjacent basins is unknown but could be just as detrimental as it has been in the Okanagan Basin. In this case the problem would have just been transferred from one basin to another.

(ii) The export of such wastes would remove as much as 20,000 acre feet of water per year from the basin, which in low flow years could present a significant amount in terms of water supply. The loss of such water would represent a cost against the waste export alternative.

(iii) Problems of waste export disposal in the winter months may be the same as for spray irrigation. This factor has not been taken into account in estimating waste export costs.

Based on the above considerations waste export has not been entertained as a viable alternative to waste treatment within the Okanagan Basin.

(b) Outfall Discharge Locations

This alternative considers the effect of existing outfall locations on local water quality, and the value, if any, of relocating these discharges. While this alternative would not reduce the total nutrient load to a lake, it could provide for short term improvements to the water quality of public beaches, which may have limited use for recreation because of poor water quality. Only the outfalls from the six major municipal centers of Armstrong, Vernon, Penticton, Kelowna,0liver and Westbank have been considered in this evaluation. The existing locations of these outfalls and the problems that arise from their locations in respect to recreation and aesthetic values are shown in Table 15.8 .

The effects shown apply only to the main receiving body of water and not to the creeks themselves.

From a limnological standpoint, extending or deepening out-fall discharges or adding diffusers simply moves the problem of nutrient enrichment and biological production from one point in a lake to another. Disposing of wastes to deep water locations does avoid unsightly scum and may keep the nutrients away from sunlight and algae during the summer months, but during spring and fall overturn these nutrients will become equally distributed throughout the water column. Problems with plant growth may then be magnified in the following year in direct proportion to the annual increase in nutrients. Any proposal for relocating outfall discharges for improvement of public beaches or for other reasons, should therefore be considered only in conjunction with the removal of major nutrient sources.

TABLE 15.8

EFFECT OF OUTFALL LOCATION ON LOCAL WATER QUALITY

MUNICIPALITY	OUTFALL LOCATION	EFFECT ON LOCAL LAKE QUALITY
Armstrong	Deep Creek which empties into North Arm of Okanagan Lake.	The North Arm has had extensive weed growth for many years and supports a varied population of wildlife. Since not developed for recreation no change in location is warranted.
Vernon	Vernon Creek which empties into Vernon Arm of Okanagan Lake	Extensive weed growth which requires harvesting. Affects Kin Beach and extensive private shoreline development. Coliform counts on Kin Beach sometimes exceed acceptable criteria.
Kelowna	Okanagan Lake	Nuisance weed growth along shoreline. continued enrichment of this area will have increasing affect on Kelowna City Beach.
Westbank	Westbank Creek which flows into Okanagan Lake	Nuisance weed growth along shoreline of Okanagan Lake.
Penticton	Okanagan River which flows into Skaha Lake	No effect on Skaha Beach - some weed growth effect on undeveloped shoreline on west side of lake.
Oliver	Okanagan River	No visual detrimental effects on Okanagan River.

The one area that would appear to benefit from a change in outfall location is that of the Vernon Arm, particularly in respect to Kin Beach, which is one of the few large public beaches in this area. The relocation of the Vernon sewage Treatment Plant outfall would mean removing the discharge from Vernon Creek and using land disposal or constructing a new discharge line to a deep section of Okanagan Lake. The cost of this relocation is estimated at $1,000,000. This can be compared against other alternatives such as spray irrigation of secondary treated effluent.

The other existing outfall locations appear acceptable providing treatment and phosphorus removal requirements meet established criteria.

c) Green Belts - Main Valley Lakes and Okanagan River

While very limited research has been carried out on this aspect certain general comments may be made.

Three main sources may be identified as contributing nutrients and excessive coliform counts to the main valley lakes and Okanagan River from surface runoff in areas immediately adjacent to the lakeshore:

- The erosion of soils from cultivated agricultural lands, and road and other forms of construction adjacent to surface waters;
- Surface runoff from confined livestock enterprises, such as cattle feedlots, riding stables, and poultry farms;
- Surface runoff from highly populated areas which is not collected by storm sewer systems:

No estimate has been made of the overall nutrient contribution of these sources although from limited field studies, the amounts from erosion and animal wastes would appear to be significant. Good management practices should include containing the surface runoff from such sources so that it will receive some treatment by filtration through the ground before reaching surface waters. The simplest way of achieving this would be to move these sources away from surface streams and provide greenbelts between these sources and surface waters. These green strips could be used for park areas, trees and open pasture provided they were properly managed.

While it may not be feasible to consider greenbelts around all of the main valley lakes and along Okanagan River they could be considered for all undeveloped areas to ensure there is no additional loadings from such sources. It is also suggested that the construction of future main highways be kept away from the lake shoreline to avoid erosion problems and discourage associated urban and industrial development of the lake and river shoreline areas.

(d) Flushing Through Increased Flows

This proposal -involves using additional water to increase the outflow of nutrients from a lake, thus lowering the concentration of nutrients and their retention time in a lake. Additional water would have to come from large scale importation, or in the case of Wood and Kalamalka Lakes by pumping from Okanagan Lake. The proposal assumes that the additional water use for flushing would have a higher quality than that existing in the lake which is being flushed.

This proposal is not considered viable for Okanagan Lake, because of the very large volume of the lake in relation to the limited amount of water that could economically be imported, and because of the present high quality of this lake compared to the quality of any imported water which might be available. The downstream lakes of Skaha, Vaseux and Osoyoos already have renewal times of one year or less, and it is considered unlikely that small additional flows would improve the quality of these lakes.

The explanation for the apparent insensitivity of these lakes to higher inflows, lies in part in the dynamics of the phosphorus cycle. Simply stated, phosphorus is taken up within minutes by algae, retained in the cell for a matter of hours or days, depending on the species, and then either sedimented or re-cycled. Thus the ebb and flow of phosphorus in the plant biomass can be measured in minutes or days, while the exchange of water in these lakes is measured in months or years. It therefore appears unlikely that minor changes in residence time for these lakes would play a substantial role in altering the present quality in Skaha or Osoyoos Lakes.

Wood Lake in the Vernon Creek sub-basin has a very small outflow (1971), long water retention time, and currently exhibits the poorest quality of the main valley lakes. Increased inflows of a reasonable magnitude and good quality would greatly reduce the renewal time of water in this lake and reduce the time required to improve its quality based on other nutrient control measures. This has already been accomplished to some extent by one of the industries in the Wood Lake area which commenced pumping cooling water from Okanagan Lake in 1972 and discharging it back into Vernon Creek above Wood Lake.

Historically, Wood Lake had a water renewal time of approximately 12 years. The construction or enlargement of storage reservoirs on the headwaters of Vernon Creek in 1908, 1931 and 1944, and the diversion of much of this water from Vernon Creek for irrigation purposes, reduced the inflow to this lake and increased the renewal time of water in Wood Lake to approximately 30 years. It is during this period of increased renewal time that Wood Lake is considered to have deteriorated the most rapidly. The recent addition of cooling water to this system again reduces the renewal time to approximately 13 years, which over a period of years should be of considerable value in improving the quality of water in this lake, providing other suitable measures are also taken to control nutrient input.

Kalamalka Lake, with an extremely good water quality, would not benefit from increased inflows, and in fact, these may be detrimental if the source is Wood Lake. If suitable nutrient control measures are undertaken to limit the total input of nutrients to this lake to the criteria outlined previously in this section, the present quality should be maintained.

(e) Waste Treatment

Nutrient sources to the main valley lakes are many and varied (Table 15.1 to 15.6) but one source - namely municipal outfalls - currently contributes approximately 50% of the total phosphorus loading to Okanagan, Skaha, and Osoyoos Lakes. Loading projections also indicate this percentage contribution will exceed 60% under a low economic growth rate, or 65% under a high economic growth rate, by the year 2020, assuming a continuation of current waste management practices.

Urban developments adjacent to Kalamalka and Wood Lake are serviced by septic tanks and it is estimated this source currently contributes 50% of the total phosphorus load to Wood Lake and 20% to Kalamalka Lake. Loading projections also indicate this percentage will increase to 75% by the year 2020 for Wood Lake and to 50% for Kalamalka Lake, based on a continuation of current waste treatment methods, and a low economic growth rate. Septic tank sources also contribute significant loadings to the other lakes which cause local nuisance conditions in areas of the lakes adjacent to these sources. The main alternative for improving or maintaining an acceptable level of water quality in the main valley lakes for multiple use purposes therefore involves advanced waste treatment processes for phosphorus removal. Multiple use is considered to include water for drinking purposes, irrigation, water contact sports and other forms of water-based recreation, fisheries and wildlife. The success of such advanced treatment processes is dependent on first attaining good conventional treatment, and where applicable, costs for upgrading existing facilities have been included. The three levels of phosphorus removal considered for municipal centers are as follows:

- Good conventional (secondary) activated sludge processes which removal approximately 30% of the phosphorus entering a sewage treatment plant:

- Physical or chemical precipitation of phosphorus following conventional treatment, which may remove up to 90% of the phosphorus input, depending on the degree of treatment required. Similar efficiencies may be obtained in lagoons, using chemical precipitation for phosphorus removal, where this form of treatment is more economical especially in the smaller urban centers.

- Spray irrigation of secondary effluent. The degree of removal in this case will depend on the location of the spray irrigation site, in respect to the groundwater table, the soil type, the crops grown, and the management care received. Under good conditions, removal of phosphorus by spray irrigation may be expected to be in excess of 90%. This form of advanced treatment also has the advantage of removing some other undesirable elements in the waste effluent including mercury and other trace elements.

The above forms of treatment are for macro-sources of nutrients which may affect a lake as a whole. Various combinations of these treatment processes for different municipal centers may be used to reduce present or projected loadings to levels required to meet the criteria established for each of the main valley lakes.

The second form of waste treatment alternative involves septic tanks which may cause localized problems or in large numbers may contribute a significant nutrient input into a lake. In the case of single or small numbers of septic tank units adjacent to surface waters, it is proposed that these be upgraded to ensure that no more than 20% of the phosphorus in the effluent reaches groundwater where soil conditions are such that special measures are required to control nutrients from this source. Upgrading would include insuring tile fields are well above groundwater levels, a desirable distance from lake shorelines, and the importation of fine soils where necessary to prevent excessive percolation. For urban areas adjacent to Kalamalka, Wood, and Osoyoos Lakes, septic tanks would have to be replaced by sewage collection systems and waste treatment facilities (including phosphorus removal) to ensure that the necessary reductions in phosphorus loadings are achieved.

Minimum phosphorus removal requirements by advanced waste treatment processes to meet standards estabiished for each of the main valley lakes are outlined below. It is re-emphasized that the accuracy of the loading data and the uncertainty of the loading criteria are such that continued monitoring of both loadings and lake quality are an essential part of this alternative to ensure that the desired results are being realized.

Regulations concerning the amount of phosphorus in household detergents were initiated by the Federal Government during the tenure of the Study, but the effect of these regulations on reducing phosphorus loadings to the main valley lakes has not been analysed.

(i) Wood Lake

The present condition of this lake is very poor with almost continuous algal blooms in the summer months and heavy aquatic plant growth along the shorelines. The current phosphorus loading has been estimated at 3300 pounds per year (average' of which approximately 50% is attributed to septic tank sources. Future loadings for both low and high economic growth projections (Projections II and III) for this area are shown in Table 15.9.

TABLE 15.9

PROJECTED PHOSPHORUS LOADINGS - WOOD LAKE

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (pounds)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (pounds)
	Low Economic Growth	High Economic Growth	
1980	5000	5000	3000
2000	8200	8800	6200 to 6800
2020	11900	16800	9900 to 14800

Because of the existing high internal loading of phosphorus in this lake - due in part to historical changes in the retention time of water in this lake - a significant decrease in the current phosphorus loadings is required to effect any change in its condition. Therefore the lower loading value of 2000 pounds has been used in estimating minimum phosphorus reductions required for Wood Lake. Due to its physical characteristics (volume, mean depth, and low volume of inflow) and the many diffuse nature of most nutrient sources, the lake will continue to be a biologically productive lake, but clarity and oxygen levels will be improved, and fisheries enhanced if the above reductions in phosphorus loadings are achieved.

The installation of a sewage collection and treatment plant in the urban center of Winfield, with facilities for 80% phosphorus removal would reduce present loadings by 1300 pounds, and 1980 loadings by 2400 pounds. Other forms of nutrient control such as eliminating outfall discharges and point source loadings to streams by 1980 should reduce total loadings to acceptable levels.

The higher inflows and reduced retention time of water in this lake, due to the recent additional industrial cooling water discharged to Vernon Creek should speed the recovery of this lake, but will have no immediate effect on its quality.

(ii) Kalamalka Lake

The relative fertility of this lake is high, but good quality conditions have been preserved by a natural self-cleansing system. Some aquatic plant growth is now occurring at the mouth of Coldstream Creek and in the south end of the lake. The present (1971) phosphorus loading to this lake has been estimated at 5200 pounds per year, of which approximately 20% is from septic tanks. These septic tank installations are nearly all in the Coldstream Creek area at the north end of the lake, and along with nutrients from Coldstream Creek itself are the main reasons for aquatic plant problems in this area. Future loading projections for this lake are shown in Table 15.10.

TABLE 15.10

PROJECTED PHOSPHORUS LOADINGS - KALAMALKA LAKE

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (*pounds*)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (*pounds*)
	Low Economic Growth	High Economic Growth	
1980	7000	7000	-
2000	8300	8400	600 - 700
2020	9300	11700	1600 - 4000

The acceptable limits for phosphorus loading to Kalamalka Lake have been established at 6600 to 8800 pounds per year, (average 7700 pounds). This should maintain an excellent quality of water in the lake as a whole particularly for recreation and aesthetic purposes, but will not protect shoreline areas from declining in quality due to local nutrient inputs from such sources as septic tanks. These loading limits are much lower than for the other takes because of the small volume of inflow and relatively long retention time of water in this lake.

While total present loadings are below the established standards, curtailment of local sources of nutrients from septic tanks is considered necessary to protect beach and other recreational areas at the north end of the lake. A sewage collection system for the urban center of Coldstream with a trunk transport line to a central treatment plant at Vernon is considered the most practical solution for this local problem. This would effect 100% phosphorus removal in serviced areas and substantially reduce nutrient loadings to the Kalamalka Beach area.

(iii) Okanagan Lake

The main water mass of Okanagan Lake is still in excellent condition, but serious deterioration has occurred around shoreline areas of the lake which are affected by wastewater outfalls and shoreline development. Present and projected loadings to this lake are shown in Table 15.3. Because of the varying trophic conditions in this lake, this total loading has also been broken down to show the approximate contributions to the north central and south basins (Table 15.11). This breakdown does not take into account any internal exchanges of nutrients between lake sections resulting from physical or biological processes.

Over 40% of the current (1971) phosphorus loading comes from the two municipal outfalls of Vernon and Kelowna, while an additional 10% may be attributed to septic tank sources.

TABLE 15.11

PROJECTED PHOSPHORUS LOADINGS - OKANAGAN LAKE

(From External Sources)*1

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (pounds)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (pounds)
	Low Economic Growth	High Economic Growth	
North Section			
1971	69,000	69,000	3000
1980	82,000	82,000	16,000
2000	100,000	110,000	34,000 to 44,000
2020	107,000	146,000	41,000 to 80,000
Central Section			
1971	85,000	85,000	19,000
1980	107,000	107,000	41,000
2000	140,000	151,000	74,000 to 85,000
2020	161,000	220,000	95,000 to 154,000
South Section			
1971	33,500	33,500	3,500
1980	35,500	35,500	5,500
2000	38,500	40,000	8,500 to 10,000
2020	40,000	45,500	10,000 to 15,500

*1 Breakdown does not take into account any internal exchanges of nutrients between lake sections resulting from physical or biological processes.

A high quality of water in Okanagan Lake is the key to good water quality in the downstream lakes and loading limits for the south basin (Table 15.7) have therefore been set lower than the rest of the lake to provide an increased margin of safety against water quality degradation. The present (1971) loadings in all three areas either exceed or equal the established standards. The removal of 80% of the phosphorus loading from the two municipal outfalls (Kelowna and Vernon) will reduce these loadings within acceptable limits beyond 1985, but local areas may still exhibit eutrophic characteristics due to local phosphorus loadings from urban shoreline development.

Sewage collection and treatment including phosphorus removal is considered necessary for the urban center of Okanagan Landing if local conditions in the Vernon Arm of Okanagan Lake are to be improved. Treatment with 80% phosphorus removal for the centers of Armstrong, Westbank, Peachland, Summerland, Naramata and other urban shoreline areas, but the implementation of these is not currently critical to the quality of the main body of Okanagan Lake itself.

(iv) Skaha Lake

This lake has the highest relative fertility and biological growth of the main valley lakes, and its quality has deteriorated the most rapidly. High quality inflows from Okanagan Lake, and annual renewal of water in this lake have prevented a more rapid deterioration. The estimated loading in 1971 was 48,000 pounds. This figure takes into account the 1972-73 average efficiency of the tertiary unit at the City of Penticton Sewage Treatment Plant of approximately 60% phosphorus removal. Projected loadings are summarized in Table 15.12.

TABLE 15.12

PROJECTED PHOSPHORUS LOADINGS TO SKAHA LAKE

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (pounds)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (pounds)
	Low Economic Growth	High Economic Growth	
1980	58,000	58,000	23,000
2000	71,000	79,000	36,000 to 44,000
2020	77,000	107,000	42,000 to 72,000

Over 50% of the phosphorus loading in 1971 came from the municipal treatment plant at Penticton even after 60% phosphorus removal had been achieved. Phosphorus loading standards for Skaha Lake have been established at 30,000 to 40,000 pounds per year. These somewhat high values take into account the very short retention time of water in this lake (one year) and t-he excellent source of good quality water flowing into Skaha from Okanagan Lake. If these limits are met a good quality water should be achieved for recreation and body contact sports.

The attainment of an average of 80% phosphorus removal at Penticton throughout the year will reduce phosphorus loading levels within acceptable standards to 1980. Increased removal of phosphorus may be necessary after 1980 as indicated by an ongoing monitoring program. Treatment and phosphorus removal of Okanagan Falls and other urban shoreline tine developments on Skaha Lake would improve local recreational areas but are not critical in respect to the lake as a whole.

(v) Vaseux Lake

Vaseux is a productive lake because of its shallow nature and rich bottom sediments. While criteria have been established for this lake (Table 15.7) its quality is almost completely dependent on the quality of water from Skaha Lake and Okanagan River. The quality of Vaseux waters may be expected to improve somewhat with improvements in Skaha and Okanagan River water, but the shoreline areas will continue to exhibit heavy aquatic plant growth. This habitat is considered suitable for this lake as it has been established as a wildlife sanctuary,

(vi) Osoyoos Lake

Approximately 60% of the nutrient loadings to Osoyoos Lake come from outflows from Skaha Lake and nutrient additions to Okanagan River between Skaha and Osoyoos Lake including the village of Oliver, drainage waters from agricultural lands and septic tank sources. The remaining loadings come primarily from groundwater return flows to the lake itself. The 1971 loading has been estimated at 37,500 pounds, which takes into account the 1972-73 effect of the tertiary treatment unit at Penticton. Projected loadings to Osoyoos Lake are shown in Table 15.13.

TABLE 15.13

PROJECTED PHOSPHORUS LOADINGS TO OSOYOOS LAKE

YEAR	PROJECTED AVERAGE ANNUAL PHOSPHORUS LOADINGS (pounds)		MINIMUM REDUCTION REQUIRED TO MEET ESTABLISHED CRITERIA (pounds)
	Low Economic Growth	High Economic Growth	
1980	51,700	51,700	20,000
2000	70,200	79,500	38,000 to 48,000
2020	78,200	115,800	47,000 to 84,000

Acceptable phosphorus loadings to Osoyoos Lake have been established at 26,000 to 37,000 pounds. These values allow for the very rapid water renewal rate of less than one year which prevents the accumulation of large amounts of biomass and nutrients. The maintenance of phosphorus loadings below 31,000 pounds per year should provide a reasonably good water quality for recreation and body contact sports but somewhat lower than that of Skaha Lake and Okanagan Lakes.

The achievement of 80% phosphorus removal at Penticton will improve the quality of inflow water to Osoyoos Lake but this in itself will not be sufficient to lower phosphorus levels within acceptable limits. Phosphorus removal at the Oliver Treatment Plant and at Osoyoos is also required, along with the inclusion of urban developments adjacent to Osoyoos Lake in the area serviced by sanitary sewers and waste treatment at Osoyoos, to ensure local quality objectives are achieved.

(f) Benefits and Costs Associated with Improvements in Water Quality

The costs associated with water quality management are related to investment in waste treatment facilities which reduce the contribution of nutrients and other wastes to the surface waters of the basin. The benefits of these measures involve the improvement or maintenance of high water quality for consumptive and non-consumptive uses. These in turn, may be translated into social and economic values through an estimation of the opportunities for water-based recreation that -would be foregone because of deteriorating water quality, should waste inflows not be reduced, and the additional costs of treating water to make it suitable for consumptive uses.

In this report cost and benefit studies have been limited to nonconsumptive uses in the main valley lakes (recreation and aesthetics). The cost of limiting phosphorus loadings to the main valley lakes through advanced waste treatment processes to control aquatic plant growth and algal blooms are compared with the opportunities for water based recreation and aesthetic enjoyment that would be foregone because of deteriorating water quality - increased aquatic plant growth and algal blooms, if phosphorus inputs are not reduced.

(i) Costs of Waste Treatment

The cost of various types of waste treatment and phosphorus removal at major centers in the valley are shown in Table 15.14 to the year 1985 assuming a low economic growth rate. The year 1985 was selected as the limit to which treatment requirements and cost estimates could be projected and still provide meaningful results based on existing quality data. All costs have been reduced to 1970 dollar values based on the Engineering News Record (E.N.R.) cost index.

Because sanitary sewers and conventional treatment are prerequisites to advanced treatment for phosphorus removal, estimates of the capital cost for selected installations are included for information purposes. These figures however, should be considered only as order of magnitude costs. Detailed surveys are required for each urban center to determine the most appropriate and economical form of conventional treatment for that particular center, and the cost, based on local conditions such as topography and housing density, etc. The type of conventional treatment will in turn affect the cost of phosphorus removal facilities and a range of costs has therefore been shown for phosphorus removal for some centers.

Based on the estimates shown in Table 15.14 the total capital costs for waste treatment facilities to 1985 for all the urban centers noted would be as fol1ows:

Sanitary Sewers	$12,700,000	58%
Secondary Treatment	$5,500,000 to 8,700,000	32% (Ave.)
Phosphorus Removal	$2,000,000 to 2,300,000	10% (Ave.)

The major cost item in any waste treatment programs is for sanitary sewers, which represents approximately 60% of the total capital involved. This is based on an average cost of $500 per lot. Septic tanks, if constructed to meet 80% phosphorus removal requirements could range in cost from $1,000 to $5,000 per home or lot.

TABLE 15.14

ESTIMATED COSTS OF WASTE TREATMENT TO 1985 FOR MAJOR URBAN CENTERS IN THE OKANAGAN

AREA	1971 POPULATION	EXISTING TREATMENT: CURRENT TREATMENT TYPE	1985 POPULATION	POPULATION AT MIDDLE OF DESIGN PERIOD (1971-1985)	TREATMENT OPTIONS WITH DESIGN CAPACITY ADEQUATE TO AT LEAST 1985	ESTIMATED CAPITAL COSTS (to 1985) THOUSANDS OF DOLLARS: SANITARY SEWERS	TREATMENT PLANT COSTS (Secondary)	PHOSPHORUS REMOVAL FACILITIES	ANNUAL COSTS-PHOSPHORUS REMOVAL: TOTAL ANNUAL: 80% PHOSPHORUS REMOVAL $000's	90% PHOSPHORUS REMOVAL $000's	TOTAL POPULATION SERVICED	AVERAGE ANNUAL COST PER HOUSEHOLD: 80% PHOSPHORUS REMOVAL $	90% PHOSPHORUS REMOVAL $
Vernon including Coldstream	18,200	Trickling Filter	32,500	32,500	Spray Irrigation (excluding land cost)	2,100	1,800	330	- 51.0 -		32,500	- 5.40 -	
				32,500	Activated Sludge Plant (All new)		1,800	440	110.0	134.0	32,500	11.60	14.10
				32,500	Renovation of Existing Plant and Construction of New Activated Sl.		1,100	410	103	134	32,500	10.80	14.00
Okanagan Landing	700	Septic Tanks	1,000	900	Batch Lagoon	135	90	3	-	2.5	900	-	9.25
				900	Trunk Mains to Vernon Plant		230	25	10	13.5	900	39.80	51.00
Armstrong	1,600	Aerated Lagoon	2,350	2,180	Batch Lagoon	110	270	6	-	6.5	2,180	-	9.90
				2,170	Activated Sludge		240	50	10	13.5	2,170	16.40	21.20
					Trunk Main to Vernon Plant		Not Economical until 1985						
Kelowna & Rutland	19,500 K.only	Activated Sludge	63,000	35,200	Activated Sludge	6,400	2,300	880	203	258	55,400	12.40	15.80
Winfield	2,200	Septic Tanks	3,600	3,100	Batch Lagoon	530	220	6	-	11	3,100	-	12.10
				3,100	Activated Sludge		270	80	15	19	3,100	16.80	21.10
				3,100	Trunk Main to Kelowna Plant		520	80	11	14.5	3,100	12.70	15.90
Westbank	1,600	Facultative Lagoon	3,500	2,700	Activated Sludge	220	280	70	15	18	2,700	18.30	22.20
Peachland	1,500	Septic Tanks	3,100	2,500	Activated Sludge	450	270	55	20	23.5	2,500	26.60	32.00
Summerland		Septic Tanks	7,900	7,200	Activated Sludge	1,150	490	120	28	36	7,200	13.20	16.90
				7,500	Trunk Main to Penticton Plant		1,600	130	38	41	7,500	17.30	18.60
Penticton	19,000	Activated Sludge & tertiary	27,000	3,600	Activated Sludge	1,200	230	320	84	99	28,400	10.05	11.85
Naramata	460	Septic Tanks	700	600	Batch Lagoon	100	60	3	-	2	600	-	10.30
				600	Trunk Main to Penticton Plant		980	11	3	3.5	600	19.00	20.40
Okanagan Falls	620	Septic Tanks	1,200	1,000	Batch Lagoon	180	100	3	-	3	1,000	-	9.40
					Trunk Main to Penticton Plant		Not Economical to 1985						
Oliver	1,600	Package Act'd. Sl.	1,800		Present Facilities - Sun-Rype removed	30	Facilities Adequate to 1985	70	9	14	1,700	18.20	27.60
Osoyoos	1,300	Facultative Lagoon	1,800	880	Spray Irrigation	75	90	120	16.0		1,600	35.00	

The capital cost of phosphorus removal facilities are relatively small once secondary treatment facilities are available. The annual cost of phosphorus removal including capital amortization, materials and operating costs ranges from $5.00 to $35.00 per lot per year, depending primarily on the type of phosphorus removal selected and the size of plant or population served.

(ii) Benefits Associated with Improvements in Water Quality

There are two major problems in assessing the economic and social benefits associated with maintaining or improving water quality in the main valley lakes. The first is that there are no readily available measures of the value of water-based recreation; the second is that the relationship between water quality deterioration and recreation participation is not clearly understood.

In this Study, it has been assumed that from the viewpoint of the Okanagan, the economic value of water-based recreation contributing to the economic growth of the basin is related to tourist expenditures while in the valley. It is recognized that these expenditures in reality represent the tourists' willingness to pay for services such as accommodation, food and travel. Due to the importance of water-based recreation as a motivation to come to the Okanagan, however, the net income returned to the valley economy from such expenditures appears to be an appropriate base for estimating the minimum value of such activities. This value was estimated at $4.50 per beach day. As tourists spend approximately 60% of their days in the Okanagan visiting public or private beaches, potential economic values of shoreline recreation can be obtained by multiplying future estimates of net income derived from tourist expenditures by 0.6.

In addition to this net income measurement, there is an unpaid surplus known as a consumer surplus which is the net value of the recreational opportunities over and above expenditures. Because recreationists' access to public beaches in the Okanagan is free of charge, they are not required to express any willingness to pay for such opportunities. In this Study, attempts were made to measure this consumer surplus by questioning a sample of beach users directly on their willingness to pay. Such values were estimated at $5.50 and $5.00 per beach day for residents and visitors respectively.

The above established the total value of shoreline recreation in the Okanagan. The next step was to estimate the proportion of this total value that would be lost due to deteriorating water quality in the event that present waste treatment facilities are not improved. It was assumed that in the absence of any improvement in waste treatment facilities, economic and social impacts would compound over the next 30 years, by which time waste treatment measures would probably have to be introduced to maintain the economic and social viability of the region. These assumptions are presented in Figure 15.3.

ASSUMED RELATIONSHIP BETWEEN WATER QUALITY AND WATER-BASED RECREATION

FOR ESTABLISHING BENEFITS FOR WASTE TREATMENT ALTERNATIVES

YEAR	LAKE	WATER QUALITY CONDITIONS	IMPACTS ON WATER-BASED RECREATION DEMANDS
1980	Wood Lake	Annual algae blooms, extensive weed growth around shorelines.	Additional costs involved in harvesting weeds. Annual decline of 10% in tourism to 1975 rising to 25% by 1980
2000	Wood Lake	Annual algae blooms and extensive weed growth around shorelines.	Continued decline in tourism estimated at 50% per annum after 1985
1980	Kalamlka Lake	Localized weed growth at Coldstream Creek spreading towards Kalamalka Beach	Additional costs of weed harvesting. Little impact on recreation due to availability of clean water at Cozen's Bay and at Kalamalka Beach
2000	Kalamalka Lake	Increased weed growth at north end of lake. Uncertainty about occurrence of algae blooms due to the unusual phosphorus ppt. cycle in lake discharge of Wood Lake water will affect resorts at south end of lake	Increased costs of weed harvesting. Estimated 10% decline in recreation after 1980 rising to 50% after 1990 due to adverse publicity from Wood Lake experience.
1980	Okanagan Lake	Continued weed growth in Vernon Arm and around Kelowna shoreline. Infrequent algae blooms in both locations. Weed growth at other local areas such as Westbank outfall and around Summerland.	Additional costs of weed harvesting At least 10% of Vernon area recreation would be reduced each year to 1980; reduction of 10% in Kelowna area after 1975 rising to 20% after
2000	Okanagan Lake	Continued weed growth and frequent algae blooms in Vernon Arm and around Kelowna area. Weed growth will continue to extend around Summerland and Westbank	50% loss of recreation opportunity in Vernon Arm after 1985. Estimated 50% reduction in Kelowna tourism by 1990 - similar reduction in resident beach-days; 10% reduction in recreation demand in south basin
1980	Skaha Lake	Occasional algae blooms in late summer, weed growth increase in south basin	Little reduction in recreation demand forecast provided Penticton attains 80% removal of phosphorus
2000		Frequent algae blooms and extending weed growth.	A 10% reduction in annual recreation demands after 1980 rising to 30% in 1985 and 50% by 1990.
1980	Osoyoos Lake	Occasional algae blooms, increase in weed growth	A 10% reduction in recreation demand after 1975
2000	Osoyoos Lake	Frequent algae blooms and increased weed growth	A 20% reduction in annual recreation demands after 1980 rising to 30% in 1985 and 50% in 1990.

Figure 15.3

The annual reductions in beach-day participation indicated in Figure 15.3 was assessed in the economic and social values associated with such recreation opportunities. It appears possible that the value of a beach day may increase faster than general living costs in future, especially as people have more leisure time available. Lacking any empirical data on this however, it was assumed that the real values would remain constant.

Present worth of total benefits associated with maintaining a high water quality for recreation and aesthetics in the main valley lakes to the year 1985, as determined from the assumed relationship between water quality and water-based recreation are:

Estimated Economic benefits - $4,100,000
Estimated Social benefits - 9,200,000

(iii) Annual Benefits and Costs

The estimated benefits and costs for improving or maintaining a high water quality in each of the main valley lakes are shown in Table 15.15. The costs shown are for phosphorus removal only, which will control aquatic plant and algal growth in the lakes to levels that permit maximum recreational and aesthetic benefits to be derived.

TABLE 15.15

ANNUAL COSTS OF PHOSPHORUS REMOVAL AND BENEFITS TO WATER BASED RECREATION TO 1985

LAKE	ANNUAL PHOSPHORUS REMOVAL COSTS RANGE DEPENDING ON TYPE OF TREATMENT	ANNUAL BENEFITS	
		ECONOMIC	SOCIAL
Wood	$10,000 to 20,000	$ 36,000	$ 69,000
Kalamalka	5,000 to 13,000	12,000	60,000
Okanagan*	305,000 to 385,000	136,000	710,000
Skaha	84,000 to 99,000	48,000	135,000
Osoyoos	25,000 to 30,000	33,000	95,000
TOTALS	$429,000 to 547,000	$265,000	$1,069,000

* Includes Phosphorus Removal at centers of Vernon, Kelowna and Okanagan Center only. Additional cost of including Armstrong, Westbank, Peachland, Summerland and Naramata would be approximately $75,000 annually.

The ratio of annual benefits (social and economic) to costs is approximately 3:1. The total economic benefits derived from water based recreation only, are not sufficient by themselves to justify the cost of phosphorus removal. However, these do not consider the economic benefits (or costs) of treating water for consumptive use due to a decline in water quality induced by heavy aquatic plant and algal growth. The major cost for phosphorus removal is for the City of Kelowna where over 30% of the Valley population is centered and which accounts for approximately 50% of the total annual cost of phosphorus removal.

(g) <u>Waste Treatment Management</u>

While any of individual treatment schemes outlined in Table 15.14 could accomplish the desired results in the control of biological production in the main valley lakes, there are many problems associated with such ventures. Waste treatment itself is not a simple process, and just providing the required works will not necessarily ensure good conventional treatment, or the removal of the required amounts of phosphorus. Smaller treatment plants in particular may have problems attaining the desired efficiencies. Different management philosophies of local governments may also affect the degree of treatment obtained and the costs involved for such treatment, and there will be many residents who may benefit from treatment but not be required to pay because of location. Local governments may also be more concerned about the local effect of phosphorus removal rather than the effect on a lake as a whole. Spray irrigation of secondary effluent may be more feasible in some centers than in others. This form of advanced treatment may, however, be more expensive than chemical precipitation because of land costs and in the case residents may be required to pay more than in areas using chemical precipitation.

The above problems could be resolved by placing the control for waste treatment in the basin under one Regional authority, and emphasizing the use of regional treatment facilities where these are practical. A regional waste treatment authority would be better equipped to arrange suitable financing, and to stage the development of regional treatment systems to allow for economic growth, and to meet the criteria for acceptable water quality in the basin as a whole. Regulatory powers should also include monitoring of phosphorus loadings to the main valley lakes and the quality of the lakes themselves, to ensure the desired results are being realized, even though such monitoring may be carried out by others.

Regional treatment facilities refer to large central plants that could service a number of communities in the same area, as opposed to individual treatment plants in each urban center. Large treatment plants allow improved operational techniques and generally higher treatment efficiencies, and could be adapted to include industrial wastes, many of which are not now treated.

15.4.3 <u>Discussion of Results</u>

Based on the various alternatives examined, the removal of phosphorus through advanced waste treatment processes is considered the most practical for the control of aquatic plant and algal growth in the main valley lakes to levels that will allow maximum recreational and aesthetic benefits to be derived. Location of outfall discharges, and green belts, should also be considered in combination with phosphorus removal in the long term management of water quality in these lakes. Flushing through increased flows will not improve the quality of any of the main valley lakes, although for Wood Lake it could reduce the time required to improve its quality. based on other nutrient control measures. The effect of these increase flows through Wood Lake on Kalamalka Lake, due to resulting nutrient carry-over, cannot be stated at this time. Careful monitoring should therefore be carried out on this aspect to ensure such practices do not endanger the quality of Kalamalka Lake water. The alternative of waste export from the basin is not considered viable.

The removal of 80% of the phosphorus loading by chemical treatment or spray irrigation from the municipal effluents of Vernon and Kelowna would reduce the total known loadings to Okanagan Lake as a whole to within the established safe loading criteria to the year 1985 for both low and high economic growth projections, but reductions in other sources may be required beyond this date.

The removal of 80% of the phosphorus from the Penticton Sewage Treatment Plant effluent is sufficient to meet safe loading criteria for Skaha Lake to 1980, but increased removal may be required before the year 2000 for either low or high growth projections.

The benefits from reduced input of phosphorus to Okanagan River from the City of Penticton will not be sufficient to bring the loadings to Osoyoos Lake within the acceptable criteria for this lake, even if 80% removal at Penticton is attained by 1980. Other sources that must be reduced to achieve the loading limits set include the City of Oliver Treatment Plant, and septic tank installations at Osoyoos and adjacent to Okanagan River.

The upgrading of septic tank units or communal sewage collection and treatment systems for urban developments adjacent to Wood and Kalamalka Lakes would reduce the phosphorus loadings to these two lakes within acceptable criteria.

Because the estimated phosphorus loadings to each of the main valley lakes are already close to, or exceed acceptable loading criteria, and because of the time still required to plan, implement, and construct or expand waste treatment facilities to reduce these loadings (3 to 5 years), any recommendations on timing for various works becomes somewhat arbitrary. It is considered necessary that most of the treatment works proposed for treating existing waste loadings be in operation not later than 1980. The expansion of these facilities along with sewage collection systems, to meet expanding populations should obviously be staged to meet expansion growth rates. The inclusion of smaller urban areas in any regional treatment schemes might also be staged, but this could involve some degree of risk that continued loadings from these sources might seriously degrade lake water quality, particularly in local shoreline areas.

The estimated social and economic benefits inherent in attaining acceptable quality levels in the main valley lakes to the year 1985, outweigh the costs of phosphorus removal by a factor of approximately 3:1. Equitable distribution of phosphorus removal costs among the beneficiaries, and assurance that the treatment levels required are met, appear to be the major problems in any wastewater management program. One basin-wide authority is therefore considered essential if the planning objective of providing lake water quality consistent with a high quality environment for recreation and aesthetic purposes is to be met.

While these benefits are based more on indirect rather than on direct economic benefits, the projections for the future indicate that waste treatment costs may represent a very small sum compared to the benefits gained. Also the present condition of the lakes is such that any delay in initiating at least minimal programs to meet the criteria for acceptable water quality might result in a further decline in quality, which in the case of Okanagan Lake may not be recoverable to acceptable standards within our lifetime.

The uncertainty involved in the accuracy of nutrient loading data, and loading criteria established for the main valley lakes requires that an on-going water quality monitoring program be implemented to ensure that the desired effects of any waste treatment program are being realized, and to modify the criteria or program as necessary based on the monitored results. In this respect the minimum phosphorus removal requirements outlined in this report may be considered as an interim program for quality control, as compared to a continuation of existing waste management policies, or the desired objective of the public task forces of eliminating all positive discharges to the lakes.

The above discussion has outlined the problems in meeting standards for the main valley lakes as a whole. Small local sources including those from industry, septic tanks, agriculture and other sources may also adversely affect local beaches and shoreline areas without affecting a lake as a whole. The economics of preventing aquatic plant growth in all areas of the lakes would certainly be questionable and in some areas (Vaseux Lake and the North Arm of Okanagan Lake) some aquatic plant growth is considered beneficial to wildlife. The preservation of public beaches and recreational areas should not be questionable however, and the control of local sources of pollution to these areas should be an important requirement of any waste management program. Again, a regional authority would appear best suited to carry out and manage the program in the most equitable manner and to the greatest benefit of all concerned.