PRAIRIE PROVINCES WATER BOARD

THE DISTRIBUTION AND VARIABILITY OF RUNOFF IN ALBERTA, SASKATCHEWAN AND MANITOBA

Prepared for the
Prairie Provinces Water Board,
by the Hydrology Div., Engineering Branch,
Prairie Farm Rehabilitation Administration,
Canada Department of Agriculture.

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PRAIRIE PROVINCES WATER BOARD

Regina, Saskatchewan,
November, 1964.

Members,
Prairie Provinces Water Board.

I am pleased to present for your consideration the attached report on the distribution and variability of runoff in Alberta, Saskatchewan, and Manitoba. This study arose from a P.P.W.B. request in minute 13-11 (October 1955):-

> "Mr. Clark suggested the Secretariat might undertake a compilation of available hydrometric data leading to a report, or reports, containing estimated yields of water available at all points (involving estimation of missing records, calculation of means for standard periods, etc.).

Many technical difficulties were encountered in launching the study but in 1959 compilation and reconstruction of basic hydrometric data were begun. Eventually, compilation of recorded and estimated monthly discharge data were assembled for 230 hydrometric stations. These tabulations have already been presented to the Board as an interim report entitled, "Compilation of Runoff Records for the Canadian Prairies."

This final report represents a three-part analysis of that compilation to determine the magnitude of the mean annual runoff, to determine the recurrence probability of low runoff years, and to study the nature of low runoff persistence in various regions. As explained in the report, the results are approximate because of the limited amount of data available. However, it is suggested that the figures are sufficiently accurate for use in preliminary water resources planning.

The study was begun by Mr. W. Stichling who has since joined the staff of the Water Resources Branch. It was under his supervision that most of the streamflow compilations and correlations were completed. Mr. W.G. Salway continued the study and supervised the runoff analysis phase.

Basic data were furnished by the Water Resources Branch, Department of Northern Affairs and National Resources, and by the Meteorological Branch, Department of Transport. Compilation, analysis, and the writing and assembling of the report were undertaken by the P.F.R.A. Hydrology Division.

Yours very truly,

E.F. Durrant

E.F. Durrant, Engineering Secretary,
Prairie Province Water Board.

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I.

SYNOPSIS

This paper sets forth the findings of an investigation of surface water runoff in the Prairie Provinces of Canada. Its distribution is considered in terms of median annual runoff values from which a water yield map has been prepared. The variability of runoff, as determined by the analysis of frequency curves and mass curves, is also considered and is illustrated by a series of graphs. In addition, a description is given of several techniques, for improving runoff estimates, which were tested without success. Suggestions are made for the refinement of an investigation of this kind when better data are available.

II.

INTRODUCTION

Increasing demands for water are stimulating interest in the development possibilities of smaller streams. Although many small streams are gauged, it will be several decades, or even centuries, before actual streamflow measurements are available for all of our streams. Meanwhile it is essential that good and consistent estimates be made of the available water supply in these ungauged watersheds. The information is needed for administration, particularly for interprovincial administration, and for planning and design.

Recognizing this need, the Prairie Provinces Water Board[1] requested the Prairie Farm Rehabilitation Administration[2] to undertake a comprehensive runoff study for the prairie area and the eastern slopes of the Rocky Mountains. The study was assigned to the PFRA Hydrology Division and was begun in 1958. At this point acknowledgement should be made of the work of W. Stichling[3] who supervised most of the data compilation and reconstruction before leaving the Hydrology Division in June 1961.

It is hoped that this study provides a sound basis for estimating the median annual runoff available for smaller streams on the Prairies, and its variability from place to place. "Smaller streams," for the purposes of this paper, are those which drain watersheds of from 30 to 2000 square miles. The paper has little application to watersheds which do not fall within these limits.

Further, the procedures outlined in this paper should not be used indiscriminately. Inaccuracies have been introduced by the necessity of using correlated data, by the analysis of only a few of the many factors which contribute to runoff, and by the generalizations necessary in preparing a broad picture of runoff patterns. Within 10 or 20 years the authors feel that completion of present topographic mapping programs, additional streamflow and precipitation records, further soil surveys, new methods of observing prairie snowfall, etc., will permit a much improved study of runoff and its causative factors. Runoff estimates provided by this paper represent a significant improvement over our past understanding of available water supplies on the Prairies, but they should be criticized and modified as new data become available.

1/ A body whose function is "to recommend the best use to be made of interprovincial waters in relation to associated resources in Manitoba, Saskatchewan and Alberta and to recommend the allocation of water as between each such province of streams flowing from one province into another province."

2/ Canada - Department of Agriculture.

3/ Sedimentation Engineer, Water Resources,
Canada Department of Northern Affairs and National Resources, Ottawa.

The paper begins with a brief description of the Canadian Prairies to acquaint the reader with the general magnitude and causes of runoff in the area. An outline of the procedure leading to the final results is followed by a reference to the reconstruction and compilation of the streamflow data which were used. Then, in a section on runoff volume, the median annual runoff is defined and is followed by a discussion of the factors influencing runoff and a description of the mapping of runoff in the study area. A section on runoff variability follows in which the mass curve and frequency curve approaches are considered. The application of the results of the investigation to water supply and storage problems is then described. Finally in the summary, the results are reviewed and suggestions are made for future studies of this kind.

It is impossible to acknowledge all the sources of information and ideas used in the furtherance of this investigation, hence the list of references given at the end is not exhaustive.

III.

DESCRIPTION OF AREA INVESTIGATED

Several thousand years ago, the Prairie Provinces were covered by a thick ice sheet except for the Rocky Mountains on the West and the Cypress Hills near the southwest edge of the area (1). With the exception of the Pembina escarpment, the Missouri Coteau and the Cypress Hills, most of the topographic relief is provided by moraine deposits. The several advances and retreats of the ice sheets covered the area with hundreds of feet of till with a high clay content. Some of the features of this till plain of interest to hydrologists are:-

(a) thousands of small closed basins where fragments of ice melted, permitting subsidence;

(b) a relatively impermeable sub-soil;

(c) moderate slopes;

(d) extreme variability in surface soils - from lacustrine clays to wind deposited sands in a few miles;

and (e) rich agricultural soils.

Most of the difficulties encountered in studying the hydrology of the area are related to the above points, particularly the difficulty of determining drainage area (2). Since annual evaporation exceeds precipitation by various amounts throughout the area, there are many closed basins which never overflow; others overflow rarely, some frequently and the remainder always. One estimate (3) suggests that runoff from two-thirds of the prairie area terminates in closed basins.

Annual precipitation is at a minimum of 11 inches at about 104° longitude (the Alberta-Saskatchewan boundary) and between 49° and 52° latitude. It increases to the east, west and north, reaching better than 22 inches at the eastern boundary of Manitoba, rising to an estimated 70 inches in the higher parts of the Rocky Mountains, and 16 inches near latitude 55° at the northern fringe of the prairie area.

On the open prairies, about 25% of the annual precipitation falls as snow, but more than 75% of the annual runoff is derived from snow melt in the spring. At this time of year, frost inhibits infiltration and improves the runoff opportunity. Parts of Alberta and Saskatchewan experience drastic reductions in snow cover in winter months due to warm dry Chinook Winds. The resultant snow melt is absorbed by the soil and subsequently evaporated. Frequently this will eliminate snow-melt runoff completely. The Chinook Winds then, are a factor in runoff variability.

Precipitation in eastern Alberta, Saskatchewan and Manitoba is subject to the inter-action of two large air masses: cold dry air from the north and warm moist air from the south. As one air mass overrides the other, storms are produced which usually cover broad areas with variable precipitation. Orographic effects in the Rocky Mountains, the Cypress Hills, and in the Riding Mountain Hills lead to a local increase in precipitation. A more variable source of rainfall in summer results from small-thunderstorm activity due to heating over land; this encourages intense storms of limited extent and adds to the variability of precipitation and runoff.

The mountain regions of Alberta are subject to the additional influence of Pacific air masses. In the higher mountain areas, this influence predominates and precipitation "spills-over" from the western slopes of The Divide giving comparatively high runoff with low variability.

IV.

PROCEDURE

The purpose of this investigation was to provide a quick and satisfactory means of assessing runoff in terms of volume and variability at any given location. To achieve this purpose, runoff volume was considered in terms of median annual values and runoff variability was viewed in the light of mass curve and frequency curve analyses.

A necessary preliminary to the examination of runoff volume and variability was the compilation and reconstruction of streamflow data. This part of the investigation has been referred to on page 2 and is described in Chapter V.

Concerning runoff volume, it was decided to adopt the median annual unit runoff as a measure. The reasons for using the median rather than the arithmetic mean are given on page 8. From the recorded and reconstructed streamflow data, graphical determinations were made of the median annual unit runoff for each hydrometric station. These runoffs were expressed in terms of acre-feet per annum per square-mile of drainage area and are given in Table 2. By plotting these runoffs on a map at the runoff centroids of their respective basins, reference points were obtained for the interpolation of runoff isopleths. For a number of the many areas lacking streamflow data, regional correlations between average annual precipitation and median annual unit runoff were used as an aid to interpolation. The isopleths are shown on the map, Fig. 1.

The problem of runoff variability was examined by the analysis of mass curves and frequency curves. In the mass curve analysis, curves were prepared from annual runoff data. From each of the mass curves, a storage versus reliable yield curve was derived in which both variables were expressed as percentages of the median annual unit runoff. Comparison of these storage-yield curves revealed distinct regional groupings, the curves in any one group being very similar. It was thus possible to delineate storage-yield regions with each region having its own composite curve. These regions are shown in the map, Fig. 2, and the regional curves are shown in Figs. 4 to 8 inclusive.

In the frequency curve analysis, curves were prepared from annual runoff data. The curves did not fall into groups so conveniently as the storage-yield curves and it was not possible to delineate many regions, but it was possible to discern three distinct groupings having "flat," "moderate" and "steep" slopes. These groupings are shown in Fig. 9 and define the mountain, foothill and prairie regions respectively as shown on the map, Fig. 3. From the individual frequency curves, the estimates of the 1:10 and 1:50 annual runoffs given in Table 2 were made.

Several other methods of analysis were tested without success. A discussion of these and a general discussion of the factors involved in runoff will be found in Chapters V, VI and VII.

V.

RECONTRUCTION OF STREAMFLOW RECORDS

Streamflow measurements were begun in 1908 in Western Canada but most of the long-term stations were established in 1911 or shortly afterward. These records are gathered and published by the Water Resources Branch of the Department of Northern Affairs and National Resources. The period 1911 to 1956 was selected for study because it was the longest continuous period for which records were readily available when the study was begun in 1958. This was also the period used for a regional flood frequency study (4) completed by the Hydrology Division in 1959.

Records were accepted for analysis: (a) if ten years or more of records were available, and (b) if satisfactory correlative relationships to nearby long-term stations existed. Table 1 shows the periods of record of the hydrometric stations used in the study.

For each station the total monthly discharge was compiled for all the months of record and the total annual discharge in acre-feet was computed for calendar years. Hydrometric data are published and summarized for "water years," i.e., 1 Oct.-30 Sept. However, it was considered advisable to compile the data on the basis of calendar years because most prairie and mountain streams reach minimum flow around the end of December and, in the case of prairie streams, most of the runoff due to precipitation in the calendar year has occurred by the same date. Where necessary, missing records were estimated by correlating monthly runoff values with those for nearby streams. No firm mathematical criteria were established for accepting or rejecting these correlations, but generally speaking, they were acceptable if the standard error of estimate was 20% of the mean or less.

Where there were several stations in the same watershed, flows were computed on a monthly and annual basis for the incremental areas between upstream and downstream stations without allowance for time lag.

The compilations were prepared in a form suitable for ozalid duplication and have proved extremely useful in themselves.

VI.

REGIONAL RUNOFF VOLUME

(a) MEDIAN ANNUAL RUNOFF

The median annual runoff was adopted as a useful measure of the manner in which runoff volume varies throughout the area of study. The annual runoff for prairie streams is characterized by a high degree of variability; hence the arithmetic mean annual runoff could easily be unduly influenced by a few flood years. To avoid this influence, the median annual runoff (2-year return period) was computed. For reasons of consistency, it was also computed for foothill and mountain streams although in the case of the latter, the median and arithmetic mean do not differ appreciably.

For each hydrometric station two graphs were constructed: an annual runoff duration curve, and an annual runoff frequency curve for the period 1911 to 1956. The first-mentioned graph provides a greater separation of points in the median range. In both cases the ordinate used was annual runoff in acre-feet. Estimated or reconstructed annual flows were used to position recorded values in the annual runoff array. Different symbols were used for plotting the estimated and recorded data on the two graphs so that proper weight could be given to the probable accuracy of the points when fitting curves.

Drainage areas were computed for all stations so that runoff could be calculated on a per-square-mile basis. Stichling and Blackwell (2) have shown the difficulties of precise drainage area determination on the prairies. Following their suggestions, we computed the "dry" drainage areas (applicable to median annual runoff), the "wet" drainage areas (applicable to 1:50 runoff), and the gross drainage areas (applicable to the probable maximum flood). Reproducible estimates of these three areas can be made only if (a) uniform maps are available for all areas, and (b) well-defined uniform criteria are used to estimate how frequently a given area will contribute to runoff. For this study, these conditions were not entirely satisfied but the results may be termed useful, and an improvement over the assumption that drainage areas are fixed in till-mantled low-runoff areas. Due to lack of suitable topographic information, satisfactory delineation of "gross" drainage areas could not be made for most of the hydrometric stations; in Tables 2 and 3 therefore, only "dry" and "wet" areas have been given. In many instances, the "gross" area is only slightly greater than the "wet."

The median-annual unit runoff values obtained as above, and given in Table 2, were plotted on a map to observe the basic nature of runoff variations across the three provinces. As could be expected, runoff was high in the Rocky Mountains and low on the Prairies. However, variations within these two broad hydrologic regions, could not be satisfactorily explained by inserting fine scale regional boundaries only or by attributing them to sampling errors inherent in a short period (46-year) study. Further, there is a marked lack of hydrometric coverage

for some parts of the Prairies and in order to extrapolate to and interpolate across these areas, some understanding was needed of the basic reasons for local runoff variations and a discussion of the factors affecting runoff is given in Chapter 6(b).

Incremental runoffs for the incremental drainage areas between gauging stations on the same stream were also computed and are given in Table 3. These figures however should be used with caution since, on account of time-lag effects and variable conveyance losses, some anomalous results were produced.

(b) FACTORS AFFECTING RUNOFF

There is a long list of factors which can cause variations in runoff. There is also a long list of material available to the conscientious researcher on this subject (5). Unfortunately, most of this material deals with runoff variations qualitatively, and is of little help in predicting quantitative variations in an area not previously studied.

Basically these factors can be grouped under four headings: topographic (slope, elevation, drainage density, etc.); geologic (soil, sub-soil, drainage pattern, etc.); cover (grass, trees, litter, cultivation, etc.); and climatic (precipitation, evaporation, drought frequency and persistence, etc.). For the Prairie Provinces, complete and consistent topographic mapping is available for the Rocky Mountain Region only. There is no consistent and comprehensive information on surficial or sub-surface geology. Cover has varied from year to year, and no reliable information is available on cover conditions related to past runoff. Precipitation, the best-defined of these factors for the Prairie Region, has been relatively un-measured for the Rocky Mountain Region. In summary, the only usable parameters appear at present to be topography for the Mountain Regions, and precipitation for the Prairies. For the Prairie area, where there are large differences between "dry, wet, and gross" drainage areas, a supplementary parameter suggest itself, namely, the ratio of wet to dry areas.

(i) Basin Elevation

A number of attempts were made to establish relationships between median annual unit runoff and mean basin elevation. Such elevations were computed for 102 gauging stations in the Rocky Mountains and foothills and are given in Table 4. For the most part, maps of the National Topographic Series scale 1:50,000 (contour interval 100 ft. or less) were used for computing basin elevations.

The runoff and elevation data were plotted on log-log graph paper, log-log paper being selected because it was considered likely that the relationship between runoff and

and elevation would take the form:

$$R_u = aE^b$$

where

R_u = median annual unit runoff in acre-feet per annum per square-mile;

E = mean basin elevation in feet above G.S.C. datum;

and a & b are constants.

A log-log plot was also convenient on account of the large range of runoffs.

A mass plot for the entire mountain and foothill region displayed appreciable scatter although there was a general indication, as would be expected, that runoff increased as elevation increased. Attempts at regionalization were made in two ways: by groupings of basins contained between the mountain chains running parallel to The Divide and by groupings of basins contained within the boundaries of the major river basins.

The former attempt to establish runoff regions parallel with The Divide was inconclusive. The latter attempt to establish runoff regions defined by the boundaries of major river basins such as the North Saskatchewan, the Bow and the Oldman appeared initially to be promising. However it was found that, although the correlations between runoff and elevation on log-log paper were apparently fair, the exponents of elevation in the equation $R_u = aE^b$ were unduly high in some cases. It was difficult to accept the idea that, in some areas, runoff could be proportional to elevation to a power greater than five! This cast suspicion on the correlations obtained and they were rejected when, on trying to apply them, they led to a number of absurdities. A mass plot of the data is given in Fig. 10 and typical plots are shown for the North Saskatchewan, Bow and Oldman River basins in Figs. 11, 12 and 13 respectively.

A criticism which may be made at this stage is that the mean basin elevations used were based on an arbitrary (G.S.C.) datum as far as runoff is concerned. An attempt was made to overcome this difficulty by plotting what was termed the "elevation productivity," i.e. unit runoff divided by mean basin elevation, against mean basin elevation. Several of these "elevation productivity"/elevation plots were made for the major river basins and the use of arithmetic paper enabled estimates to be made of the elevations at which the "elevation productivity," or runoff per foot of elevation, became negligible. It was hoped in this way to discern, for each major basin, a critical altitude

below which elevation ceased to be a dominant parameter of runoff. For each gauging station, the critical altitude was subtracted from its mean elevation above datum and the difference was divided into the unit runoff to give a revised "elevation productivity." The "unit runoff per foot of elevation above critical altitude" data so obtained were then plotted against corresponding mean elevations above datum. The results of this device were, however, inconclusive and no useful correlations could be established.

A further attempt was made to overcome the doubts associated with an arbitrary datum by plotting "elevation productivity" against, what we have called for want of a better term, the "mean areal gradient." The "mean areal gradient" was considered to be a measure of the degree to which a given basin was incised or otherwise contorted, and also a measure of the drainage density; as defined in this context it takes into account both elevation and drainage area and has the dimensions of feet of elevation per square-mile of drainage area. This does not imply that the mean areal gradient (m.a.g.) is obtained by dividing mean elevation by drainage area, although a rough approximation can be calculated in this manner. If in a given basin the rise between two adjacent contours be divided by the area enclosed by those contours, then an "areal" gradient would be obtained for that interval; the mean of such gradients for the whole of the basin is defined here as the m.a.g. Time did not permit calculation of many of these gradients to the desired degree of accuracy, but for the few cases for which they were plotted against elevation productivity, no firm conclusions could be drawn.

Finally, a multivariable regression analysis was made in which elevation and drainage area were taken as the parameters of runoff. The results of this analysis were not encouraging. For the Bow River Basin, the following relationship was indicated:-

$$R_u = 0.126E^{1.08}D^{-0.113}$$

where

R_u = median annual unit runoff in acre-feet per annum per square-mile;

E = mean basin elevation in feet above G.S.C. datum;

and D = drainage area in square miles.

For the Oldman River Basin, the relationship was:-

$$R_u = 3.99(10^{-5})E^{4.95}D^{-3.73}$$

and for the headwaters of the Bow River:-

$$R_u = 49.9E^{0.46}D^{-0.15} .$$

The wide range of values in the coefficients and the exponents of these relationships is sufficient to suggest that they are unreliable.

It was concluded from the results of the studies described in this sub-section, that elevation is an important parameter but not sufficient to define runoff in the mountain areas. It is considered that success will only be achieved when data is available to enable other parameters to be included. Topographic factors such as slope or alternatively mean areal gradient, basin orientation, and climatic factors such as precipitation and rain-shadow effects are thought to be important parameters in addition to elevation.

(ii) Mean Annual Precipitation

McKay (6) has mapped the mean annual precipitation of the Canadian Prairies. Using his map, mean annual precipitation was estimated for all basins tributary to the prairie hydrometric stations used in this study. The results are given in Table 5.

With regard to the relationship between runoff and precipitation, a variety of formulae have been proposed and used by various authorities. A most useful summary of these is given in a paper by Ayers (7) and among the formulae referred to is one used by Harrold (8) and adopted for this study; it takes the form:-

$$R_u = m \log_{10} P - b$$

where

R_u = median annual unit runoff in acre-feet per annum per square-mile;

P = average annual precipitation in inches;

and m & b are constants.

It will be noted that this relationship implies that a certain critical value of precipitation has to be reached before runoff commences. One would expect to find this condition in nature, particularly in a semi-arid region, and it was confirmed in the course of this study. In general, the relationship should be used with care and undue extrapolation should be avoided.

A mass plot for the Prairie region was prepared using the median annual unit runoff data (based on "dry" drainage areas) of Table 2 and the precipitation data of Table 5. Runoff was plotted linearly as the ordinate and precipitation was plotted logarithmically as the abscissa in order to facilitate calculation of the coefficients. Fig. 14 shows the large scatter of the mass plot. However, further examination showed that there was much less scatter within sub-regions defined mainly by the major river basins. The scatter within the sub-regions can be attributed to the influence of other parameters which could not be taken into account and errors in the basic data. It was considered that the sub-region plots would provide a useful interpolative device for the mapping of runoff. Figs. 15 and 16 show the relationships which were selected for this purpose. These relationships are applicable to an area which is bounded by the southeast corner of Alberta, the southeast corner of Manitoba and the Pasquia Hills (80 miles southwest of The Pas) as points of a triangle. Lack of data prevented the development of satisfactory relationships elsewhere.

It must be emphasized that these relationships should not be used for determining runoff from precipitation alone; they should only be regarded as a means of interpolation. Our Prairie precipitation network does not permit fine scale definition of mean annual precipitation, particularly for isolated topographic anomalies where there are very few rain gauges.

(iii) Fluctuating Drainage Area

Reference was made on page 8 to the concept of "dry," "wet" and "gross" drainage areas. One of the phenomena encountered in the prairies is the variation from year to year of the drainage area which contributes to runoff at a given location. The area which contributes to runoff in a particular year is governed by a number of factors such as antecedent precipitation, precipitation during the year, depressional storage, evaporation and so on.

There is no satisfactory method at present for adjusting drainage area from year to year in order to compare unit runoffs. The concept of "dry," "wet" and "gross" areas has however been found useful and a description of the method of delineating these areas will be found in the paper by Stichling and Blackwell referred to on page 8.

Reference to Table 2 will disclose some remarkable differences between "dry" and "wet" areas. These differences are accounted for by low drainage density and depressional storage which withholds runoff in dry years. As mentioned on page 8, lack of topographic information prevented delineation of "gross" areas for many hydrometric stations and in Tables 2 and 3 therefore only the "dry" and "wet" areas have been given.

For the purpose of assessing the importance of this fluctuating drainage area effect, the most usable parameter appeared to be the ratio of the "wet" drainage area to the "dry." A number of attempts were made to compare this ratio with yield and it was plotted against the median annual unit runoff; against the ratio of the 1:10 runoff to the median; against the ratio of the 1:50 runoff to the median and against the ratio of the average annual unit runoff to the median annual unit runoff. No significant relationships were evident in any of these plots, however in the course of the mass curve and frequency curve analysis described in Chapter VII, the "wet-dry" ratio when plotted against detention period showed groupings of points defining mountain, foothill and prairie regions similar to those in Fig. 3 obtained from the frequency curve analysis. This parameter appears then to have a greater influence on runoff variability than volume.

(iv) Size of Drainage Area

There is a rational basis for suggesting that unit runoff increases as the size of the watershed decreases. In arid areas the valley alluvium can absorb large quantities of runoff which is subsequently "lost" to phreatophytes or groundwater recharge. Also in arid areas, evaporation losses from the river surface and the wetted shorelines can be considerable. In arid and humid areas, the smaller watersheds tend to have a higher mean basin elevation (and hence greater precipitation), greater drainage density, steeper slopes, thinner soil mantle, etc. All of these factors would tend to favor higher yields from small areas than from large areas.

For the Rocky Mountain area, the influence of watershed size on yield would obviously be masked by the stronger correlation between elevation and watershed size.

For the Prairies, an attempt was made to correlate median annual unit runoff with size of drainage area after removing the influence of precipitation (graphical multiple correlation by method of deviations). Although a distinct trend toward increasing runoff with decreasing watershed size was apparent, the degree of correlation was not sufficient to justify use of this factor for adjustments at this time.

A marked inverse correlation between size and unit yield was noted for stations in tandem on the same stream indicating that transmission losses are a factor in the reduction of unit yields in larger basins. A lack of time and suitable data prevented a detailed study of this effect, but it would seem to be a profitable research project in itself.

(v) Summary

For the mountain and foothill regions of Alberta, it was found that while elevation is an important factor in runoff, it is not sufficient to define it. Satisfactory results might be obtained when more streamflow data, particulary above latitude 51°, have been gathered and when data are available to allow inclusion of factors such as gradient, orientation and precipitation.

In the Prairie Region, precipitation is the most important factor in runoff. Precipitation is not sufficient in general to define runoff, although in some areas a runoff/precipitation correlation may be used to give a "first approximation" in the estimation of runoff and may also be used, with some assurance, as an interpolative device between adjacent gauged basins. In order to define prairie runoff more exactly, it will be necessary to take into account the variation of drainage area from year to year in order to provide more accurate estimates of annual unit runoff. Streamflow data adjusted for the "Fluctuating Drainage Area Effect" should show improved correlation with precipitation, soil permeability and drainage area size as principal parameters and a further refinement may be effected by introducing factors such as vegetative cover as secondary parameters; but for the moment, there is no reliable substitute for regional runoff estimates based upon actual long-term streamflow records as presented herein.

(c) MAPPING OF RUNOFF

For the purpose of mapping runoff, the recorded and reconstructed streamflow data of Table 2 were used. The largest scale series of topographic maps giving complete coverage of the area under investigation was the 1:506,880 National Topographic Series prepared by the Canada Department of Mines and Technical Surveys. The appropriate sheets of this series were assembled as a base map and the locations of the gauging stations and corresponding watersheds were drawn in. The median annual unit runoff, in acre-feet per annum per square-mile of "dry" drainage area, was plotted at the runoff centroid of each watershed. In those watersheds in the prairie region where there were no pronounced topographic features, the runoff centroid was considered to be at the centroid of the dry drainage area; elsewhere, judicious allowance was made for the more elevated sections of a watershed which would give a greater contribution to runoff. Strictly, determination of the runoff centroid is a trial and error process

in which the position of the centroid is adjusted to give agreement between the runoff calculated from the isopleths and the runoff indicated by the gauging-station record. This was done as a check in several cases and it was found possible to locate the runoff centroid by judgement with a fair degree of accuracy.

Having plotted the median annual unit runoffs on the base map, interpolations were made between adjacent watersheds in the same manner as in the preparation of a contoured map from a series of spot elevations. In the course of topographic surveying, a trained rodman will place his levelling rod at each change of section. "Spot elevations" of runoff however, are not so conveniently located and care had to be exercised to ensure that an interpolation was not being made over a section which might have contained high or low spots of runoff; guidance in this respect was obtained from topographic maps and from the runoff precipitation correlations. The interpolations were made graphically with the aid of transparent interpolation diagrams; for most of the prairies, linear diagrams were used but in areas such as the Cypress Hills in southwestern Saskatchewan and Riding Mountain in western Manitoba, where watersheds rise steeply, logarithmic interpolation diagrams were used. The use of logarithmic diagrams in hilly areas gives a closer spacing of the isopleths of runoff in the upper region of a steep watershed than in the lower. This device is admittedly artificial but is in closer agreement with fact than a linear spacing of iso-lines in such circumstances.

Using the interpolated values of runoff, isopleths were drawn on the base map with due allowance for topographic features. As a check on the accuracy of this work, median annual runoffs were calculated from the isopleths for several large basins and were found to be in good agreement with the values obtained from the corresponding gauging-station records.

The median annual unit runoff map, Fig. 1, shows the results of this part of the investigation.

VII.

REGIONAL RUNOFF VARIABILITY

The median annual unit runoff is an interesting and useful figure in that it is a measure of the volume which may be anticipated in an average year, but it is not adequate for planning and design. It is important to know how runoff may vary from year to year; to know the extent to which it may be depended upon as a source of supply. This problem was approached in two ways: (a) by the analysis of mass curves, and (b) by the analysis of frequency curves.

(a) Mass Curve Analysis

In the construction of the mass curves, annual unit runoff data obtained from the compilation referred to in Chapter V was tabulated and summated for each year of the period 1911-56. The cumulative unit runoffs so obtained were then plotted against a time base of years. The use of unit rather than total runoffs facilitated comparison and the use of annual rather than monthly runoffs was justified in view of the long duration of the drought period of the 1930's. Typical mass curves are shown in Fig. 17, the upper curve of which characterizesthe foothill-mountain area of Alberta; the middle and lower curves characterize the "hilly" and "flat" areas respectively of the plains region. It is interesting to compare the mass curves of Fig. 17 with the frequency curves of Fig. 18. From the mass curves, the following information was obtained:-

(i) storage (in acre-feet per square-mile of "dry" drainage area) necessary to maintain annual yields equal to 25%, 50%, 75% and 100% of the median annual unit runoff;

(ii) detention period (i.e., the ratio of storage to median annual unit runoff) for the various annual yields mentioned in (i);

and (iii) "spill-to-spill period" (i.e., the time interval during which there would be no overflow) for the various annual yields mentioned in (i).

From the information obtained in (i), curves relating unit storage to unit yield were constructed in which both variables were expressed as percentages of the median annual unit runoff. It was found that these curves could be grouped into regions with each region having its own composite curve. The "storage-yield" regions are shown in Fig. 2, and the regional curves in Figs. 4 to 8 inclusive.

Concerning the detention periods obtained in (ii), these were plotted on a base map at the locations of the hydrometric stations to which they applied. The detention period represents

the average time of stay of water in a reservoir from entry to exit. It should be noted that "exit" implies not only discharge through the conduit but also evaporation from the water surface. The detention period is influenced by the amount of artificial regulation, i.e., storage, and the variability and volume of runoff. It is interesting to note that in the mountain areas of Alberta, where runoff volume is high and variability low, the detention periods are of the order of three to four years for yields equal to the median runoff. Conversely, in the plains region where runoff is low and variability high, the detention periods are longer and range from seven to ten years for yields equal to the median. In the foothills area of Alberta and the Cypress Hills area of Saskatchewan which are characterized by moderate runoff and moderate variability, the detention periods range from four to seven years. No useful conclusions however were drawn from this attempt at utilizing the detention period.

It has been mentioned on page 14, that the "wet to dry" drainage area ratio when plotted against the detention period for a yield equal to 100% of the median runoff, showed groupings of points defining the mountain, foothill and prairie regions as in Fig. 3. This broad regionalization is discussed in the next sub-section.

The "spill-to-spill" information referred to in (iii) was used in an attempt to establish criteria for determining optimum storage. The storage-yield curves of Figs. 4, 5, 6, 7 and 8 do not separate evaporation losses from yield. Evaporation losses from a reservoir are a function of storage/surface area characteristics and also the unit evaporation for the region in which the reservoir is situated. The latter has previously been investigated for the Canadian Prairies (9) (10), but the former is entirely dependent upon local topographical conditions and cannot be satisfactorily generalized. The optimum storage for a reservoir is considered to be that capacity beyond which there is no appreciable increase in yield after the deduction of evaporation losses. Ideally, evaporation losses should be considered directly in the optimum sizing of a reservoir. However, they may be considered indirectly if one accepts the principle that a given site would be "over-reservoired" if spill did not occur during a period of, say, seven consecutive dry years. The period adopted should be based upon experience and in the prairie region, a seven- to ten-year period appears to be appropriate, but in a wetter region with regular precipitation the figure could be as low as three years.

Accordingly, from the "spill-to-spill" information, estimates were made of the storage necessary to maintain yield during dry periods of seven and ten consecutive years for each of the hydrometric stations considered in the mass curve analysis. Some useful results were produced, but also some inconsistencies. It is considered that further study of this approach is necessary and it was therefore decided not to publish the results at present.

(b) Frequency Curve Analysis

Frequency curves were drawn for each hydrometric station using annual runoff data obtained from the compilation referred to in Chapter V. The annual runoffs were plotted to a linear vertical scale on Gumbel probability paper.

Most of the curves which departed from the straight line ideal were "concave up." This was particularly the case in the drier areas of the prairies and is probably due to the augmentation of drainage area in years of higher runoff. The 1:10 and 1:50 annual runoffs were estimated from the curves and are given in Tables 2 and 3.

In an attempt to establish "variability" regions and to investigate low-flow characteristics, frequency curves for those gauging stations having twelve or more years of record were prepared in which the ratios of probable annual runoff to median annual runoff were plotted. Use of this ratio facilitated comparison and a mass plot revealed that the curves could be divided into three groups which defined the mountain, foothills and prairie regions. The low-flow portion of this mass plot is illustrated in Fig. 9 in which the upper group, with flat slopes indicating low variability, consists of mountain streams, the middle group with moderate slopes or moderate variability consists of foothill streams and the lower group with steep slopes or high variability define the prairie streams. Typical curves for each group are shown in Fig. 18; the corresponding mass curves are shown in Fig. 17.

This broad regionalization into mountain, foothill and prairie streams was confirmed in the course of the "fluctuating drainage area" studies described on page 13. Due to individual variations in the curves, it was not possible to regionalize to a finer scale.

(c) Summary

Of the two approaches to the problem of runoff variability in the Canadian Prairie, the mass curve was found to have more application in that it permitted regionalization to a comparatively fine scale and thereby yielded more useful results. It was not possible from the frequency curve analysis, to draw any conclusions which could be applied with confidence. The frequency curve appears to be more susceptible to the influence of poor data and the emphasis on drought persistence is lost.

The apparent refinement of the frequency curve approach can be misleading; conversely, the simplicity of the mass curve approach is less deceptive. However, with more and better data it is likely that the frequency curve approach would have yielded reliable and useful results.

VIII.

USE OF RUNOFF MAPS & STORAGE DIAGRAMS

As mentioned on page 6, the purpose of this investigation was to enable quick estimates to be made of runoff volume and variability at a given location. Such estimates, based on the results of a generalized study of this kind, should be satisfactory for purposes of comparison and initial appraisal of a proposed project. They should not, however, be regarded as having the degree of accuracy which would be achieved as the result of an individual water budget study for the site concerned in which due allowance is made for variable inflow, fluctuating demand, reservoir characteristics and evaporation.

In order to use the results of this investigation to assess the potential of a given reservoir site, it is first necessary to delineate the "dry" drainage area with the aid of topographic and drainage maps. A median annual unit runoff for the basin tributary to the site is then selected from the unit runoff map, Fig. 1, with judicious allowance for the effects of any local topographic variations. The median annual runoff in acre-feet per annum is then obtained by multiplying the unit runoff by the drainage area. The appropriate unit storage-yield curve (in which the ordinate and abscissa are expressed as percentages of the median) is selected from Figs. 4 to 8 by referring to the regional map, Fig. 3. From the unit storage-yield curve, the storage to maintain a particular gross yield or the gross yield from a given volume of storage may be estimated. Alternatively a storage-yield curve in which the ordinate and abscissa are expressed in acre-feet and acre-feet per annum may be prepared from the unit storage-yield curve. Because a considerable portion of the gross yield leaves a reservoir as evaporation, an adjustment must be made to the storage-yield curve before using it to determine optimum reservoir size. Given the storage-surface area characteristics of the reservoir, it is possible to estimate the evaporation losses for various gross yields and prepare a storage-net draft curve from which the optimum storage may be deduced. Determinations of optimum storage made in this manner should provide a reliable basis of comparison in the selection of reservoir sites but the final "sizing" of a reservoir should, as mentioned earlier, be based on a detailed water budget study.

IX.

SUMMARY AND CONCLUSIONS

This paper presents the findings of a general investigation of the volume and variability of surface water runoff in the more populated region of the Canadian Prairie. Limitations of data, as regards quality and quantity, imposed restrictions on the extent of results. However, it was found possible to describe runoff with a useful degree of accuracy, volume being considered in terms of variation of the median annual unit runoff across the area of study, and variability by the delineation of regions within which the annual fluctuations of streamflow were essentially the same. The results presented are applicable to watersheds which have drainage areas of from 30 to 2000 square miles.

A more precise definition of run-off would require a better understanding of the effects of watershed factors on runoff. This in turn must await the gathering and analysis of more and better data. In the mountain and foothill regions of Alberta when data are available, investigation of factors such as elevation, gradient, orientation and precipitation should improve the definition of runoff. In the prairie region consideration of factors such as fluctuation of drainage area, size of drainage area, soil cover and porosity, and precipitation should give a better understanding of runoff when the necessary information is obtainable.

A variety of approaches and a number of refined statistical devices were tried in examination of the phenomena associated with runoff. The general conclusion was that the more simple techniques are the least misleading when working with limited and uncertain data.

The methods given for the determination of median annual runoff and storage potential should be regarded as having the degree of accuracy which would be associated with preliminary project studies. Recent checks on the accuracy of the runoff map, Fig. 1, have been encouraging. The runoff map may also prove helpful in the estimation of conveyance losses ~~in natural gauged channels.~~ The inflow between two hydrometric stations on the same stream, may be estimated from the map, compared with the inflow determined from streamflow records and thereby give an indication of the conveyance losses.

In conclusion, it is hoped that the results of this investigation will be useful and that the fields of research which have been indicated will prove fruitful in future studies.

X.

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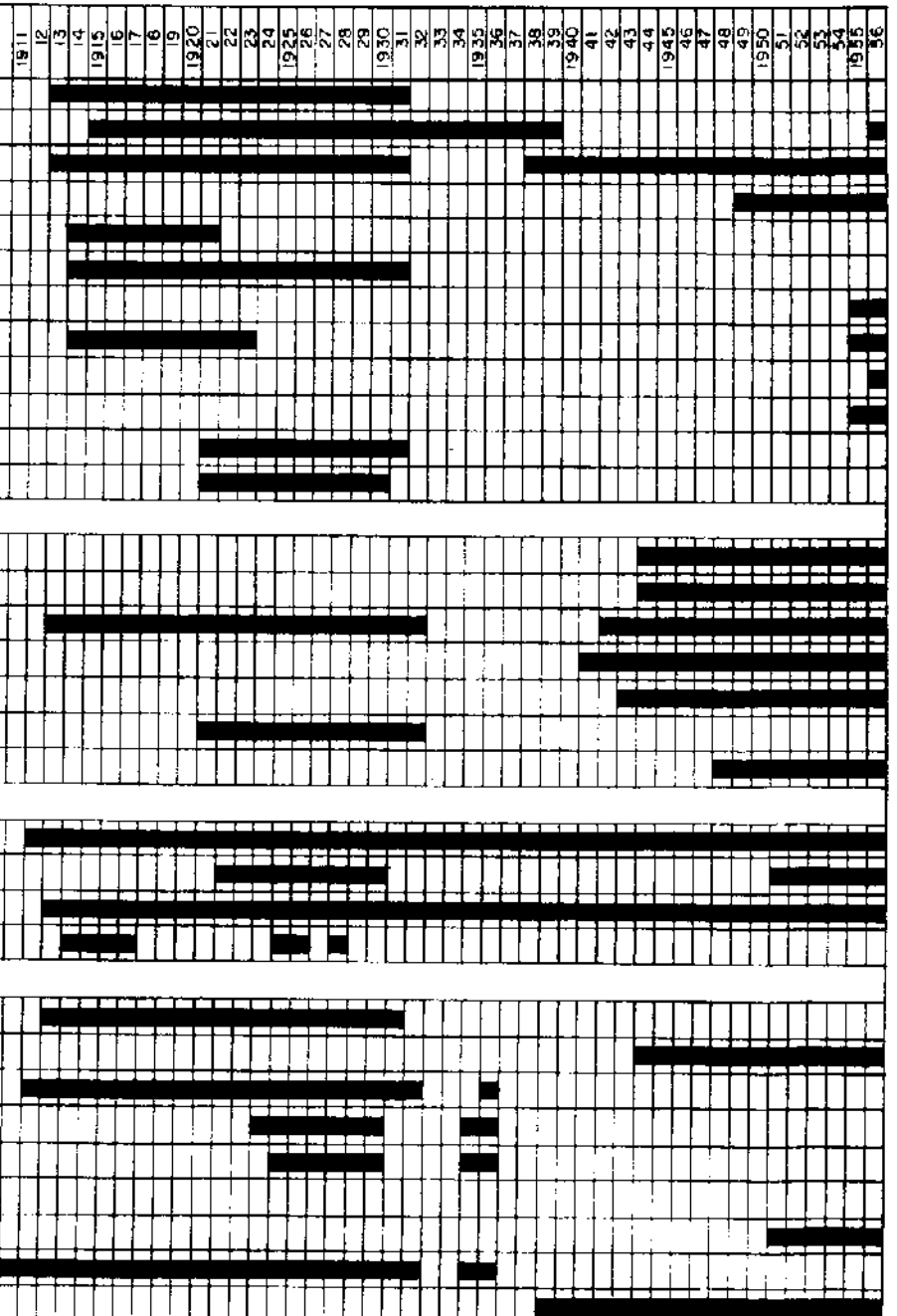
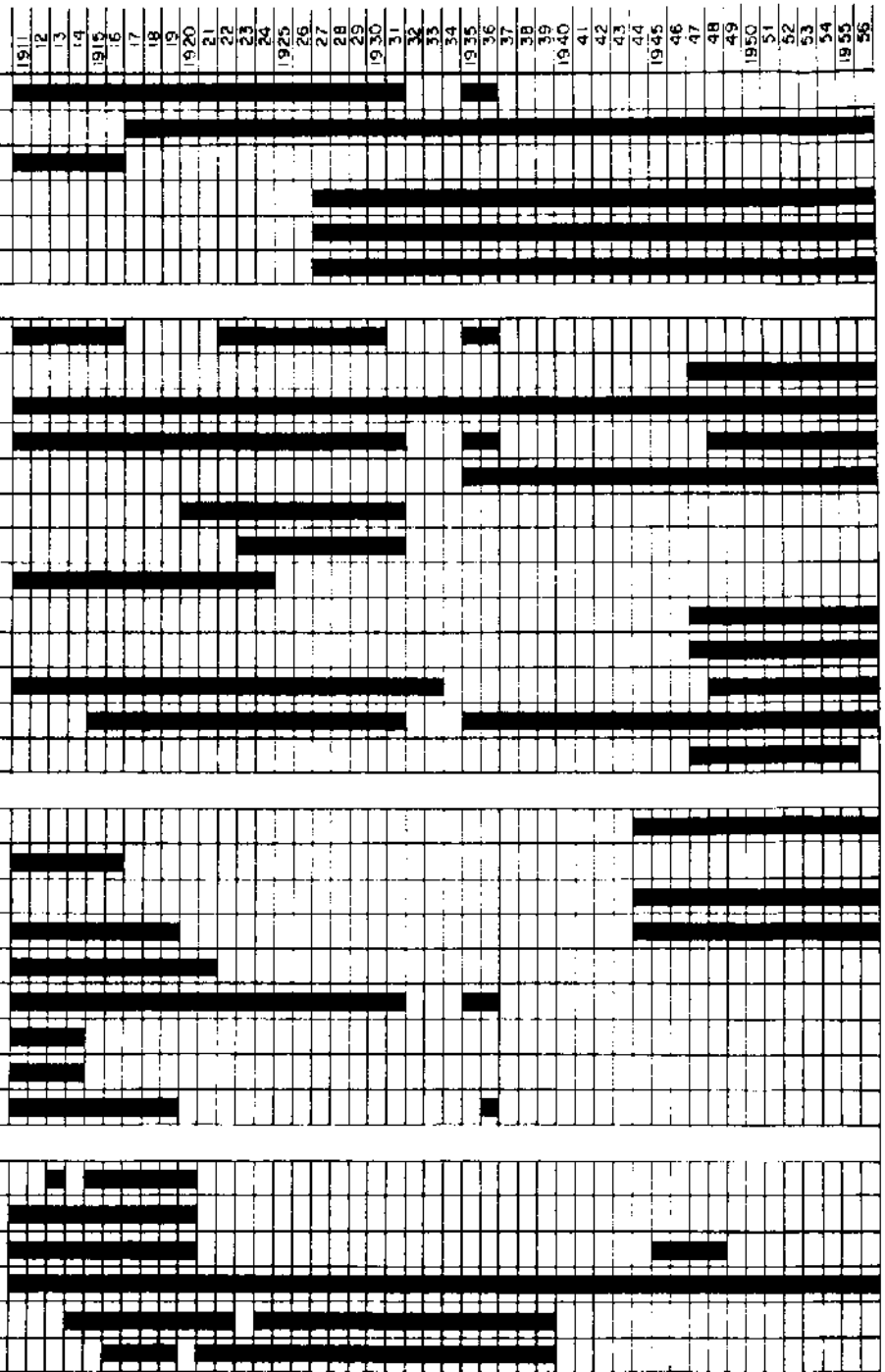
TABLE I. - AVAILABLE RECORDS OF HYDROMETRIC STATIONS

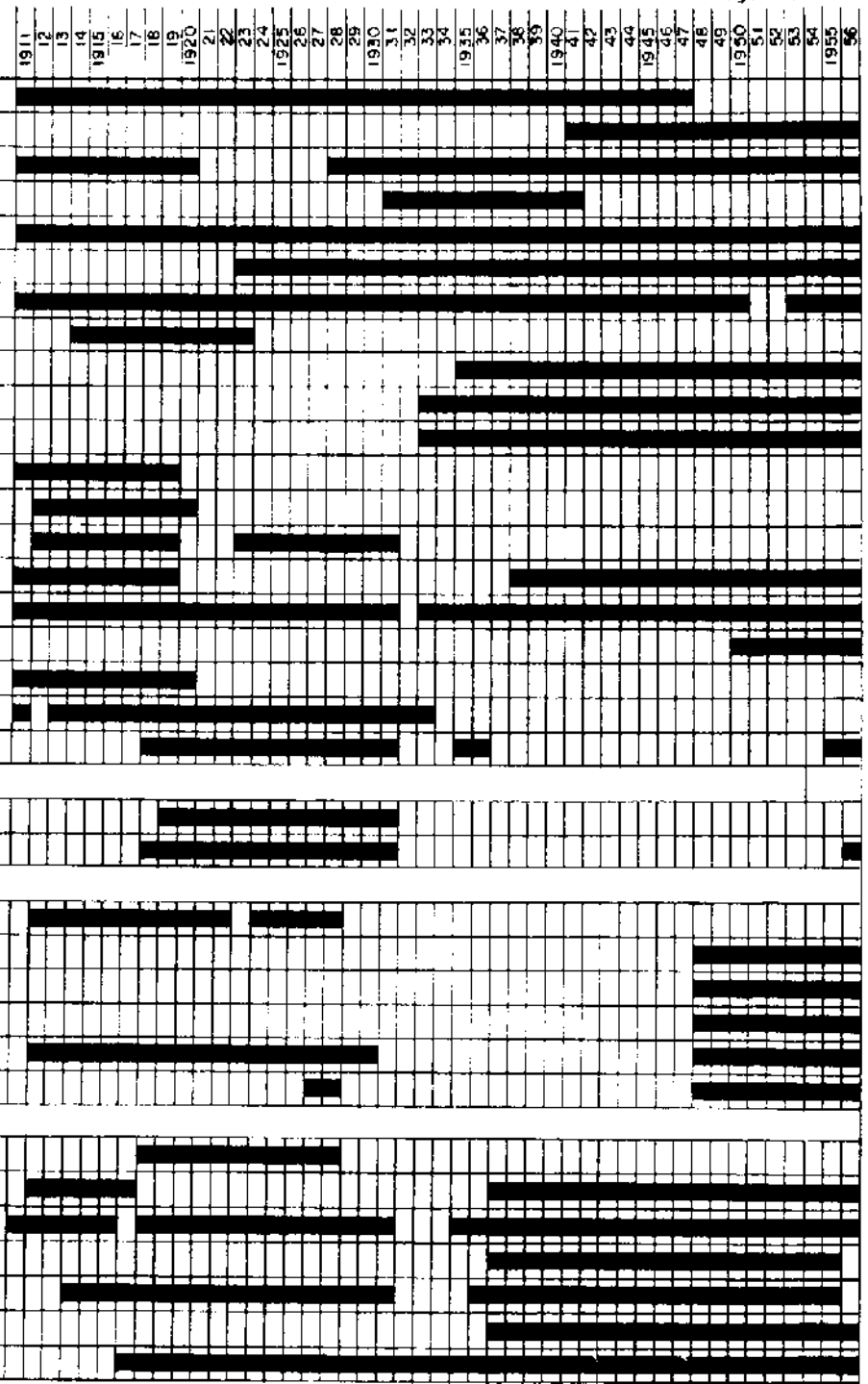
REF. NO.	STATION NO.	STATION LOCATION
1/1	7AA2	Athabasca R. near Jasper
1/2	7AD1	Athabasca R. at Entrance
1/3	7BE1	Athabasca R. at Athabasca
1/4	7AA7	Sunwapta R. at Athabasca Glacier
1/5	7AA1	Miette R. at Jasper
1/6	7AG1	McLeod R. at Wolf Creek
1/7	7AG3	Wolf Cr. at No. 16 Highway
1/8	7BB2	Pembina R. at Entwistle
1/9	7BA1	Pembina R. below Paddy Creek
1/10	7BB3	Lobstick R. near Seyal
1/11	7BF2	West Prairie R. at High Prairie
1/12	7BF4	Heart R. at High Prairie
2/13	5MC1	Assiniboine R. at Sturgis
2/14	5MD4	Assiniboine R. at Kamsack
2/15	5ME1	Assiniboine R. at Millwood
2/16	5MB1	Yorkton Cr. at Ebenezer
2/17	5MB3	Whitesand R. near Canora
2/18	5MD2	Shell R. at Roblin
2/19	5MD5	Shell R. at Inglis
3/20	5MH1	Assiniboine R. at Brandon
3/21	5MJ3	Assiniboine R. at Portage la Prairie
3/22	5MJ1	Assiniboine R. at Headingly
3/23	5ME2	Birdtail Cr. at Birtle
4/24	5FA1	Battle R. at Ponoka
4/25	5FE1	Battle R. at Unwin
4/26	5FF2	Battle R. near Battleford
4/27	5FD1	Ribstone Cr. near Heath
4/28	5FD3	Ribstone Cr. near Ribstone
5/29	11AB81	Battle Cr. at Ranger Station
5/30	11AB3	Battle Cr. at Battle Cr.
5/31	11AB76	Battle Cr. above Cypress Lake



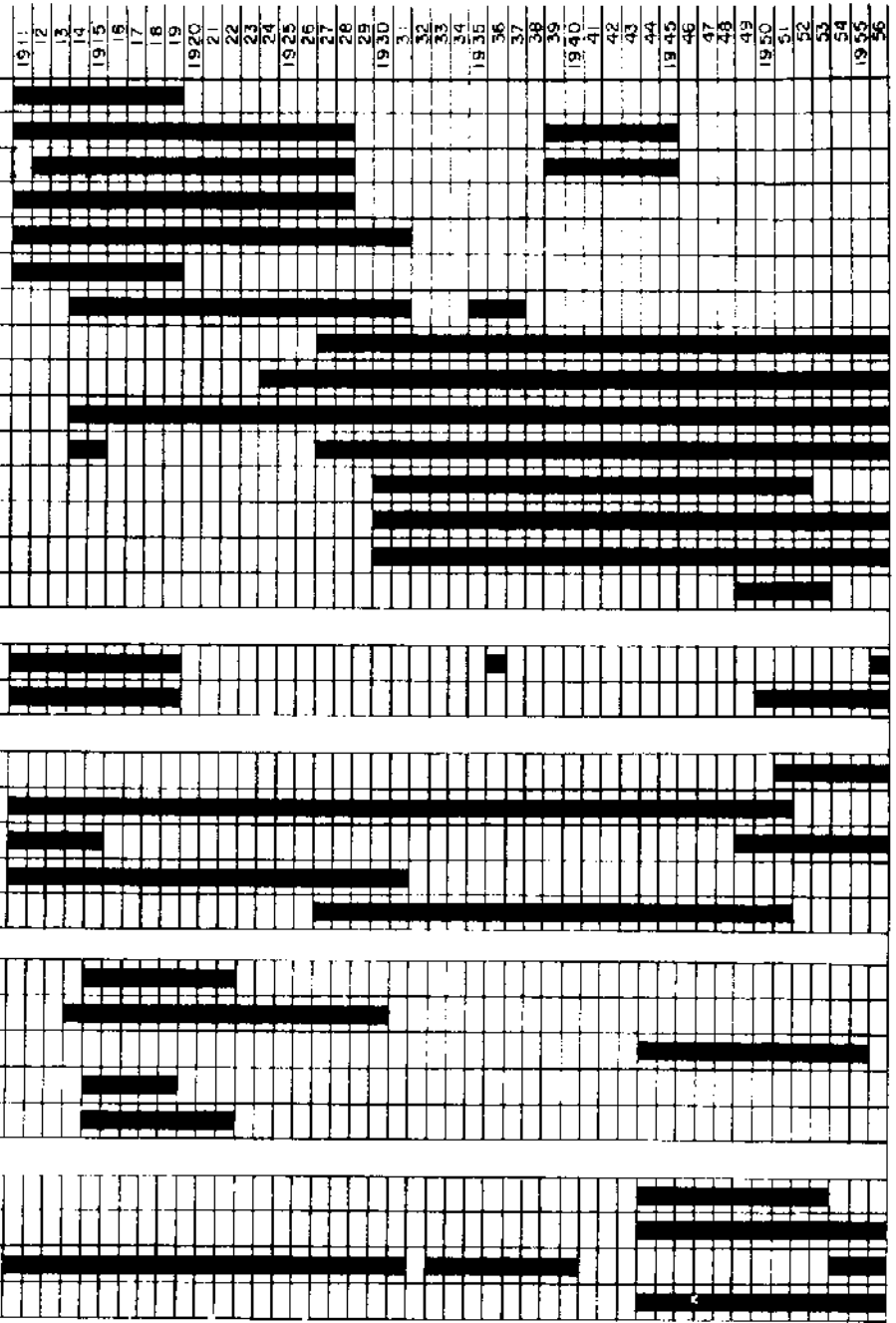
5/32	11AB10	Battle Cr. at Nash's Ranch
5/33	11AB27	Battle Cr. at International Bdry.
5/34	11AB14	Six Mile Coulee at Spangler's Ranch
5/35	11AB0.1	Woodpile Coulee near Internat. Bdry.
5/36	11AB75	Lyon's Coulee at Internat. Bdry.
5/37	11ABC.3	Battle Cr. (E. Branch) near Int. Bdry.
6/38	5AD1	Mami Cr. at Mountain View
6/39	5ADC.4	Belly R. at International Bdry.
6/40	5AD5	Belly R. at Mountain View (Nat. Flow)
6/41	5AD2	Belly R. near Standoff (Nat. Flow)
6/42	5AD16	Drywood R. (N. Branch) near Twin Butte
6/43	5AD10	Drywood R. near Fishburn
6/44	5AD12	Cottonwood Cr. near Twin Butte
6/45	5AD4	Crooked Cr. near Waterton Park
6/46	5ADC.2	Boundary Cr. at International Bdry.
6/47	5ADC.1	Waterton R. near International Bdry.
6/48	5AD3	Waterton R. at Waterton Park
6/49	5AD8	Waterton R. near Standoff
6/50	5ADC.3	Street Cr. at International Bdry.
7/51	5HA69	Gap Creek below Downie Lake Diversion
7/52	5HA9	Gap Creek near Small's Ranch
7/53	5HA72	Gap Creek above Junction Reservoir
7/54	5HA	Maple Creek above Junction Reservoir
7/55	5HA21	Hay Creek at Hay Creek School
7/56	5HA3	Bear Cr. at Unsworth's Ranch
7/57	5HA4	Bear Cr. (East Br.) at Johnston's Ranch
7/58	5HA5	Bear Cr. (West Br.) at Bertram's Ranch
7/59	5HA62	Piapot Cr. at Cumberland's Ranch
8/60	5BA3	Bath Cr. near Lake Louise
8/61	5BA1	Bow R. at Lake Louise
8/62	5BB3	Forty Mile Cr. near Banff
8/63	5BB1	Bow River at Banff
8/64	5BC3	Spray Cr. at Spray Lakes (1911 - 1948)
8/65	5BC2	Spray R. near Spray Lakes



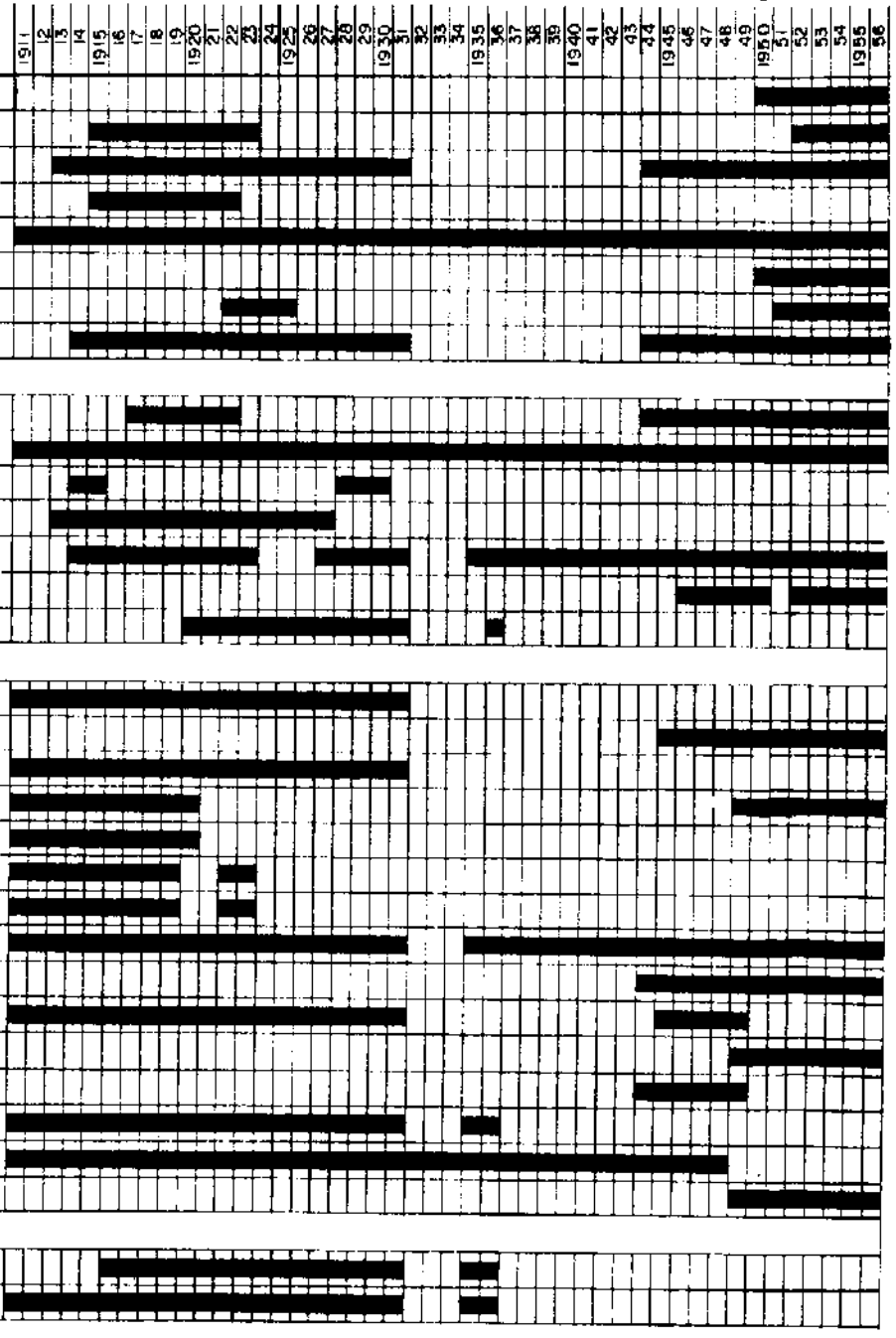
8/66	5FC1	Spray R. at Banff (1911 - 1948)
8/67	5BG2	Ghost R. near Blackrock Mtn.
8/68	5BG1	Ghost River near Cochrane
8/69	5BF4	Pocaterra Cr. near Mouth
8/70	5EF1	Kananaskis R. near Seebe
8/71	5BE4	Bow R. near Seebe
8/72	5BH4	Bow R. at Calgary
8/73	5BJ3	Elbow R. at Fullerton's Ranch
8/74	5BJ4	Elbow R. at Bragg Creek
8/75	5BJ5	Elbow R. above Glenmore Dam
8/76	5BJ1	Elbow R. below Glenmore Dam
8/77	5BH3	Nose Creek at Calgary
8/78	5BL8	Highwood R. at Brown's Ranch
8/79	5BL6	Pekisko Creek at Pekisko
8/80	5BL7	Stimson Creek near Pekisko
8/81	5BL9	Highwood R. near Aldersyde (Natural Flow)
8/82	5BL18	Sheep R. at Buck's Ranch
8/83	5BL12	Sheep R. near Okotoks
8/84	5BM4	Bow River at Bassano
8/85	5AC3	Little Bow R. at Carmangay
9/86	5KA3	Carrot R. at Beaulieu's Farm
9/87	5KA1	Carrot R. at Kinistino
10/88	5LJ4	Valley River at Valley River
10/89	5LJ10	Valley River near Dauphin
10/91	5LJ11	Wilson River near Dauphin
10/92	5LJ12	Vermilion River near Dauphin
10/93	5LJ5	Ochre River near Ochre River
10/94	5LJ7	Turtle River near Laurier
11/95	11AC40	Frenchman R. at Drury's Ranch
11/96	11AC18	Frenchman R. above Eastend Reservoir
11/97	11AC1	Frenchman R. below Eastend Reservoir
11/98	11AC57	Frenchman R. at Morrison's
11/99	11AC23	Frenchman R. at 50 Mile
11/100	11AC51	Frenchman R. below Val Marie
11/101	11AC41	Frenchman R. at International Bdry.



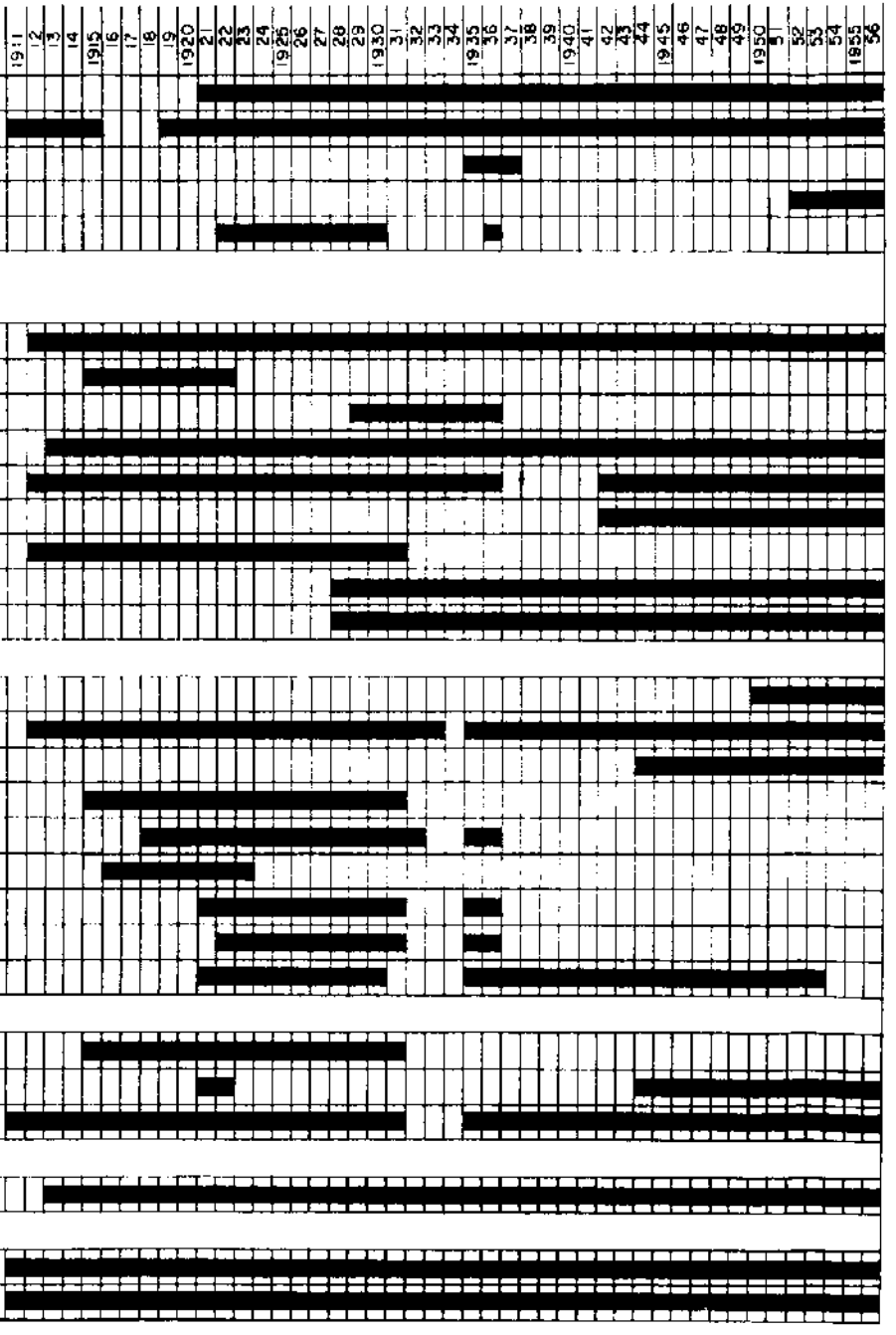
11/102	11AC9	Oxarat Cr. at Wylie's Ranch
11/103	11AC8	Sucker Cr. at Gilchrist's Ranch
11/104	11AC16	Belanger Cr. abv. Cypress L. & Inflow Canal
11/105	11AC4	Davis Cr. at Drury's Ranch
11/106	11AC3	Fairwell Cr. at Drury's Ranch
11/107	11AC2	Frenchman R. N. Branch at Cross' Ranch
11/108	11AC25	Denniel Cr. at Val Marie
11/109	11AD0.1	Whitewater Cr. at International Bdry.
11/110	11AE0.4	McEachern Cr. at International Bdry.
11/111	11AE0.3	Horse Creek at International Bdry.
11/112	11AE0.2	Rock Creek at International Bdry.
11/113	11AE2	Poplar R. (W. Branch) at International Bdry.
11/114	11AE0.5	Poplar R. (Middle Br.) at International Bdry.
11/115	11AE3	Poplar R. (East Br.) at International Bdry.
11/116	11AF0.2	Beaver Cr. at International Bdry.
12/117	5AH2	McKay Cr. at Walsh
12/118	5AH1	Boxelder Cr. at Walsh
13/119	11AB82	Lodge Cr. near Alberta Boundary
13/120	11AB6	Lodge Cr. at International Boundary
13/121	11AB9	Middle Cr. at International Boundary
13/122	11AB8	Middle Cr. at Hammond's Ranch
13/123	11AB70	McRae Coulee near International Boundary
14/124	5MF5	Minnedosa R. at Elphinstone
14/125	5MF1	Minnedosa R. at Beilby's Bridge
14/126	5MF17&18	Minnedosa R. 2 mi No. of Rivers
14/127	5MF9	Whirlpool R. at Danvers
14/128	5MF8	Rolling R. at C.N.R., Lea's Bridge
15/129	5JE5	Avonlea Cr. near Rouleau
15/130	5JE4	Moose Jaw Cr. near Rouleau
15/131	5JE1	Moose Jaw Cr. at McCarthy's
15/132	5JG8	Moose Jaw Cr. above Jctn Qu'Appelle R.



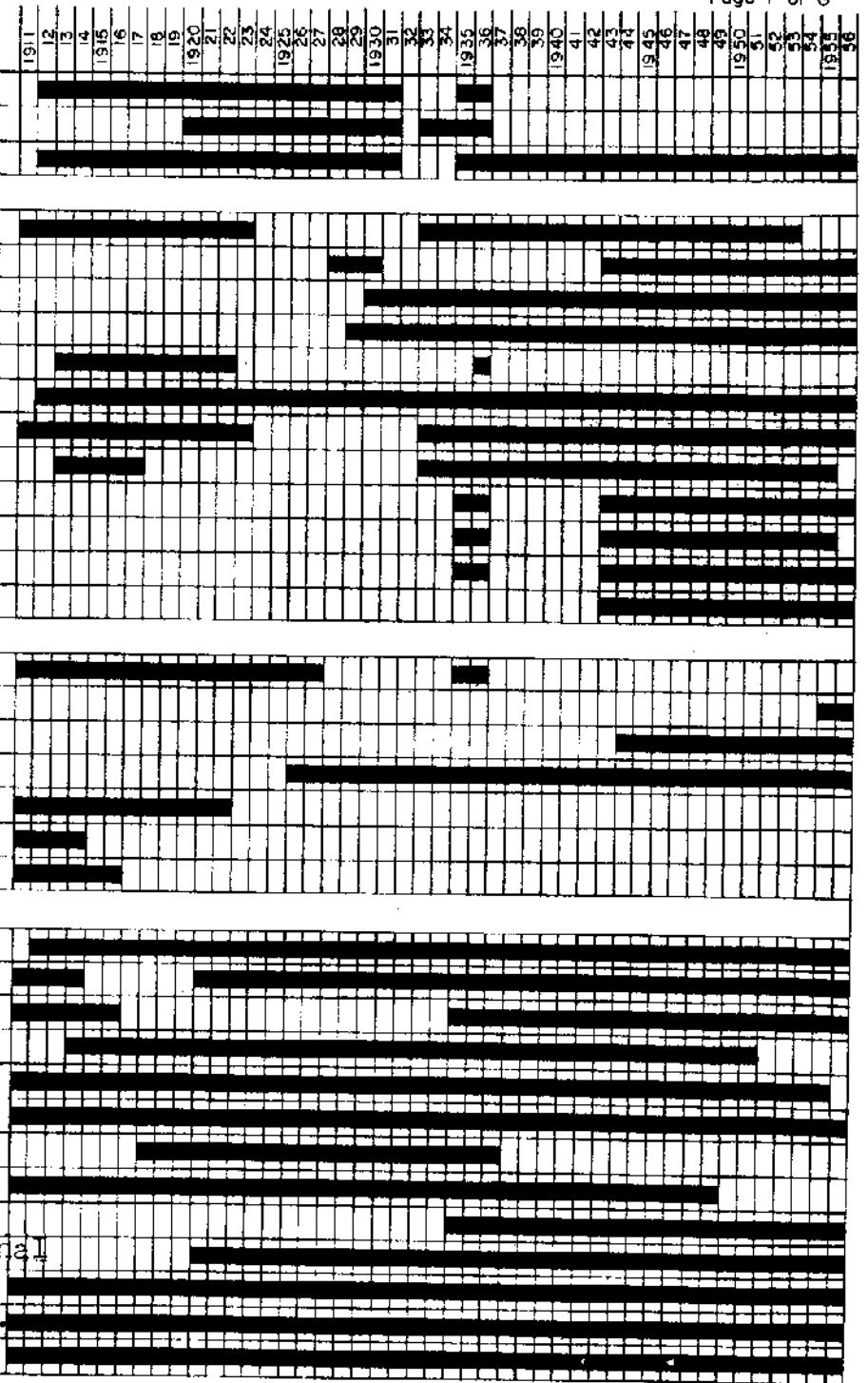
16/133	5DA6	North Saskatchewan R. at Sask. Crossing
16/134	5DC2	North Saskatchewan R. near Saunders
16/135	5DC1	North Saskatchewan R. near Rocky Mtn. House
16/136	5DE1	North Saskatchewan R. at Rocky Rapids
16/137	5DF1	North Saskatchewan R. at Edmonton
16/138	5DA7	Mistaya R. at Saskatchewan Crossing
16/139	5DB2	Prairie Cr. near Rocky Mtn. House
16/140	5DB1	Clearwater R. near Rocky Mtn. House
17/141	5EF1	North Sask. R. near Frenchman Butte
17/142	5GG1	North Sask. R. at Prince Albert
17/143	5EA5	Sturgeon R. near Villeneuve
17/144	5EA2	Sturgeon R. near St. Albert
17/145	5EA1	Sturgeon R. at Fort Saskatchewan
17/146	5GG3	Spruce R. Outlet of Anglin Lake
17/147	5GA1	Eyehill Cr. near Yonker
18/148	5AA3	Castle R. near Cowley
18/149	5AA22	Castle R. near Beaver Mines
18/150	5AA2	Crowsnest R. at Lundbreck
18/151	5AA8	Crowsnest R. at Frank
18/152	5AA9	Crowsnest R. at Coleman
18/153	5AB6	Meadow Cr. at Hart's Ranch
18/154	5AB3	Trout Cr. at Lockwood's Ranch
18/155	5AB2	Willow Cr. at Nolan
18/156	5AB21	Willow Cr. at Claresholm
18/157	5AA1	Oldman River at Cowley
18/158	5AA23	Oldman River at Waldron's Corner
18/159	5AA21	Oldman River at The Gap
18/160	5AA4	Pincher Creek at Pincher Creek
18/161	5AB7	Oldman River at McLeod (Natural Flow)
18/162	5AD19	Oldman River at Monarch
19/163	5AF8	Irrigation Cr. near Orion
19/164	5AF10	Manyberries Cr. at Brodin's Farm



		Western Tributaries
20/165	5OB3	Pembina R. at Manitou
20/166	5OCO.1	Pembina R. at Neche
20/167	5OG2	Riviere Sale at LaSalle
20/168	5OF6	Morris R. near Stephenfield
20/169	5OA2	Whitemud Cr. West of Holmfield
		Eastern Tributaries
20/170	5OC1	Red River at Emerson
20/171	5OD4	Roseau R. at Gardenton
20/172	5OD14	Roseau R. at Stuartburn
20/173	5OD1	Roseau R. near Dominion City
20/174	5OE1	Rat R. near Otterburne
20/174A	5OH6	Seine R. at Prairie Grove
20/175	5SA1	Brokenhead River at St. Queens
20/176	5ODC.4	Pine Creek near Pine Cr.
20/177	5ODC.3	Sprague Cr. near Sprague
21/178	5CA1	Red Deer R. near Sundre
21/179	5CC2	Red Deer R. at Red Deer
21/180	5CD4	Red Deer R. near Nevis
21/181	5CE1	Red Deer R. at Drumheller
21/182	5CK2	Red Deer R. at Empress
21/183	5CC1	Blindman R. near Blackfalds
21/184	5CE2	Kneehill Cr. near Drumheller
21/185	5CE3	Rosebud R. at Beynon
21/186	5CH2	Berry Cr. near Wardlow
22/187	5AH13	Bullshead Cr. near Woolchester
22/188	5AH37	Gros Ventre Cr. near Coleridge
22/189	5AH3	Ross Cr. near Irvine
23/190	5KJ1	Saskatchewan River at The Pas
24/191	5RG1	South Saskatchewan River at Saskatoon
24/192	5AJ1	South Saskatchewan River at Medicine Hat



25/193	5AH38	Paradise Cr. near Seven Persons
25/194	5AH33	Seven Persons Creek near Seven Persons
25/195	5AH5	Seven Persons Cr. at Medicine Hat
26/196	5NB2	Souris R. near Estevan
26/197	5ND3	Souris R. at Oxbow
26/198	5NF0.2	Souris R. at Sherwood N.D.
26/199	5NF0.1	Souris R. at Westhope N.D.
26/200	5NF1	Souris R. at Melita
26/201	5NG1	Souris R. at Wawanesa
26/202	5NB3	Long Cr. near Estevan
26/203	5ND2	Moose Mountain Cr. near Oxbow
26/204	5NF2	Antler Cr. near Melita
26/205	5NF3	Gainsborough Cr. near Melita
26/206	5NF4	Graham Cr. near Melita
26/207	5NG6	Pipestone Cr. near Reston
27/208	5HD5	Swift Current Cr. at Sinclairs Ranch
27/209	5HD36	Swift Current Cr. at Highway No. 37
27/210	5HD30	Swift Current Cr. below Jctn. Pelletier Cr.
27/211	5HD7	Swift Current Cr. near Swift Current
27/212	5HA16	Skull Cr. at Doyles Ranch
27/213	5HA2	Skull Cr. near Skull Cr.
27/214	5HA13	Bridge Cr. near Raymond & Boyles Ranch
28/215	5AE0.5	Swift Current Cr. at Many Glacier
28/216	5AE2	Lee Creek at Cardston
28/217	5AE5	Rolph Creek at Kimball
28/218	5AE11	Pothole Cr. (Upper Station) at Magrath
28/219	5AE1	St. Mary R. at Intern. Bdry. (Natural Flow)
28/220	5AE6	St. Mary R. at Lethbridge (Natural Flow)
28/221	5AE0.4	Canyon Cr. near Many Glacier
28/222	5AD7	Oldman R. at Lethbridge (Natural Flow)
28/223	11AA26	Sage Cr. at "Q" Ranch
28/224	11AA0.3	Milk R. North Branch above U.S. St. Mary Canal
28/225	11AA5	Milk R. at Milk River (Natural Flow)
28/226	11AA25	Milk R. (S. Branch) near International Bdry.
28/227	11AA0.2	Milk R. at Eastern Crossing (Natural Flow)



29/228	5JG4	Qu'Appelle R. above Buffalo Pd. Lake
29/229	5JG7	Qu'Appelle R. below Jctn. Moose Jaw Creek
29/230	5JF1	Qu'Appelle R. at Lumsden
29/231	5JK2	Qu'Appelle R. below Craven Dam
29/232	5JM3	Qu'Appelle R. at Tantallon
29/233	5JF4	Waskana Cr. near Sedley
29/234	5JF3	Waskana Cr. at Regina
29/235	5JF5	Waskana Cr. above Jctn. Qu'Appelle R.
29/236	5JH1	Arm R. near Bethune
29/237	5JK4	Jumping Deer Cr. near Lipton
29/238	5JL2	Indian Head Cr. near Indian Head
29/239	5JL5	Pheasant Cr. near Abernethy
29/240	5JM5	Kaposvar Cr. near Tantallon
29/241	5JM4	Cutarm Cr. near Spy Hill
30/242	5LE1	Swan R. at Swan River
30/243	5LC1	Red Deer River at Erwood
31/244	5JA2	Wood River near LaFleche
31/245	5JA1	Wood River near Gravelbourg
31/246	5JA1 &	
	5JA2	5JA1 and 5JA2 Combined
31/247	5JB2	Russel Creek near Vanguard
31/248	5JB1	Notukeu Creek near Vanguard
31/249	5JB3	Notukeu Creek near Gravelbourg
31/250	5JC1	Wiwa Creek near Gravelbourg

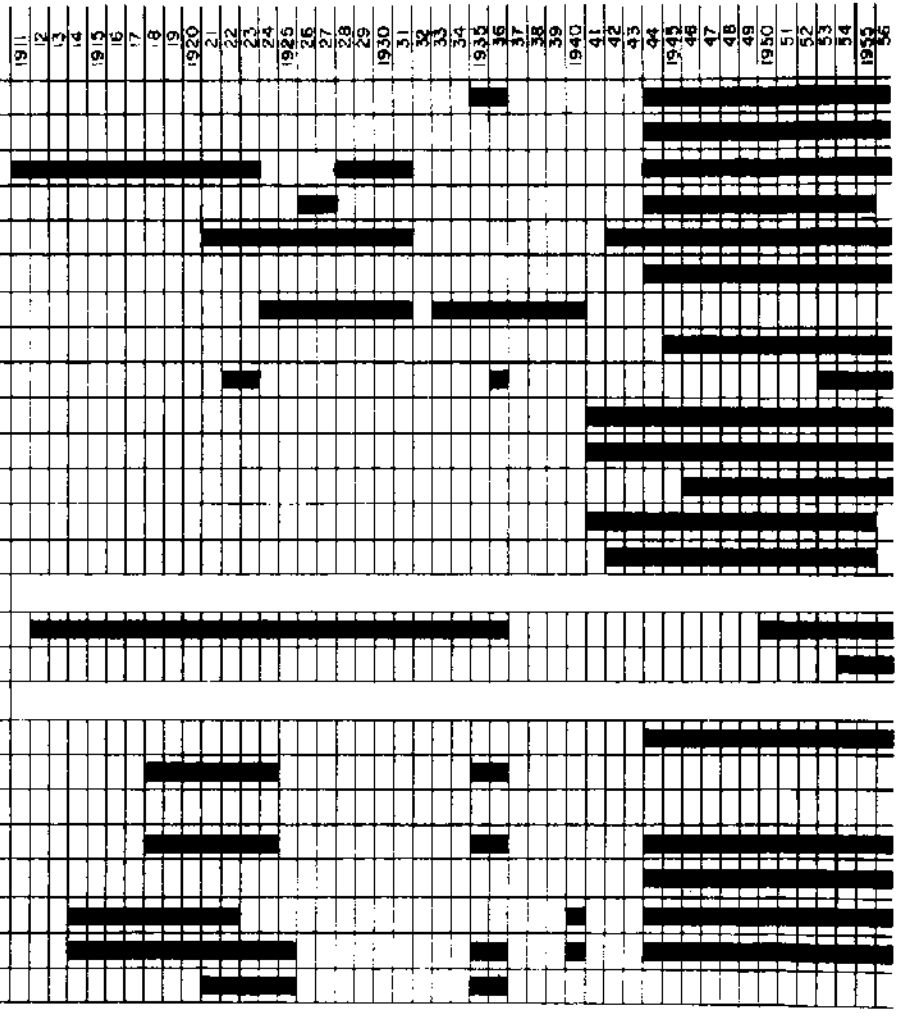


TABLE 2

STREAMFLOW DATA

REF. NO.	STATION NO.	HYDROMETRIC STATION LOCATION	DRAINAGE AREAS "DRY" D_d	DRAINAGE AREAS "WET" D_w	ANNUAL RUNOFF MEDIAN ac-ft. p.a.	MEDIAN ac-ft. p.a. /D_d	MEDIAN ac-ft. p.a. /D_w	1:10 ac-ft. p.a.	1:10 ac-ft. p.a. /D_d	1:10 ac-ft. p.a. /D_w	1:50 ac-ft. p.a.	1:50 ac-ft. p.a. /D_w
1/1	7AA2	Athabasca R. near Jasper		1,576*	2,294,000		1,456	2,610,000		1,656	2,890,000	1,834
1/2	7AD1	Athabasca R. at Entrance		3,915*	4,892,000		1,249	5,500,000		1,405	6,140,000	1,568
1/3	7BE1	Athabasca R. at Athabasca		29,643*	10,340,000		349	13,200,000		445	17,600,000	594
1/4	7AA7	Sunwapta R. at Athabasca Glacier		11*	30,250		2,750	37,800		3,436	44,500	4,045
1/5	7AA1	Miette R. at Jasper		250*	294,500		1,176	342,000		1,368	378,000	1,512
1/6	7AG1	McLeod R. at Wolf Creek		2,510*	869,000		347	1,305,000		520	1,450,000	578
1/7	7AG3	Wolf Cr. at No. 16 Highway		350*	85,000		243	125,000		357	150,000	429
1/8	7BB2	Pembina R. at Entwistle		1,706*	473,000		277	765,000		448		
1/9	7BA1	Pembina R. below Paddy Creek		1,112*	326,000		293	585,000		526	655,000	589
1/10	7BB3	Lobstick R. near Styal		700*	95,000		135	171,000		244	212,000	303
1/11	7BF2	West Prairie R. at High Prairie		430*	112,200		261	180,000		419	237,000	551
1/12	7BF4	Heart R. at High Prairie		1,725*	207,700		120	352,000		204		
2/13	5MC1	Assiniboine R. at Sturgis	370	770	51,000	138	66	200,000	540	260	387,000	503
2/14	5MD4	Assiniboine R. at Kamsack	1,575	3,147	142,500	90	45	597,000	379	190	1,062,000	337
2/15	5ME1	Assiniboine R. at Millwood	2,404	4,631	293,000	122	63	895,000	372	193	1,562,500	337
2/16	5MB1	Yorkton Cr. at Ebenezer	111	229	11,000	99	48	87,000	784	380	164,200	717
2/17	5MB3	Whitesand R. near Canora	823	1,729	47,000	57	27	280,000	340	162	622,000	360
2/18	5MD2	Shell R. at Roblin	216	445	86,000	398	193	164,300	761	369	225,000	506
2/19	5MD5	Shell R. at Inglis	249	516	104,500	420	202	199,000	799	386	284,000	550
3/20	5MH1	Assiniboine R. at Brandon	8,359	20,000	685,000	82	34	2,025,000	242	101	2,660,000	133
3/21	5MJ3	Assiniboine R. at Portage la Prairie										
3/22	5MJ1	Assiniboine R. at Headingly										
3/23	5ME2	Birdtail Cr. at Birtle	124	381	34,000	274	89	82,500	665	217	137,500	361
4/24	5FA1	Battle R. at Ponoka	165	603	63,000	382	104	185,000	1,120	306	238,000	394
4/25	5FE1	Battle R. at Unwin	1,842	5,682	172,000	93	30	447,000	243	79	607,000	107
4/26	5FF2	Battle R. near Battleford	2,197	6,432	243,000	111	38	590,000	268	92	710,000	110
4/27	5FD1	Ribstone Cr. near Heath	193	507	9,200	48	19	25,800	134	51	38,200	75
4/28	5FD3	Ribstone Cr. near Ribstone	231	714	12,500	54	18	34,000	147	48	48,500	68
5/29	11AB81	Battle Cr. at Ranger Station	78	81	12,600	162	156	30,300	389	374	53,300	658
5/30	11AB3	Battle Cr. at Battle Cr.	178	193	16,400	92	85	38,000	213	197	63,000	326
5/31	11AB76	Battle cr. above Cypress Lake	231	249	21,200	92	85	53,000	229	213	90,000	361
5/32	11AB10	Battle Cr. at Nash's Ranch	448	568	17,500	39	31	69,000	154	121	111,000	195
5/33	11AB27	Battle Cr. at International Boundary	587	756	17,800	30	24	68,700	117	91	117,000	154
5/34	11AB14	Six Mile Coulee at Spangler's Ranch	16.5	28	2,400	145	86	6,000	364	214	10,200	364
5/35	11AB0.1	Woodpile Coulee near International Bdry.	51	68	1,800	35	26	6,800	133	100	12,600	185
5/36	11AB75	Lyon's Coulee at International Bdry.	47	66	1,250	26	19	6,400	136	97	16,600	252
5/37	11AB0.3	Battle Cr. (E. Branch)near International Bdry.	82	100	1,700	21	17	7,100	87	71	14,000	140
6/38	5AD1	Mami Cr. at Mountain View		23*	3,400		147	23,000		1,000	33,500	1,456
6/39	5AD0.4	Belly R. at International Bdry.		75*	175,500		2,346	22,700		3,031	263,000	3,516
6/40	5AD5	Belly R. at Mountain View (Nat. Flow)		121*	233,500		1,929	306,000		2,528	363,000	3,000

* Taken from Water Resources Papers of Department of Northern Affairs and National Resources.

TABLE 2 (Cont'd)

REF. NO.	STATION NO.	HYDROMETRIC STATIONS LOCATION	DRAINAGE AREAS "DRY" D_d	DRAINAGE AREAS "WET" D_w	ANNUAL RUNOFF MEDIAN ac-ft p.a.	MEDIAN ac-ft. p.a. /D_d	MEDIAN ac-ft. p.a. /D_w	1:10 ac-ft. p.a.	1:10 ac-ft. p.a. /D_d	1:10 ac-ft. p.a. /D_w	1:50 ac.ft. p.a.	1:50 ac-ft. p.a. /D_w
6/41	5AD2	Belly R. near Standoff (Nat. Flow)	356	477*	260,000	730	545	365,000	1,025	765	545,000	1,142
6/42	5AD16	Drywood R. (N. Branch) near Twin Butte		12*	14,800		1,233	23,300		1,942	33,800	2,816
6/43	5AD10	Drywood R. near Fishburn	85	98*	112,000	1,318	1,143	175,000	2,059	1,785	233,000	2,378
6/44	5AD12	Cottonwood Cr. near Twin Butte		14*	7,200		514	13,600		971	19,200	1,371
6/45	5AD4	Crooked Cr. near Waterton Park		17*	8,950		526	18,800		1,105	27,400	1,612
6/46	5AD0.2	Boundary Cr. at International Boundary		21*	52,800		2,514	65,600		3,124	77,400	3,686
6/47	5AD0.1	Waterton R. near International Boundary		61*	188,000		3,082	231,500		3,795	267,000	4,377
6/48	5AD3	Waterton R. at Waterton Park		238*	458,000		1,924	610,000		2,563	722,000	3,034
6/49	5AD8	Waterton R. near Standoff	556	674*	615,000	1,106	912	925,000	1,664	1,372	1,338,000	1,985
6/50	5AD0.3	Street Cr. at International Boundary		6*	10,050		1,675	13,750		2,291	16,200	2,700
7/51	5HA69	Gap Creek below Downie Lake Diversion	88	91	3,200	36	35	11,700	133	128	21,600	237
7/52	5HA9	Gap Creek near Small's Ranch	148	153	4,200	28	27	17,250	117	113	35,100	229
7/53	5HA72	Gap Creek above Junction Reservoir	200	213	5,700	29	27	23,200	116	111	44,500	209
7/54	5HA	Maple Creek above Junction Reservoir	67	74	2,500	37	34	9,250	138	125	18,250	246
7/55	5HA21	Hay Creek at Hay Creek School	18.8	19	600	32	32	2,250	120	118	4,180	220
7/56	5HA3	Bear Cr. at Unsworth's Ranch	90	99	9,100	101	92	19,800	220	200	31,200	315
7/57	5HA4	Bear Cr. (East Br.) at Johnston's Ranch	21	23	2,508	119	109	5,980	285	260	7,770	338
7/58	5HA5	Bear Cr. (West Br.) at Bertram's Ranch	30	38	5,380	179	142	10,300	343	271	14,600	384
7/59	5HA62	Pisqot Cr. at Cumberland's Ranch	44	49	2,900	66	59	6,580	150	134	12,200	249
8/60	5BA3	Bath Cr. near Lake Louise		26.5	53,200		2,008	69,500		2,623	84,500	3,189
8/61	5BA1	Bow R. at Lake Louise		159*	269,500		1,695	315,000		1,981	344,000	2,164
8/62	5BB3	Forty Mile Cr. near Banff		62*	47,750		770	61,000		984	67,500	1,089
8/63	5BB1	Bow River at Banff		858	1,042,000		1,214	1,198,000		1,396	1,312,000	1,530
8/64	5BC3	Spray Cr. at Spray Lakes (1911 - 1948)		40	44,300		1,103	60,400		1,510	75,100	1,878
8/65	5BC2	Spray R. near Spray Lakes		193	215,000		1,114	263,000		1,363	359,000	1,860
8/66	5BC1	Spray R. at Banff (1911 - 1948)		289*	368,000		1,273	450,000		1,557	517,000	1,788
8/67	5BG2	Ghost R. near Blackrock Mtn.		81*	60,000		741	120,000		1,481	185,000	2,283
8/68	5BG1	Ghost R. near Cochrane	331	357*	165,000	498	462	308,000	930	863	390,000	1,092
8/69	5BF4	Pocaterra Cr. near Mouth		23	20,000		870	31,400		1,365	38,900	1,691
8/70	5BF1	Kananaskis R. near Seebe		373*	404,000		1,083	499,000		1,337	643,000	1,724
8/71	5BE4	Bow R. near Seebe		1,960*	2,115,000		1,079	2,550,000		1,300	2,900,000	1,480
8/72	5BH4	Bow R. at Calgary		3,000*	2,340,000		780	3,110,000		1,037	3,750,000	1,250
8/73	5BJ3	Elbow R. at Fullerton's Ranch		280	229,000		818	345,000		1,232	448,000	1,600
8/74	5BJ4	Elbow R. at Bragg Creek		300	214,000		713	365,000		1,217	498,000	1,660
8/75	5BJ5	Elbow R. above Glenmore Dam		460*	230,000		500	408,000		887	573,000	1,245
8/76	5BJ1	Elbow R. below Glenmore Dam		460*	230,000	515	500	392,000	877	852	548,000	1,191
8/77	5BH3	Nose Creek at Calgary	202	308*	14,500	72	47	44,000	218	143	79,500	258
8/78	5BL8	Highwood R. at Brown's Ranch		444	325,000		732	500,000		1,126	610,000	1,374
8/79	5BL6	Pekisko Creek at Pekisko		75	24,800		332	55,000		733	72,800	971
8/80	5BL7	Stimson Creek near Pekisko		96	17,000		177	59,300		618	82,000	854
8/81	5BL9	Highwood R. near Aldersyde (Natural Flow)	880	883*	380,000	432	430	602,000	684	682	819,000	927
8/82	5BL18	Sheep R. at Buck's Ranch		174*	126,000		724	221,000		1,270	314,000	1,804
8/83	5BL12	Sheep R. near Okotoks	559	628*	179,000	320	285	286,000	512	455	609,000	969
8/84	5BM4	Bow River at Bassano	5,831	7,610*	2,790,000	478	367	4,490,000	770	590	5,950,000	782
8/85	5AC3	Little Bow R. at Carmangay	300	1,065*	21,000	70	20	56,200	187	53	72,500	68

* Taken from Water Resources Papers of Department of Northern Affairs and National Resources.

TABLE 2 (Cont'd)

Ref. No.	STATION NO.	HYDROMETRIC STATION LOCATION	DRAINAGE AREAS "DRY" D_d	DRAINAGE AREAS "WET" D_w	ANNUAL RUNOFF MEDIAN ac-ft. p.a.	MEDIAN ac-ft. p.a. /D_d	MEDIAN ac-ft. p.a. /D_w	1:10 ac-ft. p.a.	1:10 ac.ft. p.a. /D_d	1:10 ac.ft. p.a. /D_w	1:50 ac-ft. p.a.	1:50 ac-ft. p.a. /D_w
9/86	5KA3	Carrot R. at Beaulieu's Farm	71	172	1,420	20	8	8,400	118	49	18,500	108
9/87	5KA1	Carrot R. at Kinistino	130	357	5,620	43	16	27,100	208	76	54,800	154
10/88	5LJ4	Valley River at Valley River	564	890	92,800	164	104	258,000	457	290	311,000	349
10/89	5LJ10	Valley River near Dauphin	583	914	94,000	161	103	265,000	455	290	358,000	392
10/91	5LJ11	Wilson River near Dauphin	285	330	47,000	165	142	119,000	418	361	154,000	467
10/92	5LJ12	Vermilion River near Dauphin	221	255	51,600	233	202	97,500	441	382	132,000	518
10/93	5LJ5	Ochre River near Ochre River	93	162	35,100	377	217	74,000	796	457	96,000	593
10/94	5LJ7	Turtle River near Laurier	114	203	41,300	362	203	118,000	1,035	581	169,000	833
11/95	11AC40	Frenchman R. at Drury's Ranch	54	201	7,650	142	38	20,000	370	99	34,000	169
11/96	11AC18	Frenchman R. above Eastend Reservoir	409	585	32,800	80	56	89,000	218	152	135,000	231
11/97	11AC1	Frenchman R. below Eastend Reservoir	435	611	29,800	68.5	49	82,500	190	135	145,000	237
11/98	11AC57	Frenchman R. at Morrison's	525	757	34,000	64.8	45	90,000	171	119	159,000	210
11/99	11AC23	Frenchman R. at 50 Mile	715	1,095	36,800	51.5	34	92,000	129	84	156,500	143
11/100	11AC51	Frenchman R. below Val Marie	1,024	1,507	41,100	40	27	108,000	105	72	175,000	116
11/101	11AC41	Frenchman R. at International Boundary	1,351	1,883	54,000	40	29	165,000	122	88	293,000	156
11/102	11AC9	Oxarat Cr. at Wylie's Ranch	7.2	30	1,700	236	57	5,600	776	186	10,000	332
11/103	11AC8	Sucker Cr. at Gilchrist's Ranch	34	34	2,750	81	81	6,280	185	185	10,280	302
11/104	11AC16	Belanger Cr. above Cypress L. East In flow Canal	48	59	4,720	98	80	12,500	260	212	20,700	351
11/105	11AC4	Davis Cr. at Drury's Ranch	43	43	4,700	109	109	12,500	291	291	23,400	544
11/106	11AC3	Fairwell Cr. at Drury's Ranch	129	130	9,600	74	74	23,600	183	182	41,900	322
11/107	11AC2	Frenchman R. North Branch at Cross' Ranch	43	52	4,820	112	93	12,500	289	240	22,900	440
11/108	11AC25	Dennisl Cr. at Val Marie	165	195	3,950	24	20	12,200	74	63	19,000	97
11/109	11AD0.1	Whitewater Cr. at International Boundary	85	165	1,010	12	6	13,200	155	80	34,600	210
11/110	11AE0.4	McEachern Cr. at International Boundary	175	177	5,550	32	31	18,300	105	103	31,900	180
11/111	11AE0.3	Horse Creek at International Boundary	72	74	2,980	41	40	8,550	119	116	12,300	166
11/112	11AE0.2	Rock Creek at International Bdry.	235	237	10,500	45	44	25,000	106	105	41,000	173
11/113	11AE2	Poplar R. (W. Branch) at International Bdry.	124	127	3,900	31	30	14,300	115	112	25,000	197
11/114	11AE0.5	Poplar R. (Middle Br.) at International Bdry.	354	357	11,500	33	32	37,000	105	104	53,000	148
11/115	11AE3	Poplar R. (East Br.) at International Bdry.	190	284	10,800	57	38	29,000	153	102	49,000	173
11/116	11AF0.2	Beaver Cr. at International Bdry.	165	181	8,400	51	46	22,100	134	122	36,800	203
12/117	5AH2	McKay Cr. at Welsh	122	163	5,190	43	32	30,100	247	185	47,000	288
12/118	5AH1	Boxelder Cr. at Welsh	97	118	2,400	25	20	12,350	127	105	19,750	167
13/119	11AB82	Lodge Cr. near Alberta Boundary	300	343	18,600	62	54	49,700	166	145	80,000	233
13/120	11AB6	Lodge Cr. at International Boundary	597	726	19,300	32	26	58,000	97	79	104,000	143
13/121	11AB9	Middle Cr. near Alberta Boundry	103	117	5,200	50	44	13,900	135	119	20,700	177
13/122	11AB8	Middle Cr. at Hammond's Ranch	195	236	5,770	30	24	21,000	107	89	44,000	186
13/123	11AB70	Mc Rae Coulee near International Boundary	50	58	1,130	23	19	4,000	80	69	8,900	153
14/124	5MF5	Minnedosa R. at Elphinstone	57	292	41,200	723	141	105,000	1,842	360	177,500	608
14/125	5MF1	Minnedosa R. at Bellby's Bridge	164	664	77,000	470	116	189,000	1,152	285	312,000	470
14/126	5MF17&18	Minnedosa R. 2 mi. North of Rivers	257	977	114,000	444	116	280,000	1,089	287	465,000	475
14/127	5MF9	Whirlpool R. at Danvers	40	114	16,600	415	146	40,500	1,012	355	68,000	596
14/128	5MF8	Rolling R. at C.N.R., Lea's Bridge	66	240	34,000	515	142	79,000	1,197	329	130,000	541

TABLE 2 (Cont'd)

REF. NO.	STATION No.	HYDROMETRIC STATION LOCATION	DRAINAGE AREAS "DRY" D_d	DRAINAGE AREAS "WET" D_w	ANNUAL RUNOFF MEDIAN ac-ft. p.a.	MEDIAN ac-ft. p.a. /D_d	MEDIAN ac-ft. p.a. /D_w	1:10 ac-ft. p.a.	1:10 ac-ft. p.a. /D_d	1:10 ac-ft. p.a. /D_w	1:50 ac-ft. p.a.	1:50 ac-ft. p.a. /D_w
15/129	5JE5	Avonlea Cr. near Rouleau	159	311	5,400	34	17	20,500	129	66	35,700	115
15/130	5JE4	Moose Jaw Cr. near Rouleau	430	989	16,800	39	17	78,000	181	79	138,000	139
15/131	5JE1	Moose Jaw Cr. at McCarthy's	730	1,430	20,000	27	14	101,000	138	71	177,000	124
15/132	5JG8	Moose Jaw Cr. above Jctn Qu'Appelle River	912	2,342	24,300	27	10	110,000	120	47	212,500	91
16/133	5DA6	North Saskatchewan R. at Saskatchewan Crossing		4851	1,020,000		2,103	1,210,000		2,495	1,446,000	2,981
16/134	5DC2	North Saskatchewan R. near Saunders	1,904	1,904*	2,368,000	1,244	1,244	2,845,000	1,494	1,494	3,170,000	1,665
16/135	5DC1	North Saskatchewan R. nr Rocky Mtn. Hse.	4,089	4,160*	3,500,000	856	841	4,490,000	1,098	1,079	5,220,000	1,255
16/136	5DE1	North Saskatchewan R. at Rocky Rapids	7,996	8,203*	5,600,000	700	683	7,725,000	966	942	9,620,000	1,173
16/137	5DF1	North Saskatchewan R. at Edmonton	8,852	10,500*	5,440,000	615	518	7,540,000	852	718	9,400,000	895
16/138	5DA7	Mistaya R. at Saskatchewan Crossing	94	94*	181,800	1,934	1,934	213,500	2,271	2,271	255,000	2,713
16/139	5DB2	Prairie Cr. near Rocky Mtn. House	318	318*	105,000	330	330	153,000	481	481	255,000	802
16/140	5DB1	Clearwater R. near Rocky Mtn. House		1,226	604,000		493	975,000		795	1,280,000	1,044
17/141	5EF1	North Sask. R. near Frenchman Butte		22,000*	5,780,000		263	8,090,000		368	10,050,000	457
17/142	5GG1	North Sask. R. at Prince Albert		46,100*	6,210,000		135	8,900,000		193	10,552,000	229
17/143	5EA5	Sturgeon R. near Villeneuve	60	172	37,400	623	217	121,000	2,017	703	180,000	1,047
17/144	5EA2	Sturgeon R. near St. Albert	105	273	48,800	465	178	150,750	1,436	552	240,250	880
17/145	5EA1	Sturgeon R. at Fort Saskatchewan	167	338	53,200	318	157	175,000	1,048	518	270,000	799
17/146	5GG3	Spruce R. outlet of Anglin Lake	130	218*	7,500	58	34	30,300	233	140	49,100	225
17/147	5GA1	Eyehill Cr. near Yonker	125	—	5,975	48	---	16,500	132	---	27,600	---
18/148	5AA3	Castle R. near Cowley		435*	446,000		1,025	690,000		1,586	905,000	2,080
18/149	5AA22	Castle R. near Beaver Mines		310*	411,000		1,326	590,000		1,903	704,000	2,271
18/150	5AA2	Crowsnest R. at Lundbreck		268*	170,500		636	255,000		952	327,000	1,220
18/151	5AA8	Crowsnest R. at Frank		163*	119,000		730	185,000		1,135	220,000	1,350
18/152	5AA9	Crowsnest R. at Coleman		70*	69,200		989	97,000		1,386	109,500	1,564
18/153	5AB6	Meadow Cr. at Hart's Ranch		38*	2,750		72	10,350		272	14,200	374
18/154	5AB3	Trout Cr. at Lockwood's Ranch		164*	20,600		126	65,200		398	78,000	476
18/155	5AB2	Willow Cr. at Nolan	746	1,010*	110,000	147	109	323,000	433	320	378,000	374
18/156	5AB21	Willow Cr. at Claresholm	430	462*	84,000	195	182	215,000	500	465	260,000	563
18/157	5AA1	Oldman River at Cowley		730*	359,000		492	475,000		651	820,000	1,123
18/158	5AA23	Oldman River at Waldron's Corner		545	307,000		563	488,000		895	628,000	1,152
18/159	5AA21	Oldman River at The Gap		454*	280,000		617	452,000		996	588,000	1,295
18/160	5AA4	Pincher Creek at Pincher Creek		50*	30,900		618	66,800		1,336	106,000	2,120
18/161	5AB7	Oldman River at McLeod (Natural Flow)	2,100	2,230*	1,020,000	486	457	1,755,000	835	787	2,290,000	1,027
18/162	5AD19	Oldman River at Monarch										
19/163	5AF8	Irrigation Cr. near Orton	60	76	920	15	12	3,025	50	40	3,890	51
19/164	5AF10	Manyberries Cr. at Brodin's Farm	120	126	5,450	45	43	15,200	127	121	18,800	149

* Taken from Water Resources Papers of Department of Northern Affairs and National Resources.

TABLE 2 (Cont'd)

REF. No.	STATION NO.	HYDROMETRIC STATION LOCATION	DRAINAGE AREAS "DRY" D_d	DRAINAGE AREAS "WET" D_w	ANNUAL RUNOFF MEDIAN ac-ft. p.a.	MEDIAN ac-ft. p.a. /D_d	MEDIAN ac-ft. p.a. /D_w	1:10 ac-ft. p.a.	1:10 ac-ft. p.a. /D_d	1:10 ac-ft. p.a. /D_w	1:50 ac-ft. p.a.	1:50 ac-ft. p.a. /D_w
		WESTERN TRIBUTARIES										
20/165	50B3	Pembina R. at Manitou	701	1,746	50,000	71	29	155,000	221	89	293,000	168
20/166	50C0.1	Pembina R. at Neche	1,079	2,635	85,000	79	32	243,200	225	92	432,500	164
20/167	50G2	Riviere Sale at LaSalle	---	863*	31,000	—	36	138,000	---	160	270,000	313
20/168	50F6	Morris R. near Stephenfield	168	311	14,500	86	47	55,200	329	177	99,300	319
20/169	50A2	Whitemud Cr. West of Holmfield	74	141	5,000	68	35	23,800	322	169	53,500	379
		EASTERN TRIBUTARIES										
20/170	50CT	Red River at Emerson	23,830	40,200*	1,600,000	67	40	3,550,000	149	88	5,870,000	146
20/171	50D4	Roseau R. at Gardenton	1,266	1,525*	154,000	122	101	341,000	269	224	550,000	361
20/172	50D14	Roseau R. at Stuartburn	1,320	1,590*	150,000	114	94	376,000	285	236	597,000	375
20/173	50D1	Roseau R. near Dominion City	1,489	1,840*	162,000	109	88	381,500	256	207	670,000	364
20/174	50E1	Rat R. near Otterburne	587	704*	56,000	95	80	130,500	230	185	306,000	435
20/174A	50H6	Seine R. at Prairie Grove	420	495*	39,500	94	80	95,500	228	193	152,500	308
20/175	5SA1	Brokenhead R. at St. Queens	480	579*	105,000	219	181	211,500	440	365	321,500	555
20/176	50D0.4	Pine Cr. near Pine Cr.	62	75*	19,300	311	258	30,800	496	411	48,700	649
20/177	50D0.3	Sprague Cr. near Sprague	125	151*	32,100	257	212	73,500	588	487	115,000	762
21/178	5CA1	Red Deer R. near Sundre	915	949	603,000	659	635	970,000	1,060	1,021	1,280,000	1,349
21/179	5CC2	Red Deer R. at Red Deer	3,295	3,922	1,242,000	377	317	2,320,000	704	592	3,300,000	841
21/180	5CD4	Red Deer R. near Nevis	3,783	4,877	1,362,000	360	280	2,680,000	708	550	3,850,000	892
21/181	5CE1	Red Deer R. at Drumheller	5040	7,415	1,462,000	290	197	2,850,000	565	384	4,350,000	586
21/182	5CK2	Red Deer R. at Empress	7,663	12,678	1,623,000	212	128	3,260,000	425	258	4,750,000	375
21/183	5CC1	Blindman R. near Blackfalds	265	417	72,300	273	173	211,000	796	505	288,000	690
21/184	5CE2	Kneehill Cr. near Drumheller	385	828	19,000	49	23	54,400	141	66	71,800	88
21/185	5CE3	Rosebud R. at Beynon	646	1,165	45,700	71	41	87,000	135	75	104,500	90
21/186	5CE2	Berry Cr. near Wardlow	424	874	19,800	47	23	68,800	162	79	96,000	109
22/187	5AH13	Bullshead Cr. near Woolchester	91	115	4,950	54	43	14,200	156	123	19,250	167
22/188	5AH37	Gros Ventre Cr. near Coleridge	57	78	3,220	56	41	10,700	187	137	14,800	190
22/189	5AH3	Ross Cr. near Irvine	170	211	8,200	48	39	26,000	153	123	34,700	164
23/190	5KJ1	Saskatchewan River at The Pas		125,000*	17,000,000	137		25,000,000		200	31,250,000	250
24/191	5HG1	South Saskatchewan River at Saskatoon	23,827	36,915	6,735,000	283	182	11,750,000	493	308	14,875,000	403
24/192	5AJ1	South Saskatchewan River at Medicine Hat	12,385	17,146	5,180,000	418	302	8,625,000	696	503	10,665,000	622
25/193	5AH38	Paradise Cr. near Seven Persons	74	90	1,350	18	15	5,900	80	66	11,000	122
25/194	5AH33	Seven Persons Cr. near Seven Persons	289	431	3,850	13	9	26,000	90	60	55,500	129
25/195	5AH5	Seven Persons Cr. at Medicine Hat	472	693	6,700	14	10	42,000	89	61	83,500	120
26/196	5NB2	Souris R. near Estevan	862	2,425	32,000	37	13	100,000	118	41	156,000	64
26/197	5ND3	Souris R. at Oxbow	1,471	3,568	60,000	41	17	174,000	118	49	267,000	75
26/198	5NF0.2	Souris R. at Sherwood, N.D.	1,531	3,683	64,000	42	17	186,000	122	51	260,000	71
26/199	5NF0.1	Souris R. at Westhope, N.D.	3,215	7,733	112,250	35	14	360,000	112	47	462,000	60
26/200	5NF1	Souris R. at Melita	3,756	8,918	128,000	34	14	442,000	117	50	602,000	68
26/201	5NG1	Souris R. at Wawanesa	4,203	11,065	152,000	36	14	572,000	136	52	750,000	68
26/202	5NB3	Long Cr. near Estevan	432	900	14,000	32	16	45,800	106	51	83,000	92
26/203	5ND2	Moose Mountain Cr. near Oxbow	331	582	14,300	43	24	50,000	151	86	114,000	195
26/204	5NF2	Antler Cr. near Melita	294	607	16,000	54	26	39,800	136	66	60,300	100
26/205	5NF3	Gainsborough Cr. near Melita	154	332	5,950	39	18	19,900	129	59	35,500	107
26/206	5NF4	Graham Cr. near Melita	24	70	900	38	13	4,200	175	60	8,250	118
26/207	5NG6	Pipestone Cr. near Reston	445	868	24,200	54	28	88,000	198	101	165,000	190

* Taken from Water Resources Papers of Department of Northern Affairs and National Resources.

TABLE 2 (Cont'd)

REF. NO.	STATION NO.	HYDROMETRIC STATION LOCATION	DRAINAGE AREAS "DRY" D_d	DRAINAGE AREAS "WET" D_w	ANNUAL RUNOFF MEDIAN ac-ft. p.a.	MEDIAN ac-ft. p.a. /D_d	MEDIAN ac-ft. p.a. /D_w	1:10 ac-ft. p.a.	1:10 ac-ft. p.a. /D_d	1:10 ac-ft. p.a. /D_w	1:50 ac-ft. p.a.	1:50 ac-ft. p.a. /D_w
27/208	5HD5	Swift Current Cr. at Sinclair's Ranch	270	327	22,600	84	69	45,900	170	140	85,700	262
27/209	5HD36	Swift Current Cr. at Highway No. 37	344	444	21,300	62	48	48,000	140	108	80,000	180
27/210	5HD30	Swift Current Cr. below Jctn. Pelletier Cr.	508	886	35,600	70	40	83,000	163	94	190,000	214
27/211	5HD7	Swift Current Cr. near Swift Current	563	991	40,000	71	40	104,000	184	105	179,000	180
27/212	5HA16	Skull Cr. at Doyle's Ranch	27	35	2,885	107	82	5,990	222	171	9,020	257
27/213	5HA2	Skull Cr. near Skull Cr.	34	44	2,260	66	51	4,640	136	105	7,700	175
27/214	5HA13	Bridge Cr. near Raymond & Doyle's Ranch	4.4	5	438	100	86	920	209	184	1,600	320
28/215	5AE0.5	Swift Current Cr. at Many Glacier		32*	105,500							
28/216	5AE2	Lee Creek at Cardston		112*	39,000		3,300	139,000		4,344	149,000	4,656
28/217	5AE5	Ralph Creek at Kimball	45	91	7,000	156	348	97,000		866	148,000	1,321
28/218	5AE11	Pothole Cr. (Upper Station) at Magrath	107	162*	4,000	37	77	24,500	544	270	35,200	388
28/219	5AE1	St. Mary R. at International Bdry(Natural Flow)		516	629,000		25	22,100	206	136	33,700	208
28/220	5AE6	St. Mary R. at Lethbridge (Natural Flow)	1,176	1,410	692,000	588	1,219	870,000		1,686	1,055,000	2,123
28/221	5AE0.4	Canyon Cr. near Many Glacier		7*	17,100		490	1,025,000	872	727	1,295,000	918
28/222	5AD7	Oldman R. at Lethbridge (Natural Flow)	5,420	6,710*	2,610,000	482	2,443	22,100		3,157	25,500	3,643
28/223	11AA26	Sage Cr. at "Q" Ranch	149	164*	6,300	42	389	4,140,000	764	617	5,900,000	879
28/224	11AA0.3	Milk R. North Br. above U.S. St. Mary Canal	55	62*	17,700	332	38	16,300	109	99	26,000	159
28/225	11AA5	Milk R. at Milk River (Natural Flow)	841	1,104*	90,000	107	285	38,000	691	613	50,500	815
28/226	11AA25	Milk R. (South Br.) near International Bdry.	375	433*	60,000	160	82	200,000	238	181	310,000	281
28/227	11AA0.2	Milk R. at Eastern Crossing (Natural Flow)	1,620	2,514*	104,000	64	139	139,000	371	321	194,000	448
29/228	5JG4	Qu'Appelle R. above Buffalow Pound Lake	222	427	2,200	10	414	248,000	153	99	411,000	164
29/229	5JG7	Qu'Appelle R. below Jctn. Moose Jaw Creek	1,410	3,133	24,800	18	5	19,500	88	46	36,300	85
29/230	5JF1	Qu'Appelle R. at Lumsden	1,999	4,338	41,000	20	8	118,000	84	38	229,000	73
29/231	5JK2	Qu'Appelle R. below Craven Dam	2,826	6,921	11,000	4	9	180,000	91	42	338,000	78
29/232	5JM3	Qu'Appelle R. at Tantallon	4,225	10,423	70,000	17	1.5	114,000	40	16	486,000	70
29/233	5JF4	Waskana Creek near Sedley	115	260	3,950	34	7	385,000	91	37	945,000	91
29/234	5JF3	Waskana Cr. at Regina	330	743	10,200	31	12	17,000	148	65	25,500	98
29/235	5JF5	Waskana Cr. above Jctn. Qu'Appelle R.	415	941	14,250	34	8	46,000	139	62	63,800	86
29/236	5JH1	Arm R. near Bethune	177	344	2,530	14	10	68,200	164	72	106,500	113
29/237	5JK4	Jumping Deer Cr. near Lipton	41	104	1,340	33	7	17,750	100	52	27,300	79
29/238	5JL2	Indian Head Cr. near Indian Head	45	96	1,650	37	13	6,200	151	60	12,500	120
29/239	5JL5	Pheasant Cr. near Abernethy	76	180	4,050	53	17	7,150	159	74	12,400	129
29/240	5JM5	Kaposvar Cr. near Tantallon	102	423	5,250	51	22	22,000	289	122	41,500	231
29/241	5JM4	Cutarm Cr. near Spy Hill	90	297	8,900	99	12	24,800	243	59	50,500	119
30/242	5LE1	Swan R. at Swan River	716	1,470*	166,000	232	30	26,000	289	88	43,200	145
30/243	5LC1	Red Deer River at Erwood	1,457	4,320*	345,000	237	113	389,500	544	265	493,000	335
31/244	5JA2	Wood River near LaFleche	913	1,474	30,300	33	78	1,350,000	926	313	1,930,000	447
31/245	5JA1	Wood River near Gravelbourg	928	1,510	30,700	33	20					
31/246	5JA1 & 5JA2	5JA1 and 5JA2 combine	928	1,510	30,500	33	20					
31/247	5JB2	Russel Creek near Vanguard	72	112	3,580	50	32	91,000	98	60	180,000	119
31/248	5JB1	Notukeu Creek near Vanguard	646	1,171	23,000	36	20	8,100	112	72	13,500	120
31/249	5JB3	Notukeu Creek near Gravelbourg	721	1,375	23,100	32	17	71,500	110	61	132,000	112
31/250	5JC1	Wiwa Creek near Gravelbourg	235	463	5,950	25	13	62,000	86	45	105,000	76
								17,900	76	39	33,500	72

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* Taken from Water Resources Papers of Department of Northern Affairs and National Resources.

TABLE 3

INCREMENTAL STREAMFLOW DATA

REF. NO.	STATION NO.	HYDROMETRIC STATION LOCATION	INCREMENTAL DRAINAGE AREAS "DRY" D_d	INCREMENTAL DRAINAGE AREAS "WET" D_w	INCREMENTAL ANNUAL RUNOFF (inflow between given station and those immediately upstream) MEDIAN ac-ft. p.a.	MEDIAN ac-ft. p.a. /D_d	MEDIAN ac-ft. p.a. /D_w	1:10 ac-ft. p.a.	1:10 ac-ft. p.a. /D_d	1:10 ac-ft. p.a. /D_w	1:50 ac-ft. p.a.	1:50 ac-ft. p.a. /D_w
1/1	7AA2	Athabasca River near Jasper		1,315*	1,975,000		1,502	2,270,000		1,726	2,625,000	1,996
1/2	7AD1	Athabasca River at Entrance		2,339*	2,553,000		1,091	2,970		1,270	3,330,000	1,410
1/3	7BE1	Athabasca River at Athabasca										
1/4	7AA7	Sunwapta River at Athabasca Glacier		11*	30,250		2,750	37,800		3,436	44,500	4,045
1/5	7AA1	Miette River at Jasper		250*	294,500		1,176	342,000		1,368	378,000	1,512
1/6	7AG1	McLeod River at Wolf Creek		2,160*	793,000		367	1,150,000		532	1,415,000	655
1/7	7AG3	Wolf Creek at No. 16 Highway		350*	85,000		243	125,000		357	1,500,000	429
1/8	7BB2	Pembina River at Entwistle		594*	96,000		162	150,000		253	183,000	325
1/9	7BA1	Pembina River below Paddy Creek		1,112*	326,000		293	585,000		526	655,000	589
1/10	7BB3	Lobstick River near Styal		700*	95,000		135	171,000		244	212,000	303
1/11	7BF2	West Prairie River at High Prairie		430*	112,200		261	180,000		419	237,000	551
1/12	7BF4	Heart River at High Prairie		1,295	207,700		160	352,000		272		
2/13	5MC1	Assiniboine River at Sturgis	370	770	51,000	138	66	200,000	540	260	387,000	503
2/14	5MD4	Assiniboine River at Kamsack	382	708	45,500	119	64	124,000	325	175	173,000	244
2/15	5ME1	Assiniboine River at Millwood	580	968	50,000	86	52	144,000	248	149	194,000	200
2/16	5MB1	Yorkton Creek at Ebenezer	111	229	11,000	99	48	87,000	784	380	164,200	717
2/17	5MB3	Whitesand River near Canora	712	1,500	36,000	50	24	253,000	355	168	380,000	253
2/18	5MD2	Shell River at Roblin	216	445	86,000	398	193	164,300	761	369	225,000	506
2/19	5MD5	Shell River at Inglis	33	71	17,400	527	245	33,200	1,005	467	46,000	648
3/20	5MH1	Assiniboine River at Brandon	1,259	3,291	88,000	70	27	350,000	278	106	468,000	142
3/21	5MJ3	Assiniboine River at Portage la Prairie										
3/22	5MJ1	Assiniboine River at Headingly										
3/23	5ME2	Birdtail Creek at Birtle	124	381	34,000	274	89	82,500	665	217	137,500	361
4/24	5FA1	Battle River at Ponoka	165	603	63,000	382	104	185,000	1,120	306	238,000	394
4/25	5FE1	Battle River at Unwin	1,446	4,365	89,500	62	20	231,000	160	53	275,000	63
4/26	5FF2	Battle River near Battleford	355	750	68,000	192	91	166,000	468	221	210,000	280
4/27	5FD1	Ribstone Creek near Heath	193	507	9,200	48	19	25,800	134	51	38,200	75
4/28	5FD3	Ribstone Creek near Ribstone	38	207	2,700	71	13	8,900	234	42	13,000	63
5/29	11AB81	Battle Creek at Ranger Station	78	81	12,600	162	156	30,300	389	374	53,300	658
5/30	11AB3	Battle Creek at Battle Creek	84	84	1,420	17	17	3,900	46	46	13,400	160
5/31	11AB76	Battle Creek above Cypress Lake	53	56	4,700	89	84	10,700	202	191	17,000	304
5/32	11AB10	Battle Creek at Nash's Ranch	217	319				16,500	76	52	35,800	124
5/33	11AB27	Battle Creek at International Boundary	139	188	620	4	3	10,900	78	58	15,500	82
5/34	11AB14	Six Mile Coulee at Spangler's Ranch	16.5	28	2,400	145	86	6,000	364	214	10,200	364
5/35	11AB0.1	Woodpile Coulee near International Boundary	51	68	1,800	35	26	6,800	133	100	12,600	185
5/36	11AB75	Lyon's Coulee at International Boundary	47	66	1,250	26	19	6,400	136	97	16,600	252
5/37	11AB0.3	Battle Creek (East Branch)near International Bdry.	35	35	475	14	14	1,550	44	44	2,700	77

* Taken from Water Resources Papers of Department of Northern Affairs and National Resources.

TABLE 3 (Cont'd)

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6/38	5AD1	Mami Creek at Mountain View		23*	3,400		147	2,300		1,000	33,500	1,456
6/39	5AD0.4	Belly River at International Boundary		75*	175,500		2,346	22,700		3,031	263,000	3,516
6/40	5AD5	Belly River at Mountain View (Natural Flow)		46.2	56,750		1,228	83,000		1,797	104,500	2,262
6/41	5AD2	Belly River near Standoff (Natural Flow)	216	333*	16,800	78	50	59,000	273	177	125,000	375
6/42	5AD16	Drywood River (North Branch) near Twin Butte		12*	14,800		1,233	23,300		1,942	33,800	2,816
6/43	5AD10	Drywood River near Fishburn	74	86*	100,000	1,351	1,163	153,000	2,068	1,779	205,000	2,383
6/44	5AD12	Cottonwood Creek near Twin Butte		14*	7,200		514	13,600		971	19,200	1,371
6/45	5AD4	Crooked Creek near Waterton Park		17*	8,950		526	18,800		1,105	27,400	1,612
6/46	5AD0.2	Boundary Creek at International Boundary		21*	52,800		2,514	65,600		3,124	77,400	3,686
6/47	5AD0.1	Waterton River near International Boundary		61*	188,000		3,082	231,500		3,795	267,000	4,377
6/48	5AD3	Water River at Waterton Park		150*	207,000		1,380	300,000		2,000	386,000	2,573
6/49	5AD8	Waterton River near Standoff	206	304	32,500	158	107	123,000	597	405	332,000	1,092
6/50	5AD0.3	Street Creek at International Boundary		6*	10,050		1,675	13,750		2,291	16,200	2,700
7/51	5HA69	Gap Creek below Downie Lake Diversion	88	91	3,200	36	35	11,700	133	128	21,600	237
7/52	5HA9	Gap Creek near Small's Ranch	60	62	1,100	18	17	3,850	64	62	10,800	174
7/53	5HA72	Gap Creek above Junction Reservoir	52	60	1,450	28	24	7,100	137	118	14,000	233
7/54	5HA	Maple Creek above Junction Reservoir	67	74	2,500	37	34	9,250	138	125	18,250	246
7/55	5HA21	Hay Creek at Hay Creek School	18.8	19	600	32	32	2,250	120	118	4,180	220
7/56	5HA3	Bear Creek at Unsworth's Ranch	39	38	1,000	26	26	4,000	103	105	7,600	200
7/57	5HA4	Bear Creek (East Branch) at Johnston's Ranch	21	23	2,508	119	109	5,980	285	260	7,770	338
7/58	5HA5	Bear Creek (West Branch) at Bertram's Ranch	30	38	5,380	179	142	10,300	343	271	14,600	384
7/59	5HA62	Piapot Creek at Cumberland's Ranch	44	49	2,900	66	59	6,580	150	134	12,200	249
8/60	5BA3	Bath Creek near Lake Louise		26.5	53,200		2,008	69,500		2,623	84,500	3,189
8/61	5BA1	Bow River at Lake Louise		132*	213,600		1,618	254,000		1,924	269,000	2,042
8/62	5BB3	Forty Mile Creek near Banff		62*	47,700		770	61,000		984	67,500	1,089
8/63	5BB1	Bow River at Banff		637	725,000		1,138	820,000		1,287	988,000	1,551
8/64	5BC3	Spray Creek at Spray Lakes (1911 – 1948)		40	44,300		1,103	60,400		1,510	75,100	1,878
8/65	5BC2	Spray River near Spray Lakes		193	215,000		1,114	263,000		1,363	359,000	1,860
8/66	5BC1	Spray River at Banff (1911 – 1948)		55	97,500		1,773	129,000		2,345	167,500	3,045
8/67	5BG2	Ghost River near Blackrock Mountain		81*	60,000		741	120,000		1,481	185,000	2,283
8/68	5BG1	Ghost River near Cochrane	251	276*	103,800	412	375	175,000	697	634	236,000	855
8/69	5BF4	Pocaterra Creek near Mouth		23	20,000		870	31,400		1,365	38,900	1,691
8/70	5BF1	Kananaskis River near Seebe		350*	386,000		1,103	470,000		1,343	605,000	1,729
8/71	5BE4	Bow River near Seebe		440	317,000		720	474,000		1,077	559,000	1,270
8/72	5BH4	Bow River at Calgary		683	47,500		70	350,000		512	408,000	597
8/73	5BJ3	Elbow River at Fullerton's Ranch		280	229,000		818	345,000	1,232	1,232	448,000	1,600
8/74	5BJ4	Elbow River at Bragg Creek		20*				38,000		1,900	80,500	4,025
8/75	5BJ5	Elbow River above Glenmore Dam		160*	21,800		136	57,000		356	101,000	631
8/76	5BJ1	Elbow River below Glenmore Dam										
8/77	5BH3	Nose Creek at Calgary	202	308	14,500	72	47	44,000	218	143	79,500	258
8/78	5BL8	Highwood River at Brown's Ranch		444	325,000		732	500,000		1,126	610,000	1,374
8/79	5BL6	Pekisko Creek at Pekisko		75	24,800		332	55,000		733	72,800	971
8/80	5BL7	Stimson Creek near Pekisko		96	17,000		177	59,300		618	82,000	854

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TABLE 3 (Cont'd)

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8/81	5BL9	Highwood River near Aldersyde (Natural Flow)		268				37,500		140	85,000	317
8/82	5BL18	Sheep River at Buck's Ranch		174*	126,000		724	221,000		1,270	314,000	1,804
8/83	5BL12	Sheep River near Okotoks	385	454*	49,000	127	108	120,000	312	264	352,000	775
8/84	5BM4	Bow River at Bassano	1,048	2,195*				340,000	324	155	870,000	396
8/85	5AC3	Little Bow River at Carmangay	300	1,065*	21,000	70	20	56,200	187	53	72,500	68
9/86	5KA3	Carrot River at Beaulieu's Farm	71	172	1,420	20	8	8,400	118	49	18,500	108
9/87	5KA1	Carrot River at Kinistino	59	185	3,900	66	21	20,500	348	111	40,800	221
10/88	5LJ4	Valley River at Valley River	564	890	92,800	164	104	258,000	457	290	311,000	349
10/89	5LJ10	Valley River near Dauphin	19	24	2,350	124	98	6,750	355	281	11,300	471
10/91	5LJ11	Wilson River near Dauphin	285	330	47,000	165	142	119,000	418	361	154,000	467
10/92	5LJ12	Vermilion River near Dauphin	221	255	51,600	233	202	97,500	441	382	132,000	518
10/93	5LJ5	Ochre River near Ochre River	93	162	35,100	377	217	74,000	796	457	96,000	593
10/94	5LJ7	Turtle River near Laurier	114	203	41,300	362	203	118,000	1,035	581	169,000	833
11/95	11AC40	Frenchman River at Drury's Ranch	6	142	2,770	461	19	11,200	1,866	79	16,300	115
11/96	11AC18	Frenchman River above Eastend Reservoir	140	159	5,800	41	36	15,600	111	98	32,800	206
11/97	11AC1	Frenchman River below Eastend Reservoir	26	26		---	---	1,300	50	50	11,600	445
11/98	11AC57	Frenchman River at Morrison's	90	146	2,800	31	20	6,500	72	45	11,400	79
11/99	11AC23	Frenchman River at 50 mile	190	338	1,000	5	3	11,900	63	35	34,000	101
11/100	11AC51	Frenchman River below Val Marie	144	217	1,000	7	5	17,500	121	81	54,000	248
11/101	11AC41	Frenchman River at International Boundary	327	376	15,000	49	40	42,100	129	112	73,200	195
11/102	11AC9	Oxarat Creek at Wylie's Ranch	7.2	30	1,700	236	57	5,600	776	186	10,000	332
11/103	11AC8	Sucker Creek at Gilchrist's Ranch	34	34	2,750	81	81	6,280	185	185	10,280	302
11/104	11AC16	Belanger Cr. above Cypress L. East in flow canal	48	59	4,720	98	80	12,500	260	212	20,700	351
11/105	11AC4	Davis Cr. at Drury's Ranch	43	43	4,700	109	109	12,500	291	291	23,400	544
11/106	11AC3	Fairwell Cr. at Drury's Ranch	129	130	9,600	74	74	23,600	183	182	41,900	322
11/107	11AC2	Frenchman River North Branch at Cress' Ranch	43	52	4,820	112	93	12,500	289	240	22,900	440
11/108	11AC25	Denniel Creek at Val Marie	165	195	3,950	24	20	12,200	74	63	19,000	97
11/109	11AD0.1	Whitewater Cr. at International Boundary	85	165	1,010	12	6	13,200	155	80	34,600	210
11/110	11AE0.4	McEachern Cr. at International Boundary	175	177	5,550	32	31	18,300	105	103	31,900	180
11/111	11AE0.3	Horse Creek at International Boundary	72	74	2,980	41	40	8,550	119	116	12,300	166
11/112	11AE0.2	Rock Creek at International Boundary	235	237	10,500	45	44	25,000	106	105	41,000	173
11/113	11AE2	Poplar River West Branch at International Bdry.	124	127	3,900	31	30	14,300	115	112	25,000	197
11/114	11AE0.5	Poplar River Middle Br. at International Bdry.	354	357	11,500	33	32	37,000	105	104	53,000	148
11/115	11AE3	Poplar River East Br. at International Bdry.	190	284	10,800	57	38	29,000	153	102	49,000	173
11/116	11AF0.2	Beaver Creek at International Boundary	165	181	8,400	51	46	22,100	134	122	36,800	203
12/117	5AH2	McKay Creek at Walsh	122	163	5,190	43	32	30,100	247	185	47,000	288
12/118	5AH1	Boxelder Creek at Walsh	97	118	2,400	25	20	12,350	127	105	19,750	167

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TABLE 3 (Cont'd)

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					MEDIAN			1:10			1:50	
			"DRY" D_d	"WET" D_w	ac-ft. p.a.	ac-ft. p.a. /D_d	ac-ft. p.a. /D_w	ac-ft. p.a.	ac-ft. p.a. /D_d	ac-ft. p.a. /D_w	ac-ft. p.a.	ac-ft. p.a. /D_w
13/119	11AB82	Lodge Creek near Alberta Boundary	300	343	18,600	62	54	49,700	166	145	80,000	233
13/120	11AB6	Lodge Creek at International Boundary	102	147							2,000	14
13/121	11AB9	Middle Creek near Alberta Boundary	103	117	5,200	50	44	13,900	135	119	20,700	177
13/122	11AB8	Middle Creek at Hammond's Ranch	92	119	25	0.27	0.21	10,100	110	85	23,000	193
13/123	11AB70	McRae Coulee near International Boundary	50	58	1,130	23	19	4,000	80	69	8,900	153
14/124	5MF5	Minnedosa River at Elphinstone	57	292	41,200	723	141	105,000	1,842	360	177,500	608
14/125	5MF1	Minnedosa River at Beilby's Bridge	41	132	1,650	40	12	6,200	151	47	16,600	126
14/126	5MF17&18	Minnedosa River 2 miles North of Rivers	93	313	38,000	409	121	91,000	978	290	148,000	472
14/127	5MF9	Whirlpool River at Danvers	40	114	16,600	415	146	40,500	1,012	355	68,000	596
14/128	5MF8	Rolling River at Lea's Bridge	26	126	17,400	669	138	38,200	1,470	303	61,500	488
15/129	5JE5	Avonlea Creek near Rouleau	159	311	5,400	34	17	20,500	129	66	35,700	115
15/130	5JE4	Moose Jaw Creek near Rouleau	271	678	12,000	44	18	56,000	207	83	117,000	172
15/131	5JE1	Moose Jaw Creek at McCarthy's	300	441	3,000	10	7	21,800	73	49	38,800	88
15/132	5JG8	Moose Jaw Creek above Junction Qu'Appelle River	182	912	4,850	27	5	19,200	105	21	35,000	38
16/133	5DA6	North Saskatchewan River @ Saskatchewan Crossing		485	1,020,000		2,103	1,210,000		2,495	1,446,000	2,981
16/134	5DC2	North Saskatchewan River near Saunders	1,325	1,325*	1,178,000	890	890	1,412,000	1,066	1,066	1,575,000	1,189
16/135	5DC1	North Saskatchewan River near Rocky Mtn. House	959	1,030*	552,000	576	536	760,000	792	738	1,010,000	981
16/136	5DE1	North Saskatchewan River near Rocky Rapids	3,907	4,043*	2,070,000	530	512	3,400,000	870	841	4,710,000	1,165
16/137	5DF1	North Saskatchewan River @ Edmonton	856	2,297*							480,000	209
16/138	5DA7	Mistaya River @ Saskatchewan Crossing	94	94*	181,800	1,934	1,934	213,500	2,271	2,271	255,000	2,713
16/139	5D82	Prairie Creek near Rocky Mountain House	318	318*	105,000	330	330	153,000	481	481	255,000	802
16/140	5DB1	Clearwater River near Rocky Mountain House		908*	499,000		564	815,000		898	1,058,000	1,165
17/141	5EF1	North Saskatchewan River near Frenchman Butte		22,000*	5,780,000		263	8,090,000		368	10,050,000	457
17/142	5GG1	North Saskatchewan River at Prince Albert		46,100*	6,210,000		135	8,900,000		193	10,552,000	229
17/143	5EA5	Sturgeon River near Villeneuve	60	172	37,400	623	217	121,000	2,017	703	180,000	1,047
17/144	5EA2	Sturgeon River near St. Albert	45	101	12,250	272	121	41,500	922	411	74,000	733
17/145	5EA1	Sturgeon River at Fort Saskatchewan	62	65	6,800	110	105	22,500	363	346	41,000	631
17/146	5GG3	Spruce River outlet of Anglin Lake	130	218*	7,500	58	34	30,300	233	140	49,100	225
17/147	5GA1	Eyehill Creek near Yonker	125	---	5,975	48	---	16,500	132	---	27,600	---
18/148	5AA3	Castle River near Cowley		125*	35,600		285	116,000		928	166,000	1,328
18/149	5AA22	Castle River near Beaver Mines		310*	411,000		1,326	590,000		1,903	704,000	2,271
18/150	5AA2	Crowsnest River near Lundbreck		105*	51,000		485	80,500		767	109,500	1,043
18/151	5AA8	Crowsnest River at Frank		93*	50,800		546	84,000		903	109,500	1,177
18/152	5AA9	Crowsnest River at Coleman		70*	69,200		989	97,000		1,386	109,500	1,564
18/153	5AB6	Meadow Creek at Hart's Ranch		38*	2,750		72	10,350		272	14,200	374
18/154	5AB3	Trout Creek at Lockwood's Ranch	164	164*	20,600	126	126	65,200	398	398	78,000	476
18/155	5AB2	Willow Creek at Nolan	114	346*	3,700	32	11	25,000	220	72	59,800	173
18/156	5AB21	Willow Creek at Claresholm	430	462*	84,000	195	182	215,000	500	465	260,000	563
18/157	5AA1	Oldman River at Cowley	177	187*	45,000	254	241	112,000	633	599	171,000	914
18/158	5AA23	Oldman River at Waldron's Corner		93*	18,600		200	44,000		473	96,000	1,032
18/159	5AA21	Oldman River at The Gap		454*	280,000		617	452,000		996	588,000	1,295
18/160	5AA4	Pincher Creek at Pincher Creek		50*	30,900		618	66,800		1,336	106,000	2,120
18/161	5AB7	Oldman River at McLeod	670	747*	44,000	66	59	212,000	316	284	302,000	404

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19/163	5AF8	Irrigation Creek near Orion	60	76	920	15	12	3,025	50	40	3,890	51
19/164	5AF10	Manyberries Creek at Brodin's Farm	120	126	5,450	45	43	15,200	127	121	18,800	149
		Western Tributaries										
20/165	5O83	Pembina River at Manitou	701	1,746	50,000	71	29	155,000	221	89	293,000	168
20/166	5OC0.1	Pembina River at Neche	378	889	31,500	83	35	85,000	225	96	186,000	209
20/167	5OG2	Riviere Sale at LaSalle	---	863*	31,000	---	36	138,000	---	160	270,000	313
20/168	5OF6	Morris River near Stephenfield	168	311	14,500	86	47	55,200	329	177	99,300	319
20/169	5OA2	Whitemud Creek West of Holmfield	74	141	5,000	68	35	23,800	322	169	53,500	379
		Eastern Tributaries										
20/170	5OC1	Red River at Emerson	22,751	37,011*	1,500,000	66	41	3,480,000	153	94	5,450,000	147
20/171	5OD4	Roseau River at Gardenton	1,079	1,199*	105,000	97	88	260,000	241	217	450,000	375
20/172	5OD14	Roseau River at Stuartburn	54	65*	2,000	37	31	16,000	296	246	37,500	577
20/173	5OD1	Roseau River near Dominion City	169	250*	13,750	81	55	32,500	192	130	62,000	248
20/174	5OE1	Rat River near Otterburne	587	704	56,000	95	80	130,500	230	185	306,000	435
20/174A	5OH6	Seine River at Prairie Grove	420	495	39,500	94	80	95,500	228	193	152,500	308
20/175	5SA1	Brokenhead River at St. Ouens	480	579	105,000	219	181	211,500	440	365	321,500	555
20/176	5OD0.4	Pine Creek near Pine Creek	62	75	19,300	311	258	30,800	496	411	48,700	649
20/177	5OD0.3	Sprague Creek near Sprague	125	151	32,100	257	212	73,500	588	487	115,000	762
21/178	5CA1	Red Deer River near Sundre	915	949	603,000	659	635	970,000	1,060	1,021	1,280,000	1,349
21/179	5CC2	Red Deer River at Red Deer	2,380	2,973	570,000	240	192	1,452,000	610	480	2,090,000	704
21/180	5CD4	Red Deer River near Nevis	223	538	68,000	305	126	214,000	960	398	316,000	587
21/181	5CE1	Red Deer River at Drumheller	872	1,710	26,000	30	15	300,000	344	175	462,000	270
21/182	5CK2	Red Deer River at Empress	1,553	3,272	95,000	61	29	290,000	187	89	594,000	183
21/183	5CC1	Blindman River near Blackfalds	265	417	72,300	273	173	211,000	796	505	288,000	690
21/184	5CE2	Kneehill Creek near Drumheller	385	828	19,000	49	23	54,400	141	66	71,800	88
21/185	5CE3	Rosebud River at Beynon	646	1,165	45,700	71	41	87,000	135	75	104,500	90
21/186	5CH2	Berry Creek near Wardlow	424	874	19,800	47	23	68,800	162	79	96,000	109
22/187	5AH13	Bullshead Creek near Woolchester	91	115	4,950	54	43	14,200	156	123	19,250	167
22/188	5AH37	Gros Ventre Creek near Coleridge	57	78	3,220	56	41	10,700	187	137	14,800	190
22/189	5AH3	Ross Creek near Irvine	113	133	4,800	42	36	15,500	137	117	21,200	159
23/190	5KJ1	Saskatchewan River at The Pas		125,100*	17,000,000		137	6,800,000		247	8,150,000	296
24/191	5HG1	South Saskatchewan River at Saskatoon	2,483	5,081	75,000	30	15	575,000	232	113	1,350,000	265
24/192	5AJ1	South Saskatchewan River at Medicine Hat	834	2,221							600,000	270
25/193	5AH39	Paradise Creek near Seven Persons	74	90	1,350	18	15	5,900	80	66	11,000	122
25/194	5AH33	Seven Persons Creek near Seven Persons	289	431	3,850	13	9	26,000	90	60	55,500	129
25/195	5AH5	Seven Persons Creek at Medicine Hat	109	172	1,400	13	8	13,300	122	77	31,900	186

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26/196	5NB2	Souris River near Estevan	430	1,525	15,750	37	10	64,000	149	42	93,000	61
26/197	5ND3	Souris River at Oxbow	278	561	17,400	62	31	31,200	112	56	44,000	78
26/198	5NF0.2	Souris River at Sherwood	60	115	2,900	48	25	9,100	151	79	12,500	109
26/199	5NF0.1	Souris River at Westhope	1,684	4,050	42,000	25	10	222,000	132	53	294,000	73
26/200	5NF1	Souris River at Melita	69	176		---		40,000	580	227	135,000	766
26/201	5NG1	Souris River at Wawanesa	447	2,147	24,800	55	12	101,000	246	47	134,000	62
26/202	5NB3	Long Creek near Estevan	432	910	14,000	32	16	45,800	106	51	83,000	92
26/203	5ND2	Moose Mountain Creek near Oxbow	331	582	14,300	43	24	50,000	151	86	114,000	195
26/204	5NF2	Antler Creek near Melita	294	607	16,000	54	26	39,800	136	66	60,300	100
26/205	5NF3	Gainsborough Creek near Melita	154	332	5,950	39	18	19,900	129	59	35,500	107
26/206	5NF4	Graham Creek near Melita	24	70	900	38	13	4,200	175	69	8,250	118
26/207	5NG6	Pipestone Creek near Reston	445	868	24,200	54	28	88,000	198	101	165,000	190
27/208	5HD5	Swift Current Creek at Sinclair's Ranch	270	327	22,600	84	69	45,900	170	140	85,700	262
27/209	5HD36	Swift Current Creek at Highway No. 37	74	117		---	---	4,000	54	34	12,000	103
27/210	5HD30	Swift Current Creek below Jctn. Pelletier Creek	164	442	14,300	87	32	39,000	238	88	88,000	199
27/211	5HD7	Swift Current Creek near Swift Current	55	105	8,000	145	76	16,000	290	152	44,000	419
27/212	5HA16	Skull Creek at Doyle's Ranch	27	35	2,885	107	82	5,990	222	171	9,020	257
27/213	5HA2	Skull Creek near Skull Creek	34	44								
27/214	5HA13	Bridge Creek near Raymond and Boyle's Ranch	4.4	5	438	100	86	920	209	184	1,600	320
28/215	5AE0.5	Swift Current Creek at Many Glacier		32*	105,500		3,300	139,000		4,344	149,000	4,656
28/216	5AE2	Lee Creek at Cardston		112*	39,000		348	97,000		866	148,000	1,321
28/217	5AE5	Ralph Creek at Kimball	45	91	7,000	156	77	24,500	544	270	35,200	388
28/218	5AE11	Pothole Creek (Upper Station) at Magrath	107	162*	4,000	37	25	22,100	206	136	33,700	208
28/219	5AE1	St. Mary River at International Bdry. (Natural Flow)		477*	512,000		1,073	720,000		1,509	882,000	1,949
28/220	5AE6	St. Mary River at Lethbridge (Natural Flow)	396	529	5,000	13	10	66,000	167	125	120,000	227
28/221	5AE0.4	Canyon Creek near Many Glacier		7*	17,100		2,443	22,100		3,157	25,500	3,643
28/222	5AD7	Oldman River at Lethbridge (Natural Flow)	486	970*				147,000	302	152	400,000	412
28/223	11AA26	Sage Creek at "Q" Ranch	149	164*	6,300	42	38	16,300	109	99	26,000	159
28/224	11AA0.3	Milk River nr. Bdry. above U.S. St. Mary Canal	55	62*	17,700	332	285	38,000	691	613	50,500	815
28/225	11AA5	Milk River at Milk River (Natural Flow)	411	727*	10,000	24	14	42,500	103	70	63,500	104
28/226	11AA25	Milk River (South Br.)near International Bdry.	375	433*	60,000	160	139	139,000	371	321	194,000	448
28/227	11AA0.2	Milk River Eastern Crossing (Natural Flow)	779	1,410*	13,800	18	10	49,000	63	35	128,000	91
29/228	5JG4	Qu'Appelle River above Buffalo Pound Lake	222	427	2,200	10	5	19,500	88	46	36,300	85
29/229	5JG7	Qu'Appelle River below Junction Moose Jaw Creek	297	364		---		11,000	37	30	19,800	54
29/230	5JF1	Qu'Appelle River at Lumsden	174	264		---		7,200	41	27	66,000	250
29/231	5JK2	Qu'Appelle River below Craven Dam	650	2,239				12,500	19	6	81,000	36
29/232	5JM3	Qu'Appelle River at Tantallon	1,235	2,699	46,000	38	17	235,000	190	87	384,000	142
29/233	5JF4	Waskana Creek near Sedley	115	260	3,950	34	12	17,000	148	65	25,500	98
29/234	5JF3	Waskana Creek at Regina	215	483	6,000	28	12	31,000	144	64	44,250	92
29/235	5JF5	Waskana Creek above Junction Qu'Appelle River	85	198	2,500	29	13	14,000	165	71	27,000	136
29/236	5JH1	Arm River near Bethune	177	344	2,530	14	7	17,750	100	52	27,300	79
29/237	5JK4	Jumping Deer Creek near Lipton	41	104	1,340	33	13	6,200	151	60	12,500	120

* Taken from Water Resources Papers of Department of Northern Affairs and National Resources.

TABLE 3 (Cont'd)

REF. NO.	STATION NO.	HYDROMETRIC STATION LOCATION	INCREMENTAL DRAINAGE AREAS "DRY" D_d	INCREMENTAL DRAINAGE AREAS "WET" D_w	INCREMENTAL ANNUAL RUNOFF (inflow between given station and those immediately upstream) MEDIAN ac-ft. p.a.	MEDIAN ac-ft. p.a. /D_d	MEDIAN ac-ft. p.a. /D_w	1:10 ac-ft. p.a.	1:10 ac-ft. p.a. /D_d	1:10 ac-ft. p.a. /D_w	1:50 ac-ft. p.a.	1:50 ac-ft. p.a. /D_w
29/238	5JL2	Indian Head Creek near Indian Head	45	96	1,650	37	17	7,150	159	74	12,400	129
29/239	5JL5	Pheasant Creek near Abernethy	76	180	4,050	53	22	22,000	289	122	41,500	231
29/240	5JM5	Kapasvar Creek near Tantallon	102	423	5,250	51	12	24,800	243	59	50,500	119
29/241	5JM4	Cutarm Creek near Spy Hill	90	297	8,900	99	30	26,000	289	88	43,200	145
30/242	5LE1	Swan River at Swan River	716	1,470	166,000	232	113	389,500	544	265	493,000	335
30/243	5LC1	Red Deer River at Erwood	1,457	4,320	345,000	237	78	1,350,000	926	313	1,930,000	447
31/244	5JA2	Wood River near LaFleche	913	1,474	30,300	33	20					
31/245	5JA1	Wood River near Gravelbourg	928	1,510	30,700	33	20					
31/246	5JA1& 5JA2	5JA1 and 5JA2 combined	928	1,510	30,500	33	20	91,000	98	60	180,000	119
31/247	5JB2	Russel Creek near Vanguard	72	112	3,580	50	32	8,100	112	72	13,500	120
31/248	5JB1	Notukeu Creek near Vanguard	574	1,059	20,000	35	19	55,000	96	52	115,000	109
31/249	5JB3	Notukeu Creek near Gravelbourg	75	204				2,700	36	13	5,900	29
31/250	5JC1	Wiwa Creek near Gravelbourg	235	463	5,950	25	13	17,900	76	39	33,500	72

* Taken from Water Resources Papers of Department of Northern Affairs and National Resources.

TABLE 4

ELEVATION DATA

REF. NO.	STATION NO.	HYDROMETRIC STATION LOCATION	MEAN ELEVATION IN Feet
1/1	7AA2	Athabasca River near Jasper	6,700
1/2	7AD1	Athabasca River at Entrance	6,150
1/3	7BE1	Athabasca River at Athabasca	3,700
1/4	7AA7	Sunwapta River at Athabasca Glacier	9,500
1/5	7AA1	Miette River near Jasper	6,450
1/6	7AG1	McLeod River near Wolf Creek	3,950
1/7	7AG3	Wolf Creek at #16 Highway Crossing	3,300
1/8	7BB2	Pembina River near Entwistle	3,400
1/9	7BA1	Pembina River below Paddy Creek	3,650
1/10	7BB3	Lobstick River near Styal	2,800
1/12	7BF4	Heart River at High Prairie	2,400
4/24	5FA1	Battle River near Ponoka	2,800
4/26	5FF2	Battle River near Battleford	2,200
6/38	5AD1	Mami Creek near Mountain View	4,650
6/39	5AD0.4	Belly River at International Bdry.	6,200
6/40	5AD5	Belly River near Mountain View	6,050
6/41	5AD2	Belly River near Standoff	4,500
6/42	5AD16	Drywood River (North Br.) near Twin Butte	6,250
6/43	5AD10	Drywood Creek near Fishburn	5,500
6/44	5AD12	Cottonwood Creek at Twin Butte	4,750
6/45	5AD4	Crooked Creek at Waterton Park	4,950
6/46	5AD0.2	Boundary Creek near International Bdry.	6,300
6/47	5AD0.1	Waterton River at International Bdry.	6,150
6/48	5AD3	Waterton River at Waterton Park	6,050
6/49	5AD8	Waterton River at Standoff	5,050
6/50	5AD0.3	Street Creek at International Bdry.	6,430
8/60	5AA3	Bath Creek near Lake Louise	6,800
8/61	5BA1	Bow River near Lake Louise	7,350
8/62	5BB3	Forty Mile Creek near Banff	7,050
8/63	5BB1	Bow River at Banff	6,850
8/64	5BC3	Spray Creek at Spray Lakes	7,150
8/65	5BC2	Spray River at Spray Lakes	7,400
8/66	5BC1	Spray River at Banff	7,050
8/67	5BG2	Ghost River near Black Rock Mountain	7,150
8/68	5BG1	Ghost River near Cochrane	5,900
8/69	5BF4	Pocaterra Creek near Mouth	7,000
8/70	5BF1	Kananaskis River near Seebe	6,900
8/71	5BE4	Bow River at Seebe	6,750
8/72	5BH4	Bow River at Calgary	6,050
8/73	5BJ3	Elbow River at Fullerton's Ranch	6,450
8/74	5BJ4	Elbow River at Bragg Creek	6,300
8/75	5BJ5	Elbow River above Glenmore Dam	5,550
8/77	5BH3	Nose Creek at Calgary	3,800
8/78	5BL8	Highwood River at Brown's Ranch	5,650

REF. NO.	STATION NO.	HYDROMETRIC STATION LOCATION	MEAN ELEVATION IN Feet
8/79	5BL6	Pekisko Creek near Pekisko	5,350
8/80	5BL7	Stimson Creek near Pekisko	4,550
8/81	5BL9	Highwood River near Aldersyde	5,000
8/82	5BL18	Sheep River at Buck's Ranch	6,100
8/83	5BL12	Sheep River near Okotoks	4,900
16/133	5DA6	North Sask. River at Sask. Crossing	7,480
16/134	5DC2	North Sask. River at Saunders	6,800
16/135	5DC1	North Sask. River near Rocky Mtn. House	6,050
16/136	5DE1	North Sask. River at Rocky Rapids	5,300
16/137	5DF1	North Sask. River near Edmonton	4,700
16/138	5DA7	Mistaya River near Sask. Crossing	7,500
16/139	5DB2	Prairie Creek near Rocky Mtn. House	4,550
16/140	5DB1	Clearwater River near Rocky Mtn. House	5,400
17/143	5EA5	Sturgeon River near Villeneuve	2,350
17/147	5GA1	Eyehill Creek near Yonker	2,350
18/148	5AA3	Castle River near Cowley	5,450
18/149	5AA22	Castle River near Beaver Mines	5,600
18/150	5AA2	Crowsnest River near Lundbreck	5,350
18/151	5AA8	Crowsnest River near Frank	5,550
18/152	5AA9	Crowsnest River near Coleman	5,700
18/153	5AB6	Meadow Creek at Hartt's Ranch	4,300
18/154	5AB3	Trout Creek at Lockwood's Ranch	4,500
18/155	5AB2	Willow Creek near Nolan	4,200
18/156	5AB21	Willow Creek near Claresholm	4,500
18/157	5AA1	Oldman River at Cowley	5,700
18/158	5AA23	Oldman River at Waldron's Corner	6,050
18/159	5AA21	Oldman River at The Gap	6,250
18/160	5AA4	Pincher Creek at Pincher Creek	4,900
18/161	5AB7	Oldman River near McLeod	5,050
18/162	5AD19	Oldman River at Monarch	4,650
21/178	5CA1	Red Deer River near Sundre	6,600
21/179	5CC2	Red Deer River at Red Deer	4,500
21/180	5CD4	Red Deer River near Nevis	4,400
21/181	5CE1	Red Deer River at Drumheller	3,300
21/182	5CK2	Red Deer River near Empress	3,000
21/183	5CC1	Blindman River near Blackfalds	3,050
21/184	5CE2	Kneehills Creek near Drumheller	2,850
21/185	5CE3	Rosebud River at Beynon	3,050
21/186	5CH2	Berry Creek near Wardlow	2,400
28/215	5AE0.5	Swift Current Creek at Many Glacier	6,500
28/216	5AE2	Lee Creek at Cardston	4,650
28/217	5AE5	Rolph Creek near Kimball	4,300
28/218	5AE11	Pothole Creek near Magrath	3,900

TABLE 4 (Cont'd.)

REF. NO.	STATION NO.	HYDROMETRIC STATION LOCATION	MEAN ELEVATION IN Feet
28/219	5AE1	St. Mary River at International Bdry.	5,850
28/220	5AE6	St. Mary River near Lethbridge	4,400
28/221	5AE0.4	Canyon Creek near Many Glacier	6,800
28/222	5AD7	Oldman River at Lethbridge	4,500
28/223	11AA26	Sage Creek at Q Ranch	3,100
28/224	11AA0.3	Milk River (North Br.) above U. S. St. Mary Canal	4,850
28/225	11AA5	Milk River at Milk River	4,400
28/226	11AA25	Milk River (South Br.) at International Bdry.	4,750
28/227	11AA0.2	Milk River at Eastern Crossing	3,800
	5BK1	Fish Creek near Priddis	4,350
	5AE8	Lee Creek at Layton's Ranch	4,850
	7AG2	McLeod River near Edson	4,100
	11AA1	Milk River (North Br.) at International Bdry.	4,650
	5AE0.6	Swift Current Creek at Sherburne	6,100
1/11	7BF2	West Prairie River at High Prairie	2,550

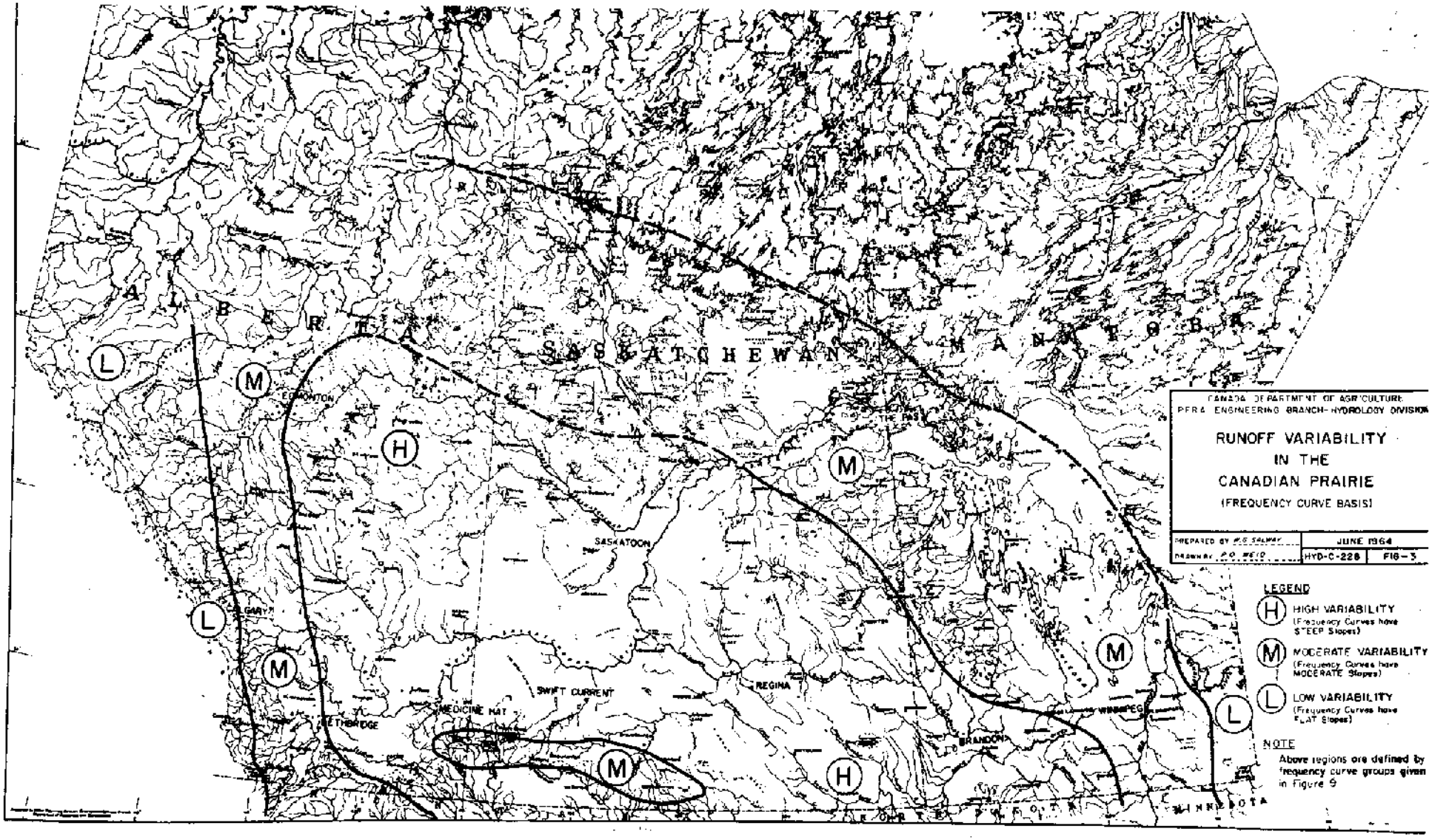
TABLE 5 (Cont'd.)

REF. NO.	STATION NO.	HYDROMETRIC STATION LOCATION	AVERAGE ANNUAL PPN. inches
9/86	5KA3	Carrot River at Beaulieu's Farm	14.3
9/87	5KA1	Carrot River at Kinistino	14.6
10/88	5LJ4	Valley River at Valley River	17.4
10/89	5LJ10	Valley River near Dauphin	17.4
10/91	5LJ11	Wilson River near Dauphin	16.6
10/92	5LJ12	Vermillion River near Dauphin	17.8
10/93	5LJ5	Ochre River near Ochre River	19.5
10/94	5LJ7	Turtle River near Laurier	19.7
11/102	11AC9	Oxarat Creek at Wylie's Ranch	14.5
11/104	11AC16	Belanger Creek above Cypress Lake	16.6
11/105	11AC4	Davis Creek at Drury's Ranch	16.5
11/106	11AC3	Fairwell Creek at Drury's Ranch	16.5
11/107	11AC2	Frenchman R. (North Br.) at Cross' Ranch	16.4
11/108	11AC25	Denniel Creek at Val Marie	12.5
11/109	11AD0.1	Whitewater Creek at Inter. Bdry.	11.5
11/110	11AE0.4	McEachern Creek at Inter. Bdry.	13.0
11/111	11AE0.3	Horse Creek at Inter. Bdry.	14.6
11/112	11AE0.2	Rock Creek at Inter. Bdry.	14.5
11/113	11AE2	Poplar River (West Br.) at Inter. Bdry.	14.0
11/114	11AE0.5	Poplar River (Middle Br.) at Inter. Bdry.	15.5
11/115	11AE3	Poplar River (East Br.) at Inter. Bdry.	15.6
11/116	11AF0.2	Beaver Creek at International Bdry.	15.5
12/117	5AH2	McKay Creek at Walsh	15.7
12/118	5AH1	Boxelder Creek at Walsh	15.0
13/119	11AB82	Lodge Creek near Alta. Bdry.	14.5
13/120	11AB6	Lodge Creek at International Bdry.	13.2
13/121	11AB9	Middle Creek near Alta. Bdry.	16.0
13/122	11AB8	Middle Creek at Hammond's Ranch	14.5
13/123	11AB70	McRae Coulee near Inter. Bdry.	11.0
14/124	5MF5	Minnedosa River at Elphinstone	17.0
14/125	5MF1	Minnedosa River at Beilby's Bridge	17.7
14/126	5MF17&18	Minnedosa River 2 mi. north of Rivers	17.9
14/127	5MF9	Whirlpool River at Danvers	21.0
14/128	5MF8	Rolling River at Lea's Bridge	18.0
15/129	5JE5	Avonlea Creek near Rouleau	15.4
15/130	5JE4	Moose Jaw Creek near Rouleau	15.5
15/131	5JE1	Moose Jaw Creek at McCarthy's	15.2
15/132	5JG8	Moose Jaw Creek above Jctn. Qu'Appelle R.	15.0
16/139	5DB2	Prairie Creek near Rocky Mtn. House	24.4

...F. ..O.	STATION NO.	HYDROMETRIC STATION LOCATION	AVERAGE ANNUAL PPN. inches
17/143	5EA5	Sturgeon River near Villeneuve	18.1
17/144	5EA2	Sturgeon River near St. Albert	18.0
17/145	5EA1	Sturgeon River at Fort Sask.	17.7
17/147	5GA1	Eyehill Creek near Yonker	13.4
18/148	5AA3	Castle River near Cowley	29.9
18/149	5AA22	Castle River near Beaver Mines	33.0
18/150	5AA2	Crowsnest River at Lundbreck	24.5
18/151	5AA8	Crowsnest River at Frank	26.0
18/152	5AA9	Crowsnest River at Coleman	27.0
18/153	5AB6	Meadow Creek at Hart's Ranch	18.4
18/154	5AB3	Trout Creek at Lockwood's Ranch	19.7
18/155	5AB2	Willow Creek at Nolan	19.9
18/156	5AB21	Willow Creek at Claresholm	22.0
18/157	5AA1	Oldman River at Cowley	29.5
18/158	5AA23	Oldman River at Waldron's Corner	30.1
18/159	5AA21	Oldman River at The Gap	31.0
18/160	5AA4	Pincher Creek at Pincher Creek	28.0
18/161	5AB7	Oldman River at McLeod	25.3
18/162	5AD19	Oldman River at Monarch	23.4
19/163	5AF8	Irrigation Creek near Orion	12.2
19/164	5AF10	Manyberries Creek at Brodin's Farm	13.5
20/165	5OB3	Pembina River at Manitou	19.0
20/166	5OC0.1	Pembina River at Neche, N.D.	18.7
20/167	5OG2	Riviere Sale at La Salle	19.3
20/168	5OF6	Morris River at Stephenfield	19.4
20/169	5OA2	Whitemud Creek West of Holmfield	18.2
20/171	5OD4	Roseau River at Gardenton	20.0
20/172	5OD14	Roseau River at Stuartburn	20.0
20/173	5OD1	Roseau River near Dominion City	19.7
20/174	5OE1	Rat River near Otterburne	20.7
20/174A	5OH6	Seine River at Prairie Grove	20.6
20/175	5SA1	Brokenhead River at St. Ouens	21.6
20/176	5OD0.4	Pine Creek at Pine Creek	21.2
20/177	5OD0.3	Sprague Creek near Sprague	21.4
21/183	5CC1	Blindman River near Blackfalds	18.9
21/184	5CE2	Kneehill Creek near Drumheller	16.0
21/185	5CE3	Rosebud River at Beynon	15.9
21/186	5CH2	Berry Creek near Wardlow	13.0
22/187	5AH13	Bullshead Creek near Woolchester	14.7
22/188	5AH37	Gros Ventre Creek near Coleridge	15.8
22/189	5AH3	Ross Creek near Irvine	15.7
25/193	5AH38	Paradise Creek near Seven Persons	13.5
25/194	5AH33	Seven Persons Creek near Seven Persons	13.3
25/195	5AH5	Seven Persons Creek near Medicine Hat	13.4

TABLE 5 (Cont'd.)

REF. NO.	STATION NO.	HYDROMETRIC STATION LOCATION	AVERAGE ANNUAL PPN. inches
26/196	5NB2	Souris River near Estevan	15.9
26/197	5ND3	Souris River near Oxbow	16.5
26/198	5NF0.2	Souris River near Sherwood, N.D.	16.5
26/202	5NB3	Long Creek near Estevan	15.8
26/203	5ND2	Moose Mountain Creek at Oxbow	17.2
26/204	5NF2	Antler Creek near Melita	17.3
26/205	5NF3	Gainsborough Creek near Melita	17.4
26/206	5NF4	Graham Creek near Melita	17.7
26/207	5NG6	Pipestone Creek near Reston	17.7
27/208	5HD5	Swift Current Creek at Sinclair's Ranch	13.5
27/212	5HA16	Skull Creek at Doyle's Ranch	16.7
27/213	5HA2	Skull Creek near Skull Creek	16.4
27/214	5HA13	Bridge Creek near Raymond & Boyle Ranch	16.5
28/215	5AE0.5	Swift Current Creek at Many Glacier	32.5
28/216	5AE2	Lee Creek at Cardston	24.0
28/217	5AE5	Rolph Creek at Kimball	18.1
28/218	5AE11	Pothole Creek (Upper Stn.) at Magrath	17.5
28/219	5AE1	St. Mary River at Inter. Bdry.	27.5
28/220	5AE6	St. Mary River at Lethbridge	22.2
28/221	5AE0.4	Canyon Creek near Many Glacier	32.0
28/222	5AD7	Oldman River at Lethbridge	23.4
28/223	11AA26	Sage Creek at "Q" Ranch	12.0
28/224	11AA0.3	Milk River (North Br.) above U.S. St. Mary Canal	18.5
28/225	11AA5	Milk River at Milk River	16.7
28/226	11AA25	Milk River (South Br.) near Inter. Bdry.	17.8
28/227	11AA0.2	Milk River at Eastern Crossing	14.5
29/228	5JG4	Qu'Appelle River above Buffalo Pound Lake	13.9
29/229	5JG7	Qu'Appelle River below Jctn. Moose Jaw Creek	14.1
29/230	5JF1	Qu'Appelle River at Lumsden	14.4
29/231	5JK2	Qu'Appelle River below Craven Dam	14.4
29/232	5JM3	Qu'Appelle River at Tantallon	15.8
29/233	5JF4	Waskana Creek near Scdley	15.5
29/234	5JF3	Waskana Creek at Regina	15.3
29/235	5JF5	Waskana Creek above Jctn. Qu'Appelle River	15.0
29/236	5JH1	Arm River near Bethune	13.5
29/237	5JK4	Jumping Deer Creek near Lipton	16.0
29/238	5JL2	Indian Head Creek near Indian Head	17.5
29/239	5JL5	Pheasant Creek near Abernethy	16.0
29/240	5JM5	Kaposvar Creek near Tantallon	16.2
29/241	5JM4	Cutarm Creek near Spy Hill	16.2
30/242	5LE1	Swan River at Swan River	16.5
30/243	5LC1	Red Deer River at Erwood	16.2
31/244	5JA2	Wood River near LaFleche	14.8


ALBERTA
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MANITOBA
EDMONTON
CALGARY
SASKATOON
THE PAS
REGINA
SWIFT CURRENT
MEDICINE HAT
LETHBRIDGE
BRANDON
WINNIPEG
MINNESOTA
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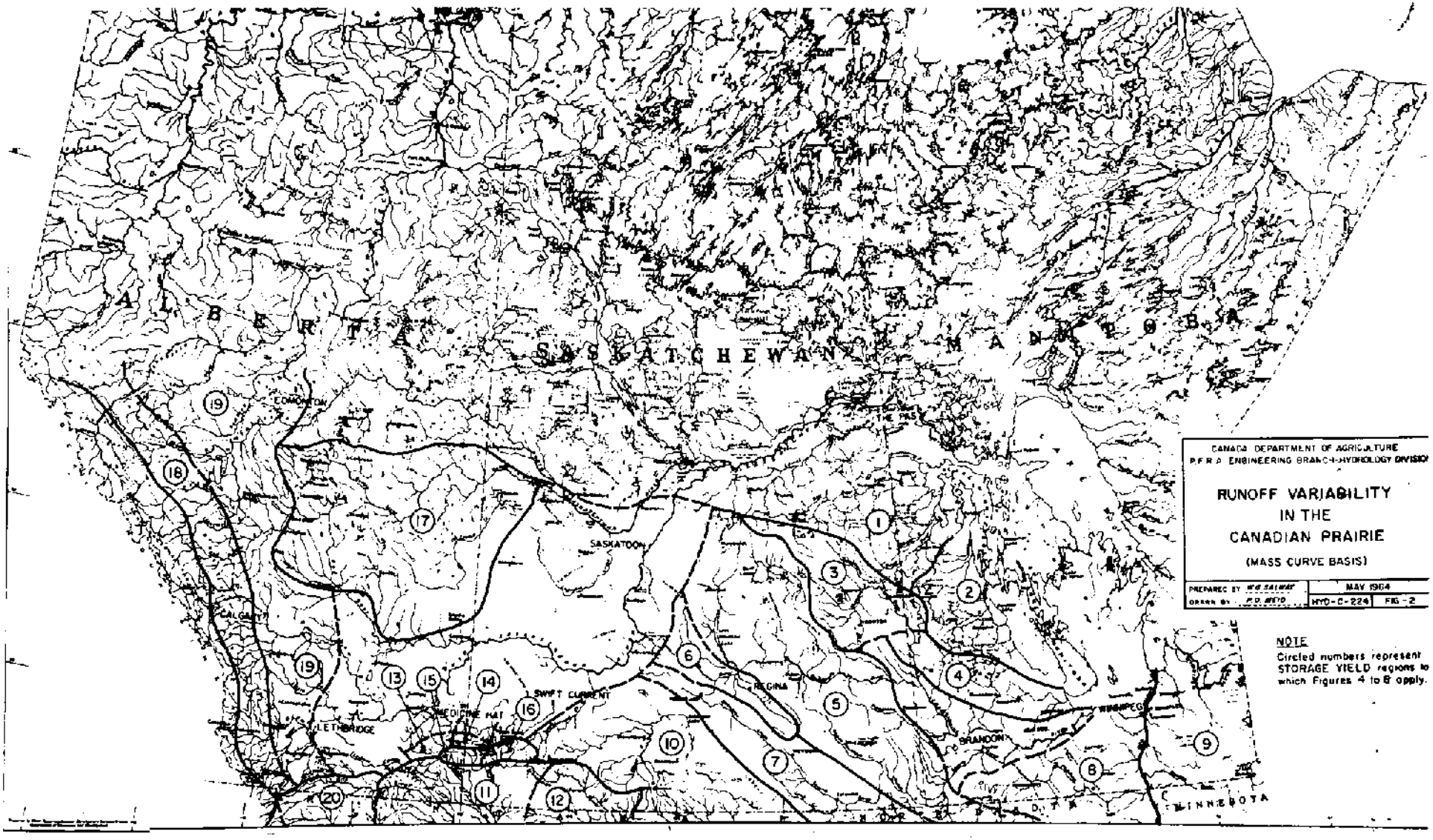
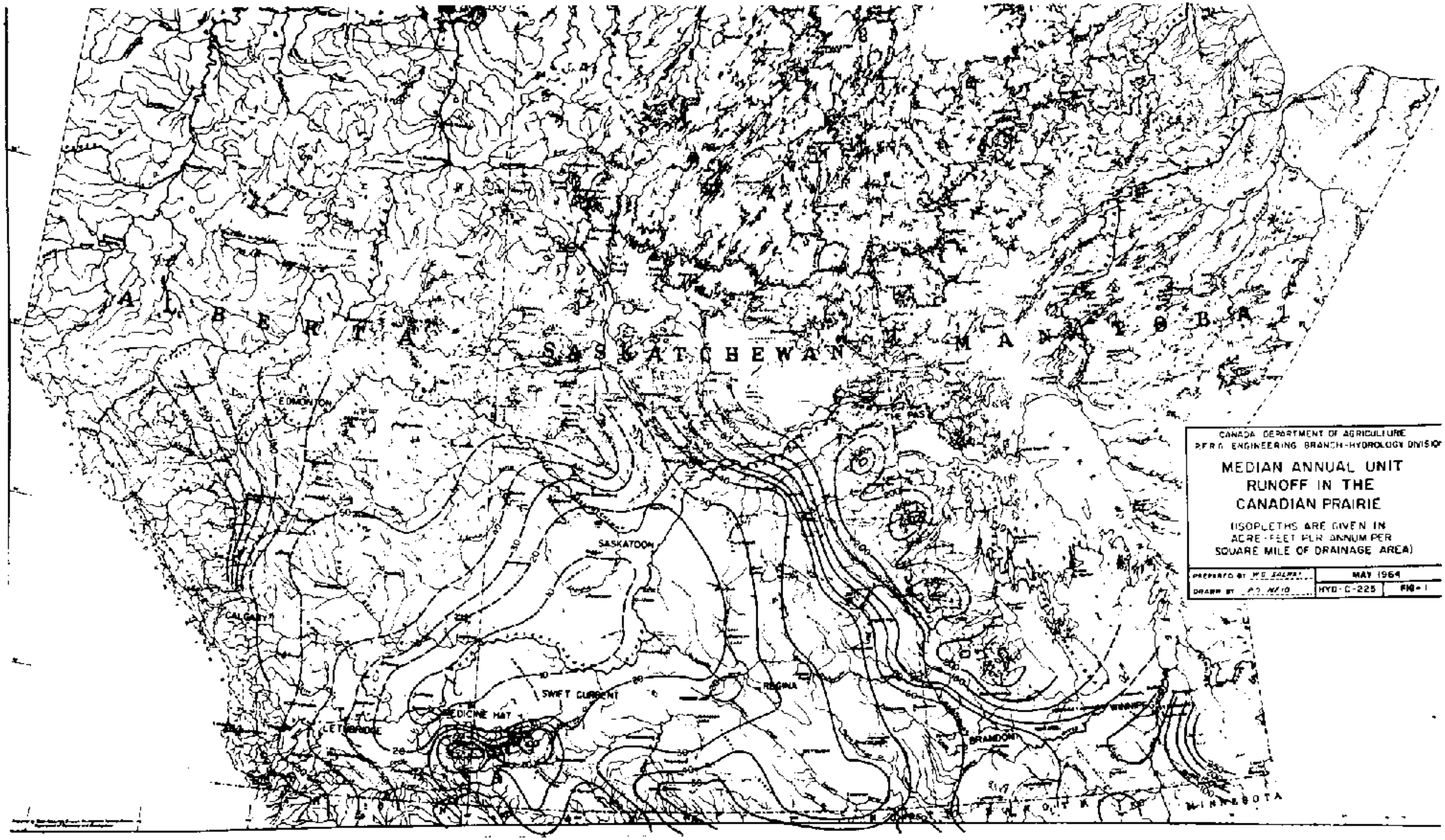
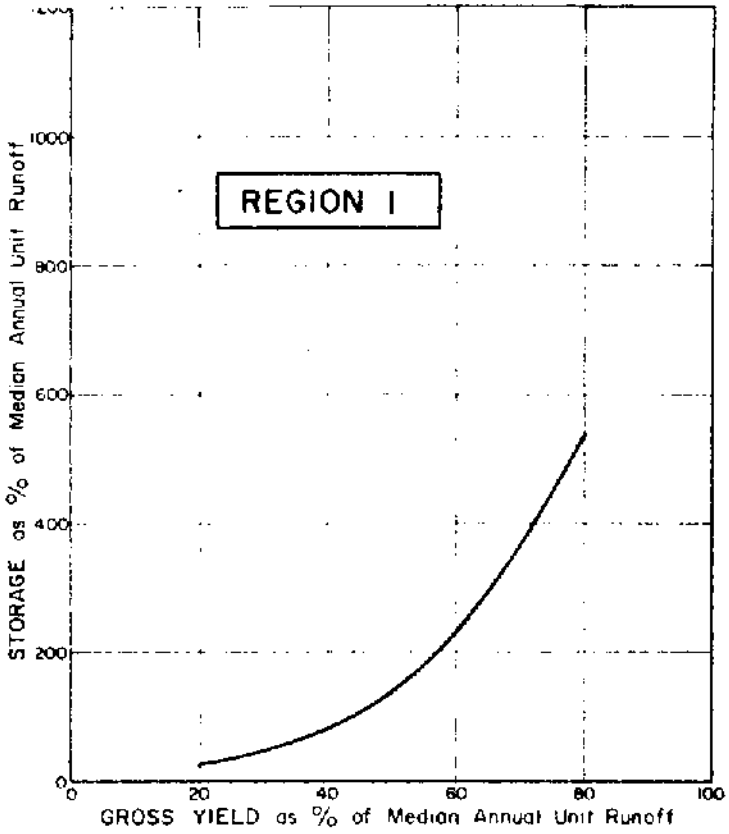
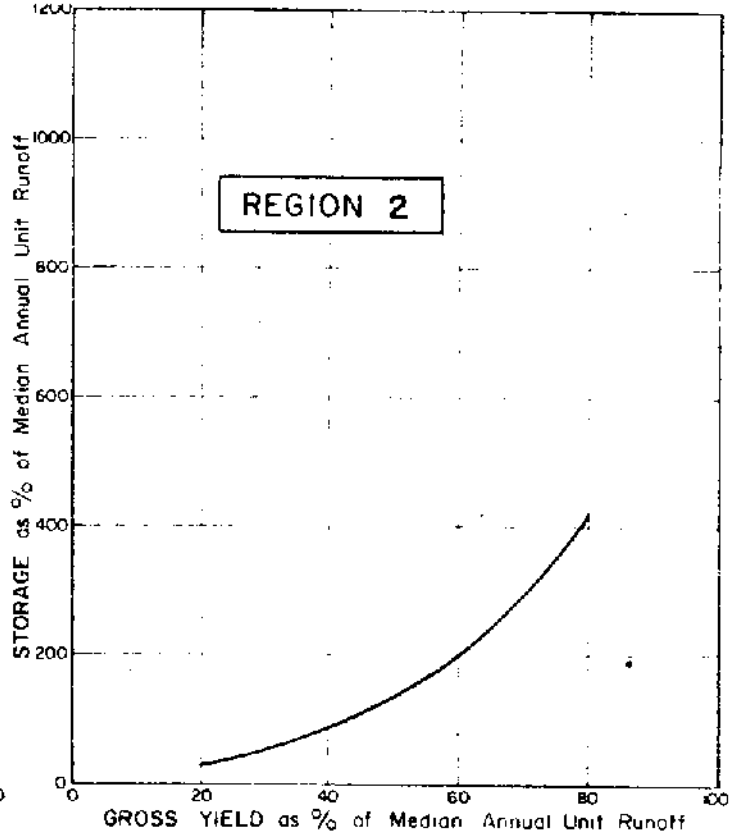
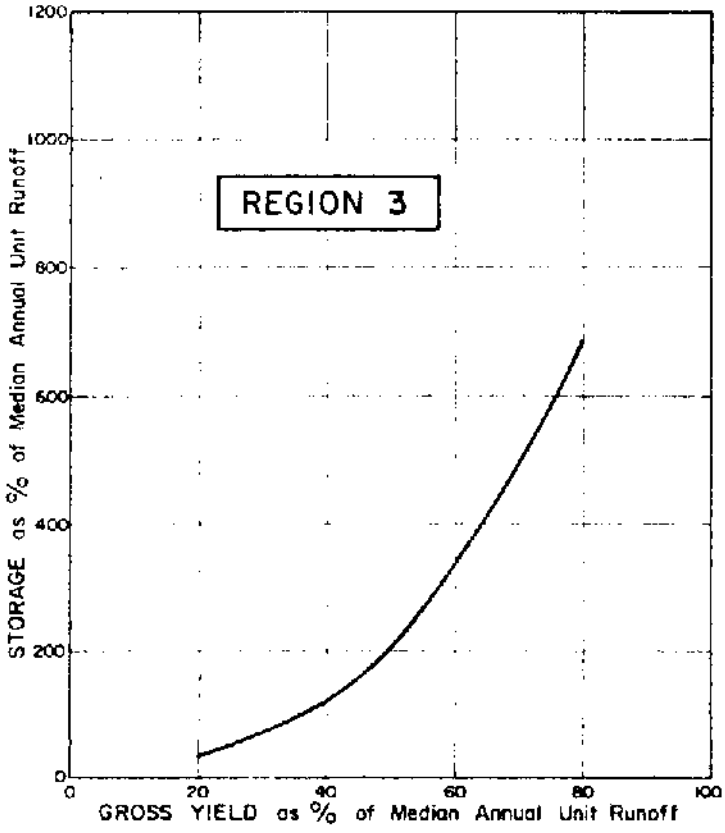
CANADA DEPARTMENT OF AGRICULTURE
PFRA ENGINEERING BRANCH- HYDROLOGY DIVISION
RUNOFF VARIABILITY
IN THE
CANADIAN PRAIRIE
(FREQUENCY CURVE BASIS)
PREPARED BY W.G. SALWAY
DRAWN BY A.O. REID
JUNE 1964
HYD-C-226
FIG-5
LEGEND
H HIGH VARIABILITY
(Frequency Curves have STEEP Slopes)
M MODERATE VARIABILITY
(Frequency Curves have MODERATE Slopes)
L LOW VARIABILITY
(Frequency Curves have FLAT Slopes)
NOTE
Above regions are defined by frequency curve groups given in Figure 9

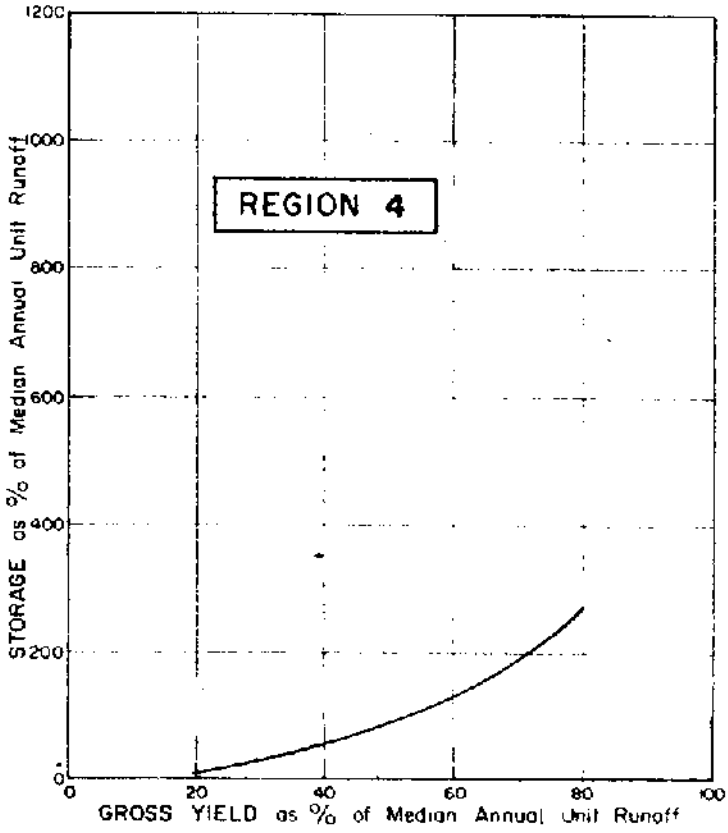

ALBERTA
SASKATCHEWAN
MANITOBA
EDMONTON
CALGARY
SASKATOON
REGINA
LETHBRIDGE
MEDICINE HAT
SWIFT CURRENT
BRANDON
WINNIPEG
MINNESOTA
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION
RUNOFF VARIABILITY
IN THE
CANADIAN PRAIRIE
(MASS CURVE BASIS)
PREPARED BY W.G. SALWAY
MAY 1964
DRAWN BY P.D. METO
HYD-C-224
FIG - 2
NOTE
Circled numbers represent STORAGE YIELD regions to which Figures 4 to 8 apply.


A L B E R T A
S A S K A T C H E W A N
M A N I T O B A
EDMONTON
CALGARY
LETHBRIDGE
MEDICINE HAT
SWIFT CURRENT
SASKATOON
REGINA
THE PAS
BRANDON
WINNIPEG
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION
MEDIAN ANNUAL UNIT
RUNOFF IN THE
CANADIAN PRAIRIE
(ISOPLETHS ARE GIVEN IN
ACRE-FEET PER ANNUM PER
SQUARE MILE OF DRAINAGE AREA)
MAY 1964
HYD-C-225
FIG-1
50
30
20
10
200
100









NOTE : GROSS YIELD is the sum of the NET DRAFT plus EVAPORATION and other LOSSES

CANADA DEPARTMENT OF AGRICULTURE
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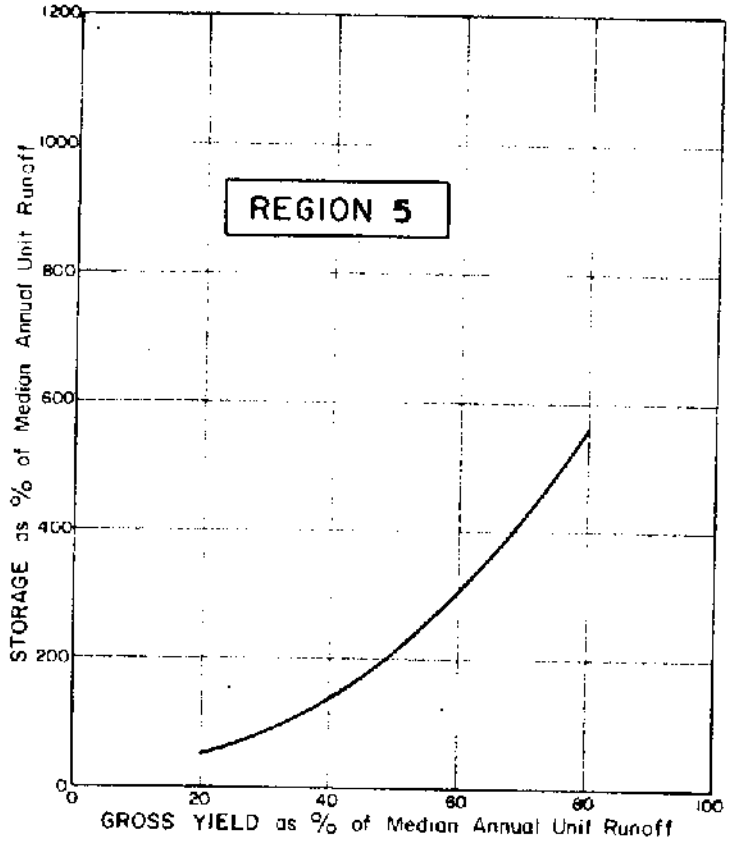
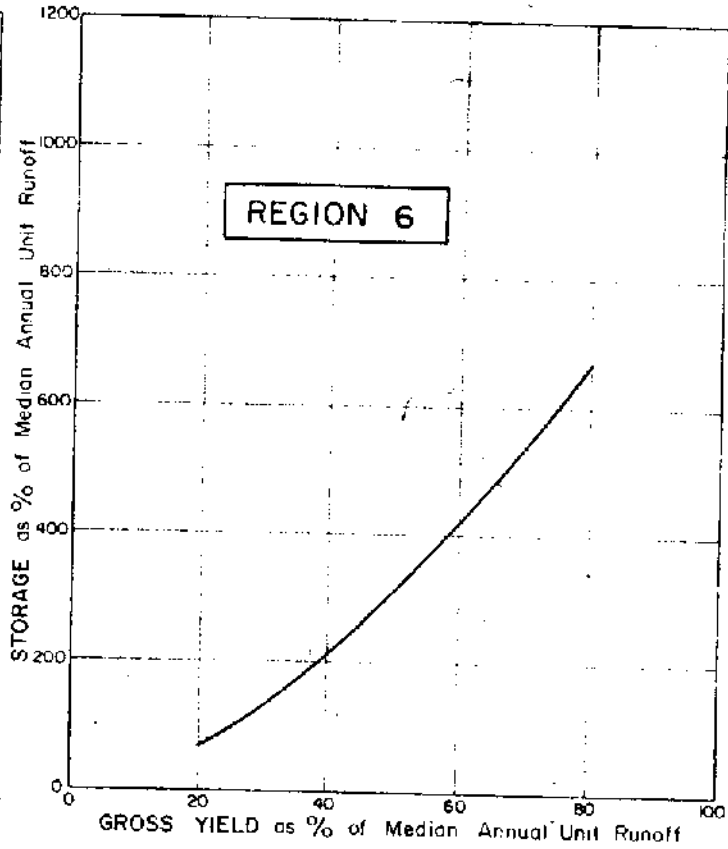
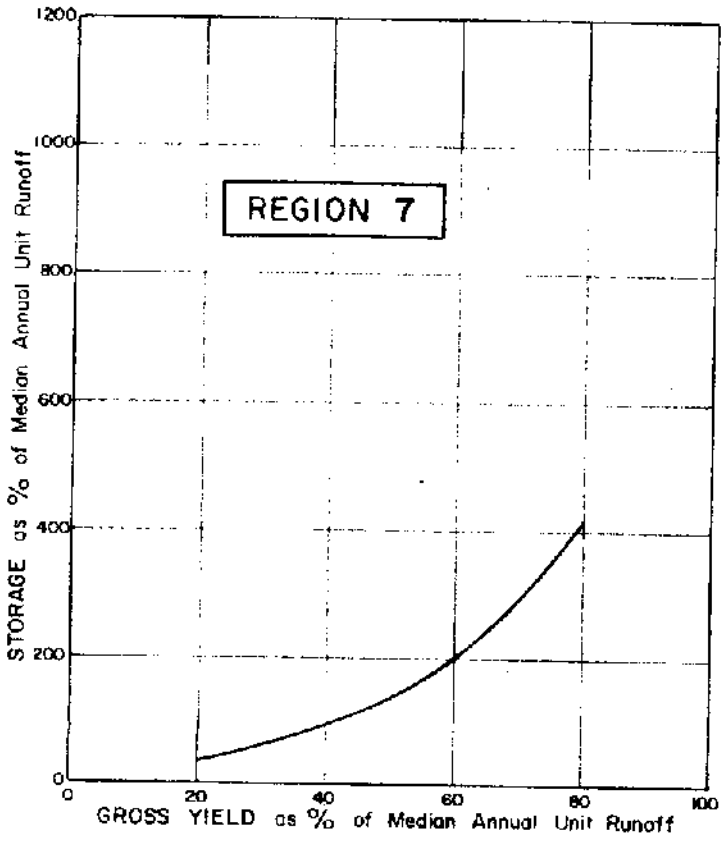
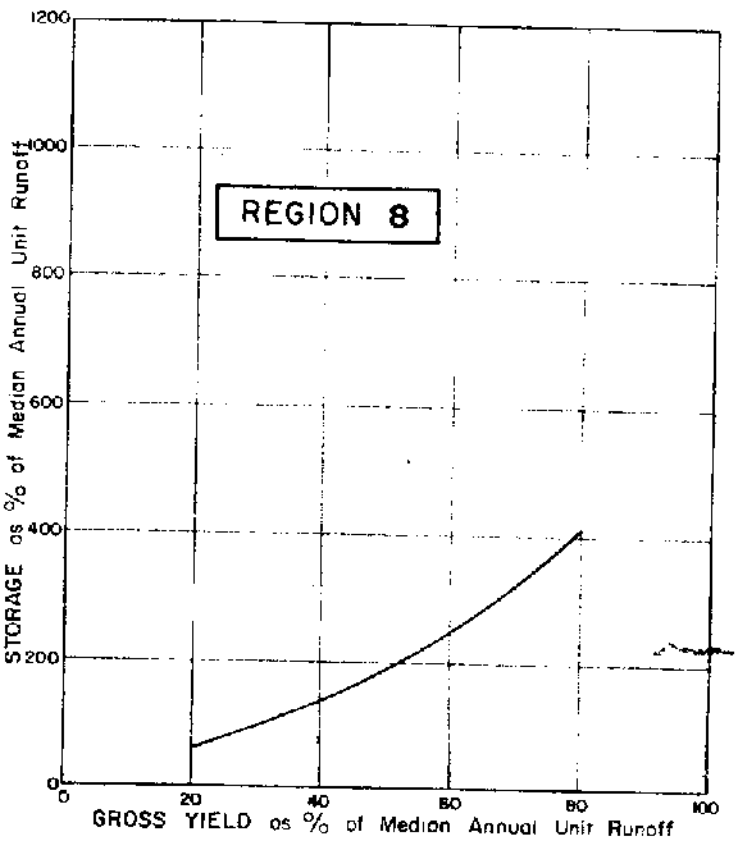
REGIONAL UNIT STORAGE-YIELD RELATIONSHIPS

PREPARED BY : W.G. SALWAY DRAWN BY : P.O. MEID	MAY 1964	HYD-A-532	FIG - 4







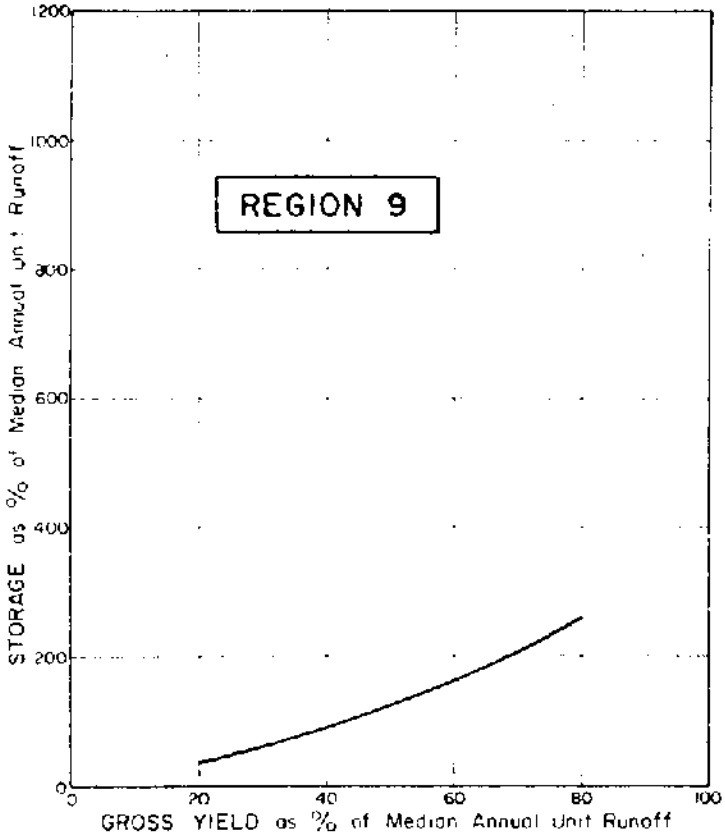


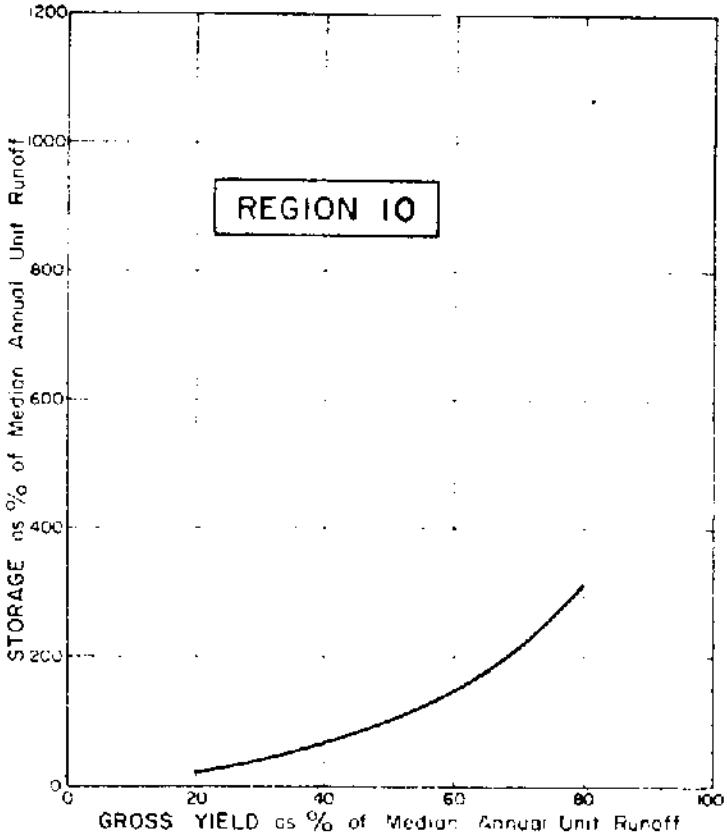
NOTE : GROSS YIELD is the sum of the NET DRAFT plus EVAPORATION and other LOSSES

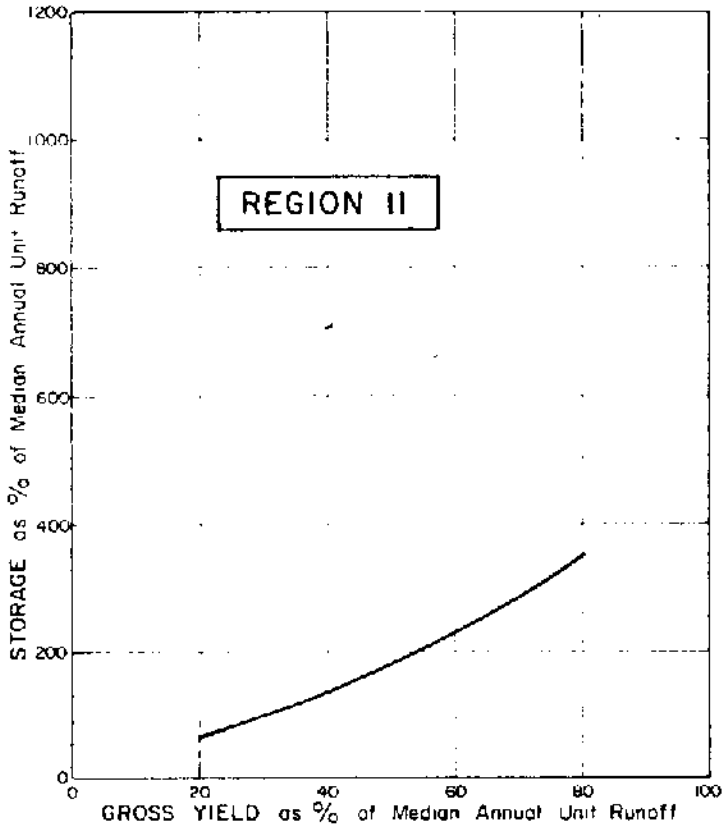
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION

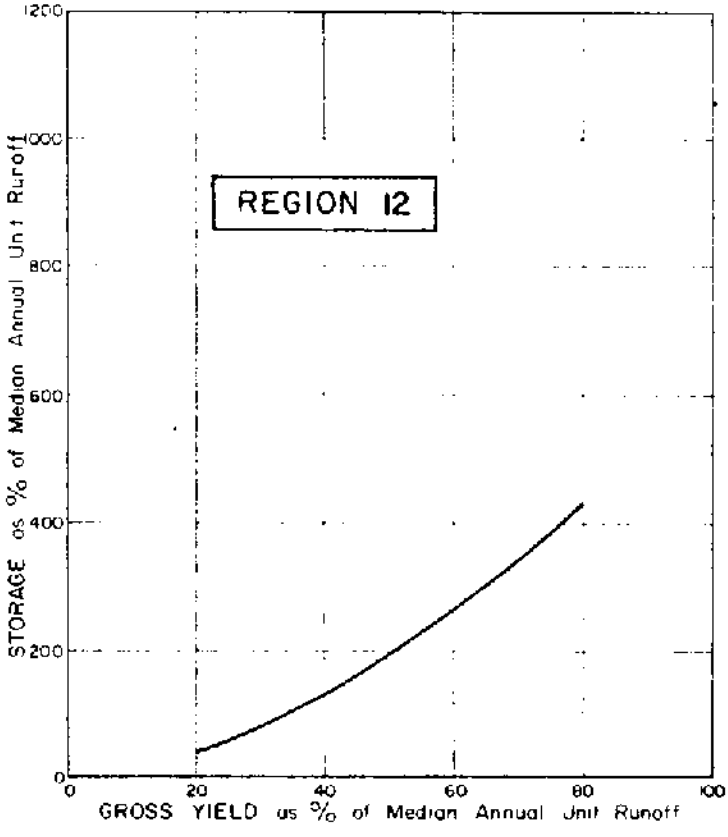
REGIONAL UNIT STORAGE-YIELD RELATIONSHIPS

PREPARED BY W.G. SALWAY DRAWN BY P.O. MEID	MAY 1964	HYD-A-533	FIG-5







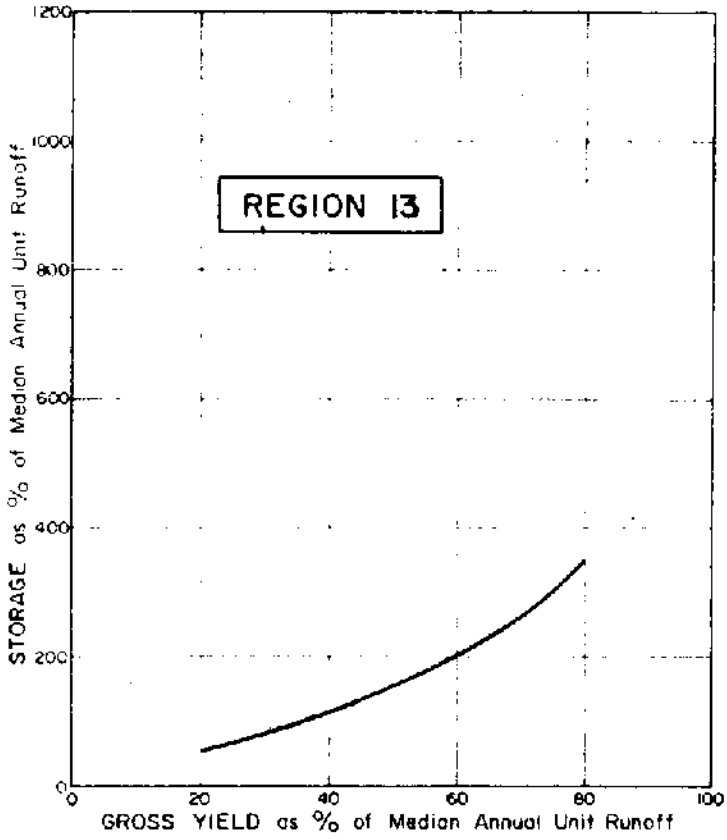


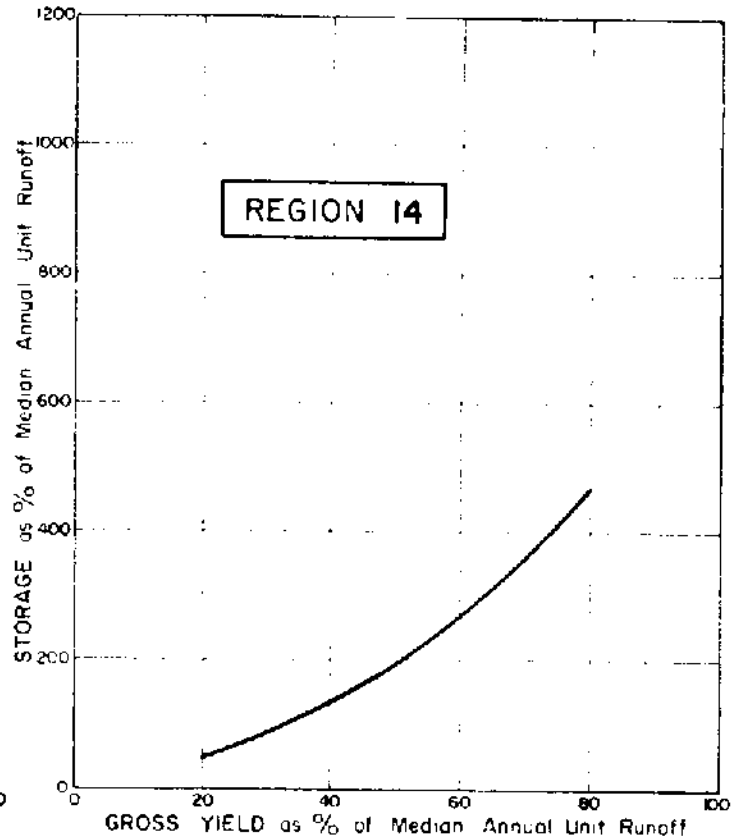
NOTE : GROSS YIELD is the sum of the NET DRAFT plus EVAPORATION and other LOSSES

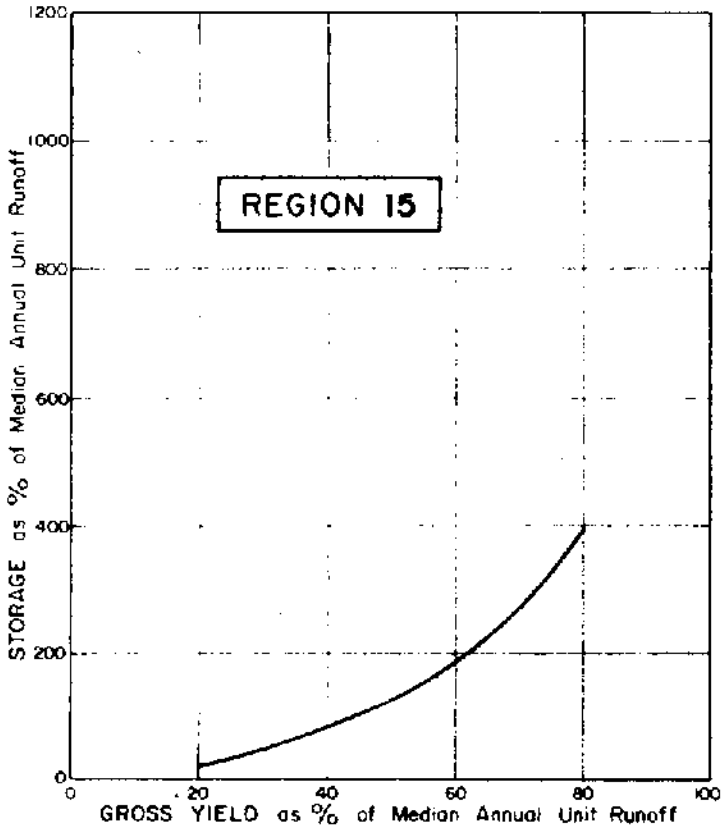
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION

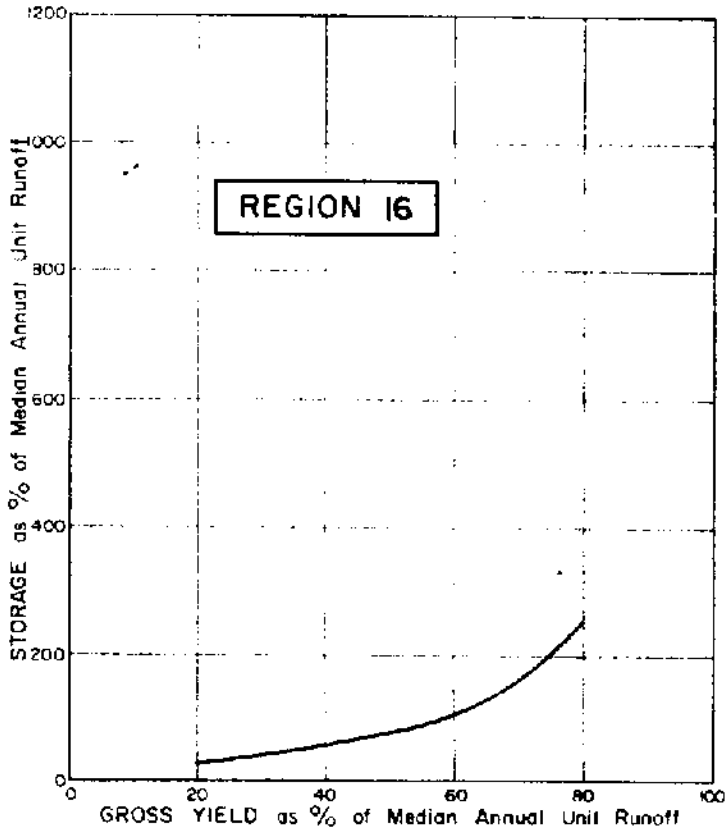
REGIONAL UNIT STORAGE-YIELD RELATIONSHIPS

PREPARED BY W.G. SALWAY DRAWN BY P.O. MEID	MAY 1964	HYD-A-534	FIG-6







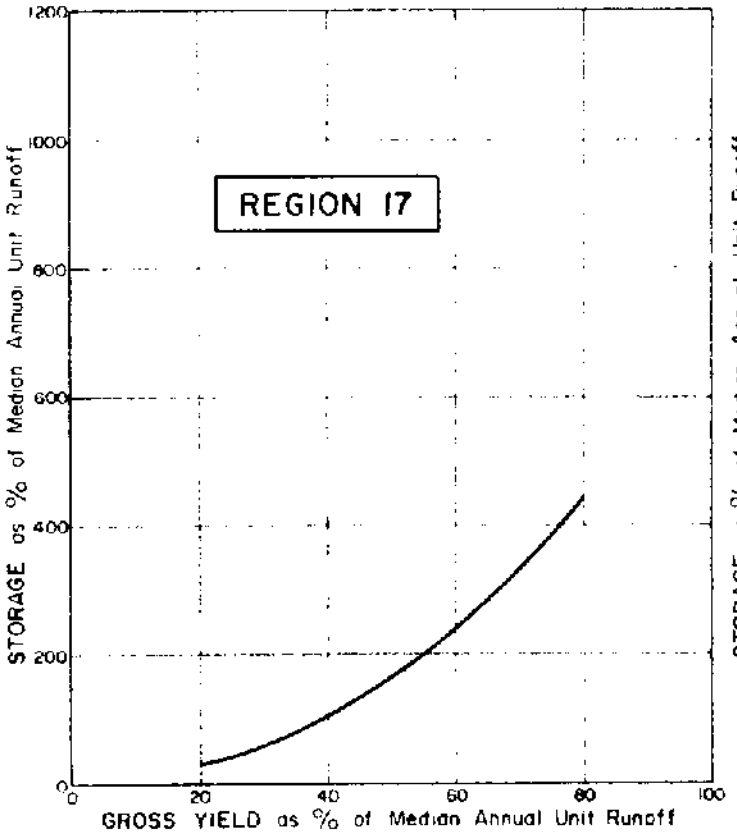


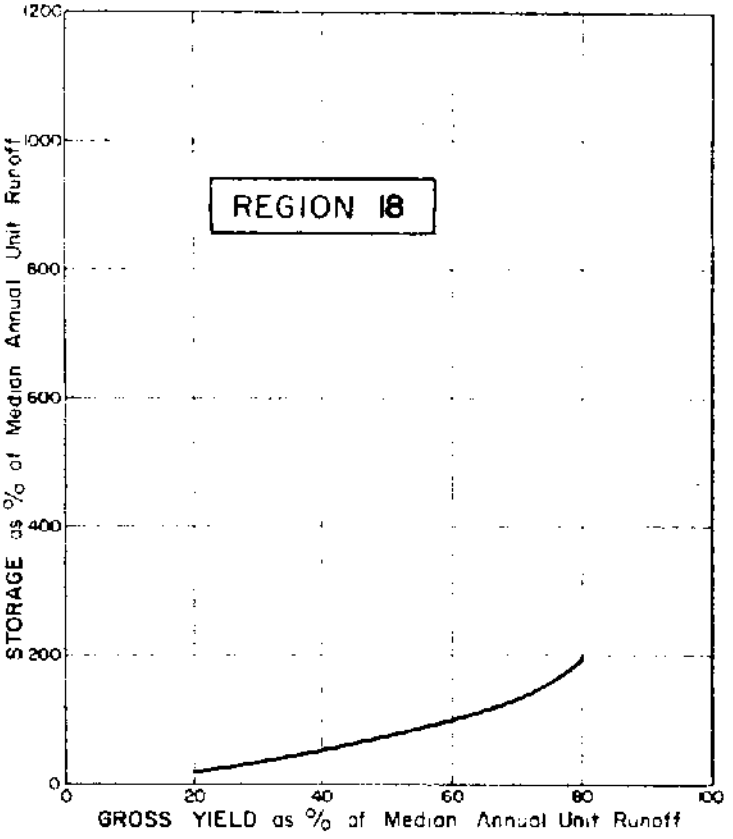
NOTE : GROSS YIELD is the sum of the NET DRAFT plus EVAPORATION and other LOSSES

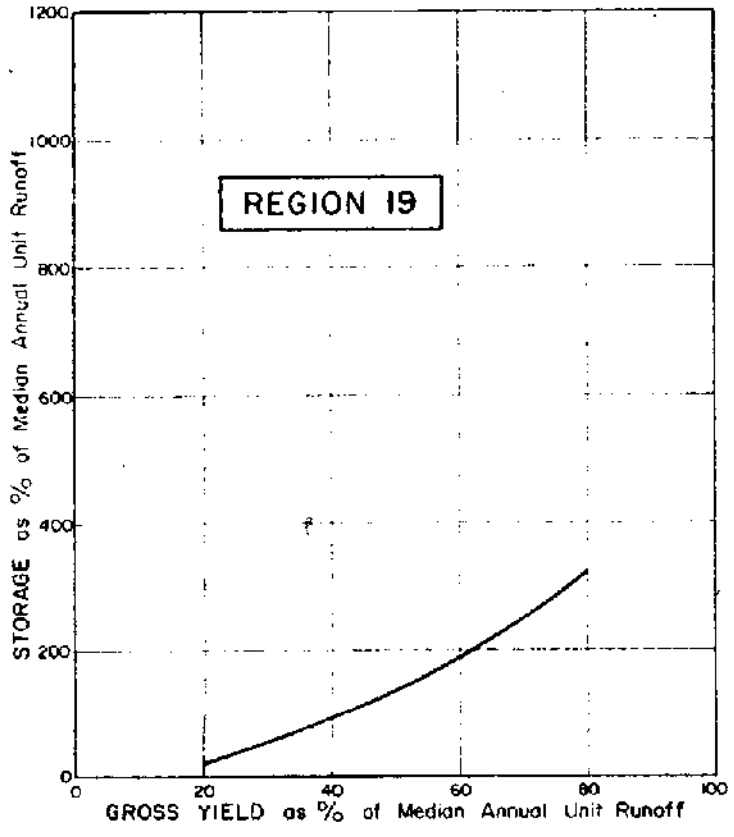
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION

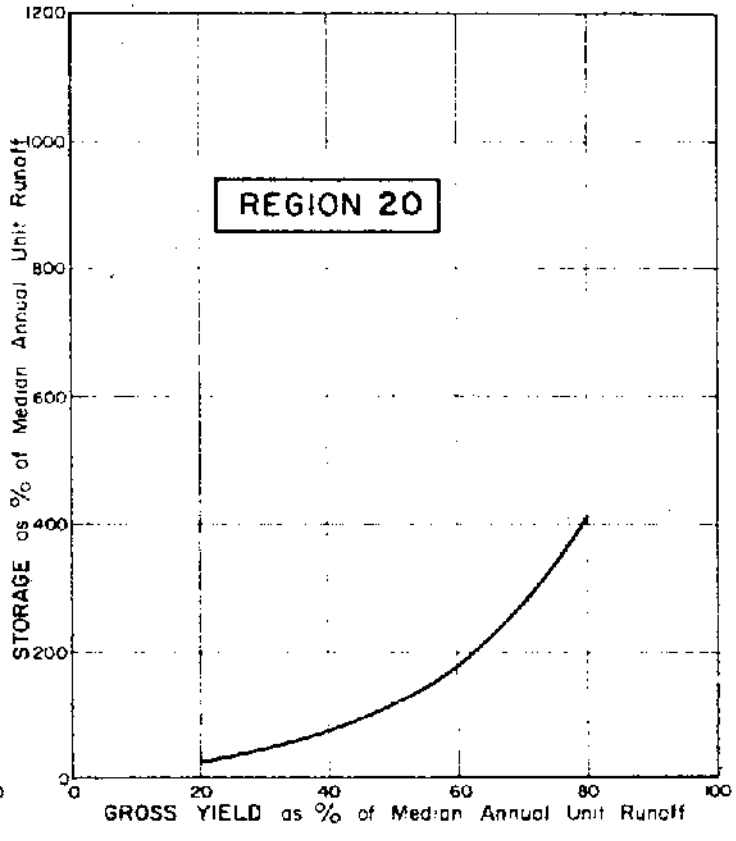
REGIONAL UNIT STORAGE-YIELD RELATIONSHIPS

PREPARED BY : W.G. SALWAY DRAWN BY : P.A. MEID	MAY 1964	HYD-A-535	FIG-7







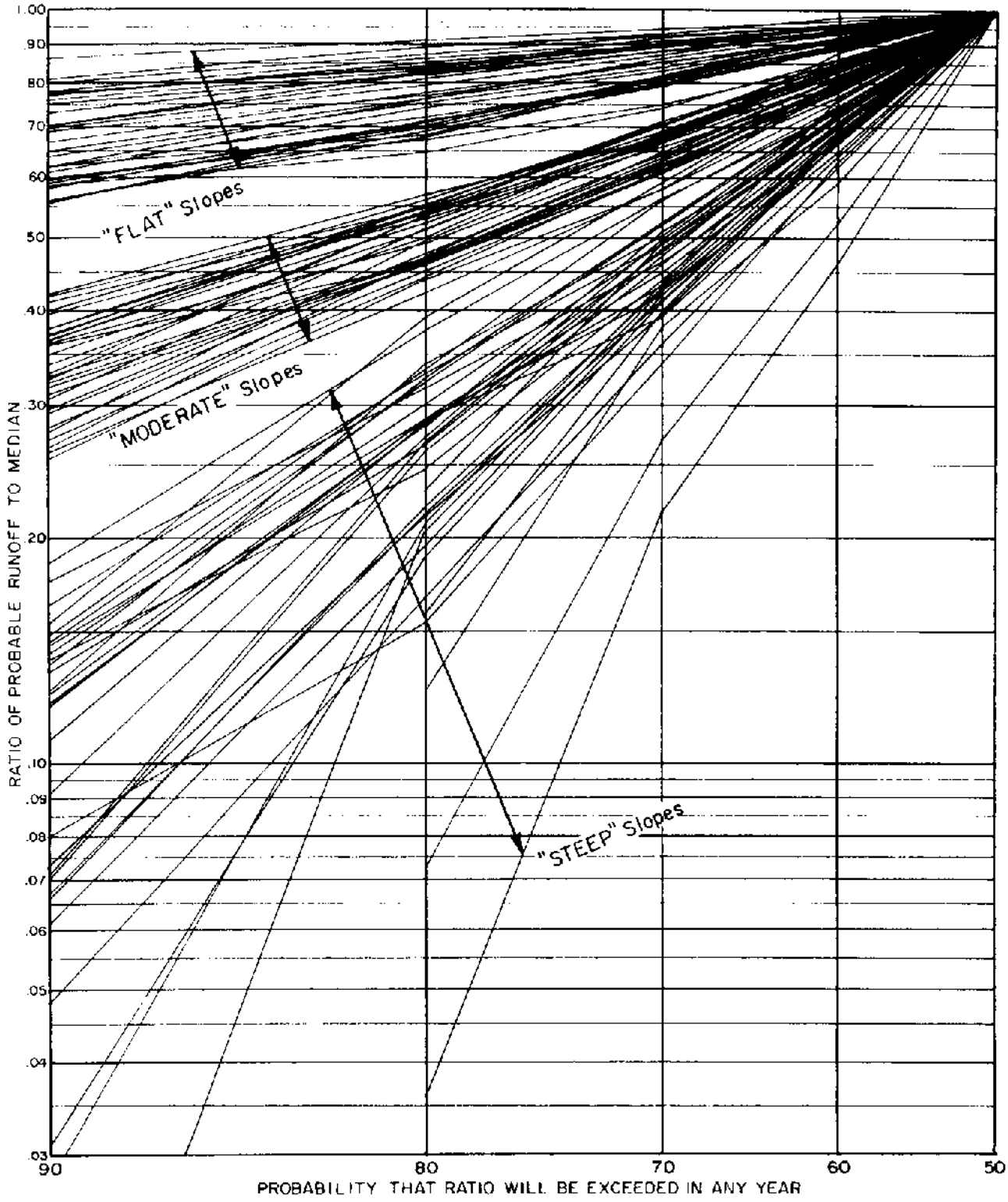


NOTE : GROSS YIELD is the sum of the NET DRAFT plus EVAPORATION and other LOSSES

CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION

REGIONAL UNIT STORAGE-YIELD RELATIONSHIPS

PREPARED BY : W.G. SALWAY DRAWN BY : P.O. MEID	MAY 1964	HYD-A-536	FIG-8



NOTE - The above groups of curves define the variability regions given in Figure 3.

CANADA DEPARTMENT OF AGRICULTURE
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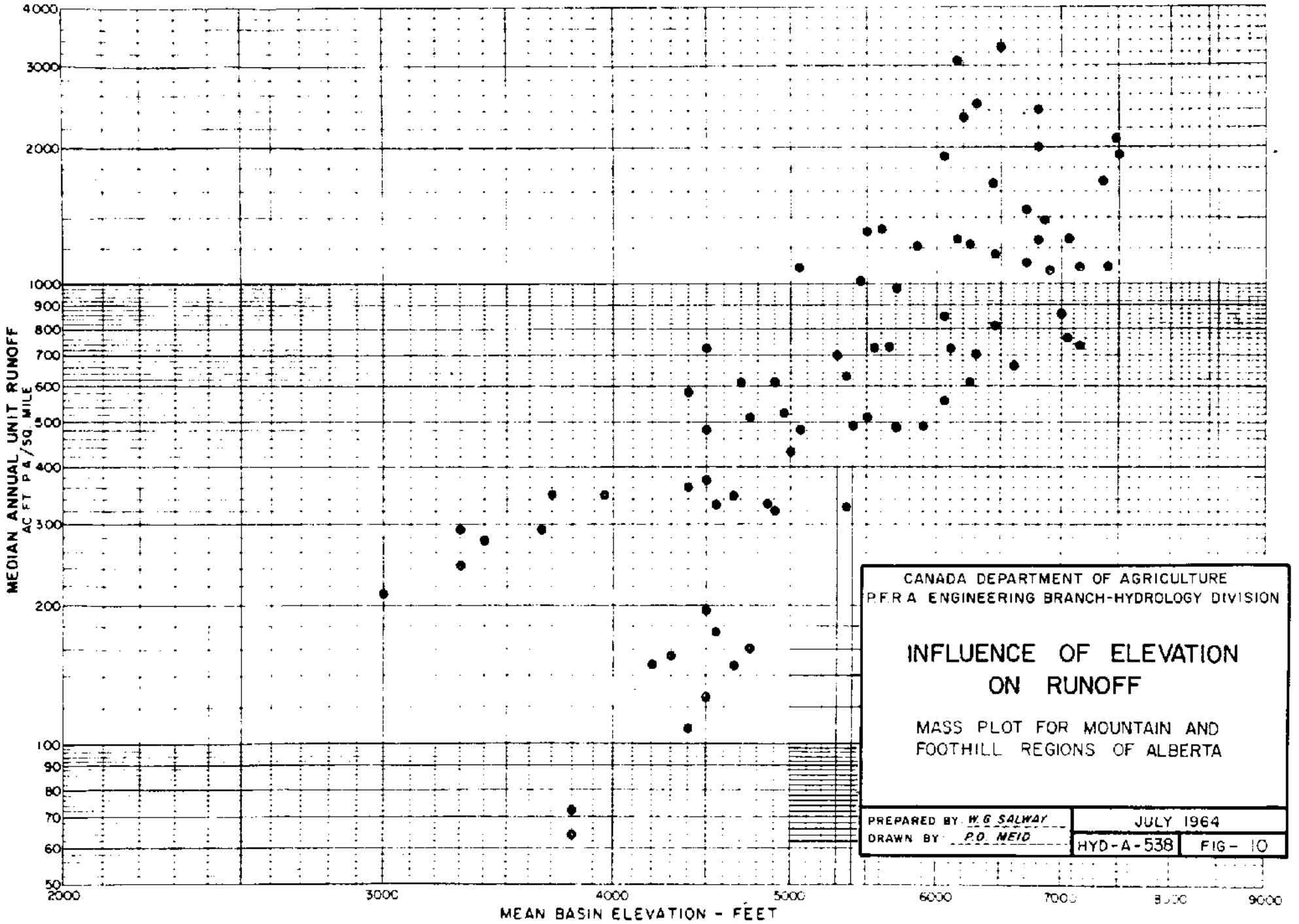
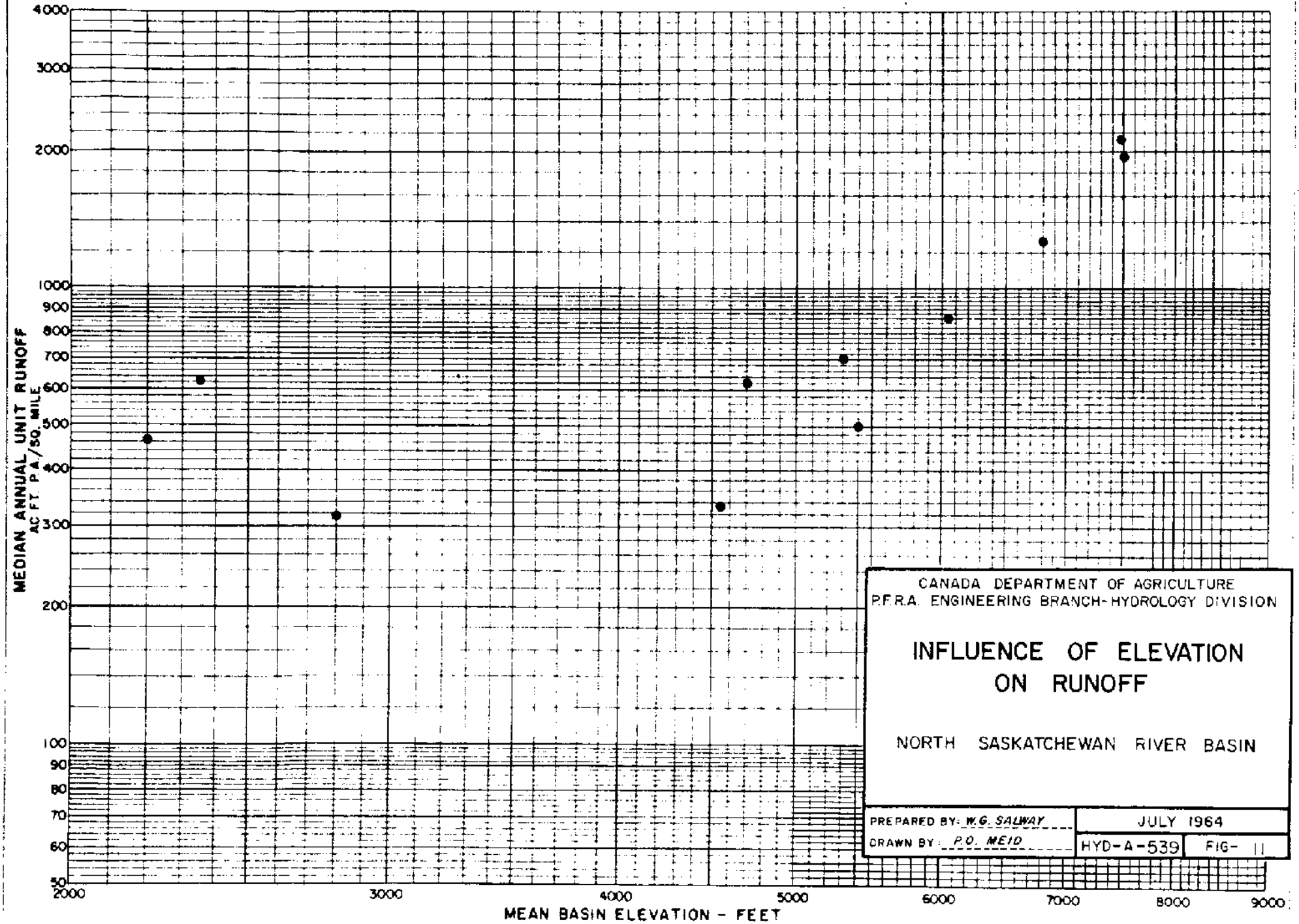
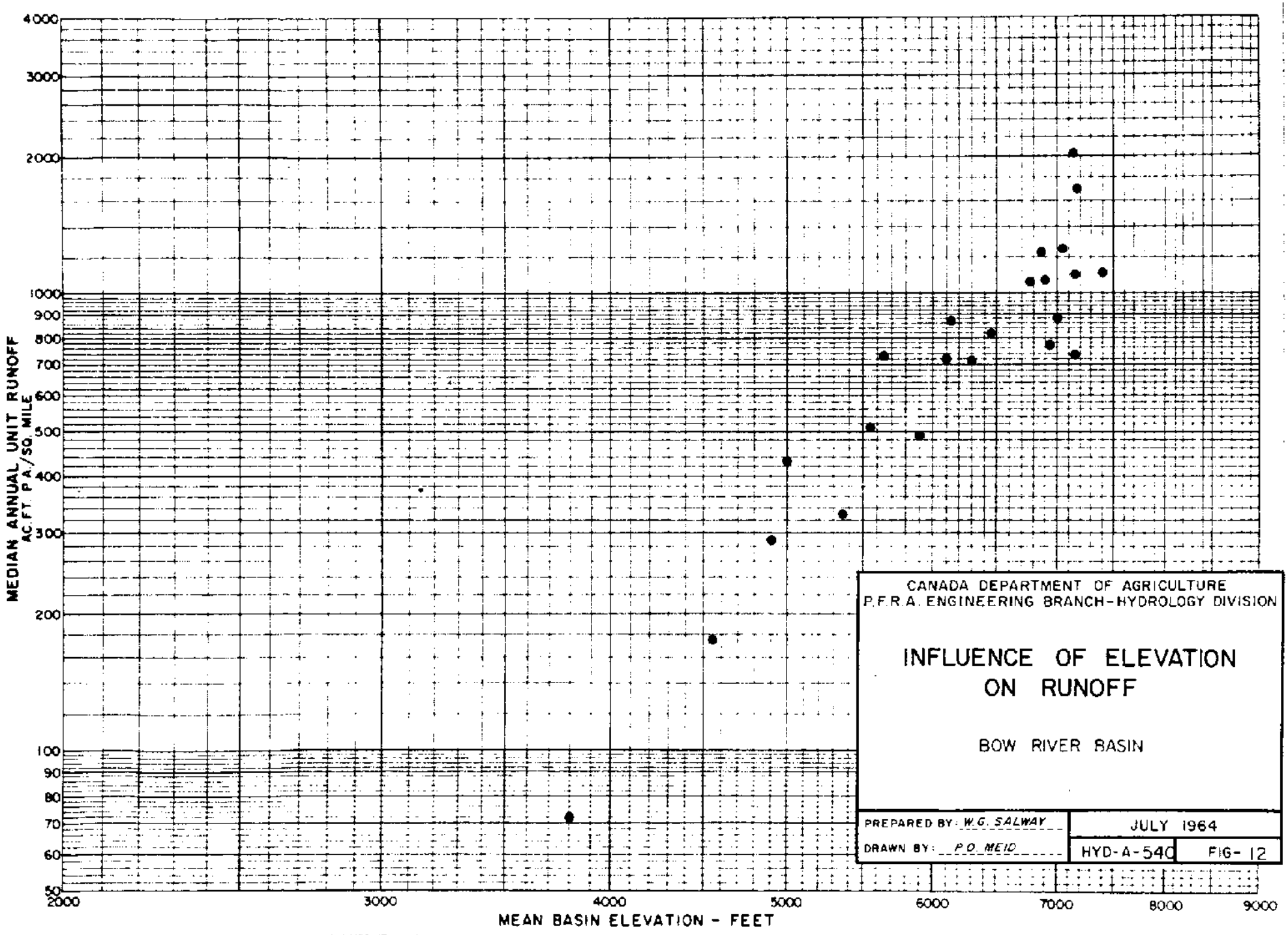
RUNOFF VARIABILITY

FREQUENCY CURVE MASS PLOT FOR LOW FLOWS

PREPARED BY W.G. SALWAY DRAWN BY P.O. MEID	MAY 1964	HYD-A-537	FIG-9


MEDIAN ANNUAL UNIT RUNOFF
AC FT P.A./SQ. MILE
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
2000
3000
4000
5000
6000
7000
8000
9000
MEAN BASIN ELEVATION - FEET
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION
INFLUENCE OF ELEVATION ON RUNOFF
MASS PLOT FOR MOUNTAIN AND FOOTHILL REGIONS OF ALBERTA
PREPARED BY W.G. SALWAY
DRAWN BY P.O. MEID
JULY 1964
HYD-A-538
FIG- 10


MEDIAN ANNUAL UNIT RUNOFF
AC FT. P.A./SQ. MILE
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
2000
3000
4000
5000
6000
7000
8000
9000
MEAN BASIN ELEVATION - FEET
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION
INFLUENCE OF ELEVATION ON RUNOFF
NORTH SASKATCHEWAN RIVER BASIN
PREPARED BY: W.G. SALWAY
DRAWN BY: P.O. MEID
JULY 1964
HYD-A-539
FIG- 11

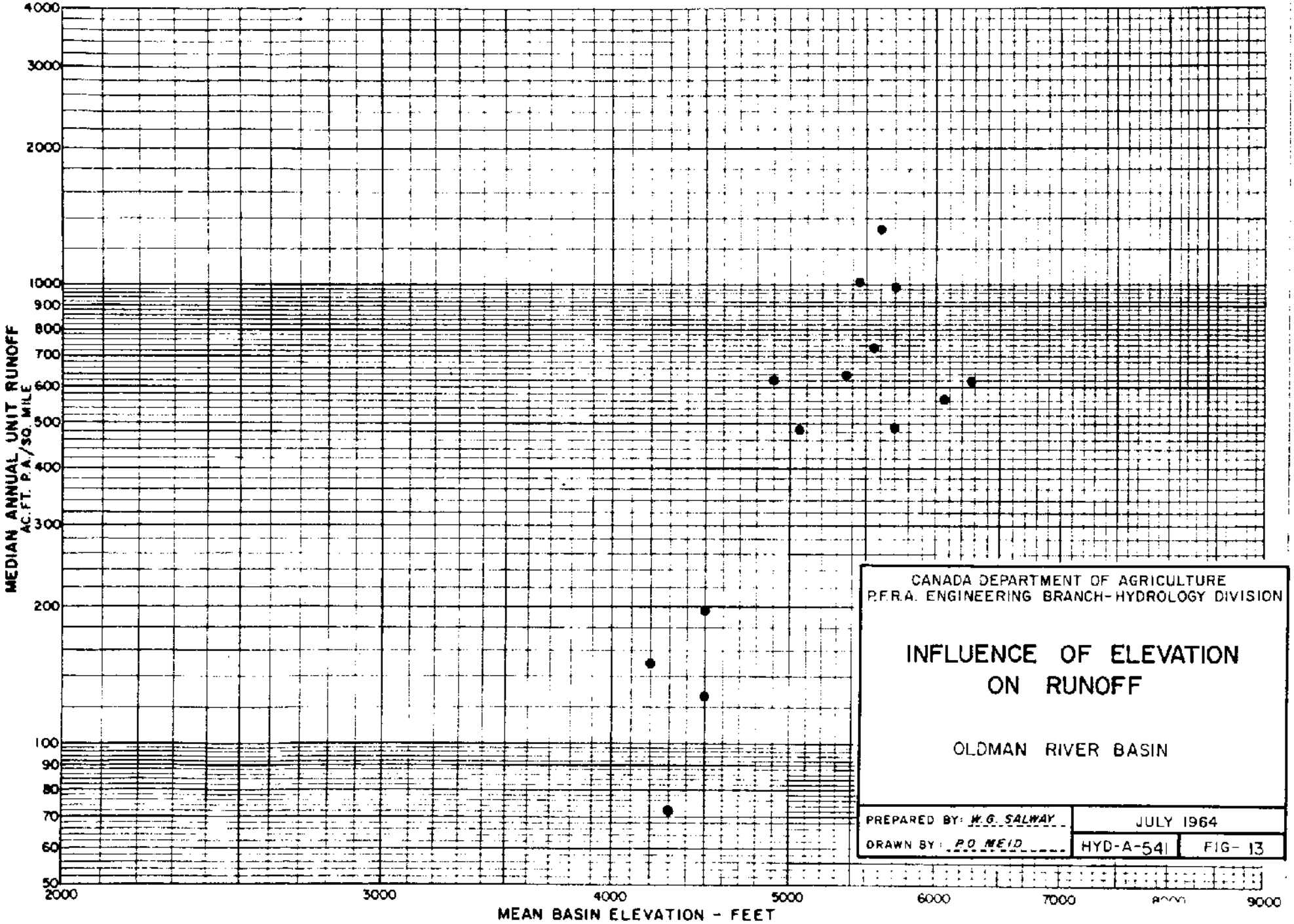


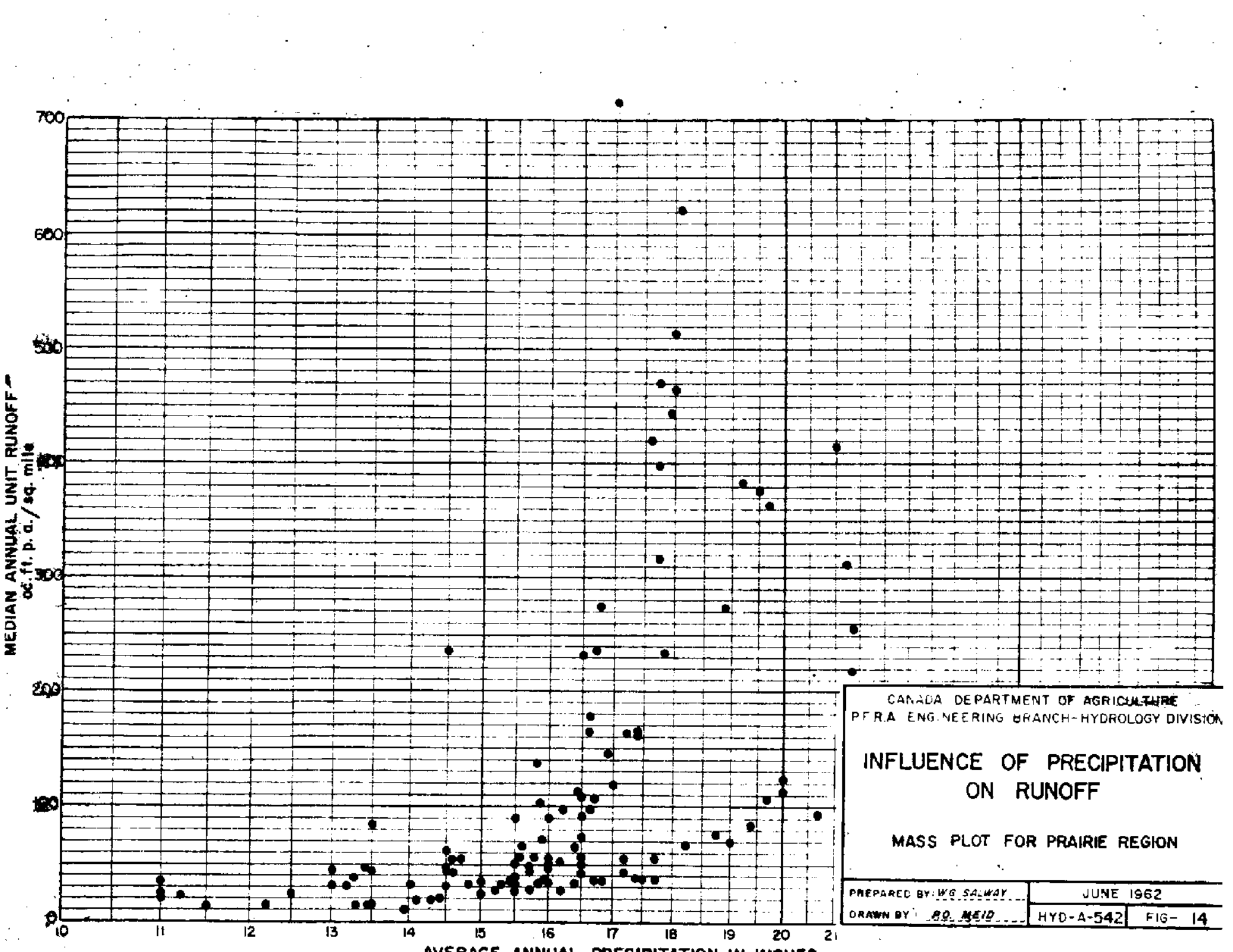
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH - HYDROLOGY DIVISION

INFLUENCE OF ELEVATION ON RUNOFF

BOW RIVER BASIN

PREPARED BY: W.G. SALWAY	JULY 1964	
DRAWN BY: P.O. MEID	HYD-A-540	FIG- 12


MEDIAN ANNUAL UNIT RUNOFF
AC.FT. P.A./SQ. MILE
4000
3000
2000
1000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
2000
3000
4000
5000
6000
7000
9000
MEAN BASIN ELEVATION - FEET
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION
INFLUENCE OF ELEVATION ON RUNOFF
OLDMAN RIVER BASIN
PREPARED BY: W.G. SALWAY
DRAWN BY: P.O. MEID
JULY 1964
HYD-A-541
FIG- 13

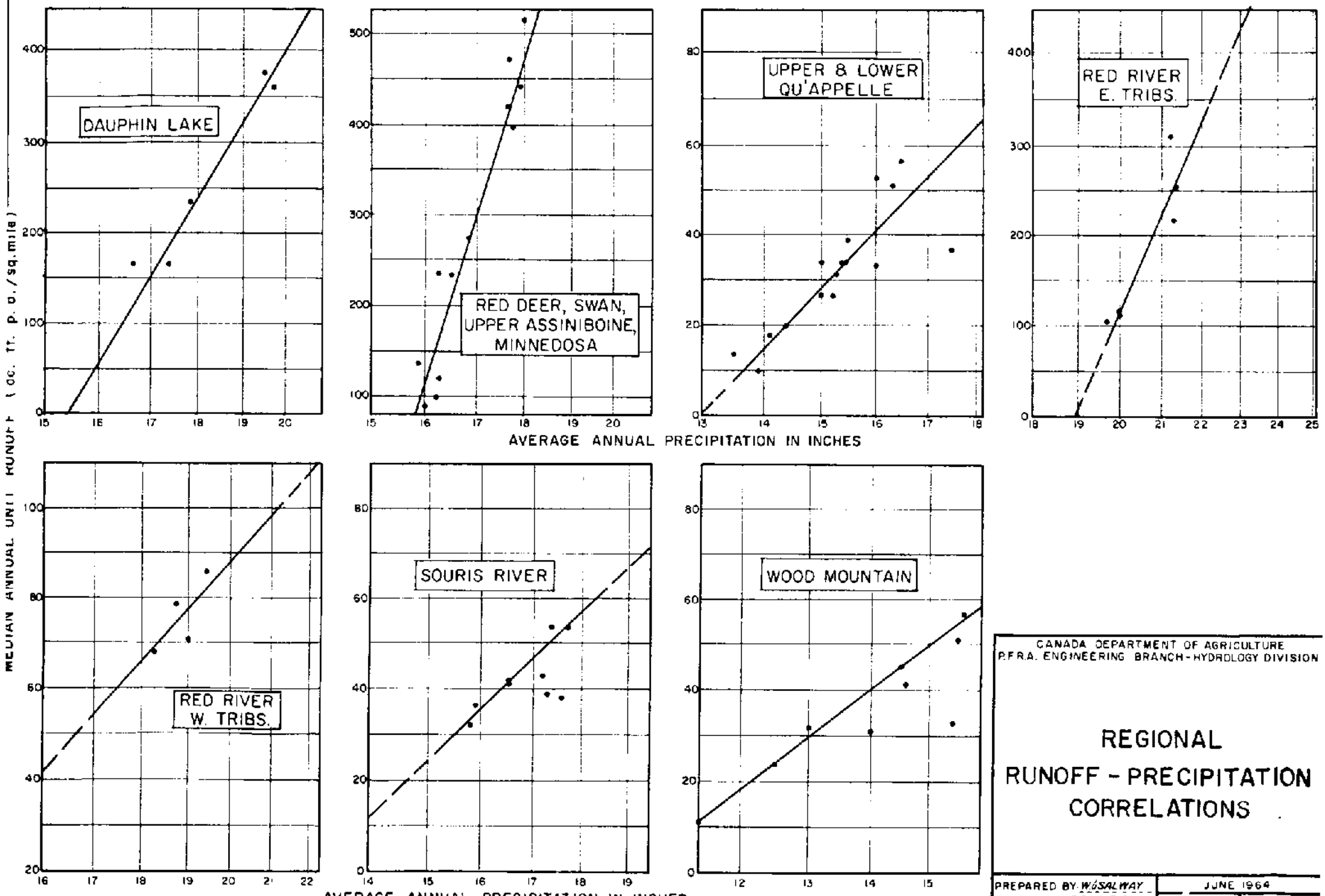


CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH - HYDROLOGY DIVISION

INFLUENCE OF PRECIPITATION ON RUNOFF

MASS PLOT FOR PRAIRIE REGION

PREPARED BY: W.G. SALWAY	JUNE 1962	
DRAWN BY: R.D. REID	HYD-A-542	FIG- 14

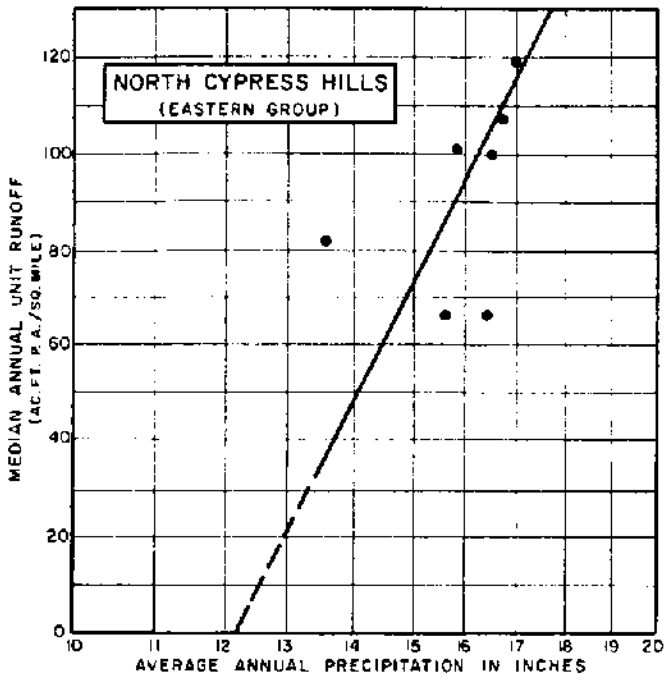


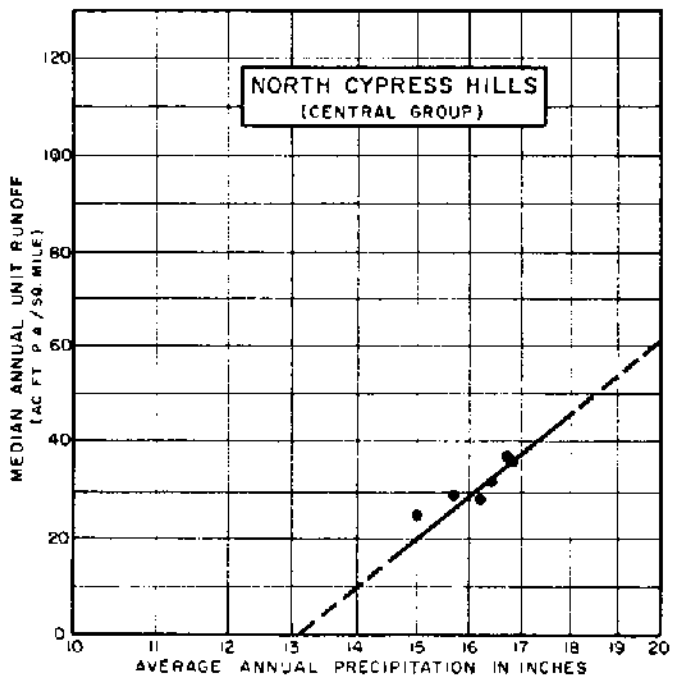
CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH - HYDROLOGY DIVISION

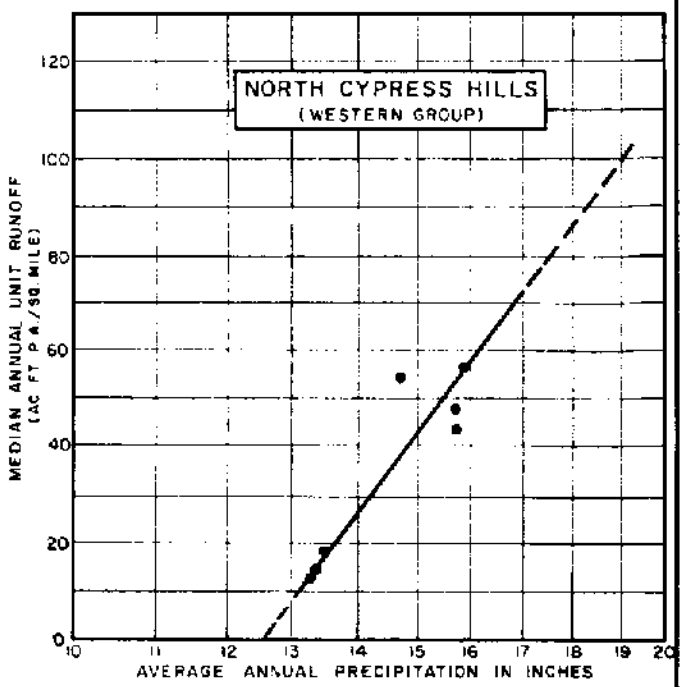
REGIONAL RUNOFF - PRECIPITATION CORRELATIONS

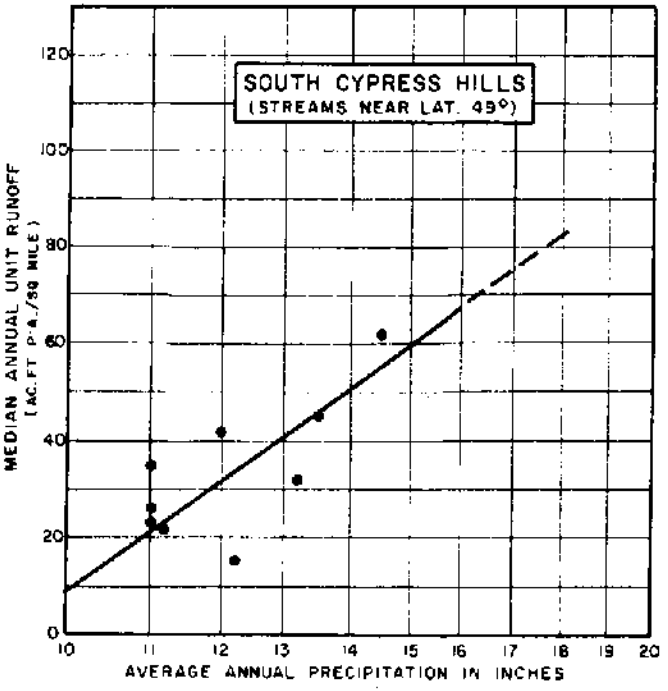
PREPARED BY W.G.SALWAY
DRAWN BY P.D. MEID

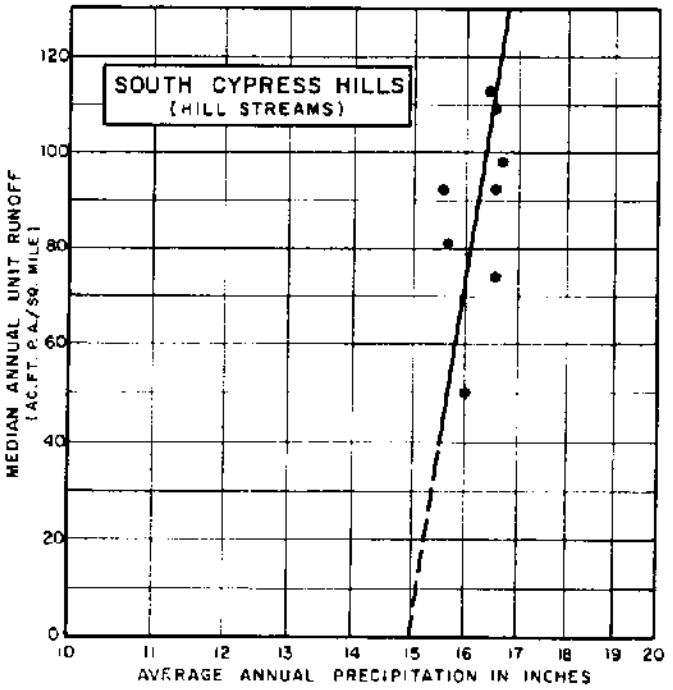
JUNE 1964
HYD-A-543 FIG- 15







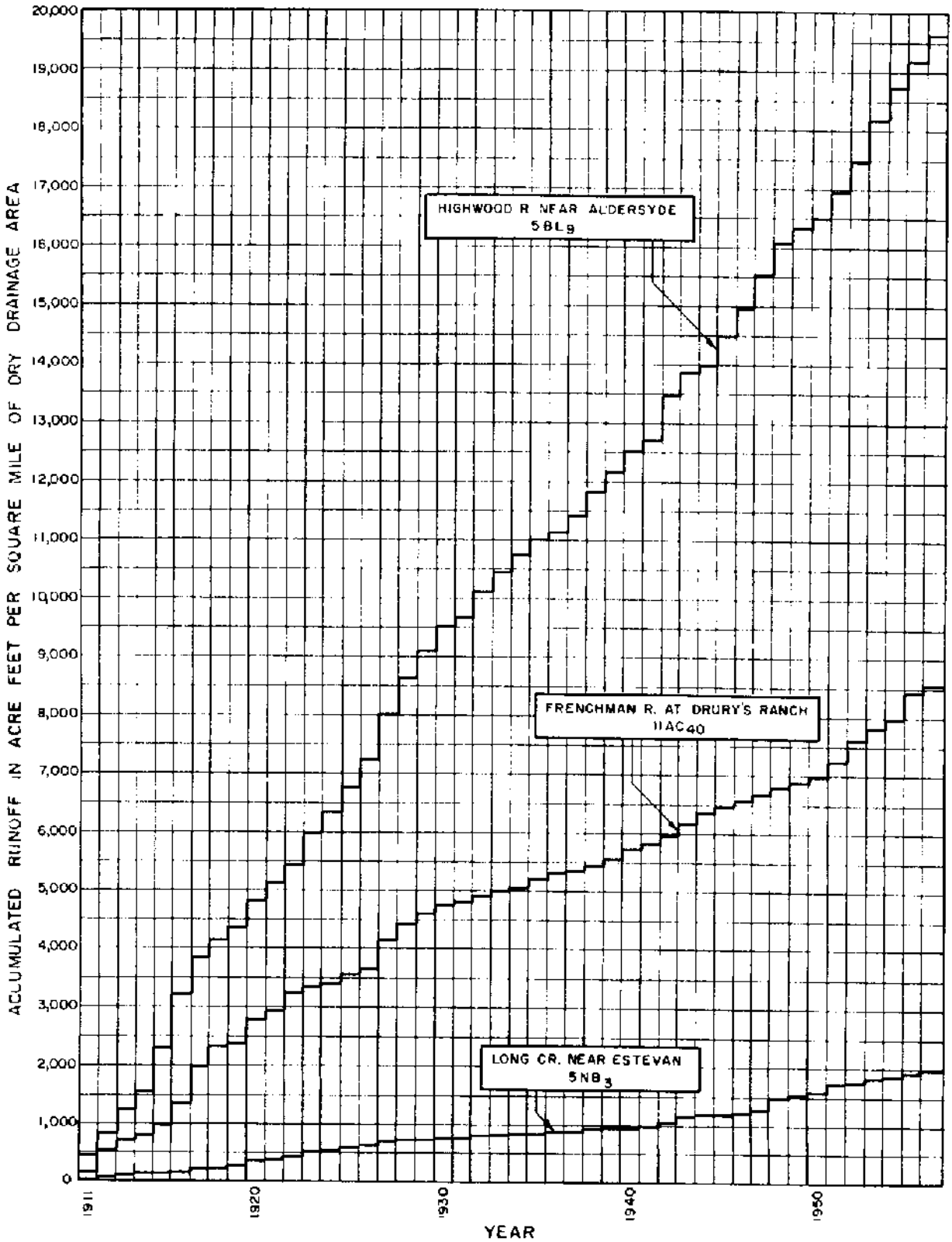




CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION

REGIONAL RUNOFF - PRECIPITATION CORRELATIONS

PREPARED BY: W.G. Solway	JULY 1964	
DRAWN BY: P.O. Meld	HYD-A-544	FIG- 16

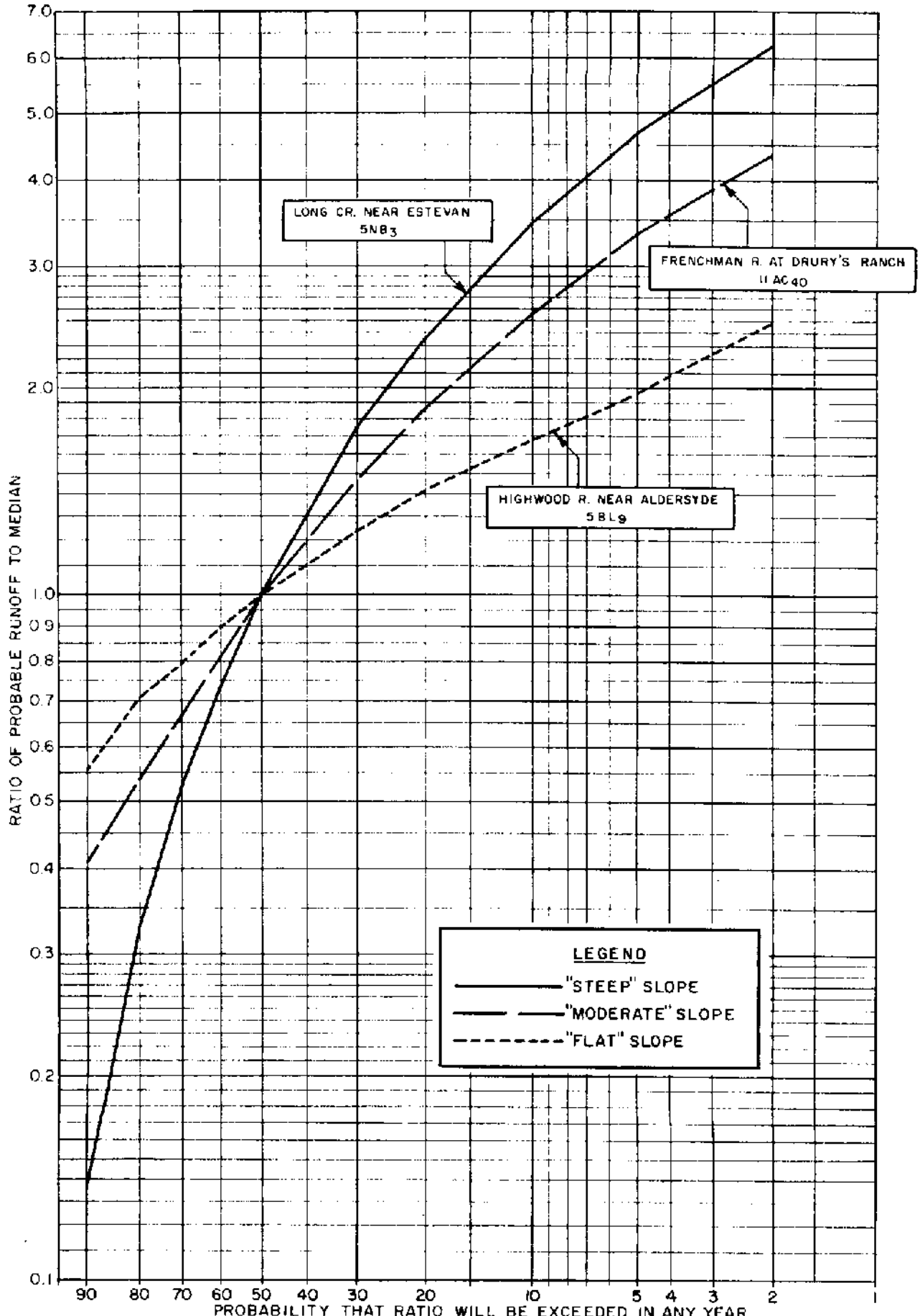


CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION

RUNOFF VARIABILITY

TYPICAL MASS CURVES

PREPARED BY: W. G. SALWAY DRAWN BY: P. O. MEID	MAY 1964	HYD-A-545	FIG-17



CANADA DEPARTMENT OF AGRICULTURE
P.F.R.A. ENGINEERING BRANCH-HYDROLOGY DIVISION

RUNOFF VARIABILITY
TYPICAL FREQUENCY CURVES

PREPARED BY: W.G. SALWAY DRAWN BY: P.O. MEIO	MAY 1964	HYD - A - 546	FIG - 18