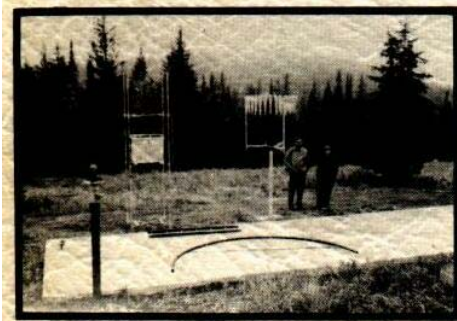
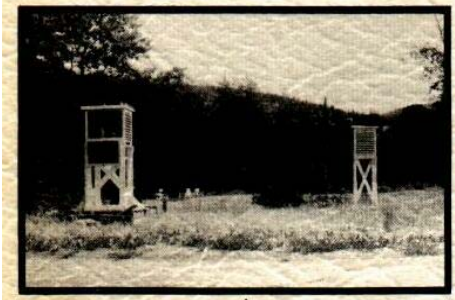


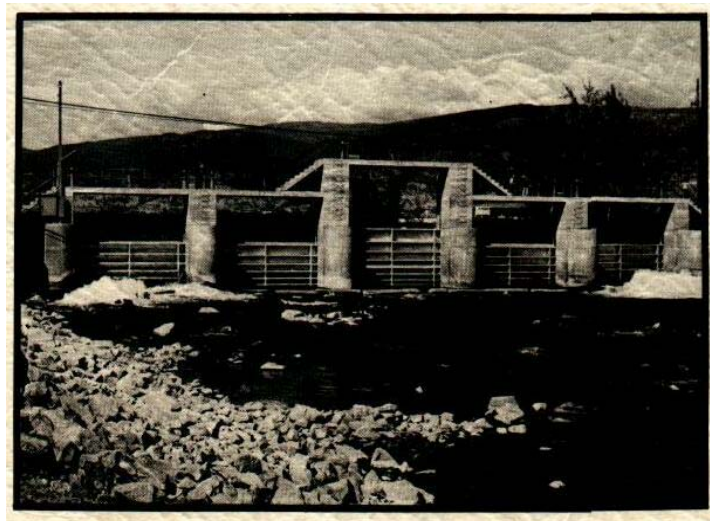
CANADA - BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT



WATER QUANTITY IN THE OKANAGAN BASIN

"To use water effectively
you have to control it."

MARCH 1974



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1. SUMMARY REPORT OF THE CONSULTATIVE BOARD
2. THE MAIN REPORT OF THE CONSULTATIVE BOARD
3. TECHNICAL SUPPLEMENTS TO THE MAIN REPORT
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 - II Water Quantity Computer Models
 - III Water Quantity Alternatives and Supporting Water Quantity Data
 - IV Water Quality and Waste Loadings in the Okanagan Basin
 - V The Limnology of the Major Okanagan Basin Lakes
 - VI Review and Evaluation of Wastewater Treatment in the Okanagan Basin
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CANADA - BRITISH COLUMBIA OKANAGAN BASIN AGREEMENT

TECHNICAL SUPPLEMENT I

TO THE
FINAL REPORT

WATER QUANTITY IN THE
OKANAGAN BASIN

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THE CONTRIBUTION OF THE FOLLOWING PEOPLE IN
THE PREPARATION OF THIS TECHNICAL SUPPLEMENT

COMPILATION

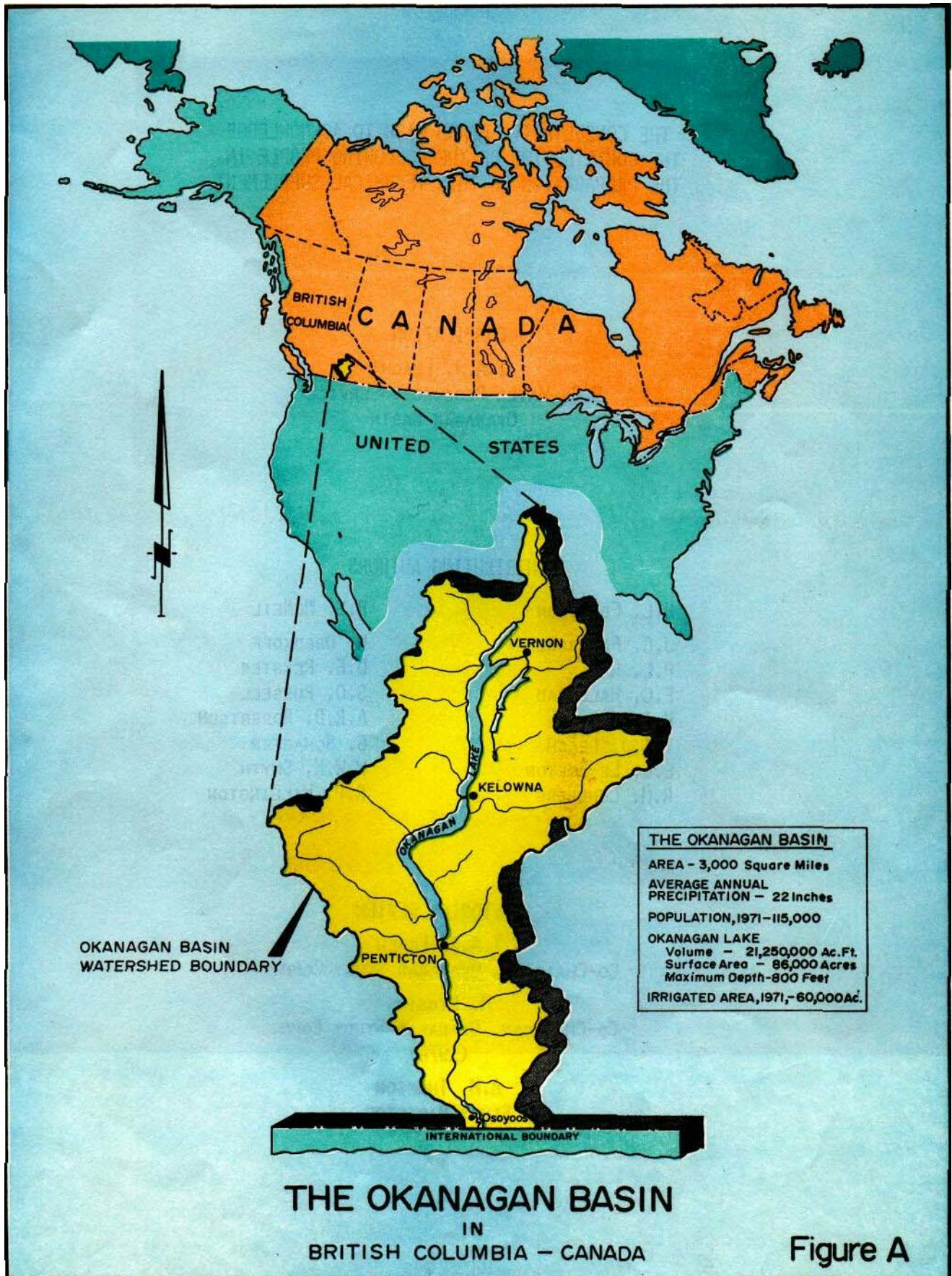
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FOREWORD

Technical Supplement I describes and presents the results of water quantity studies as carried out under the Okanagan Basin Agreement, including the synthesis of all historical water quantity resource data into a summarized form. The results of studies concerning water quantity computer models and water quantity alternatives are covered separately in Technical Supplements II and III respectively. Supporting water quantity data tables for all three supplements (I,II,and III) are included in Technical Supplement III. Other Study publications are listed on the Inside front cover of this report.

The material presented in this supplement supercedes that of all earlier preliminary reports or publications prepared under the Canada-British Columbia Okanagan Basin Agreement.

A. Murray Thomson
Study Director

SYNOPSIS

1. THE STUDY AREA

The Okanagan Basin including its major tributary the Similkameen River in its entirety drains an area of 6,000 square miles in south central British Columbia and 2,400 square miles in north central Washington upstream of its junction with the main Columbia River Valley near Brewster, Washington. The portion of the Basin referred to as "the study area" in this report includes the upper mainstem river and its tributaries above Zosel Dam located at the outlet to Osoyoos Lake at Oroville, Washington. Some additional reference is also made to the Similkameen River Basin which during high water can affect the discharge from Osoyoos Lake. It will be noted that the termination of the study area at Oroville rather than at the International Boundary (which cuts across Osoyoos Lake) was done in order that high and low water conditions on Osoyoos Lake could be evaluated.

About 68% of the land within the Canadian portion of the study area is forested while an additional 9% is classified as arable. The latter is located within the 1,000 foot elevation band of the valley bottom (up to elevation 2,000 feet). Only about one half of the arable land is cultivated and because of the semi-arid conditions a major portion of this is irrigated.

Major tributaries which discharge into Okanagan Lake and provide the main source of supply for the study area listed in order of decreasing annual discharge are: Mission, Vernon, Trout, Penticton, Equisis, Kelowna, Penticton and Powers Creeks.

These tributaries were the first to be developed for water supply primarily for agriculture and today about 70% of the total water consumed comes from this source. However, the major water requirements including non-consumptive in channel flow needs are met from the mainstem system extending from Okanagan Lake through to Osoyoos Lake.

The total population in the Basin in 1971 was some 115,000 people.

2. CLIMATE

The climate of the Okanagan Basin with its warm summers, fairly low humidity and mild winters provide an attractive environment for agriculture and recreation.

Annual precipitation in the valley bottom is 10 to 15 inches in the south increasing to 15 to 20 inches in the north while some mountainous areas to the northeast receive 35 to 40 inches mostly in the form of snow. Mean annual precipitation over the study area is estimated at 21.9 inches.

North and south winds are most common and these together with the south southeast and north northwest air flows occur during 70% of the hours when winds are recorded.

During the winter months when relative humidities linger in the high seventies or low eighties which are slightly below comparable coastal values; however, due to the lower air temperatures, the actual vapour content of the area is only about two-thirds of that measured at the coast. During summer months relative humidity drops to about 50%.

Outbreaks of very cold continental Arctic air occasionally reach the Okanagan Valley and minimum temperatures as low as -15°F to -25°F in the southern parts of the Valley and -30°F to -45°F in the north has been recorded.

In contrast, temperatures in excess of 100 degrees Fahrenheit have been recorded at most Okanagan Valley locations.

3. HYDROLOGY

The Okanagan Basin hydrology is typical of the interior rivers of British Columbia where the major portion of the annual runoff occurs during April to July inclusive, due primarily to snow melt in the higher portions of the Basin. Thus, in the Okanagan Lake Basin (where about 80% of the inflow to the study area occurs) snow accumulates during the winter months in the 4,000 to 7,000 foot elevation band. Commencing in January, snow surveys are conducted at selected stations from which forecasts of inflow to Okanagan Lake are estimated for the upcoming freshet period.

A portion of the inflow to Okanagan Lake Basin is retained in the 50 headwater reservoirs of the major tributaries which in total amounts to about 113,000 acre-feet of active storage. The remaining inflow in its passage downstream to Okanagan Lake is partially depleted by diversions from the tributaries primarily for irrigation purposes. The residual water entering Okanagan Lake, either as surface or groundwater flow, is further reduced through evaporation "losses from the lake surface of some 200,000 to 300,000 acre-feet per year equivalent to 28.5 to 35.5 inches respectively over the lake surface. In summary, out of a total estimated average annual gross inflow to Okanagan Lake Basin of 664,000 acre-feet only about one half of this appears as net inflow to the lake after deducting natural losses and consumptive use.

In years of average or near average inflow, no major problem occurs in regulating Okanagan Lake within its normal four foot range which is equivalent to some 340,000 acre-feet and about equal to the average annual net inflow to the lake.

However, problems do arise in flood years when up to double the average inflow may occur because of the relatively limited discharge capacity of the Okanagan River downstream of Okanagan Lake Dam at Penticton which capacity may be further reduced by local inflow. Discharges may also be severely restricted at the outlet to Osoyoos Lake near Oroville, Washington due to high water from the Similkameen River.

A flood year for this study has been defined as one in which the total inflow is equal to or greater than 550,000 acre-feet. Its average re-occurrence interval is estimated to be about 1 year in 14.

In contrast to this are the drought years when the net inflow to Okanagan Lake may be less than 100,000 acre-feet.

The determination of a drought year has been based on water requirements along the mainstem which amount to some 244,000 acre-feet per year. Thus, net inflows to Okanagan Lake of less than 244,000 acre-feet have been classified as drought years and have an average re-occurrence interval of 1 year in 4.

4. MAINSTEM SYSTEM

The Okanagan Lake reservoir provides the major portion of the water for the mainstem and is controlled by a concrete dam at Penticton. The Okanagan Lake Dam along with other structures and improved river channels between Penticton and Osoyoos Lake make up the Okanagan Flood Control Works. Ancillary Works include the debris retaining basins at the mouths of Shattford (Shingle), Ellis and Shuttleworth Creeks. The operation of these works is under the direction of the British Columbia Water Resources Service, Department of Lands, Forests and Water Resources while maintenance costs are shared by this Department and the Federal Department of Public Works.

These works were constructed during 1950-58 by the Federal and Provincial Governments under the Okanagan Flood Control Act. While one of the main objectives of the project was to prevent flooding such as occurred in 1942 and 1948 it also provides storage regulation for salmon fisheries, water based recreation and aesthetics.

Discharges from Okanagan Lake Dam are limited by the channel capacity of the Okanagan River which varies from 2,100 cfs at Penticton to 3,400 cfs

at the inlet to Osoyoos Lake. Only minor regulation (9,400 acre-feet) can be obtained in Skaha Lake (surface area 4,710 acres) which is maintained between elevation 1107.6 and 1109.6 by a concrete dam at Okanagan Falls.

In addition to the Okanagan Flood Control Works, a small concrete dam at the outlet of Vaseux Lake (surface area 690 acres), operated by the Southern Okanagan Land Improvement District (SOLID), maintains a water elevation on the lake of 975 feet and diverts a portion of the flow, up to 150 cfs through a canal to serve irrigation requirements in and around Oliver.

The maximum discharge at Oliver below Vaseux Lake Dam is currently held below 3,000 cfs because of channel capacity limitations, local inflow from tributaries which is not controllable, and high water levels in Osoyoos Lake when flows in the Similkameen are high.

The level of Osoyoos Lake is normally maintained between 910.0 and 912.0 feet GSC (910.3 and 912.3 USCGS) although the upper level may be exceeded in any flood year due to lack of control of flood waters on the Similkameen River. Normally, the lower level is maintained by the Zosel Dam near Oroville, Washington. However, at times the low level control may change to points upstream where bars have been formed by tributaries such as Tonasket Creek.

The Zosel Dam was originally constructed In 1927 by the Zosel Lumber Company to create a mill pond for log storage. During flood periods the structure is almost completely submerged while during low water periods there is considerable leakage through it which have to be compensated for by additional releases from Okanagan Lake in order to maintain Osoyoos Lake at its normal summer elevation of 911 feet (USCGS).

5. PRESENT DAY WATER REQUIREMENTS

Present day water requirements within the Okanagan Basin include consumptive use within, the tributaries and along the mainstem system as well as non-consumptive inflow channel requirements for the latter. This in total amounts to 312,000 acre-feet which can be met in a normal inflow year. It will be noted that about two-thirds of these water requirements are needed to maintain adequate lake levels and maintain in channel flows for fisheries, recreation, adequate intake, submergence and aesthetic purposes.

6. DROUGHTS AND FLOODS

Droughts have been defined as those years when the net inflow into Okanagan Lake is less than the water requirements along the mainstem system namely 244,000 acre-feet. A drought year does not necessarily mean a shortage of water providing there is sufficient to carry over storage in Okanagan Lake

to make up the deficit or failing this Okanagan Lake is drawn down below its normal low water elevation. However, it is estimated that a re-occurrence of the 1929 to 1932 drought would result in Okanagan Lake being drawn down some 3.2 feet below its normal low water elevation assuming all water requirements are met at all times. Under these conditions, the lake would drop below its normal low water elevation in the middle of the second year of the drought and not refill to a level of 3 feet about normal low water until 3 years later. Such a prolonged drought has only occurred once in this century and was prevalent over much of North America.

At the other end of the spectrum are those years in which excessive inflows or flood occur. In general, a forecast seasonal inflow greater than 550,000 acre-feet is considered to indicate a potential flood and Okanagan Lake would have to be drawn down to its normal low water elevation or even lower prior to the freshet.

In the flood of 1972, Okanagan Lake exceeded its normal high water elevation by 0.9 feet in controlling the maximum April to July inflow to occur in this century. The estimate flood damage around Okanagan Lake amounted to \$56,500, exclusive of flood damage at the mouths of Mission, Kelowna and Trout Creeks and other tributaries.

During this period Osoyoos Lake which has about 7% of the area of Okanagan Lake and whole outflow was severely restricted by flood flows in the Similkameen, rose almost 5 feet to reach a maximum elevation of 917.1 GSC. It is estimated that some \$212,000 worth of damage occurred within the Canadian portion of Osoyoos Lake through property damage or lost revenue to the tourist industry.

7. WATER SUPPLY IN EIGHT SELECTED TRIBUTARIES

Hydrometric data in selected tributaries which are being heavily utilized is much more limited than the 50 years continuous records available for the mainstem system. Within these limitation, it appears that with the exception of Vernon and Kelowna Creeks there are no consumptive use deficiencies under the present methods of operation.

With the exception of Penticton Creek (which is not considered a fishery stream) a modified regulation of upstream reservoirs have been carried out with the objective of meeting both consumptive use requirements throughout the sub-basins and minimum fishery flows at the mouths. While this should not be regarded as a recommended method of multi purpose operation, it does show that for a single year starting with a full reservoir, present methods of regulation can be modified to improve fishery flows significantly. However, such improvements result in practically complete depletion of headwater reservoir

storage where up to 50% carry over storage is normally held in anticipation of the occurrence of a drought year. Further details of the operation of the selected tributary streams can be found in Technical Supplement III.

8. FOREST HYDROLOGY

It is estimated there exists approximately 1.2 million acres of merchantable forest land in the Okanagan Basin in Canada. Only about 300,000 acres are in the zone north of Penticton above 4,000 feet which is the area from which the major portion of the runoff occurs.

In 1971 some 10,000 acres of merchantable timber were harvested in the Basin while an additional 1,000 acres was lost to wild fires. This represents 1/120 year rotation for the Basin.

Water yield increases accruing from forest harvesting within the 300,000 acres north of Penticton have been estimated at between 3.31% and 4.20%. These increases would only be realized within the area harvested and would likely be consumed in water deficits sites at lower elevations. This includes correction for sequential regrowth effects on increasing evapotranspiration. Additional increases for those areas lost to wild fires are estimated between 1.24% and 1.55% annually.

By adjusting the computed percentage water increases in the areas where forest harvesting and fires are taking place to the whole Basin water yield increases are only 0.50% to 0.64% for the former and 0.19% to 0.23% for the latter. These computed annual increases are not cumulative due to the effect of regrowth on evapotranspiration consumption.

In summary, it can be stated that:

- a) Any increases are too small to be measured. Thus, yield increases would go undetected with the possible exception of very small tributaries where intensive forest harvesting is taking place.
- b) Any increases occurring under (1) in the merchantable forest area above elevation 4,000 feet would be lost in the water deficit areas at the lower elevations.

9. GROUNDWATER

Evidence from seismic surveys, exploratory drilling and pump tests indicate that there is not nearly sufficient groundwater in the North Okanagan to meet water deficits within the Basin during drought years.

Well yields for aquifers in the study area are commonly expected to be less than 200 imperial gallons per minute (igpm) for pump settings of 200

feet. Locally, higher yields of up to 500 igpm or possibly 1,000 igpm may be obtained. Aquifers with well yields in the 200 to 500 igpm, are considered to occur in the O'Keefe Valley; and in the main valley in the locality just south of Armstrong and in parts of the fan deposits along the east valley wall, Well yields of up to 1,000 igpm may possibly be obtained near Enderby and also in the O'Keefe Valley, but more adequate testing is essential to verify these high yields.

The potential for groundwater development without depleting the resources is estimated to be from 3 1/3 to 6 c.f.s. It is unlikely that the total groundwater withdrawal is close to the lower value, so that there is limited scope for increasing the use of groundwater in this area.

Analysis of groundwater sampled in the study area show the chemical quality of the water is very good. The total dissolved solids content is in the range of 200 to 500 ppm and the water is primarily calcium and magnesium carbonate. The water is quite suitable for human consumption and for irrigation use and should require very little treatment for industrial purposes.

In addition to the intensive groundwater investigation in the North Okanagan which included depths of up to 2,000 feet, one test hole was drilled and seismic work was carried out near Okanagan Falls in the south end of the Valley.

Sub-basin Groundwater Reconnaissance studies were also carried out for Vaseux, Vernon, Penticton, Pearson, Lambly and Greata Creeks. In general, the groundwater contribution to the runoff is not considered significant when compared to the surface flow.

10. WATER QUANTITY MONITORING

The lack of adequate basic data in water quantity, climatology and particularly water quality at the start of this study has required that heavy reliance be placed on new station information collected during the past three or four years in the case of hydrology or about two years in the case of water quality. Fortunately, the last three years have provided a wide range of hydrological events varying from drought conditions in 1970 to a record flood year in 1972.

Future monitoring as outlined in this report are based on the following objectives:

- a) To provide current data on water storages, diversions, discharges, precipitations, temperature, water quality and waste water treatment for day to day decision in water management.
- b) To provide a check on water quantity models developed during the Okanagan Study as well as nutrient loadings and limnological changes that have been forecast for the next 10 to 15 years assuming tertiary or equivalent treatments is undertaken and recommendations.

- c) To provide a basic data bank on hydrology, meteorology, limnology and water quality of sufficient length and detail for comprehensive statistical analysis.

11. TECHNOLOGICAL ADVANCES

The combined efforts of the hydrologist and meteorologist are required in hydrological studies with emphasis on the following:

- a) Seasonal Volume Forecasts:
Through the development of water budgeting models, it is evident there is a need for Improved weather forecasts together with better knowledge of soil moisture conditions.
- b) Vegetation Management:
With better water quantity and quality modelling, it will be possible to assess the affect of alternative methods of forest harvesting and other types of vegetative management.
- c) Weather Modifications:
At present, weather modification to increase precipitation is a technique having some potential but being primarily in the experimental stage.

12. CONCLUSIONS

The water quantity studies carried out in this Technical Supplement and Technical Supplement III - Water Quantity Alternatives and Supporting Water Quantity Data, were carried out to meet the following objectives:

- a) To evaluate the existing hydrologic regime of the Basin.
- b) To evaluate means of regulating flows through storage and diversion.
- c) To evaluate means augmenting and the surface water supply within the Okanagan Basin.

13. SUMMARY OF BASIC DATA

Okanagan-Similkameen Basin

Drainage area, Total	8,400 sq.mi.
Drainage area, in BC	6,000 sq.mi.
Drainage area, in Washington	2,400 sq.mi.

Okanagan Basin

Drainage area, Total	3,250 sq.mi.
Drainage area, in B.C.	3,165 sq.mi.
Drainage area, in Washington	85 sq.mi.

Irrigated Land (in B.C.)	60,070 ac.
Potentially Irrigable Land (in B.C.)	177,320 ac.

Morphology

Maximum Elevation (Baldy Mtn)	7,558 ft.
Median Elevation (Okanagan Lk. Basin)	3,860 ft.

Minimum Elevation (Osoyoos Lk.) 910 ft.

<u>Climate</u>	<u>Temperature in °F</u>	<u>Precipitation in Inches</u>
Mean Annual		
Armstrong	45	17.6
Kelowna	47	12.0
Penticton	48	11.7
Oliver	48	11.8

Hydrology

Okanagan River

- (i) Annual Discharge in cfs at Penticton
Mean, 52 years of continuous record.

1921-1972 Climatic (April-March) Year inclusive 499

Maximum, 1948 Climatic (April-March) Year 1,042

Maximum, 1972 Calendar (January-December) Year 1,070

Minimum, 1930 Climatic (April-March) Year 89

- (ii) Annual Discharge in cfs near Oliver

Mean, 20 years of intermittent record,

1945-1972 Climatic (April-March) Year inclusive 605

Maximum, 1972 Climatic (April-March) Year 1,029

Maximum, 1972 Calendar (January-December) Year 1,240

Minimum, 1970 Climatic (April-March) Year 249

Okanagan lake

Surface Area 84,200 ac.

Maximum Depth 800 ft.

Mean Depth 250 ft.

Volume, Total 21,000,000 ac.ft.

Operation Range, Normal: 4 ft., between Elevation 1119.8 - 1123.8 ft.

Operation Range, Extreme: 5 ft., between Elevation 1118.8 - 1123.8 ft.

Usable Storage (Volume):

at Normal Operation Range 336,800 ac.ft.

at Extreme Operational Range 421,000 ac.ft.

Skaha Lake

Surface Area 4,710 ac.

Maximum Depth 187 ft.

Skaha Lake con't

Mean Depth	85 ft.
Volume, Total	453,0000 ac.ft.
Operational Range: 2 ft., between Elevation	1107.6 - 1109.6 ft.
Usable Storage at Operational Range	9,420 ac.ft.

Osoyoos Lake

Surface Area, Total	5,660 ac.
Surface Area, in B.C.	3,660 ac.
Surface Area, in Washington	2,000 ac.
Maximum Depth	206 ft.
Mean Depth	49 ft.
Volume, Total	323,000 ac.ft.
Normal Range of Lake Level: 1.6 ft., between Elevation	910 - 912.0 ft.

Kalamalka Lake

Surface Area	6,340 ac.
Maximum Depth	465 ft.
Mean Depth	193 ft.
Volume, Total	1,233,000 ac.ft.
Operational Range: 1.4 ft., between Elevation	1282.6 - 1284.0 ft.
Usable Storage at Operational Range	8,876 ac.ft.

Woods Lake

Surface Area	2,260 ac.
Maximum Depth	112 ft.
Mean Depth	72 ft.
Volume, Total	162,200 ac.ft.
Operation Range: 1.4 ft., between Elevation	1282.6 - 1284.0 ft.
Usable Storage at Operational Range	3,164 ac.ft.

TABLE OF CONTENTS

	PAGE
FOREWORD	
SYNOPSIS	
TABLE OF CONTENTS	
LIST OF TABLES	
LIST OF FIGURES	
PART I SURFACE WATER	1
CHAPTER 1 INTRODUCTION	3
1.1 Purpose	3
1.2 Scope	3
1.3 Types of Data	4
1.4 Relationship to Other Parts of Report	4
1.5 Description of Basin	5
1.5.1 Physiography	9
1.5.2 Drainage	11
1.5.3 Soils	20
1.5.4 Vegetation	24
CHAPTER 2 METEOROLOGICAL RECORDS	27
2.1 Climate	27
2.1.1 Weather Records	27
2.1.2 Precipitation	35
2.1.3 Snow Courses	39
2.1.4 Temperature	42
2.1.5 Wind	45
2.1.6 Humidity, Cloud, and Sunshine	50
2.1.7 Evaporation and Evapotranspiration	51
2.1.8 Storms	52
CHAPTER 3 HYDROLOGIC REGIME	59
3.1 Quantity	59
3.2 Hydrology	59
3.2.1 Mainstem System	59
3.3 Okanagan Lake Basin Water Budget	77
3.4 Hydrometric, Water Use and Climatic Data	83
3.5 Present (1970) Water Requirements	84
3.6 Water Supply and Flood Control	87
3.6.1 Okanagan Mainstem Operation	87
3.6.2 Droughts and Floods, Okanagan Lake	87
3.6.3 Droughts and Floods, Osoyoos Lake	99
3.6.4 Flood Control, Osoyoos Lake	106

CHAPTER 4	FOREST HYDROLOGY	111
4.1	Introduction	111
4.2	Pearson Creek and Tree Farm Licence No. 9	111
4.3	Conclusions	114
4.3.1	South of Penticton	114
4.3.2	North of Penticton below 4,000' elevation	115
4.3.3	North of Penticton above 4,000' elevation	115
PART II	SELECTED TRIBUTARY STUDIES	119
CHAPTER 5	SELECTED TRIBUTARIES	121
5.1	Introduction	121
5.2	Objectives of Tributary Study	122
5.3	Distribution of Flows in Okanagan Lake Basin	123
5.4	Selection of Tributaries	123
5.5	General Approach to Problem	126
5.5.1	Basic Data and Assumptions	127
5.6	Computer Models	127
5.7	Land Use and Consumptive Water Requirements (General)	128
5.7.1	Irrigation	129
5.7.2	Domestic	129
5.7.3	Industry	129
5.8	Non-Consumptive Water Requirements (Fisheries)	129
5.9	Regulation of Storage	129
5.10	Historic (simulated) Operation	130
5.11	Modified Operation	131
5.12	Explanation of Figures	131
5.13	Water Management	132
CHAPTER 6	TROUT CREEK	133
6.1	General Description	133
6.2	Historical Background	134
6.3	Land Use and Water Requirements	137
6.4	Estimated Natural Water Supply	141
6.5	Storage	145
6.5.1	Residual Flows	148
CHAPTER 7	PEACHLAND CREEK	157
7.1	General Description	157
7.2	Historical Background	161
7.2.1	Brenda Mines Limited	162
7.3	Land Use and Water Requirements	162
7.4	Estimated Natural Water Supply	167
7.4.1	Water Management	168
7.5	Storage	168
CHAPTER 8	POWERS CREEK	175
8.1	General Description	175
8.2	Historical Background	176

CHAPTER 8	POWERS CREEK (cont'd)	
8.3	Land Use and Water Requirements	181
8.4	Estimated Natural Water Supply	182
8.5	Storage	186
8.5.1	Residual Flow	191
CHAPTER 9	EQUESIS CREEK	
9.1	General Description	197
9.2	Historical Background	198
9.3	Land Use and Water Requirements	198
9.4	Estimated Natural Water Supply	203
9.4.1	Storage	205
9.4.2	Pinaus Lake	205
9.4.3	Residual Flows	207
CHAPTER 10	VERNON CREEK	213
10.1	General Description	213
10.2	Historical Background	214
10.3	Land Use and Water Requirements	220
10.4	Estimated Natural Water Supply	221
10.5	Storage	226
10.5.1	Regulated Flows	231
10.5.2	BX Creek	232
10.6	Mainstem Vernon Creek	232
CHAPTER 11	KELOWNA CREEK	
11.1	General Description	239
11.2	Historical Background	239
11.3	Land Use and Water Requirements	240
11.4	Estimated Natural Water Supply	243
11.5	Storage	246
11.5.1	Residual Flows	246
CHAPTER 12	MISSION CREEK	259
12.1	General Description	259
12.2	Historical Background	260
12.3	Land Use and Water Requirements	265
12.4	Natural Water Supply	269
12.5	Storage	275
12.6	Residual Flows	279
CHAPTER 13	PENTICTON CREEK	285
13.1	General Description	285
13.2	Historical Background	286
13.3	Land Use and Water Requirements	289
13.4	Estimated Natural Water Supply	292
13.5	Storage	292
13.5.1	Greyback Reservoir	295
13.6	Residual Flows	297

CHAPTER 14	SUMMARY OF SELECTED TRIBUTARY STUDIES	303
14.1	Summary	303
14.2	Detailed Conclusions	305
14.2.1	Trout Creek	305
14.2.2	Peachland Creek	306
14.2.3	Powers Creek	306
14.2.4	Equesis Creek	306
14.2.5	Vernon Creek	306
14.2.6	Kelowna Creek	307
14.2.7	Mission Creek	307
14.2.8	Penticton Creek	307
PART III	GROUNDWATER STUDIES	313
CHAPTER 15	HYDROGEOLOGICAL STUDY OF THE NORTH END OF THE OKANAGAN RIVER BASIN	315
15.1	Introduction	315
15.1.1	Methods of Investigation	315
15.1.2	Previous Investigation	315
15.2	Geography	316
15.2.1	Location and Extent of the Area	316
15.2.2	Topography and Drainage	316
15.2.3	Climate	316
15.3	Geology	317
15.3.1	Bedrock Geology	317
15.3.2	Structure	317
15.3.3	Surficial Deposits	317
15.4	Seismic Exploration (Task 39)	318
15.4.1	Objective	318
15.4.2	The Seismic Program	318
15.4.3	An Analysis of the Seismic Program	319
15.5	Rotary Test Hole Drilling Programs (Task 40)	324
15.5.1	Objective	324
15.5.2	Achievements	324
15.6	Hydrogeology	325
15.6.1	General Statement	325
15.6.2	Basic Water-Well Data	325
15.6.3	Aquifers in the Surficial Deposits	325
15.6.4	Groundwater Movement, Recharge and Discharge Areas	328
15.6.5	Transmissivity Values	332
15.6.6	Water-Well Yields (Task 41)	336
15.6.7	Groundwater Flow Calculations	338
15.6.8	Theoretical Calculation of Recharge	340
15.6.9	Hydrogeochemistry	342
15.7	Evaluation of Results	343
15.8	Potential Groundwater Development	344
15.8.1	Lower Part of the Surficial Deposits	344
15.8.2	Upper Part of the Surficial Deposits	346
15.8.3	O'Keefe Valley Aquifer	347
15.8.4	Parkinson Bedrock Channel Aquifer	347
15.8.5	Groundwater Mining	348
15.9	Economics of Groundwater Development	349
15.9.1	Costs of Groundwater for High-Yield Wells	349
15.9.2	Cost of Groundwater for Low-Yield Wells	352
15.10	Conclusions	352

CHAPTER 16	SUB-BASIN GROUNDWATER RECONNAISSANCE STUDIES	
16.1	Hydrogeology of Vaseux Creek Sub-Basin	355
16.1.1	Geology	355
16.1.2	Hydrology	355
16.1.3	Conclusions	358
16.2	Hydrogeology of Vernon Creek Sub-Basin	360
16.2.1	Geology	360
16.2.2	Hydrology	360
16.2.3	Conclusions	363
16.3	Hydrogeology of Penticton Creek Sub-Basin	366
16.3.1	General	366
16.3.2	Morphology	366
16.3.3	Hydrology	368
16.3.4	Conclusions	383
16.4	Hydrogeology of Pearson Creek Sub-Basin	385
16.4.1	Introduction	385
16.4.2	Geology	386
16.5	Hydrogeology of Lambly Creek Sub-Basin	389
16.5.1	Introduction	389
16.5.2	Geography	389
16.5.3	Geology	392
16.5.4	Hydrogeology	392
16.6	Hydrogeology of Greata Creek Sub-Basin	396
16.6.1	Introduction	396
16.6.2	Geography	396
16.6.3	Geology	396
16.6.4	Hydrogeology	396
16.6.5	Conclusions	399
PART IV	MONITORING, TECHNOLOGICAL ADVANCES AND CONCLUSIONS	400 (a)
CHAPTER 17	WATER QUANTITY MONITORING	401
17.1	Introduction	401
17.2	Objectives of Monitoring	401
17.3	Monitoring Accuracy	402
17.4	Water Quantity Monitoring	404
17.4.1	Water Quantity Analysis to be Carried out in 1980	409
17.4.2	Climatic Analysis to be Carried out in 1980	409
17.5	Water Quality Records Available from Study	410
17.5.1	Selection of Water Quality Monitoring Stations	410
17.6	Conclusions	414
17.7	Recommendations	415
CHAPTER 18	TECHNOLOGICAL ADVANCES	431
18.1	Introduction	431
18.2	Seasonal Volumetric Forecasts	431
18.3	Vegetation Management	433
18.4	Weather Modifications	433
CHAPTER 19	CONCLUSIONS	435
19.1	Objectives	435
19.2	Existing Hydrologic Regime	435
19.3	Means of Regulating through Storage and Diversion	436

CHAPTER 19 CONCLUSIONS (cont'd)	
19.4 Means of Augmenting and Conserving Surface Water Supplies	438
19.4.1 Ground Water	438
19.4.2 Vegetation Management	438
19.4.3 Improved Inflow Forecasts to Okanagan Lake	438
ACKNOWLEDGEMENTS	441
REFERENCES	443
APPENDICES	455
APPENDIX A LAKE EVAPORATION	457
APPENDIX B SNOW SURVEYS	469
APPENDIX C ESTIMATED NATURAL HISTORIC INFLOWS	485
APPENDIX D STATISTICAL ANALYSIS, MAIN VALLEY OKANAGAN RIVERS	499
APPENDIX E EVALUATION OF WATERSHED DEFORESTATION AND HARVESTING PRACTICES IN THE OKANAGAN BASIN	529
APPENDIX F OKANAGAN VALLEY SEISMIC SURVEY	605

LIST OF TABLES

TABLE NUMBER	TITLE	PAGE
1.1	Land Use in the Okanagan Basin 1970	23
2.1	Representative Climatic Data, Okanagan Valley	28
2.2a	Climatological Stations - Okanagan Basin and Adjoining Area Active During All or Period 1921 - 1973	30
2.3	Active Snow Courses - Okanagan Basin and Surrounding Area	35
2.4	Mean Precipitation Statistics (1941 - 70 Normals)	36
2.5	Mean Temperature for Selected Stations in Okanagan Basin (1941 - 70 Normals)	46
2.6	Wind Direction and Velocities at Penticton Airport, Penticton (A), British Columbia	49
2.7	Mean Humidity, Cloud and Sunshine at Okanagan Valley Stations	49
3.1	Elevations and Design Discharges, Okanagan Flood Control Works and Other Control Structures	60
3.2	Average Annual Water Budget - Okanagan Lake Basin	64
3.3a	Net Historic Inflows To Okanagan Lake During Freshet Period April To July Inclusive	82
3.3b	Net Historic Inflows to Okanagan Lake During April To June Inclusive	83
3.4	Diversion (Withdrawal), Consumptive Use & Return Flow For Okanagan River Basin in B.C. - 1970	85
3.5	Diversion (Withdrawal), Consumptive Use & Return Flow For Okanagan River Basin in B.C. - 1970	85
3.6	Summary of Fishery and Minimum Flow Requirements For The Okanagan River in British Columbia	86
3.7	Present (1970) Consumptive Use Requirements in Okanagan Lake Basin and Total Water Requirements Okanagan River Basin in Canada	86
3.8	Comparison of Annual Gross Historic Inflows to Various Segments of Okanagan River Basin Upstream of Oroville, Wash. with Annual Gross Historic Inflow to Okanagan Lake Basin For Selected Years.	91
3.9	Comparison of Computer Simulation of Floods of 1928 and with 1972 Flood Present Method Operation and Existing Storage Facilities	99
3.10	Desirable Elevations for Osoyoos Lake	101
3.11	Okanagan and Osoyoos Lake Elevations During Period When Similkameen River at Nighthawk Exceeded 14,000 CFS - For 1948 and 1972 Floods	108
4.1	Water Yield Increases From Forest Harvesting on Forest Land Of Tree Farm Licence No. 9 and Pearson Creek for Different Rotation Lengths	115

TABLE NUMBER	TITLE	PAGE
5.1	Tributaties Selected for Detailed Modelling Within Okanagan Lake Basin	123
5.2	Estimated Minimum Water Requirements for Fisheries Acre-Feet Per Month	130
6.1	Water Users in the Trout Creek Watershed (1970)	139
6.2	Water Utilization in Trout Creek (1970)	139
6.3	Diversion Requirements on Trout Creek (1970)	139
6.4	Water Licences on Trout Creek (1970)	140
6.5	Natural Water Yields For Trout Creek Sub-Basin	141
6.6	1970 Storages in the Trout Creek System	147
6.7	Rule Curve Values For Trout Creek Reservoirs	147
6.8	Comparison Between inflows to Trout Creek and Okanagan Lake	155
7.1	Water Users in the Peachland Creek Watershed (1970)	164
7.2	Water Utilization in Peachland Creek (1970)	164
7.3	Diversion Requirements on Peachland Creek (1970)	165
7.4	Water Licences on Peachland Creek (1970)	167
7.5	Estimated Natural Water Yields for Peachland Sub-Basin	167
7.6	1970 Storage in the Peachland Creek System	169
7.7	Rule Curve Values for Peachland Creek Reservoir	169
7.8	Comparison Between Inflows to Peachland Creek and Okanagan Lake	171
8.1	Water Users in the Powers Creek Watershed (1970)	181
8.2	Water Utilization in Powers Creek (1970)	182
8.3	Diversion Requirements on Powers Creek (1970)	183
8.4	Water Licences on Powers Creek (1970)	182
8.5	Estimated Natural Water Yields for Powers Creek Sub-Basin	186
8.6	1970 Storages in the Powers Creek System	188
8.7	Rule Curve Values for Powers Creek Reservoirs	191
8.8	Comparison Between Estimated Inflows	195
9.1	Water Users in the Equesis Creek Watershed (1970)	201
9.2	Water Utilization in Equesis Creek (1970)	202
9.3	Diversion Requirements on Equesis Creek (1970)	202

TABLE NUMBER	TITLE	PAGE
9.4	Water Licences on Equesis Creek (1970)	203
9.5	Estimated Natural Water Yields for Equesis Creek Sub-Basin	203
9.6	1970 Storage in the Equesis Creek System	205
9.7	Rule Curve Values for Equesis Creek Reservoir	207
9.8	Comparison between Inflow to Equesis Creek and Okanagan Lake	211
10.1	Water Users in the Vernon Creek Watershed (1970)	220
10.2	Water Utilization in Vernon Creek (1970)	221
10.3	Computed Diversion Requirements on Vernon Creek (1970)	222
10.4	Water Licensed on Vernon Creek (1970)	226
10.5	Estimated Natural Water Yields for Vernon Creek Sub-Basin	226
10.6	1970 Storage in the Vernon Creek System	228
10.7	Rule Curve Values for Vernon Creek Reservoirs	231
10.8	Comparison Between Estimated Inflows to Vernon Creek and Okanagan Lake	238
11.1	Irrigation Diversions from Kelowna Creek Watershed (1970)	243
11.2	Water Utilization in Kelowna Creek (1970)	244
11.3	Diversion Requirements on Kelowna Creek (1970)	245
11.4	Water Licences on Kelowna Creek (1970)	246
11.5	Estimated Natural Water Yields for Kelowna Sub-basin	246
11.6	1970 Storages in the Kelowna Creek System	249
11.7	Rule Curve Values for Kelowna Reservoirs	251
11.8	Comparison Between Estimated Inflows to Kelowna Creek and Okanagan Lake	255
12.1	Water Users in the Mission Creek Watershed (1970)	268
12.2	Water Utilization in Mission Creek (1970)	269
12.3	Diversion Requirements on Mission Creek (1970)	270
12.4	Water Licenses on Mission Creek (1970)	274
12.5	Estimated Natural Water Yields for Mission Creek Sub-Basin	274
12.6	1970 Storages in the Mission Creek System	278
12.7	Rule Curve Values for Mission Creek Reservoirs	278
12.8	Comparison Between Estimated Inflows to Mission Creek and Okanagan Lake	284

TABLE NUMBER	TITLE	PAGE
13.1	Water Users in the Penticton Creek Watershed (1970)	290
13.2	Water Utilization in Penticton Creek (1970)	290
13.3	Diversion Requirements on Mission Creek (1970)	291
13.4	Water Licenses on Penticton Creek (1970)	292
13.5	Estimated Natural Water Yields for Penticton Creek Sub-Basin	292
13.6	1970 Storages in the Penticton Creek System	295
13.7	Rule Curve Values for Penticton Cr. Reservoirs	297
13.8	Comparison Between Estimated Inflows to Penticton Creek And Okanagan Lake	301
14.1	Contribution to Okanagan Lake Inflow of Eight Major Tri- butaries Under Present (1970) Development for Dry, Average and Wet Year	304
14.2	Reservoirs in Which Dry Year Natural Inflow Exceeds Storage Capacity By 20% or More Quantities given in Acre- Feet	304
15.1	Composite Test Hole Logs - Contracts 42 & 43	326
15.2	Table of Pumping Information	331
15.3	Basic Criteria To Determine Availability of Groundwater	348
16.1	Analyses of Water Samples	359
16.2	Area - Evaluation Data - Penticton Creek	366
16.3	Mean Annual Precipitation	369
16.4	Y ₂ October - March Precipitation (Penticton Creek)	369
16.5	Water Samples from Penticton Creek	384
16.6	Estimated Precipitation of Pearson Creek Sub-Basin	385
17.1	Framework Plan for Water Quantity, Quality and Waste Treatment Monitoring	403
17.2	Mean Annual Runoff of Tributary Streams	418

LIST OF FIGURES

FIGURE NUMBER	TITLE	PAGE
1.1	Okanagan Basin Physiographic Map Canada - U.S.A.	6
1.2	Okanagan - Similkameen Stream Profiles	7
1.3	Okanagan Drainage Basin in Canada	8
1.4	Okanagan Basin Physiographic Map Canada	10
1.5	Okanagan - Similkameen Basin	12
1.6	Okanagan Flood Control Works	13
1.7a	Plan Showing Zonal Soil Groups, Okanagan Basin	21
1.7b	Soil Profile Okanagan Valley	22
2.1	Okanagan Basin and Surrounding Area Climatic Stations	29
2.2	Okanagan Basin and Surrounding Snow Courses	34
2.3	Okanagan Basin Mean Annual Precipitation	37
2.4	Average Monthly Precipitation at Vernon	40
2.5	Average Snow Water Equivalent	40
2.6	Okanagan Basin North at Oroville Showing Upper Drainage Area Above 4000 Feet Elevation	41
2.7	Snow Course Water Equivalent (April 1st). Versus Elevation Okanagan Lake Basin	43
2.8	Variation of Mean Monthly Temperatures at 4 Selected Stations in B.C.	44
2.9	Mean Annual Wind Rose at Penticton Airport	48
2.10	Lake Evaporation at Summerland, B.C.	54
2.11	Mean Annual Lake Evaporation (inches) over the Okanagan Basin	55
2.12	Okanagan Basin Mean Annual Grid Square Actual Evapotranspir- ation in inches	56
3.1	Plan and Profile of Okanagan Valley Lakes and Okanagan River	61
3.2	Area - Elevation Curve Okanagan Lake Basin	62
3.3	Headwater Storage Reservoirs in 8 selected Tributaries	63
3.4	Monthly Net History Inflow, Okanagan Lake Basin	65
3.5	Okanagan Lake Control Dam at Penticton	67
3.6	Skaha Lake Control Dam at Okanagan Falls	68
3.7	Vaseux Lake Solid Diversion Dam	70
3.8	Drop Structure No.11 Okanagan River	72
3.9	Zosel Dam, Osoyoos Lake	78

FIGURE NUMBER	TITLE	PAGE
3.10	Water Use Diagram	79
3.11	Historic and Simulated Okanagan Lake Elevations and Monthly Discharges for Dry (1970), Average (1958), and Wet (1959) Years	89
3.12	Historic and Simulated Discharges, Okanagan River Near Oliver and Historic Discharges at Oroville, Washington for Dry (1970) Average (1958) Years	90
3.13	Relative Contribution of the Various Segments to the Total Runoff of Okanagan River Basin Upstream of Oroville, Wash.	92
3.14	Frequency Curve, Computer Model Simulation of Annual Discharge, Okanagan River at Penticton and Oliver and Annual Okanagan River at Oroville, Wash.	93
3.15	Modified Inflows, Elevations, and Discharges for Okanagan Lake Based on Operation of Computer Model for Period 1921-70	94
3.16	Low-Flow Frequency Curve, Seasonal (April-July) Net Inflows, Okanagan Lake	96
3.17	Low-Flow Frequency Curve, 2 Year Moving Average Seasonal (April-July) Net Inflows, Okanagan Lake	97
3.18	Low-Flow Frequency Curve, 3 Year Moving Average Seasonal (April-July) Net Inflows, Okanagan Lake	98
3.19	High-Flow Frequency Curve, Seasonal (April-July) Net Inflows Okanagan Lake	100
3.20	Frequency and Duration of Flooding on Osoyoos Lake	102
3.21	Okanagan River Discharges at Oliver and Oroville, and Osoyoos Lake Elevations for 1970	105
3.22	Similkameen River Near Nighthawk	107
4.1	Annual Historic Data, Means, and 9 Year Moving Averages of Precipitation on Okanagan Lake and Inflows to Okanagan Lake Basin	112
4.2	Forest Hydrology Study Areas	113
5.1	Planning Model	124
5.2	Relative Contribution of the 4 Quadrants to the Total Runoff of Okanagan Lake Basin	125
6.1	Key Map Trout Cr.	135
6.2	Trout Cr. Schematic	136
6.3	Trout Cr. Dry Year (Natural Flow)	142
6.4	Average Year (Natural Flow)	143
6.5	Wet Year (Natural Flow)	144
6.6	Trout Cr. Dry Year (1970)	151

FIGURE NUMBER	TITLE	PAGE
6.6	Trout Cr. Average Year (1970)	152
6.8	Trout Cr. Wet Year (1970)	153
6.9	Trout Cr. (1970) Edficiency Diagram	154
7.1	Key Map Peachland Cr.	159
7.2	Peachland Cr. Schematic	160
7.3	Peachland Cr. Dry Year (Natural Flow)	166
7.4	Peachland Cr. Average Year (Natural Flow)	166
7.5	Peachland Cr. Wet Year (Natural Flow)	166
7.6	Peachland Cr. Dry Year (1970)	172
7.7	Peachland Cr. Average Year (1970)	172
7.8	Peachland Cr. Wet Year (1970)	173
7.9	Peachland Cr. (1970) Deficiency Diagram	174
8.1	Key Map Powers Cr.	177
8.2	Powers Cr. Schematic	178
8.3	Powers Cr. Dry Year (Natural Flow)	184
8.4	Powers Creek Average Year (Natural Flow)	184
8.5	Powers Cr. Wet Year (Natural Flow)	185
8.6	Powers Cr. Dry Year (1970)	192
8.7	Powers Cr. Average Year (1970)	193
8.8	Powers Cr. Wet Year (1970)	194
8.9	Powers Cr. (1970) Deficiency Diagram	196
9.1	Key Map Equesis Cr.	199
9.2	Equesis Cr. Schematic	200
9.3	Equesis Cr. Dry Year (Natural Flow)	203
9.4	Equesis Cr. Average Year (Natural Flow)	204
9.5	Equesis Cr. Wet Year (1970)	204
9.6	Equesis Cr. Dry Year (1970)	208
9.7	Equesis Cr. Average Year (1970)	208
9.8	Equesis Cr. Wet Year (1970)	209
9.9	Equesis Cr. (1970) Deficiency Diagram	210
10.1	Key Map Vernon Cr.	215
10.2	Vernon Cr. Schematic	216
10.3	Vernon Cr. Dry Year (Natural Flow)	223

FIGURE NUMBER	TITLE	PAGE
10.4	Vernon Cr. Average Year (Natural Flow)	224
10.5	Vernon Cr. Wet Year (Natural Flow)	225
10.6	Vernon Cr. Dry Year (1970)	233
10.7	Vernon Cr. Average Year (1970)	234
10.8	Vernon Cr. Wet Year (1970)	235
10.9	Deficiency Hydrographs Vernon Creek.	236
10.10	Vernon Cr. (1970) Deficiency Diagram	237
11.1	Key Map Kelowna Cr.	241
11.2	Kelowna Cr. Schematic	242
11.3	Kelowna Cr. Dry Year (Natural Flow)	247
11.4	Kelowna Cr. Average Year (Natural Flow)	247
11.5	Kelowna Cr. Wet Year (Natural Flow)	248
11.6	Kelowna Cr. Dry Year (1970)	252
11.7	Kelowna Average Year (1970)	253
11.8	Kelowna Cr. Wet Year (1970)	254
11.9	Kelowna Cr. (1970) Deficiency Diagram	256
11.10	Deficiency Hydrographs Kelowna Cr.	257
12.1	Key Map Mission Cr.	261
12.2	Mission Cr. Schematic	262
12.3	Mission Cr. Dry Year (Natural Flow)	271
12.4	Mission Cr. Average Year (Natural Flow)	272
12.5	Mission Cr. Wet Year (Natural Flow)	273
12.6	Mission Cr. Dry Year (1970)	280
12.7	Mission Cr. Average Year (1970)	281
12.8	Mission Cr. Wet Year (1970)	282
12.9	Mission Cr. (1970) Deficiency Diagram	283
13.1	Key Map Penticton Cr.	287
13.2	Penticton Cr. Schematic	288
13.3	Penticton Cr. Dry Year (Natural Flow)	283
13.4	Penticton Cr. Average Year (Natural Flow)	293

FIGURE NUMBER	TITLE	PAGE
13.5	Penticton Cr. Wet Year (Natural Flow)	294
13.6	Penticton Cr. Dry year (1970)	298
13.7	Penticton Cr. Average Year (1970)	298
13.8	Penticton Cr. Wet year (1970)	299
13.9	Penticton Cr. (1970) Deficiency Diagram	300
14.1	Okanagan Basin Location Map	308
14.2	Area - Elevation Curves	309
14.3	Creek Profiles	310
14.4	Hydrographs	311
14.5	Basic Data (All Creeks)	312
15.1	Hydrogeological Map North End, Okanagan River Basin	
15.2	Location of Seismic Lines North End Okanagan River Basin	320
15.3	Seismic Profiles 1, 2, 8, 3	321
15.4	Seismic Profiles 4, 5, 8, 6	322
15.5	Location of Seismic Lines, South End of Okanagan River Basin	323
15.6	Diagrammatic Cross-Section Okanagan Drainage Basin Showing East Face of Section with Inferred Cross Groundwater Flow Direction	329
15.7	Canada - British Columbia Okanagan Basin Study Task No. 41	333
15.8	Canada - British Columbia Okanagan Basin Study Task No. 41	334
15.9	Canada - British Columbia Okanagan Basin Study Task No. 41	335
15.10	Canada - British Columbia Okanagan Basin Study Task No. 41	337
15.11	Areas Indicated for Groundwater Exploration	345
16.1	Vaseux Creek Drainage Basin	356
16.2	Vernon Creek Drainage Basin	361
16.3	Penticton Creek Drainage Basin	367
16.4	Plan & Profile of Upper Penticton Creek After P.F.R.A. Drill- ing with Schematic Groundwater Flow Paths Superimposed	371
16.5	Penticton Creek Drainage Basin	375
16.6	Penticton Creek Drainage Basin	376
16.7	Water Samples from Penticton Creek	381

NUMBER

16.8	Pearson Creek Drainage Basin	387
16.9	Water Samples from Pearson Creek	388
16.10	Bedrock Geology Lambly Creek Basin	390
16.11	Surficial Geology Lambly Creek Basin	391
16.12	Groundwater Map Lambly Creek Basin	393
16.13	Bedrock Geology Greata Creek Sub-Basin	397
16.14	Surficial Geology Greata Creek Sub-Basin	398
16.15	Groundwater Zones Greata Creek Sub-Basin	400
17.1	Okanagan Basin Hydrometric Stations	406
17.2	Okanagan Basin and Surrounding Area Climatic Stations	407
17.3	Okanagan Basin and Surrounding Area Snow Courses	408
17.4	Stream Water Quality and Outfall Discharges Locations in the Okanagan Basin	411
17.5	Dustfall and Precipitation Station Locations	412
17.6	Concentrated Septic Tank Areas Requiring groundwater Monitoring	413
17.7	Okanagan Basin Hydrometric Station Records Upstream Oroville, Washington - Part 1	419
17.8	Okanagan Basin Hydrometric Station Records Upstream Oroville, Washinton - Part 2	420
17.9	Okanagan Basin Hydrometric Station Records Upstream Oroville, Washinton - Part 3	421
17.10	Okanagan Basin Hydrometric Station Records Upstream Oroville, Washinton - Part 4	421
17.11	Trout Cr. Annual 1970 Diversion Requirements at use Points	422
17.12	Peachland Creek Annual 1970 Diversion Requirements at use Points	423
17.13	Powers Creek Annual 1970 Diversion Requirements at use Points	424
17.14	Equesis Cr. Annual 1970 Diversion Requirements at use points	425
17.15	Vernon Cr. Annual 1970 Diversion Requirements at use points	426
17.16	Kelowna Cr. Annual 1970 Diversion Requirements at use points	427
17.17	Mission Cr. Annual 1970 Diversion Requirements at use points	428
17.18	Penticton Cr. Annual 1970 Diversion Requirements at use Points	429
17.19	Mean Annual Runoff of Tributary Streams Upstream of Osoyoos Lake	430