CHAPTER 14

Water Quantity Evaluations

The planning objectives in water quantity management, as laid out in Chapter 12 are:

1) to supply water for all consumptive and non-consumptive uses;
2) to minimize economic and social consequences of floods and droughts, and
3) to minimize conflicts between existing and potential uses of water.

Projections of water requirements for the entire Okanagan Basin to the year 2020 for the three economic growth projections are compared in Table 14.1. Only consumptive water demands for agricultural and domestic use have been projected for tributary streams, while both consumptive and non-consumptive uses (total water requirements) are shown for the mainstem system. It is anticipated that in the future, selected tributary creeks will support both consumptive and non-consumptive water requirements are described later in this chapter.

There is a lack of sensitivity between the various 2020 projections with total water requirements ranging from 344,000 to 347,000 acre-feet for all projections examined, compared to 312,000 acre-feet under present day development. The main reason for the small variation in future water requirements is the relatively small change in agricultural landuse development over the next 50 years. Irrigation makes up over 75% of total water consumption to the Basin at present, and this pattern is expected to continue assuming that most agricultural land is protected from sub-division for residential and domestic purposes.

Although total water requirements are not expected to increase significantly over present-day figures, conflicts in water use, especially in tributaries, will likely increase in magnitude over the next 50 years.

While the building of headwater reservoirs has created or enhanced recreation and fisheries at some of these headwater locations, the rapid drawdown of these storages to supply irrigation requirements adversely affect fishery and recreation potential in these lakes. Similarly the lack of adequate minimum flows in the lower reaches of the tributaries in the summer and fall months seriously affects the reproduction of kokanee and rainbow trout from Okanagan Lake.

In contrast to the tributaries (which are regulated primarily for consumptive use and in total supply about 22% of the water requirements for the Basin), the mainstem system consisting of the Okanagan Flood Control Works and the Vaseux Lake (SOLID) Dam provides for multiple water use including conservation, flood

TABLE 14.1

CONSUMPTIVE USE REQUIREMENTS IN THE OKANAGAN LAKE BASIN AND

TOTAL WATER REQUIREMENTS FOR OKANAGAN RIVER BASIN IN CANADA

A. PRESENT OPERATING CONDITIONS with 300 cubic feet per second minimum flow In the Okanagan River between April September inclusive, and 100 c.f.s. min. flow between October and March inclusive

	1970		2020					
			GROWTH PROJECTION 1 Continuation of Present policies		GROWTH PROJECTION 2 High Economic Growth (Low Agriculture)		GROWTH PROJECTION 3 Low Economic Growth (High Agriculture)	
Population	113,480		391,000		430,000		290,000	
Irrigated Acres	60,070		59,600		56,600		73,700	
	acre-feet	%	acre-feet	%	acre-feet	%	acre-feet	%
1. OKANAGAN LAKE BASIN								
(a) Consumptive Use from tributaries and directly from areas adjacent to Okanagan Lake								
- IRRIGATION	57,000		52,000		48,000		66,000	
- MUNICIPAL & DOMESTIC	8,000		35,000		39,000		26,000	
- INDUSTRIAL	4,000		18,000		20,000		13,000	
TOTAL CONSUMPTIVE USE - OKANAGAN LAKE BASIN	69,000	22.0	105,000	30.5	107,000	30.9	105,000	30.3
2. MAINSTEM OKANAGAN RIVER								
(a) Consumptive Use - Okanagan River	32,000	10.4	44,000	12.8	43,000	12.4	46,000	13.3
(b) Evaporation Losses from Skaha, Vaseux and Osoyoos Lakes and from Okanagan River channel	49,000	67.6	49,000	56.7	49,000	56.7	49,000	56.4
(c) Minimum In-Channel Needs for intake submergence and flushing	123,000		107,000		108,000		108,000	
(d) In-Channel Fishery Requirements additional to min.flows in (c)	39,000		39,000		39,000		39,000	
TOTAL CONSUMPTIVE USE, LOSSES, MINIMUM FLOW FOR OKANAGAN RIVER REGION	243,000		239,000		239,000		242,000	
TOTAL BASIN CONSUMPTIVE USE + MAIN OKANAGAN RIVER WATER REQUIREMENTS	312,000	100.0	344,000	100.0	346,000	100.0	347,000	100.0

control, recreation, fisheries and aesthetics. The heart of this system is the Okanagan Lake Storage Dam at Penticton which controls about 80% of the inflow to the Basin.

In the Okanagan, water flows down the tributary streams into the mainstem and then down Okanagan River to cross the international border at Osoyoos Lake. The evaluations presented in this chapter follow this hydrologic sequence, starting with an examination of future water management options on the tributaries.

14.1 TRIBUTARIES

Water is required in tributary streams to supply consumptive uses (irrigation and domestic users) and sport fisheries in both the headwater storages and in the streams themselves. At present, however, tributaries are principally managed to meet consumptive use requirements, with water supply systems developed originally through private initiative and recently with help from the Federal and Provincial governments under the Agricultural Rehabilitation and Development Act (ARDA).

14.1.1 Future Water Requirements in Tributaries

Under tributary flows in Chapter 4, the eight most heavily utilized streams were selected for detailed study with the objective of determining the adequacy of the existing tributary supplies to meet present and future water requirements. As these tributaries included over 60% of the present consumptive use requirements in the Okanagan Lake Basin they are considered to be a good representative sample.

In the initial studies of tributary stream management, a computer model was developed based on the present method of operating the headwater storage releases to meet consumptive use demands only at the various diversion points in each selected tributary. This model was used to match supply and demand under dry, average and wet years for 1970, 1980 and 2020 levels of development. No return flows from irrigation were credited to the stream although such water was assumed to return to Okanagan Lake.

Each of the eight selected tributary basins are too small to be considered independent economic units, so reliable projections of future growth potential were not possible. Consequently, a range of growth patterns in population and agricultural landuse based on landuse capability were developed for each basin for the year 2020. This range included three projections of water demands;

1) a high projection based on maximum agricultural landuse development, plus maximum likely population growth on non-agricultural lands; 2) a low projection based on minimum population growth rates with a reduction of agricultural lands due to subdivision, and 3) a minimum projection representing the arithmetic mean of the two extreme projections.

TABLE 14.2

BASIC DATA SHEET FOR EIGHT SELECTED TRIBUTARIES - OKANAGAN LAKE BASIN

		TROUT CREEK	PEACHLAND CREEK	POWERS CREEK	EQUESIS CREEK	VERNON CREEK	KELOWNA CREEK	MISSION CREEK	PENTICTON CREEK	TOTALS
Area	Sq. Miles	289	59	56	77	358	86	336	70	1,331
Natural Flow	Dry Year	23,700	8,900	8,000	10,200	39,100	9,900	96,900	21,900	218,600
at Mouth	Av. Year	54,400	15,000	13,800	17,800	67.800	17,000	142,900	34,800	363,500
Acre-feet/Year	Wet Year	122,000	27,500	25,800	34,100	138,200	34,300	239,200	58,200	679,300
Storage	1970	10,332	9,656	3,754	2,156	46,719	5,715	17,981	10,240	106,543
(Acre-Feet)	2020	13,066	9,540	4,820	2,200	62,578	7,277	28,761	9,850	138,048
Area	1970	4,306	617	1,637	356	14,075	4,848	10,135	1,666	37,640
Under	2020 High	6,274	1,591	1,818	1,282	23,157	8,176	12,371	1,433	56,102
Irrigation	2020 Med	5,354	1,236	1,719	1,189	20,021	5,905	9,678	1,464	46,566
(Acres)	2020 Low	3,918	514	1,432	355	13,410	4,446	8,501	1,426	34,002
	1970	5,960	1,444	3,490	90	24,360	10,420	10,340	18,146	74,250
Population	2020 High	21,360	4,670	6,510	410	100,050	15,335	48,940	51,850	249,125
	2020 Med	17,380	3,105	5,450	345	83,020	11,802	41,090	48,055	210,247
(Persons)	2020 Low	13,400	1,540	4,390	280	65,990	8,270	33,240	44,260	171,370
Water	1970	13,384	3,416	5,293	1,021	33,525	12,888	31,814	11,173	112,514
Requirement	2020 High	25,169	7,527	7,372	3,613	72,887	26,432	51,315	19,036	213,351
(Diversion)	2020 Med	21,221	6,143	6,757	3,340	62,994	19,086	41,142	18,083	178,766
Acre-Feet/Year	2020 Low	15,718	3,536	5,576	1,027	46,115	13,704	35,377	16,924	137,977
Consumptive	1970	0	0	0	0	1,540	2,296	0	0	3,836
Use Deficiencies*	2020 High	2,059	0	111	0	26,301	12,946	8,103	1,517	51,037
In Dry Year	2020 Med	715	0	0	0	18,598	5,781	0	766	25,860
Acre-Feet/Year	2020 Low	0	0	0	0	5,649	1,093	0	0	6,742

* Annual consumptive use deficiencies determined from summation of deficiencies at various use points. The natural flow at the mouth cannot be compared directly to total water requirements because the natural flow recorded at the mouth is not necessarily available at specific use points on the tributary stream.

The capability of the eight tributary basins to supply the water demands of these three projections was assessed on the computer model. This model assumed that the present works would remain in operation to 2020 and that headwater storages would be increased in accordance with present planning as indicated by the various water users. It was also assumed that there would be no change in the location or number of diversion points over those used in 1970. Details of water use projections for the eight tributaries are included in Table 14.2.

Tributary flows developed by the model can be considered as preliminary estimates of the probable monthly discharges under varying climatic conditions. Such monthly flows do not define the sharp peaks that may occur within a few days particularly on the small tributaries. With no allowance for return flow and the assumption that agriculture consumptive use is in accordance with the recommendations of the B. C. Department of Agriculture the residual flows are probably underestimated. The computer model is assumed to have an accuracy of ± 20% of actual flows.

In addition to the consumptive water requirements discussed above, minimum flow requirements are required to satisfy sport fish spawning and incubation in the lower portions of the tributaries. These minimum flow requirements are outlined in Table 14.3. Existing and potential headwater storages and costs are detailed in Table 14.4.

TABLE 14.3

ESTIMATED MINIMUM WATER REQUIREMENTS FOR FISHERIES IN ACRE-FEET AT MOUTHS OF SELECTED TRIBUTARIES IN OKANAGAN LAKE BASIN

	TROUT	PEACHLAND	POWERS	EQUESIS	BX UPPER	VERNON		COLDSTREAM	KELOWNA	MISSION
						UPPER	LOWER			
Jan	600	150	240	360	150	420	480	360	240	1,800
Feb	600	150	240	360	150	420	480	360	240	1,800
Mar	600	150	240	360	150	420	480	360	240	1,800
Apr	600	150	240	360	150	420	480	360	240	1,800
May	900+	300+	300+	600+	240+	600+	600+	480+	300+	2,700+
June	600	150	240	360	150	420	480	360	240	1,800
July	600	150	240	360	150	420	480	360	240	1,800
Aug	600	150	240	360	150	420	480	360	240	1,800
Sep	600	270	300	360	150	420	480	360	240	2,400
Oct	900	270	300	480	240	480	600	480	300	2,400
Nov	600	150	240	360	150	420	480	360	240	1,800
Dec	600	150	240	360	150	420	480	360	240	1,800
TOTAL	7,800	2,190	3,060	4,680	1,980	5,280	6,000	4,560	3,000	23,700

TABLE 14.4

POSSIBLE STRUCTURAL DEVELOPMENTS IN SELECTED OKANAGAN LAKE TRIBUTARIES TO MEET AGRICULTURAL AND FISHERY WATER REQUIREMENTS

TRIBUTARY	RESERVOIR	1973 STORAGE ACRE-FEET	2020 STORAGE (AGRICULTURE) ACRE-FEET	2020 STORAGE (FISHERIES) ACRE-FEET	TOTAL ACREAGE SERVED		AGRICULTURE			SPORT FISHERIES		
					1970	2020	COSTS OF STORAGE (DOLLARS)	ANNUAL[*1] COSTS (DOLLARS)	ANNUAL BENEFITS (DOLLARS)	COSTS OF STORAGE (DOLLARS)	ANNUAL COSTS (DOLLARS)	ANNUAL BENEFITS (DOLLARS)
TROUT	Crescent	755	1,000	-	4,306	5,000				250,000	25,000	32,600[*2]
	Whitehead	920	1,020									
	Thirsk	2,628	4,000	1,000								
	Isintok	570	1,000				193,700	20,000	43,000	1,000,000	110,000	221,000[*2]
	Subtotal	4,873	7,020	1,000	4,306	5,000	193,700	20,000	43,000	1,250,000	135,000	253,600
MISSION	Mission	600	650	Storage Locations not Identified	10,135	12,371						
	McCulloch	12,231	14,000									
	Others	-	4,000				1,450,000	153,000	97,000	175,000	18,000	26,600[*2]
	Subtotal	12,831	18,650	3,600	10,135	12,371	1,450,000	153,000	97,000	175,000	18,000	26,600
EQUESIS	Pinaus	2,156	2,156	150	356	356	-	-	-	-	-	-
	Other	-		550								
	Subtotal	2,156	2,156	700	356	356						
VERNON	Crooked	2,460	3,374	-	14,075	17,300						
	Swan	2,460	3,512	-								
	Other	-	3,834				1,450,000	153,000	280,000	-	-	-
	Subtotal	4,920	10,720		14,075	17,300	1,450,000	153,000	280,000			
KELOWNA	Moore	-	1,000	-	4,848	8,176						
	Other	-	560	-			390,000	40,000	93,000			
	Subtotal	-	1,560		4,848	8,176	390,000	40,000	93,000			
Powers	Lambly	1,801	2,560	-	1,637	1,990						
	Islaht	343	650	-			266,500	27,000	66,000	-	-	-
	Subtotal	2,144	3,210		1,637	1,990	266,500	27,000	66,000			
	TOTALS	26,924	43,316	5,300	35,357	45,193	3,750,200	393,000	579,000	1,425,000	153,000	280,200

*1 Benefits and costs not discounted

*2 Includes improvements to spawning habitat.

14.1.2 Alternatives

There are four management options for tributary streams in the Okanagan to meet projected consumptive and non-consumptive uses.

1) Continuation of the present method of operation with existing storage development.
2) Continuation of present operation with increased storage development
3) Modification of present operation with present storage development.
4) Modification of present operation with increased storage development in the headwaters or by pumping water from Okanagan Lake.

In addition to these structural alternatives, two non-structural measures for improving the efficiency of water use in tributary systems were examined, including the efficiency of irrigation systems and metering and pricing.

(a) Tributary Storage Alternatives

(i) Existing Storage and Operating Practices

If present water management and storage development remained unchanged, only Peachland and Equesis Creeks could meet future consumptive uses under the high growth projection. This would also be at the expense of providing minimum flows for fisheries and thus would increase conflicts between consumptive and non-consumptive water uses.

(ii) Increased Headwater Storage and Present Operating Practice's

Increases in headwater storages appear hydrological feasible on the six major creeks other than Peachland or Equesis and such increases would allow all projected future consumptive water demands to be met in all except Kelowna and Vernon Creeks (Table 14.2). It appears that the costs of headwater storage increases could be justified by the economic returns from increased agricultural development, but the costs of distributing water from headwater storage to the farm plus development costs of preparing agricultural acreage are not included, so total costs may well exceed benefits. Average capital costs of reservoir development are estimated' at $250 per acre-foot with annual costs of $26 compared with average annual benefits of $63 per acre-foot, these benefits include both direct and indirect monetary returns from the expansion of agricultural production within the Okanagan economy. Non-monetary, social and environmental benefits were not estimated for agricultural development, because of the difficulty in quantifying such benefits.

Under maximum development of agricultural lands and population, consumptive use deficiencies increase significantly in Vernon and Kelowna Creeks and small deficiencies appear in Mission, Trout and Penticton Creeks. In the cases of Vernon and Kelowna Creeks, headwater storage increases would have to be supplemented by pumping from Okanagan Lake. This is already in effect on Vernon Creek, where water is pumped from Okanagan Lake to supply industrial use at Winfield. The return flow is discharged to Vernon Creek immediately upstream of Ellison

Lake. This additional water, if supplied continuously at a rate of 10 c.f.s. would remove all present and future water deficits in the lower main portion of Vernon Creek (Ellison Lake to mouth) and would in addition, meet fishery flow requirements at the mouth.

Kelowna Creek in the past, has provided water for the Rutland area, which was incorporated into the boundaries of the City of Kelowna in 1973. If the present population of the Rutland region could be served by an expanded municipal water system which pumps from Okanagan Lake, then other potential agricultural lands in this sub-basin could be supplied from headwater storages on Kelowna Creek.

Detailed costs of a pumping scheme for Kelowna Creek are not available, but would be two to three times the costs of developing headwater storages. Such a pumping scheme would not be economical for agricultural development, but might be justified for domestic use, with headwater storage reserved for irrigation.

Trepanier Creek (not listed in tables) was subsequently considered as a desirable fishery stream. However, because of the lack of any suitable storage site, the alternative of pumping from Okanagan Lake to the lower reaches of the stream was investigated. This alternative is discussed further under Fishery Evaluations, Chapter 17.

It should be emphasized that the models have been limited to operation over single drought years and it has not been possible, because of lack of hydrometric data, to run through the standard study period 1921 to 1970 (which contained the 1929 to 1932 drought), as was done for the mainstem computer model. Thus, while the tributary models indicate that there would be carry-over storage in the larger reservoirs at the end of one drought year to augment the flows should a second successive drought year occur, a continuation of such conditions into a third year as happened in the 1929-1932 drought period, could prove very critical. These limitations in headwater storage are in sharp contrast to Okanagan Lake which, as a source of water to the mainstem, can be drawn down below its normal low water elevation by several feet under a severe three year drought.

The above alternatives assume that only consumptive demands will be met. Conflicts between water withdrawals for irrigation and required in-channel minimum flows would continue and possibly increase. Alternatives for resolving such conflicts were examined and are summarized here, but are evaluated in more detail in Chapter 17.

(iii) Modified Operation of Headwater Storages

This alternative involves modifying the existing operation of headwater storage reservoirs to meet both consumptive and non-consumptive (fishery) flows

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Continuous rate of 10 cubic feet per second provides a volume of 600 acre-feet per month. The present rate of diversion for industrial use provides a volume of approximately 400 acre-feet per month.

at the creek mouth. At present, water is retained in the headwater reservoirs at the end of the irrigation season to provide carry-over storage in the event of a succeeding dry year. Under modified operations, some or all of this storage would be released during the fall and winter months to support kokanee and in the summer months, rainbow trout.

A comparison of the historic and modified methods of operation are shown in the graphs (Figures 14.1 and 14.2) covering flows and deficits in Trout, Peachland, Powers, Equesis, Vernon, Kelowna and Mission Creeks. Penticton Creek has been omitted as it has only a small fishery potential.

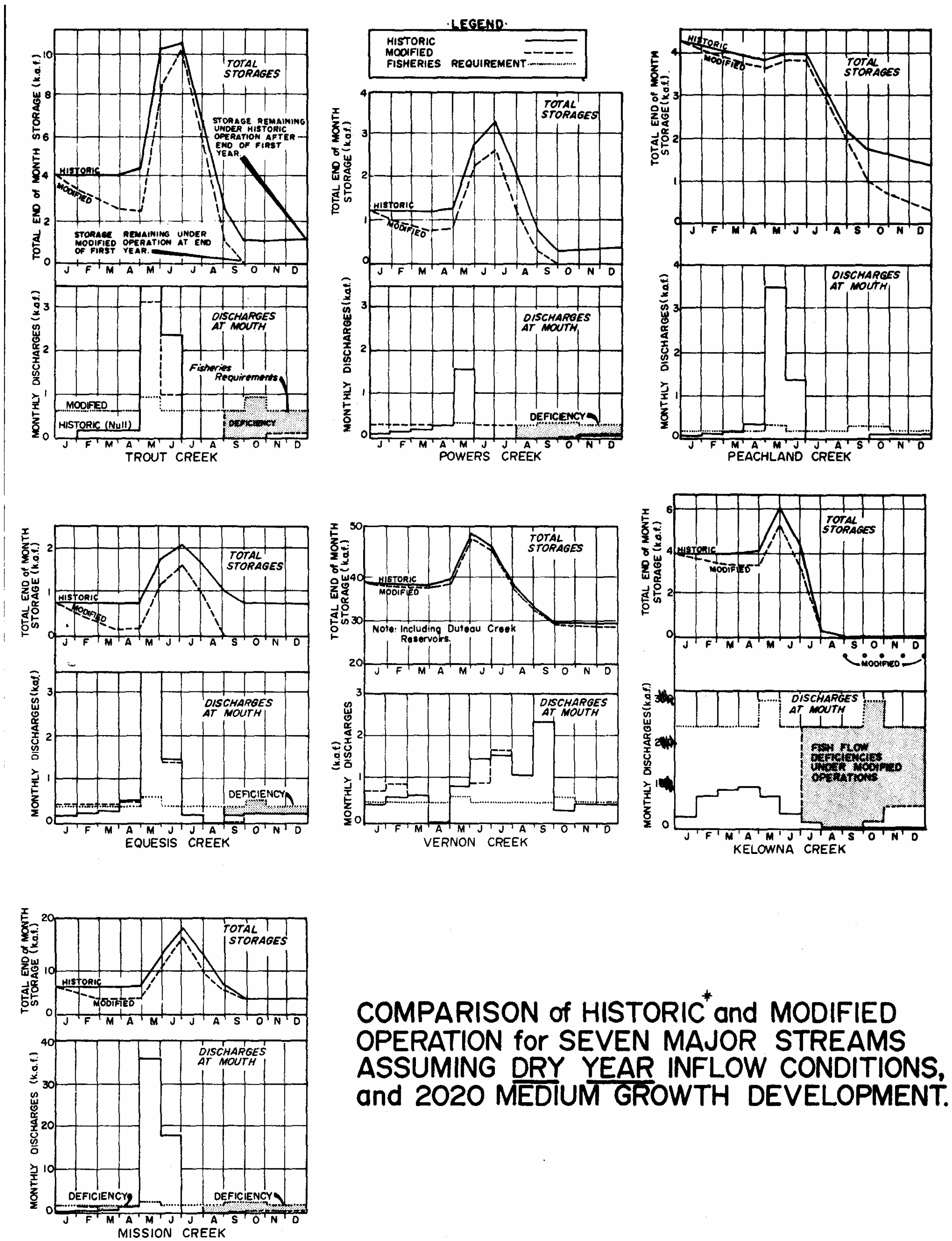
The modified flows as shown in the graphs under 2020 medium development for dry and average inflow years and existing storage conditions, would reduce the fishery flow deficiencies at the mouths of the tributaries appreciably and in the cases of Peachland and Vernon Creeks practically eliminate such conditions. However, in order to produce these improved fishery flows, a portion of the carry-over storage which is normally retained in the event of an ensuing drought year would have to be used up. The effect of increases in headwater fluctuations on fisheries and other types of water based recreation in these reservoirs is not known.

(iv) <u>Modified Operation and Increased Storage</u>

The need for retention of reserve storage capacity in the tributaries led to an examination of the possibilities of increasing 2020 storage over those presently planned with the objective of meeting the fishery flows while still retaining proposed carry-over storage. For these additional storages to be effective, they must be physically and hydrologically feasible so that any enlarged or new storage sites developed can be filled each year. Preliminary investigations indicated that there were no additional sites that could be developed without exceeding inflows during dry years. It therefore appears more practical to allocate some of the planned development of headwater storages for fishery water requirements in certain key tributaries with high fishery potential and allocate the remaining supplies to consumptive uses.

(b) <u>Efficiency of Irrigation Systems</u>

In the last ten years, primarily through the Agricultural Rehabilitation and Rural Development Act, most of the irrigation systems have been modernized through reconstruction of headwater reservoirs, diversion dams and the replacement of earth ditches with pipelines and lateral feeders to sprinklers through pressure regulating valves. It has been estimated that gross water requirements have been reduced by as much as 30% through reductions in conveyance losses and more uniform application. With equal flow from each sprinkler through the use of pressure regulating valves, it is easier to control water application.

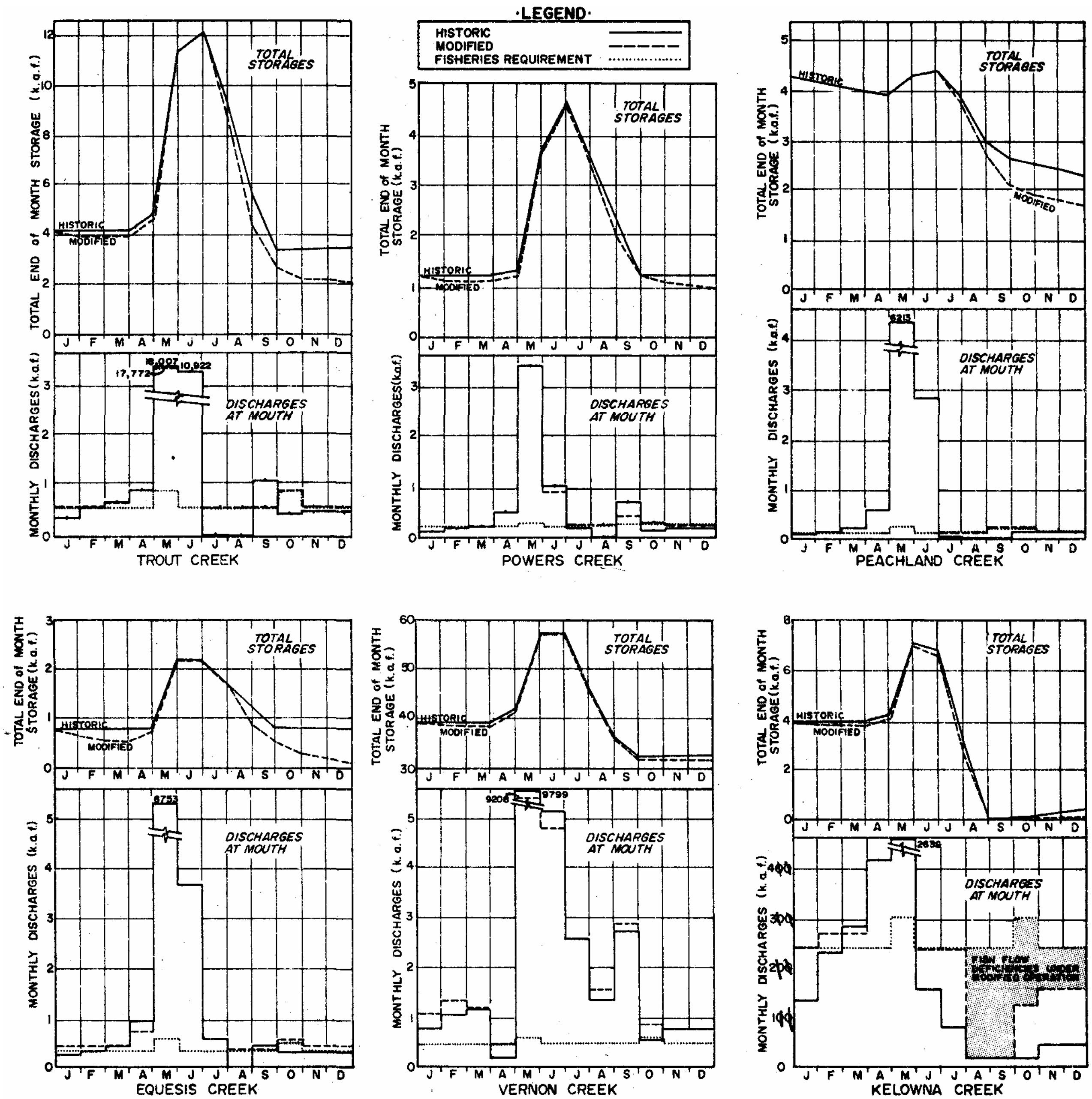


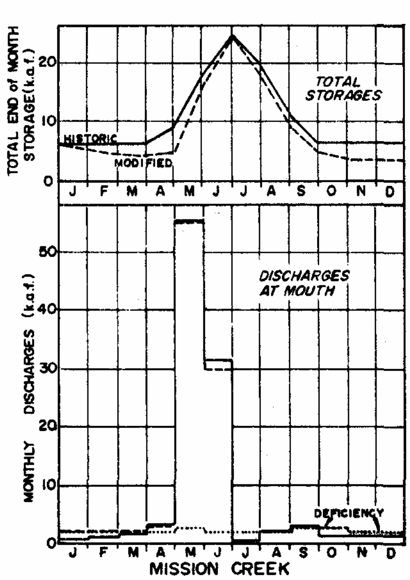
COMPARISON of HISTORIC* and MODIFIED OPERATION for SEVEN MAJOR STREAMS ASSUMING DRY YEAR INFLOW CONDITIONS, and 2020 MEDIUM GROWTH DEVELOPMENT.

Notes: 1. Graphs actually show simulated historic* values. There are few actual historical records for the tributary streams.

2. Penticton Creek omitted because of limited fishery potential.

Figure 14.1





COMPARISON of HISTORIC* and MODIFIED OPERATION for SEVEN MAJOR STREAMS ASSUMING AVERAGE YEAR INFLOW CONDITIONS, and 2020 MEDIUM GROWTH DEVELOPMENT.

Note: *See Figure 14.1 for notes.

Figure 14.2

Flow meters are now located at pumped diversions and provide data on total water withdrawals. Extension of this type of metering for gravity supplies will provide irrigation districts and municipalities with basic data needed for future planning of tributary water supplies.

While better monitoring of water use for agriculture and domestic and industrial purposes is needed, it is possible that in the future these uses may be reduced through improved methods of irrigation and recycling.

One promising new method is trickle irrigation, which applies water through very small diameter tubing to the roots of individual plants at a low pressure range of 10 to 30 pounds per square inch (compared to a range of 60 to 125 pounds per square inch for existing systems). By providing water directly to the root zone, direct evaporation of water from the ground surface which occurs under springling systems, is eliminated. Depending on the soil type, up to 30% of diverted water requirements can be conserved by trickle irrigation, assuming no groundwater return flow.

The main requirement in trickle irrigation is the availability of a clean source of water free from solid particles, to prevent clogging of the small aiemeter drip tubes. For most systems some form of filtration or solid settlement must be used by the farmer or by the central distribution agency. The determination of the optimum amount of water needed is still in the experimental stage, as some return flow may be desirable for soil leaching to prevent the accumulation of salts in the soil.

(c) Metering and Pricing

In addition to the more efficient use of water by improved types of irrigation, reductions may be achieved through metering and pricing. It is probable that metering and pricing would be most effective in local areas receiving water from the smaller tributaries where shortages are presently occurring. However, it is anticipated that such savings would not be significant with respect to conserving water for in-channel flows for fisheries or other non-consumptive uses. Moreover the water quantity modelling developed in this report is not sensitive enough to attempt such a detailed analysis.

Metering of all future water diversions is encouraged, as it allows for better management, especially during drought conditions. As the urban population grows in the Okanagan, pricing mechanisms can be more effectively employed to reduce consumptive uses in tributary watersheds and consequently reduce conflicts with non-consumptive uses for fisheries and recreation.

14.1.3 Discussion of Tributary Alternatives

The following discussion is limited to methods of operating upstream storage to meet consumptive and non-consumptive requirements, assuming present day water use efficiencies. Undoubtedly these will improve in the future as will the accuracy of the simulated tributary discharges which for the present can only be considered as first estimates.

Studies on fish spawning potential around Okanagan Lake indicate that three creeks-Mission, Trepanier and Equesis contain the best spawning areas. (Chapter 17). These creeks should be managed for the multiple use of agriculture and fisheries. The other creeks have limited fishery potential and with the exception of Vernon and Peachland Creeks which support small fish runs, can essentially be man aged for consumptive uses only. An outline of water management proposals on the eight selected tributaries over the next 50 years follows.

(a) Mission Creek

1) Attempts should be made to modify headwater storage discharges to improve fishery flows in the fall and winter. This measure could conserve up to 4000 acre-feet for fishery purposes.

2) An additional 3600 acre-feet of storage should be licenced and developed or existing storage purchased for fisheries. The cost of this storage has been estimated at $900,000.

3) Studies indicate there is an additional 3600 acre-feet of potential firm storage in the upper reaches of Mission Creek. The development of this storage may involve the construction of several dams.

4) The management of Mission Creek as a multipurpose stream to meet both consumptive and non-consumptive uses may require limitations on future agriculture development in this tributary.

(b) Equesis Creek

There is limited opportunity for increased headwater storage on this creek, and in view of significant fishery potential, all future storage development on Pinaus Lake (estimated at 550 acre-feet) should be allocated to supply fishery flows. Further development of agriculture in this basin should be discouraged.

(c) Vernon Creek

1) The present pumped diversion from Okanagan Lake to Vernon Creek near Winfield should be continued, and if necessary, operated on a continuous basis to meet future potential demands in the Ellison Lake to Okanagan Lake portion of the sub-basin.

2) Additional potential storage in the headwaters of Vernon Creek should be developed to meet existing shortages in other parts of this sub-basin, and future agricultural development should be limited to the capability of the basin to supply additional water for such development. The latter requires more detailed water quantity modelling to evaluate the limitations of such future development.

(d) Trout Creek

Additional storage of 2,700 acre-feet appears to be available in this creek and can be reserved for municipal and agricultural expansion. If artificial spawning facilities can be constructed in the lower part of the creek, 1,000 acre-feet of this storage would be required to support the fishery.

(e) Powers Creek

Additional storage of some 1,100 acre-feet could be developed in headwaters for irrigation and domestic uses.

(f) Peachland Creek

There is little or no additional storage potential so agricultural development should not expand above current development levels. As this creek supports a significant run of kokanee to Okanagan Lake, withdrawals and habitat should be carefully controlled to protect this run.

(g) Kelowna Creek

1) Urban development in lower parts of the creek should be serviced within the municipal water supply system of Kelowna if potential agricultural development in the tributary is to be realized.

2) Additional storage of 1,500 acre-feet would be available to service potential expansion of agricultural lands.

(h) Penticton Creek

Penticton Creek appears to have reached its ultimate development with respect to water regulation. Limited irrigation is provided from this source and by 2020 the predominant use may be for municipal purposes.

14.2 MAINSTEM WATER QUANTITY EVALUATIONS

14.2.1 Alternatives

The development of mainstem alternatives has been based on meeting present and future water requirements (Table. 14.5) while at the same time maintaining satisfactory lake elevations and river elevations and discharges".

With limited water available in the system, particularly when two or three drought years occur consecutively as happened in 1929-1932, it is important that water be conserved through efficient use in order that reasonably adequate water elevations may be realized, particularly on Okanagan Lake. In contrast to this are the flood years when the lakes and rivers must be controlled within their normal high water elevations.

These problems led to an examination of three different approaches to managing the mainstem system:

1) Continuation of the present operational procedures (Alternatives (a) and (b). Table 14.6).

TABLE 14.5

WATER REQUIREMENTS-MAINSTEM OKANAGAN RIVER FOR 1970 DEVELOPMENT AND 2020 GROWTH PROJECTIONS FOR PRESENT AND IMPROVED OPERATING CONDITIONS

	1970		2020					
A. PRESENT OPERATING CONDITIONS - with 300 cubic feet per second minimum flow in the Okanagan River between April & September inclusive, and 100 c.f.s. minimum flow between October & March inclusive.	1970		GROWTH PROJECTION 1 Continuation of Present Policies		GROWTH PROJECTION 2 High Growth		GROWTH PROJECTION 3 Low Growth	
	Population 11,000		51,000		55,000		37,000	
	Irrigated Acres 14,000		16,000		15,000		18,000	
	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%	Ac-Ft	%
MAINSTEM OKANAGAN RIVER								
(a) Consumptive Use - Okanagan River	32,000	13.2	44,000	18.4	43,000	18.0	46,000	19.0
(b) Evaporation Losses from Skaha, Vaseux & Osoyoos Lakes and from the Okanagan River channel	49,000)		49,000)		49,000)		49,000)	
(c) Minimum In-Channel Needs for intake submergence & flushing	123,000)	86.8	107,000)	81.6	108,000)	82.0	108,000)	81.0
(d) In-Channel Fishery Requirements additional to min. flows in (c)	39,000)		39,000)		39,000)		39,000)	
TOTAL CONS. USE, LOSSES, MIN. FLOW FOR OKANAGAN RIVER REGION	243,000	100.0	239,000	100.0	239,000	100.0	242,000	100.0

B. IMPROVED OPERATING CONDITIONS - with 100 cubic feet per second minimum flow the year round in the Okanagan River channel.	1970 Ac-Ft	1970 %	GP 1 Ac-Ft	GP 1 %	GP 2 Ac-Ft	GP 2 %	GP 3 Ac-Ft	GP 3 %
MAINSTEM OKANAGAN RIVER								
(a) Consumptive Use - Okanagan River	32,000	15.8	44,000	22.1	43,000	21.6	46,000	22.8
(b) Evaporation Losses from Skaha, Vaseux & Osoyoos Lakes and from the Okanagan River channel	49,000)		49,000)		49,000)		49,000)	
(c) Minimum In-Channel Needs for intake submergence & flushing	50,000)	84.2	34,000)	77.9	35,000)	78.4	35,000)	77.2
(d) In-Channel Fishery Requirements additional to min. flows in (c)	71,000)		72,000)		72,000)		72,000)	
TOTAL CONS. USE, LOSSES, MIN. FLOW FOR OKANAGAN RIVER REGION	202,000	100.0	199,000	100.0	199,000	100.0	202,000	100.0

TABLE 14.6

MAINSTEM SUB-ALTERNATIVES

(1) LTERNATIVE	(2) OKANAGAN FLOOD CONTROL WORKS[1] AMORTIZED 7%-50 YRS. ON $8,800,000	(3) FLOOD CONTROL WORKS OPER-ATIONAL	(4) OKANAGAN LAKE INTAKES	(5) OKANAGAN R. INTAKES & SPAWNING CHANNEL	(6) KELOWNA BRIDGE AND OTHER FLOOD CONTROL WORKS	(7) DIVERSION COSTS	(8) TOTAL COSTS	(9) INCREMENTAL CAPITAL COST (1970 $)	(10) INCREMENTAL COST LESS ALTERNATIVE COST (1970 $)	(11) FLOOD BENEFITS	(12) RECREATION BENEFITS	B
ent Operation-Fishery ; met Incidentally. · Reqts.1970-273 KAF 2020-306-317 KAF	$755,000	$102,000	$10,000	0	$ 10,000	-	$ 877,000	0	0	-$4,860	-$15,000	-
ent Operation-Fishery ; met all times · Reqts.1970-312 KAF 2020-345-356 KAF	$755,000	$102,000	$10,000	0	$ 10,000	-	$ 877,000	0	0	-$4,860	-$37,500	-
· Conservation-Fishery ; met Incidentally · Reqts.1970-200 KAF 2020-254-261 KAF	$755,000	$70,000?	$10,000(2)	$23,000	$ 10,000(2)	-	$ 868,000	$ 375,000	+ $9,000	-$4,860	0	-
· Conservation-Fishery ; met all times · Reqts.1970-271 KAF 2020-325-332 KAF	$755,000	$70,000?	$10,000(2)	$23,000	$ 10,000	-	$ 868,000	$ 375,000	+ $9,000	-$4,860	-$ 7,500	-
· Conservation-Spawning nel-OK River Fishery ; met all times · Reqts.1970-256 KAF 2020-307-314 KAF	$755,000	$70,000?	$10,000(2)	$23,000 +$54,000	$ 10,000	-	$ 924,000	$ 913,000	-$54,000	-$4,860	-$ 7,500	-
l Control-Measures ctural Alterations to iver, Regulation of Lake. Fishery Flows Incidentally · Reqts. 1970-273 KAF l 2020-306-317 KAF ration)	$755,000	$70,000?	$10,000	0	$ 13,000	-	$ 848,000	$ 984,000	-$2,9000	-$2,580	-$15,000	-
tenance of Okanagan L. is. Importation of · Fishery Flow met all ; · Reqts.1970-312 KAF 2020-345-356 KAF	$755,000	$102,000	0	0	$ 10,000(2)	$1,176,000	$2,043,000	$10,725,000	-$1,166,000	-$2,440	0	-
tenance of Okanagan L. ls. Importation of · Improved Intakes l Control Measures ery Flows Met all times · reqts.1970-312 KAF 2020-345-356 KAF	$755,000	$70,000?	0	$23,000	0	$1,176,000	$2,024,000+	$12,084,000	-$1,147,000	-$2,440	0	-

1) Cost of existing Okanagan Flood Control Works, exclusive of Zosel Dam was $8,800,000 (1970 dollar value)

2) While Okanagan Lake intakes and Kelowna Bridge would not require adjustments under 1970 development such will be needed before 2020. Hence these costs are included here.

3) For continuation of this Table see Table 14.10.

4) For detailed estimates see Figure 14.6.

2) Examination of a number of water conservation and flood control measures within the Okanagan Basin (Alternatives 2(a), 2(b), 2(c) and 2(d), Table 14.6).

3) Importation of water into the Okanagan during drought years (Alternatives 3(a) and 3(b), Table 14.6).

As is the practice in this evaluation chapter, a11 alternatives are compared with the existing operational procedures. When possible each alternative will be broken down into separate components, but in some cases the alternatives are not mutually exclusive and in fact structural and non-structural changes in one alternative may be useful in meeting the objective of others.

A number of sub-alternatives have been identified within each of the three management approaches described above. A summary of these sets of sub-alternatives is contained in Table 14.6, together with associated capital and annual costs based on 1970 prices and financing over 25 years at 7%. Detailed costs are shown in Table 14.7. These costs can only be considered approximate and would have to be revised upward to consider present day prices.

(a) Alternative 1 - Continuation of Present Operation

(i) Sub-Alternative 1(a) - Fishery Flows Met Incidentally

This alternative simulates the existing operation of the Okanagan Mainstem system which is operated primarily for water conservation in drought years when freshet inflows are less than 244,000 acre-feet (present day water requirements) and for flood control when freshet inflows are greater than 550,000 acre-feet. For the near normal inflow years which fall between these two extremes, regulation tends to follow a more uniform procedure based primarily on historic records of lake levels and discharges for average inflow years. In drought years (net inflows less than 244,000 acre-feet), minimum flows for the Sockeye salmon run }n Okanagan River are reduced to conserve water in Okanagan Lake.

The extremes between droughts and floods are illustrated in Figure 14.3 for the period 1925 to 1935 under the present operation, assuming both existing and future developments.

Under such conditions, Okanagan Lake would be drawn down to at least 1116.8 feet in severe droughts, necessitating ajustments to the Kelowna Floating Bridge and to intakes around Okanagan Lake totalling $132,000 and $100,000 in capital costs respectively (Table 14.7). In addition some $102,000 are required annually to operate the Okanagan Flood Control Works. There are also $15,000 of recreation benefits foregone annually due to drawdowns on Okanagan Lake and $4,860 of flood damage, (property, ballasting Kelowna Bridge, revenue lost at marinas and campgrounds). Okanagan Lake drawdowns under extreme drought conditions could result in important environmental and social costs, particularly in relation to shoreline recreation, boat launching and general aesthetics.

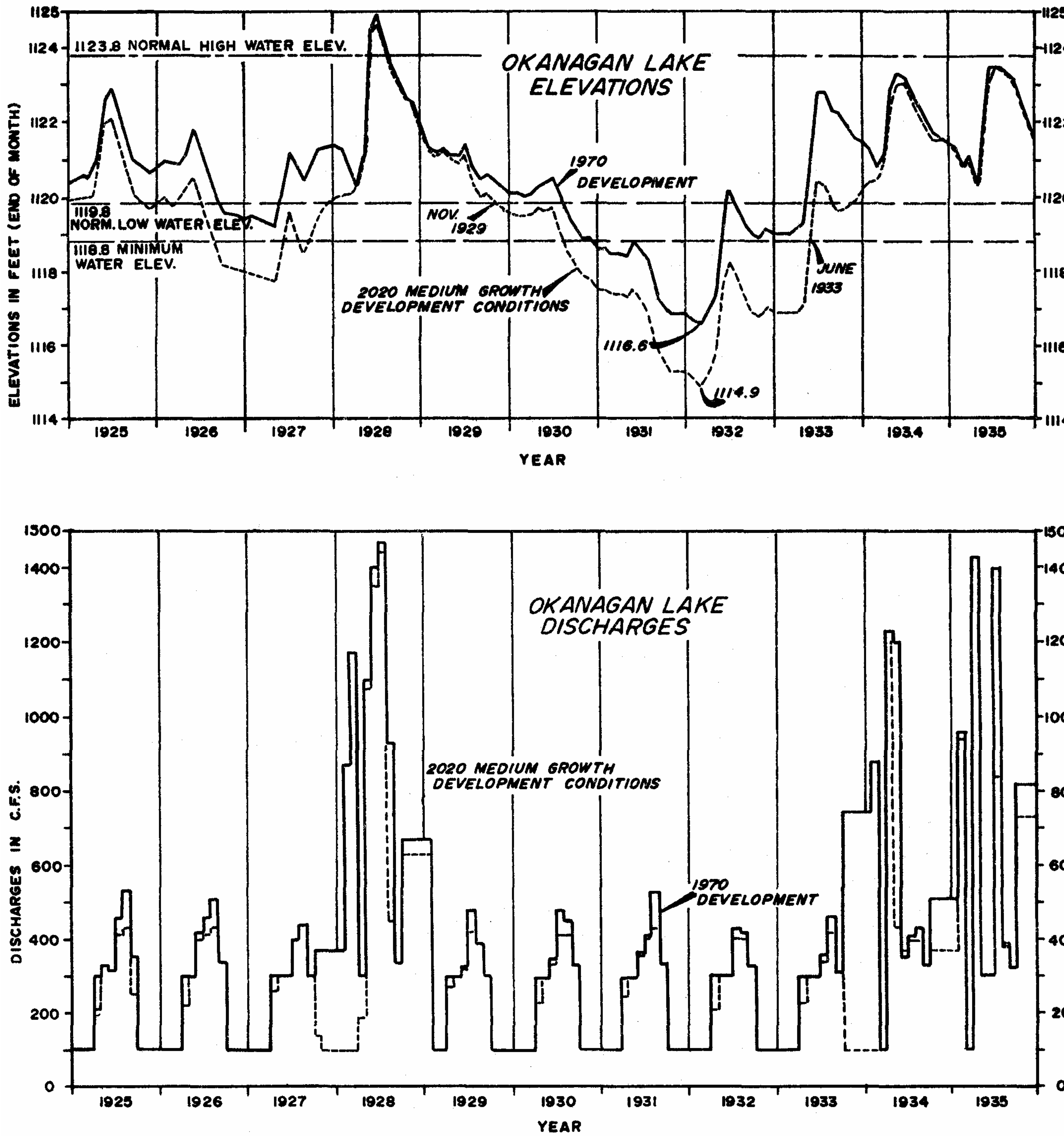
TABLE 14.7

ECONOMIC EVALUATIONS

Mainstem Water Quantity Alternatives

(Based on 1970 Development Only)

F VE	ITEM	CAPITAL COST 1970 Costs Includes 25% for Engineering & Contingencies $	ANNUAL COST 7% - 25 yrs. Plus Operation & Maintenance $/Year	WATER BASIN REQUIREMENTS 1970 Salmon Fishery Requirements Met Incidental to Other Uses	WATER BASIN REQUIREMENTS 1970 Salmon Fishery Requirements Met at All Times	WATER BASIN REQUIREMENTS 2020 ECONOMIC GROWTH PROJECTION 1 Fish Incid. KAF	WATER BASIN REQUIREMENTS 2020 ECONOMIC GROWTH PROJECTION 1 Fish All Times KAF	WATER BASIN REQUIREMENTS 2020 ECONOMIC GROWTH PROJECTION 2 Fish Incid. KAF	WATER BASIN REQUIREMENTS 2020 ECONOMIC GROWTH PROJECTION 2 Fish All Times KAF	WATER BASIN REQUIREMENTS 2020 ECONOMIC GROWTH PROJECTION 3 Fish Incid. KAF	WATER BASIN REQUIREMENTS 2020 ECONOMIC GROWTH PROJECTION 3 Fish All Times KAF	COMPUTER RUNS 1970 Fish Incid.	COMPUTER RUNS 1970 Fish All Times	COMPUTER RUNS 2020 Fish Incid.	COMPUTER RUNS 2020 Fish All Times	RANGE OF WATER CONSERVED IN YEAR 2020 FOR 3 GROWTH PROJECTIONS OVER NULL OPERATION Fish Incid. KAF	RANGE OF WATER CONSERVED IN YEAR 2020 FOR 3 GROWTH PROJECTIONS OVER NULL OPERATION Fish All Times KAF	
F WATER kanagan n Lake king to ing	Lower Okanagan River intakes Lower Okanagan Lake intakes Kelowna Floating Bridge Sub-Total	143,000 120,000 112,000 375,000	23,000 10,000 10,000 43,000	200	271	258	329	254	325	261	332	3	4		38	24-52	16-24	Some difficu ling Tugulnu level in 197 is elev. 971 may indicate for conserva control floo pumping for included her
F WATER ng nels in nagan ce y flow	Spawning channels in Lower Okanagan River	600,000	54,000	200	256	243	314	239	310	246	307	NO RUN				63-71	31-49	Saving of 30 drought year about 1/3 of Lake.
by anagan igh on by od ing ing el & e re- ine ay 97); lnuit works; low ood for	*Adjustments to Kel-*owna Floating Bridge Improvement Okanagan & Skaha Dams (gates; prevention of icing) Replacement McAlpine Bridge Tugulnuit Lake control works Osoyoos and Okanagan Lake flood plain zoning Improved Forecasting Procedures Channel: Excavation & removal of temporary rock weirs Fill in over-excavation & erosion holes in channel Bank errosion protection Total	34,000 25,000 166,000 45,000 ? ? 7,000 317,000 390,000 984,000	3,000 4,000 14,000 8,000 ? ? 1,000 51,000 63,000 144,000	273	312	306	345	310	349	317	356	3	4		38	0	0	Okanagan Lak normal range (G Osoyoos Lake desirable ra Replacement may not be w basis of imp conditions o Bank erosion quired if fl be sustained design capac
F ught h f me- tion	Diversion of up to 36,000 acre-feet per *month in drought* years from the Shuswap River	10,725,000	1,176,000	273	312	306	345	310	349	317	356	30		40	42	0	0	Diversion co assuming no diversion ca



SIMULATED OKANAGAN LAKE ELEVATIONS and DISCHARGES 1925 to 1935. BASED on COMPUTER MODEL DATA ASSUMING PRESENT OPERATING PROCEDURES and 2020 MEDIUM GROWTH DEVELOPMENT CONDITIONS.

Figure 14.3

(ii) Sub-Alternative 1(b) - Fishery Flows Met All Times

An additional 39,000 acre-feet must be released from Okanagan Lake to meet all Okanagan River fishery requirements in all years. In drought years, this release would result in greater drawdowns of Okanagan Lake with increased impacts on shoreline recreation, wildlife and aesthetics. It is extremely doubtful that benefits to fisheries would outweigh the increased damage to Okanagan shoreline uses.

(b) Alternative 2 - Water Management Options Within Okanagan Basin

(i) Sub-Alternative 2(a)

Objective - Water Conservation (Fishery Flows Met Incidentally)

Method - Lower Okanagan River Intakes
- Contingency Plan for Modifications to Kelowna Floating Bridge
- Lower Okanagan Lake Intakes
- Zosel Dam Regulation
- Tugulnuit Lake Water Management

Lower Okanagan River Intakes

The Okanagan Flood Control Works included the straightening and improvements to the Okanagan River channel. This resulted in the cutting off of a number of meanders or oxbows which contained irrigation and domestic water intakes. In order to service these intakes, each oxbow was connected to the main channel at its upper and lower ends by culverts.

When the Okanagan Flood Control Works were completed, it was found that the river water elevations at normal summer flows did not provide adequate submergence for the intake culverts, nor for some of the intakes located directly on the river due, primarily, to lower water profiles than those anticipated. This problem was remedied by the placing of stop logs across the weir openings at the drop structures, thus raising water elevations at these points by some two to three feet. Normally the stop logs are placed immediately after the freshet and remain there until the end of the irrigation season in September when they are removed.

Even with the addition of stop logs up to the top of the weirs, it has been necessary to maintain a minimum residual flow of 300 cfs during the irrigation season to provide adequate submergence. After mid-September, releases are normally governed by fishery requirements in the lower portion of the Okanagan River although in a drought year it may be necessary to reduce the minimum flows to 100 cfs depending upon the amounts of carry-over storage available in Okanagan Lake.

Studies were undertaken to determine if the oxbows might be deepened and the culverts and intakes lowered so that the required discharges (the greater of the fishery requirements or the minimum flows) could be met without the need for stop logs.

From limited field investigations it would appear that this sub-alternative is feasible and could result in the saving of 40,000 acre-feet per year during drought periods, assuming fishery requirements are met at all times. A saving of up to 70,000 acre-feet could be made in a drought year if fishery flows were not met (i.e. if operation were similar to the present operation). Prior to the implementation of such a proposal, it should be tested in the field to ensure a base flow of 100 cfs plus consumptive use requirements will meet the need? of the water users along Okanagan River. This test would also indicate the improvements required to various intakes should this proposal be implemented.

Kelowna Floating Bridge and Okanagan Lake Intakes

In severe droughts, similar to that which occurred between 1929 and 1932, Okanagan Lake would drop to 1119.2 feet (0.6 feet below normal low water elevation) under present levels of development, and to 1116.8 feet under 2020 conditions of development. The present minimum operating level of the Kelowna Floating Bridge is 1118.8 feet. Therefore, while no immediate adjustments are needed, a contingency plan should be prepared to cover any future adjustments and dredging required should these conditions occur. Water intakes on Okanagan Lake would also have to be lowered so that they are operable at elevation 1116.8 feet. The lead time required to lower Okanagan Lake intakes prior to the occurance of a major drought (1-1/2 to 2 years) is such that this work should be undertaken immediately. The capital cost of the bridge modifications and the lowering of Okanagan Lake intakes have been estimated at $120,000 and $112,000 respectively.

By reducing Okanagan Lake drawdowns in drought years, this sub-alternative also would lessen potential negative impacts on shoreline recreational resources around Okanagan Lake, effectively eliminating these in all but the most severe drought on record (1929-32). These economic and environmental benefits would have to be weighed against the increased damage to both the sockeye and sport fishery resources due to the lower minimum Okanagan River flows and greater fluctuations of Okanagan Lake during kokanee shore spawning and incubation. In view of the importance of these resources to the economic and environmental health of the Okanagan, other water conservation sub-alternatives that attempt to meet fishery water requirements should also be considered.

Zosel Dam at Osoyoos Lake

Experience during the 1970 and 1973 droughts indicates that Osoyoos Lake levels cannot be maintained at 911 feet (USCGS) when inflows from Okanagan River drop below 270 cfs. This is due to considerable leakage from Zosel Dam, which normally controls the outlet of Osoyoos Lake in the United States. Reductions of Okanagan River inflows to 100 cfs would cause Osoyoos Lake levels to drop below the elevation of Zosel Dam until the lake was controlled by gravel bars upstream of the dam. The precise elevation at which these gravel bars take control is not known and thus the consequences of Osoyoos Lake drawdowns on recreation and aesthetics in the area cannot be fully assessed.

Because Osoyoos Lake is an international waterway, any further consideration of the effects of this water conservation sub-alternative should be referred to the International Joint Commission.

Tugulnuit Lake Water Management

Pumping from Tugulnuit Lake is needed to supplement gravity drainage when Okanagan River is high. The pumping system would operate during the freshet periods and at other times when high discharges much be maintained in Okanagan River (See Sub-Alternative 3). It is estimated that the cost of the pumping system would be $45,000, with annual costs including amortization at about $8,000. These costs together with a discussion of benefits are included in Sub-Alternative 3 rather than with the other costs of the sub-alternative.

(ii) Sub-Alternative 2(b)

Objective - Water Conservation (Fishery Flows Met At All Times)

Methods - Lower Okanagan River Intakes

- Modifications to Kelowna Floating Bridge and Okanagan Lake Intakes

If full fishery flows are met in Okanagan River at all times, and intakes are adjusted to allow minimum flows of 100 cfs during the irrigation season, water requirements for the basin would total 271,000 acre-feet under the 1970 level of development, which is the same as under the present operation, when fishery flows are not met in drought years. Equivalent requirements under 2020 levels of development could increase to 307,000 acre-feet.

Thus the saving of water during the irrigation season could be transferred directly to meeting fishery flows. However, Okanagan Lake levels would drop. 3.5 feet below the normal low water elevation during prolonged droughts and adjustments to Kelowna Bridge and Okanagan Lake intakes would again be required.

As a compromise, it would be possible to meet fishery flow requirements in all single drought years, which cannot be achieved under the present operation, and reduce flows in the second and third years of prolonged droughts. The amount of reduction would depend on the size of the salmon run and the magnitude of the drought, but could be negotiated by Federal Fishery officials and B.C. Water Resources Service.

(iii) Sub-Alternative 2(c)

Objective - Water Conservation (Fishery Flows Met At A11 Times)

Methods - Lower Okanagan River Intakes

- Construction of Spawning Channels on Okanagan River

Construction of a spawning channel for sockeye salmon near Okanagan River would enable additional water conservation in drought years. Because full channel water requirements would be necessary to enable the salmon to migrate to and from the channel, savings could only be realized during the period of October to February 15 inclusive (Table 14.8).

Also while flows could be reduced to 75 cfs during the period of November to February 15, it is considered that the minimum residual flow in Okanagan River should be 100 cfs. The amount of water conserved in a drought year by the construction of a spawning channel would therefore be approximately 30,000 acre-feet.

TABLE 14.8

COMPARISON OF FLOW REQUIREMENTS IN OKANAGAN RIVER FOR SALMON WITH AND WITHOUT PROPOSED SPAWNING CHANNEL

MONTH	PRESENT SALMON REQUIREMENTS		REQUIREMENTS WITH SPAWNING CHANNEL	
	Minimum (cfs)	Maximum (cfs)	Minimum (cfs)	Maximum (cfs)
August	300	350	300	450
September	350	550	350	550
October	350	550	100	-
November 1 to February 15	175	1000	75	-
February 16 to April 30	175	1000	175	-

* Flows exceeding the maximums shown cause scouring and loss of spawning habitat.

The capital cost of this sub-alternative has been estimated at $600,000 with an annual cost of $54,000.

(iv) Sub-Alternative 2(d)

Objective - Flood Control Methods - Increase Okanagan Lake Elevation by One Foot in Flood years.

- Adjust Kelowna Floating Bridge
- Tugulnuit Lake Pumping and Erosion Control
- Replace McAlpine Bridge
- Improved Inflow Forecasts

Provision for flood control within the mainstem includes some four feet of storage on Okanagan Lake equivalent to 340,000 acre-feet as well as design channel discharges ranging from 2100 cfs at Penticton to 3400 cfs at Osoyoos Lake. Because of the limited channel capacities and the high freshet during April to July, it is necessary to plan the regulation of Okanagan Lake well in advance of an impending flood.

Under normal winter conditions, Okanagan Lake can be lowered about one foot a month although operations in February and March may be impeded by icing conditions on the gates of Skaha Lake Dam as well as at the inlet to Osoyoos Lake where ice can plug the river channel.

During past floods such as occurred in 1975, it was found that Okanagan Lake average discharges were limited to about 70% of the channel capacity at Penticton to allow for local channel inflows downstream, limitations in the safe discharges into Osoyoos Lake, local channel restrictions such as McAlpine pile trestle highway bridge north of Oliver and the need for gravity drainage from Tugulnuit Lake.

Increase Okanagan Lake Elevation by One Foot in Flood Years

With the present limited channel capacity of Okanagan River, net inflows exceeding 600,000 acre-feet cannot be contained within the normal four foot operating range on Okanagan Lake. Experience with the 1972 flood indicated that if Okanagan Lake is allowed to rise to one foot above normal maximum elevation, about $50,000 of damage to shoreline property will occur. As such events occur very infrequently, annual costs are estimated at $4500. When possible, Okanagan Lake should be drawn down below its normal minimum elevation when larger runoff is forecast. This would reduce the impact of flooding above the normal high lake elevation.

Without expensive structural adjustments to Okanagan River, this sub-alternative appears inevitable and should be accompanied by flood plain zoning around Okanagan Lake to elevation 1127.5 feet (200 year flood elevation, plus two feet of freeboard) to reduce any potential damage from flooding.

Adjust Kelowna Floating Bridge

During the 1972 flood, approximately $30,000 were spent on ballasting the Kelowna Floating Bridge to accommodate the extreme high water elevations. This investment would have to continue in the event of subsequent floods, as such floods are too infrequent to support more permanent adjustments.

Erosion Control and Tugulnuit Lake Pumping

Erosion protection around the drop structures on Okanagan River and adjustments to the gates on Okanagan and Skaha Lake dams to prevent icing could permit continuous discharges down Okanagan River at 80% channel capacity, compared to 70% at present. These measures would allow the evacuation of an additional 12,000 acre-feet per month prior to and during the freshet and thus would improve the flexibility of operating Okanagan Lake. Capital costs are estimated at $739,000 (Table 14.7).

Increased discharges down Okanagan River would cause local flooding around Tugulnuit Lake, the natural drainage of which can be impeded during high flows in the main channel. Improvements to prevent such flooding should include the addition of a pumping unit to supplement the existing improved channel way between Tugulnuit Lake and Okanagan River. This improvement will allow sufficient flexibility to control lake water levels within the desirable range and in the event of a mechanical failure, still allow some inflow or outflow as required.

McAlpine Bridge

Replacement of McAlpine Bridge on Highway 97, to eliminate the trestles which presently trap debris, would cost an estimated $166,000 or $14,000 annually. This investment cannot be justified on the basis of flood control, unless it can be demonstrated that the debris pile-ups at the bridge seriously threaten the structure.

Improved Inflow Forecasts

The value of improved forecasting models both for the total freshet inflow forecasts and for the short term forecasts a few days in advance are recognized. Forecasting models are presently in operation and their performance is under review by the British Columbia Water Resources Service.

Volume inflow forecasts to Okanagan Lake for the freshet period April to July inclusive are published in the April 1 Snow Survey Bulletin of the British Columbia Water Resources Service, who with the assistance of the Department of Highways, operate the Okanagan Flood Control Works. These forecasts are made on the assumption that normal weather conditions will prevail during the freshet period, and have a standard error of forecast of some 84,000 acre-feet, equal to about one foot of storage on Okanagan Lake. In subsequent revisions of the forecasts during the snow melt period up to the end of July, about one half the error can be explained by variations from the normal weather pattern. The remaining half of the forecast error can be attributed to the limited understanding of the hydrology of the basin, particularly with respect to changing soil moisture conditions. The elimination of this portion of the error would conserve up to 40,000 acre-feet, which represents half a foot of storage on Okanagan Lake. However, in drought and flood years this may not be too important because conservation or flood control action is normally taken well in advance of inflow forecasts and is based primarily on the accumulated snow pack data. Nevertheless, for a better understanding of the hydrology of the basin and the contribution to be expected from its major tributaries, it does appear that the continuous monitoring model has much to offer.

(c) Alternative 3 - Water Importation

For all the above sub-alternatives, Okanagan Lake would be drawn down below its normal low water elevation of 1119.8 feet should the 1929-32 drought recur. It appears that this situation can only be avoided by importation of water. The periods over which the diversion would take place within the study period 1921-1970 are shown in Table 14.9.

Although maximum diversion shown in Table 14.9 is 500 cfs, it is now considered that a 600 cfs capacity canal would be required for diversion of water from the Shuswap River near Enderby over a seven month period (March to July inclusive and October and November) in drought years.

Over the 50 year study period, diversion would only be required for a total of 20 months on nine different occasions, assuming 2020 development conditions - a frequency of about one year in eight. The maximum diversion would occur with conditions similar to the 1929-32 drought, with up to 167,000 acre-feet required in 1931. However, the average annual volume diverted over the 50 years would be less than 10,000 acre-feet.

TABLE 14.9

IMPORTATION OF WATER REQUIRED TO MAINTAIN OKANAGAN LAKE ABOVE NORMAL LOW WATER ELEVATION 1119.8 (C.F.S. - MONTHS)*

YEAR	M	A	M	J	J	A S	O	N	TOTAL
1926					500		500	500	1,500
1927	110	247							
1929					500				500
1930		500	500	500	500			106	2,106
1931	208	500	500	500	500		191	379	2,778
1932	401	500							901
TOTAL C.F.S. MONTHS	719	1,747	1,000	1,000	2,000		691	985	8,142
TOTAL MONTHS	3	4	2	2	4		2	3	20

* 1 c.f.s. (cubic feet per second) - month is equivalent to approximately 60 acre-feet.

Under these conditions, energy costs for pumping are not significant when compared to annual interest and amortization charges on the $10 million capital costs. Total annual costs are estimated at $1.2 million, assuming no irrigation in the areas adjacent to the canal.

The diversion canal could be used to irrigate adjacent lands in the Spallumcheen Valley, but due to pumping requirements, the annual cost per acre-foot (excluding water costs at the canal side and local distribution costs) are estimated at $60-70. As annual net benefits from tree fruits and pasture range from $63 to $18 per acre-foot respectively, such pumping systems would not be economical, especially as most agricultural production in this section of the valley would be mainly forage crops because of climatic conditions.

Because water conservation sub-alternatives within the Okanagan do significantly reduce lake drawdowns in such extreme droughts, the investment of over $10 million, or $1.2 million annually to avoid such infrequent droughts does not appear to be justified. Although water importation would basically eliminate all social and environmental consequences of extreme Okanagan Lake level fluctuations, it could have a detrimental effect on shore-spawning kokanee. This is because Okanagan Lake would be regulated less conservatively and therefore be subject to greater drawdowns than at present with the knowledge that there was additional water available in the event of a drought. Large lake level drawdowns during the spawning and incubation period (September to February) would expose fish eggs, resulting in a significant fish mortality. Because more than half the total kokanee population is dependent on shore-spawning habitats, such events could have serious consequences on the quality of angling on Okanagan Lake.

14.2.2 Discussion of Alternatives

A number of possible solutions to water management problems along the mainstem have been outlined. The evaluation of these alternatives is complex because economic and social values must be placed on a wide range of water uses. Such costs and benefits are summarized in Tables 14.7 to 14.10), which compare all benefits and costs for each sub-alternative according 'to economic, environmental and social goals. The matrix has been prepared for 1970 and for 2020 development, where changes are significant.

Economic impacts include flood damage to shoreline property and developments, loss of tourist resources due to lake drawdowns, adjustments to water intakes around Okanagan Lake and along Okanagan River and adjustments to Kelowna Floating Bridge.

The environmental impacts involve loss of public beaches, loss of use of launching and mooring facilities, exposure of lake bottom, reduction in kokanee and rainbow trout shore spawning habitats, and inundation or desiccation of wildlife nesting grounds.

Social impacts include loss of opportunity to use private boat docks due to high or low water levels.

TABLE 14.10

ENVIRONMENTAL AND SOCIAL EVALUATIONS

Mainstem Water Quantity Alternatives

(Based on 1970 Development Only)

ALTERNATIVE	SOCKEYE SALMON	SPORT FISH	WILD-LIFE	OKANAGAN LAKE RECREATION BEACHES	OKANAGAN LAKE PRIVATE BOAT DOCKS	OKANAGAN LAKE PUBLIC BOAT DOCKS	OKANAGAN LAKE PRIVATE PROPERTY FLOODED	OKANAGAN LAKE LAKE BOTTOM EXPOSURE	RECREATION ACRE DAYS	PRIVATE BOAT DOCK DAYS	PUBLIC BOAT DOCK DAYS	PRIVATE PROPERTY ACRE DAYS	LAKE BOTTOM EXPOSED AREA-DAYS
1(a) Null Operation Fishery Flows met Incidentally Water Reqts.1970-273 KAF 2020-306-317 KAF	0	0	0	0	0	0	0	0	64.0	6023	109.4	106.5	950
(b) Null Operation Fishery Flows met all times Water Reqts.1970-312 KAF 2020-345-356 KAF	+7	+2	-2	0	-4	-4	0	-8	64.0	8208	153.5	106.5	1679
2(a) Water Conservation Fishery Flows met Incidentally Water Reqts.1970-200 KAF 2020-254-261 KAF	-2	-10	+5	0	+8	+9	0	+9	64.0	1129	13.0	106.5	77
(b) Water Conservation Fishery Flows met all times Water Reqts.1970-271 KAF 2020-325-332 KAF	+8	+2	+2	0	+6	+2	0	+1	64.0	2538	91.4	106.5	850
(c) Water Conservation Spawning Channel-Ok.River Fishery Flows met all times Water Reqts.1970-256 KAF 2020-307-314 KAF	+10	+2?	+2?	0	+7	+3	0	+2	64.0	1500 e/	80.0 e/	106.5	800 e/
(d) Flood Control Measures Structural Alterations to Ok.River.,Regulation of Ok.Lake. Fishery Flows met Incidentally. Water Reqts. 1970-273 KAF (Null 2020-306-317 KAF Operation)	0	0	0	+10	+2	+3	+10	+2	43.3	5000	78.4	52.0	840
3(a) Maintenance of Okanagan Lake Levels. Importation of Water Fishery Flow met all times Water Reqts.1970-312 KAF (Null 2020-345-356 KAF Operation)	+7	-5	+4	0	+10	+10	0	+10	64.0	650	6.9	106.5	.24
(b) Maintenance of Okanagan Lake Levels Importation of Water Improved Intakes Flood Control measures Fishery Flows met all times Water Reqts.1970-312 KAF 2020-345-356 KAF	+8	-5	+2	+10	+10	+10	+10	+10	43.3	284	5.6	52.0	.24

NOTE: For commencement of this Table see Table 14.11.

K.A.F. - Kilo Acre Feet

'e' - estimated

To account for seasonal variation in use (for example, boat docks are mainly used during the summer months), each social and environmental landuse category was adjusted by a monthly weighting factor (Table 14.11). These factors were based on observed or estimated seasonal use patterns obtained from the creel census, socio-economic fishing survey and recreation studies (Table 14.12). For each sub-alternative, total damage in dollars or other units for all extreme events in the 50 year study period was summed and divided by 50 to obtain average annual damage values.

Although there is little doubt that Okanagan Lake drawdowns below the minimum low water elevation of 1118.8 feet during the summer would have significant implications on the economics of the tourist industry, it is almost impossible to quantify this effect. During the 1972 beach-user survey, shoreline recreationists were asked for their possible reaction to such drawdowns, but responses were not enlightening because they had not experienced such conditions.

The Okanagan tourist trade has considerable resilience to single events which which effect recreation quality. This has been demonstrated by the effect of the Skaha and Wood Lake algae blooms of 1967 and 1971 respectively. Although some long-term Okanagan tourists did avoid the basin, they were replaced by others who either had not known about these blooms, or who placed less emphasis on water quality as a factor in their recreational enjoyment.

However, water quality deterioration in a small portion of the Basin over a single year is of limited value in anticipating loss to the tourist industry as well as the environmental and social impacts of Okanagan Lake levels remaining below normal low water elevations for periods up to three years (See Figure 14.3).

To provide some estimate of economic impacts, it was assumed there would be a 10$ reduction in the tourist trade in two consecutive drought years, under normal operating conditions. Based on the 1979 net income from tourists expenditures of $4.5 million, this impact is valued at $450,000, which is again reduced to $15,000 on an annual basis, assuming an average return period of one in 50 years. The capitalized value of this loss to 2020, discounted at 7% per annum, would be $400,000.

Incremental impacts for each sub-alternative relative to simulated historic inflows regulated by Okanagan Lake Dam were scored according to the following procedure: -

The extreme range in annual damage values for each landuse category was noted and the difference between the annual value for the simulated operation and both extreme values (above and below the historic) was calculated. The larger difference, whether positive (benefit) or negative (cost) was scored at 10. Differences between the annual values for the simulated operation (based on computer model data) and the respective annual values for all other sub-alternatives were then scored as a percentage of this maximum difference, decreases

TABLE 14.11

MONTHLY WEIGHTINGS IN DAYS FOR SHORELINE DAMAGE

	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
Public Boat Access Ramps	0	0	5	10	15	25	31	31	20	10	5	0
Private Boat Docks	0	0	5	10	15	25	31	31	20	10	5	0
Public Recreation Beaches	0	0	0	0	5	15	31	31	10	0	0	0
Marinas	0	0	0	0	20	30	31	31	20	10	0	0
Campgrounds	0	0	0	0	10	20	31	31	10	0	0	0

TABLE 14.12

IMPACTS ASSOCIATED WITH MAINSTEM OKANAGAN WATER MANAGEMENT ALTERNATIVES

ASSOCIATED GOAL	IMPACT CATEGORY	LOCATION	UNIT OF MEASUREMENT
Economic	Kelowna Floating Bridge Flood damage to private property Revenue lost - marinas - lake drawdowns Intake adjustments	Okanagan Lake Okanagan Lake Okanagan Lake Okanagan Lake Okanagan River Okanagan Lake	dollars dollars dollars dollars dollars dollars
Environmental	Recreation beaches flooded Public boat ramps inoperable Shoreline exposed by lake draw-down Sockeye salmon Sport fisheries - Kokanee (shore spawning) - trout & Kokanee Wildlife	Okanagan Lake Okanagan Lake Okanagan Lake Okanagan River Okanagan Lake Okanagan River Okanagan Lake Okanagan River	acre days ramp days area-days *1 spawning fish spawning fish spawning fish
Social	Private property flooded Private boat docks inoperable	Okanagan Lake Okanagan Lake	acre days boat-dock days

*1 "Area-Days" - Due to the difficulty in surveying lake bottom area exposed at various drawdowns below the minimum level of 1119.8 feet, a dimensionless index of "area-days" was developed. The maximum extent of shoreline exposed at any location around the lake at 1116.8 feet was rated at 100, and incremental drawdowns between 1119.8 and 1116.8 feet for this and other sections of the shoreline were pro-rated to 100. The pro-rated numbers were then multiplied by the number of days the drawdown at each 0.5 foot increment occurred to produce the index "area-days".

in annual damage being scored positively and increases scored negatively. In most categories of landuse, as at least one sub-alternative effectively eliminated the damage due to high or low water, a score of +10 means that the planning objective was fully achieved.

In the case of sockeye salmon, an approximate relationship between Okanagan River discharges and spawning success was generated and the discharge regime of each sub-alternative was then analysed to project sockeye production. Discharges which enabled optimum production of salmon (average escapement of 51,000) were scored as 10, while those that effectively eliminated the run were scored as zero. Socres were pro-rated according to the estimated success of sockeye reproduction associated with various minimum flows for each alternative.

Other impacts on sport fishing resources in the mainstem included Okanagan Lake fluctuations on shore spawning kokanee and Okanagan River discharge regimes on kokanee and rainbow trout spawning habitat in Okanagan River, and subsequent rearing success in Skaha, Vaseux and Osoyoos Lakes.

A single score represented an integration of impacts on each sport fishery component. This score was based on the magnitude of impacts due to lake level fluctuations or Okanagan River flows falling outside desirable ranges and weighted according to the size of the fishery supported by shore or main river spawning, incubation and rearing. Because angling for large rainbow trout in the lower Okanagan River was known to be a highly prized recreation, impacts on this resource were weighted three times that of other sport fishery components.

Although cultural changes in shoreline landuse have significantly reduced natural wildlife habitat, potential threats to remaining habitat due to alternative operation of the Okanagan mainstem system could occur in the north arm of Okanagan Lake and in the oxbows adjacent to the Okanagan River Flood Channel. Impacts on wildlife habitats around Okanagan Lake were not scored, as no alternative created prolonged changes in the present operating range which would seriously affect natural habitat. Scoring of the effects of various minimum flow regimes in Okanagan River was based on a qualitative relationship between flow and wildlife breeding success.

14.2.3 Conclusions

By 2020, growth in population and irrigated acreage could change total basin water requirements for both consumptive and non-consumptive uses to between 344,000 and 347,000 acre-feet under the three projections examined, compared to 312,000 acre-feet at present (1970). Although these possible increases are not considered large enough to affect mainstem operation significantly, they will further aggravate the potential drought problems in the system. Thus, should the present method of operation be continued, recurrence of prolonged droughts would result in greater drawdowns of Okanagan Lake in the future than those anticipated when the Okanagan Flood Control Works were constructed, and have relatively greater impacts on shoreline recreation and could threaten the viability of the sockeye salmon fishery over the next 50 years.

It is also apparent that importation of water to the Okanagan Basin cannot be justified on either economic or environmental considerations. Inflows to Okanagan Lake are sufficient to meet all water requirements in most years with proper management and the environmental costs associated with a prolonged drought such as occurred in 1929 to 1932 appear to be preferable than annual expenditures of over $1 million to pay the costs of importation.

To provide greater flexibility for operating the system during such droughts, one of the water conservation sub-alternatives should be implemented. Lowering the irrigation intakes on Okanagan Lake and River will produce economic and environmental benefits that appear to outweigh their relatively modest annual costs, though further consideration would have to be given to the consequences of minimum flows of 100 cfs on Osoyoos Lake levels and the possibility of replacing Zosel Dam.

Discussions with public task forces, indicate that the Okanagan residents place highest priority on maintaining water supplies to domestic and irrigation uses followed by recreation and fishery requirements. Consequently, in extreme and prolonged droughts, operating procedures would have to be developed so that consumptive uses were met at all times, and some fishery requirements in Okanagan River foregone to the point where reductions of negative impacts of Okanagan and Osoyoos Lake drawdowns balance the losses of fishery production.

Because Okanagan Lake would only fail below its extreme minimum elevation of 1118.8 feet very infrequently, actual adjustments to Kelowna Floating Bridge might best be undertaken when Okanagan Lake approaches its minimum elevation of 1118.8. A contingency plan should be prepared for this however, so that such modifications can be carried out without delay. In the case of the Okanagan Lake intakes, it would not be feasible to wait because of the number involved, and such improvements should be undertaken at the same time as the Okanagan River intakes are lowered.

Flooding around Okanagan Lake only occurs about once in 15 years and cannot be considered a serious problem. Improvements in forecasting resulting from an increased understanding of tributary hydrology and soil moisture balance will assist in better flood regulation. Some of the real physical constraints of maintaining maximum discharges in Okanagan River should be overcome, such as control works for regulating Tugulnuit Lake levels and some bank and erosion protection measures.

It does not appear that the costs of constructing fish spawning facilities adjacent to Okanagan River to maintain the sockeye salmon run can be justified solely by the amount of water conserved and associated environmental benefits around Okanagan Lake in drought years. An additional problem with respect to salmon is the adequacy of the Zosel Dam fish ladders. The release of water specifically for fisheries to the lower reaches of the Okanagan River upstream is contingent on adequate upstream and downstream migration at Zosel Dam.

14.3 OSOYOOS LAKE ELEVATIONS

14.3.1 Statement of Problems

The objective of water management in the Okanagan Basin is to provide adequate water of good quality at satisfactory elevations.

Through structural improvements and good water management it is possible to approach these objectives for the mainstem system to the inlet of Osoyoos Lake. This is due primarily to the large storage capacity of Okanagan Lake (340,000 acre-feet) which can retain a major portion of the freshet inflows while tributaries downstream of Penticton are peaking and filling the river channel to capacity.

Similarly, in dry periods releases from Okanagan Lake can sustain consumptive use and minimum residual flow requirements through to Osoyoos Lake.

In contrast, Osoyoos Lake with about 7% of the area of Okanagan Lake, has very limited storage capacity in its desirable operating range of 1.6 feet as outlined in Table 14.13. This desirable range can only be positively controlled by Zosel Dam at the lake outlet, when near average flow conditions are occurring. There are no obstructions upstream of the dam which affect Osoyoos Lake high water elevations.

In the past, Osoyoos Lake outflows during heavy floods have been retarded or sometimes reversed by backwater from the Similkameen River, while under less severe conditions the control has shifted to the channel upstream of Zosel Dam when delta material from Tonasket Creek has built a bar across the main channel.

TABLE 14.13

DESIRABLE ELEVATIONS FOR OSOYOOS LAKE

Geodetic Survey of Canada 1961 Datum	Okanagan Flood Control Datum	United States Coast and Geodetic Survey Datum
(G.S.C. feet)	(O.F.C.feet)	(U.S.C.G.S. feet)
910.4	909.0	910.7
912.0	910.6	912.3

NOTE: Preferred summer elevation of Osoyoos Lake is 911.0 feet (USCGS) or 910.7 feet (GSC).

In summary, the two water quantity problems that can be identified with respect to Osoyoos Lake are:

1) Maximum elevations occurring above 912.0 GSC (912.3 USCGS).
2) Minimum elevations occurring below 910.4 GSC (910.7 USCGS).

14.3.2 Maximum Elevations of Osoyoos Lake

Serious flooding occurs around Osoyoos Lake on average about once a decade, resulting in an average annual cost of $26,000. During extreme flood conditions such as occurred in June 1972, Osoyoos Lake rose over 5 feet above the normal maximum, causing $212,000 of damage to shoreline property or lost revenue to the local tourist industry. However, this size of flood is only expected to occur about once every 45 years.

Extreme flooding on Osoyoos Lake results from high flows on the Similkameen River which back up into Osoyoos Lake, effectively stopping any outflow of water. Since inflows to the lake during such runoff periods come largely from tributary inflows between Okanagan and Osoyoos Lakes, the control of Okanagan Lake outflows has little effect on Osoyoos Lake levels (Figure 14.4).

14.3.3 Alternatives

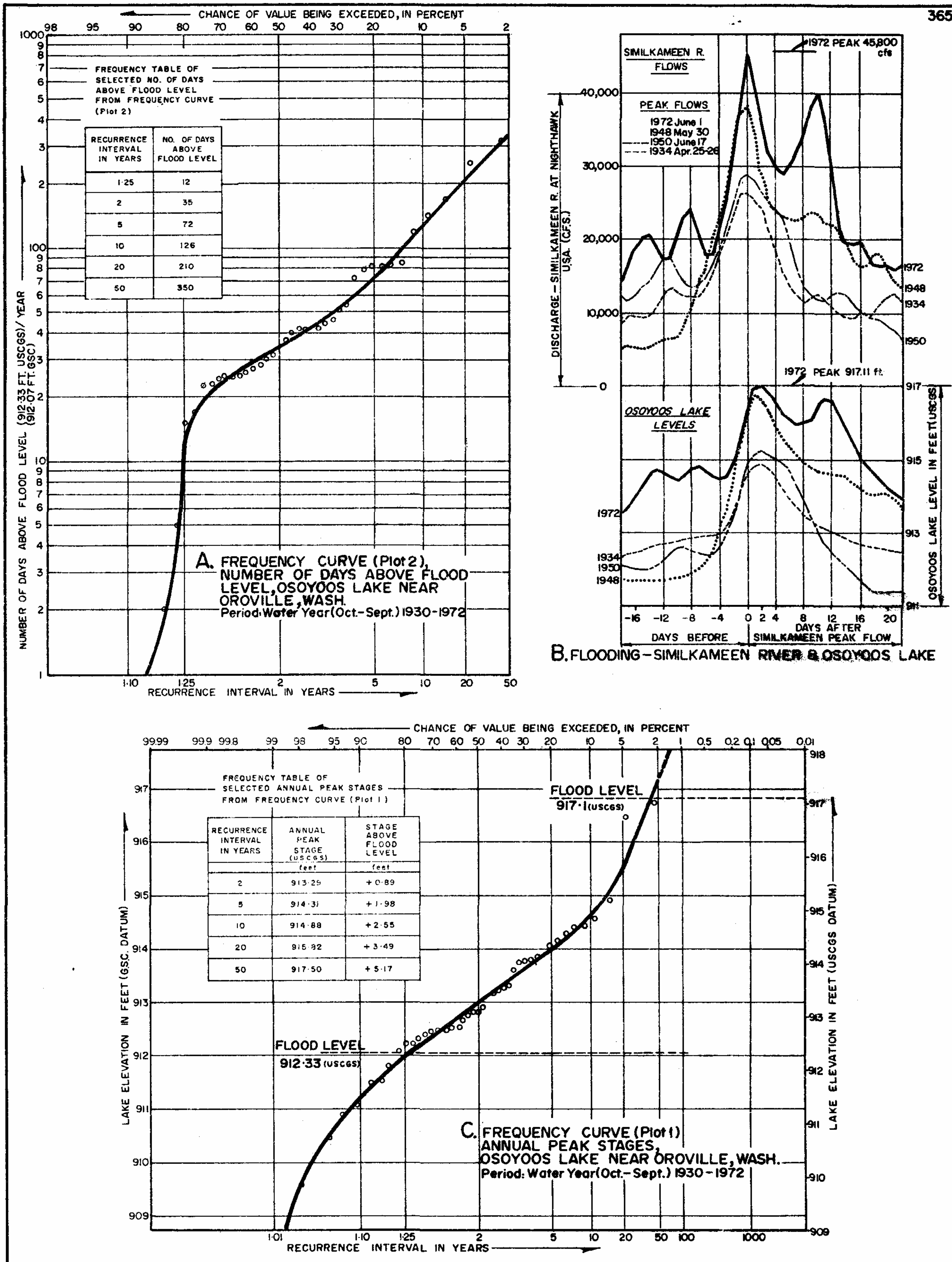
Structural and non-structural alternatives for controlling Osoyoos Lake water elevation or preventing flood damage are as follows:

Structural

- Flood storage on Similkameen River of sufficient capacity to reduce maximum flows on the Similkameen River to 17,000 cfs or less at the Nighthawk gauge.
- Construct a dam at the outlet of Osoyoos Lake to prevent backwater effect and reverse flow from the Similkameen River at high stage, together with a pumping station to carry the discharge of Okanagan River over the dam. This would also maintain Osoyoos Lake at a desirable summer water elevation which cannot be done with the present structure.
- Replacement of Zosel Dam with limited flood control features.
- Construct permanent dykes to protect affected built-up areas around Osoyoos Lake
- Construct emergency dyking to protect affected built-up areas aro-und Osoyoos Lake.
- Channel improvements below Zosel Dam in the United States.

Non-Structural

- Forecasting and Flood Warning Systems
- Plan and Implement emergency preventative measures, together with a program of educating residents in flood fighting techniques.
- Flood plain zoning.



RECURRENCE INTERVAL IN YEARS	NO. OF DAYS ABOVE FLOOD LEVEL
1·25	12
2	35
5	72
10	126
20	210
50	350

RECURRENCE INTERVAL IN YEARS	ANNUAL PEAK STAGE (U.S.C.G.S.) feet	STAGE ABOVE FLOOD LEVEL feet
2	913·29	+0·89
5	914·31	+1·98
10	914·88	+2·55
20	915·82	+3·49
50	917·50	+5·17

FREQUENCY and DURATION of FLOODING on OSOYOOS LAKE

Figure 14.4

(a) Structural Sub-Alternatives

(i) Flood Control Storage on the Similkameen River

Although the Simi1kameen River is not within the terms of reference of the Okanagan Basin Study, the river in flood stage certainly has an effect on Osoyoos Lake, which is within the Study area. Storage at upstream sites on the Similkameen River in the United States and further upstream in Canada, could be a solution to the flood problem at Osoyoos.

For the purpose of this report it has been assumed that discharges into Osoyoos Lake as well as the local inflow (which is relatively small) will not be greater than 3,000 cubic feet per second. With free flow out of Osoyoos Lake (that is, no backwater effect from the Similkameen River) the maximum lake level would be 913.8 (USCGS) to achieve a discharge of 3,000 cubic feet per second. This free flow would be achieved if the discharge of the Similkameen River at Nighthawk could be held to 14,000 cubic feet per second or less during the freshet period (April to July inclusive). Lesser degrees of control (to 17,000 or even higher) would also be worthy of consideration.

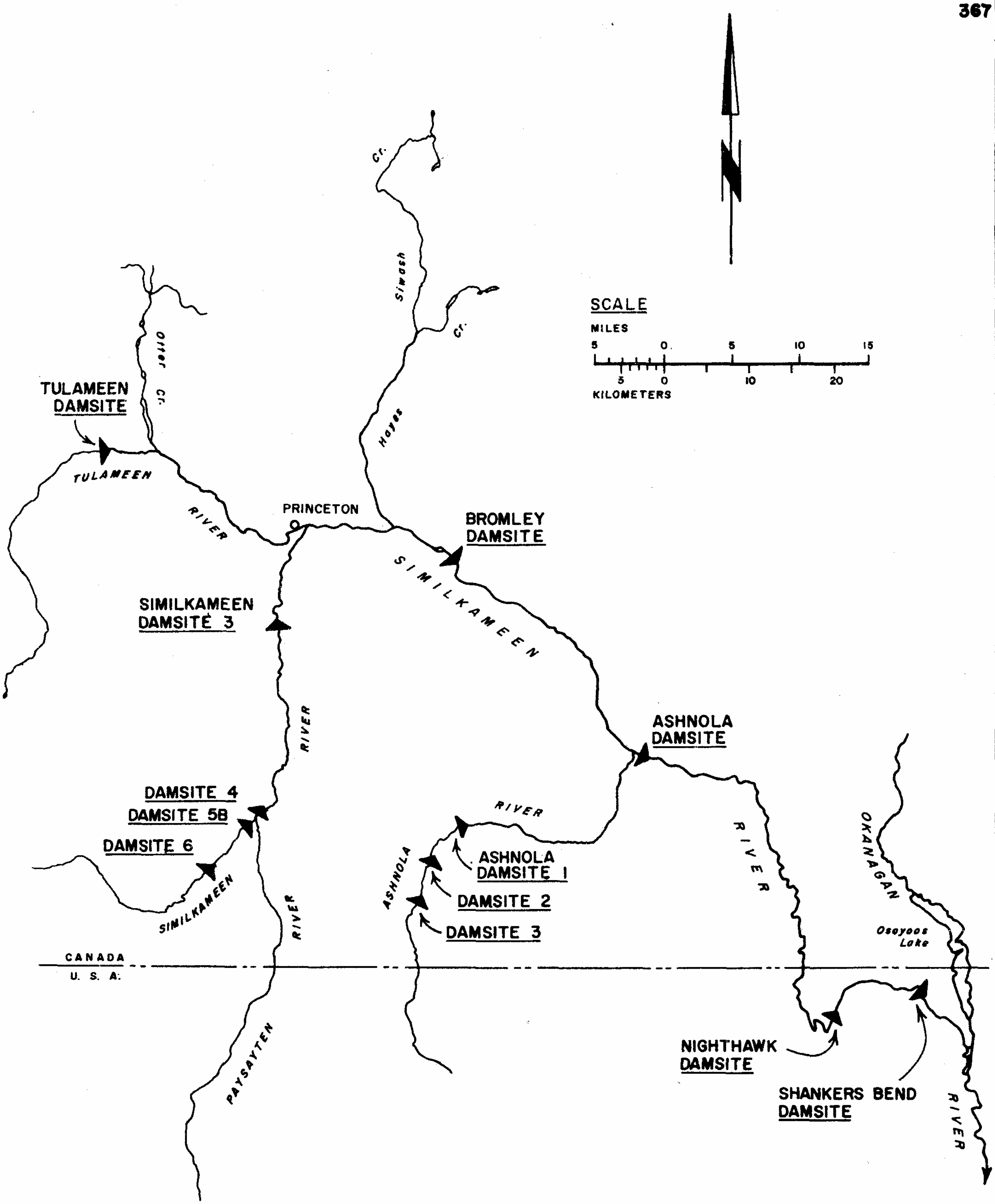
The retention of all flood water on the Similkameen River in excess of 14,000 cubic feet per second, would require the following upstream storage requirements:

TABLE 14.14

STORAGE REQUIREMEHTS-SIMILKAMEEN RIVER IN CANADA

LOCATION	STORAGE REQUIRED In Acre-Feet		POTENTIAL STORAGE In Acre-Feet		
	1948	1972	Tributaries	Mainstem	Totals
Above Princeton	463,000	895,000	158,000	273,000 (Bromley)	431,000
Below Princeton	197,000	384,000	70,000	62,000	132,000
TOTALS	660,000	1,279,000	228,000	335,000	563,000

It is evident from Table 14.14 that the total potential tributary storages on the Similkameen in Canada of 228,000 acre-feet would not be nearly sufficient to meet the 1948 flood storage requirements of 660,000 acre-feet and would be totally inadequate in meeting the 1,279,000 acre-feet required to control the 1972 flood. Even with the addition of the mainstem storages at Bromley and Ashnola, the total potential storage of 563,000 acre-feet falls short of the 1948 requirements and is only about 44% of the 1972 requirements (Figure 14.5).



STORAGE SITE LOCATION MAP
SIMILKAMEEN RIVER

Figure 14.5

In a report to the International Joint Commission (24), reference is made to a potential damsite on the Similkameen River at Shankers Bend in the State of Washington. The Shankers Bend High Dam, some five miles upstream from Oroville, would provide storage between elevation 1,150 and 1,289 feet, equivalent to 1,310,000 acre-feet. This would back water almost to Cawston in Canada (Figure 14.5) and would appear to be the size of storage needed to control the record runoff of 1972.

While any significant reduction in the peak flow of the Similkameen River would have a beneficial effect on Osoyoos Lake in years of high runoff, it is obvious that the cost of providing such storage on the Similkameen River either in Canada or the United States, cannot be justified solely on the basis of benefits in flood relief around Osoyoos Lake.

At the present time, the U.S. Army Corps of Engineers are carrying out a study of the Okanogan River in Washington with respect to flood control, which in time, should provide more information on the regulation of the Similkameen.

(ii) Osoyoos Lake Dam and Pumping Station

Flooding on and around Osoyoos Lake could be effectively prevented by constructing a dam below the outlet of Osoyoos Lake at Oroville (near existing Zosel Dam) of sufficient height to prevent any reverse flow from the Similkameen River into Osoyoos Lake. A pumping station would be a necessary part of the project in order to lift water entering Osoyoos Lake from the Okanagan River and other tributaries and discharge it over the dam.

The dam would need to be constructed to elevation 925 feet. This would afford protection against backwater from the Similkameen River to elevation 920 (about one foot higher than the level reached on May 29, 1894 - the highest known), and give a margin for wave action.

As the annual flood damages around Osoyoos Lake amount to about $25,000, such a project would not be economically justified and has not been given further consideration.

(iii) Replacement of Zosel Dam

The present 140 long Zosel Dam, which accords some degree of low-level control for Osoyoos Lake, is nearing the end of its useful life and will probably have to be reconstructed or replaced by a more satisfactory structure. The original purpose of the structure in 1927 was to create a mill pond for log storage. In 1948 it was modified to increase its capacity for passing large flows. The mill pong is no longer used, and the control structure is operated by the company as a public service to maintain the level of the lake during periods of low flow. During flood periods, the structure is inundated and lake levels are controlled by the level of the Similkameen River.

Since regulations concerning the operation of this structure come under the International Joint Commission, further studies of Osoyoos Lake level regulation should be referred to this group to determine what measures need to be undertaken either in Canada or the United States to -

1. maintain Osoyoos Lake levels during drought periods

2. reduce flood damage around Osoyoos Lake.

(iv) Permanent Dykes to Protect Built-up Areas Around Osoyoos Lake

Dyking around high value properties on the lakeshore was explored as a possible solution to the threat of flooding, but was dismissed because of the obviously high cost of construction in relation to the infrequent need for protection. Further, there is little material locally suitable for building dykes and it would be difficult to prevent water seeping through the sandy soil on which the dykes would have to be built unless extensive and expensive grouting was carried out. When considered with the length of shoreline that would need protection, the cost of dyking could be far more than property owners might be prepared to pay. The cost of building some 23,300 linear feet of permanent dyke is estimated to be $450,000.

(v) Emergency Dyking to Protect Affected Built-up Areas Around Osoyoos Lake

This option envisages hastily-built dykes of local material to protect high-value properties when a flood threat develops. The same problems apply to emergency dykes as to permanent dykes. Seepage becomes even more of a problem with emergency construction, even if polythene sheets were available to provide an impervious core, since it would still occur through the underlying porous soils. Emergency dykes would only be effective if used directly against a house as a support for a water-proof membrane, and under these conditions seepage under basement floors becomes a problem. Experience during the 1972 flood emergency showed that when water was pumped out of flooded basements, the uplift caused by water pressure below the basement floors caused damage by c acking the floor slabs.

It is estimated that some 27,000 feet of temporary dyke would be required, and including the restoration of the beach after the flood, the total cost has been placed at $180,000. The equivalent figures excluding the north end of Osoyoos Lake are 23,300 feet of dyke and $160,000 respectively.

This is considerably more than the damage sustained in 1972, Further, even using six construction crews working around the dock, it would require 32 days to built the 27,000 feet of dyke, which is clearly impractical when only one or two days' warning may be possible.

(vi) Channel Improvements Below Zosel Dam

One of the flood control studies proposed by the U.S. Army Corps of Engineers is to deepen and widen portions of the Okanogan River. This would improve local conditions in the United States but would not appreciably change the overall river gradient, which is only two feet per mile between the confluence of the Similkameen and the Columbia River, a distance of approximately 68 miles. The cost of the local improvement proposal for flood control is estimated at about 5 million dollars. To effectively control Osoyoos Lake elevations, however, major excavation to increase this river gradient would. be required, costing many times this amount.

(b) Non-Structural Sub-Alternatives

(i) Forecasting and Flood Warning Systems

As discussed in Chapter 4, Section 4.3, forecasts of the volume inflows to Okanagan Lake are made each year by the British Columbia Water Resources Service. The more accurate and reliable these forecasts are, the easier is the management of the system, including that of Osoyoos Lake. If the likely inflow to the Basin could be predicted accurately, then the releases from Okanagan Lake could be scheduled to have the least detrimental effect on Osoyoos Lake levels. For the most effective scheduling of releases from Okanagan River however, a reliable short-term quantitative forecast of Similkameen River flows would be required. At the present time it is possible to predict fluctuations in the Similkameen River flows only qualitatively, and thus predict whether Osoyoos Lake is likely to rise or fall.

These combinations of Basin volume inflow forecasts and the short-term qualitative forecasts enable flood warnings to be disseminated to community leaders, local authorities and the media. While this has been done in the past, a more effective means of communicating with the residents in the area appears. necessary in years of anticipated high runoff.

(ii) Emergency Preventative Measures and Education in Flood-fighting Techniques

The 1972 flood damage survey around Osoyoos Lake indicated that about 80 percent of lakeshore residents attempted some type of emergency action to reduce flood damage. These measures ranged from removal of contents to higher elevations in the house, to properly placed sandbags wrapped in impervious polyethylene sheeting, supplemented by pumping. In the 1972 flood, much of this emergency work was ineffective due to lack of knowledge of effective techniques and lack of available materials. The rapid rise of Osoyoos Lake in the critical three days prior to the peak (daily increases of 0.65, 0.87 and 0.52 between May 30 and June 2, for a total rise of 2.04 feet in three days) was virtually indefensible for householders trying to keep sandbag defences above the water line.

Unless positive flood prevention measures can be achieved for the Osoyoos Lake area, a program of educating residents in flood-fighting techniques under emergency conditions should be instituted well in advance of any flood threat.

It must also be recognized that an education program of this nature would have to be repeated year after year, when conditions warranted it, as a refresher to long-time residents as well as to educate new arrivals.

A supply of materials (sandbags, impervious sheeting, etc.) should be stockpiled locally in anticipation of emergency needs.

Civil Defence and local government officials, profiting from the experience of the 1972 situation, should be in a position to plan for similar emergencies and devise methods of coordinating volunteer and employed workers, and providing logistical support.

(iii) Flood Plain Zoning

The most realistic solution in the long term to the flood problem around Osoyoos Lake appears to be flood plain zoning, under which any construction on lakeshore land subject to inundation would be regulated to prevent damage from floods. While the details of the flood plain zoning will require further field investigations, it is evident that it would have to extend to about elevation 921 with certain horizontal limits set for buildings and other improvements above this level.

14.3.4 Minimum Elevations of Osoyoos Lake

The low lake levels experienced in Osoyoos Lake in 1973 have resulted in several complaints from residents of the area. The following discusses some possible reasons for the low levels and courses of action that could be followed to remedy the situation both now and in the future.

Records of Osoyoos Lake levels are available as far back as 1928, with discharge measurements in the reach between Osoyoos Lake and the junction with the Similkameen River since 1942. As the Zosel dam was constructed in 1927, this means that there are no records available of the Osoyoos Lake fluctuations prior to construction of the dam. It is not easy to determine the control which regulates Osoyoos Lake and it is probable that the control changes both according to lake elevation and from year to year. Other than during very high flows in the Similkameen River, the control would appear to be either:

(a) the bar at the south end of the lake
(b) the bar at Tonasket Creek, or
(c) Zosel's dam.

The first two will no doubt, vary from year to year and the Zosel dam is probably the control either when the lake is fairly low or when the stoplogs in the dam are sufficiently high to cause a backwater to the lake.

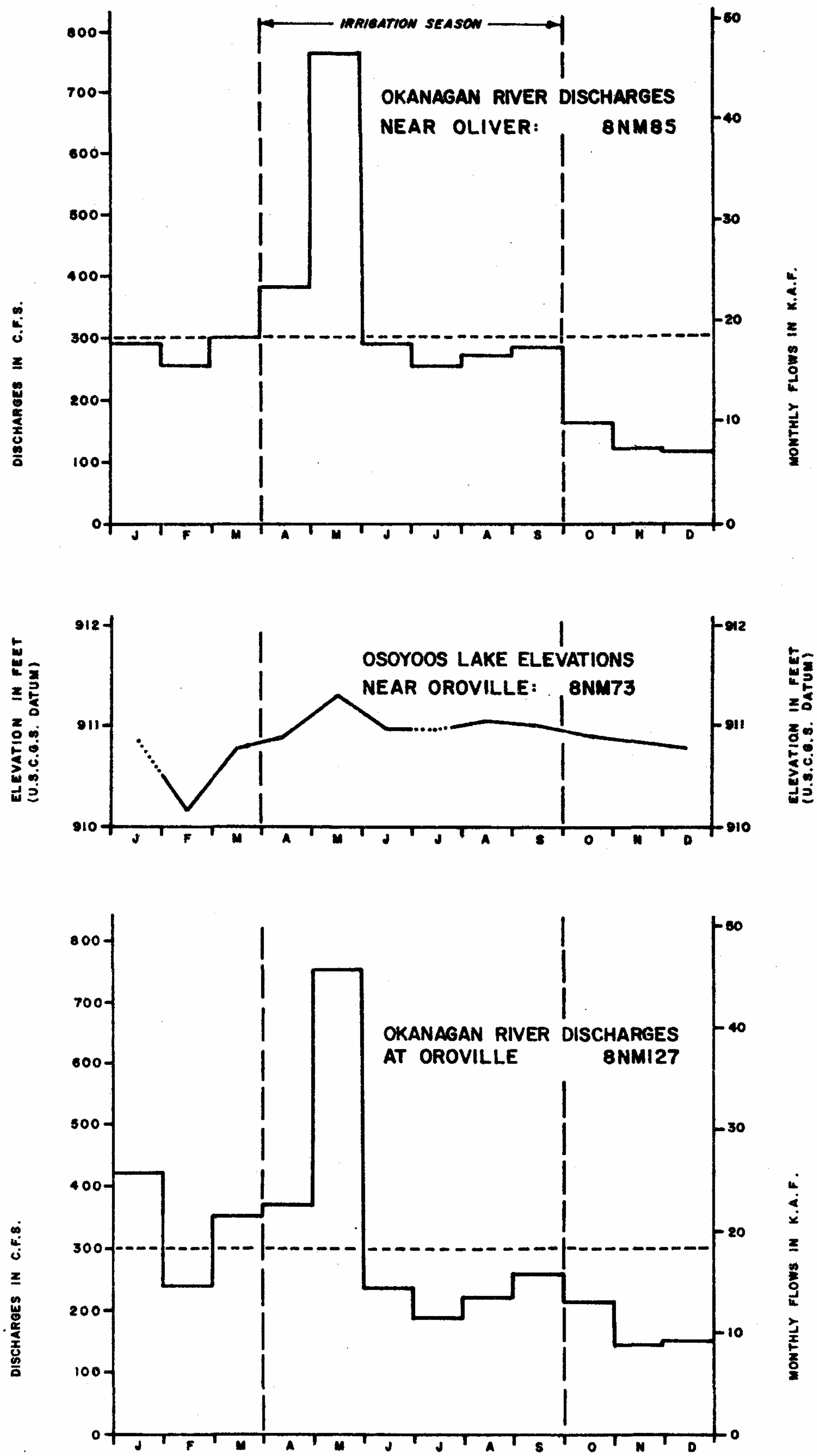
The question of the effect of the Zosel dam on the level of Osoyoos Lake was brought before the IJC (by the State of Washington, on behalf of the town of Oroville, and the County of Okanogan), in late 1942 as the result of many complaints about high water levels in Osoyoos Lake. During the course of the hearings held in 1943, it became apparent that Osoyoos Lake had increased in level by about two feet in the period 1934 to 1942, with the biggest change occurring in 1939. It seems almost certain that during this period, the bars at the mouth of the lake and at Tonasket Creek accumulated material resulting in the higher lake levels. The argument was made that the Zosel dam, by reducing the velocity of flow in the river, stopped the bars being washed away as had happened previously. Other factors may have helped make the bars more stable at this time; a temporary fish screen was placed across the mouth of the lake to stop salmon escapement and a flash flood in Tonasket Creek brought down large amounts of apple tree prunings amongst the granular material, making the bar much more cohesive.

The 1943 IJC hearings resulted in the appointment of a Board of Engineers to study the problems raised. The Board reported in 1945 with further public hearings being held in 1946. This resulted in the IJC issuing an "Order of Approval" in which they found that the Zosel dam "sometimes raises the level of Osoyoos Lake" and which ordered alterations to the spillway of the dam such that it would be capable of discharging 2,500 cfs with a headwater elevation of 911 feet. The Order says nothing about how the dam should be operated, although it is implied that it would be desirable to keep Osoyoos Lake below elevation 911 feet (USCGS).

Some alterations were made to the dam in the late 1940's as a result of the IJC Order, but even prior to this in about 1945, Osoyoos Lake levels dropped by about two to two and a half feet. This may have been due to dredging, but no record can be found of this. It appears that the dam is not capable of passing the 2,500 cfs at elevation 911 (USCGS) required by the IJC Order, although without knowing how many flashboards, (if any) are installed at any time, it is not possible to be sure. Some further modification to the fishways were undertaken in 1965-66, but these probably had little effect on the dam's control of the river.

Because of the difficulties of maintaining Osoyoos Lake at its desirable summer elevation of 911 in 1973, a study was undertaken of a similar drought year - namely 1970.

In Figure 14.6, the discharges at Oliver, Osoyoos Lake elevations and the discharges at Oroville are shown for 1970. With discharges of some 300 cfs at Oliver during the irrigation season, Osoyoos Lake remains at or near elevation 911. Assuming no other inflow, this can be equated with evaporation and consumptive use of 70 cfs plus the discharge at Zosel dam.



OKANAGAN RIVER DISCHARGES
AT OLIVER AND OROVILLE, AND
OSOYOOS LAKE ELEVATIONS FOR 1970 Figure 14.6

Under similar conditions in August 1973 with measured flow downstream of the dam of 230 cfs, the apparent discharge over the stop logs at Zosel dam was estimated at 60 to 70 cfs leaving a residual flow of some 160 cfs which can only be accounted for by leakage through the dam.

Any water conservation scheme which would reduce the minimum residual flow from 300 cfs to 100 cfs during the irrigation season may result in lower Osoyoos Lake elevations. With continuing leakage through Zosel dam, it is probable that as Osoyoos Lake drops below elevation 911 (USCGS) control may shift from Zosel dam to the Tonasket Creek fan upstream.

The problems of low water elevations on Osoyoos Lake have been evident in the last three years and will remain a problem unless a structure can be built at the lake outlet which can properly regulate water with little or no loss by seepage. Such a dam should be able to maintain Osoyoos Lake summer elevations at 911 feet with inflows from Oliver of 100 cfs (rather than the 300 cfs presently required). Stringent operation would be required to conserve water under conditions similar to the 1929-32 drought.

14.3.5 Discussion of Alternatives

Although Osoyoos Lake fluctuates outside its desirable range of 910.7 to 912.3 feet, the economic and social consequences of these extreme fluctuations are not large. Annual flood damage under 1972 levels of development is estimated at $25,000 although in extreme floods, such as occurred in 1972, over $100,000 damage can occur.

No structural alternatives on Similkameen River or around Osoyoos Lake can be economically justified. Thus, non-structural alternatives involving flood plain zoning to 921 feet, flood warning systems, education and emergency preparations, will be necessary to reduce the potential damage when floods occur. Furthermore, it is also apparent that management of Okanagan Lake and Okanagan River discharges to Osoyoos Lake will not significantly reduce flood levels caused by backflows in the Similkameen.

As noted in Section 14.3.4, reductions of minimum flows down Okanagan River from 300 cfs to 100 cfs would cause Osoyoos Lake to drop below 911 feet until the Tonasket Creek sandbar became the control. Replacement of Zosel dam by a structure that did not leak would maintain Osoyoos Lake levels close to 911 feet, but as the benefits of such a structure affect both Canadian and American interests, this sub-alternative should be referred to the International Joint Commission for further study.