1972 PEACE RIVER FLOOD ATTENUATION BY WILLISTON LAKE

Prepared by: B. A. Broderick
W. Nemanishen

Approved by: R.D. May,
District Engineer

Water Survey of Canada,
Calgary, Alberta.

September 1973

SYNOPSIS

Exceptional heavy rainfall occured in the headwaters of the Peace River basin from June 9 to 13,1972. Historic flood crests were subsequently recorded at many points in unregulated portions of the drainage basin. Severe flooding was caused in the town of Peace River where Water Survey of Canada operates a gauging station. The river crested here at a gauge height of 42.32 feet, which corresponds to a discharge of 550,000 cubic feet per second (cfs). This is the second highest recorded flood crest: the historic 1935 crest has been estimated at 600,000 cfs.

Most of the Peace River flood waters were contributed by the Smoky River which experienced 8.0 inches of rainfall in the headwaters. The main stem Peace River discharges, above the Smoky River confluence, are partly regulated by Williston Lake in British Columbia. This lake has been the subject of considerable study in connection with possible adverse effects on Athabasca Lake levels, yet in 1972, Williston Lake provided some beneficial flood control for the Peace River system.

The US Army Corp of Engineers SSARR Computer Model was used to compute natural discharges along the Peace River for 1972. Flood routing calculations indicate that without the attenuation provided by Williston Lake, a flood crest of 814,000 cfs would have been experienced at the Peace River townsite. This corresponds to a gauge height of approximately 48.0 feet, which is 5.7 feet greater than actually recorded.

TABLE OF CONTENTS

Figures Cont'd.

INTRODUCTION

Originating in the Rocky Mountains of British Columbia, the Peace River discharges, some 700 miles later, into the Slave River at the west end of Lake Athabasca. Until 1967 no man-made structures regulated its discharge. Regulation commenced on December 12,1967, at the W A C Bennett Dam, 11 miles upstream of Hudson Hope, B.C. This dam has created a large man-made reservoir called Williston Lake. Filling operations, particularly in 1968, resulted in low discharges on the Peace River. Several studies (1, 2, 3, 4) have been undertaken to determine downstream affects of W A C Bennett Dam.

Studies by Coulson and Adamcyk (1) suggested that W A C Bennett Dam would benefit downstream areas by reducing flood peaks and increasing winter discharges. The 1972 Peace River flood provides the first occasion to measure peak discharges attenuation by storage in Williston Lake.

Meteorologic conditions contributing to the June 1972 Peace River flood are documented in a report by Warner and Thompson (5).

This report evaluates the flood attenuation provided by Williston Lake. Natural discharges at Peace River town (and elsewhere) were reconstructed using the US Army Corp of Engineers SSARR Model. A complete description of this model is provided in their report Program Description and Users Manual for SSARR Model published September 1972.

All office hydrologic studies and routing procedures employed are described.

RECONSTITUTION

Major tributaries to the Peace River system between the Williston Reservoir and the town of Peace River are shown in Figure 1. The streamflow gauging network operated by Water Survey of Canada (WSC) in this area is also shown on the map. Only gauges close to the mouths of the streams were utilized in order to achieve as much accuracy as possible.

The WSC and SSARR names and station numbers assigned to the stations are given in Table 1. To clarify the comments column, a manual gauge is a staff type gauge read three or four times a week by an observer and a recording gauge is a strip chart recorder giving a continuous record of water levels.

From Table 1, using the stations designated, the Peace River basin was configurated as shown in Figure 2. This configuration arranges the streamflow network into a form the SSARR program can use.

Time lags were calculated from historic recorder chart data. This information was subsequently used to compute some of the hydraulic parameters required in the SSARR program. Final adjustment of all parameters was achieved by using several historic flood crests. The SSARR parameters were adjusted to yield the best peak coincidence with respect to both time of the peak and approaching and receding limbs of the hydrograph comparing the computed and recorded flow values for the particular stations.

The flow data used is the instantaneous flows at 0600, 1200, 1800 and 2400 hours for all the stations in the network. The manual gauges have no records yielding the required four daily flows so the published flow figure is taken as the 1200 hour value and the other values are interpolated over the 24-hour period. This yields a good approximation as long as the mean daily values do not change sharply. Pine River at East Pine is a manual gauge.

Being a large tributary, it contributes a significant discharge to the Peace River itself. Because only one daily stage reading is available from the manual gauge, an error may occur in prorating this value into four readings per day.

To calculate the outflow from Williston Reservoir without the dam, the daily water levels and the area—capacity curve are needed. The resulting outflow hydrograph is given in Figure 3A, the water level plot of the reservoir is in Figure 3B and the portion of the area—capacity curve is reproduced in Figure 3C.

The manner in which the outflow was calculated is oulined stepwise below:

1. Calculate the change in storage on a daily basis using Figures 3B and 3C.

2. Convert this daily stage change (in acre-feet/day) to cfs by dividing by 1.9835 acre-feet/cfs-day.

3. The value from step 2 is delayed 12 hours to approximate a flow time lag from the upper end to the lower end of the reservoir.

4. The daily values are plotted using the value obtained in step 3 as the 12:00 value.

5. The four 6-hourly values of flow at Hudson Hope 0600, 1200, 1800, 2400) are added to the resulting hydrograph of step 4, resulting in a hydrograph depicting the calculated outflow from Williston Reservoir if the W.A.C. Bennett Dam had not been present.

6. Pick off the instantaneous flows at 0600, 1200, 1800 and 2400 hours and use these as input data for the SSARR program.

The comparison of recorded flow at Hudson Hope and the much larger outflow from the reservoir with no dam can be seen in Figure 4.

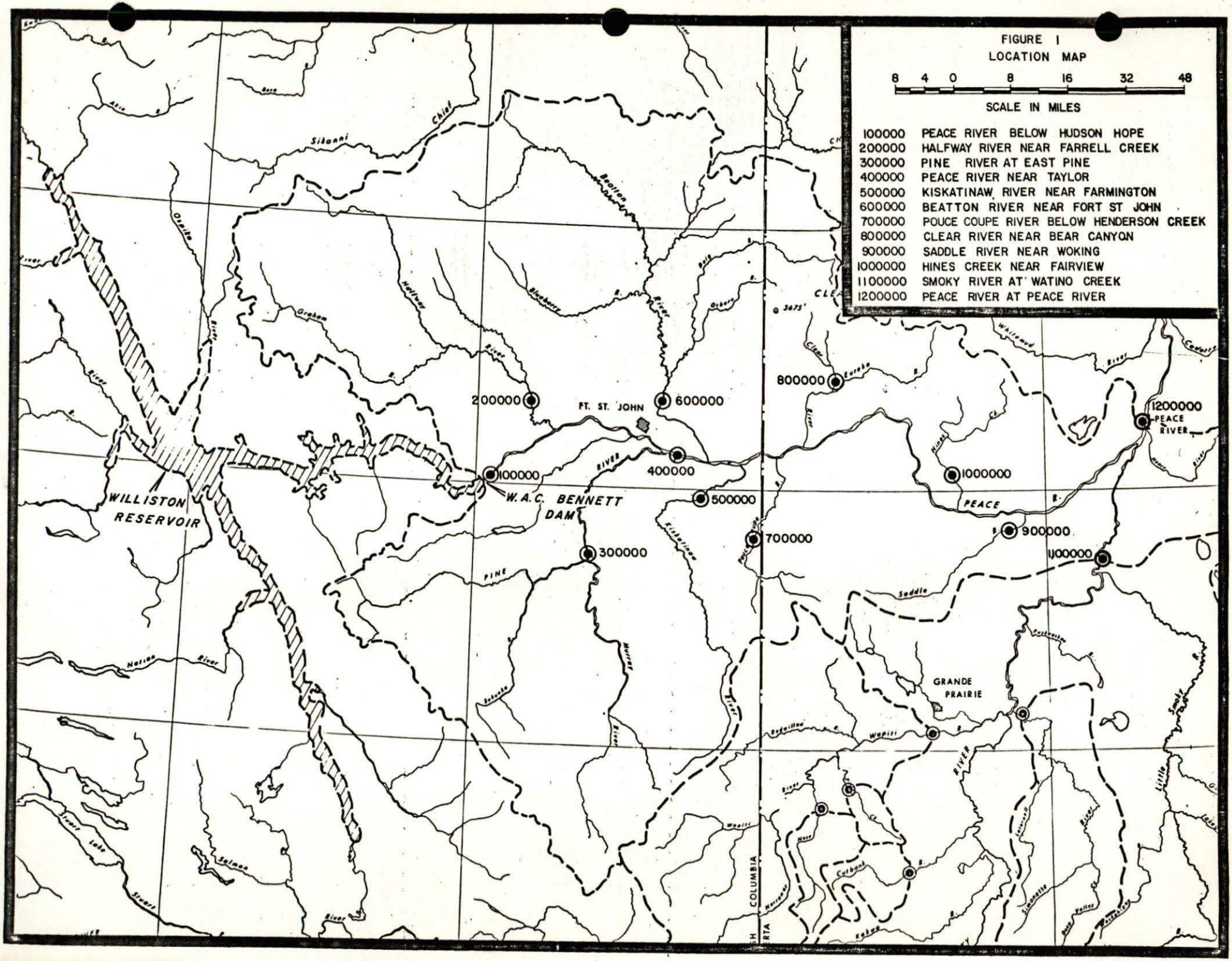
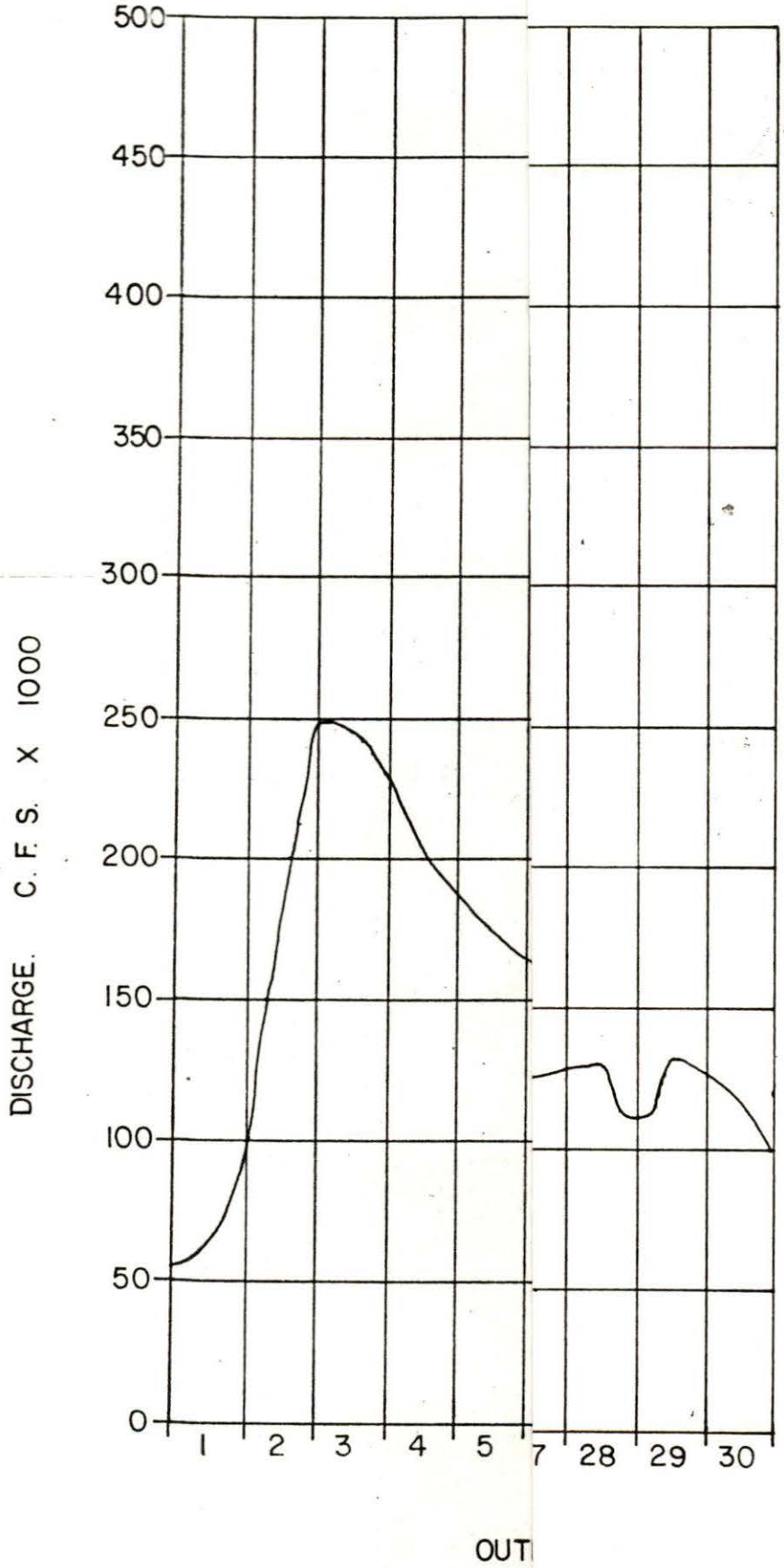
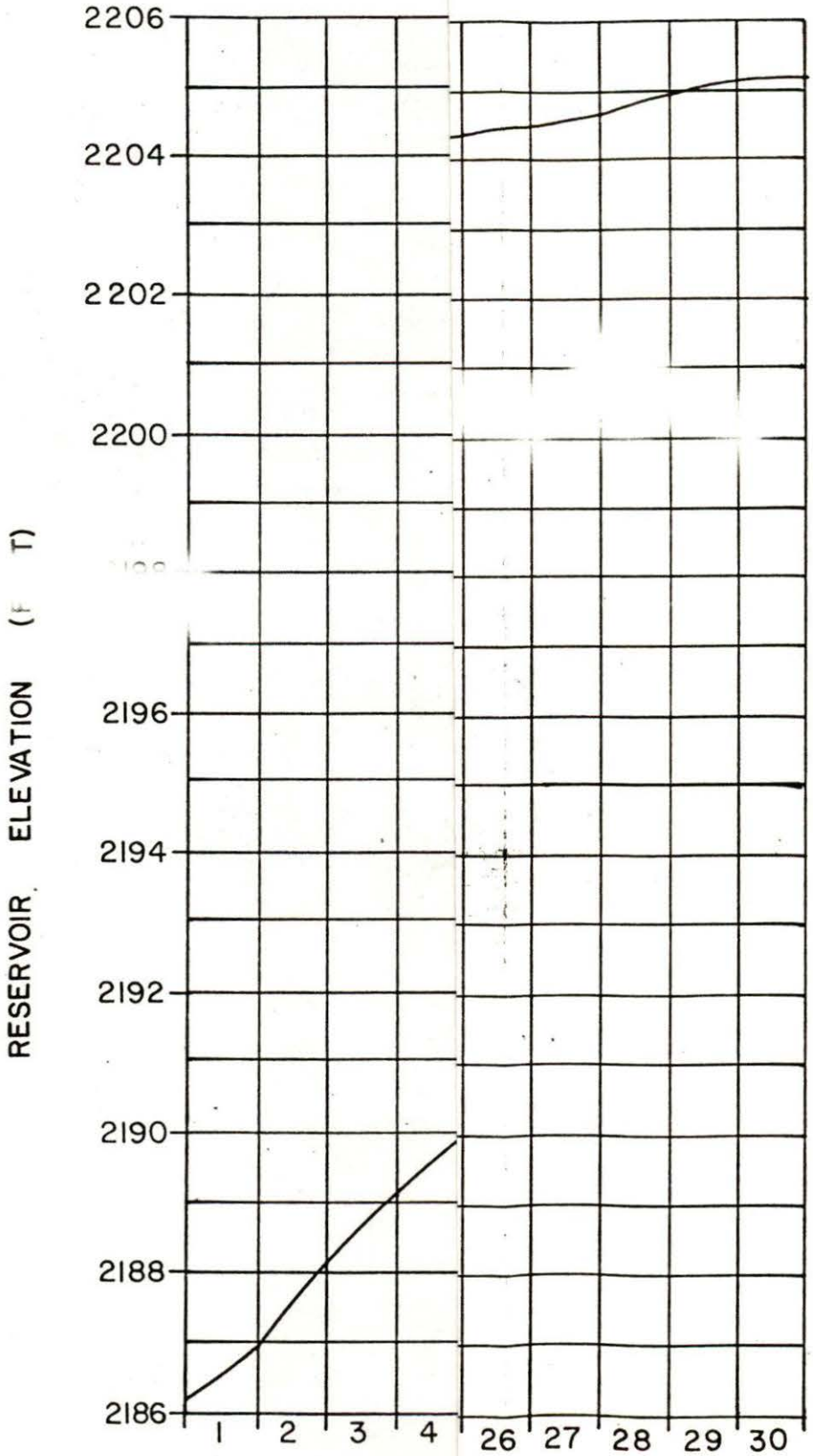


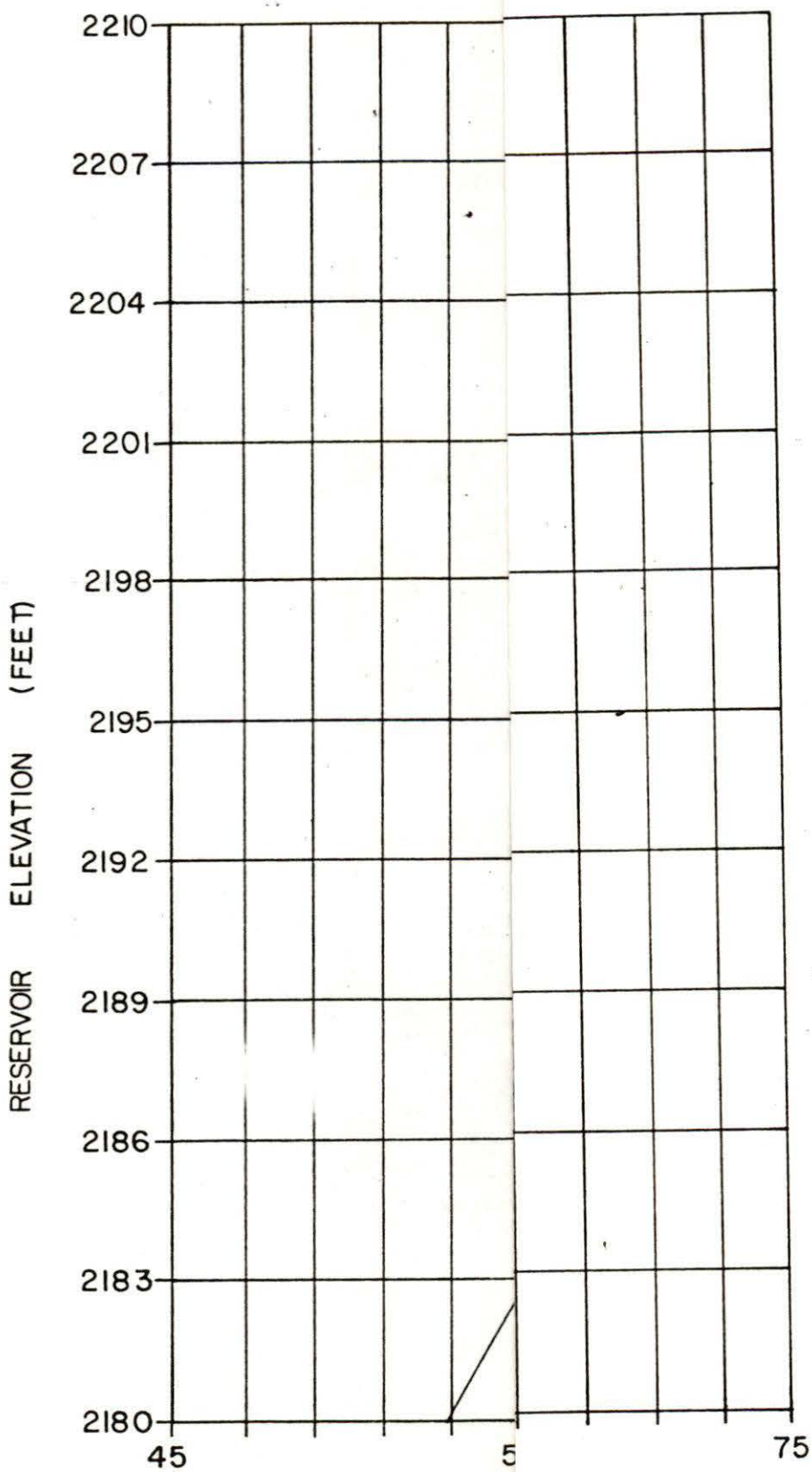
FIGURE I
LOCATION MAP
8 4 0 8 16 32 48
SCALE IN MILES
100000 PEACE RIVER BELOW HUDSON HOPE
200000 HALFWAY RIVER NEAR FARRELL CREEK
300000 PINE RIVER AT EAST PINE
400000 PEACE RIVER NEAR TAYLOR
500000 KISKATINAW RIVER NEAR FARMINGTON
600000 BEATTON RIVER NEAR FORT ST JOHN
700000 POUCE COUPE RIVER BELOW HENDERSON CREEK
800000 CLEAR RIVER NEAR BEAR CANYON
900000 SADDLE RIVER NEAR WOKING
1000000 HINES CREEK NEAR FAIRVIEW
1100000 SMOKY RIVER AT WATINO CREEK
1200000 PEACE RIVER AT PEACE RIVER
WILLISTON RESERVOIR
W.A.C. BENNETT DAM
FT. ST. JOHN
GRANDE PRAIRIE
PEACE RIVER
PINE RIVER
COLUMBIA

TABLE 1

Gauging Station Location	WSC Number	SSARR Number	COMMENTS
Inflow to Williston Reservoir	-	50 000	Calculated from reservoir levels & area-capacity curve.
Peace River at Hudson Hope	07EF001	100 000	Manual gauge in 1965, recorder gauge in 1971, '72.
Halfway River near Farrell Creek	07FA001	200 000	Recorder gauge in 1965, '71, '72.
Pine River at East Pine	07FB001	300 000	Manual gauge in 1965, '71, '72.
Peace River at Taylor	07FD002	400 000	Recorder gauge in 1965, '71, '72.
Kiskatinaw River near Farmington	07FD001	500 000	No gauge in 1965, recorder gauge in '71, '72.
Beatton River near Ft. St. John	07FC001	600 000	Manual gauge in 1965, recorder gauge in 1971, '72.
Pouce Coupe River below Henderson Creek	07FD007	700 000	No gauge in 1965, manual gauge in '71, '72.
Clear River near Bear Canyon	07FD009	800 000	No gauge in 1965, '71. Recorder gauge in '72.
Saddle River near Woking	07FD006	900 000	No gauge in '65, recorder gauge in '71, '72.
Hines Creek near Fairview	07FD008	1000 000	No gauge in 1965, recorder gauge in '71, '72.
Smoky River at Watino	07GJ001	1100 000	Recorder gauge in 1965, '71, '72.
Peace River at Peace River	07HA001	1200 000	Recorder gauge in 1965, '71, '72.


500
450
400
350
300
250
200
150
100
50
0
DISCHARGE. C. F. S. X 1000
1
2
3
4
5
7
28
29
30
OUT


RESERVOIR ELEVATION (F T)
2206
2204
2202
2200
2196
2194
2192
2190
2188
2186
1
2
3
4
26
27
28
29
30


RESERVOIR ELEVATION (FEET)
2210
2207
2204
2201
2198
2195
2192
2189
2186
2183
2180
45
5
75

E

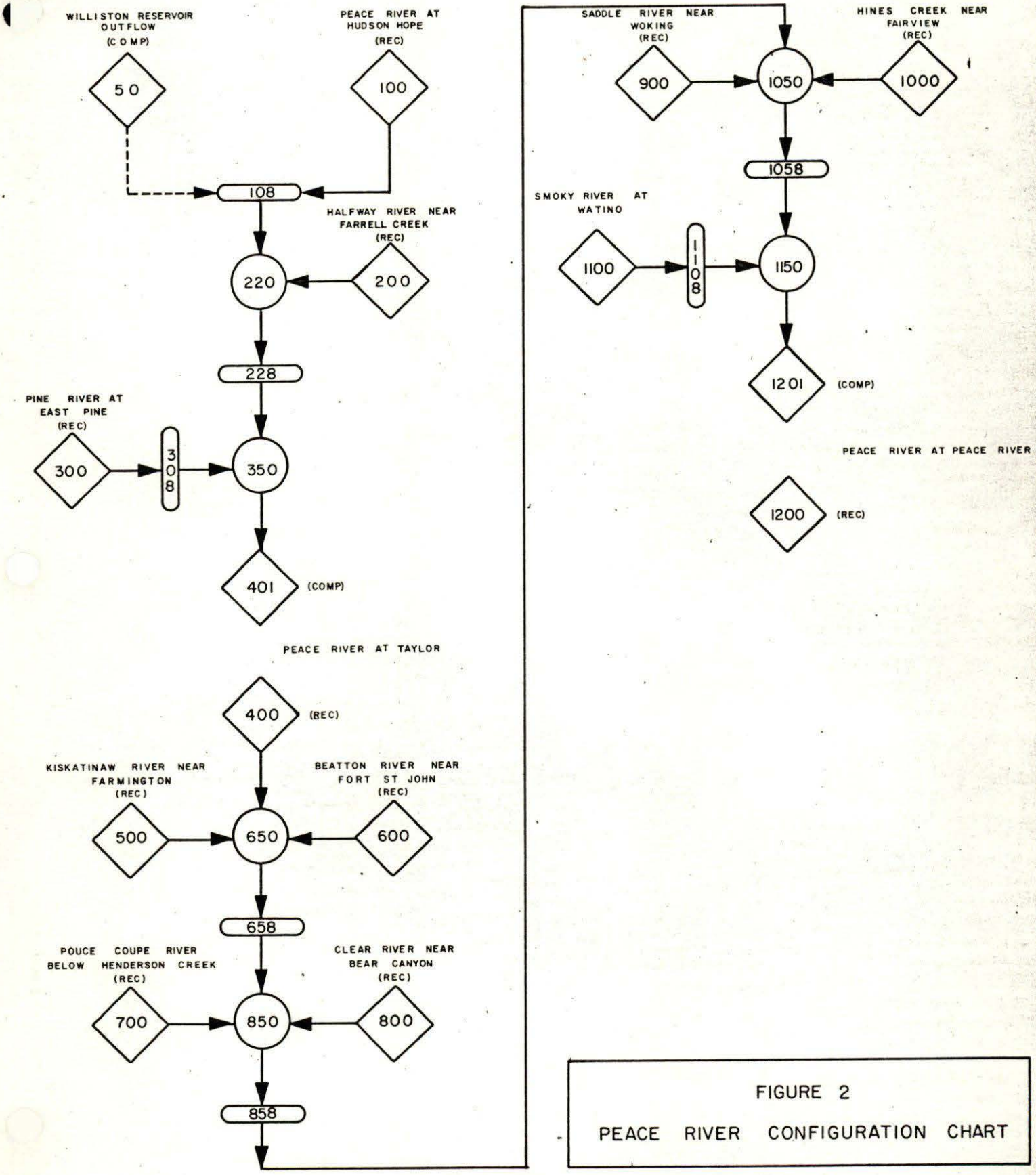


FIGURE 2

PEACE RIVER CONFIGURATION CHART

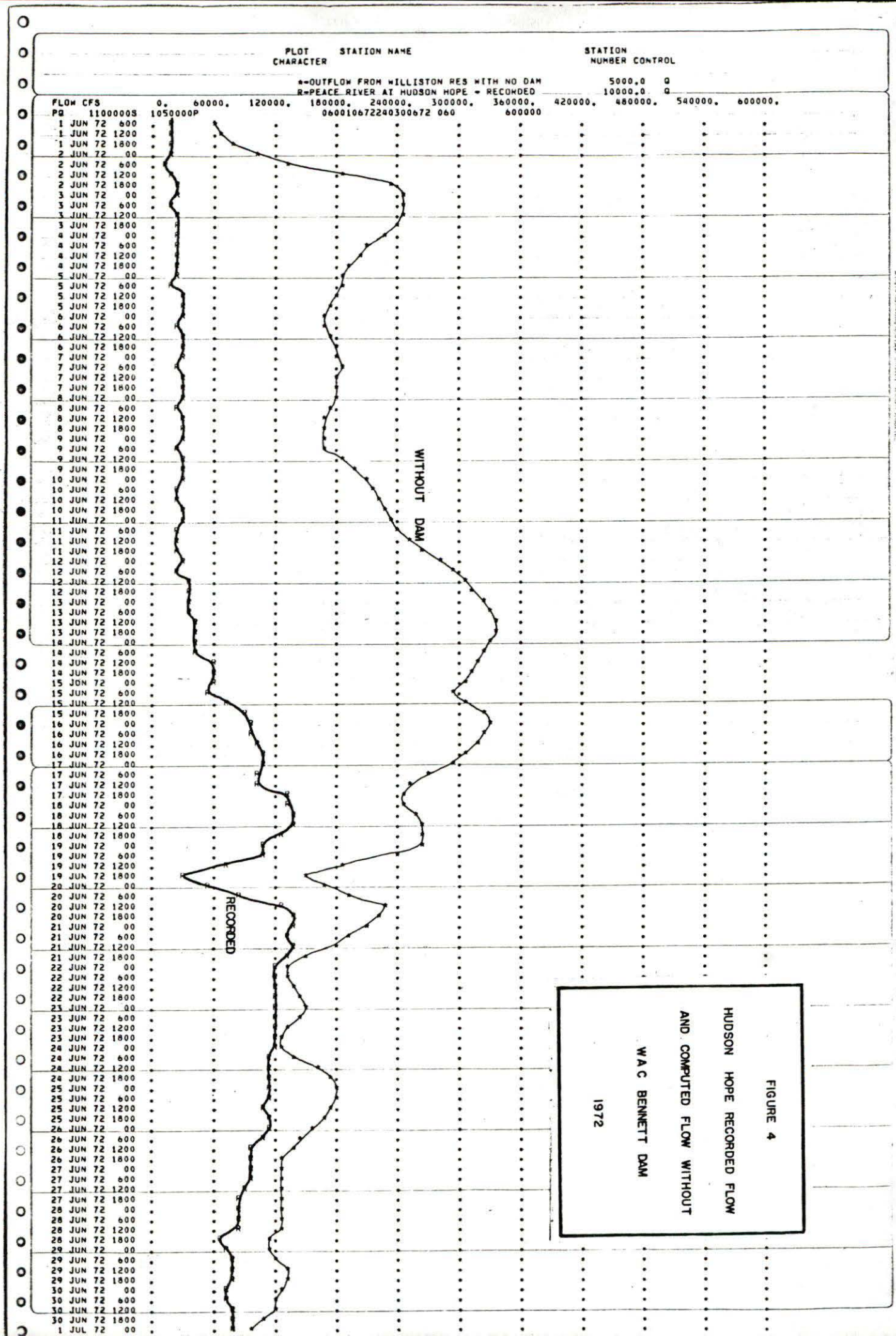


FIGURE 4

HUDSON HOPE RECORDED FLOW AND COMPUTED FLOW WITHOUT W A C BENNETT DAM 1972

Results and Discussion of Reconstitution

As can be seen in Figures 5, 7 and 9, the computed flow (C) for the Peace River at Taylor underestimates the recorded flow (R) at the peaks. This is caused by the gauging stations Pine River at East Pine and Peace River at Hudson Hope being manual gauges. Being manual gauges, the exact times and magnitudes of the peaks are not known so the time of the peak can be up to 24 hours out and the peak is underestimated. The first peak (1965) is over estimated and this is thought to be caused by inaccurate records for the Peace River at Taylor. In 1971 the recorder at Hudson Hope was in operation and fluctuated greatly due to the dam releases, hence some error here. The first ten computed points in all hydrographs are incorrect as the program is stabilizing, but from that point on the values are accurate.

Figure 6 shows the computed and recorded flows in 1965 for the Peace River at Peace River. In 1965, five gauging stations between Taylor and Peace River were not in operation. They are Kiskatinaw River near Farmington, Pouce Coupe River below Henderson Creek, Clear River near Bear Canyon, Saddle River near Woking and Hines Creek near Fairview. The Kiskatinaw River flow is significant so without it, the computed value is low. Also, the poor peak coincidence is due to lack of all the necessary flows.

The 1971 flows for Peace River at Peace River (Figure 8) show excellent peak coincidence with respect to time and magnitude. Here all stations except Clear River near Bear Canyon were in operation and this station is a small contributor so in effect all stations are present. The 1972 hydrographs in Figures 9 and 10 also show excellent results in the very high flow period of June, 1972.

Since the calculated outflow from the Williston Reservoir will be routed thru Taylor directly to Peace River rather than to Taylor and then the recorded flow at Taylor routed downstream, a run was made routing past Taylor with the 1972 recorded flow at Hudson Hope to illustrate the reliability of doing such. This was done for Figure 11.

From Figure 12 it is apparent that without the Bennett Dam the flow on the Peace River would have been extreme and combined with both the very large flow in the Smoky River and peaks simultaneously occuring, the resulting flood crest at Peace River would have been nearly six feet higher than the recorded peak.

Water Survey of Canada's records show the peak in Peace River occured at 16:00 MDT on June 14 at a gauge height of 42.32 feet (550,000 cfs). This study shows if Bennett Dam had not been there, that at 12:00 MDT on June 14, a peak discharge of ~~795~~ 814,000 cfs would have occured. This corresponds to a WSC gauge height of ~~47.85~~ 48.27 feet. From studies of maps along the Peace River between Hudson Hope and Peace River town, it became apparent that very little overbank flow could have taken place since the river channel is so well defined by steep banks on both sides. The hydrograph which illustrates the recorded flow at Peace River and the flow at Peace River without the dam can be found in Figure 13, and the corresponding plot of gauge heights can be found in Figure 14.

As a further step in the study, it was desired to route the flow without the dam past Peace River to Peace Point. During reconstitution an interesting development occured. In going from Peace River to Fort Vermilion (a distance of approximately 200 miles) water at high stage is lost. Over a certain flow (approximately 300,000 cfs at Peace River) overbank type flow occurs but the water does not appear to reach Fort Vermilion. Extensive office studies were done and either the curves are erroneous at high flows for Peace River and/or Fort Vermilion, or the overbank flow goes into non-returning storage. Figures 15, 16 and 17 shows the best fit obtained in routing from Peace River to Fort Vermilion for 1965, 1971 and 1972 respectively. Only in high flow periods does a large discrepancy occur. In Figures 18, 19 and 20 the so-called "overbank" flow is taken out and not returned to the river. This overbank flow is found from Figure 21 which was

done by trial and error. It can be seen that a much better fit occurs leading one to suspect the lost water hypothesis is correct. In routing up to Peace River and from Fort Vermilion to Peace Point (see Figures 22 to 24), excellent results are obtained in comparing the recorded and SSARR computed flow values. This would indicate the discharge records at Fort Vermilion are good.

In the event of another major flow above 300,000 cfs at Peace River, aerial reconnaissance of the Peace River system between Peace River and Fort Vermilion should be done in order to actually see if overbank flow is in fact diverting and not returning to the river after the crest.

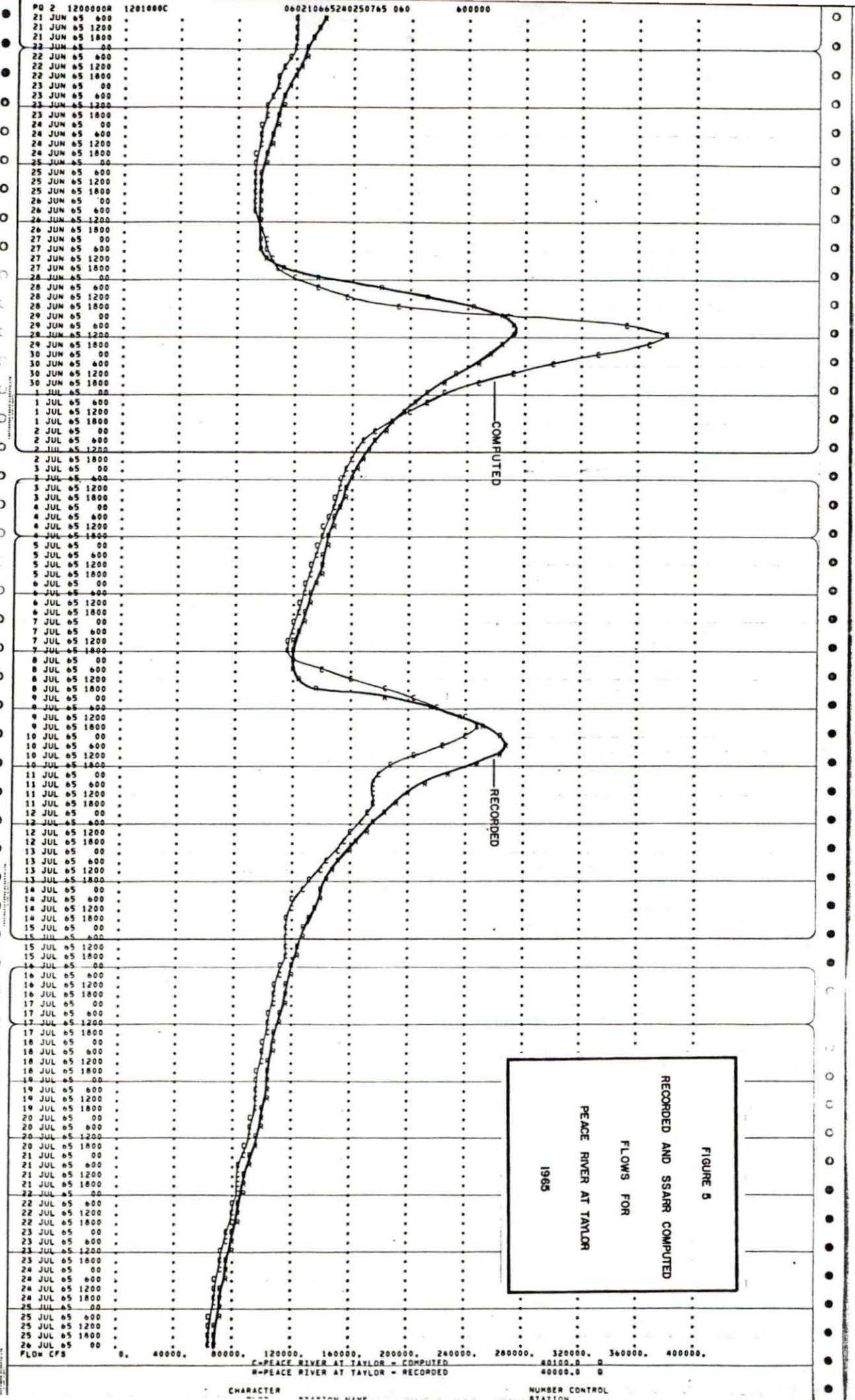


FIGURE 5

RECORDED AND SSARR COMPUTED

FLOWS FOR

PEACE RIVER AT TAYLOR

1965

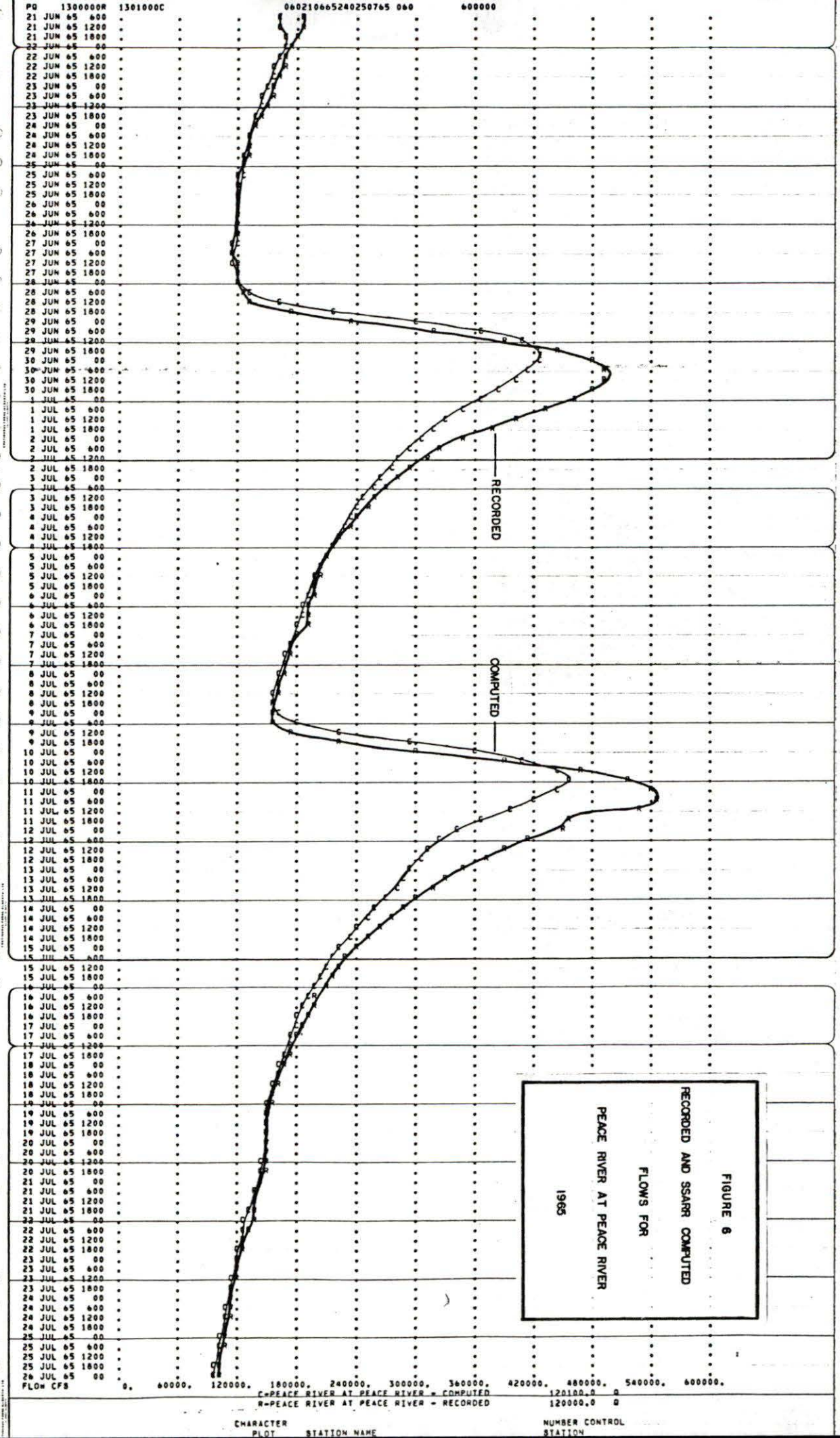


FIGURE 6

RECORDED AND SSARR COMPUTED FLOWS FOR PEACE RIVER AT PEACE RIVER 1965

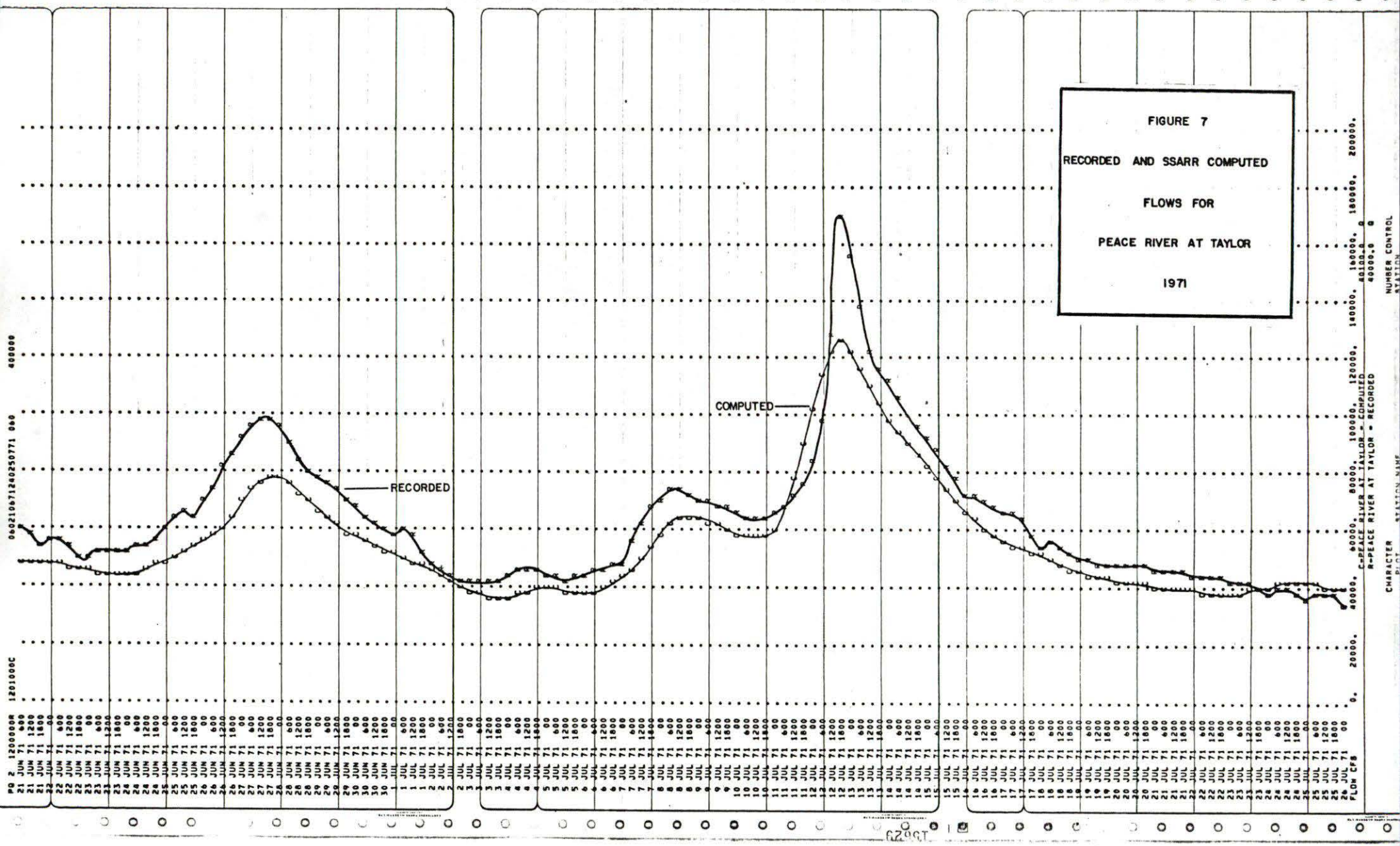


FIGURE 7
RECORDED AND SSARR COMPUTED
FLOWS FOR
PEACE RIVER AT TAYLOR
1971
COMPUTED
RECORDED
C-PEACE RIVER AT TAYLOR - COMPUTED
R-PEACE RIVER AT TAYLOR - RECORDED
CHARACTER PLOT
STATION NAME
NUMBER CONTROL STATION
FLOW CFS
0.
20000.
40000.
60000.
80000.
100000.
120000.
140000.
160000.
180000.
200000.

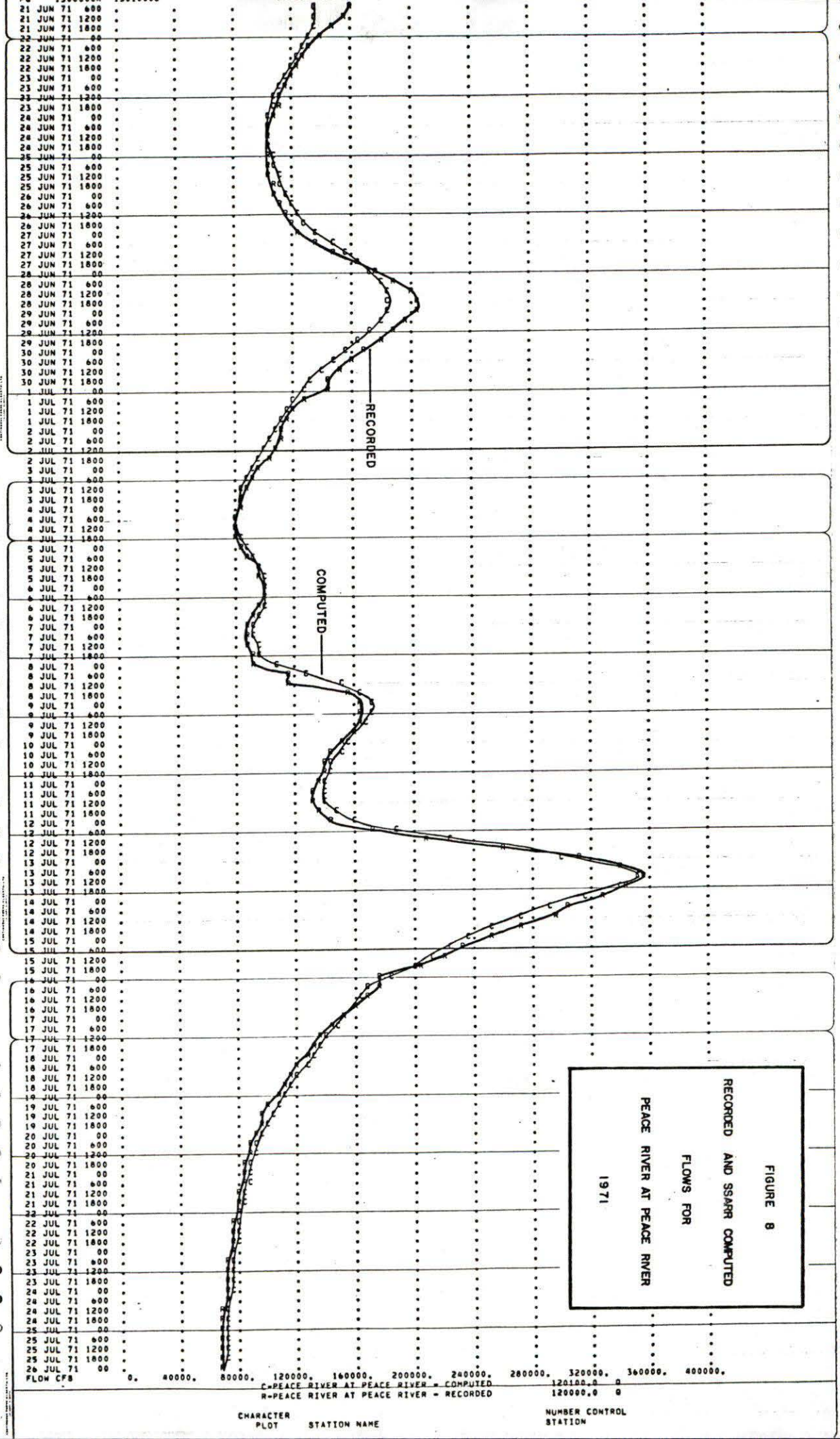


FIGURE 8

RECORDED AND SSARR COMPUTED FLOWS FOR PEACE RIVER AT PEACE RIVER 1971

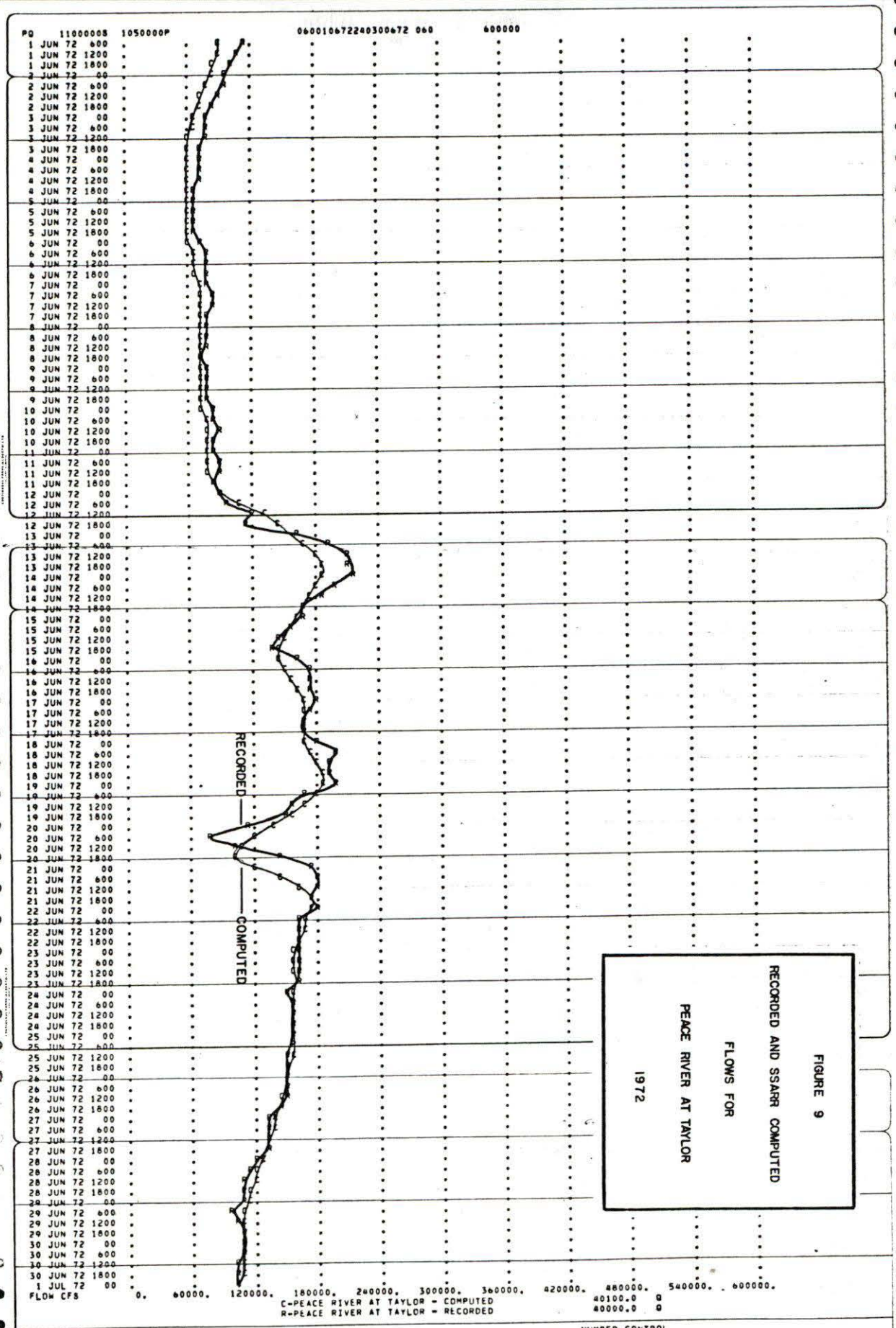


FIGURE 9

RECORDED AND SSARR COMPUTED FLOWS FOR PEACE RIVER AT TAYLOR 1972

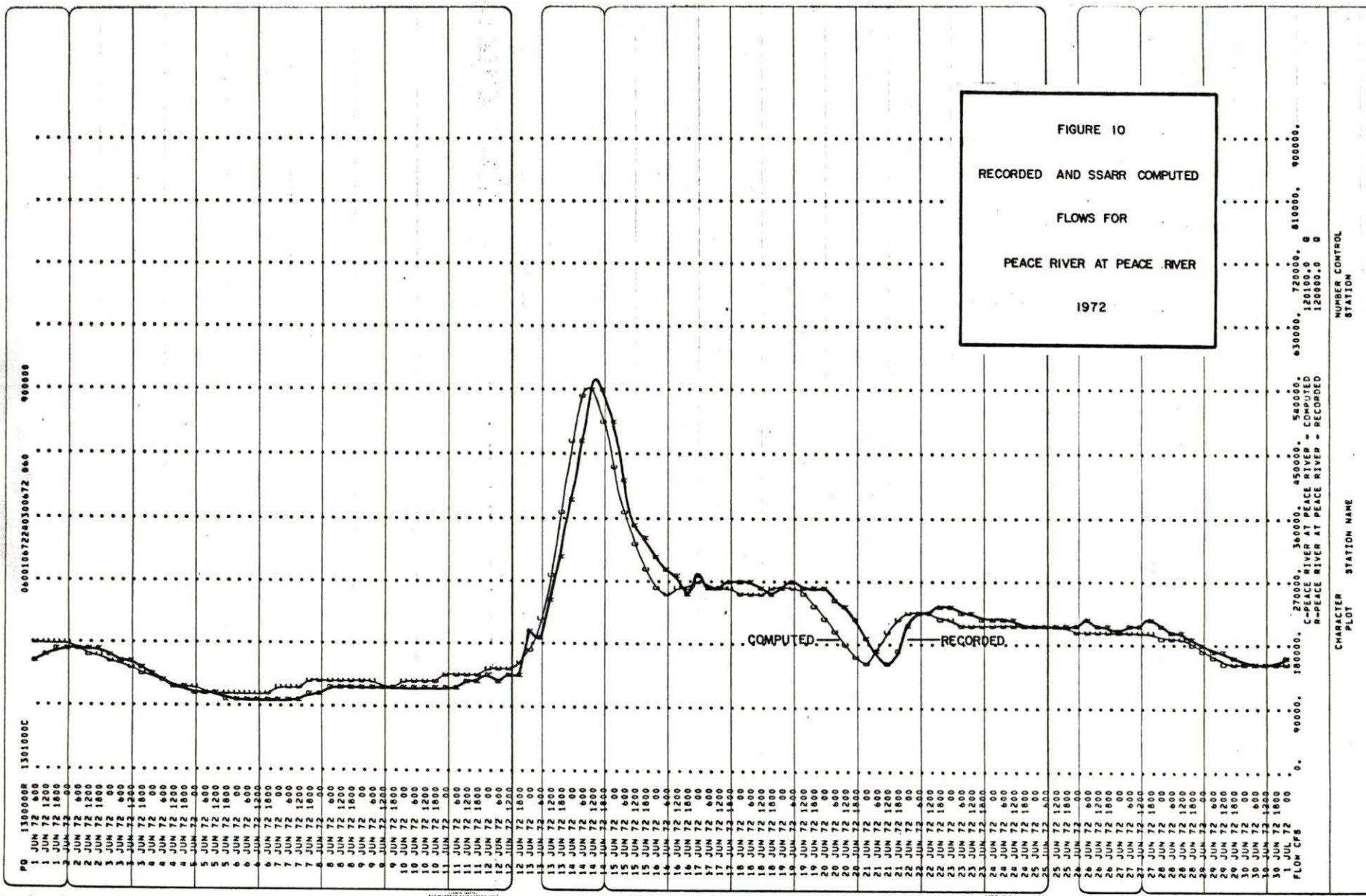


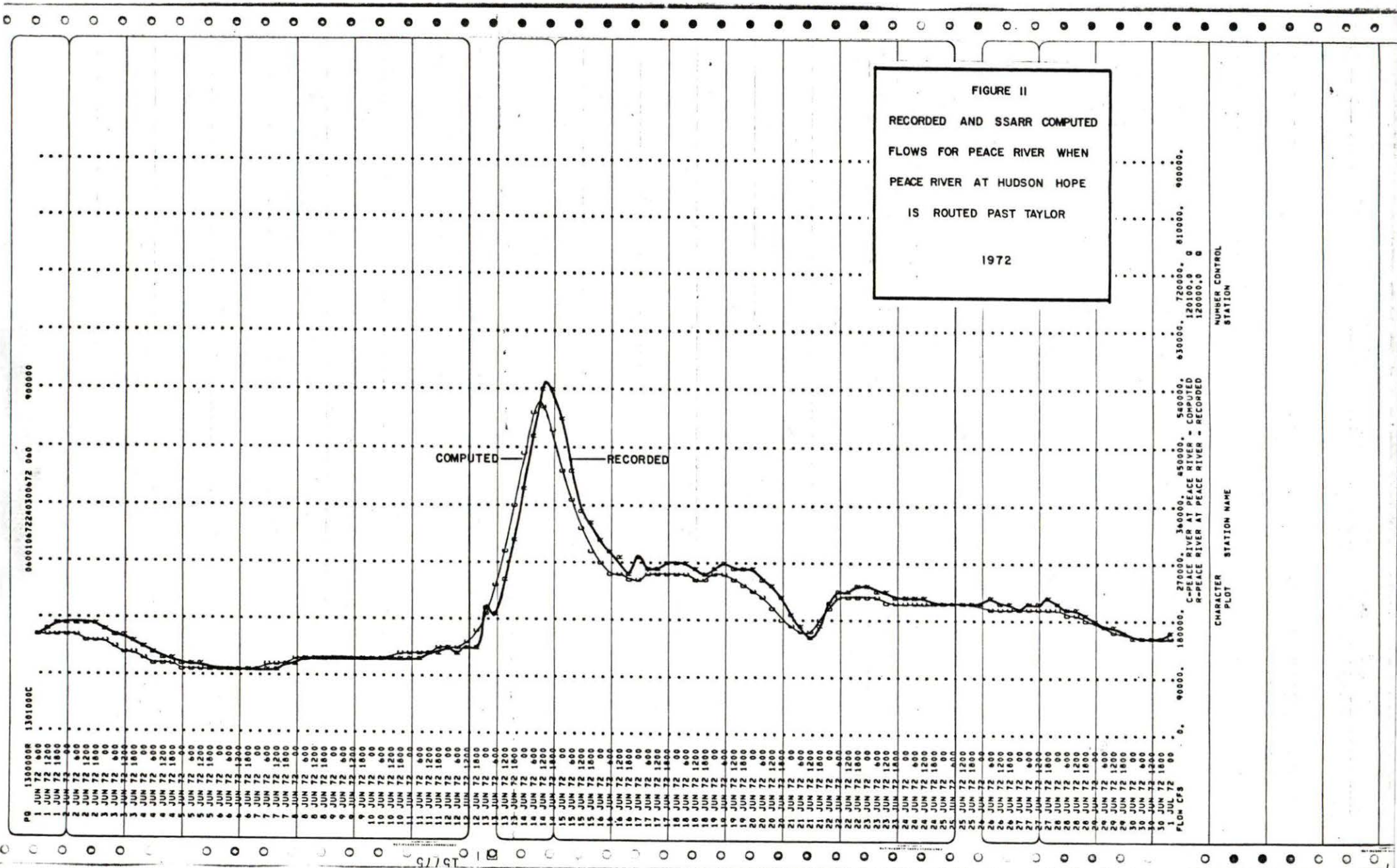
FIGURE 10

RECORDED AND SSARR COMPUTED

FLOWS FOR

PEACE RIVER AT PEACE RIVER

1972


COMPUTED
RECORDED
FIGURE II
RECORDED AND SSARR COMPUTED
FLOWS FOR PEACE RIVER WHEN
PEACE RIVER AT HUDSON HOPE
IS ROUTED PAST TAYLOR
1972
C-PEACE RIVER AT PEACE RIVER - COMPUTED
R-PEACE RIVER AT PEACE RIVER - RECORDED
CHARACTER PLOT STATION NAME
NUMBER CONTROL STATION
FLOW CFS

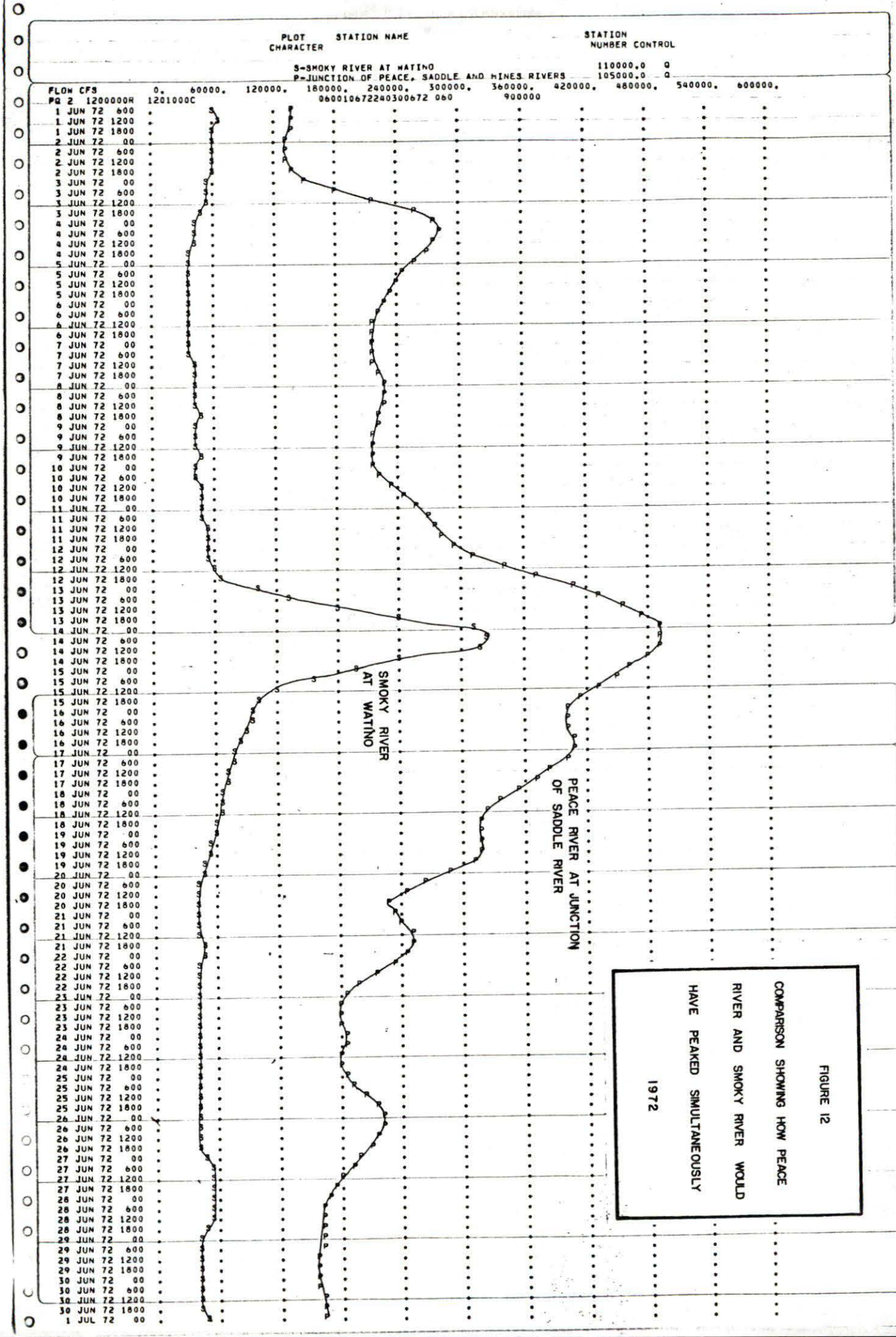


FIGURE 12

COMPARISON SHOWING HOW PEACE RIVER AND SMOKY RIVER WOULD HAVE PEAKED SIMULTANEOUSLY

1972

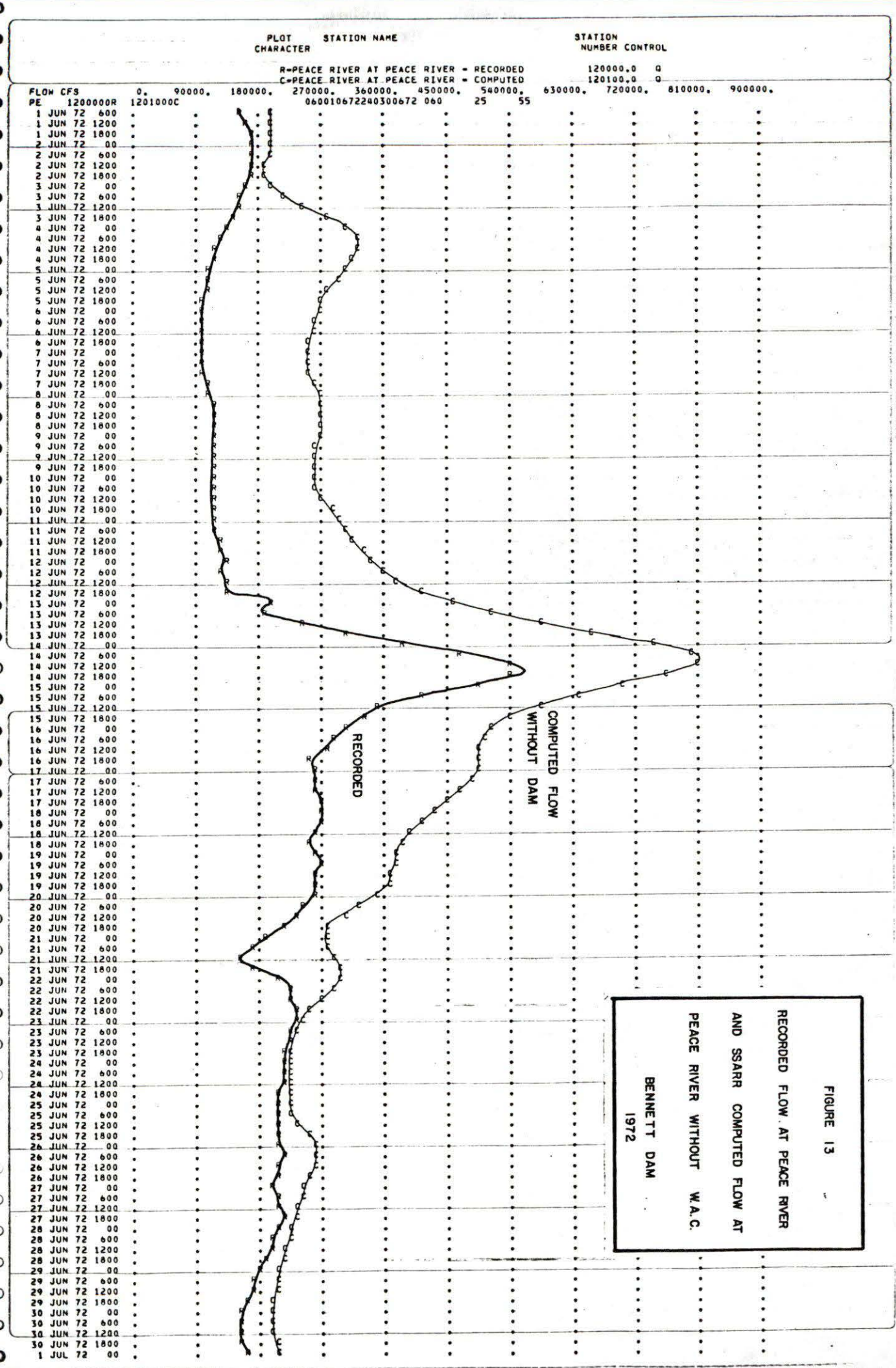


FIGURE 13

RECORDED FLOW AT PEACE RIVER AND SSARR COMPUTED FLOW AT PEACE RIVER WITHOUT W.A.C. BENNETT DAM 1972

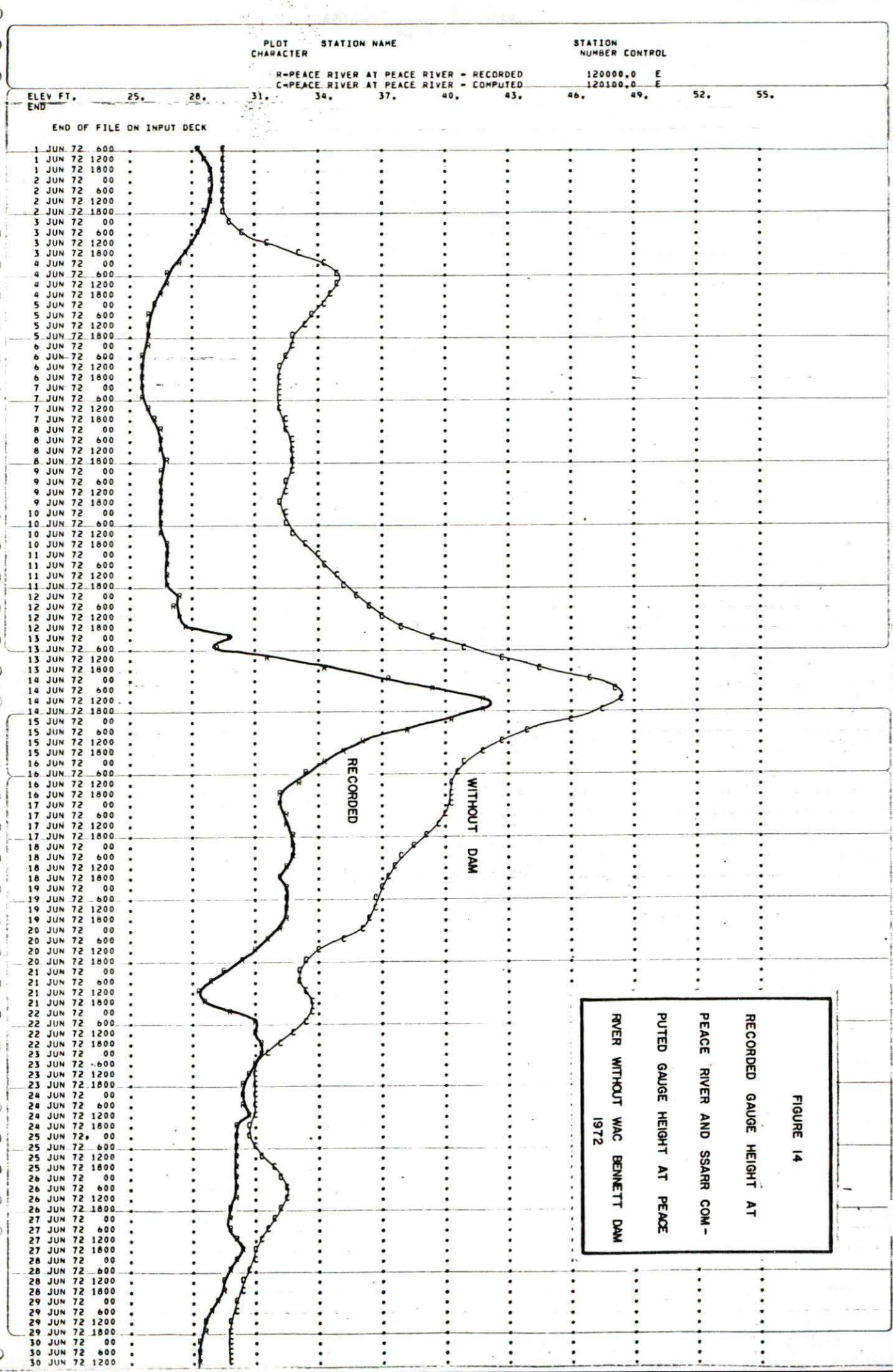


FIGURE 14

RECORDED GAUGE HEIGHT AT PEACE RIVER AND SSARR COMPUTED GAUGE HEIGHT AT PEACE RIVER WITHOUT WAC BENNETT DAM 1972

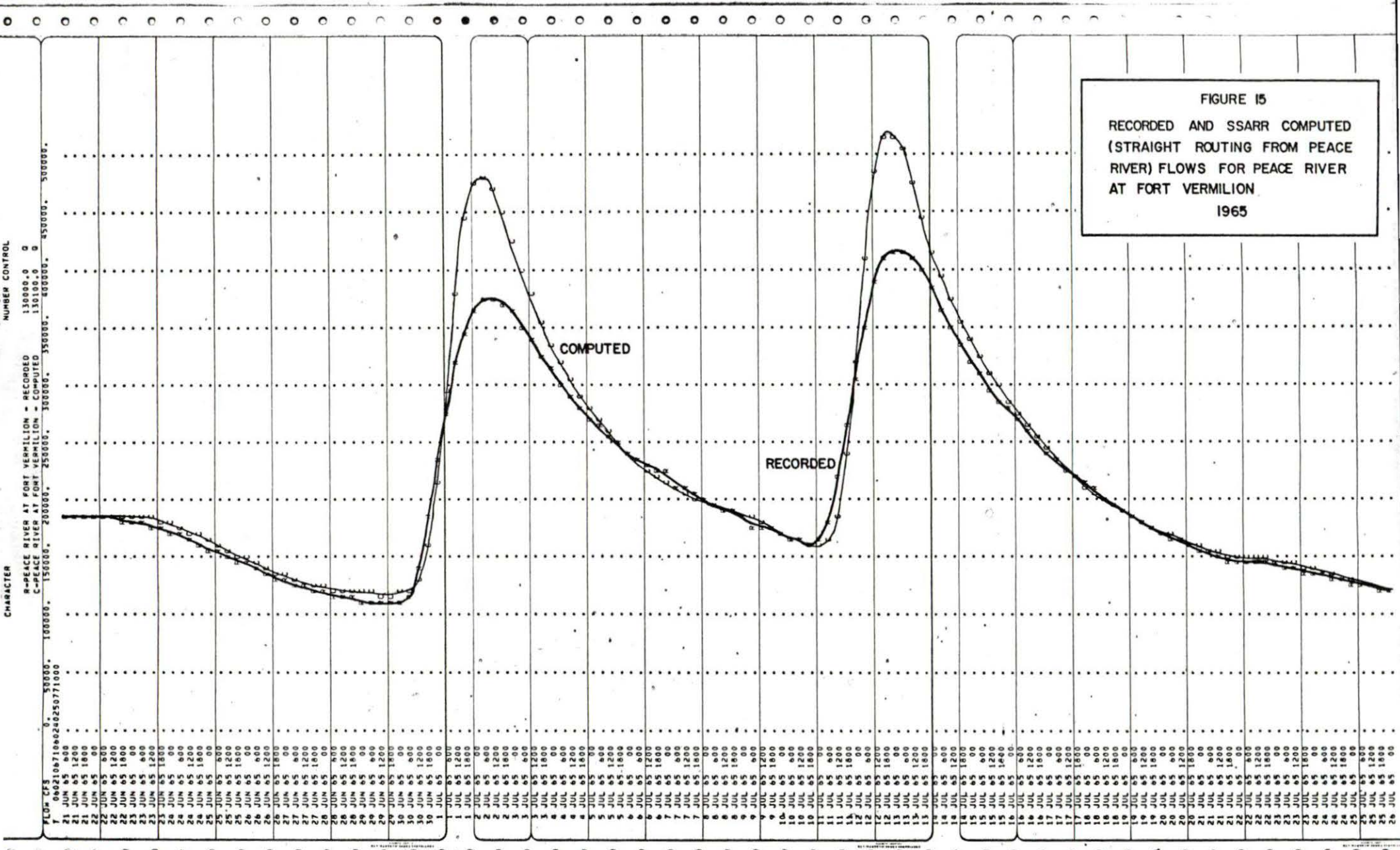


FIGURE 15

RECORDED AND SSARR COMPUTED (STRAIGHT ROUTING FROM PEACE RIVER) FLOWS FOR PEACE RIVER AT FORT VERMILION

1965

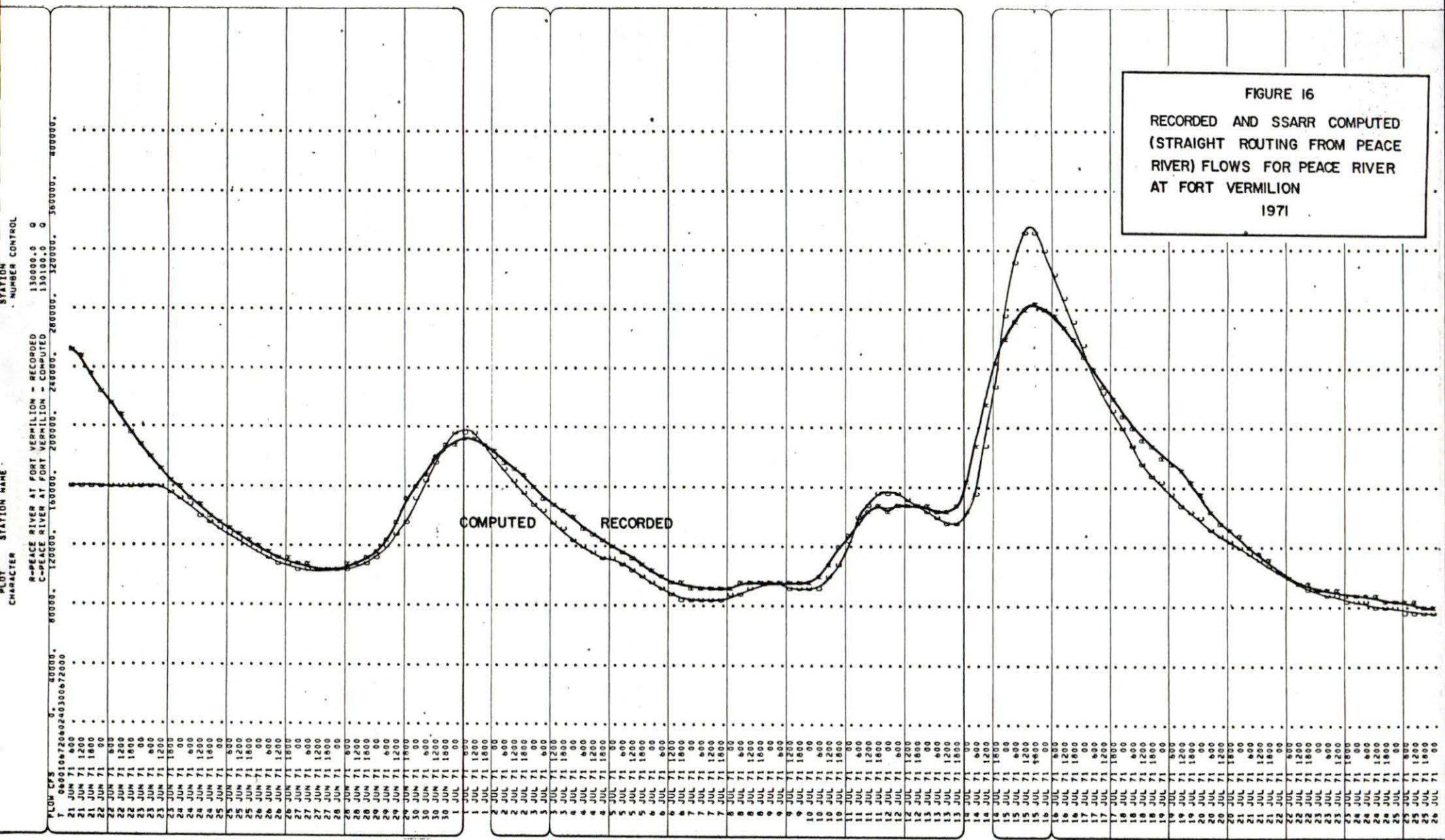


FIGURE 16

RECORDED AND SSARR COMPUTED (STRAIGHT ROUTING FROM PEACE RIVER) FLOWS FOR PEACE RIVER AT FORT VERMILION

1971

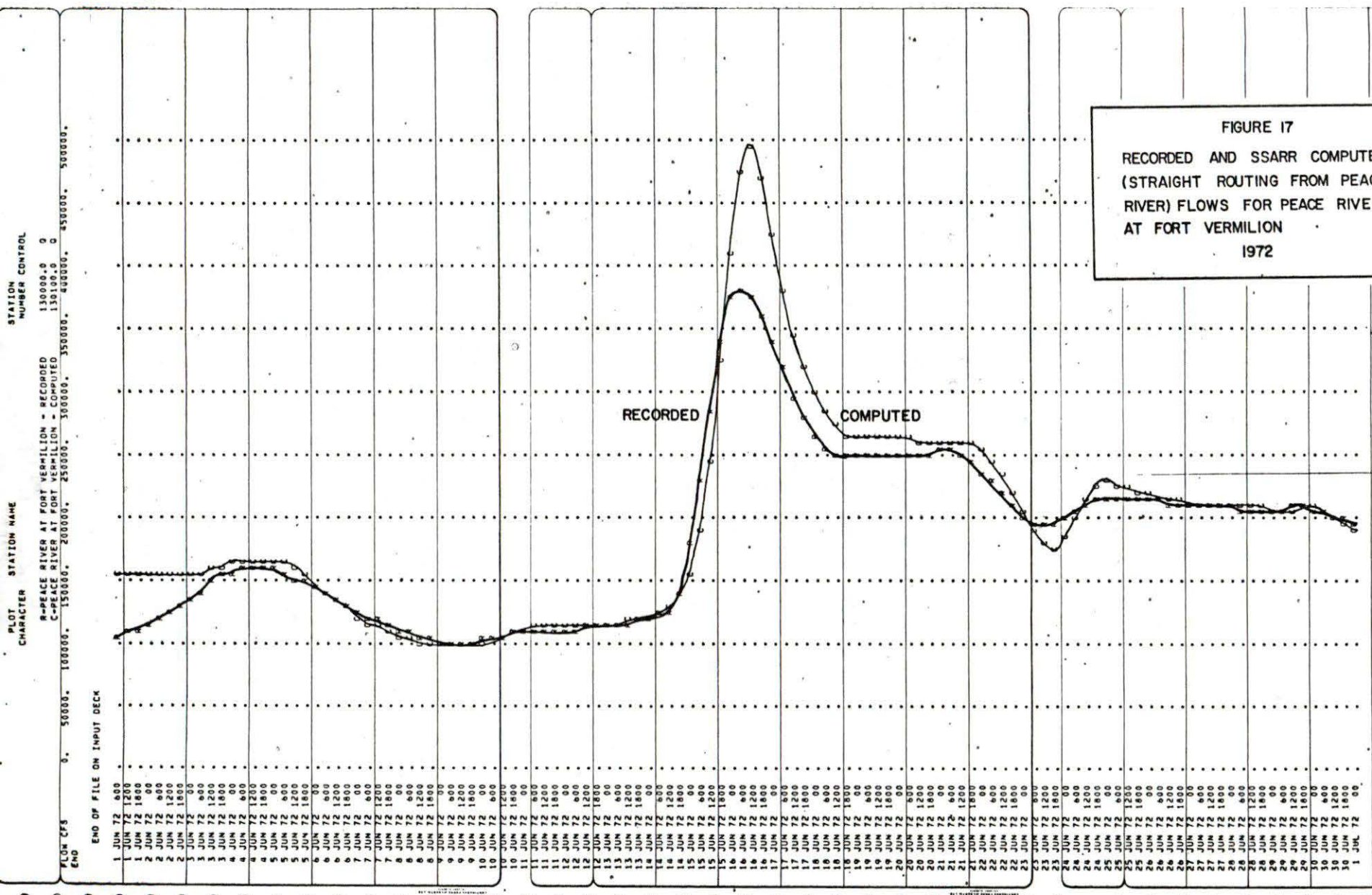


FIGURE 17

RECORDED AND SSARR COMPUTED (STRAIGHT ROUTING FROM PEACE RIVER) FLOWS FOR PEACE RIVER AT FORT VERMILION

1972

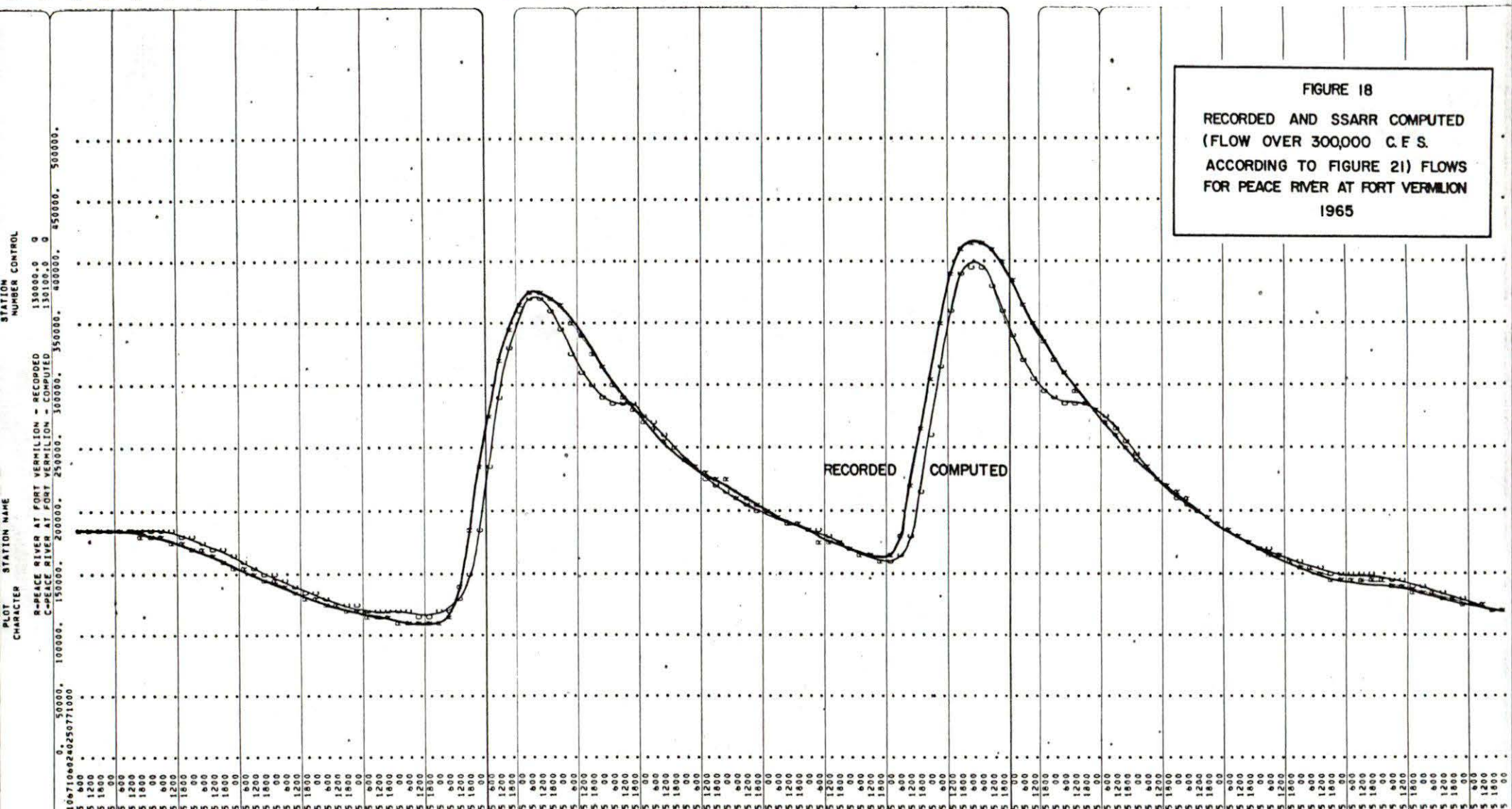


FIGURE 18

RECORDED AND SSARR COMPUTED (FLOW OVER 300,000 C.F.S. ACCORDING TO FIGURE 21) FLOWS FOR PEACE RIVER AT FORT VERMILION 1965

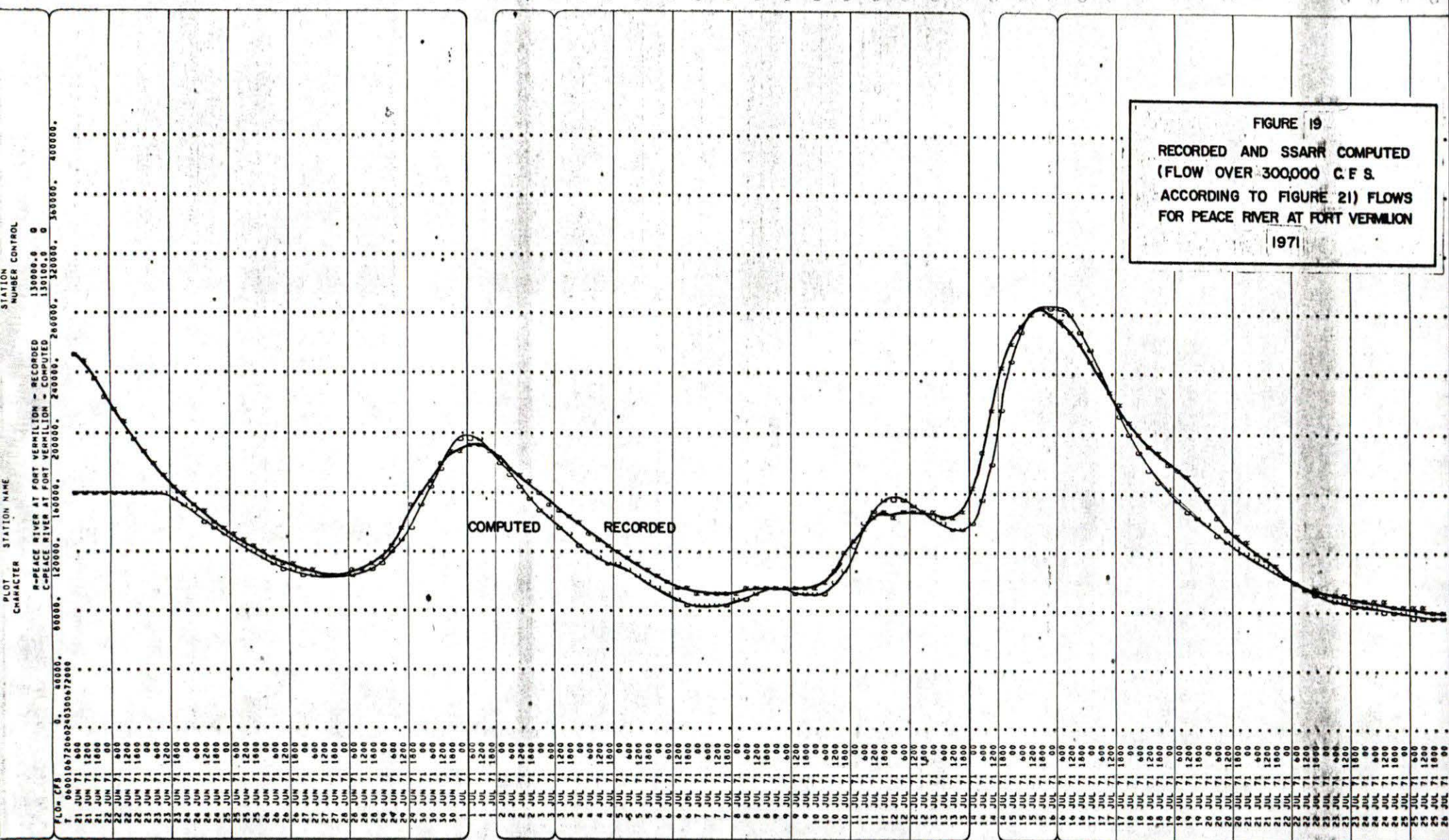


FIGURE 19

RECORDED AND SSARR COMPUTED (FLOW OVER 300,000 C.F.S. ACCORDING TO FIGURE 21) FLOWS FOR PEACE RIVER AT FORT VERMILION

1971

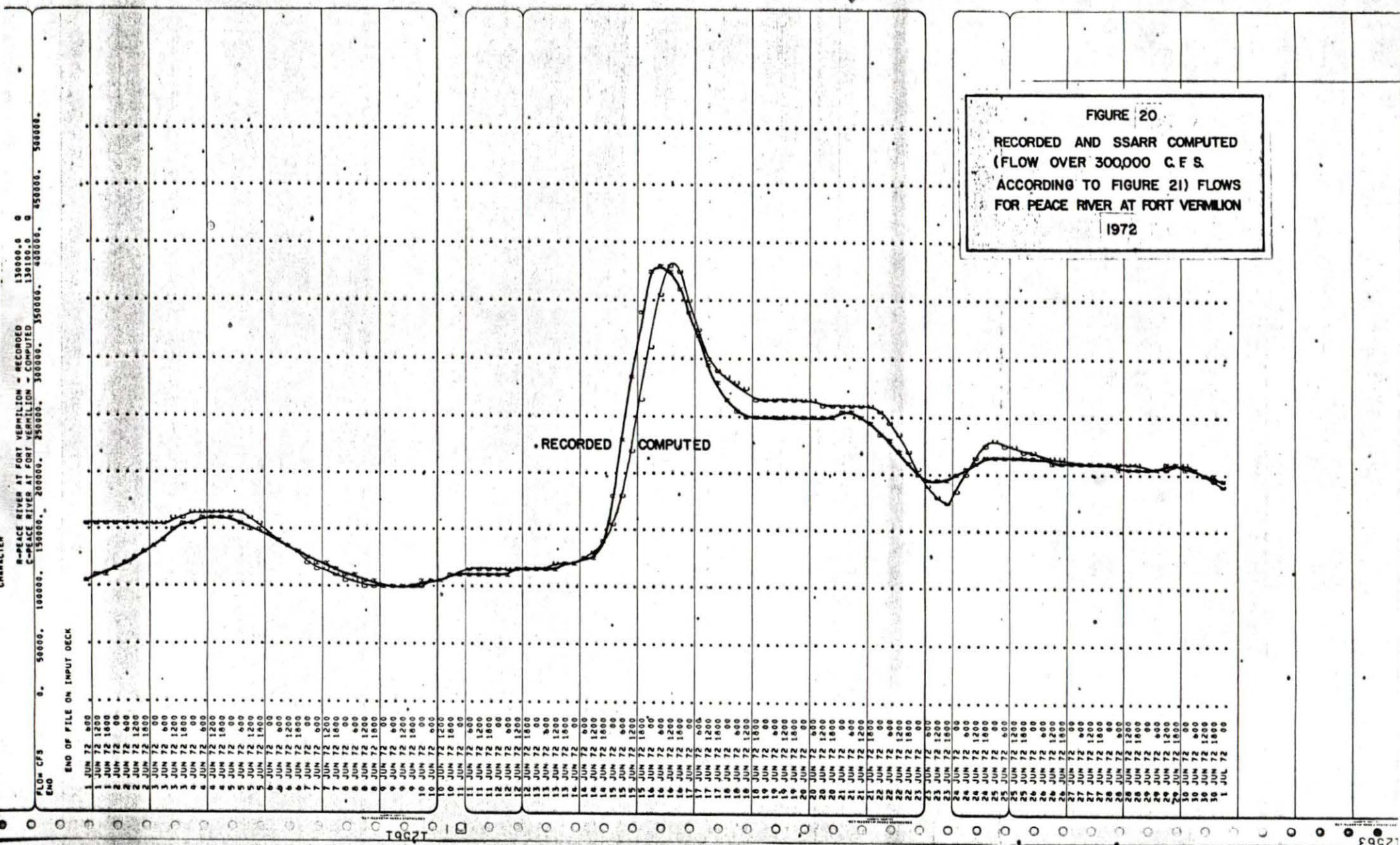


FIGURE 20
RECORDED AND SSARR COMPUTED (FLOW OVER 300,000 C.F.S. ACCORDING TO FIGURE 21) FLOWS FOR PEACE RIVER AT FORT VERMILION
1972
RECORDED
COMPUTED
R-PEACE RIVER AT FORT VERMILION - RECORDED
C-PEACE RIVER AT FORT VERMILION - COMPUTED
FLOW CFS 0. 50000. 100000. 150000. 200000. 250000. 300000. 350000. 400000. 450000. 500000.
END OF FILE ON INPUT DECK

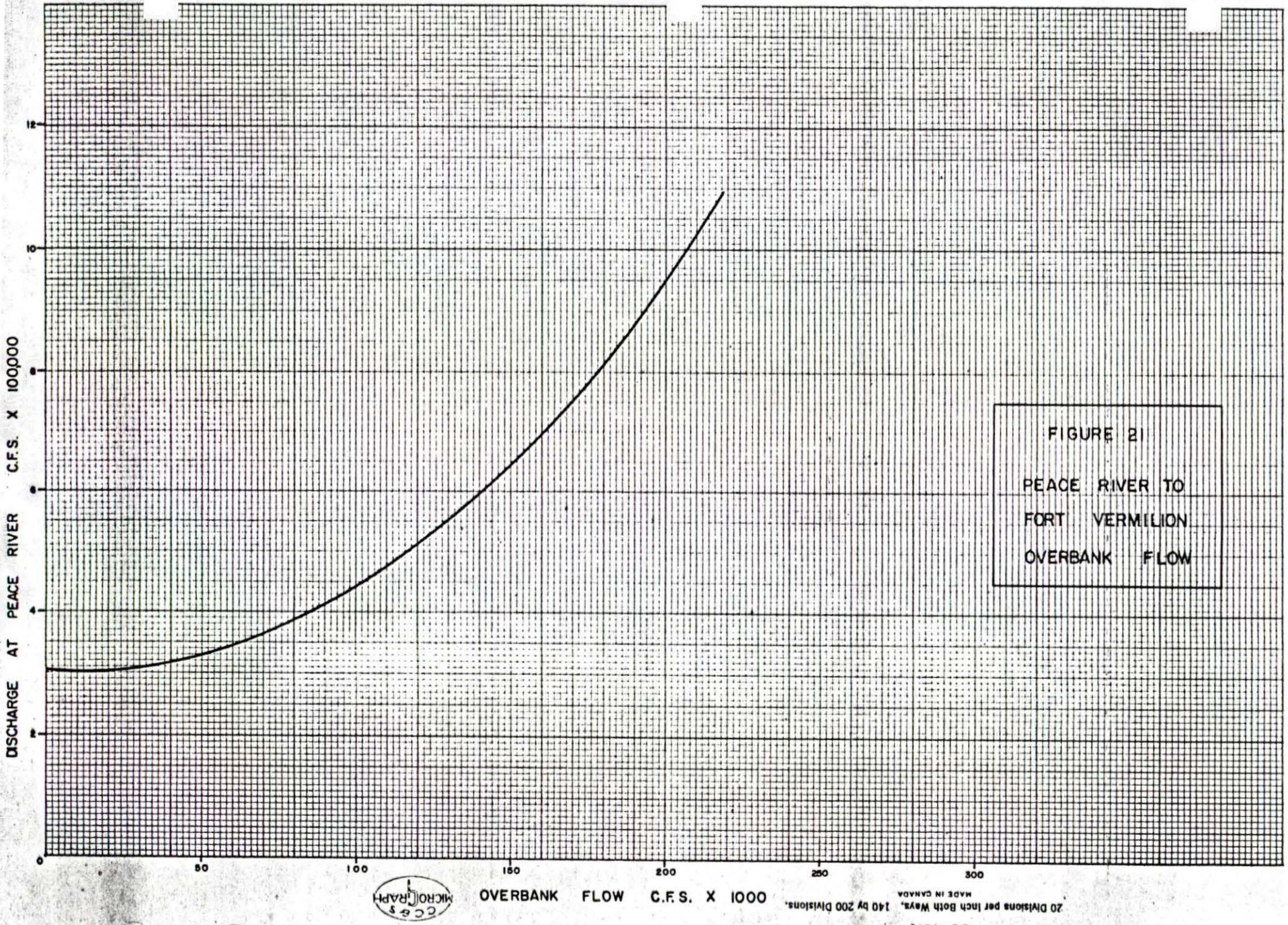
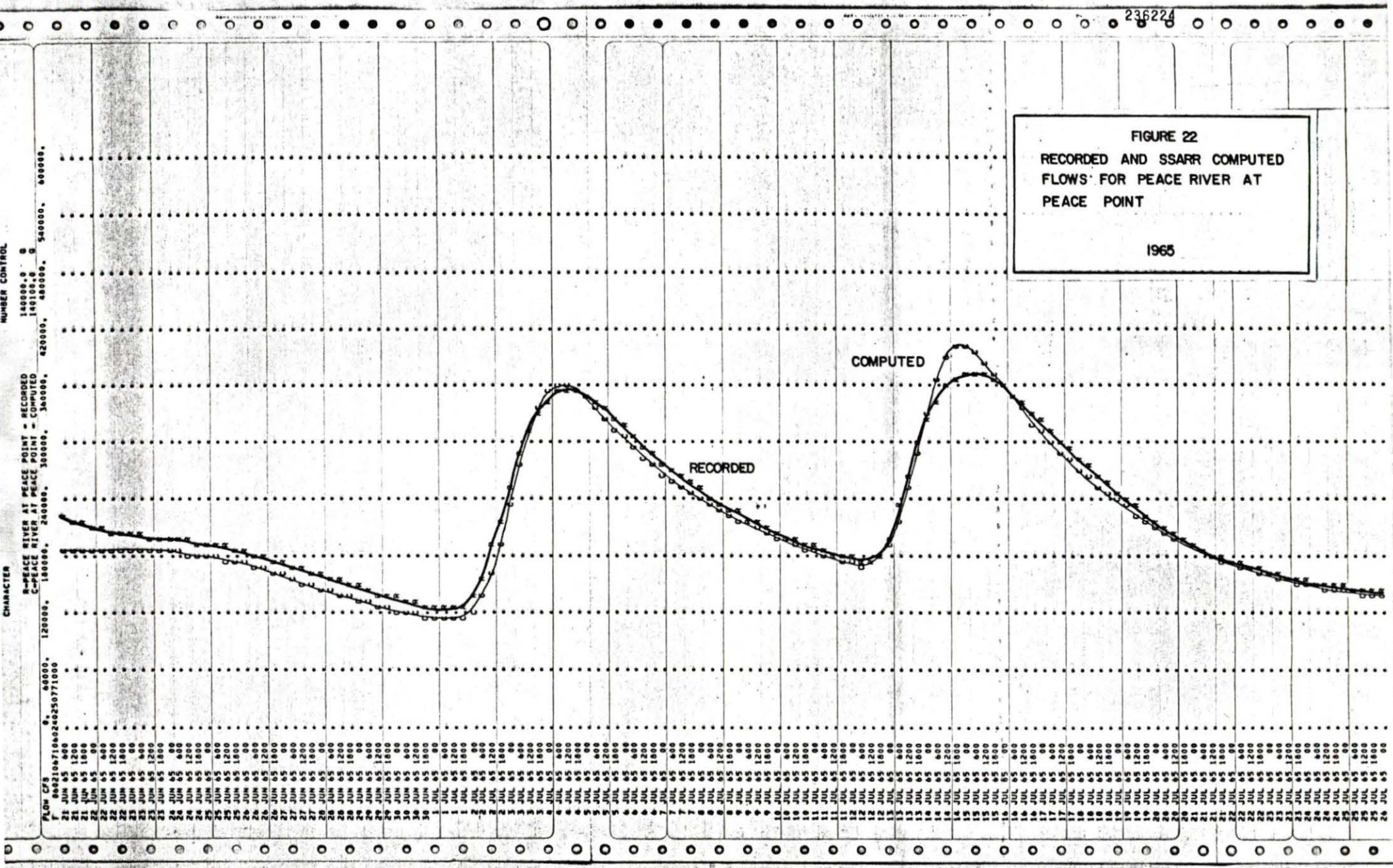


FIGURE 21
PEACE RIVER TO
FORT VERMILION
OVERBANK FLOW
DISCHARGE AT PEACE RIVER C.F.S. X 100000
0
2
4
6
8
10
12
50
100
150
200
250
300
OVERBANK FLOW C.F.S. X 1000
20 Divisions per Inch Both Ways, 140 by 200 Divisions.
MADE IN CANADA
G9-104
CCG'S MICROGRAPH


236224
FIGURE 22
RECORDED AND SSARR COMPUTED FLOWS FOR PEACE RIVER AT PEACE POINT
1965
COMPUTED
RECORDED
R-PEACE RIVER AT PEACE POINT - RECORDED
C-PEACE RIVER AT PEACE POINT - COMPUTED
CHARACTER
NUMBER CONTROL
140000.0 0
141100.0 0
FLOW CFS
0. 60000. 120000. 180000. 240000. 300000. 360000. 420000. 480000. 540000. 600000.

236216

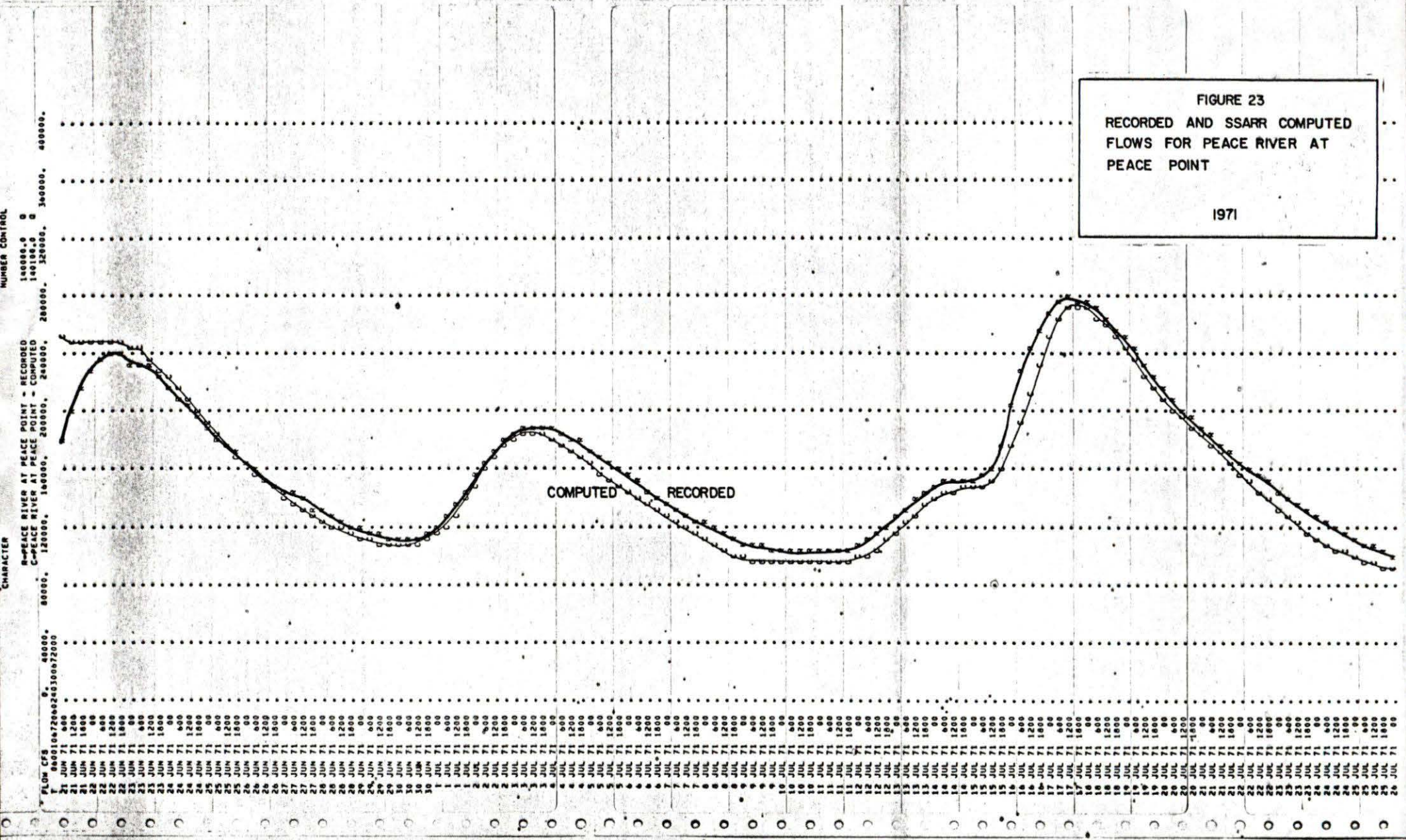


FIGURE 23
RECORDED AND SSARR COMPUTED FLOWS FOR PEACE RIVER AT PEACE POINT
1971
COMPUTED
RECORDED
R=PEACE RIVER AT PEACE POINT - RECORDED
C=PEACE RIVER AT PEACE POINT - COMPUTED
CHARACTER
NUMBER CONTROL
FLOW CFS

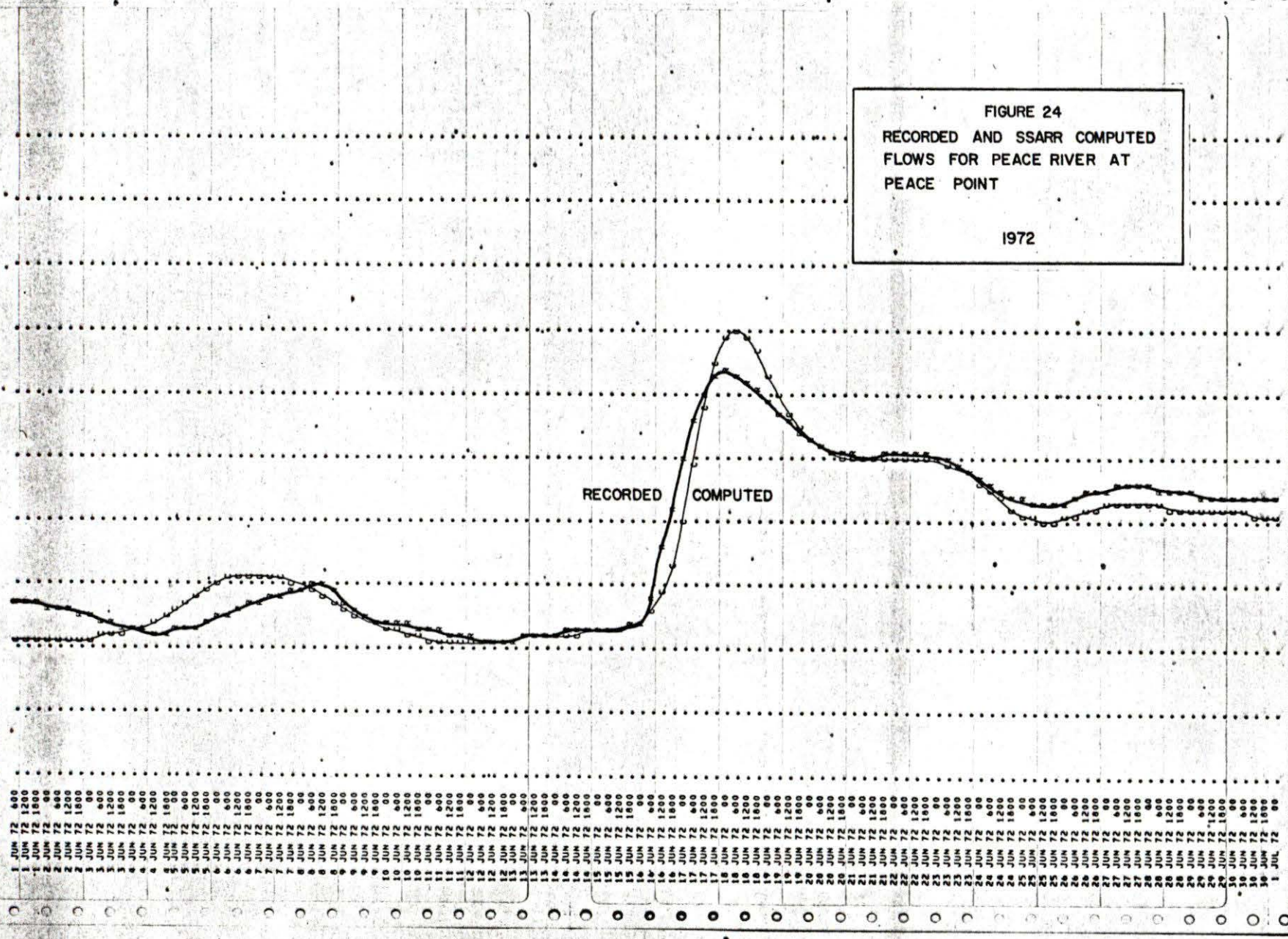


FIGURE 24
RECORDED AND SSARR COMPUTED FLOWS FOR PEACE RIVER AT PEACE POINT

1972

REFERENCES

1. Coulson, A., and Adamcyk, R. J., 1969. The Effects of the W A C Bennett Dam on Downstream Levels and Flows. Technical Bulletin No. 18, Department of Energy, Mines and Resources.

2. Peace-Athabasca Delta Committee, 1970. Death of a Delta: Brief submitted to the Alberta Government, June 1970.

3. Card, J. R., and Yaremko, E. K., 1970. Athabasca Delta Project Report No. 1 (1970). Alberta Department of Agriculture, Hydrology Branch.

4. Peace-Athabasca Delta Project Group, 1972. The Peace Athabasca Delta - A Canadian Resource. Summary Report, 1972.

5. Warner, L. A., and Thompson, W. C., 1972. Preliminary Report Peace River Basin Flood, June 1972. Canada Department of the Environment, Water Management Branch.