PART II

SELECTED TRIBUTARY STUDIES

CHAPTER 5

Selected Tributaries

5.1 INTRODUCTION

Water requirements for the tributaries under present day (1970) development have been confined to consumptive use since there is little or no water released from headwater storages for in channel flow. The development of these sub-basins has been almost entirely through private initiative with considerable Federal and Provincial Governments assistance in recent years under the Agricultural and Rural Development Act (ARDA).

Since the early part of this century water licences have been granted to individuals, municipalities, irrigation districts and water user communities for headwater storages and downstream diversion for use in specific areas.

About 70% of the water consumed in the Okanagan Basin occurs within the tributaries of Okanagan Lake. Historically, tributary water has been relatively inexpensive as it is a gravity water supply to agricultural lands. In order to make full use of tributary sources, headwater reservoirs have been constructed to regulate the flows during the irrigation season of April to September inclusive.

While such use is generally referred to as single purpose it will be noted that some benefits have been derived by recreation and sport fisheries through the creation of headwater reservoirs and access roads to these areas. Further, although there is little or no residual stream flow within the tributaries below the last diversion point in the late summer and fall, flows upstream are maintained to the end of the irrigation season in September. Lack of flow near the mouth of the tributaries in that latter part of the year has an adverse effect on the mainstem fishery resource while continuous summer flows upstream of the last diversion point benefit stream habitants.

For the most part, hydrometric and meteorological stations have only been operated in the lower reaches of the tributaries or within the main valley. The irrigation districts and municipalities who own and regulate most of the headwater reservoirs and diversions provide the British Columbia Water Resources Service with monthly reservoir water elevations during the freshet and, in a few instances, measure the water diverted.

The lack of hydrometeorological data has become increasingly significant in the allocation of further water licences by the Water Rights Branch, British Columbia Water Resources Service. Some tributaries are now designated as "fully licenced" pending the attainment of further hydrological records.

It is evident that in order to develop and manage the tributary supplies efficiently for present and future demands, it is necessary to estimate as closely as possible the natural flows occurring in the various reaches of each stream under varying climatic conditions and to compare them with present and future water requirements.

5.2 OBJECTIVES OF TRIBUTARY STUDY

The objectives of the tributary water quantity study were:

1) The estimation of natural flows under varying climatic conditions (dry year, average inflow year and wet year).
2) Regulation of the natural flows in accordance with present day (1970) procedures for the three types of years in (1) to meet present and future water requirements.
3) Regulation of the natural flows in accordance with improved methods of operation to meet present and future water requirements.

Objectives (1) and first part of (2) are dealt with in this Technical Supplement while the second part of (2) and objective (3) are covered in Technical Supplement 3.

In order to meet these objectives the following detailed data have been obtained:

1. The determination of land use for agricultural, domestic, industrial and other purposes and the equivalent water requirements for the various time horizones. It has been assumed future water requirements will be met from existing diversion points (use points).
2. Inventory of present storage reservoirs, their capacities and regulation practice and make projections for the future.
3. Minimum flows required for the maintenance or enhancement of fisheries.

The development of a computer model to meet the above objectives using the detailed data listed is described in Technical Supplement 2 while, as noted previously, future flow results are shown, in Technical Supplement 3.

The scope of the project embraces estimates of monthly flows in each of the eight creeks at a number of upland points and under a variety of conditions.

A graphical presentation of the foregoing is provided by the Planning Model as shown on Figure 5.1.

5.3 DISTRIBUTION OF FLOWS IN OKANAGAN LAKE BASIN

In Chapter 2 the average precipitation pattern within Okanagan Basin was illustrated using an isohyetal map (Figure 2.3) which shows lines of equal precipitation. A contrast was also drawn between the precipitation shadow occurring in the western portion of Okanagan Lake Basin and the considerably heavier precipitation occurring to the northeast within the headwaters of Mission Creek.

These conditions with respect to inflow to Okanagan Lake are reflected in the average runoff map shown in Figure 5.2 in which Okanagan Lake Basin has been divided roughly into quadrants.

In spite of the unequal area distribution, it is evident that the northeast quadrant provides almost 50% of the total inflow while there is little difference between the northwest and southwest sections.

The percentages of inflow shown in Figure 5.2 have been obtained from estimates of the natural monthly inflows to Okanagan Basin for the 50-year study period broken down within 35 tributaries in accordance with drainage areas and location.

5.4 SELECTION OF TRIBUTARIES

Ideally, in order to parallel the computer modelling along the mainstem, it would be necessary to determine the natural flows of tributaries not only at the mouth, but also at specific points upstream for the same 50-year study period.

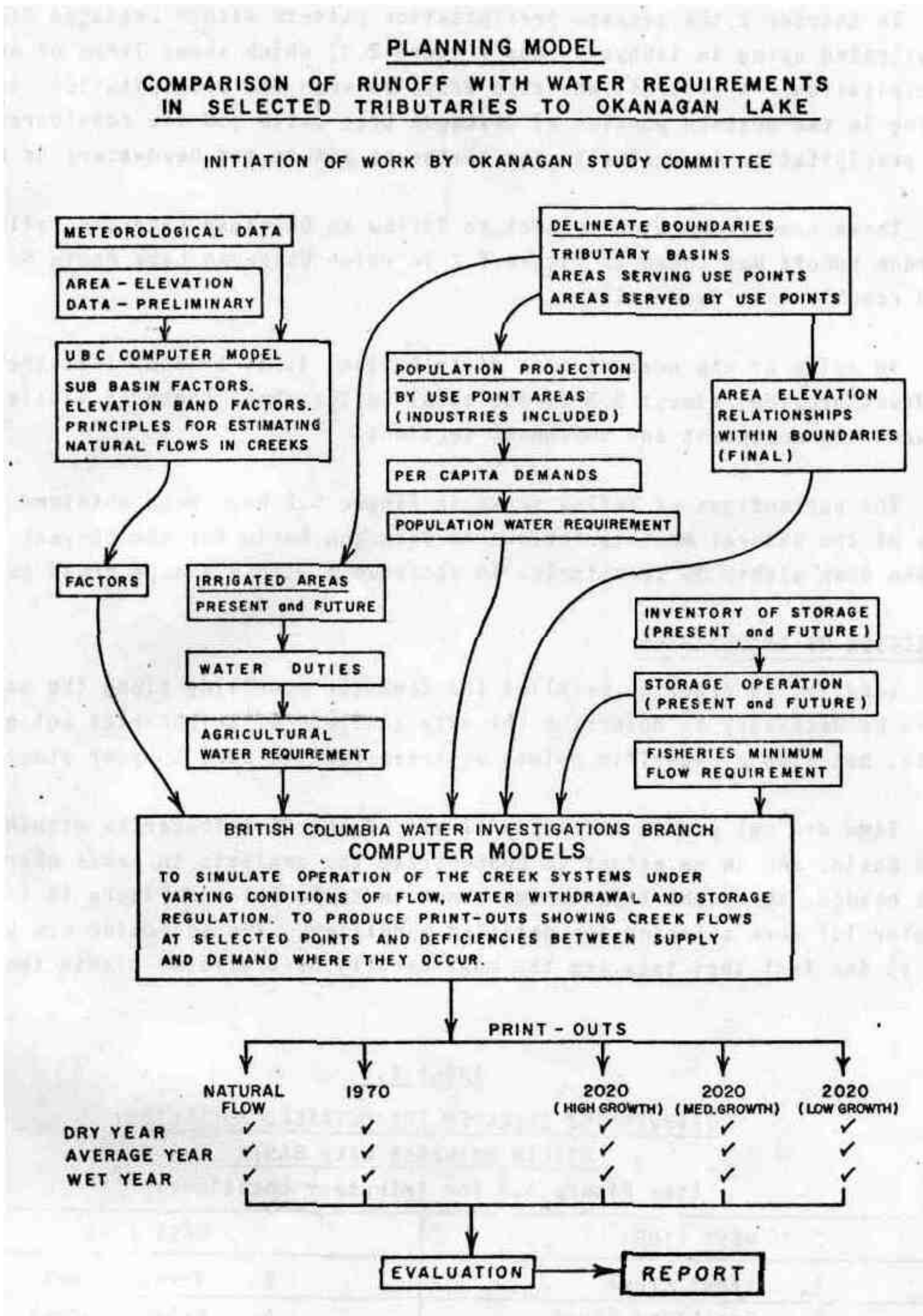
Time did not permit the study of all of the 35 tributaries within the Okanagan Basin, and in an effort to concentrate the analysis in areas where it was most needed, the eight tributaries shown in Table 5.1 and Figure 14.1 (End of Chapter 14) were selected for detailed modelling. The selection was based primarily on the fact that they are the most heavily used streams within the Basin.

TABLE 5.1

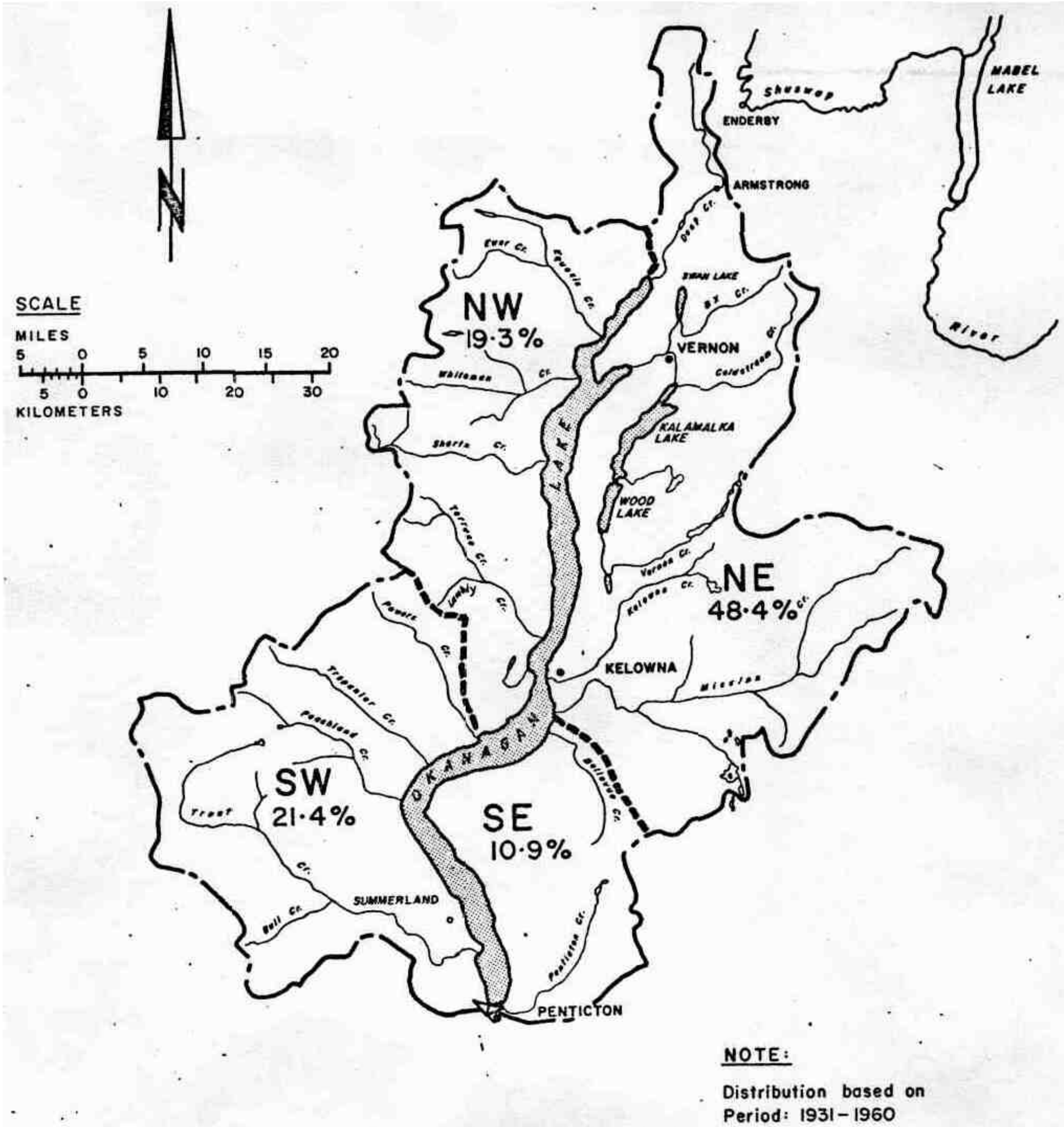
TRIBUTARIES SELECTED FOR DETAILED MODELLING WITHIN OKANAGAN LAKE BASIN (See Figure 4.3 for Tributary Locations)

WEST SIDE	EAST SIDE
1. Trout Creek	5. Vernon Creek
2. Peachland Creek	6. Kelowna Creek
3. Powers Creek	7. Mission Creek
4. Equesis Creek	8. Penticton Creek

These tributary watersheds contain 95% of all upland tributary storage within Okanagan Lake Basin and supply 60% of the total inflow to Okanagan Lake. About 37,000 acres out of the 45,000 acres of irrigated land within Okanagan Lake Basin are supplied from these sources.



PLANNING MODEL Figure 5.1



RELATIVE CONTRIBUTION OF THE 4 QUADRANTS TO THE TOTAL RUNOFF OF OKANAGAN LAKE BASIN

Figure 5.2

Reference to the Location Map (Figure 14.1)* shows the boundaries of these sub-basins and their relative positions as tributaries to Okanagan Lake. Each creek is given a number, starting at the south and moving clockwise around the basin. These numbers, appearing as a prefix to tables and drawings, are of value in locating pertinent data of specific creeks.

5.5 GENERAL APPROACH TO PROBLEM

The study was limited to three types of years:

Dry Year - Those falling within the five driest of the 50 year study period and roughly equivalent to the 1970 and 1973 runoff conditions.

Average Year - Those falling within the middle five years of the 50 year study period and roughly equivalent to 1971 runoff conditions.

Wet Year - Those falling within the five wettest years of the 50 year study period and roughly equivalent to 1948 and 1972 runoff conditions.

Using 500 foot elevation band increments the total annual runoff was computed and distributed by months to provide an estimate of the monthly natural dry year flow at specific points in each of the selected tributaries. The 1970 runoff was used for comparison. Similar calculations were made with respect to average flows in which 1971 was equated to the long-term average for 1921 to 1970. A record high runoff occurred in 1972 and the flows that resulted agree reasonably well with the estimated flows developed for the flood year prior to its occurrence.

Normally, natural runoff with minor releases from storage is adequate for water users during April and May. At the same time the headwater reservoirs are filling and major releases from these reservoirs do not take place until the latter part of June. These releases continue through July and August and in some instances, most of September, at which time releases from headwater reservoirs are discontinued. The remaining carry-over storage water is either retained as a cushion against subsequent droughts, or released in the fall to draw the reservoir down to a predetermined safe level for the winter months. The latter releases could benefit fisheries as discussed in a later section although some additional storage water would also be required.

As shown by the Planning Model on Figure 5.1, all available data on meteorology, topography, land use and water requirements are collected and processed through computer models to yield print-outs of information on water requirements and monthly flows for selected points along the course of the subject creek.

*See Fold-out at end of Chapter 14.

5.5.1 Basic Data and Assumptions

1. Farm water duties used in this study are equal to or slightly higher than those recommended by the Department of Agriculture for the specific soil and/or allocated by water licence. These farm duties increased by 10% to allow for conveyance losses indicate the following diversion requirements:

Trout Creek annual diversion water duty	3.03 acre feet/acre
Peachland Creek annual diversion water duty	3.03 acre feet/acre
Powers Creek annual diversion water duty	3.03 acre feet/acre
Equesis Creek annual diversion water duty	3.75 acre feet/acre
Vernon - Winfield and Wood Lake Irrigation Districts	3.03 acre feet/acre
- Others	1.80 acre feet/acre
Mission Creek annual diversion water duty	3.03 acre feet/acre
Penticton Creek annual diversion water duty	3.03 acre feet/acre

2. Water diversions into or out of the watershed are recognized and their effect estimated as accurately as possible.
3. Domestic water consumption - Estimated actual domestic water consumption rates are employed in calculations for 1970.
4. Reservoir operation as used in computations treats each reservoir individually and attempts to emulate current practice. Incomplete data collected between 1964 and 1971 were available for this purpose.
5. Natural flows, as calculated, ignore the natural regulation which would have existed in pristine, uncontrolled lakes. Since there is no way of knowing the operation of natural lake outlets, it is impossible to estimate natural control. The effect of ignoring natural regulation is considered to be of minor significance.
6. All existing and Potential irrigable-land, including that within Indian Reserves have been considered in determining present and future water requirements.

5.6 COMPUTER MODELS

A computer model has been developed for each creek. Print-out from the basin model provides estimated flow data for "natural" or "virgin" monthly flows at a number of selected points along the subject creek and its tributarires. Variations of the model are made for a number of conditions, e.g., dry, average, or wet years. Upon these basic models, it is then possible to impose loads and constraints, e.g., storage regulation, water diversion to or from the system, minimum flow constraints for Fisheries' requirements and so on. Computer print-outs showing residual flows after all loads and constraints have been applied are called "regulated" flows and form the basis for determining if and where a water "deficiency" will occur.

These print-outs form the bulk of this portion of Supplement 1 and the following details are provided at each water use point.

1) Water requirement (demand) for irrigation.
2) Water requirement (demand) for domestic purposes.
3) Water requirement (demand) for industrial purposes.
4) Total water requirement (demand) at the point.
5) Residual flow in creek upstream of use point.
6) Residual flow in creek downstream of use point.
7) Demand Deficiency, i.e., the amount by which the water available falls short of the water requirement. Any diversion deficiency indicates a dry creek bed.
8) Fisheries' Deficiency, i.e., the amount by which the residual flow in thecreek falls short of stated minimum flow requirements for Fisheries.

It will be noted that the demand referred to in the above listing is the diversion requirement.

In all the print-outs shown, the pattern of storage regulation simulates present practice, i.e., the "simulated" or "historic" condition. In the course of researching for the study, however, computer programs were run which attempt to meet Fisheries' requirements more closely by modifying the timing and amounts of releases from storage, sometimes at the expense of consumptive water users. Plots of the results of modified regulation are shown, where appropriate, on the Deficiency Diagrams which accompany this text. It is emphasized, however, that the modified operation shown is the result of a rudimentary and preliminary model and should not be regarded as a recommended method for multi-purpose operation. Further, time did not permit investigation of the practicability of these releases with respect to existing structures, and their accessibility to accomplish such regulation. Finally, it should be emphasized that such operations (unlike the mainstem modelling) have been limited to single drought years and the occurrence of two successive dry years would probably deplete the reservoirs entirely.

5.7 LAND USE AND CONSUMPTIVE WATER REQUIREMENTS (GENERAL)

Consumptive water requirements in the uplands areas are almost entirely for irrigation purposes while, in the lower areas, demand for domestic water are high. In order to estimate the amount of water withdrawn it has been necessary to determine the land irrigated and/or the people or industry served by each major intake along the tributaries.

While in channel tributary flows for fisheries have been investigated, their major significance is in the maintenance of adequate flows at the mouths of Mission, Equesis and Trepanier Creeks which next to the main lake system are the major habitant areas for the Kokanee and Rainbow Trout sport fisheries. Hence, as will be noted later in this chapter, emphasis on non-consumptive in channel flows has been placed on these 3 streams.

5.7.1 Irrigation

Areas under irrigation at 1970 development have been derived from two sources:

a) Provincial ARDA Present Land Use Project mapping which was prepared by Canada Land Inventory, Victoria, released in 1968 and updated to 1970 using coloured air photograph. Map scale 1:50,000.

b) The irrigation requirements of small upland areas not covered by Canada Land Inventory mapping have been deduced by some field observations and from existing water licencing data.

5.7.2 Domestic

1970 estimates of land use for domestic purposes are based on a knowledge of existing conditions.

5.7.3 Industry

Water use for industry is considered to be of relatively small importance where the tributaries are concerned. Important industrial users such as Hiram Walkers Distillery and Brenda Mines are recognized by the location and demands of possible future industries is impossible to forecast. It is assumed that, if large, industrial demands will be met from Okanagan Lake and, if small, that demands can be absorbed within general population and irrigation requirements.

5.8 NON-CONSUMPTIVE WATER REQUIREMENTS (FISHERIES)

In the tributaries the dominant non-consumptive use is Fisheries. Other possible demands, such as power and pollution-control minima are either nonexistent or unstated.

Estimates of minimum flow requirements for the propagation of rainbow trout and kokanee have been made by Fisheries Research Board of Canada and are listed on Table 5.2. These minimum flow water requirements are recognized throughout this report. In the detailed print-outs their absolute values are subtracted from the estimated residual stream flows for various conditions and the results expressed as a deficiency where and if such should occur.

5.9 REGULATION OF STORAGE

Within the eight tributary basins there are 43 active storage reservoirs with a combined capacity of 106,543 acre-feet (1970). See Figure 3.3 and Tables contained in Chapters 6 to 14.

It is important to note that the availability of storage and the pattern of its release can have a marked effect on whether or not deficiencies will appear. Regulation of storage is considered in two ways:

a) Historic (simulated) operation.
b) Modified operation.

TABLE 5.2

ESTIMATED MINIMUM WATER REQUIREMENTS FOR FISHERIES ACRE-FEET PER MONTH

	TROUT	PEACH-LAND	POWERS	EQUESIS	BX UPPER	VERNON		COLD-STREAM	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
Sept.	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

5.10 HISTORIC (SIMULATED) OPERATION

This is an attempt to simulate current practice and gives primary consideration to the needs of consumptive water users. Enveloping curves of maximum desirable storage have been developed for each reservoir. Any particular month, where inflow surplus over maximum occurs, and this surplus is sufficient to meet downstream requirements, that amount is released downstream to meet consumptive uses and provide residual stream flows. When natural inflow to the reservoir does not meet consumptive demands, the precise amount of the consumptive use is released from storage. Hence, as may be seen on the print-outs, there are many occasions where all consumptive uses are met exactly but leave no residual flows in the stream. In practice, such precision of release could not be achieved, but is is anticipated that return flows, which are ignored in calculations, would make up for any operational imperfections. All the print-outs in this report are based on the historic method of storage operation. Rule curve values for the operation of each reservoir are shown describing each individual tributary.

5.11 MODIFIED OPERATION

This method of regulating storage releases attempts to accommodate both Fisheries' minimum flow and consumptive water use requirements. There are so many possible variations to modified operation that it could properly become a study in its own right. This Supplement considers Modified Operation only briefly in the Deficiency Diagrams. Its form of operation releases storage primarily for consumptive use as first priority while at the same time attempting to meet more fully Fishery minimum flow requirements. In this way, storage is depleted more rapidly than by Historic Operation and, in dry years, consumptive users suffer reduced flows as well as Fisheries. It will be noted that this is particularly true in a two year drought cycle where normally all carry-over storage is used up for consumptive use purposes.

It will be noted that nearly all deficiencies with respect to fishery flows occur below the last major diversion point within each stream. Hence, it may be more practical to provide water by pumping in this portion of the creek rather than through upstream manipulation of existing or additional storages.

5.12 EXPLANATION OF FIGURES

Detailed scrutiny of each individual creek follows the same basic pattern. First:

1) Key Map - This is a photo reduction of 1:50,000 mapping upon which all the more important tributary and irrigation district boundaries are marked. The Location of control points (CP), measuring points (MP) and use points (UP) is given.
2) Schematic - This shows clearly, in diagrammatic form, the way the system operates, noting the relative position of all control points (CP), measuring points (MP) and use points (UP).
3) Computer Print-Outs - These provide very detailed information on flows and deficiencies under varying conditions and for all the upstream points shown on the Schematic.
4) Hydrographs of Flows at Mouth - These diagrams illustrate how residual flows in the creeks may be diminished as development and water withdrawal increases. Current minimum Fisheries' water requirements are shown also. Noteworthy are the large water surpluses during freshet (usually May, June, July) falling to increasingly serious shortages in late summer, usually in August and September.
5) Deficiency Diagrams - These diagrams have been prepared for "Dry" and "Average" years for each creek at the 1970 stage of development. Consumptive use

deficiencies are totals for the whole basin and non-consumptive deficiencies are those at the creek mouth where they are normally required. Deficiencies are given monthly and expressed as a percentage of the total requirement. The results illustrated are based on two types of storage regulation:

i) Historic Operation (simulated), and

ii) Modified Operation

The former copies current procedures while the latter is a rudimentary attempt to operate for optimum multiple purpose use, i.e.. Irrigation and Fisheries.

6) Deficiency Hydrographs - The computer print-outs show that, in a "Dry" year at 1970 development, there are consumptive water deficiencies at some upstream points in the Vernon and Kelowna Watersheds. These are plotted in hydrograph form.

In the material which follows, a general description and historic background is provided for each of the eight selected tributaries. Present water-utilization including water licencing (as of 1970) are also described together with the type of water management presently practiced. Finally, a detailed analysis is shown including capability of the stream to meet present day water requirements at the various use or diversion points.

It should be emphasized that the water requirements are based on what are considered to be optimum needs with allowances of some 10% for conveyance losses in the case of irrigation. This approach has been taken rather than the use of water licence data which may or may not be indicative of actual condition. The results are summarized at the end of this chapter.

5.13 WATER MANAGEMENT

Estimated natural water yields as described in the following chapters 6 to 13 inclusive, estimate flows under pristine conditions. Under the influence of Man, water has been diverted for various purposes and reservoirs have been created to retard natural runoff. All these changes in natural conditions are included under the general title of Water Management.