COMMITTEE ON HYDROLOGY

RETURN FLOW FROM IRRIGATION SOUTHERN ALBERTA

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Water Resources Branch
Calgary, Alberta

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PPWB Report # 72

PRAIRIE PROVINCES WATER BOARD

CANADA ALBERTA SASKATCHEWAN MANITOBA

TECHNICAL REPORT TO THE
PRAIRIE PROVINCES WATER BOARD
COMMITTEE ON HYDROLOGY

RETURN FLOW FROM IRRIGATION

SOUTHERN ALBERTA

PPWB REPORT #72, OCTOBER 1985

ENVIRONMENT CANADA
INLAND WATERS DIRECTORATE
WATER RESOURCES BRANCH
HYDROLOGY DIVISION
CALGARY, ALBERTA

SYNOPSIS

The present report is an update to the technical report to the Prairie Provinces Water Board (PPWB) Committee on Hydrology entitled "Natural Flow - Determination of Irrigation Return Flow in Southern Alberta", Environment Canada, March 1974, and deals specifically with the estimation of return flow from the Lethbridge Northern, St. Mary River, Taber, Magrath, Raymond, Mountain View, Leavitt, Aetna and United irrigation districts in the Oldman River Basin. These are the irrigation districts studied in the aforementioned report and to date no study has been undertaken to evaluate the current procedure of estimating return flows from diversions in the Bow River Basin.

An evaluation of the existing relationships for return flow estimation revealed the need for revisions. Subsequent to the analysis of all available data, new return flow regression equations are recommended for the Lethbridge Northern, St. Mary River, and Taber irrigation districts. These new equations require the use of eleven index stations, as compared to nine for the 1974 equations; however, by using existing stations and relocating others, the recommendations result in no net increase in the number of hydrometric stations.

A new relationship is recommended for return flow estimation from the Magrath and Raymond irrigation districts and revised "percentage-of-diversion" estimates are recommended for the Mountain View, Leavitt, Aetna, and United irrigation districts.

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1. INTRODUCTION

The present report is an update to the technical report to the Prairie Provinces Water Board (PPWB) Committee on Hydrology entitled "Natural Flow - Determination of Irrigation Return Flow in Southern Alberta", Environment Canada, March 1974, and deals specifically with the estimation of return flow from the Lethbridge Northern, St. Mary River, Taber, Magrath, Raymond, Mountain View, Leavitt, Aetna and United irrigation districts.

The PPWB accepted the methodology and hydrometric network proposed in the report "Natural Flow - South Saskatchewan River below Red Deer River", Environment Canada, September 1974, and recognized that, as irrigation systems and methods evolve, it would likely be necessary to modify the return flow monitoring network. At that time, it was considered advisable to review the return flow estimation procedures and monitoring network at approximate 10-year intervals. Chapter 3 of the present report provides an evaluation of the existing return flow estimation.

Due primarily to a perceived change in return flow volumes and patterns resulting from the increasing trend toward the use of mechanical sprinkler systems beginning about the mid-1970's, the PPWB recommended a field program to verify the return flow estimates and the monitoring network. Consequently, a field program was conducted during the 1979 and 1981 irrigation seasons to collect return flow data from 173 sites in the study area. Chapter 4 includes a map (PLATE 1) of the study area. PLATES 2 through 8 (in Appendix) show the irrigation districts in detail with the location of all significant return flow sites and recommended index stations. The data collected during 1979 and 1981 was combined with data collected during the original study in 1971 and 1972, and placed in the Appendix to this report.

Chapter 5 presents a detailed data analysis and rationale for the recommended relationships to estimate return flow from each irrigation district. Chapter 2 summarizes the results and recommendations of the study.

2. SUMMARY AND RECOMMENDATIONS

The results of the evaluation of present return flow estimation carried out in Chapter 3 show a definite need to revise existing return flow relationships. That need was brought about by a significant, though gradual change in irrigation practice; primarily a changeover to mechanical sprinkler systems during the mid-1970's in the Lethbridge Northern (L.N.I.D.), St. Mary River (S.M.R.I.D.), and Taber (T.I.D.) irrigation districts.

The field program conducted in 1979 and 1981 collected data from 173 return flow sites and, together with the data collected in 1971 and 1972, formed the basis for the analyses described in Chapter 5. The following sections summarize the present recommendations for the determination of total return flow from the irrigation districts under study.

2.1 Lethbridge Northern Irrigation District

On a monthly basis,

(L.N.I.D.) Return Flow (dam^3) = 338.34 +

$0.955X_1 + 1.308X_2 + 1.237X_3 - 1.251X_4 + 0.830X_5$

using monthly recorded flows (dam^3) at the following index stations:

X_1 = Piyami Drain near Picture Butte (05AD037)

X_2 = Battersea Drain near the Mouth (05AD038)

X_3 = Little Bow River near the Mouth (05AC023)

X_4 = Little Bow River below Travers Dam (05AC012)

X_5 = Drain L-5 near Diamond City

The recommendation would involve a net increase of one hydrometric station (Drain L-5 near Diamond City), since all others are presently in existence. Table 4 (page 22) shows the improvement in return flow estimation when the recommended equation is applied.

2.2 St. Mary River and Taber Irrigation Districts

On a monthly basis,

(S.M.R.I.D. + T.I.D.) Return Flow (dam^3) = 1554.1 +

$1.558X_1 + 2.132X_2 + 2.106X_3 + 3.631X_4 + 3.064X_5 +$

$1.322X_6$

using monthly recorded flows (dam^3) at the following index stations:

X_1 = Seven Persons Creek at Medicine Hat (05AH005)

X_2 = Drain S-10 near Bow Island (05AJ003)

X_3 = Drain S-4 near Grassy Lake (05AJ002)

X_4 = T-1

X_5 = Bountiful Coulee Inflow near Cranford (05AG026)

X_6 = II

NOTE: The index stations shown here are identical to those shown in Chapter 5; only the X_i numbers were changed here for convenience.

Four of the recommended index stations are presently in existence and, while use of the recommended equation would require the establishment of two new recording stations (i.e., T-1, and II), it is likely that three of the present index stations (i.e., Bountiful Coulee near Cranford - 05AG008, Drain T-2 near Taber - 05AG023 and Drain T-11 near Fincastle - 05AG025) would be discontinued. There would, therefore, be a net decrease of one hydrometric station. Table 9 (page 34) shows the significant improvement in return flow estimation when the recommended equation is applied.

2.3 Magrath and Raymond Irrigation Districts

On a monthly basis,

(M.I.D. + R.I.D.) Return Flow (dam^3) = Monthly Recorded Flows (dam^3) at Dry Coulee near Magrath (05AE041) + Pothole Creek at Russell's Ranch (05AE016).

As evidenced by field inspections and the data collected, more than 95% of the return flow from the M.I.D. and R.I.D. is accounted for by those two recording stations.

2.4 Mountain View, Leavitt, and Aetna Irrigation Districts

Based on the considerations explained in Section 5.4, it is recommended that Mountain View, Leavitt and Aetna irrigation districts' monthly return flow be determined as a percentage of the respective monthly diversion recorded by the gauge on the Mountain View Irrigation District Canal (05AD017), as follows:

May	June	July	Aug.	Sept.	Oct.
100%	100%	40%	35%	20%	35%

2.5 United Irrigation District

Based on the considerations explained in Section 5.5, it is recommended that United Irrigation District monthly return flow be determined as a percentage of the respective monthly diversion recorded by the gauge on the United Irrigation District Canal near Hill Spring (05AD013), as follows:

May	June	July	Aug.	Sept.	Oct.
100%	100%	35%	30%	25%	20%

2.6 Future Reliability of the Recommended Return Flow Estimations

Most irrigation districts under present consideration are undergoing a continual process of upgrading. As distribution systems are made more efficient (e.g., lined vs unlined canals and sprinkler vs gravity-feed irrigation), it is expected that the recommended return flow relationships will become less accurate each year subsequent to 1981. An ongoing contact with irrigators and district managers is therefore recommended to keep abreast of changes. Further, it is recommended that a full return flow monitoring program be carried out in the field every five to ten years.

3. EVALUATION OF PRESENT RETURN FLOW ESTIMATION

The 1974 report (6.1) recommended a procedure to check the reliability of the established regression equations in subsequent years. In an attempt to follow that procedure, precipitation data for Lethbridge, Vauxhall, and Medicine Hat was compiled for the years 1972 to 1981 inclusive, and seasonal moisture conditions (i.e., wet, normal or dry) for those years were identified for the S.M.R.I.D and L.N.I.D. (according to Table 10 from the 1974 report). Tables 8 and 9 from the 1974 report give return flows as a percentage of the respective diversions to the S.M.R.I.D and L.N.I.D. The 1974 report suggests that if, in years subsequent to 1972, the return flows computed from the regression equations differ significantly from those table values, then it is likely that a change in irrigation practice has occurred. While there were significant differences for all years subsequent to 1972, it is not certain whether those differences reflect a change in irrigation practice or whether the derivation of Tables 8, 9 and 10 in the 1974 report was in error.

Further to the previous considerations, there was a perceived change in return flow volumes and patterns occurring about the mid-1970's. Consequently, a field program was conducted during the 1979 and 1981 irrigation seasons to again monitor the return flows. In addition, a field inspection was carried out in 1982, together with some twenty individual interviews with managers and irrigators in the S.M.R.I.D. and L.N.I.D., to determine the extent of and dates of changeover to sprinkler irrigation.

It was determined that significant, though not abrupt, changeover to sprinkler systems began about 1976 in the S.M.R.I.D. and somewhat earlier in the L.N.I.D.

Figures 1 and 2, showing irrigated land, unit consumptive use and unit return flow together with the indicated trends, were plotted for the St. Mary River, Taber, Magrath, and Raymond irrigation districts (Fig. 1) and the L.N.I.D. (Fig. 2). As shown in both figures, there was a decreasing trend in consumptive use and return flow with increasing irrigated land, thereby indicating a more efficient use of irrigation water. These trends and the significant changeover to sprinkler irrigation dictate the need to revise the existing return flow estimations.

FIGURE 1

TRENDS IN IRRIGATED LAND, CONSUMPTIVE USE AND RETURN FLOW

ST. MARY RIVER, TABER, MAGRATH AND RAYMOND IRRIGATION DISTRICTS

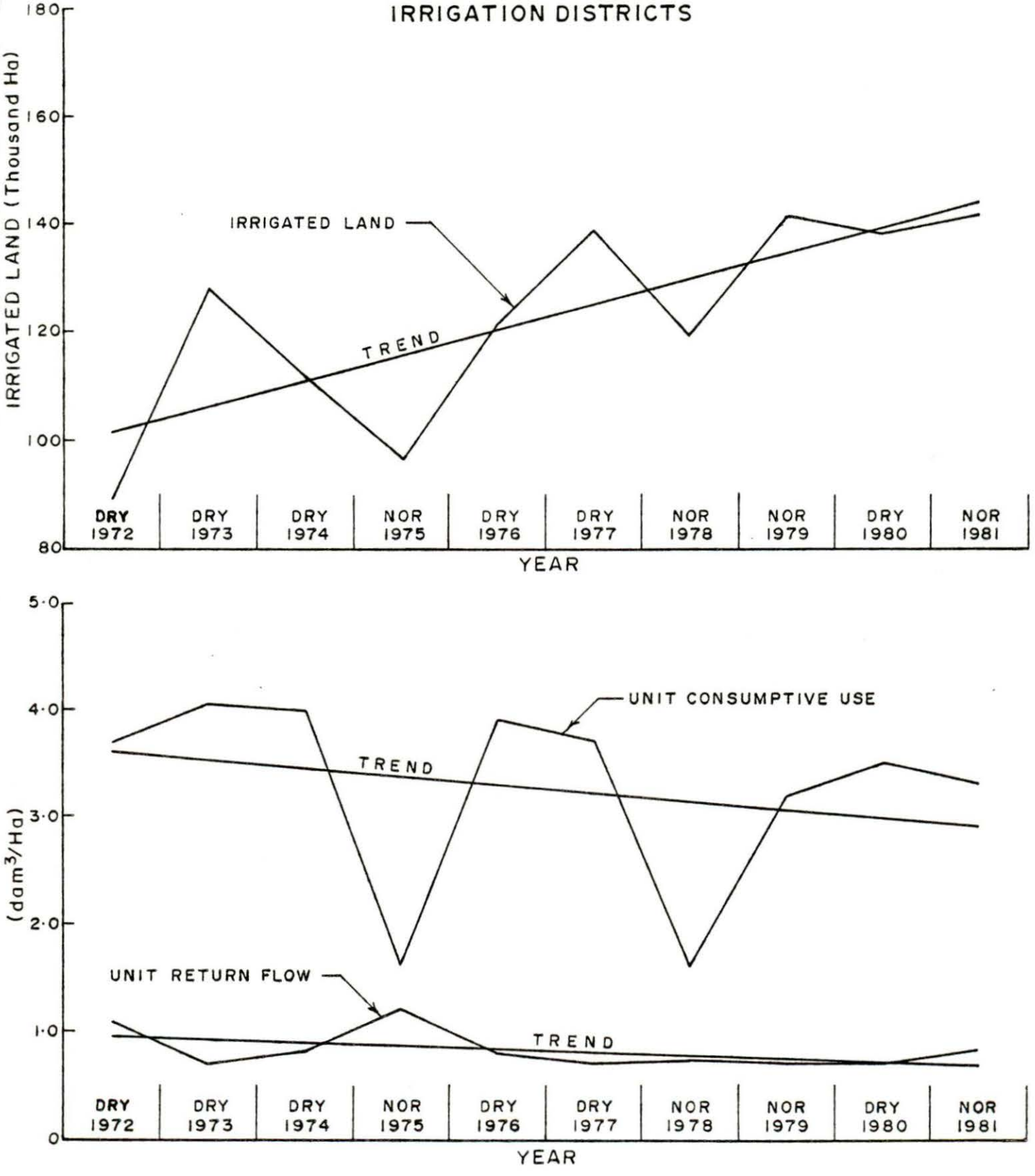
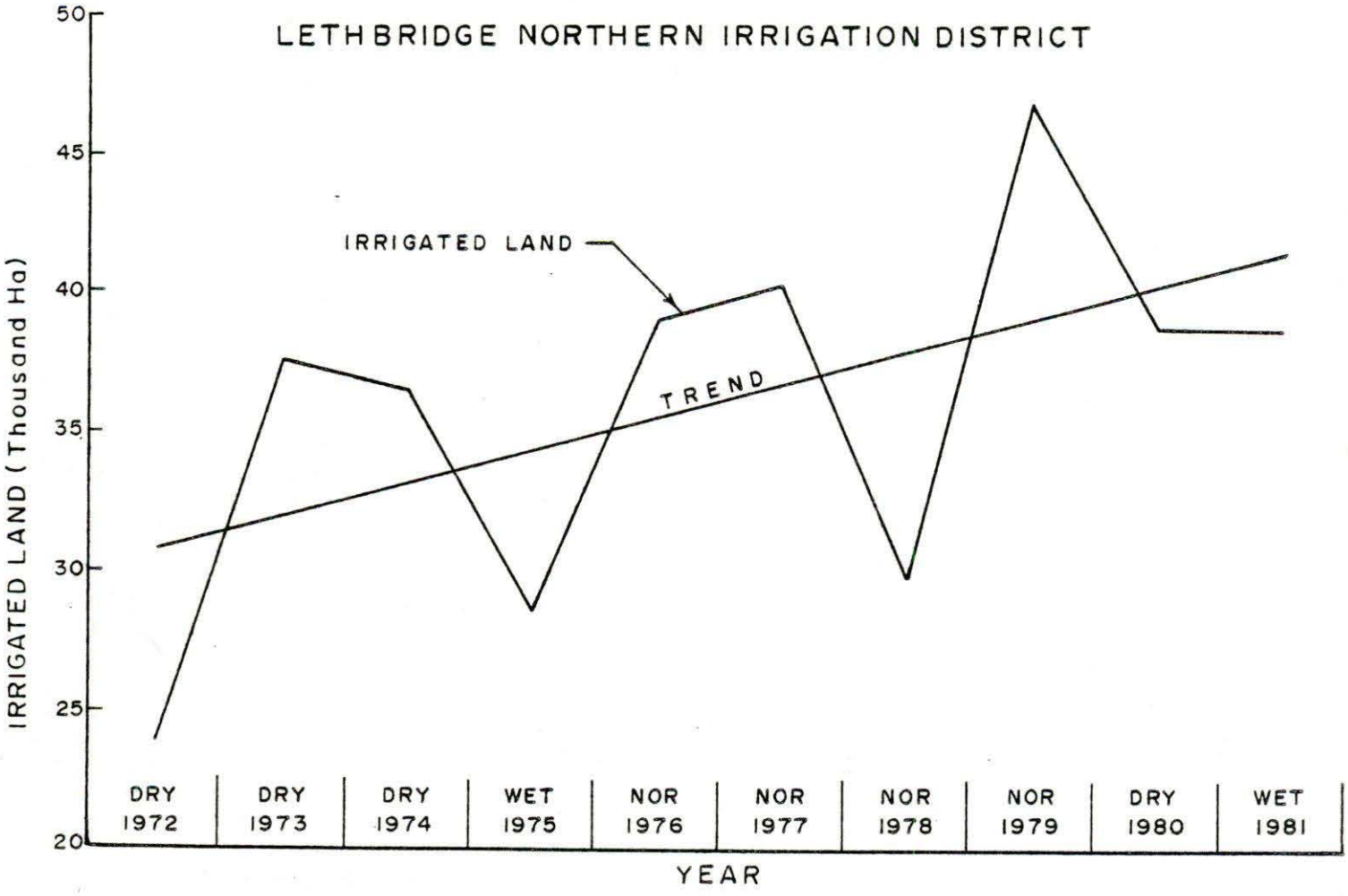
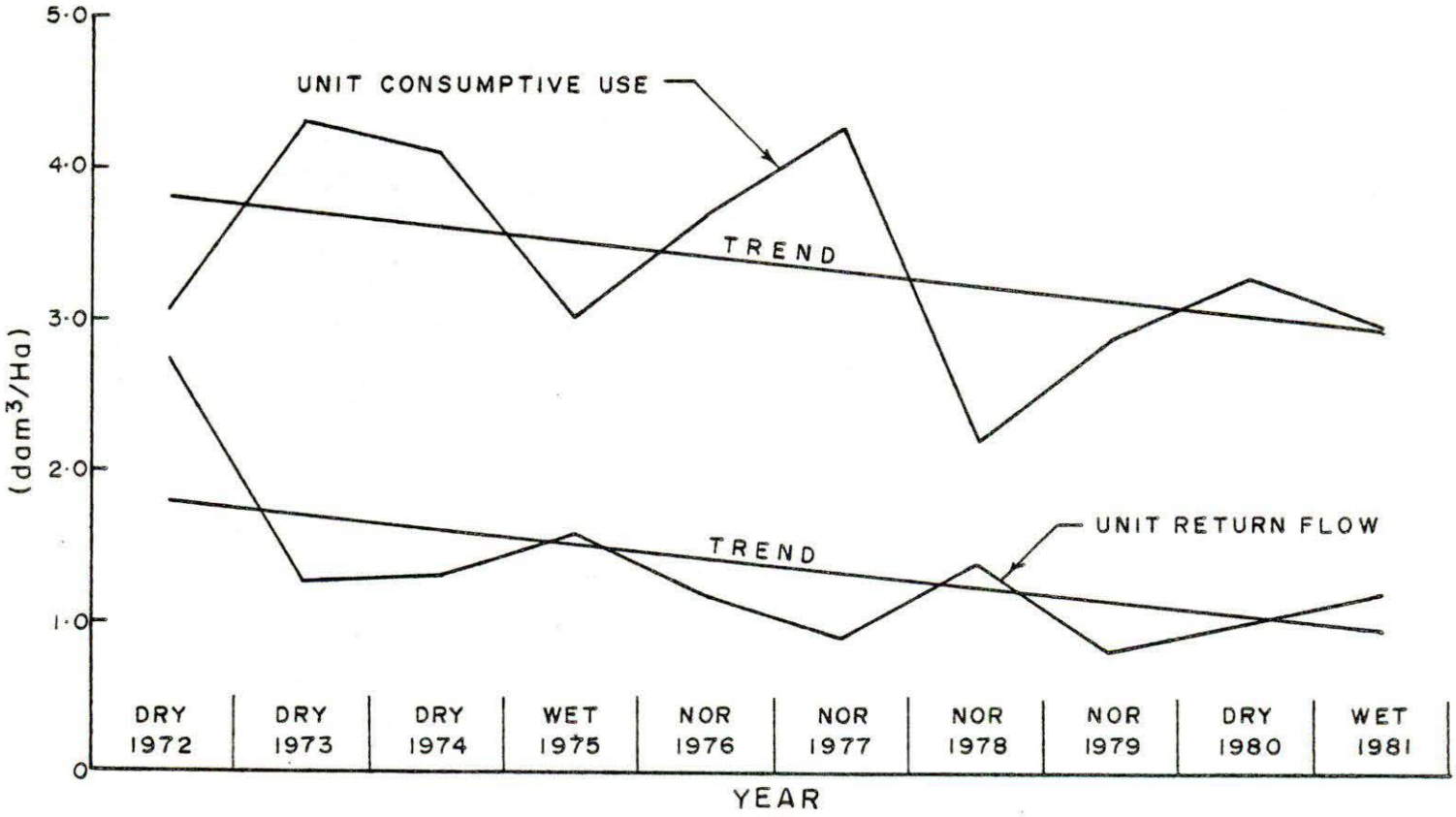


FIGURE 2

TRENDS IN IRRIGATED LAND, CONSUMPTIVE USE AND RETURN FLOW

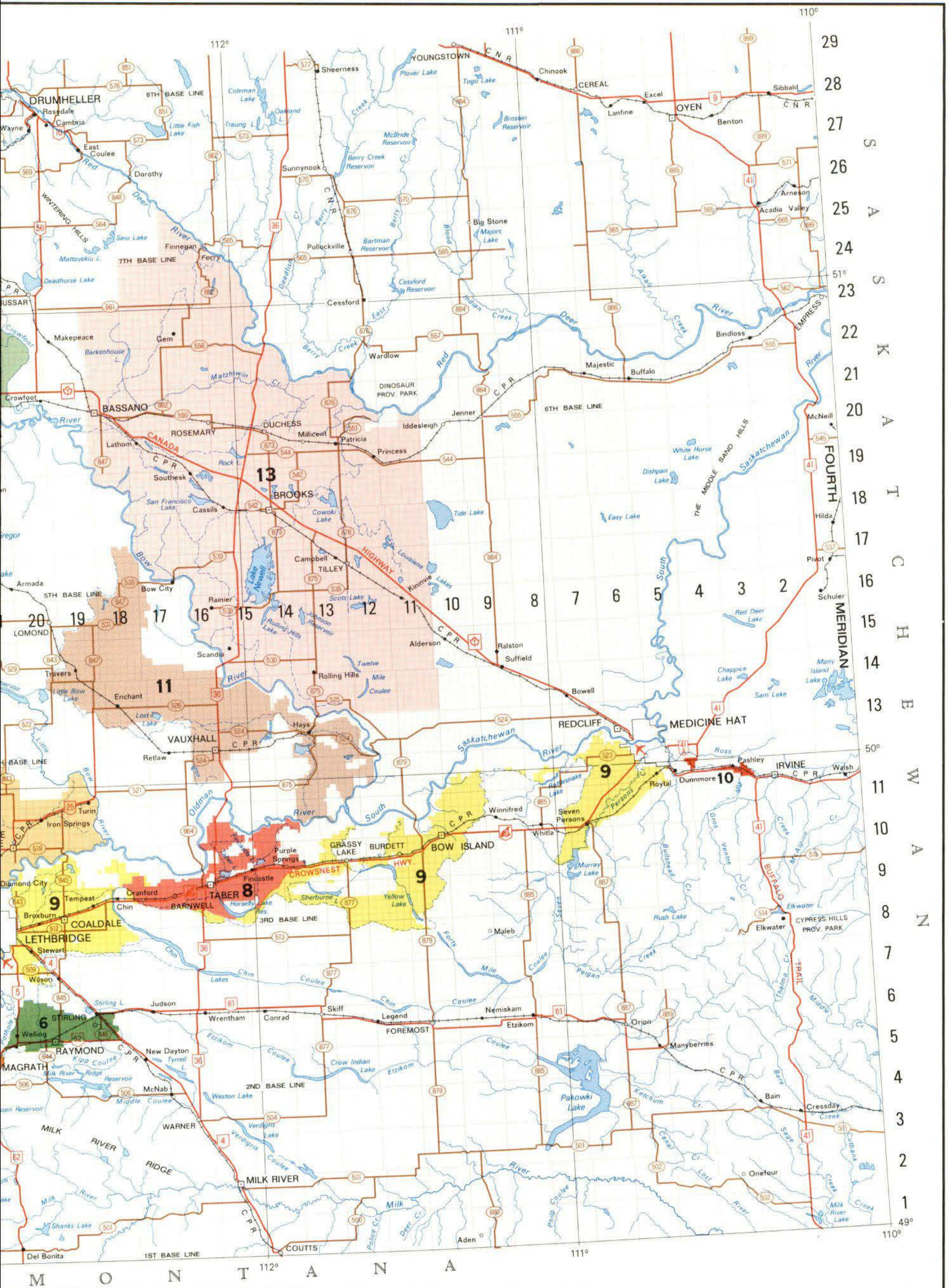




4. RETURN FLOW MONITORING PROGRAM

The field program carried out during the 1979 and 1981 irrigation seasons collected data from 173 return flow sites. Plate 1 shows the extent and location of all irrigation districts in Alberta and Plates 2 through 8 (in Appendix) are enlargements of the individual irrigation districts under present study, and show the existing distribution systems and locations of significant return flow channels. The data collected during 1971, 1972, 1979, and 1981 have been placed in the Appendix.


Alberta
AGRICULTURE
IRRIGATION DISTRICTS
MARCH 1983
km 10 0 10 20 30 km
miles 10 0 10 20 miles
MOUNTAIN VIEW IRRIGATION DISTRICT 1
LEAVITT IRRIGATION DISTRICT 2
AETNA IRRIGATION DISTRICT 3
UNITED IRRIGATION DISTRICT 4
MAGRATH IRRIGATION DISTRICT 5
RAYMOND IRRIGATION DISTRICT 6
LETHBRIDGE NORTHERN IRRIGATION DISTRICT 7
TABER IRRIGATION DISTRICT 8
ST MARY RIVER IRRIGATION DISTRICT 9
ROSS CREEK IRRIGATION DISTRICT 10
BOW RIVER IRRIGATION DISTRICT 11
WESTERN IRRIGATION DISTRICT 12
EASTERN IRRIGATION DISTRICT 13
PRODUCED BY THE ALBERTA BUREAU OF SURVEYING AND MAPPING © 1983
BANFF
NATIONAL
PARK
BRITISH
COLUMBIA
ROCKY
MOUNTAINS
FOREST
RESERVE
FIFTH MERIDIAN
CALGARY
COCHRANE
CROSSFIELD
AIRDRIE
STRATHMORE
OKOTOKS
HIGH RIVER
NANTON
CLARESHOLM
FORT MACLEOD
PINCHER CREEK
CARDSTON
VULCAN
GLEICHEN
CANMORE
BLACK DIAMOND
TURNER VALLEY
STAVELY
GRANUM
COALHURST
MUNICIPALITY OF CROWSNEST PASS


DRUMHELLER
Rosedale
Cambria
East Coulee
Dorothy
8TH BASE LINE
7TH BASE LINE
6TH BASE LINE
5TH BASE LINE
3RD BASE LINE
2ND BASE LINE
1ST BASE LINE
Sheerness
YOUNGSTOWN
Chinook
CEREAL
Lanfine
Excel
OYEN
Benton
Sibbald
Sunnynook
Big Stone
Pollockville
Finnegan
Cessford
Makepeace
Gem
Wardlow
DINOSAUR PROV. PARK
Majestic
Buffalo
Bindloss
EMPRESS
Acadia Valley
Arneson
Crowfoot
BASSANO
ROSEMARY
DUCHESS
Millicent
Patricia
Iddesleigh
Jenner
Princess
Lathom
Southesk
Cassils
BROOKS
13
Campbell
TILLEY
Kininvie
Bow City
Rainier
Armada
LOMOND
Scandia
Alderson
Ralston
Suffield
Rolling Hills
Travers
Enchant
11
VAUXHALL
Retlaw
Hays
Bowell
REDCLIFF
MEDICINE HAT
Dunmore
10
Pashley
IRVINE
Walsh
Royal
Seven Persons
9
Winnifred
Whitla
BOW ISLAND
BURDETT
GRASSY LAKE
Purple Springs
Turin
Iron Springs
Diamond City
Tempest
Cranford
Chin
BARNWELL
TABER
8
Fincastle
Broxburn
COALDALE
LETHBRIDGE
Stewart
Wilson
Maleb
Elkwater
CYPRESS HILLS PROV. PARK
Judson
Wrentham
Conrad
Skiff
Legend
FOREMOST
Nemiskam
Etzikom
Orion
Manyberries
STIRLING
6
Welling
RAYMOND
New Dayton
MAGRATH
McNab
WARNER
MILK RIVER
Bain
Cressday
Onefour
Aden
COUTTS
Del Bonita
McNeill
Hilda
Pivot
Schuler
CANADA HIGHWAY
CROWSNEST HWY.
BUFFALO TRAIL
FOURTH MERIDIAN
SASKATCHEWAN
MONTANA
112°
111°
110°
51°
50°
49°
29
28
27
26
25
24
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21
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1

PLATE No. 1

5. DATA ANALYSIS

5.1 Lethbridge Northern Irrigation District (L.N.I.D.)

The return flow data collected from the L.N.I.D. for the years 1971, 1972, 1979 and 1981 are included in the Appendix as Tables 71-1, 72-1, 79-1, and 81-1. The data was screened for sites having significant flow volumes for most of the four years being considered. The return flows selected as independent variables for the subsequent regression analysis are shown in Table 1. The volumes shown in Table 1 were derived by first assuming each spot-measurement value from Tables 71-1, 72-1, 79-1, and 81-1 as representing a daily mean flow and using that value to generate a monthly flow volume (i.e., according to the particular month during which the spot measurement occurred). In the same manner, the total measured return flows shown in Tables 71-1, 72-1, 79-1, and 81-1 for each period were used to generate the total return flow volumes shown in Table 2, and were used as the dependent variables in the regression analysis. Thus, 24 data sets were derived for the L.N.I.D. analysis.

TABLE 1

SELECTED INDEPENDENT VARIABLES

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

(All Figures in dam^3)

Data sets derived for the years shown / Selected Indep. Variables (Return Flow Stations)	1971						1972						
	1	2	3	4	5	6	1	2	3	4	5	6	7
L-6: Piyami Drain (05AD037)	1042	1623	2480	1424	1403	1396	903	1974	2359	1517	1593	1196	1214
L-13: Battersea Drain (05AD038)	623	2162	1122	1130	2356	1138	887	1028	1744	1631	1198	1541	713
Little Bow River at the Mouth (05AC023)	4464	5937	6162	5551	5397	3787	7289	6136	4809	6090	4680	3472	3466
Little Bow River below Travers Dam (05AC012)	2205	1554	1716	1500	1343	1453	3451	2429	2124	842	789	763	736
L-1	235	40	235	235	477	341	228	308	36	190	387	1	114
L-4	0	19	0	0	0	0	0	0	0	30	0	0	0
L-5	433	57	986	910	827	228	1176	1651	751	106	940	1549	523
L-7	152	547	475	147	903	827	432	352	425	493	114	609	940
L-9	330	410	58	95	21	326	22	1	83	265	144	381	8
C	7	0	121	4	1	2	64	9	9	7	-	18	7
D	81	0	11	42	62	121	114	12	14	65	129	117	74
I	176	0	23	95	117	349	28	22	74	99	-	24	24

Data sets derived for the years shown / Selected Indep. Variables (Return Flow Stations)	1979						1981				
	1	2	3	4	5	6	1	2	3	4	5
L-6: Piyami Drain (05AD037)	1251	1127	733	1327	623	746	1150	1875	1365	1684	1389
L-13: Battersea Drain (05AD038)	1152	620	588	1342	1232	1482	658	1490	1589	1379	1602
Little Bow River at the Mouth (05AC023)	3235	1936	1550	3798	2820	2921	4396	6332	7323	5526	4759
Little Bow River below Travers Dam (05AC012)	998	1309	1457	1267	1033	918	2773	2758	2792	2820	2670
L-1	62	0	64	356	70	351	0	-	201	129	103
L-4	36	27	0	421	52	423	0	179	1157	472	223
L-5	308	276	3	316	23	75	0	153	228	251	197
L-7	270	78	5	37	10	75	21	56	182	176	101
L-9	122	145	3	75	31	5	65	244	212	104	-
C	187	99	13	8	3	11	23	161	13	41	8
D	18	16	19	37	8	56	44	134	78	18	67
I	187	35	3	0	10	62	0	21	3	0	190

TABLE 2

DEPENDENT VARIABLE

TOTAL RETURN FLOW FOR DATA SETS IN TABLE 1

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

(All Figures in dam^3)

Data sets derived for the years shown / Dependent Variable	1971						1972						
	1	2	3	4	5	6	1	2	3	4	5	6	7
Total Return Flow	5537	9567	10248	8326	10516	7457	7867	9422	8595	9940	9037	8357	6661

Data sets derived for the years shown / Dependent Variable	1979						1981				
	1	2	3	4	5	6	1	2	3	4	5
Total Return Flow	7237	3945	1470	7283	3865	5742	3940	9107	9894	7141	6426

TABLE 3

REGRESSION ANALYSIS

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

TRIAL COMBINATIONS				REGRESSION EQUATIONS	MULTIPLE CORRELATION COEFFICIENT	STANDARD ERROR OF ESTIMATE (%)	DATA SETS USED IN ANALYSIS	INDEX STATIONS REQUIRED
1971	1972	1979	1981	$Y=1540.03+1.477X_1+1.436X_3-1.656X_4$	.95	10.5	24	3
1971	1972	1979	1981	$Y=1328.62+1.693X_1+1.160X_3-1.311X_4+1.471X_8$	.91	15.2	24	4
1971	-	1979	1981	$Y=2048.26+1.875X_3-2.065X_4+5.597X_7$	.96	11.8	17	3
-	1972	1979	1981	$Y=455.60+1.270X_1+1.130X_2+1.219X_3-1.332X_4+0.788X_5$	.98	8.3	18	5
	1972	1979	1981	$Y=1203.04+1.732X_1+1.239X_3-1.544X_4+0.915X_5+1.412X_8$	.98	8.2	18	5
-	1972	1979	1981	$Y=1056.22+1.643X_1+1.245X_3-1.624X_4+1.082X_5+6.591X_7+1.700X_8$	.99	5.9	18	6
1971	1972	-	1981	No Significant Equation				
1971	1972	1979	-	$Y=1676.25+1.495X_1+1.370X_3-1.567X_4$	.95	11.2	19	3
-	1972	-	1981	$Y=1389.69+1.576X_1+1.373X_3-1.497X_4$	.93	9.3	12	3
-	1972	-	1981	$Y=918.24+1.538X_1+1.359X_3-1.408X_4+0.667X_5$	.96	8.1	12	4
* -	1972	-	1981	$Y=338.34+0.955X_1+1.308X_2+1.237X_3-1.251X_4+0.830X_5$	.98	5.5	12	5
1971	-	-	1981	No Significant Equation			11	
1971	-	1979	-	No Significant Equation			12	
-	1972	1979	-	$Y=1227.03+1.795X_1+1.347X_3-1.475X_4$	.96	11.6	13	3
-	-	1979	1981	$Y=1285.19+1.703X_3-1.686X_4+6.031X_5$	.98	8.8	11	3
-	-	1979	1981	$Y=662.60+2.779X_1+1.682X_3-2.554X_4$	.99	7.9	11	3
-	-	1979	1981	$Y=784.92+1.780X_1+1.649X_3-2.172X_4+2.962X_5$	.99	7.3	11	4
-	-	1979	1981	$Y=1336.04+1.449X_3-1.589X_4+7.012X_6+14.072X_6$	.99	5.4	11	4
-	-	1979	-	$Y=2821.70+3.954X_1+1.185X_3-4.244X_4$	.99	8.5	6	3

* Recommended Equation

X_1 = L-6 Piyami Drain (05AD037)
X_2 = L-13 Battersea Drain (05AD038)
X_3 = Little Bow River near the Mouth (05AC023)
X_4 = Little Bow River below Travers Dam (05AC012)
X_5 = L-5
X_6 = L-7
X_7 = C
X_8 = L-4

Table 3 shows the trial combinations of data sets used in the regression analysis. The computer program MULCOR (6.2) was first applied and the resulting regression equations were verified using the P9R (6.3) program. The recommended equation

$$\text{(L.N.I.D.) Monthly Return Flow } (dam^3) = 338.34 + 0.955X_1 + 1.308X_2 + 1.237X_3 - 1.251X_4 + 0.830X_5$$

using monthly recorded flows (dam^3) at the following index stations:

X_1 = Piyami Drain near Picture Butte (05AD037)

X_2 = Battersea Drain near the Mouth (05AD038)

X_3 = Little Bow River near the Mouth (05AC023)

X_4 = Little Bow River below Travers Dam (05AC012)

X_5 = Drain L-5 near Diamond City

was chosen from Table 3 based on the following considerations:

(a) Statistical Significance

Multiple Correlation Coefficient = 0.98

Coefficient of Determination = 0.96

Standard Error of Estimate = 5.5%

Student's "t"-test was applied to the regression coefficients of the recommended equation and the computed "t-values" were tested at the 95% confidence level.

Independent Variable	Regression Coefficient	"t"
X_1	.955	2.53
X_2	1.308	3.06
X_3	1.237	9.12
X_4	-1.251	-6.97
X_5	.830	3.47

The minimum acceptable "t-value", at the 95% confidence level, is 2 and is exceeded for each of the regression coefficients.

The constant term (338.34) of the recommended equation is significantly lower than that of any alternate choice of equations. The lower the constant term in a given equation, the more significant is the contribution to the relationship by the variables. In addition, the index stations (variables) in the recommended equation contribute more uniformly to the relationship (as evidenced by their regression coefficients, 0.955, 1.308, 1.237, 1.251, 0.830) than those of any alternate choice.

(b) Physical Significance

The five index stations all have significant flows during the irrigation season and, with the exception of Little Bow River below Travers Dam - 05AC012, are situated within the L.N.I.D. so as to provide a fair areal representation of return flow (i.e., they are not clustered in a relatively small area - See PLATE 2). The flow at Little Bow River near the Mouth - 05AC023 includes the flow at Little Bow River below Travers Dam - 05AC012. The flow at Little Bow River below Travers Dam must therefore be subtracted to obtain return flow in the intervening reaches. In addition, the recommended equation results from the analysis of data from relatively dry (1972) and wet (1981) years. Having five, rather than fewer, index stations should prove advantageous during a future reassessment of the return flow estimates.

(c) Hydrometric

Of the five recommended index stations, four have been in existence for periods ranging from 10 to 27 years and are equipped with recording instruments. Together with the new station recommended for Drain L-5 near Diamond City, all are readily accessible during the irrigation season. Since four of the recommended index stations are presently in use for the determination of return flow there would be a net increase of one station.

Comparison Between Recommended and Previous (1974) Return Flow Equations

Table 4 shows the resulting standard error of estimate in percent when the recommended and previous (1974) regression equations are applied to each of the four years under consideration. It is evident that there is a significant improvement in return flow estimation for the later years, 1979 and 1981.

TABLE 4

COMPARISON BETWEEN RECOMMENDED AND
PREVIOUS (1974) RETURN FLOW EQUATIONS

LETHBRIDGE NORTHERN IRRIGATION DISTRICT

Return Flow Equation \ Year	1971	1972	1979	1981
Standard Error of Estimate in Percent for the Recommended Equation	6.8	5.2	13.9	4.0
Standard Error of Estimate in Percent for the Previous (1974)* Equation	9.1	7.2	49.1	20.7

* 1974 Equation: Return Flow (Ac-Ft.) = 2546.6
+0.841 (Piyami Drain)
-0.800 (Little Bow River below Travers Dam)
+.800 (Little Bow River near the Mouth)
+0.994 (Battersea Drain)

5.2 St. Mary River Irrigation District (S.M.R.I.D.) and Taber Irrigation District (T.I.D.)

Due to their proximity and apparent similarity in irrigation practices, the S.M.R.I.D. and T.I.D. were combined for the present analysis. The return flow data collected from the S.M.R.I.D. for the years 1971, 1972, 1979 and 1981 are included in the Appendix as Tables 71-2, 72-2, 79-2 and 81-2, and similarly, the data for the T.I.D. are included as Tables 71-3, 72-3, 79-3, and 81-3. The return flows selected as independent variables for the regression analysis are shown in Table 5 and were determined, and their monthly flow volumes derived, in the same manner as those for the L.N.I.D. analysis. Similarly, the combined S.M.R.I.D. and T.I.D. total return flows shown in Table 6 were used to generate the total return flow volumes in Table 7 which were used as the dependent variables in the regression analysis. In all, 24 data sets were derived for the analysis.

TABLE 5

SELECTED INDEPENDENT VARIABLES

ST. MARY RIVER IRRIGATION DISTRICT AND TABER IRRIGATION DISTRICT

(All Figures in dam^3)

Data sets derived for the years shown / Selected Indep. Variables (Return Flow Stations)	1971						1972						
	1	2	3	4	5	6	1	2	3	4	5	6	7
Drain S-10 near Bow Island (05AJ003)	213	728	630	279	440	91	0	367	758	621	554	396	99
I - Seven Persons Creek at Medicine Hat (05AH005)	2701	3148	3670	1013	2261	250	3421	4308	3618	2290	1593	1284	1949
S-2 - Lateral 10 Spillway near Chin (05AG007)	132	228	440	316	198	12	379	352	516	0	372	15	15
Drain S-4 near Grassy Lake (05AJ002)	617	478	197	815	213	7	531	213	690	516	455	1130	584
S-5	411	167	1092	286	426	683	0	352	554	68	167	9	485
S-6	4	796	296	110	15	296	4	14	303	364	303	154	137
S-8	286	523	910	499	859	470	326	1020	0	545	683	73	167
S-9	242	11	319	382	125	311	76	213	3	288	258	161	35
S-11	125	212	152	161	206	159	220	440	387	129	281	235	0
76	-	-	-	-	-	-	-	-	-	-	-	-	-
S-17	106	26	41	0	1	311	220	301	83	64	-	0	106
II	1791	1138	2283	1402	1174	1100	713	2099	1016	827	1691	1512	538
Bountiful Coulee near Cranford (05AG008)	1277	2101	1623	1028	903	774	758	2128	1418	1449	1418	228	690
Drain T-2 near Taber (05AG023)	734	827	963	873	756	690	463	404	432	1130	921	286	394
Drain T-11 near Fincastle (05AG025)	382	265	470	477	440	83	0	617	546	258	334	360	281
Bountiful Coulee Inflow near Cranford (05AG026)	1198	1599	131	1285	44	1797	539	1221	737	1055	659	189	190
T-1	369	675	660	418	705	940	-	440	827	1039	842	330	508
T-3	3	114	584	389	807	751	660	719	1274	705	827	220	167
T-8	242	212	190	316	417	34	523	26	311	174	538	132	410
T-9	110	394	1251	352	462	341	0	235	0	15	728	389	349
T-10	272	341	288	308	492	74	0	389	76	61	288	264	159
T-13	250	379	1077	851	492	447	167	499	250	887	561	734	630
58	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE 5
(continued)

SELECTED INDEPENDENT VARIABLES

ST. MARY RIVER IRRIGATION DISTRICT AND TABER IRRIGATION DISTRICT

(All Figures in dam^3)

Data sets derived for the years shown / Selected Indep. Variables (Return Flow Stations)	1979						1981				
	1	2	3	4	5	6	1	2	3	4	5
Drain S-10 near Bow Island (05AJ003)	1835	1637	1387	143	287	371	1390	1277	921	233	760
I - Seven Persons Creek at Medicine Hat (05AH005)	3955	4312	5051	2692	2750	2928	3447	4756	4250	3577	4261
S-2 - Lateral 10 Spillway near Chin (05AG007)	374	579	331	136	461	99	306	206	423	881	410
Drain S-4 near Grassy Lake (05AJ002)	374	601	1069	1095	98	622	610	727	845	610	358
S-5	677	541	600	865	88	589	1820	501	1195	1026	798
S-6	13	313	279	279	5	375	65	554	637	596	573
S-8	270	418	643	463	251	327	415	785	745	814	962
S-9	332	372	0	40	202	442	29	412	249	376	376
S-11	715	147	21	64	194	471	65	0	8	469	441
76	228	399	629	102	3	236	236	812	78	39	337
S-17	474	56	171	29	0	88	109	166	434	363	168
II	482	846	375	1773	884	2108	1278	1243	321	933	-
Bountiful Coulee near Cranford (05AG008)	1434	1708	1716	1214	1275	630	1507	1390	1347	1407	1543
Drain T-2 near Taber (05AG023)	874	658	569	599	737	621	1100	970	1207	857	448
Drain T-11 near Fincastle (05AG025)	398	197	533	451	208	584	597	608	518	537	378
Bountiful Coulee Inflow near Cranford (05AG026)	1174	774	512	581	710	415	764	787	1027	1067	864
T-1	765	0	54	520	529	573	238	704	648	964	371
T-3	441	404	0	595	301	1173	277	621	252	594	137
T-8	430	56	150	828	669	1004	975	129	412	288	573
T-9	643	402	418	544	399	662	181	351	383	482	156
T-10	490	0	557	214	358	346	487	1229	485	531	456
T-13	1024	174	445	1093	964	415	365	720	849	373	1369
58	194	27	276	177	176	228	384	142	230	0	148

TABLE 6

COMBINED TOTAL RETURN FLOW

ST. MARY RIVER IRRIGATION DISTRICT AND TABER IRRIGATION DISTRICT

1971 TOTAL RETURN FLOW (m^3/sec.)					
JUNE	JULY	AUGUST	SEPTEMBER		OCTOBER
17	13	4	1	21	13
4.906	6.197	7.545	5.013	4.810	3.863

1972 TOTAL RETURN FLOW (m^3/sec.)						
MAY	JUNE	JULY	AUGUST		SEPTEMBER	OCTOBER
25	13	11	1	29	26	17
3.506	6.584	5.921	5.560	5.421	4.005	3.107

1979 TOTAL RETURN FLOW (m^3/sec.)					
JUNE	JULY	AUGUST		SEPTEMBER	OCTOBER
13	11	1	29	19	17
7.326	6.175	6.389	5.881	4.897	5.277

1981 TOTAL RETURN FLOW (m^3/sec.)				
JUNE	JULY	AUGUST	SEPTEMBER	
24	22	12	2	23
6.111	7.470	6.535	6.581	6.346

TABLE 7

DEPENDENT VARIABLE
TOTAL RETURN FLOW FOR DATA SETS IN TABLE 6

ST. MARY RIVER IRRIGATION DISTRICT AND TABER IRRIGATION DISTRICT

(All Figures in dam^3)

Data sets derived for the years shown / Dependent Variables	1971						1972						
	1	2	3	4	5	6	1	2	3	4	5	6	7
Total Return Flow	12716	16598	20209	12994	12468	10347	9390	17066	15859	14892	14520	10381	8322

Data sets derived for the years shown / Dependent Variables	1979						1981				
	1	2	3	4	5	6	1	2	3	4	5
Total Return Flow	18989	16539	17112	15752	12693	14134	15840	20008	17503	17058	16449

TABLE 8

REGRESSION ANALYSIS

ST. MARY RIVER IRRIGATION DISTRICT AND TABER IRRIGATION DISTRICT

TRIAL COMBINATIONS				REGRESSION EQUATIONS	MULTIPLE CORRELAT'N COEFF.	STANDARD ERROR OF ESTIMATE (%)	DATA SETS USED IN ANALYSIS	INDEX STNS. REQ'D.
1971	1972	1979	1981	$Y=924.57+1.788X_1+2.515X_3+3.393X_{14}+2.563X_{15}+1.231X_{17}+2.128X_{18}$	0.97	6.4	24	6
1971	-	1979	1981	$Y=3340.62+1.824X_1+4.328X_6+5.739X_{13}+2.452X_{17}$	0.95	6.4	17	4
1971	-	1979	1981	$Y=4253.55+3.871X_2+1.460X_3+6.164X_6+4.381X_{13}+5.576X_{19}$	0.95	6.8	17	5
-	1972	1979	1981	$Y=4668.78+1.988X_4+3.944X_6+5.640X_{12}+2.187X_{13}+7.965X_{17}$	0.98	5.4	18	5
1971	1972	-	1981	$Y=2235.41+0.741X_1+3.396X_2+2.693X_3+1.930X_4+1.643X_8+6.842X_{10}+3.180X_{13}$	0.99	5.1	18	7
1971	1972	-	1981	$Y=4514.46+0.791X_1+2.866X_2+3.139X_3+6.752X_{10}+2.860X_{13}$	0.97	6.6	18	5
1971	1972	1979	-	$Y=3988.36+3.026X_2+3.790X_3+2.394X_{15}+2.316X_{18}$	0.96	6.9	19	4
-	1972	-	1981	$Y=5795.22+2.666X_3+6.113X_6+6.866X_{10}+4.422X_{17}$	0.98	6.1	12	4
1971	-	-	1981	No Significant Equation			11	
1971	-	1979	-	$Y=682.20+1.539X_1+2.087X_4+5.697X_5+6.327X_{13}+1.707X_{17}$	0.99	4.2	12	5
-	1972	1979	-	$Y=1526.30+1.064X_3+3.306X_4+3.806X_5+8.300X_6+4.910X_{11}+4.820X_{17}$	0.99	5.1	13	6
-	1972	1979	-	$Y=13.41+4.311X_4+4.796X_5+8.725X_6+6.619X_{11}+5.365X_{17}$	0.98	6.2	13	5
-	-	1979	1981	$Y=7433.72+2.723X_4+5.746X_{12}+1.157X_{14}+6.583X_{17}$	0.99	2.4	11	4
-	-	1979	-	No Significant Equation			6	

*Recommended Equation

X_1 = I - Seven Persons Creek at Medicine Hat (05AH005)
X_2 = Bountiful Coulee near Cranford (05AG008)
X_3 = Drain S-10 near Bow Island (05AJ003)
X_4 = Drain S-4 near Grassy Lake (05AJ002)
X_5 = Drain T-2 near Taber (05AG023)
X_6 = Drain T-11 near Fincastle (05AG025)

X_8 = T-3
X_{10}= S-9
X_{11}= S-2 - Lateral 10 Spillway near Chin (05AG007)
X_{12}= 76
X_{13}= T-9
X_{14}= T-1
X_{15}= T-13
X_{17}= Bountiful Coulee Inflow near Cranford (05AG026)
X_{18}= II
X_{19}= 58

Table 8 shows the trial combinations of data sets used in the regression analysis. The computer programs previously referred to were applied and the recommended equation

(S.M.R.I.D. + T.I.D.) Monthly Return Flow (dam^3) = 924.57

+ $1.788X_1$ + $2.515X_3$ + $3.393X_{14}$ + $2.563X_{15}$ + $1.231X_{17}$

+ $2.128X_{18}$

using monthly recorded flows (dam^3) at the following index stations:

X_1 = Seven Persons Creek at Medicine Hat (05AH005)

X_3 = Drain S-10 near Bow Island (05AJ003)

X_{14} = T-1

X_{15} = T-13

X_{17} = Bountiful Coulee Inflow near Cranford (05AG026)

X_{18} = II

was chosen from Table 8 based on the following considerations:

(a) Statistical Signficance

Multiple Correlation Coefficient = 0.97

Coefficient of Determination = 0.94

Standard Error of Estimate = 6.4%

Student's "t"-test was applied to the regression coefficients of the recommended equation and the computed "t-values" were tested at the 95% confidence level.

Independent Variable	Regression Coefficient	"t"
X_1	1.788	8.38
X_3	2.515	4.99
X_{14}	3.393	4.33
X_{15}	2.563	3.97
X_{17}	1.231	2.57
X_{18}	2.128	5.89

The minimum acceptable "t-value", at the 95% confidence level, is 2 and is exceeded for each of the regression coefficients.

The relative magnitude of the constant term and the relative contribution of each index station (variable) in the equation to the total result suggests a relationship superior to any reasonable alternate choice from Table 8.

(b) Phyical Significance

The six index stations all have significant flows during the irrigation season and are situated within the S.M.R.I.D. and T.I.D. so as to provide a fair areal representation of return flow. The recommended equation results from the analysis of all available data sets (13 from dry years 1971 and 1972 and 11 from normal years 1979 and 1981). Having six, rather than fewer, index stations should prove advantageous during a future reassessment of the return flow.

(c) Hydrometric

Three of the recommended index stations are presently in existence and have been equipped with recording instruments for 3 to 13

years. Together with the three proposed new stations at T-1, T-13 and II (Ross Creek near Medicine Hat), all are readily accessible during the irrigation season.

While use of the recommended equation would require the establishment of three new recording stations, it is likely that three of the present index stations (i.e., Bountiful Coulee near Cranford - 05AG008, Drain T-2 near Taber - 05AG023, Drain T-11 near Fincastle - 05AG025) would be discontinued and relocated to the new required sites. There would, therefore, be no net increase in the total number of stations.

Revision/Update

Subsequent to the recommendation of the new return flow equation for the S.M.R.I.D. and T.I.D., a final reconnaissance of the proposed new gauging sites revealed that a severe landslide had occurred in the only suitable area for a station on Drain T-13. Consequently, a further regression analysis was performed on data from the following combinations of years:

1971,	1972,	1979,	1981	-	24 data sets
	1972,	1979,	1981	-	18 data sets
1971,		1979,	1981	-	17 data sets
1971,	1972,		1981	-	18 data sets
1971,	1972,	1979		-	19 data sets

By applying the previously mentioned criteria and excluding T-13 from the analysis, a satisfactory result was obtained from using the 18 data sets from 1972, 1979 and 1981:

(S.M.R.I.D. + T.I.D.) Monthly Return Flow (dam^3) = 1554.1

$+ 1.558X_1 + 2.132X_3 + 2.106X_4 + 3.631X_{14} + 3.064X_{17}$

$+ 1.322X_{18}$

using monthly recorded flows (dam^3) at the following index stations:

X_1 = Seven Persons Creek at Medicine Hat (05AH005)

X_3 = Drain S-10 near Bow Island (05AJ003)

X_4 = Drain S-4 near Grassy Lake (05AJ002)

X_{14} = T-1

X_{17} = Bountiful Coulee Inflow near Cranford (05AJ026)

X_{18} = II

The statistical characteristics of the equation are:

Multiple Correlation Coefficient	= 0.97
Coefficient of Determination	= 0.94
Standard Error of Estimate	= 6.9%

Student's "t"-test was applied to the regression coefficients of the recommended equation and the computed "t-values" tested at the 95% confidence level were found significantly different from zero.

The revised equation makes use of one additional existing station (i.e., Drain S-4 near Grassy Lake - 05AJ002) in place of T-13, so that there remains the need to construct only two new stations, T-1 and II.

As before, it is recommended that the stations Bountiful Coulee near Cranford (05AG008), Drain T-2 near Taber (05AG023) and Drain T-11 near Fincastle (05AG025) be discontinued. There would, therefore, be a net decrease of one hydrometric station.

Comparison Between Recommended and Previous (1974) Return Flow Equations

Table 9 shows the resulting standard error of estimate in percent when the recommended and previous (1974) equations are applied to each of the four years under consideration. It is evident that there is a significant improvement in return flow estimation for all years 1971, 1972, 1979, and 1981.

TABLE 9

COMPARISON BETWEEN RECOMMENDED AND PREVIOUS (1974) RETURN FLOW EQUATIONS

ST. MARY RIVER IRRIGATION DISTRICT AND TABER IRRIGATION DISTRICT

Year / Return Flow Equation	1971	1972	1979	1981
Standard Error of Estimate in Percent for the Recommended Equation	4.3	5.3	3.2	3.4
Standard Error of Estimate in Percent for the Previous (1974)* Equation	9.8	5.5	11.2	14.1

* 1974 Equation: Return Flow (Ac-Ft.) = 2467.8+1.252
(Bountiful Coulee near Cranford)
+4.545 (Drain T-2 near Taber)
+6.913 (Drain T-11 near Fincastle)
+3.165 (Drain S-10 near Bow Island)
+0.841 (Seven Persons Creek at Medicine Hat)

5.3 Magrath Irrigation District (M.I.D.) and Raymond Irrigation District (R.I.D.)

The return flow data collected from the M.I.D. for the years 1979 and 1981 is included in the Appendix as Tables 79-4 and 81-4. The only return flow data collected from the R.I.D. was that recorded by Pothole Creek at Russell's Ranch (05AE016) and is included in the Appendix as Tables 72-5, 79-5 and 81-5. As evidenced by field inspections and the data collected, more than 95% of the return flow from the M.I.D. and R.I.D. combined is accounted for by the two recording stations, Dry Coulee near Magrath (05AE041) and Pothole Creek at Russell's Ranch (05AE016). Therefore, it is recommended that, on a monthly basis,

(M.I.D. + R.I.D.) Return Flow (dam^3) = Monthly Recorded Flows at Dry Coulee near Magrath (05AE041) + Pothole Creek at Russell's Ranch (05AE016).

5.4 Mountain View, Leavitt, and Aetna Irrigation Districts

Data collected for the Mountain View Irrigation District for the years 1972, 1979, and 1981 are included in the Appendix as Tables 72-6, 79-6, and 81-6. No usable data could be found for the Leavitt or Aetna districts. Due to the relatively small diversion and consumptive use applicable to these irrigation districts, it would not likely be practical to establish index stations with a view to obtaining a satisfactory regression equation. Additionally, the significant amount of natural runoff in the return flow channels would make such a determination difficult. Consequently, Table 10 was prepared to show the measured return flow as a percentage of the recorded diversion at Mountain View Irrigation District Canal (05AD017).

TABLE 10

CALCULATION OF RETURN FLOW AS A PERCENTAGE OF DIVERSION

MOUNTAIN VIEW IRRIGATION DISTRICT (M.V.I.D.)

(All Figures in m^3/sec)

Irrigation Season	1972						1979						1981				
Return Flow Monitoring Dates	June	July		Sept.		Oct.	June	July		Aug.	Sept.	Oct.	June	July	August		Sept.
	23	18	28	6	22	24	11	9	30	27	17	15	22	20	10	31	21
Total Return Flow for each date from all M.V.I.D. measurement sites shown in Tables 72-6;79-6;81-6.	.448	.542	.139	.221	.175	.344	.122	.057	.015	.143	.100	0	.093	.105	.076	.093	.096
Total Diversion as recorded by Mountain View Irrigation District Canal (05AD017)	.042	2.02	.484	1.36	1.15	.915	.070	3.37	.016	.391	1.58	.033	.088	.619	2.18	1.98	1.70
*Return Flow as a percentage of diversion	>100	26.8	28.7	16.3	15.2	37.6	>100	1.7	93.8	36.6	6.3	0	>100	17.0	3.5	4.7	5.7

*Note that the M.V.I.D. Canal (05AD017) supplies the Leavitt and Aetna irrigation districts as well as the M.V.I.D., and since return flow for the Leavitt and Aetna districts is not accounted for, these figures are lower than actual.

Based on the limited data available and the calculation shown in Table 10, and partly on judgement, it is recommended that Mountain View, Leavitt and Aetna irrigation districts' monthly return flow be determined as a percentage of the respective monthly diversion recorded by the gauge on the Mountain View Irrigation District Canal (05AD017), as follows:

May	June	July	Aug.	Sept.	Oct.
100%	100%	40%	35%	20%	35%

As for the United Irrigation District, the Mountain View, Leavitt and Aetna irrigation districts receive significantly more precipitation and moisture from spring snowmelt than the irrigation districts to the east. As a result, irrigation from diversion tends to begin much later in the season; hence the 100% values shown for May and June.

5.5 United Irrigation District (U.I.D.)

The return flow data collected from the U.I.D. for the years 1979 and 1981 is included in the Appendix as Tables 79-7 and 81-7. The data was treated in a manner similar to that for the L.N.I.D., S.M.R.I.D. and T.I.D., and a "best possible" regression equation was obtained; however, a very high standard error of estimate resulted, likely due to the high proportion of natural flow in the return flow channels, and the equation was rejected. Table 11 was then prepared to show the measured return flow as a percentage of the recorded diversion at U.I.D. Canal near Hill Spring (05AD013).

TABLE 11

CALCULATION OF RETURN FLOW AS A PERCENTAGE OF DIVERSION

UNITED IRRIGATION DISTRICT (U.I.D.)

(All Figures in m^3/sec)

Irrigation Season	1979						1981				
Return Flow Monitoring Dates	June	July		Aug.	Sept.	Oct.	June	July	August		Sept.
	11	9	30	27	17	15	22	20	10	31	21
Total Return Flow for each date from all U.I.D. measurement sites shown in Tables 79-7 and 81-7	.137	.983	1.228	.592	.099	.325	.266	.670	.527	.717	.516
Total Diversion to the U.I.D. (United Irrigation District Canal - near Hill Spring 05AD013)	1.57	3.02	2.94	.335	1.08	1.54	.066	1.74	2.04	1.87	1.89
Return Flow as a percentage of diversion	8.7	32.5	41.8	>100	9.2	21.1	>100	38.5	25.8	38.3	27.3

Based partly on the limited data available and the calculation described in Table 11, and partly on judgement, it is recommended that U.I.D. monthly return flow be determined as a percentage of the respective monthly diversion recorded by the gauge on the U.I.D. Canal near Hill Spring (05AD013), as follows:

May	June	July	Aug.	Sept.	Oct.
100%	100%	35%	30%	25%	20%

The U.I.D. receives significantly more precipitation and moisture from spring snowmelt than irrigation districts to the east. As a result, irrigation from diversion tends to begin much later in the season; hence the 100% values shown for May and June.

6. BIBLIOGRAPHY

6.1 "Natural Flow - Determination of Irrigation Return Flow in Southern Alberta". Technical Report to the PPWB Committee on Hydrology, Environment Canada, March 1974.

6.2 "MULCOR - Multiple Correlations". IBM Scientific Subroutine Package, 1971.

6.3 "P9R - All Possible Subsets Regressions". BMDP Statistical Software, University of California Press, Berkley, Los Angeles, 1981.

A P P E N D I X

TABLE 71-1

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1971 Return Flow Data

STATION	1971 Return Flow (m^3/sec)																
	June				July			August			September					October	
	14	22	23	24	15	16	19	6	9	10	1	3	22	23	24	14	15
I	.068				0				.009			.037	.045			.130	
G	0				0				0			0			0		0
F	0				0				0			.001			.001		.003
E	0				.004				0			0			0		0
D			.031		0				.004			.016			.024		.045
C	.003				0				.045			.001			.001		.007
B	0				0				0			0			0		.003
L-1		.091					.015		.088			.091			.184		.127
L-2			.001		.004					.001		.031			.005		.006
L-3			0		.008					.001		0			.008		.045
L-4			0		.007					0		0			0		0
L-5			.167		.021					.368		.351			.309		.085
L-6: Piyami Drain (05AD037)			.402		.606					.926		.549			.524		.521
L-7			.059		.204					.177		.057			.348		.309
L-8			.015		0					0		0			0		0
L-9			.127		.153					.022		.037			.008		.122
L-10			.008		.024					.043		0			.004		0
L-11			.018		.079					.040		.004			.048		.034
L-12				.009		.004		.007				.009			.013		.003
H	0				0				0			0		0			.003
L			.001*		.001*					.001*		.001*	.001			.001	
M			.001*		.003*					.003*		.003*	.003			.001	
N			.005*		.057*					.057*		.057*	.057			.005	
O			.391*		.926*					.926*		.926*	.926			.391	
P			.002*		.110*					.110*		.110*	.110			.002	
Q			0*		0*					0*		0*	0			0	
R			.001*		0*					0*		0*	0			.001	
S			.007*		.001*					.001*		.001	.001			.007	
T			.013*		.024*					.024*		.024*	.024			.013	
U			.001*		.001*					.001*		.001*	.001			.001	
V			0*		0*					0*		0*	0			0	
W			.001*		.001*					.001*		.001*	.001			.001	
X			.040*		.147					.178	.022		.003			.040	
Y			.323*		.357*			.357			.343		.323			.323	
Z			.085*		.001*			.001			.074		.153			.085	
L-0	.009						0			0	.013				.015		.011
L-13: Battersea Drain (05AD038)			.241		.807			.419				.436			.909		.425
Estimated Additional Flows between L-1 & L-13			.016*		.007*				.016*			.016*			.008*		.034*
TOTAL for the period shown	2.136				3.572			3.826			3.212		4.057			2.784	

*Estimated Values

TABLE 72-1

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1972 Return Flow Data

STATION	1972 Return Flow (m^3/sec.)																
	May				June			July		August					September		October
	25	26	29	30	20	21	22	12	13	2	3	4	30	31	28	29	19	20
I			.010			.009			.028					.037		.009		.009
G		0				0			0		0					0		.003
F		.001				0			.001		0					.006		.006
E		.021				.001			0		0					.004		0
D		.042				.005			.005	.024				.048		.045		.028
C		.024				.003			.004	.003						.007		.003
B		0				.005			.010		0					.003		.004
L-1			.085			.119		.013			.071			.144		0		.042
L-2			0			.048			.025		.010			.008	0			0
L-3			0			.012			0		.008			0	0		.003	
L-4			0			0		0			.011			0		0	0	
L-5			.439			.637			.280		.040			.351	.597		.195	
L-6: Piyami Drain (05AD037)			.337			.762			.881		.566			.595	.462		.453	
L-7				.161		.136			.159		.184			.042	.235		.351	
L-8			0			.001			0		0			0	0		0	
L-9				.008		.001			.031		.099			.054	.147		.003	
L-10				.026		.010			0		0			.003	0		0	
L-11				.003		.034			.021		0			.093	.010		.016	
L-12		.003					.004		.003			.007		.007	.005		.007	
L-13: Battersea Drain (05AD038)	.331						.396		.651			.609	.447		.595		.266	
L-0			0			0		.007			0			0		.045		.026
Estimated Additional Flow between L-0 & L-13		.012*				.022*			.088*			.119*		.062*		.010*		.053*
J		0				0		0		0				.031		0		0
Little Bow River near the Mouth (05AC023)	2.72				2.367			1.795			2.274		1.747		1.339		1.294	
Minus																		
Little Bow River below Travers Dam (05AC012) (see note)	-1.288					-.937		-.793			-.314		-.295		-.295		-.275	
TOTAL for the period Shown	2.935				3.635			3.209		3.711			3.374		3.224		2.487	

*Estimated Values

NOTE: The difference in flows from Little Bow River below Travers Dam to Little Bow River near the Mouth is equivalent to the sum of flows for stations L through Z, shown in Table 71-1.

TABLE 79-1

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1979 Return Flow Data

STATION	1979 Return Flow (m^3/sec.)					
	June	July		Aug.	Sept.	Oct.
	12	10	31	28	18	16
I	0.072	0.013	0.001	0	0.004	0.023
G	0	0	0	0	0	0
F	0	0	0*	0.002	0	0
F-1	0	0	0	0	0	0
E	0	0	0.001*	0.007	0.002	0.060
D	0.007	0.006	0.007	0.014	0.003	0.021
C	0.072	0.037	0.005	0.003	0.001	0.004
B	0	0	0	0.002	0.002	0.001
1	0.077	0.175	0.185	0.252	0.054	0.069
1-A	0.015	0	0	0	0	0*
L-1	0.024	0*	0.024	0.133	0.027	0.131
L-2A	0*	0	0.001	0	0	0
L-2	0.033	0.013	0	0	0	0.001
L-3-1	0.001*	0	0	0.002	0	0.001*
L-3	0.055	0.019	0.001	0	0	0.001
L-3-2	0.001	0	0	0	0	0
L-4-A	0	0.005	0	0	0	0*
L-4	0.014	0.010	0	0.157	0.020	0.158
L-4-B	0	0.104	0.018	0	0	0
L-4-C	0	0	0	0	0	0
L-4-D	0	0	0	0	0	0

TABLE 79-1 (cont'd)

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1979 Return Flow Data

STATION	1979 Return Flow (m^3/sec.)					
	June	July		Aug.	Sept.	Oct.
	12	10	31	28	18	16
L-5	0.119	0.103	0.001	0.118	0.009	0.028
L-5-A	0	0	0	0.001	0	0.001*
L-5-A-1	0	0	0	0.014	0	0
L-5-A-2	0	0	0	0.014	0	0
8-A	0	0	0	0	0.023	0
8	0	0	0	0	0	0
9	0.044	0.028	0	0	0	0
10	0	0	0	0	0	0
10-A	0	0*	0	0	0	0
11	0	0	0	0	0	0
12	0	0	0	0	0	0
L-6: Piyami Drain (05AD037)	0.511	0.441	0.172	0.524	0.216	0.232
15	0	0	0	0	0	0
16	0	0	0	0	0	0
L-7	0.104	0.029	0.002	0.014	0.004	0.028
17	0.014	0	0	0	0	0
17-A	0	0	0	0	0	0
L-8	0.141	0	0	0	0	0
L-8-A	0	0	0	0	0	0
18	0	0	0	0	0	0

TABLE 79-1 (cont'd)

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1979 Return Flow Data

STATION	1979 Return Flow (m^3/sec.)					
	June	July		Aug.	Sept.	Oct.
	12	10	31	28	18	16
18-A	0	0	0	0	0.001	0
20	0	0	0	0	0	0
21	0	0	0	0	0	0
23	0	0	0	0	0	0
L-9	0.047	0.054	0.001	0.028	0.012	0.002
26	0	0	0	0	0	0
28	0.008	0	0	0	0	0
28-1	0	0	0	0	0	0
28-2	0	0	0	0	0	0
29	0	0	0	0	0.001	0
L-10	0.020	0.015	0	0	0.002	0.109
31	0	0	0	0	0	0
32	0	0	0.001	0	0	0
L-11	0.011	0	0	0.002	0.006	0
36	0	0	0	0	0	0
L-12	0.005	0.012	0	0	0.002	0.001
39	0.010	0.001	0	0	0.001	0
40	0	0	0	0	0	0
L-13: Battersea Drain (05AD038)	0.522	0.164	0.094	0.482	0.440	0.523
41	0	0	0	0	0	0

TABLE 79-1 (cont'd)

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1979 Return Flow Data

STATION	1979 Return Flow (m^3/sec.)					
	June	July		Aug.	Sept.	Oct.
	12	10	31	28	18	16
41-A	0	0	0	0.001*	0	0
41-B	0	0.012	0	0.002	0	0.003
Little Bow River near the Mouth (05AC023)	1.25	0.721	0.579	1.42	1.09	1.09
Minus						
Little Bow River Below Travers Dam (05AC012) (See Note)	-0.385	-0.489	-0.544	-0.473	-0.399	-0.343
TOTAL for Period Shown	2.792	1.473	0.549	2.719	1.491	2.144

*Estimated Values

NOTE: The difference in flows from Little Bow River below Travers Dam to Little Bow River near the Mouth is equivalent to the sum of flows for Stations L through Z, shown in Table 71-1.

TABLE 81-1

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec.)				
	June	July	Aug.	September	
	23	21	11	1	22
I	0	0.008	0.001	0	0.071
G	0	0	0	0.001	0
F	0	0	0	0	0
F-1	0	0	0.002	0.003	0.003
E	0	0.070	0.006	0.006	0.005
D	0.017	0.050	0.029	0.007	0.026
C	0.009	0.060	0.005	0.016	0.003
B	0.001	0.029	0.002	0.004	0.001
1	0.061	0.220	0.143	0.005	0.003
1-A	0	0	0	0	0
L-1	0	0	0.075	0.050	0.041
L-2-A	0	0	0	0.001	0
L-2	0	0.011	0.001	0.018	0
L-3-1	0	0.011	0.001	0	0*
L-3	0*	0	0	0	0
L-3-2	0	0	0	0	0
L-4-A	0	0	0	0	0
L-4	0	0.067	0.432	0.182	0.086
L-4-B	0.026	0	0	0	0
L-4-C	0	0	0*	0	0

TABLE 81-1 (cont'd)

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec.)				
	June	July	Aug.	September	
	23	21	11	1	22
L-4-D	0	0	0.014	0	0
L-5	0	0.057	0.085	0.097	0.076
L-5-A	0	0	0	0	0
L-5-A-1	0	0	0	0	0
L-5-A-2	0	0	0	0	0
8-A	0	0	0	0	0
8	0.007	0.031	0.086	0	0.093
9	0	0.008	0.007	0	0
10	0	0	0.014	0	0.002
10-A	0	0	0	0	0
11	0	0	0	0	0
12	0	0	0	0	0
L-6: Piyami Drain (05AD037)	0.435	0.674	0.426	0.613	0.425
15	0	0	0	0	0
16	0	0	0	0	0
L-7	0.008	0.021	0.068	0.068	0.039
17	0	0	0	0	0
17-A	0	0	0	0	0
L-8	0	0	0	0	0

TABLE 81-1 (cont'd)

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec.)				
	June	July	Aug.	September	
	23	21	11	1	22
L-8-A	0	0	0	0	0
18	0	0	0	0	0
18-A	0	0	0	0	0
20	0	0	0	0	0
21	0	0	0	0	0*
23	0	0	0	0	0
L-9	0.025	0.203	0.079	0.040	0
26	0	0	0	0	0
28	0	0	0	0	0
28-1	0	0	0	0	0
28-2	0	0	0	0	0
29	0	0	0	0	0
L-10	0.001	0.002	0.005	0.004	0
31	0	0	0	0	0
32	0	0	0	0	0
L-11	0	0	0	0.011*	0
36	0	0.003	0.001	0*	0
L-12	0.014	0.002	0.001	0.001	0.003
39	0.014	0.002	0.002	0.001*	0.002
40	0	0	0	0	0

TABLE 81-1 (cont'd)

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (L.N.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec.)				
	June	July	Aug.	September	
	23	21	11	1	22
L-13: Battersea Drain (05AD038)	0.265	0.531	0.489	0.595	0.759
41	0	0	0	0	0
41-A	0	0	0.002	0	0
41-B	0.007	0.003	0.002	0.001*	0.003
Little Bow River near the Mouth (05AC023)	1.70	2.36	2.73	2.13	1.84
Minus					
Little Bow River bel. Travers Dam (05AC012) (See Note)	-1.07	-1.03	-1.04	-1.09	-1.03
TOTAL for Period Shown	1.520	3.400	3.694	2.755	2.479

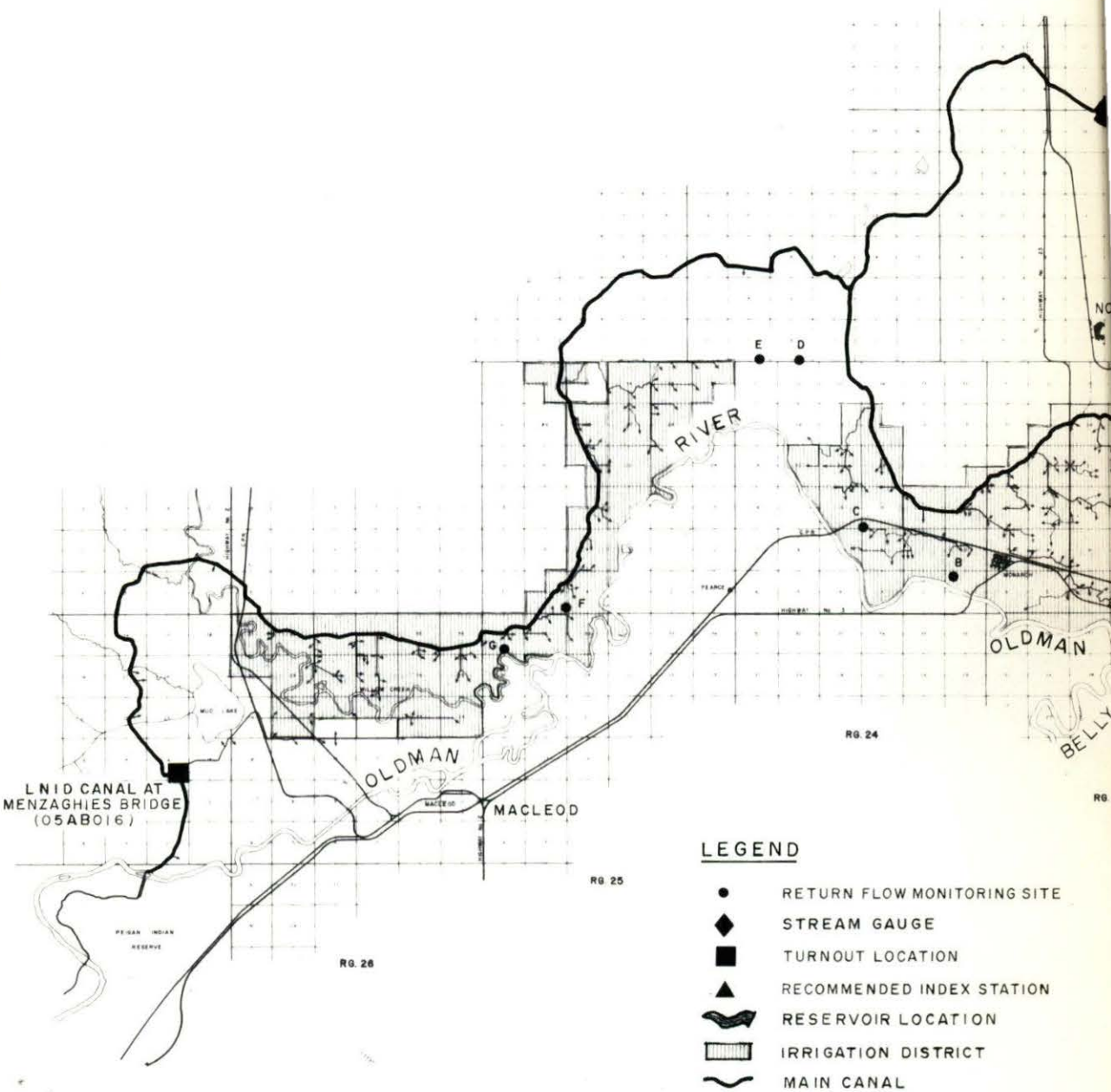
*Estimated Values

NOTE: The difference in flows from Little Bow River below Travers Dam to Little Bow River near the Mouth is equivalent to the sum of flows for Stations L through Z, shown in Table 71-1.

LETHBRIDGE NORTHERI

NOTE

MAP COURTESY OF ALBERTA AGRICULTURE
IRRIGATION DIVISION, LETHBRIDGE, ALTA.



IRRIGATION DISTRICT

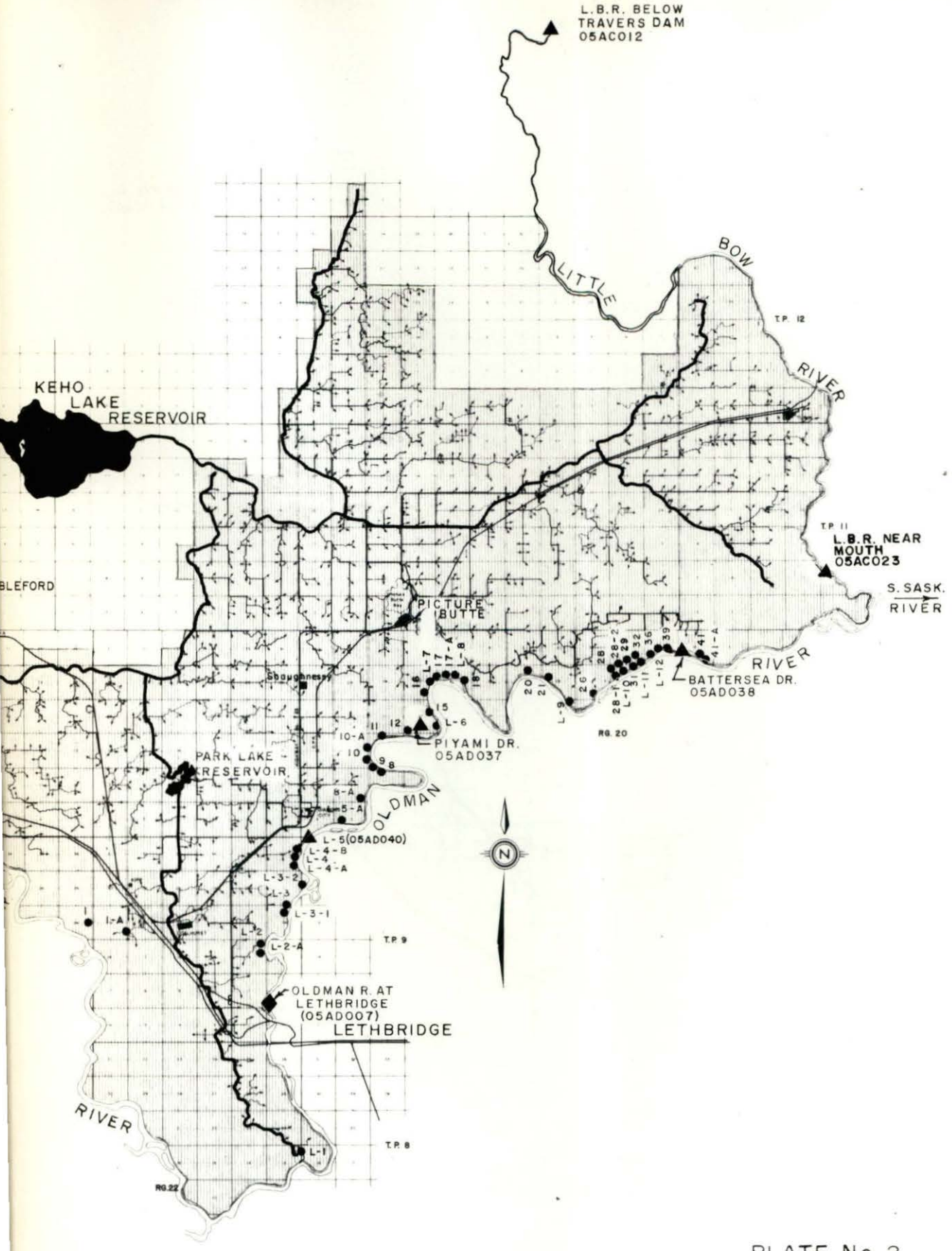


PLATE No. 2

TABLE 71-2

ST. MARY RIVER IRRIGATION DISTRICT (S.M.R.I.D.)

1971 Return Flow Data

STATION	1971 Return Flow (m^3/sec.)					
	JUNE	JULY	AUGUST	SEPTEMBER		OCTOBER
	17	13	4	1	21	13
Six Mile Coulee Spillway near Lethbridge (05AD020)	.300	.283	.317	.198	.159	.193
S-1	.037	0	0	0	0	0
S-2 Lateral-10 Spillway near Chin (05AG007)	.051	.085	.164	.122	.076	.005
S-3	.048	.065	.059	.042	.048	.085
Drain S-4 near Grassy Lake (05AJ002)	.238	.178	.074	.314	.082	.003
S-5	.159	.062	.408	.110	.164	.255
S-6	.001	.297	.110	.042	.006	.110
S-7	.003	.006	.011	.007	.014	.018
S-8	.110	.195	.340	.193	.331	.176
S-9	.093	.004	.119	.147	.049	.116
Drain S-10 near Bow Island (05AJ003)	.082	.272	.235	.108	.170	.034
S-11	.048	.079	.057	.062	.079	.059
S-12	.093	.073	.167	.057	0	0
S-13	.150	.278	.227	.071	.133	.028
S-14	0	.065	.065	.001	0	.028
S-14-A	0	.003	.027	.020	.054	.003
S-15	0	.013	0	.001	.001	0
S-16	0	.009	.006	.034	.003	.005
S-17	.040	.010	.015	0	.001	.116
S-18	.002	.028	.003	.034	.099	.037
I-Seven Persons Creek at Medicine Hat (05AH005)	1.042	1.175	1.416	.391	.872	.093
II	.691	.425	.852	.541	.453	.411
III*	-.328	-.099	-.085	-.074	-.127	-.150
IV*	-.004	-.007	-.002	-.001	-.006	-.003
V*	-0	-0	-0	-0	-.001	-0
Estimated Additional Flow between S-1 & S-18	.002	.001	.025	.031	.001	0
TOTAl for the Period Shown	2.858	3.500	4.610	2.451	2.661	1.622

*III, IV and V are natural flow stations.
Return flow at II = Flow at II - Flow at III - Flow at IV
Return flow at I = Flow at I - Flow at V.

TABLE 72-2

ST. MARY RIVER IRRIGATION DISTRICT (S.M.R.I.D.)

1972 Return Flow Data

STATION	1972 Return Flow (m^3/sec.)						
	MAY	JUNE	JULY	AUGUST		SEPTEMBER	OCTOBER
	25	13	11	1	29	26	17
Six Mile Coulee Spillway near Lethbridge (05AD020)	.011	.295	.207	.360	.210	.031	.057
S-1	.037	0	0	0	0	0	0
S-2: Lateral-10 Spillway near Chin (05AG007)	.142	.136	.193	0	.139	.006	.006
S-3	0	.002	.001	.020	.003	.002	.027
Drain S-4 near Grassy Lake (05AJ002)	.198	.082	.258	.193	.170	.436	.218
S-5	0	.136	.207	.025	.062	.003	.181
S-6	.001	.005	.113	.136	.113	.059	.051
S-7	.006	.012	.023	.009	.019	.009	.006
S-8	.122	.394	0	.204	.255	.028	.062
S-9	.028	.082	.001	.108	.096	.062	.013
Drain S-10 near Bow Island (05AJ003)	0	.142	.283	.232	.207	.153	.037
S-11	.082	.170	.144	.048	.105	.091	0
S-12	.011	.009	0	.040	.016	.021	0
S-13	0	0	.127	.195	0	.110	.062
S-14	0	0	0	0	.051	.007	.009
S-14-A	.034	.110	.054	.136	.096	.623	.001
S-15	.001	0	0	0	0	.015	.003
S-16	.001	0	.004	.006	.012	.003	.003
S-17	.082	.116	.031	.024	0	0	.040
S-18	.034	.099	.004	.074	.007	.144	.008
I - Seven Persons Creek at Medicine Hat (05AH005)	1.277	1.662	1.351	.855	.595	.496	.728
II	.266	.810	.379	.309	.631	.583	.201
III*	-.091	-.513	-.079	-.054	-.059	-.099	-.110
IV*	-.016	-.010	-.004	-.006	-.001	-.012	-.005
V*	-0	-0	-.001	-0	-0	-0	-0
Estimated Additional Flows Between S-1 and S-18	.042	.159	0	.004	.007	.002	.010
TOTAL for the Period Shown	2.268	3.898	3.296	2.918	2.734	2.773	1.608

* III, IV and V are natural flow stations.
Return Flow at II = Flow at II - Flow at III - Flow at IV.
Return Flow at I = Flow at I - Flow at V.

TABLE 79-2

ST. MARY RIVER IRRIGATION DISTRICT (S.M.R.I.D.)

1979 Return Flow Data

STATION	1979 Return Flow (m^3/sec.)					
	JUNE	JULY	AUGUST		SEPTEMBER	OCTOBER
	14	12	2	30	20	18
Six Mile Coulee Spillway near Lethbridge (05AD020)	.297	.401	.312	.213	.059	.056
6, 7, 13, 19, 22, 24, 25	0	0	0	0	0	0
27	0	.001	0	0	0	0
30, 33, 35, 37	0	0	0	0	0	0
S-2 Lateral-10 Spillway near Chin (05AG007)	.144	.216	.124	.051	.179	.037
S-3	0	0	.001	.200	.029	0
Drain S-4 near Grassy Lake (05AJ002)	.144	.224	.399	.409	.037	.232
S-5	.261	.202	.224	.323	.034	.220
S-6	.005	.117	.104	.104	.002	.140
S-7	.101	.010	.013	.005	.008	.017
S-8	.104	.156	.240	.173	.097	.122
71-1	.001	0	0	.002	.001	.001
72	0	0	0	0	0	0
S-9	.128	.139	0	.015	.078	.165
73	0	0	0	0	0	0
Drain S-10 near Bow Island (05AJ003)	.708	.611	.518	.053	.111	.139
S-11	.276	.055	.008	.024	.075	.176
S-12	.026	.096	.039	0	0	.051
S-12-A	.023	0	0	0	0	0
76	.088	.149	.235	.038	.001	.088
76-1	0	0	0	0	0	0
S-13	0	0	.035	0	0	0
S-14	0	0	0	.002	.081	0
S-15-A	0	0	.015	0	.007	0
76-3	0	0	0	0	.005	0
76-4	0	0	0	0	0	0
77	.014	0	.015	.020	.028	0
77-A	0	0	.020	0	0	0
77-B	0	0	.020	0	0	0
78	.006	0	0	0	0	0
79	0	.001	0	0	0	0
S-15	.001	0	.001	.018	0	.001
S-16	0	0	.034	.001	.001	.001
S-17	.183	.021	.064	.011	0	.033
S-18	.037	.109	.002	.002	.147	.065
I-Seven Persons Creek at Medicine Hat (05AH005)	1.53	1.61	1.89	1.01	1.06	1.09
II	.186	.316	.140	.662	.341	.787
III*	-.064	-0	-.073	-.020	-.010	-.644
IV*	-.005	-.010	-.002	-.010	-.007	-.007
V*	-.005	-0	-.005	-.001	-0	-0
TOTAL for the Period Shown	4.189	4.424	4.373	3.305	2.364	2.770

*III, IV, and V are natural flow stations.
Return Flow at II = Flow at II - Flow at III - Flow at IV.
Return Flow at I = Flow at I - Flow at V.

TABLE 81-2

ST. MARY RIVER IRRIGATION DISTRICT (S.M.R.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec.)				
	JUNE	JULY	AUGUST	SEPTEMBER	
	25	22	12	3	24
Six Mile Coulee Spillway near Lethbridge (05AD020)	Discont'd prior to 1981 season				
6	0	.001	0	0	0
7	0	0	0	0	0
13	0	0	.003	0	0
19, 22, 24, 25, 27, 30, 33, 35 37	0	0	0	0	0
S-2: Lateral-10 Spillway near Chin (05AG007)	.118	.077	.158	.340	.158
S-3	.104	.094	.040	.013	.015
Drain S-4 near Grassy Lake (05AJ002)	.235	.271	.315	.235	.138
S-5	.702	.187	.446	.396	.308
S-6	.025	.207	.238	.230	.214
S-7	.006	0	.007	.005	.010
S-8	.160	.293	.278	.314	.371
71-1	.001	0	0	.001	0
72	0	0	0	0	0
S-9	.011	.154	.093	.145	.145
73	0	0	0	0	0
Drain S-10 near Bow Island (05AJ003)	.536	.477	.344	.090	.293
S-11	.025	0	.003	.181	.170
S-12	.076	0	0	.005	0
S-12-A	0	.045	.041	.001	0
76	.091	.303	.029	.015	.130
76-1	0	.001	.001	.007	0
S-13	.025	.042	0	.002	.002
S-14	0	0	0	0	0
S-15-A	0	0	0	0	.001
76-3	0	0	0	0	0
76-4	0	0	0	.001	0
77	.089	.014	.021	.001	.001
77-A	0	0	.014	.075	0
77-B	0	0	0	0	0
78	0	.039	0	0	0
79	.028	.035	0	0	0
S-15	0	0	.001	0	0
S-16	.002	0	0	0	.001
S-17	.042	.062	.162	.140	.065
S-18	.056	0	0	0	0
I - Seven Persons Creek at Medicine Hat (05AH005)	1.33	1.78	1.59	1.38	1.64
II	.493	.464	.120	.360	.419
III*	-.472	-.014	-.020	-.005	-.010
IV*	-.012	-.003	-0	-.002	-.001
V*	-0	-0	-0	-.013	-.003
TOTAL for the Period Shown	3.671	4.529	3.884	3.917	4.067

* III, IV and V are natural flow stations.
Return Flow at II = Flow at II - Flow at III - Flow at IV.
Return Flow at I = Flow at I - Flow at V.

TABLE 71-3

TABER IRRIGATION DISTRICT (T.I.D.)

1971 Return Flow Data

STATION	1971 Return Flow (m^3/sec.)					
	JUNE	JULY	AUGUST	SEPTEMBER		OCTOBER
	17	13	4	1	21	13
Bountiful Coulee near Cranford (05AG008)	.493	.784	.606	.396	.348	.289
Bountiful Coulee Inflow near Cranford (05AG206)	.461	.598	.048	.499	.017	.671
T-1	.142	.252	.246	.161	.272	.351
Drain T-2 near Taber (05AG023)	.283	.309	.360	.337	.292	.258
T-3	.001	.042	.218	.150	.311	.280
T-4	.071	0	.045	.001	.001	.001
T-5	.074	0	.006	0	.006	.003
T-6	.015	.034	.057	.001	0	.006
T-7	0	.079	.068	.040	.028	.001
T-8	.093	.079	.071	.122	.156	.013
T-9	.042	.147	.467	.136	.178	.127
T-10	.105	.127	.108	.119	.019	.028
Drain T-11 near Fincastle (05AG025)	.147	.099	.176	.184	.170	.031
T-12	.021	0	0	0	.127	.015
T-13	.096	.142	.402	.328	.190	.167
Estimated Additional Flow between T-1 and T-13	.004	.005	.057	.088	.034	0
TOTAL for the Period Shown	2.048	2.697	2.935	2.562	2.149	2.241

TABLE 72-3

TABER IRRIGATION DISTRICT (T.I.D.)

1972 Return Flow Data

STATION	1972 Return Flow (m^3/sec.)						
	MAY	JUNE	JULY	AUGUST		SEPTEMBER	OCTOBER
	25	13	11	1	29	26	17
Bountiful Coulee near Cranford (05AG008)	.283	.821	.530	.541	.530	.088	.258
Bountiful Coulee Inflow near Cranford (05AG026)	.201	.470	.274	.393	.246	.073	.070
T-1	0	.170	.309	.388	.314	.127	.190
Drain T-2 near Taber (05AG023)	.173	.156	.161	.422	.348	.110	.147
T-3	.246	.278	.476	.263	.309	.085	.062
T-4	.010	.013	.007	.074	.001	.005	.003
T-5	.001	.010	.004	.004	.001	.003	.003
T-6	.051	0	.019	.010	0	.001	.001
T-7	.016	.037	.042	.017	.007	.008	.012
T-8	.195	.010	.116	.065	.201	.051	.153
T-9	0	.091	0	.006	.272	.150	.130
T-10	0	.150	.028	.023	.108	.102	.059
Drain T-11 near Fincastle (05AG024)	0	.238	.204	.096	.125	.139	.105
T-12	0	.009	0	0	.015	.007	.003
T-13	.062	.193	.093	.331	.201	.283	.235
Estimated Additional Flows Between T-1 and T-13	0	.040	.362	.009	0	0	.068
TOTAL for the Period Shown	1.238	2.686	2.625	2.642	2.687	1.232	1.499

TABLE 79-3

TABER IRRIGATION DISTRICT (T.I.D.)

1979 Return Flow Data

STATION	1979 Return Flow (m^3/sec.)					
	JUNE	JULY	AUGUST		SEPTEMBER	OCTOBER
	13	11	1	29	19	17
Bountiful Coulee near Cranford (05AG008)	.553	.638	.641	.453	.492	.235
Bountiful Coulee Inflow near Cranford (05AG026)	.453	.289	.191	.217	.274	.155
T-1	.295	0	.020	.194	.204	.214
Drain T-2 near Taber (05AG023)	.337	.246	.212	.224	.284	.231
T-3	.170	.151	0	.222	.116	.438
T-4	.025	0	0	0	0	0
T-4-A	0	0	.023	0	0	0
T-5	.001	.005	.001	.006	.001	.001
T-6	.001	.009	0	0	0	0
50	0	0	0	0	0	0
51-A	0	0	0	.021	.008	0
51	0	0	0	0	0	0
T-7	0	0	0	0	0	0
52	0	0	0	0	0	0
T-8	.166	.021	.056	.309	.258	.375
52-2	0	0	0	0	0	0
T-9	.248	.150	.156	.203	.154	.247
T-10	.189	0	.208	.080	.138	.129
55	0	0	0	0	0	0
Drain T-11 near Fincastle (05AG025)	.154	.074	.199	.168	.080	.218
57	0	0	0	.001	.002	.008
58	.075	.010	.103	.066	.068	.085
58-A	0	.021	.012	0	.012	0
58-B	0	0	.007	0	.001	.001
58-C	0	0	0	0	.004	.001
58-D	0	0	0	0	0	0
T-12	.075	0	0	0	0	0
T-13	.395	.065	.166	.408	.372	.155
61	0	0	0	0	0	0
61-A	0	0	.001	0	0	0
62	0	.036	.020	.002	.065	.014
62-A	0	0	0	0	0	0
62-B	0	0	0	0	0	0
62-C	0	.035	0	.002	0	0
63	0	0	0	0	0	0
64	0	0	0	0	0	0
65	0	.001	0	0	0	0
TOTAL for the Period Shown	3.137	1.751	2.016	2.576	2.533	2.507

TABLE 81-3

TABER IRRIGATION DISTRICT (T.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec)				
	JUNE	JULY	AUGUST	SEPTEMBER	
	24	22	12	2	23
Bountiful Coulee near Cranford (05AG008)	.581	.519	.503	.543	.595
Bountiful Coulee Inflow near Cranford (05AG026)	.295	.294	.383	.412	.333
T-1	.092	.263	.242	.372	.143
Drain T-2 near Taber (05AG023)	.424	.362	.451	.331	.173
T-3	.107	.232	.094	.229	.053
T-4	.026	0	.001	0	0
T-4-A	0	0	0	0	0
T-5	.001	.016	.023	.005	.005
T-6	0	.001	0	0	0
50	0	0	0	0	0
51-A	.004	.003	0	0	0
51	0	0	0	0	0
T-7	0	0	0	0	0
52	0	0	0	0	0
T-8	0	0	0	0	0
52-2	0	0	0	0	0
T-9	.070	.131	.143	.186	.060
T-10	.188	.459	.181	.205	.176
55	0	0	0	0	0
Drain T-11 near Fincastle (05AG025)	.230	.227	.193	.207	.146
57	.007	.001	.002	.005	0
58	.148	.053	.086	0	.057
58-A	0	0	0	0	0
58-B	.001	.001	0	.001	0
58-C	.034	.042	.018	0	0
58-D	0	.001	0	0	0
T-12	0	0	0	0	.004
T-13	.141	.269	.317	.144	.528
61	0	0	0	0	0
61-A	0	0	0	0	0
62	.022	0	0	0	0
62-A	0	0	0	0	0
62-B	0	0	0	0	0
62-C	0	0	0	0	0
63	0	0	0	0	0
64	0	0	0	.024	0
65	.069	.067	.014	0	.006
TOTAL for the Period Shown	2.440	2.941	2.651	2.664	2.279

ST. MARY RIVER IRRIGATION DISTRICT - WEST

NOTE

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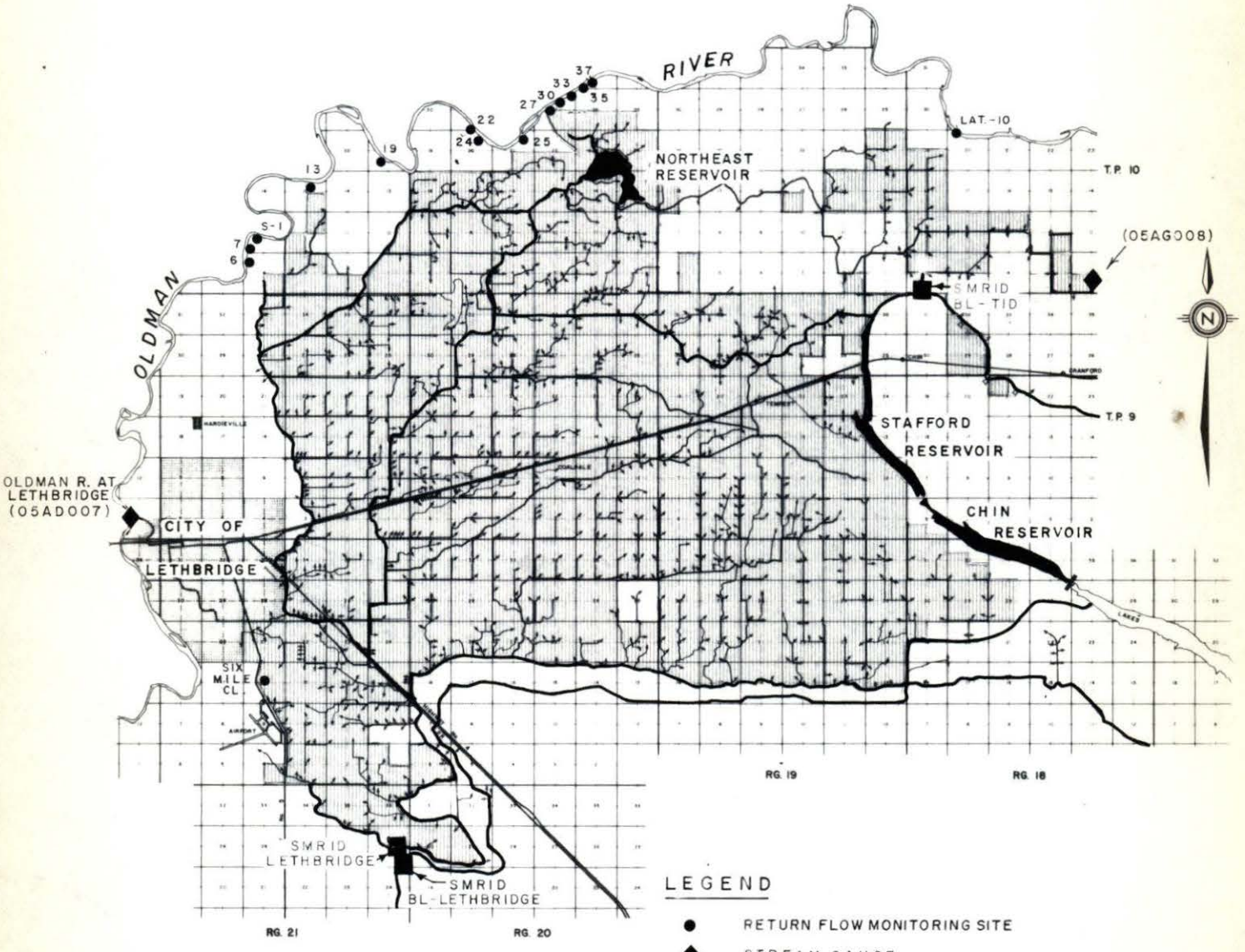

LEGEND

- RETURN FLOW MONITORING SITE
- STREAM GAUGE
- TURNOUT LOCATION
- RECOMMENDED INDEX STATION
- RESERVOIR LOCATION
- IRRIGATION DISTRICT
- MAIN CANAL

PLATE No. 3

TABER IRRIGATION DISTRICT

NOTE

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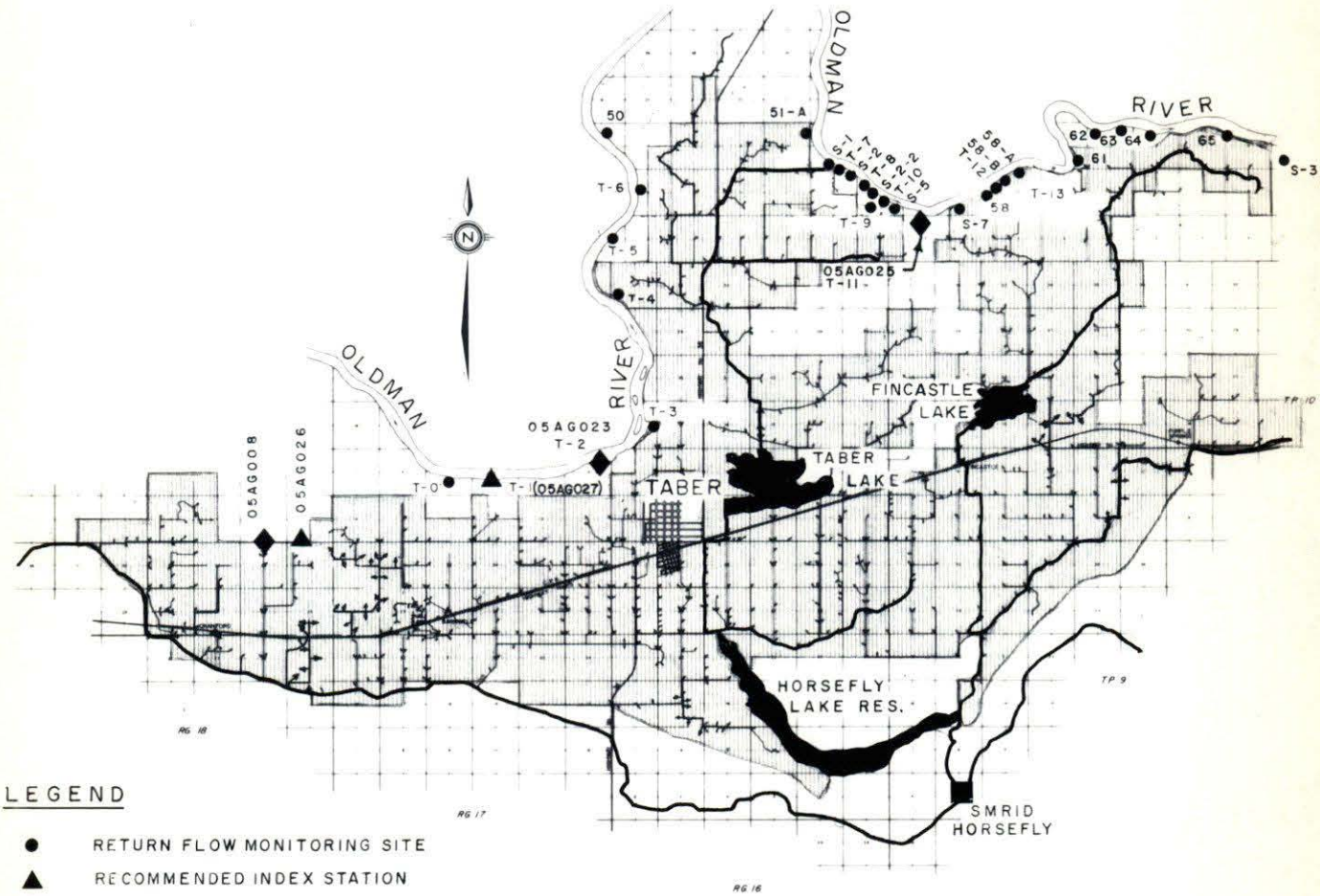

LEGEND

- RETURN FLOW MONITORING SITE
- RECOMMENDED INDEX STATION
- STREAM GAUGE
- TURNOUT LOCATION
- RESERVOIR LOCATION
- IRRIGATION DISTRICT
- MAIN CANAL

PLATE No. 4

TION DISTRICT - CENTRAL

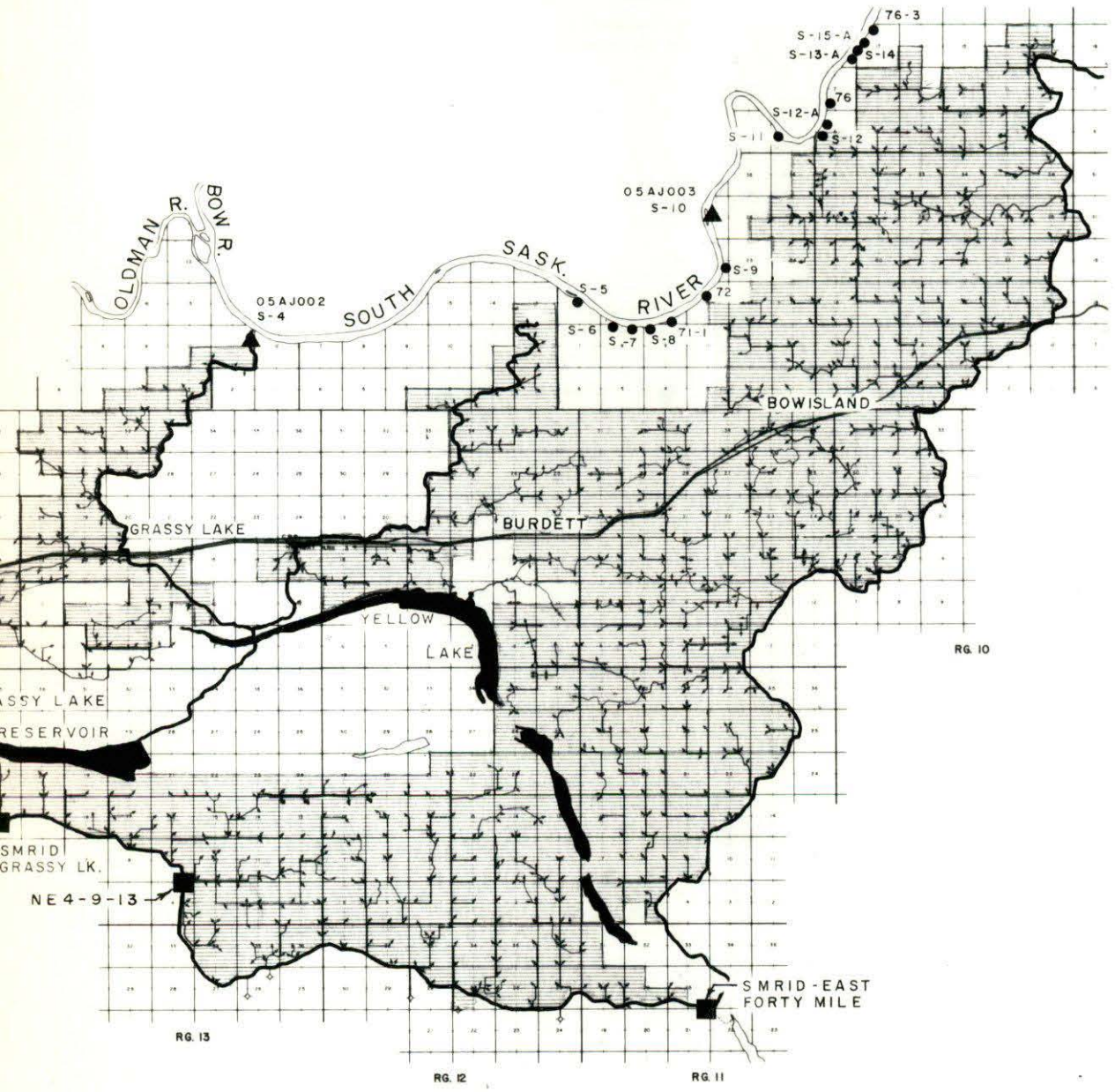

PLATE No. 5

ST. MARY RIVER IRRIGA

NOTE

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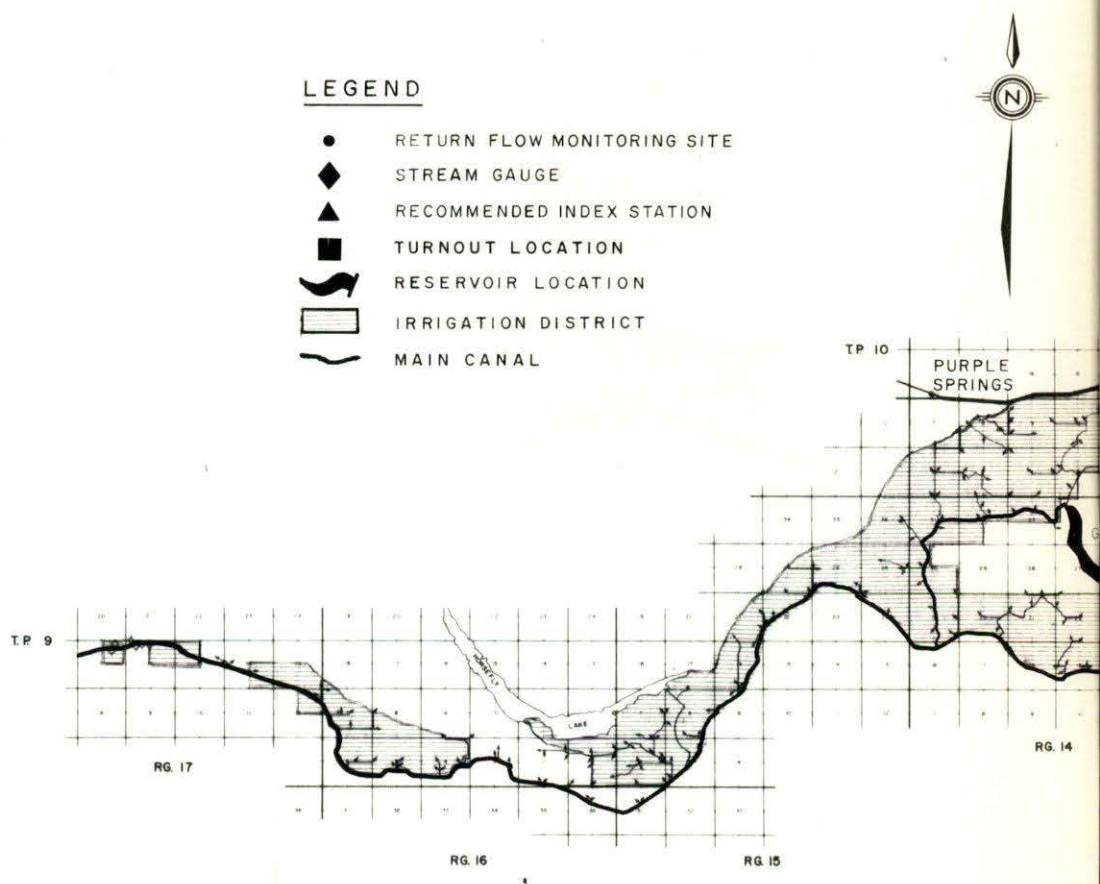

ST. MARY RIVER IRRIGATION DISTRICT - EAST

NOTE

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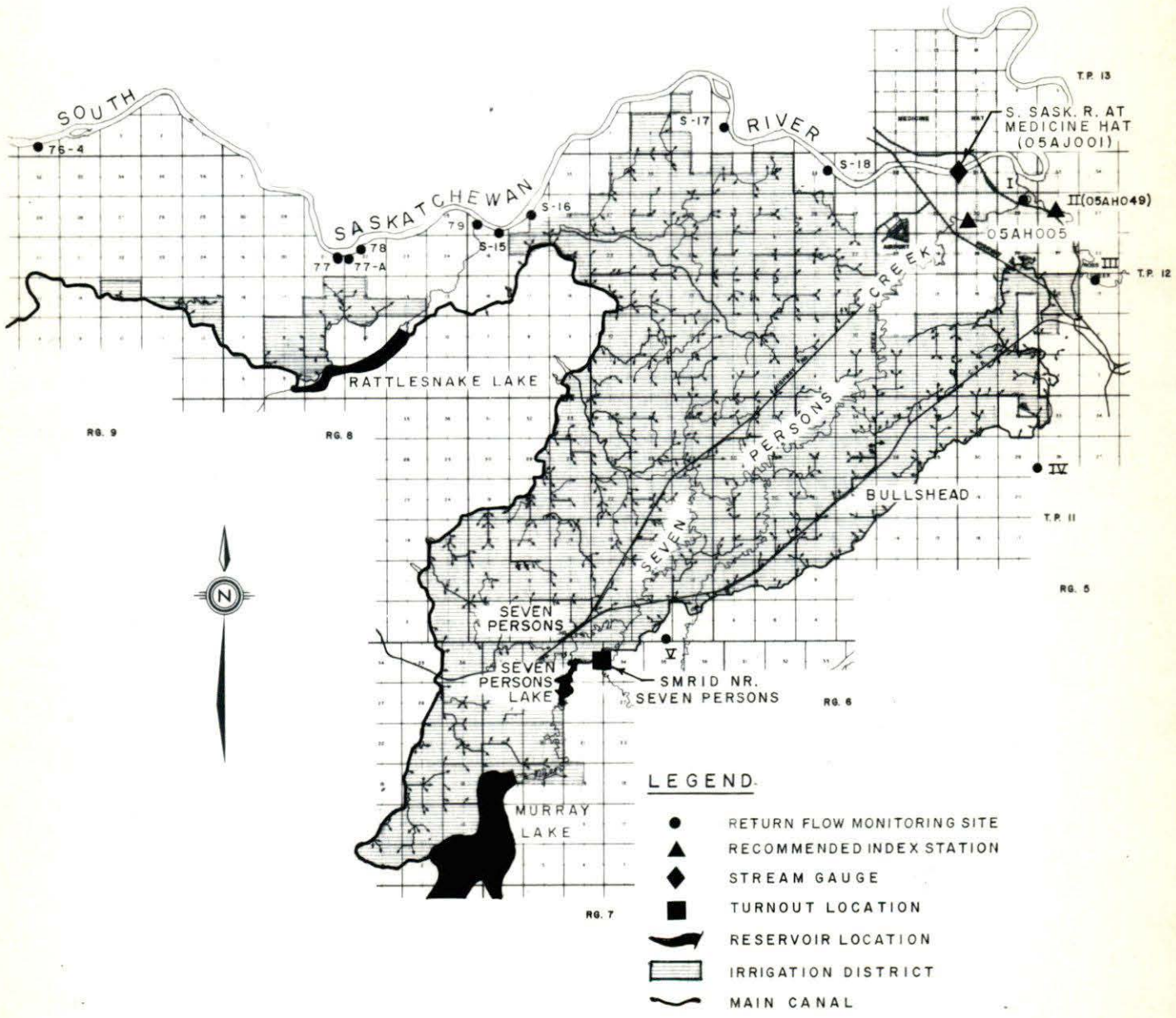


PLATE No. 6

TABLE 79-4

MAGRATH IRRIGATION DISTRICT (M.I.D.)

1979 Return Flow Data

STATION	1979 Return Flow (m^3/sec.)					
	JUNE	JULY		AUGUST	SEPTEMBER	OCTOBER
	11	9	30	27	17	15
MG-1: Dry Coulee near Magrath (05AE041)	.160	.328	.298	.250	.021	.113
MG-2	.001	.005	.003	.002	0	.001
MG-3	.004	0	0	0	0	0

TABLE 81-4

MAGRATH IRRIGATION DISTRICT (M.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec.)				
	JUNE	JULY	AUGUST		SEPTEMBER
	22	20	10	31	21
MG-1: Dry Coulee near Magrath (05AE041)	.400	.427	.133	.133	.216
MG-2	.007	.014	.010	.002	.003
MG-3	0	.003	0	.001	0

TABLE 72-5

RAYMOND IRRIGATION DISTRICT (R.I.D.)

1972 Return Flow Data

STATION	1972 Return Flow (m^3/sec.)						
	MAY	JUNE	JULY		SEPTEMBER		OCTOBER
	31	19	14	28	5	22	23
Pothole Creek at Russell's Ranch (05AE016)	.751	.691	.813	.791	.697	.784	.059

TABLE 79-5

RAYMOND IRRIGATION DISTRICT (R.I.D.)

1979 Return Flow Data

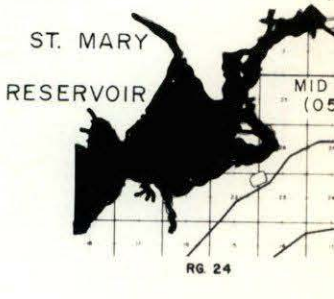
STATION	1979 Return Flow (m^3/sec.)					
	JUNE	JULY		AUGUST	SEPTEMBER	OCTOBER
	11	9	30	27	17	15
Pothole Creek at Russell's Ranch (05AE016)	.496	.207	.169	.291	0	.360

TABLE 81-5

RAYMOND IRRIGATION DISTRICT (R.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec.)				
	JUNE	JULY	AUGUST		SEPTEMBER
	22	20	10	31	21
Pothole Creek at Russell's Ranch (05AE016)	.636	.674	.709	.280	.379


ST. MARY
RESERVOIR
RG. 24

AGRATH AND RAYMOND IRRIGATION DISTRICTS

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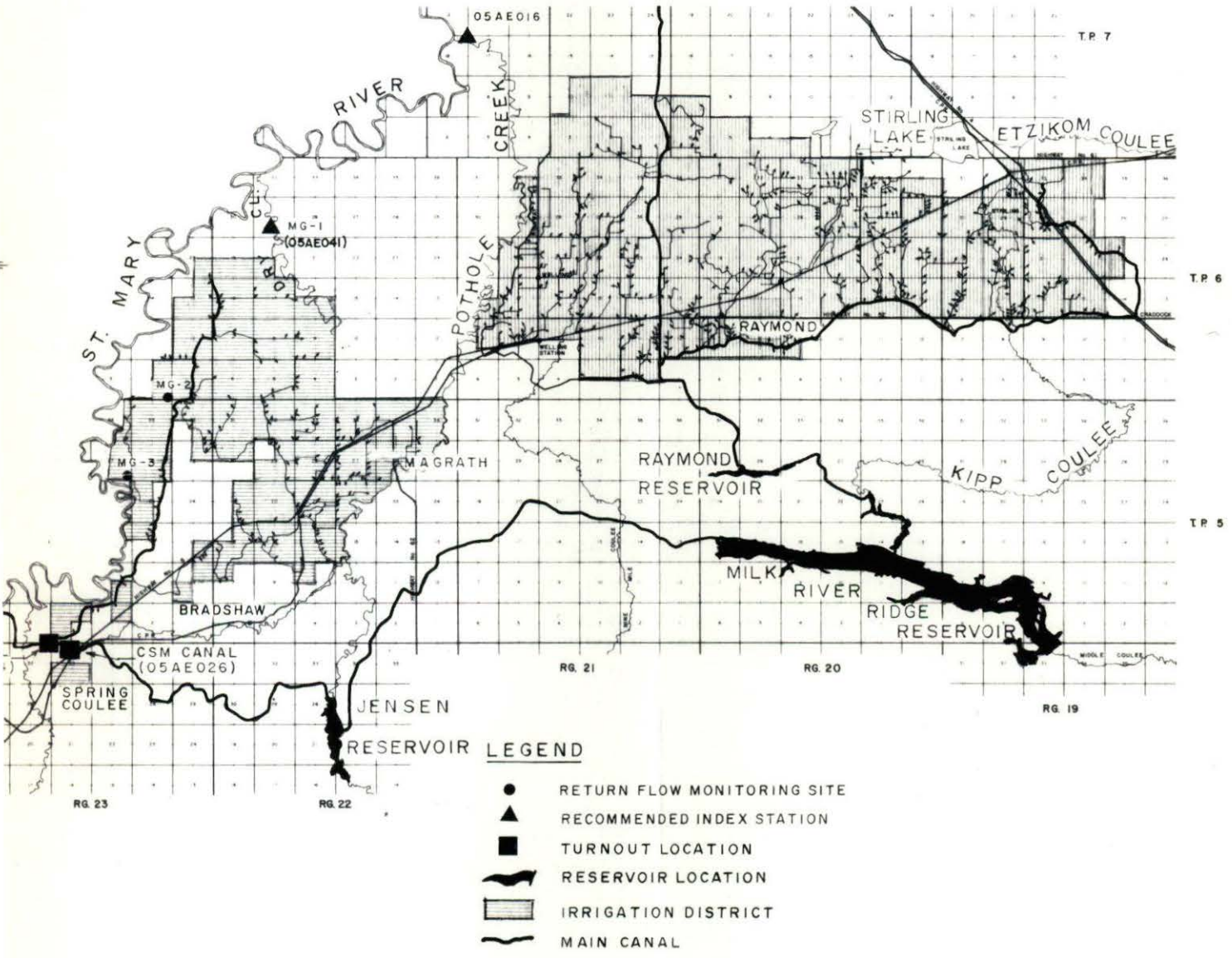

PLATE No. 7

TABLE 72-6

MOUNTAIN VIEW IRRIGATION DISTRICT (M.V.I.D.)

1972 Return Flow Data

STATION	1972 Return Flow (m^3/sec.)					
	JUNE	JULY		SEPTEMBER		OCTOBER
	23	18	28	6	22	24
M-1	.413	.314	.028	.283	.122	.328
M-2	.004	.018	.011	.006	.006	.016
*M-3	.266	.042	.013	.133	.027	.034
M-4	.297	.252	.113	.065	.074	.034

* Natural Flow.
NOTE: M-3 is situated upstream from M-1 on the same channel. Therefore, if the flow at M-3 is larger than that for M-1, the return flow in that channel = 0; otherwise, the return flow = M-1 - M-3.

TABLE 79-6

MOUNTAIN VIEW IRRIGATION DISTRICT (M.V.I.D.)

1979 Return Flow Data

STATION	1979 Return Flow (m^3/sec.)					
	JUNE	JULY		AUGUST	SEPTEMBER	OCTOBER
	11	9	30	27	17	15
M-1	.485	.181	.132	.180	.105	0
M-2	.005	.002	.001	.001	0	0
M-3*	.511	.150	.122	.038	.005	.033
M-4	.117	.024	.004	0	0	0

* Natural Flow.
NOTE: M-3 is situated upstream from M-1 on the same channel. Therefore, if the flow at M-3 is larger than that for M-1, the return flow in that channel = 0; otherwise, the return flow = M-1 - M-3.

TABLE 81-6

MOUNTAIN VIEW IRRIGATION DISTRICT (M.V.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec.)				
	JUNE	JULY	AUGUST		SEPTEMBER
	22	20	10	31	21
M-1	.796	.206	.104	.154	.176
M-2	.007	.004	.001	0	.001
*M-3	.749	.181	.036	.061	.081
M-4	.039	.076	.007	0	0

* Natural Flow
NOTE: M-3 is situated upstream from M-1 on the same channel. Therefore, if the flow at M-3 is larger than that for M-1, the return flow in that channel = 0, otherwise, the return flow = M-1 - M-3.

TABLE 79-7

UNITED IRRIGATION DISTRICT (U.I.D.)

1979 Return Flow Data

STATION	1979 Return Flow (m^3/sec.)					
	JUNE	JULY		AUGUST	SEPTEMBER	OCTOBER
	11	9	30	27	17	15
U-1	.002	.758	.710	.571	.021	.130
U-1-A	0	0	0	0	0	0
*U-2	.086	.102	.324	.011	0	.163
U-2-A	0	0	0	0	0	0
U-2-B	0	0	0	0	0	0
U-2-C	0	0	0	0	0	0
U-3	.004	0	.002	.001	.001	0
U-4	.018	.001	.002	0	0	0
U-4-A	.010	0	.094	0	.002	.032
U-4-B	0	0	0	0	0	0
*U-5	.014	.113	.044	.003	.074	0
U-5-A	0	0	.004	0	0	0
U-5-B	0	0	.004	.004	.001	0
U-6	.003	.009	.044	.002	0	0

* Adjusted for Natural Flow

TABLE 81-7

UNITED IRRIGATION DISTRICT (U.I.D.)

1981 Return Flow Data

STATION	1981 Return Flow (m^3/sec.)				
	JUNE	JULY	AUGUST		SEPTEMBER
	22	20	10	31	21
U-1	.228	.459	.223	.497	.383
U-1-A	.001	.026	.001	0	0
*U-2	0	.063	.187	.137	.053
U-2-A	0	0	.014	.001	0
U-2-B	0	0	.002	.005	.001
U-2-C	0	0	.030	.070	0
U-3	.005	.001	0	0	0
U-4	0	.054	.001	.006	.001
U-4-A	.011	0	.010	0	.008
U-4-B	0	.002	0	0	0
*U-5	0	.048	.043	0	.067
U-5-A	0	.001	0	0	0
U-5-B	.014	.008	.014	0	.002
U-6	.007	.008	.002	.001	.001

* Adjusted for Natural Flow

MOUNTAIN VIEW, LEAVITT, AETNA AND UNITED IRRIGATION DISTRICTS

NOTE

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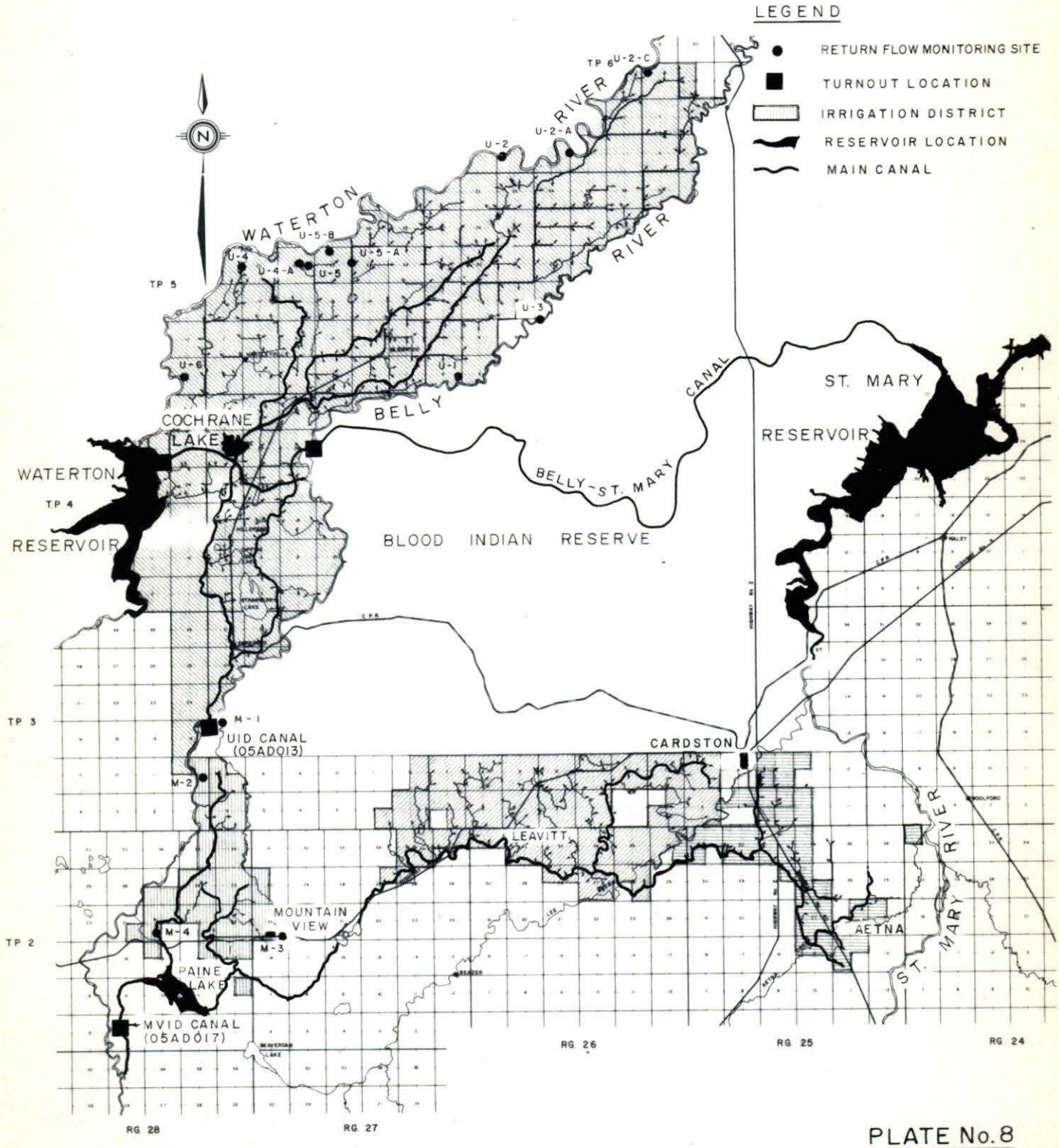

PLATE No. 8