CANADA

HYDROLOGIC ZONES

IN THE

HEADWATERS OF THE SASKATCHEWAN RIVER

TECHNICAL BULLETIN No. 6

D.A. DAVIS

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DEPARTMENT OF ENERGY, MINES AND RESOURCES

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FOREWORD

The East Slopes (Alberta) Watershed Research Program is a comprehensive long-term watershed research program centered in the Saskatchewan River headwaters area of the Rocky Mountains. This area of 15,000 square miles is bounded by the Alberta-British Columbia border to the west and approximately the 4,000 foot M.S.L. contour to the east. Most of the area is forested Crown land, gradually merging into grassland and scrub toward the eastern boundary. The purpose of the research program is to develop and test watershed management techniques with a view to improvement of water yield, timing and quality through controlled manipulation of the forest cover.

The research program is a co-operative venture of eleven governmental agencies at both the provincial and federal levels. The Steering Committee on Watershed Research is responsible for the research program, acting on recommendations submitted by the Technical Co-ordinating Committee on which each participating agency is represented. A project co-ordinator is responsible for implementation of the recommended program and examines and co-ordinates the individual efforts of the various agencies.

Prime attention has been given to the establishment of small watershed research basins for pilot studies into watershed management techniques and accurate measurement of the hydrometeorological parameters involved. These research basins are located in each of the three dominant cover types and the two basins presently instrumented are described in detail by Jeffrey (1965). In addition, inventory types of studies are being carried on in the Saskatchewan River headwaters area with the existing meteorologic and hydrometric networks being given prime consideration. The meteorologic network data have been summarized by McKay, Curry and Mann (1963).

At the request of the co-ordinator of the research program, the Inland Waters Branch has undertaken an analysis of the existing hydrometric data in the Saskatchewan River headwaters with a view to dividing the area into distinct hydrologic zones and this bulletin presents the results of this analysis.

Many different interpretations may be given to the term hydrologic zone depending on the purpose for which the zone is required. It was considered that the purposes of the watershed research program would be best served if a hydrologic zone was defined as a zone in which the flows of any two streams are correlated. A hydrologic zone in this context is, therefore, primarily a climatic zone modified to some extent by topography and vegetation cover. There is no implication that the yield will be the same for all streams in a particular hydrologic zone.

HYDROLOGIC ZONES
IN
THE HEADWATERS OF THE SASKATCHEWAN RIVER

Introduction

The sound design of any water use project requires an adequate knowledge of the streamflow, whether the project involves a small creek or a large river. Long-term hydrometric records obtained over a period of 30 years or more are desirable, but are seldom available, at the design location or even on the stream in question. An estimate of the streamflow can, however, be based on extension of available short-term records by correlation with long-term stations or by extrapolation of available streamflow records collected on neighbouring streams. For either method to be successful, the streams being compared should drain areas which are hydrologically similar.

Modification or expansion of the existing hydrometric network also requires a knowledge of the hydrologic characteristics of the various basins. The choice of a hydrometric station location is important, since the record collected is of greater value to the hydrologist when the station is located on a basin typical of the surrounding area. Streams which derive flow from several climatic or topographic zones should be avoided unless required for specific purposes.

Division of the Saskatchewan River headwaters area into hydrologic zones has been accomplished by comparison of the correlation coefficients obtained by correlating the mean monthly discharges of both existing and discontinued hydrometric stations. It has been assumed, for the purposes of this study, that a high coefficient of correlation signifies that both streams drain the same hydrologic zone while a low coefficient signifies that the streams drain different zones. The results of all the correlations are presented in this bulletin, together with a map showing the seven hydrologic regions in the headwaters of the Saskatchewan River.

Poor hydrometric coverage, especially in the headwaters area north of the Bow River, made zone boundary delineation of doubtful accuracy in areas where streamflow records are available for large basins only.

Data used

Hydrometric records from a total of 77 existing or discontinued stations were used in the analysis. In addition, streamflow data obtained by subtraction of flows at two hydrometric stations on the same stream were used if the inflow between the two stations was large and represented natural flow. All existing hydrometric stations in the Saskatchewan River headwaters area with five or more years of record were included in the

analysis, provided that the recorded flow was natural flow or that natural flow could be computed by adjusting for storage or diversions from or to the stream.

The majority of the mean monthly flow values were obtained or computed from the published Water Resources Papers covering the Arctic and Western Hudson Bay Drainage. Calgary Power Ltd. provided weekly average natural flow data on the Kananaskis and Spray Rivers computed from turbine ratings and reservoir elevations. This information is not published and is not available from any other source.

The streamflow records are of three types: all year, open water and partial, depending on the individual station. For all year records, monthly mean discharges are available for the complete calendar year. For open water records, monthly mean discharges are available covering most of the yearly runoff, normally from breakup or start of snowmelt runoff in the spring to freeze-up in the autumn. For plains or low foothills regions, the open water period is March to October, and at higher elevations it is April or May to October. For partial records, monthly mean discharges may be available for incomplete open water periods, peak flow periods or winter months only. Some stations are classified as having both open water and partial records; this signifies that some monthly mean discharges are available in addition to the normal open water period.

In general, winter and summer flows for an individual stream have approximately the same percentage variance. Summer flows, however, tend to be slightly more variable than winter flows, resulting in a slightly higher coefficient of correlation for open water stations than for all year stations. In several cases, where correlations were run for two different periods of record, one open water and the other all year, the difference in correlation coefficient was small, indicating that no appreciable error is introduced by using both types of streamflow record.

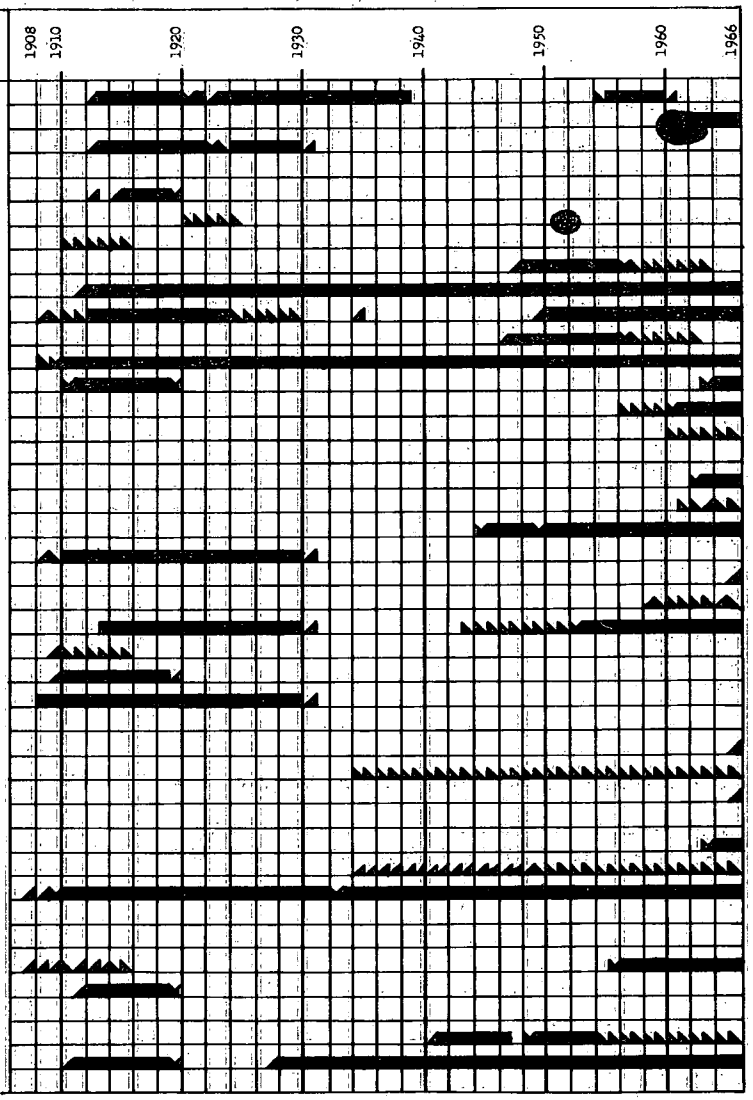
The majority of the discontinued station streamflow records are pre-1930, at which time manual gauges were used almost exclusively for collection of stream water levels. Accuracy of these older records is probably below present standards and consequently the correlation coefficients will not be strictly comparable with the results obtained from present-day recorder-equipped streamflow stations.

Table 1 is a bar chart showing the period and type of record for all stations used in the study and also for all stations where the record was too short to be used for correlation.

Method of correlation

All correlations were computed using an IBM 1620 computer following the method described by Langbein (1960), in which correlations are made in terms of the deviations in log units from the geometric mean of each calendar month's discharges. The computer program is described in detail by Lyons (1965).

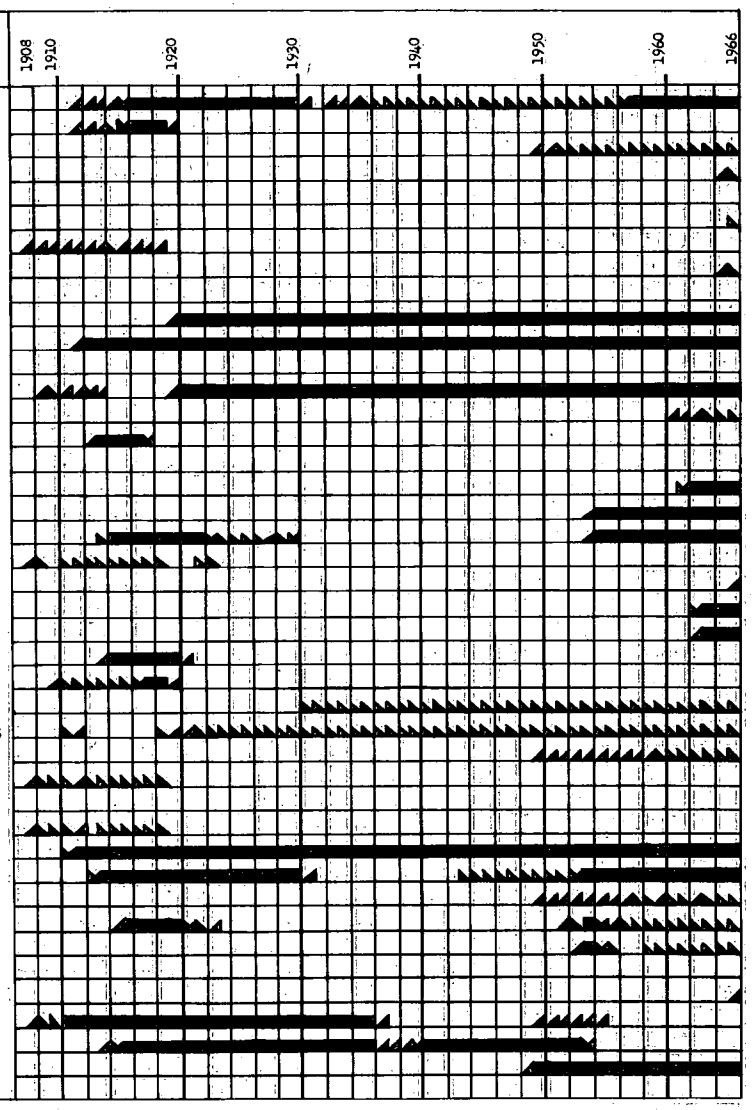
STATION NAME	USED IN STUDY	DRAINAGE AREA Sq. Mi.	INDEX NUMBER
Athabasca River at Entrance	*	3,920	7AD-1
Athabasca River at Hinton	*	4,000	7AD-2
Athabasca River at Jasper	*	1,580	7AA-2
Bath Creek near Lake Louise	*	31	7BA-3
Beaver Creek near Brocket			5AB-13
Beaver Mines Creek near Beaver Mines	*	23	5AA-10
Belly River at International Boundary	*	75	5AD-0.4
Belly River near Mountain View	*	121	5AD-5
Belly River near Standoff	*	476	5AD-2
Boundary Creek near International Boundary	*	21.0	5AD-0.2
Bow River at Banff	*	858	5BB-1
Bow River near Lake Louise	*	163	5BA-1
Brazeau River below Brazeau Dam	*	2,120	5DD-5
Brazeau River below Cardinal River	*	1,000	5DD-7
Cabin Creek near Seebe		0.82	5BF-19
Cardinal River at the Mouth		186	5DD-8
Castle River near Beaver Mines	*	319	5AA-22
Castle River near Cowley	*	435	5AA-3
Cataract Creek near Forestry Road			5BL-22
Clearwater River above Limestone Creek	*	500	5DB-3
Clearwater River near Rocky Mountain House	*	1,210	5DB-1
Cow Creek near Cowley	*	29	5AA-5
Crowsnest River at Frank	*	162	5AA-8
Crowsnest River near Lundbreck	*	268	5AA-2
Deer Creek Main Stem		23	5CA-3
Drywood Creek near Twin Butte	*	11.8	5AD-16
Dutch Creek near the Mouth		56.0	5AA-26
East Streeter Creek near Nanton		0.20	5AB-24
Elbow River at Bragg Creek	*	306	5BJ-4
Elbow River above Glenmore Dam	*	471	5BJ-5
Elbow River near Fullerton's Ranch	*	254	5BJ-3
Fish Creek near Priddis	*	103	5BK-1
Forty Mile Creek near Banff	*	54	5BB-3
Ghost River near Black Rock Mountain	*	80.5	5BG-2
Ghost River near Cochrane	*	346	5BG-1



Open Water Partial Record All Year

Table 1 - Gauging stations on Saskatchewan River headwaters area (Sheet 1 of 3)

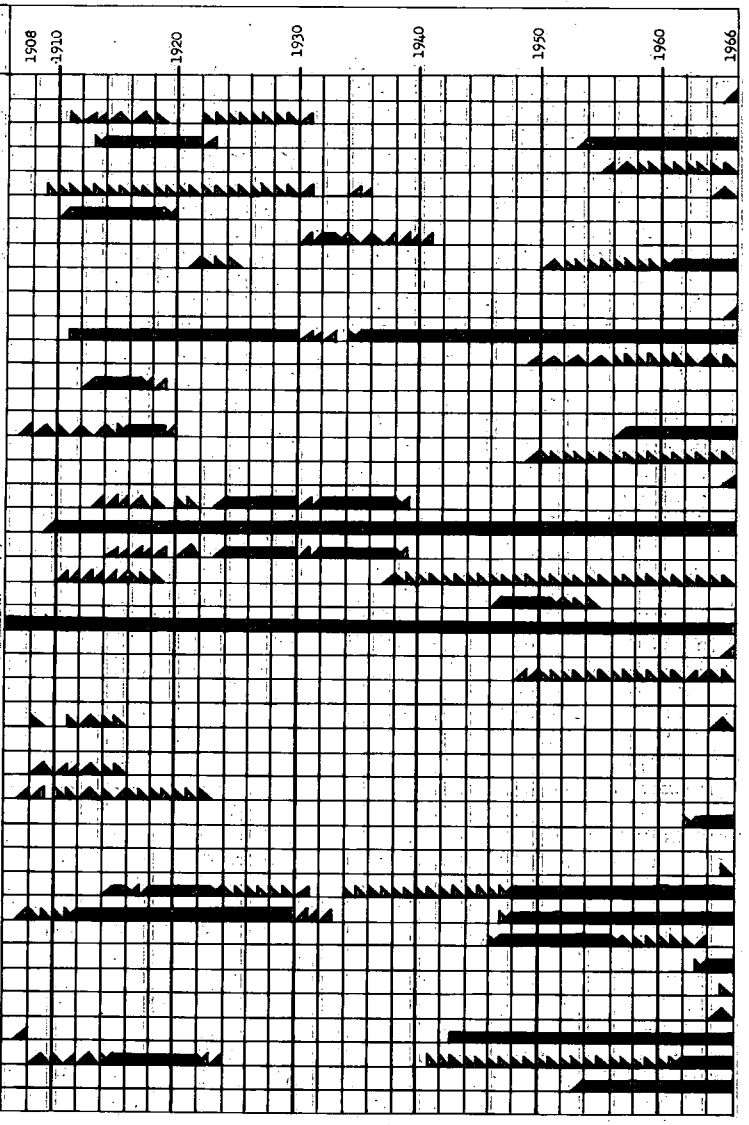
STATION NAME	USED IN STUDY	DRAINAGE AREA Sq. Mi.	INDEX NUMBER
Highwood River near Aldersyde	*	906	5BL-9
Highwood River at Brown's Ranch	*	421	5BL-8
Highwood River at Diebel's Ranch	*	300	5BL-19
Highwood River below Picklejar Creek		51.4	5BL-21
James River near Sundre		320	5CA-2
Jumpingpound Creek near Jumping Pound	*	187	5BH-6
Jumpingpound Creek near the Mouth		219	5BH-9
Kananaskis River above Pocaterra Creek	*	136	5BF-3
Kananaskis River near Seebe	*	362	5BF-1
Lee Creek at Cardston	*	117	5AE-2
Little Red Deer River near Water Valley		178	5CB-2
Louise Creek near Lake Louise	*	10	5BA-4
Marmot Creek Main Stem		3.63	5BF-16
McLeod River above Embarras River	*	1,000	7AF-2
McLeod River near Wolf Creek	*	2,510	7AG-1
Meadow Creek at Hart's Ranch	*	38	5AB-6
Meadow Creek near the Mouth		50.9	5AB-29
Middle Fork Creek near Seebe	*	1.10	5BF-17
Middle Streeter Creek near Nanton		0.35	5AB-23
Miette River near Jasper	*	250	7AA-1
Mill Creek near Beaver Mines	*	64	5AA-11
Milk River at Western Crossing	*	397	11AA-25
Milk River (North Branch) above St. Mary Canal	*	61.8	11AA-0.3
Mistaya River near Saskatchewan Crossing	*	94	5DA-7
Mosquito Creek near Nanton		178	5AC-1
Nanton Creek near Nanton	*	46	5AC-2
North Saskatchewan River at Edmonton	*	10,500	5DF-1
North Saskatchewan River near Rocky Mountain House	*	4,220	5DC-1
North Saskatchewan River at Saskatchewan Crossing	*	492	5DA-6
North Saskatchewan River at Saunders	*	1,980	5DC-2
North Saskatchewan River below Tershishner Creek		1,430	5DC-7
Oldman River near Brocket			5AA-24
Oldman River near Cowley	*	730	5AA-1
Oldman River near Fort MacLeod	*	2,230	5AB-7
Oldman River near Waldron's Corner	*	551	5AA-23



Open Water Partial Record All Year

Table 1 - Gauging stations on Saskatchewan River headwaters area (Sheet 2 of 3)

STATION NAME	USED IN STUDY	DRAINAGE AREA Sq. Mi.	INDEX NUMBER
Pekisko Creek near Longview			5BL-23
Pekisko Creek at Pekisko	*	99	5BL-6
Pembina River near Entwistle	*	1,710	7BB-2
Pembina River below Paddy Creek	*	1,110	7BA-1
Pincher Creek at Pincher Creek	*	57.2	5AA-4
Pipestone River near Lake Louise	*	136	5BA-2
Pocaterra Creek near the Mouth	*	21.5	5BF-4
Prairie Creek near Rocky Mountain House	*	318	5DB-2
Racehorse Creek near the Mouth		839	5AA-27
Red Deer River at Red Deer	*	4,420	5CC-2
Red Deer River near Sundre	*	954	5CA-1
Rocky River at Hawes	*	395	7AA-3
Sheep River near Aldersyde	*	660	5BL-20
Sheep River at Buck Ranch	*	176	5BL-18
Snowfence Creek at Plateau Mountain		0.014	5AA-25
Spray Creek at Spray Lakes	*	445	5BC-3
Spray River at Banff	*	276	5BC-1
Spray River near Spray Lakes	*	143	5BC-2
Stimson Creek near Pekisko	*	96	5BL-7
Street Creek at International Boundary	*	6.1	5AD-0.3
St. Mary River at International Boundary	*	469	5AE-27
Streeter Creek Main Stem		2.30	5AB-30
Sunwapta River at Athabasca Glacier	*	11.4	7AA-7
Threepoint Creek near Millarville (North Sheep River)		199	5BL-13
Todd Creek at Elton's Ranch	*	57	5AA-6
Trout Creek at Lockwood's Ranch	*	164	5AB-3
Twin Creek near Seebe		1.02	5BF-18
Waiparous Creek near the Mouth			5BG-6
Waterton River near Standoff	*	674	5AD-8
Waterton River near Waterton Park	*	238	5AD-3
Waterton River near International Boundary	*	61	5AD-0.1
West Streeter Creek near Nanton		0.53	5AB-22
Whirlpool River near the Mouth		227	7AA-9
Willow Creek above Chain Lakes		628	5AB-28
Willow Creek near Claresholm	*	446	5AB-21
Willow Creek near Nolan	*	900	5AB-2
Wolf Creek at Highway No. 16 Crossing	*	350	7AG-3



Open Water Partial Record All Year

Table 1 - Gauging stations on Saskatchewan River headwaters area (Sheet 3 of 3)

The monthly mean flows of the two hydrometric stations being correlated are used as input. Up to 50 years of flow data can be stored but the program input is limited to the most recent 20 years of record. Only those months for which there is hydrometric records at both stations are used to determine the mean monthly flows.

The program output lists essential correlation data in addition to the computer results. The deviations from the mean in log units for each month of overlapping records used in the correlation is given for both stations. Special coding indicates months for which records are non-existent or unused. The logarithms of the mean monthly flow for each month are also given for both stations. The line of relation is described in terms of slope and intercept along with the coefficient of correlation, standard error of estimate and standard deviation of the dependent variable.

Table 2 is an example of a typical correlation. The dependent station "Kananaskis River at Seebe" is correlated against the independent station "Highwood River at Diebel's Ranch". The input is shown first, the flow values being monthly means expressed in cfs. The first set of output data are deviations from the mean monthly flows in log units for the period of overlapping record. The correlation constants are shown next, along with the mean of the logarithms of the monthly flows.

Correlation results

The results of all the correlations are given in Table 3. Not all the correlations listed were used in the actual determination of hydrologic zones, but those not used have been included for general interest. Explanations of the column headings in Table 3 are as follows:

STATION NAME - The station used as the independent variable appears first in each group followed by the dependent variable stations.

INDEX NUMBER - A number assigned to a hydrometric station and based on a national system of identification. Stations are classified according to location within the major drainage basins by a series of regional divisions. The location of each station is shown on Figure 1. The exact station location may be determined by referring to the appropriate Water Resources Paper in which each station is listed by name, index number, latitude and longitude, and sectional co-ordinates. There is no index number for areas from which the hydrometric record is obtained by subtraction.

DRAINAGE AREA - Drainage area of the basin above the stream gauge or, in the cases of data obtained by subtraction, the difference in area for the stream gauges used in the computation. The drainage area is the area enclosed by a topographic divide such that direct surface runoff from precipitation would drain by gravity into the stream above the station.

PERIOD OF CORRELATED RECORD - The period of overlapping hydrometric record at both the dependent and independent stations used in the correlation analysis. The hydrometric record may not be complete in that individual

months of record may be missing, but the majority of the data will be for the months indicated in this column.

COEFFICIENT OF CORRELATION - The coefficient of correlation obtained from the Langbein method computations of relation between the dependent and independent hydrometric stations.

STANDARD ERROR - The standard error of estimate as computed in terms of log units. The per cent figure is an arithmetical average of the positive and negative standard error of estimate computed as a percentage. For example, a percentage standard error of estimate of 50 per cent is an average of the +62 per cent and the -38 per cent obtained from a log standard error of estimate of 0.209.

Delineation of hydrologic zones

Zones have been delineated on the basic premise that streams which correlate well, as indicated by the coefficient of correlation, have their drainages in the same hydrologic zone. This does not mean that the water yields within a hydrologic zone will be uniform, but rather that all parts of the zone are subject to similar climatic variations and that the topography and vegetation cover is generally uniform.

The delineation of zones has been accomplished by correlating all available mean monthly flow data for neighbouring streams. The coefficients of correlation were plotted on a working map using the basin centroid as the plotted point. Definite patterns emerged, sometimes clouded by the fact that some hydrometric stations measure flow from two or more hydrologically dissimilar areas. The arbitrary ranges of correlation coefficient given below were used as rough categories on which to base the hydrologic zone boundaries:

R above 0.80 - acceptable

R 0.60 to 0.79 - marginal

R less than 0.59 - not acceptable

In general the hydrologic zone boundaries follow major topographical changes within the Saskatchewan River headwaters area. All zones are oriented with the long axis northwest and southeast, paralleling the mountain and foothills structure orientation. The southernmost regions tend to be coincident with precipitation zones as defined by Curry and Mann (1965) indicating the importance of the appreciable annual precipitation decrease between Waterton Park and the Crowsnest Pass areas, and the changing ratio of summer to winter precipitation in this same area. Farther north, where both precipitation amounts and the percentage that falls as snow are less variable, the topographic features seem to become the dominant feature with orientation and position relative to the Continental Divide playing a major role.

Figure 1 is a map of the Saskatchewan River headwaters area showing

```
      1101    3    1                                                                                    1101
KANANASKIS RIVER AT SEEBE      (NATURAL FLOW)                                                          1101
      JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC                          1101
1940   70    44   182   201   768  1070   861   615   775   433   170   134                          1101
1941   47    96   157   181   400   929   803   668   620   349   221   219                          1101
1942  110    34   192   222  1350  1770  1550  1040   663   403   222   299                          1101
1943  150   157   180   403   590  1280  1630   843   474   339   160   190                          1101
1944  101   128   134   166   572   972   794   778   509   353   138    42                          1101
1945   20    75    68   126   562  1730  1460   833   598   395   223   190                          1101
1946   97   120   126   235  1110  1820  1190   780   667   356   243   295                          1101
1947  164   182   130   266  1250  1800  1410   775   747   577   296   241                          1101
1948  124   122   141   189  1540  2210  1220   983   501   255   156   124                          1101
1949   81   133   119   174   677   904   724   569   422   230   152   116                          1101
1950  109   141    88   114   427  2060  1500   830   441   270   132   108                          1101
1951   41   106    91   168  1130  2010  2490  1110   985   610   285   194                          1101
1952  140   128   110   180   881  1450  1181   810   467   285   141   130                          1101
1953  126   114    91   155   637  2040  1590   854   521   310   186   163                          1101
1954   54   127   142   147   858  1950  1950  1020   643   381   253   201                          1101
1955  103   136   123   114   355  1690  1550   768   479   328   237   182                          1101
1956   89    95    75   173  1190  1870  1450   781   468   306   146    89                          1101
1957   48    94   139   162  1130  1340   833   564   418   292   196   134                          1101
1958   67   105    96   169  1100  1310  1180   777   483   277   172   167                          1101
1959  117   116   121   162   679  1830  1290   771   658   383   205   176                          1101
1960   89    98   142   181   577  1530  1270   782   416   242   145   135                          1101
1961   93   110   120   137  1080  2130  1080   866   505   453   223   205                          1101
1962  105   137   235   249   526  1380   907   654   493                                            1101
                                                                                                    9999
      1619 1101        0  0  1  1  1  1  1  1  1  1  0  0
      HIGHWOOD RIVER AT DIEBELS  RANCH                                                          ER  1619
      JAN   FEB   MAR   APR   MAY   JUN   JUL   AUG   SEP   OCT   NOV   DEC                     ER  1619
1950                                                  212   110   101                           ER  1619
1951                              1433  1779  1653   534   720   495                           ER  1619
1952              77.1   322   800   994   583   304   189   128                               ER  1619
1953              64.6  90.0   885  3074   886   265   149   130                               ER  1619
1954              73.2  71.4  1027  1651  1043   318   227   281                               ER  1619
1955              65.1  83.4   448  1357   855   236   138   162                               ER  1619
1956              51.9   143  1160  1268   888   292   162   125                               ER  1619
1957              39.5  88.8  1117   857   302   157   133   113                               ER  1619
1958              45.8  88.6  1045   732   700   268   165   113                               ER  1619
1959              63.6  98.9   729  1417   598   224   239   182                               ER  1619
1960              95.2   182   685  1213   486   225   129    88                               ER  1619
1961              63.0  67.7  1071  1482   376   252   186   336                               ER  1619
1962              65.1  27.3   633   975   391   177   144   101                               ER  1619
1963              63.0  91.0   502  1440  1180   213   115    92                               ER  1619
1964              53.8  72.8   750  1980   594   188   158   151                               ER  1619
                                                                                                    9999
```

Table 2 - Correlation of Kananaskis River at Seebe
with Highwood River at Diebel's Ranch
(Sheet 1 of 2)

OUTPUT

KANANASKIS RIVER AT SEEBE (NATURAL FLOW) 1101
DEVIATIONS FROM MTH MEAN LOGS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1950	0.000	0.000	9.000	9.000	9.000	9.000	9.000	.014	-.072	-.091	0.000	0.000
1951	0.000	0.000	9.000	9.000	.152	.076	.270	.140	.276	.262	0.000	0.000
1952	0.000	0.000	-.042	.042	.044	-.065	-.053	.003	-.047	-.068	0.000	0.000
1953	0.000	0.000	-.125	-.022	-.096	.082	.075	.026	0.000	-.031	0.000	0.000
1954	0.000	0.000	.067	-.045	.033	.063	.164	.103	.091	.057	0.000	0.000
1955	0.000	0.000	.005	-.156	-.350	0.000	.064	-.019	-.036	-.007	0.000	0.000
1956	0.000	0.000	-.209	.024	.175	.044	.035	-.012	-.046	-.037	0.000	0.000
1957	0.000	0.000	.058	-.003	.152	-.099	-.205	-.153	-.095	-.057	0.000	0.000
1958	0.000	0.000	-.102	.014	.141	-.109	-.053	-.014	-.033	-.080	0.000	0.000
1959	0.000	0.000	-.001	-.003	-.068	.035	-.015	-.018	.101	.060	0.000	0.000
1960	0.000	0.000	.067	.044	-.139	-.042	-.021	-.011	-.097	-.139	0.000	0.000
1961	0.000	0.000	-.005	-.076	.133	.101	-.092	.032	-.013	.133	0.000	0.000
1962	0.000	0.000	.286	.182	-.179	-.087	-.168	-.089	-.024	9.000	0.000	0.000

HIGHWOOD RIVER AT DIEBELS RANCH 1619
DEVIATIONS FROM MTH MEAN LOGS

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1950	0.000	0.000	9.000	9.000	9.000	9.000	9.000	-.079	-.213	-.205	0.000	0.000
1951	0.000	0.000	9.000	9.000	.212	.135	.402	.321	.602	.485	0.000	0.000
1952	0.000	0.000	.092	.434	-.041	-.117	-.049	.076	.021	-.102	0.000	0.000
1953	0.000	0.000	.015	-.119	.002	.372	.131	.017	-.081	-.095	0.000	0.000
1954	0.000	0.000	.069	-.219	.067	.102	.202	.096	.101	.239	0.000	0.000
1955	0.000	0.000	.018	-.152	-.292	.017	.116	-.032	-.114	0.000	0.000	0.000
1956	0.000	0.000	-.079	.081	.120	-.011	.132	.059	-.045	-.112	0.000	0.000
1957	0.000	0.000	-.198	-.125	.103	-.182	-.335	-.209	-.130	-.156	0.000	0.000
1958	0.000	0.000	-.133	-.126	.074	-.250	.029	.022	-.037	-.156	0.000	0.000
1959	0.000	0.000	.008	-.078	-.081	.036	-.038	-.055	.123	.050	0.000	0.000
1960	0.000	0.000	.183	.186	-.108	-.031	-.128	-.053	-.144	-.264	0.000	0.000
1961	0.000	0.000	.004	-.243	.085	.055	-.240	-.004	.014	.316	0.000	0.000
1962	0.000	0.000	.018	.362	-.142	-.126	-.223	-.157	-.096	9.000	0.000	0.000

CORRELATION CONSTANTS
HIGHWOOD RIVER AT DIEBELS RANCH 1619
KANANASKIS RIVER AT SEEBE (NATURAL FLOW) 1101
SLOPE= 1.285 INTERCEPT= 0.000 R= .796 SE= .106 SD= .176 COR 1619/1101
MEAN MTHLY LOGS, MTHS 1-12, STA 1619
0.000 0.000 1.794 2.073 2.944 3.115 2.815 2.405 2.254 2.209 0.000 0.000
MEAN MTHLY LOGS, MTHS 1-12, STA 1101
0.000 0.000 2.084 2.213 2.900 3.226 3.125 2.905 2.717 2.523 0.000 0.000
TOTX= 0.000 TOTY= 0.000 DTXX= 1.136 DTYY= 2.962 DTXY= 1.461

Table 2 - Correlation of Kananaskis River at Seebe
with Highwood River at Diebel's Ranch
(Sheet 2 of 2)

the seven hydrologic zones delineated in this study. A detailed description of each zone and the most pertinent correlation results used in delineating the zone boundary are contained in the following sections.

Zone 1 - Waterton-Crowsnest Pass Area

Zone 1 is characterized by steep, rugged mountains drained by streams having a high yield: 40 inches or more of runoff per year is not uncommon. Precipitation amounts drop off rapidly to the east and north of the zone and the winter precipitation is high, being approximately 65 per cent of the yearly total (McKay et al, 1963). Most of the zone is heavily forested, with spruce-fir the dominant cover type.

The zone delineation to the east is sharp and definite, as indicated by the Milk River versus St. Mary River at the International Boundary correlation (R = 0.44) and Lee Creek at Cardston versus Belly River near Mountain View (R = 0.59), and roughly parallels the 6,000-foot contour. Mill Creek correlates well with Pincher Creek (R = 0.89) as both have headwater areas well above the 6,000-foot contour, yet the Mill Creek versus Beaver Mines Creek correlation (R = 0.53) is poor, largely because Beaver Mines Creek has very little high elevation drainage. Accordingly, the zonal boundary was drawn to exclude Beaver Mines Creek drainage and include the upper ends of both Pincher and Mill Creeks. The boundary delineation is further substantiated by the good correlation of Waterton River near Standoff, which includes Yarrow and Drywood Creeks, and St. Mary River at the International Boundary (R = 0.82).

The northern boundary of Zone 1 is less distinct, but there is a definite change in hydrologic characteristics in the Crowsnest Pass area. The Castle and Crowsnest Rivers are very similar, as evidenced by the good correlation coefficient of 0.89. The Oldman River at Waldron's Corner is also similar to the Crowsnest River (R = 0.80) but the similarity with rivers farther south in Zone 1 is progressively poorer, as indicated by the Oldman River versus Castle River (R = 0.74) and Oldman River versus Waterton River near Waterton Park (R = 0.55). The boundary of Zone 1 was drawn to exclude the low yield, low precipitation areas of the Castle River and the southward flowing eastern tributaries of the Crowsnest River.

All hydrometric stations with drainage exclusively within Zone 1 correlate well and hence have similar flow characteristics. A few examples are Waterton River at the International Boundary versus Belly River at the International Boundary (R = 0.92), St. Mary River at the International Boundary versus Belly River at Mountain View (R = 0.88), and Castle River versus Waterton River at Waterton Park (R = 0.84).

Zone 1 is well defined because of the rapid topographic and climatic changes within a relatively confined geographic area. Hydrometric coverage in the area is excellent, with nine hydrometric stations gauging the flow from basins almost exclusively within the zone. Most of these basins are small in size with extremely high yield compared to other areas within the Saskatchewan River headwaters.

Zone 2 - Highwood and Oldman River Tributaries Area

Zone 2 is characterized by low mountains, with only a very small portion of the zone lying above 8,000 feet elevation. The annual precipitation tends to be lower than in the mountainous areas to both the north and south. Approximately 55 per cent of the annual precipitation falls in the winter period, (based on McKay et al, 1963). Almost all the area is forested, with lodgepole pine the dominant cover type; aspen and spruce-fir are also present. Much of the zone is similar topographically, with wide valleys and well developed drainage. The major river orientation is north-south, deviating from the normal west-east drainage pattern of the surrounding area. The two hydrometric stations with drainage almost exclusively within Zone 2 correlate well, the coefficient of correlation being 0.87. The correlation of Highwood River at Brown's Ranch and Pekisko Creek near Pekisko (R = 0.87) indicates that the headwaters area of Pekisko Creek should be included in Zone 2. This is further borne out by the correlation of Pekisko Creek with Mosquito Creek (R = 0.73): a correlation poorer than is common for stations exclusively in the Zone 3 area.

The Highwood River at Diebel's Ranch correlations with Sheep River at Buck Ranch (R = 0.72) and Kananaskis River above Pocaterra Creek (R = 0.56) indicate a definite change in flow similarity between the Highwood River Basin and the high elevation and steeper gradient areas behind the front mountain range to the north and west. The north boundary of Zone 2 was accordingly drawn to exclude the steep, high mountain basin tributaries of the Highwood River.

Zone 2 is reasonable well defined, although somewhat indirectly, as there are only two gauged basins lying almost exclusively within the zone. The boundary between Zone 2 and the zones to the north and east can be explained almost completely in terms of topographic change. Both precipitation and vegetation tend to be comparable for areas of comparable elevation throughout the region.

Zone 3 - Southern Foothills Area

Zone 3 is mainly rolling foothills country varying in elevation from approximately 6,000 feet to 4,000 feet M.S.L. The land is variable, most of it being ranch country with areas of both natural grass and scrub and developed pastureland. Some of the flatter areas near the eastern boundary of the zone are farmed, with cereal crops predominating. Convective storms provide a significant portion of the summer precipitation in Zone 3, resulting in a larger variation in monthly and annual precipitation amounts for areas of similar topography and exposure compared to Zones 1 and 2. Monthly and annual streamflow are also more variable than for the mountainous areas to the west.

The eastern boundary of Zone 3 has been arbitrarily drawn at approximately the 4,000-foot contour, the eastern limit of the study. The western boundary is well defined as previously discussed and stations within Zone 3 correlate well, as demonstrated by the correlations among

the 13 hydrometric stations with drainage almost exclusively within the zone. Correlation coefficients range from 0.78 to 0.93. The one exception is the correlation of North Milk River with Belly River between Standoff and Mountain View (R = 0.55). An unknown amount of water diverted upstream for irrigation returns to the Belly River in the Mountain View to Standoff reach making the computations of natural flow of doubtful accuracy.

The northern boundary of Zone 3 is not definite but is rather a gradual transition in streamflow characteristics, and in land use from ranching to farming. The only correlation of stations exclusively within Zones 3 and 4 is the Fish Creek near Priddis and Stimpson Creek near Pekisko. The record for the period 1911 to 1916 correlated well (R = 0.95) but the 1956 to 1964 period correlation (R = 0.68) is poor, probably reflecting the trend to farming over the years in the region north of the North Sheep River. Other correlations in the Fish Creek area reflect this gradual change in streamflow characteristics moving northward but a quantitative assessment is not possible because all other gauged streams in the area have headwaters in the high mountain drainage.

Zone 3 can be regarded as a reasonably well defined hydrologic zone with considerable hydrometric record available. Approximately one-half of the stations exclusively within the area were discontinued about 1920 but fortunately the active hydrometric stations are reasonably well distributed throughout the zone.

Zone 4 - Northern Headwaters Area

Zone 4 is characterized by rugged, steep sloped, high elevation drainages with permanent glaciers in headwaters areas and a high annual yield. The region is also characterized by an almost complete lack of either streamflow or precipitation information. The zonal boundaries are not well defined and are based more on the lack of correlation with other areas than on positive correlations within the zone. There are three active hydrometric stations with five years of records or more and with drainage exclusively within Zone 4. The North Saskatchewan River at Saskatchewan Crossing and Mistaya River correlate well (R = 0.84), but neither compare favourably with drainage areas outside the zone. For example, the North Saskatchewan River at Saskatchewan Crossing has almost no resemblance to the Clearwater River above Limestone Creek (R = 0.15). The Sunwapta River at Athabasca Glacier does not correlate well with the North Saskatchewan River (R = 0.62) for two principal reasons. Firstly, the drainage areas are considerably different in size and, secondly, the Sunwapta drainage is covered almost exclusively by deep snowpack or glacier ice. Glacier ablation is a significant part of the annual yield. The major river orientation is north-south, a change from the surrounding regions.

There is a definite difference in flow characteristics between the east and west slope drainage into the Bow River valley. Bath Creek correlates poorly with the Pipestone River drainage directly across the Bow River valley (R = 0.35) and Forty Mile Creek farther south (R = 0.29). The Bow River at Lake Louise does not correlate well with the Pipestone

River either (R = 0.29) as the majority of the Bow River headwaters drain from the high elevation western side of the valley. Accordingly, the eastern boundary of Zone 4 was positioned to exclude the eastern drainage of the Athabasca River valley since the flow characteristics should be comparable to the similarly-oriented Bow River valley.

Zone 4 is a region for which both hydrometric and precipitation data are very limited. The lack of data is a partial reflection of the ruggedness of the zone and the inaccessibility of a large part of the area. Glacier ice and permanent snowpack areas make Zone 4 a unique high yield region with flow characteristics different from any other zone in the Saskatchewan River headwater.

Zone 5 - Northern Intermountain Area

Zone 5 is almost entirely a high elevation mountainous area, the significant difference from Zone 4 being that the latter has large areas of glacier ice and permanent snowpack areas, whereas the former does not. There are glaciers in Zone 5, but the volumes of ice are small compared to Zone 4 and not as widely distributed. The drainage pattern tends to be oriented north-south. Hydrometric and meteorological data coverage is poor, except in the portion of Zone 5 south of the Bow River.

There appears to be an inconsistency within Zone 5 in the Kananaskis River headwaters area. In all probability this high-elevation, steep-sloped mountain area is similar to Zone 4 in runoff characteristics. However, insufficient hydrometric data are available to make this area either an extension of Zone 4 or a separate zone. The only record from this area is Kananaskis River above Pocaterra Creek and this correlates poorly with the close-by similarly-oriented Spray River near Spray Lakes (R = 0.65). The lower portion of the Kananaskis River drainage appears to be similar to near-by drainage within Zone 5.

There is a definite change in streamflow characteristics between the Kananaskis River Basin and drainage with headwaters originating farther east, such as the Sheep and Elbow Rivers. Accordingly, the boundary of Zone 5 was drawn to coincide with the drainage divide between these two areas. The poor correlation of Kananaskis River above Pocaterra Creek and Highwood River at Diebel's Ranch (R = 0.65) indicates a definite change in runoff pattern near Highwood summit. This break is further substantiated by the poor correlation of Kananaskis River near Seebe and Oldman River near Waldron's Corner (R = 0.53), although the Kananaskis River versus Highwood River at Diebel's Ranch (R = 0.80) indicates that the drainage in the lower portion of the Kananaskis valley must be similar to the headwaters of the Highwood River.

The Ghost, Clearwater and Red Deer Rivers headwaters areas are definitely similar, as indicated by the good correlations, yet none correlate well with Bow River drainage. Forty Mile Creek is similar to Spray Creek (R = 0.89) and dissimilar to the Ghost River, indicating that the boundary of Zone 5 follows the chain of mountains to the east of the

Forty Mile Creek Basin. This chain of mountains, slightly higher in elevation than areas to the east and west, was assumed to be the boundary of Zone 5 up to the northern limits of the study.

Hydrometric stations on drainage exclusively within Zone 5 tend to correlate well, although there are some inconsistencies. Water yield of streams within the zone varies widely, dependent to a large extent on orientation and elevation. Some of the hydrometric records for this region are of questionable accuracy, being based on power dam releases and reservoir elevations and this further complicates the comparison of records within the zone.

Zone 6 - Northern Mountain Area

Zone 6 is mountainous, but valleys are broad and slopes less steep than the zones further west. Almost the entire area is covered by forest, varying from mature spruce-fir stands to over-dense fire-regrowth pine. The drainage pattern tends to be oriented east-west with most streams draining toward the east. Annual precipitation is relatively uniform for comparable elevation areas (McKay et al, 1963), based on the limited data available.

Hydrometric coverage within Zone 6 is largely confined to large and medium sized basins, of which approximately half contain drainage from source areas outside the zone. Hydrometric records are not extensive but are well distributed throughout the zone and boundary definition can be regarded as reasonable. Internal correlations of mean monthly flow are good to excellent. The eastern boundary of Zone 6 represents a major in streamflow characteristics as evidenced by the lack of correlation with drainage areas in Zone 7.

The Fish Creek drainage correlates poorly with the Sheep River at Buck Ranch ($R = 0.59$) which, in turn, is similar topographically to the headwaters of the Elbow River, indicating the boundary of Zone 6 is located west of the Fish Creek Basin. This boundary location is further substantiated by the poor correlation of Elbow River at Bragg Creek with Sheep River between Buck Ranch and Aldersyde ($R = 0.70$). The Ghost River at Blackrock Mountain and Ghost River near Cochrane do not correlate well, the main difference being the Waiparous River drainage. Accordingly, the boundary of Zone 6 was drawn to the west of Waiparous River Basin. The Jumpingpound Creek correlations fit in well with the boundary delineation mentioned above in that enough of the flow originates from the headwaters area to correlate well with the Elbow River at Bragg Creek, but the correlation with the Ghost River near Cochrane is even better because of the Zone 7 drainage measured at both hydrometric stations. Correlations of Prairie Creek with surrounding areas indicate that the boundary of Zone 6 lies to the west of the Prairie Creek Basin. The exact location is impossible to determine in this area because all correlated stations are medium to large drainages and contain flow from one or more hydrologic zones.

Correlation of mean monthly flow within Zone 6 are good to excellent with no discrepancies among stations with drainage mainly within the zone. Hydrometric stations draining proportionate areas from both Zones 6 and 7 also tend to correlate well, as indicated by the North Saskatchewan River versus Brazeau River correlations.

Zone 6 can be regarded as reasonably well defined and has similar flow characteristics throughout as indicated by the good to excellent correlations among stations within the zone. Hydrometric record in small drainage areas is almost non-existent and there is a definite need for gauged basins of small size to substantiate the homogeneity of the region based on the hydrometric record from large basins.

Zone 7 - Northern Foothills Area

Zone 7 is almost exclusively a foothills region, but is well drained throughout. Cover varies from a combination of mature forest, open grass and shrub to grassland in the southern end of the zone. Annual rainfall in Zone 7 is less than in the more rugged zones to the west but is more variable. Approximately 65 per cent of the annual precipitation falls during the May to October period (McKay et al, 1963), the summer precipitation percentage being higher than for any other zone, based on the limited precipitation data available.

Only two hydrometric stations, collecting records from drainage exclusively within Zone 7, have five years or more of discharge records. Both hydrometric records fit well into the zonal pattern.

Delineation of the zonal boundaries is partly arbitrary. The eastern and northern boundaries correspond to the geographical limits of the present study, the eastern boundary being arbitrarily defined as approximately the 4,000-foot M.S.L. contour. The southern boundary is also partially arbitrary, corresponding to a gradual change in hydrologic characteristics as previously discussed. The delineation of the western boundary is also discussed in previous sections.

Additional hydrometric records, with emphasis on small and medium-sized drainage basins, is required within Zone 7 for estimates of regional characteristics. The assumptions made on the basis of the two hydrometric stations in the zone will require verification by additional hydrometric records as they become available.

Summary

The Saskatchewan River headwaters area of Alberta can be divided into seven hydrologically similar zones, based on correlations of mean monthly discharge at existing and discountinued stream discharge stations. Within a hydrologic zone, the runoff characteristics of streams will be similar, yet the water yield per unit of area may be variable from basin to basin. On the other hand, streams from different zones will have dissimilar runoff characteristics, indicated by poor correlations of mean

monthly discharge. The coefficient of correlation based on mean monthly discharges and obtained by using the Langbein method of correlation will generally be above 0.80 within a hydrologic zone.

Zonal boundaries are reasonably well defined except for Zones 4 and 7 where lack of hydrometric data makes the boundaries of doubtful accuracy. As more hydrometric data become available, the boundaries may be subject to modification or revision.

The study points out the need for increased hydrometric coverage within the Saskatchewan River headwaters, a vitally important water source area for the Canadian Prairies. An increase in the hydrometric coverage in small and medium-sized basins in particular is required. Many of the present discharge stations are located on streams deriving flow from several hydrologic regions and as such are not representative of any given type of area. The use of hydrometric records from these stations complicates regional studies aimed at estimating the hydrologic characteristics of ungauged areas. In any future expansion of the base network, streams which derive flow from several climatic or topographic zones should be avoided unless required for specific purposes.

Station Name	Index No.	Drainage Area Sq. Mi.	Period of Correlated Record	Coefficient of Corr. "R"	Standard Error	
					Log Units	Per cent
Athabasca River at Jasper	7AA-2	1,576				
Bow River at Banff	5BB-1	858	1913-31	0.629	0.080	19
Athabasca River at Entrance	7AD-1	3,915				
Bow River at Banff	5BB-1	858	1927-39, 1955-58	0.623	0.091	21
McLeod River above Embarras River	7AF-2	1,000	1955-61	0.226	0.086	20
North Saskatchewan River at Edmonton	5DF-1	10,500	1927-39, 1955-60	0.320	0.108	25
Bath Creek near Lake Louise	5BA-3	31				
Forty Mile Creek near Banff	5BB-3	54	1913, 1915-20	0.294	0.106	25
Beaver Mines Creek near Beaver Mines	5AA-10	23				
Mill Creek near Beaver Mines	5AA-11	64	1911-16, April to October	0.534	0.270	66
Belly River at International Boundary	5AD-0.4	75				
Belly River near Mountain View *	5AD-5	121	1947-63	0.876	0.079	18
Waterton River near International Boundary	5AD-0.1	61	1947-63	0.916	0.066	15
Belly River near Mountain View *	5AD-5	121				
Lee Creek at Cardston	5AE-2	117	1930, 1948-64	0.594	0.152	36
St. Mary River at International Boundary *	5AE-27	470	1944-63	0.810	0.102	24
Waterton River near Waterton Park	5AD-3	238	1948-63	0.823	0.101	24
Belly River between Stand Off and Mountain View		355				
Lee Creek at Cardston	5AE-2	117	1949-63	0.590	0.418	112
Belly River near Stand Off *	5AD-2	476				
Belly River near Mountain View *	5AD-5	121	1930-31, 1935-36, 1948-63	0.723	0.134	32
Lee Creek at Cardston	5AE-2	117	1928-30, 1948-64	0.525	0.184	44
Boundary Creek near International Boundary	5AD-0.2	21.0				
Belly River near Mountain View *	5AD-5	121	1947-63	0.820	0.113	27
Brazeau River below Brazeau Dam	5DD-5	2,118				
North Saskatchewan River at Edmonton	5DF-1	10,500	1957-63	0.812	0.062	14
North Saskatchewan River near Saunders	5DC-2	1,903	1957-61, May to October	0.709	0.080	19
North Saskatchewan River near Rocky Mountain House	5DC-1	4,160	1957-61, May to October	0.828	0.063	15
McLeod River above Embarras River	7AF-2	1,000	1957-61, May to October	0.656	0.085	20
Pembina River below Paddy Creek	7BA-1	1,112	1957-61, May to October	0.728	0.078	18
Castle River near Beaver Mines	5AA-22	319				
Belly River near Mountain View *	5AD-5	121	1945-63	0.739	0.134	32
Oldman River at Waldron's Corner	5AA-23	551	1949-64	0.739	0.130	30
Waterton River near Waterton Park	5AD-3	238	1948-64	0.837	0.107	25
Clearwater River above Limestone Creek	5DB-3	500				
Bow River at Banff	5BB-1	858	1959-64, May to October	0.305	0.101	24
Brazeau River below Cardinal River	5DD-7	1,000	1961-64, May to October	0.641	0.085	20
North Saskatchewan River near Rocky Mountain House	5DC-1	4,160	1959-64, May to October	0.802	0.063	15
North Saskatchewan River at Saskatchewan Crossing	5DA-6	485	1959-64, May to October	0.149	0.097	22
North Saskatchewan River near Saunders	5DC-2	1,903	1959-64, May to October	0.340	0.102	24
North Sask. River between Saunders and Saskatchewan Crossing		1,418	1959-64, May to October	0.528	0.084	20
Red Deer River near Sundre	5CA-1	954	1959-64, May to October	0.902	0.046	10
Clearwater River near Rocky Mountain House	5DB-1	1,210				
Ghost River near Cochrane *	5BG-1	357	1916-20, 1955-64	0.693	0.101	24
North Saskatchewan River near Rocky Mountain House	5DC-1	4,160	1945-64	0.802	0.097	22
Red Deer River at Red Deer	5CC-2	4,420	1945-64	0.824	0.090	21
Clearwater River between Rocky Mountain House and Limestone Creek		710				
Red Deer River between Red Deer and Sundre		3,466	1959-62, 64, May to October	0.743	0.120	28
Cow Creek near Cowley	5AA-5	29				
Todd Creek at Elton's Ranch	5AA-6	57	1911-16, April to October	0.932	0.083	20
Crowsnest River at Frank	5AA-8	162				
Belly River near Mountain View *	5AD-5	121	1915-20, 1949-62	0.741	0.112	26
Castle River near Beaver Mines	5AA-22	319	1949-64, March to October	0.890	0.078	18
Kananaskis River near Seebe *	5BF-1	362	1917-20, 1949-62	0.584	0.138	33
Oldman River at Waldron's Corner	5AA-23	551	1949-64, March to October	0.798	0.096	22

* - Natural Flow.

Table 3 - Summary of correlated results (Sheet 1 of 5)

Station Name	Index No.	Drainage Area Sq. Mi.	Period of Correlated Record	Coefficient of Corr. "R"	Standard Error	
					Log Units	Per cent
Crowsnest River near Lundbreck	5AA-2	268				
Castle River near Cowley	5AA-3	435	1912-31	0.847	0.093	22
Oldman River near Cowley	5AA-1	730	1912-31	0.798	0.105	24
Drywood Creek near Twin Butte	5AD-16	12				
Belly River near Mountain View *	5AD-5	121	1945-63	0.674	0.161	38
Castle River near Beaver Mines	5AD-22	319	1945-64, April to October	0.870	0.107	25
Waterton River near Waterton Park	5AD-3	238	1948-64, April to October	0.806	0.129	30
Elbow River at Bragg Creek	5BJ-4	307				
Bow River at Banff	5BB-1	858	1945-64, March to October	0.374	0.145	34
Elbow River above Glenmore Dam	5BJ-5	471	1945-64, March to October	0.907	0.066	15
Kananaskis River near Seebe *	5BF-1	362	1943-61, March to October	0.637	0.126	29
Sheep River between Aldersyde and Buck Ranch		484	1957-64, March to October	0.698	0.073	17
Elbow River above Glenmore Dam	5BJ-5	471				
Fish Creek near Priddis	5BK-1	103	1908-16, 1956-64, April to October	0.839	0.095	22
Fish Creek near Priddis	5BK-1	103				
Sheep River near Buck Ranch	5BL-18	176	1956-64, March to October	0.588	0.301	75
Forty Mile Creek near Banff	5BB-3	54				
Ghost River near Cochrane *	5BG-1	357	1912-20, 1946-48	0.397	0.128	30
Pipestone River near Lake Louise	5BA-2	136	1912-20	0.536	0.112	26
Spray River at Banff	5BC-1	289	1912-20, 1946-48	0.634	0.108	25
Ghost River near Black Rock Mountain	5BG-2	80				
Bow River at Banff	5BB-1	858	1944-58	0.640	0.109	26
Ghost River near Cochrane *	5BG-1	357	1944-63	0.726	0.094	22
Ghost River near Cochrane *	5BG-1	357				
Elbow River at Bragg Creek	5BJ-4	307	1944-63, March to October	0.867	0.083	20
Red Deer River near Sundre	5CA-1	954	1950-63, March to October	0.800	0.098	23
Highwood River near Aldersyde	5BL-9	906				
Elbow River above Glenmore Dam	5BJ-5	471	1944-63	0.867	0.116	27
Highwood River at Diebel's Ranch	5BL-19	300	1950-63, March to October	0.866	0.116	27
Kananaskis River near Seebe *	5BF-1	362	1944-62	0.661	0.174	41
Highwood River at Diebel's Ranch	5BL-19	300				
Bow River at Banff	5BB-1	858	1950-64, March to October	0.510	0.148	35
Kananaskis River above Pocaterra Creek*	5BF-3	136	1950-63, March to October	0.558	0.145	34
Kananaskis River at Seebe *	5BF-1	362	1950-62, March to October	0.796	0.106	25
Oldman River at Waldron's Corner	5AA-23	551	1950-64, March to October	0.871	0.084	20
Jumpingpound Creek near Jumping Pound	5BH-6	187				
Elbow River near Fullerton's Ranch	5BJ-3	254	1914-19, April to October	0.825	0.265	65
Ghost River near Cochrane	5BG-1	357	1911-19, April to October	0.875	0.217	52
Kananaskis River near Seebe *	5BF-1	362				
Ghost River near Cochrane	5BG-1	357	1943-62	0.520	0.113	27
Lee Creek at Cardston	5AE-2	117				
Belly River near Mountain View *	5AD-5	121	1944-63	0.517	0.257	63
Louise Creek near Lake Louise	5BA-4	10				
Bath Creek near Lake Louise	5BA-3	31	1913-18, March to October	0.359	0.205	49
McLeod River above Embarras River	7AF-2	1,000				
North Saskatchewan River at Edmonton	5DF-1	10,500	1954-64	0.350	0.172	41
Pembina River below Paddy Creek	7BA-1	1,112	1956-64, March to October	0.846	0.105	24
McLeod River near Wolf Creek	7AG-1	2,510				
Athabasca River at Jasper	7AA-2	1,576	1923-31, 1914-23	0.173	0.245	59
Pembina River near Entwistle	7BB-2	1,753	1954-63	0.697	0.176	42
Meadow Creek at Hart's Ranch	5AB-6	38				
Todd Creek at Elton's Ranch	5AA-6	57	1911-16, April to October	0.824	0.210	50
Trout Creek at Lockwood's Ranch	5AB-3	164	1911-19, 1922-23	0.894	0.203	48
Miette River near Jasper	7AA-1	250				
Athabasca River at Jasper	7AA-2	1,576	1913-18	0.478	0.147	34
McLeod River near Wolf Creek	7AG-1	2,510	1914-21	0.288	0.150	35
Pembina River near Entwistle	7BB-2	1,753	1914-21	0.173	0.154	36
Rocky River at Hawes	7AA-3	395	1914-18	0.716	0.092	21
Mill Creek near Beaver Mines	5AA-11	64				
Pincher Creek at Pincher Creek	5AA-4	50	1910-19, April to October	0.891	0.132	31

* - Natural Flow.

Table 3 - Summary of correlated results (Sheet 2 of 5)

Station Name	Index No.	Drainage Area Sq. Mi.	Period of Correlated Record	Coefficient of Corr. "R"	Standard Error	
					Log Units	Per cent
Milk River at Western Crossing	11AA-25	433				
St. Mary River at International Boundary *	5AE-27	470	1944-63, March to October	0.588	0.368	95
Mistaya River near Saskatchewan Crossing	5DA-7	94				
Bow River at Banff	5BB-1	858	1950-64, June to October	0.557	0.068	16
North Saskatchewan River at Saskatchewan Crossing	5DA-6	485	1950-64, June to October	0.843	0.046	11
Nanton Creek near Nanton	5AC-2	46				
Mosquito Creek near Nanton	5AC-1	178	1908-19, April to October	0.932	0.179	43
North Milk River above Canal	11AA-0.3	62				
Belly River between Stand Off and Mountain View		355	1927-30, 1949-61, April to September	0.550	0.176	42
Lee Creek at Cardston	5AE-2	117	1944-63, April to October	0.758	0.178	42
Milk River at Western Crossing	11AA-25	433	1944-63, April to October	0.799	0.164	39
St. Mary River at International Boundary *	5AE-27	470	1944-63, April to October	0.437	0.245	59
North Saskatchewan River near Rocky Mountain House	5DC-1	4,220				
North Saskatchewan River at Edmonton	5DF-1	10,500	1944-60	0.852	0.058	14
North Saskatchewan River at Saskatchewan Crossing	5DA-6	492				
Athabasca River at Entrance	7AD-1	3,915	1955-61, May to October	0.533	0.083	20
Bow River at Banff	5BB-1	858	1950-64, May to October	0.600	0.086	20
North Saskatchewan River at Edmonton	5DF-1	10,500	1950-64, May to October	0.120	0.107	25
North Saskatchewan River near Rocky Mountain House	5DC-1	4,220	1950-61, May to October	0.383	0.087	20
North Saskatchewan River at Saunders	5DC-2	1,980				
Athabasca River at Entrance	7AD-1	3,915	1915-23, 1955-61, April to October	0.666	0.075	17
Athabasca River at Jasper	7AA-2	1,576	1915-23	0.514	0.077	18
Bow River at Banff	5BB-1	858	1917-23, 1952-64	0.742	0.066	15
North Saskatchewan River at Edmonton	5DF-1	10,500	1917-23, 1952-64	0.517	0.085	20
Red Deer River at Red Deer	5CC-2	4,420	1917-23, 1955-64	0.314	0.096	22
Oldman River near Fort MacLeod *	5AB-7	2,230				
Belly River near Mountain View *	5AD-5	121	1941-60	0.674	0.166	39
Oldman River near Waldron's Corner	5AA-23	551				
Kananaskis River near Seebe *	5BF-1	362	1949-62	0.533	0.150	35
Oldman River near Fort MacLeod *	5AB-7	2,230	1949-60	0.829	0.098	23
Pekisko Creek at Pekisko	5BL-6	99				
Highwood River at Brown's Ranch	5BL-8	421	1912-19, April to October	0.836	0.224	54
Mosquito Creek near Nanton	5AC-1	178	1911-19, April to October	0.729	0.215	52
Pembina River below Paddy Creek	7BA-1	1,112				
Athabasca River at Hinton	7AD-2	4,000	1956-61, March to September	0.213	0.190	45
McLeod River between Wolf Creek and Embarras River		1,510	1956-64, March to October	0.765	0.149	35
North Saskatchewan River at Edmonton	5DF-1	10,500	1956-64, March to October	0.515	0.199	48
Wolf Creek at Highway No. 16 Crossing	7AG-3	350	1956-64, March to October	0.816	0.134	32
Pincher Creek near Pincher Creek	5AA-4	50				
Lee Creek at Cardston	5AE-2	117	1914, 1920-31, 1935-36, Mar. to Oct.	0.853	0.226	54
Todd Creek at Elton's Ranch	5AA-6	57	1911-16, April to October	0.801	0.173	41
Pipestone River near Lake Louise	5BA-2	136				
Bath Creek near Lake Louise	5BA-3	31	1913, 1915-20, May to September	0.351	0.100	24
Bow River near Lake Louise	5BA-1	163	1911-20	0.286	0.140	33
Ghost River near Cochrane	5BG-1	346	1911-20	0.080	0.146	34
Pocaterra Creek near the Mouth	5BF-4	21.5				
Kananaskis River near Seebe *	5BF-1	362	1931-41, June to October	0.827	0.111	26
Prairie Creek near Rocky Mountain House	5DB-2	318				
Brazeau River between Cardinal River and Brazeau Dam		1,120	1961-63, May to October	0.023	0.198	47
Clearwater River near Rocky Mountain House	5DB-1	1,210	1922-25, 1951-64, March to October	0.774	0.160	38
Ghost River near Cochrane *	5BG-1	346	1951-64	0.667	0.177	42
North Saskatchewan River near Rocky Mountain House	5DC-1	4,220	1951-64, March to October	0.599	0.202	48
North Saskatchewan River between Saunders and Rocky Mountain House		2,240	1922, 1953-64, April to October	0.791	0.148	35
Red Deer River at Red Deer	5CC-2	4,420	1922-25, 1951-63, March to October	0.733	0.089	21

* - Natural Flow.

Table 3 - Summary of correlated results (Sheet 3 of 5)

Station Name	Index No.	Drainage Area Sq. Mi.	Period of Correlated Record	Coefficient of Corr. "R"	Standard Error	
					Log Units	Per cent
Red Deer River at Red Deer	5CC-2	4,420				
Ghost River near Cochrane *	5BG-1	346	1945-64	0.797	0.130	30
Red Deer River near Sundre	5CA-1	954				
Bow River at Banff	5BB-1	858	1950-64, March to October	0.545	0.119	28
Ghost River near Black Rock Mountain	5BG-2	80	1950-63, April to October	0.848	0.077	18
Red Deer River at Red Deer	5CC-2	4,420	1955-64, March to October	0.648	0.092	21
Rocky River at Hawes	7AA-3	395				
Athabasca River at Jasper	7AA-2	1,576	1913-18	0.478	0.147	35
McLeod River near Wolf Creek	7AG-1	2,510	1914-18	0.633	0.130	31
Pembina River near Entwistle	7BB-2	1,710	1914-18	0.430	0.152	36
Sheep River near Aldersyde	5BL-20	660				
Ghost River near Cochrane *	5BG-1	346	1911-20, 1957-63	0.778	0.172	41
Sheep River at Buck Ranch	5BL-18	176				
Elbow River at Bragg Creek	5BJ-4	307	1950-64, March to October	0.781	0.140	33
Elbow River above Glenmore Dam	5BJ-5	471	1950-64, March to October	0.848	0.119	28
Ghost River near Cochrane *	5BG-1	346	1950-64, March to October	0.723	0.156	37
Highwood River at Diebel's Ranch	5BL-19	300	1950-64, March to October	0.719	0.156	37
Sheep River between Aldersyde and Buck Ranch		484				
Highwood River between Aldersyde and Diebel's Ranch		606	1957-63, March to October	0.805	0.242	59
Spray Creek at Spray Lakes	5BC-3	44.5				
Forty Mile Creek near Banff	5BB-3	54	1914-19, May to October	0.887	0.077	18
Kananaskis River between Seebe and Pocaterra Creek		225	1921-22, 1924-39	0.575	0.089	21
Spray River at Banff	5BC-1	276	1921-39	0.749	0.072	17
Spray River near Spray Lakes	5BC-2	143	1921-39	0.723	0.075	18
Spray River at Banff	5BC-1	276				
Bow River at Banff	5BB-1	858	1930-49	0.753	0.066	15
Kananaskis River near Seebe	5BF-1	362	1912-31	0.660	0.077	18
Spray River near Spray Lakes	5BC-2	143				
Bath Creek near Lake Louise	5BA-3	31	1915-19, May to October	0.188	0.088	21
Kananaskis River above Pocaterra Creek			1921-22, 1924-39	0.648	0.091	21
Kananaskis River near Seebe *	5BF-1	362	1921-39	0.452	0.107	25
Spray River at Banff	5BC-1	276	1921-39	0.851	0.063	15
Stimson Creek near Pekisko	5BL-7	96				
Fish Creek near Priddis	5BK-1	103	1911-16, 1956-64, March to October	0.828	0.369	98
Highwood River between Aldersyde and Diebel's Ranch		606	1950-63, March to October	0.819	0.350	90
Pekisko Creek at Pekisko	5BL-6	99	1911-19, April to October	0.844	0.415	111
Sheep River at Buck Ranch	5BL-18	176	1950-64, March to October	0.634	0.476	133
Trout Creek at Lockwood's Ranch	5AB-3	165	1911-19, April to October	0.857	0.399	106
Willow Creek near Claresholm	5AB-21	446	1944-63, March to October	0.869	0.298	74
Street Creek at International Boundary	5AD-0.3	6.1				
Belly River near Mountain View *	5AD-5	121	1947-55	0.916	0.119	28
Sunwapta River at Athabasca Glacier	7AA-7	11				
Bow River at Banff	5BB-1	858	1949-64, May to October	0.367	0.146	34
North Saskatchewan River at Saskatchewan Crossing	5DA-6	492	1950-64, June to October	0.656	0.115	27
Todd Creek at Elton's Ranch	5AA-6	57				
Beaver Mines Creek near Beaver Mines	5AA-10	27	1911-16, March to October	0.858	0.116	27
Mill Creek near Beaver Mines	5AA-11	64	1911-16, April to October	0.547	0.171	40
Trout Creek at Lockwood's Ranch	5AB-3	165				
Mosquito Creek near Nanton	5AC-1	178	1908-19, April to October	0.783	0.302	75
Waterton River near International Boundary	5AD-0.1	61				
Belly River near Mountain View *	5AD-5	121	1947-61	0.800	0.133	31
St. Mary River at International Boundary *	5AE-27	469	1947-61	0.884	0.104	24
Waterton River near Waterton Park	5AD-3	238				
Oldman River at Waldron's Corner	5AA-23	511	1949-64	0.548	0.160	38
Waterton River near Stand Off	5AD-8	674				
Belly River near Stand Off	5AD-2	476	1910-19, April to October	0.786	0.128	30
Oldman River near Cowley	5AA-1	730	1915-31	0.839	0.111	26
St. Mary River at International Boundary *	5AE-27	469	1942-61	0.815	0.122	28

* - Natural Flow.

Table 3 - Summary of correlated results (Sheet 4 of 5)

Station Name	Index No.	Drainage Area Sq. Mi.	Period of Correlated Record	Coefficient of Corr. "R"	Standard Error	
					Log Units	Per cent
Willow Creek near Claresholm	5AB-21	446				
Elbow River above Glenmore Dam	5BJ-5	471	1945-64	0.768	0.255	62
Highwood River between Aldersyde and Diebel's Ranch		606	1950-63, March to October	0.868	0.206	49
Lee Creek at Cardston	5AE-2	117	1945-64	0.740	0.267	65
Sheep River at Buck Ranch	5BL-18	176	1950-64	0.665	0.314	79
Willow Creek near Nolan	5AB-2	900				
Elbow River above Glenmore Dam	5BJ-5	471	1945-64, March to October	0.790	0.262	64
Lee Creek at Cardston	5AE-2	117	1945-64, March to October	0.764	0.271	66
Oldman River near Fort MacLeod *	5AB-7	2,230	1945-60, March to October	0.713	0.277	68
Wolf Creek at Highway No. 16 Crossing	7AG-3	350				
Athabasca River at Hinton	7AD-2	4,000	1955-61	0.107	0.272	67
McLeod River above Embarras River	7AF-2	1,000	1954-64	0.620	0.252	61
McLeod River between Wolf Creek and Embarras River		1,510	1954-64	0.697	0.230	56
North Saskatchewan River at Edmonton	5DF-1	10,500	1954-60	0.535	0.227	55

Table 3. - Summary of Correlated Results (Sheet 5 of 5).

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FIGURE 1

Hydrologic Zones in the Headwaters of the Saskatchewan River

Other TECHNICAL BULLETINS issued:

No. 1 E. P. Collier and A. Coulson, October 1965. Natural flow of North Saskatchewan River at Alberta - Saskatchewan boundary by the rim station method.

Discusses methods of estimating the natural flow of the North Saskatchewan River at the provincial boundary by simple regression with the flow at Rocky Mountain House and also by multiple regression techniques involving precipitation.

No. 2 R. O'N. Lyons, November 1965. LACOR - Program for streamflow correlation.

A program for the IBM 1620 computer to correlate streamflow records in terms of deviations in log units from the geometric mean of each calendar month's discharges.

No. 3 A. Coulson, 1966. Tables for computing and plotting flood frequency curves.

A compilation of tables for the computation and plotting of flood frequency curves according to the first asymptotic distribution of extreme values (the Gumbel method). A worked example of the use of the tables is included.

No. 4 A. Coulson, 1967. Flood frequencies of Nova Scotia streams.

Recorded flood flows have been analysed on a regional basis and a method for estimating the flood frequency curve for any stream in Nova Scotia is outlined.

No. 5 A. Coulson and P. N. Gross, 1967. Measurement of the physical characteristics of drainage basins.

Methods of obtaining quantitative descriptions of certain physical characteristics of drainage basins are outlined using as examples Marmot Creek and Streeter Creek, two of the experimental basins of the East Slopes (Alberta) Watershed Research Program.

Copies of the technical bulletins are available free from:

Director,
Inland Waters Branch,
Department of Energy, Mines
and Resources,
588 Booth St.,
Ottawa, Ont.