REPORT # 12

STREAM FLOW DEPLETION

and

CONSUMPTIVE USE IN BEAR RIVER BASIN

above

BORDER, WYOMING

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G E N E R A L

The determination of stream flow depletions in the alluvium filled State valley sections of the Bear River Basin can be made by the inflow-outflow method. The data available is best applicable to volumetric determination on a valley basis for the irrigation period May 1 to September 30. With records of water applied in irrigation and records of precipitation and temperature, the depletion data can be extended into a study of consumptive use which may explain the seasonal variations in the stream flow depletions.

Although the stream flow investigation in the Bear River Basin was not organized along the lines of a consumptive use study, it is believed a reasonable analysis can be made on a valley basis. The short season water supply, common each year in the upper sections of the basin, introduces a variable about which little is known. Preliminary studies have indicated that some consistent relations may exist between seasonal consumptive use, length of irrigation period, water applied, and available heat. Any derived information may be peculiar to the data available and apply only to conditions existing in this basin. The presentation and discussion in this analysis probably contains more detail than necessary, but it has been deemed advisable to include the information as it may have some value in the future in connection with the Bear River water problem.

"Valley stream flow depletion" is defined as the amount of water that flows into a valley or onto a particular land area minus the amount that flows out of the valley or away from the particular land area.

"Valley consumptive use" is the sum of the water absorbed by and transpired from crops and native vegitation and lands upon which they are grown and that evaporated from bare land and water surfaces in the valley.

As applied to this study, the valley stream flow depletion is computed as the difference between valley inflow, consisting of surface streams entering the valley, and valley outflow, consisting of surface streams flowing out of the valley. The valley consumptive use is the sum of the valley stream flow depletion and precipitation on the surface. In both of these determinations groundwater inflow into and out of the valley areas, change in groundwater storage in the valley areas, and change in soil moisture and water of saturation are not taken into account. These later items may cause gross errors in final results, but since quantitative information relative to them have not been obtained, it is assumed they have minor effect and can be eliminated. A subsequent discussion on some groundwater observations, which were obtained, in some degree indicates the change in groundwater storage may be minor. Surface water and groundwater contributions from ungaged contributing areas are considered to be minor due to the small runoff from such areas as compared to the total involved, however, there may be some exceptions for which adjustments will need be made.

In the following presentation the valley areas are considered in downstream order and the data is presented in considerable detail to facilitate additional study and analysis if such should be warranted.

GROUNDWATER TABLE OBSERVATIONS IN THE UPPER BASIN

In the late summer of 1944 three lines of ground-water observation wells were installed in the Upper Bear River Basin. Observations of the water table were obtained in September 1944 and monthly during the irrigation season in 1945. The object of these observations was to determine the variation in the water table during the irrigation season and to establish whether or not the valley ground-water is effluent to the river. Shown on Plates 1 to 3 are cross-sections of the valley along the observation lines and ground-water levels at the time of observation.

A-Line Wells - Plate 1

Location and description:- In north-half of sec. 35, T. 15 N., R. 120 W., 6th Principal Meridian three miles southeast of Evanston, Wyoming. Seven wells, extending from the river in a southwest direction across the valley, in line with the Millis gaging station and approximately perpendicular to the valley axis. The river is situated close to the hills on the northeast side of the valley and the southwest extension of the line reached to the toe of the foothills on the opposite side.

The top soil is clay-loam averaging about one and a half feet in thickness. Below the clay-loam top soil is a dense layer of clay one to three feet thick and underlaying this, is sand and coarse gravel of unknown depth. A heavy willow growth extends for about 500 feet along the well line from the bank of the river. Hay and pasture lands occupy the rest of the valley width. Application of irrigation water occurred principally during June and July and practically no water was applied after August 1st.

Analysis:- The depression in the water table near the river was probably caused by consumptive use in the heavy willow growth. The borrow pit at the side of the railroad tracks acted as a drain and carried more or less water throughout the irrigation season. Although, water surface readings were not obtained on the drain, it was reported to have been one to two feet higher in the drain than in well A-5, located a few feet from the drain. It appears there might be a buried channel which acts as an underground drain and the bed and sides of the drain have become sealed with silt. It would appear from the general flatness of the water table there is considerable underground movement of water down the valley rather than toward the river. The fall in the land and river surface is about 33 feet per mile along the axis of the valley. The small seasonal variation in water levels, most of which occur in tight soils, indicate there would be only a relatively small amount of water held in ground-water storage.

<u>B-Line Wells - Plate 2</u>

<u>Location and description:</u>- In close proximity to range line between T. 15 N., and 16 N., 6th Principle Meridian, four miles northwest of Evanston, Wyoming. Ten wells extending on an east-west line across the valley and in line with the Bear River near Evanston, Wyoming gaging station. The well line is approximately perpendicular to the valley axis. The river is situated about in the center of the valley. Pasture and hay lands cover the entire valley floor.

On the east side of the valley clay-loam top soil one to four feet thick overlays sand and gravel of unknown depth. On the west side of the river the clay-loam top soil is one to two feet thick. Below the clay-loam on the west side is a layer of yellow clay which apparently increases in thickness toward the west edge of the valley. Sand and gravel of unknown depth underlays the clay and clay-loam.

<u>Analysis:</u>- On the east side, the water table slopes toward the river and apparently is mostly contained in the sand and gravel zone. Irrigation in the summer raises the water table three to four feet. After irrigation ceases about August 1, effluent flow to the river lowers the water table. This flow is probably quite

rapid, while the water table is high and since it is contained mostly in sand and gravel, assists to sustain the river flow in the late summer.

On the west side of the river, the ground surface and water table slopes away from the river. The river apparently loses water to the ground-water table at this point. It is very likely that the river at one time occupied a now buried channel at a lower elevation on the west side of the valley. This ancient channel may have become filled with coarse, very permeable material and now acts as an underground drain with its water returning to the river at some point between this section and Woodruff Narrows.

There is also a possibility of a buried permeable formation underlaying the hills on the west side of the valley into which this depressed water table may be draining. However, to determine what might be the case, would require additional observation wells north of the present valley cross-section. The fall in the valley lands and river surface is about 12 feet per mile along the valley axis and the fall from the river to the lowest point on the east-west line is about 8 feet per mile, which adds some thought to the possibility of valley leakage, as this results in only a four foot head for underground flow down the valley axis.

Studies made of the river reach between the Bear River near Evanston and Bear River near Woodruff gaging stations indicate there is practically no gain or loss in the reach after application of water in irrigation ceases. This would tend to rule out the possibility of any excessive valley leakage.

C-Line Wells - Plate 3

Location and description:- In north halves of Sections 26, 27, 28, and 29, T. 11 N., R. 7 E., Salt Lake Meridian and on an east-west line with the north edge of Randolph, Utah. Twelve wells extend along this east-west line, eight being on the west side of the river and four on the east side. The river flows in a northerly direction about one-fourth of the valley width west of the east side of the valley. The well line is closely perpendicular to the axis of the valley. Pasture and hay lands cover practically the entire width of the valley floor.

Clay-loam top soil of about 4-foot thickness overlays sand of unknown depth across the entire valley width.

<u>Analysis:</u>- It is believed this cross-section fairly well represents the conditions throughout the Woodruff-Randolph valley. However, the seasonal range in water levels on the west side in this line of wells may be influenced by underflow from Randolph Creek and leakage from the Randolph Creek Reservoir. In the vicinity of Woodruff, which is on the Woodruff Creek alluvial fan, the material underlaying the top soil is coarser gravel and there is known to be considerable, greater seasonal range in water table than evidenced in this line of water levels. The same is probably true along the valley sides in other parts of the valley.

The valley water table as evidenced by this line of observation wells is tributary to the river, with a slope of about 15 feet per mile on the west side and about 5 feet per mile on the east. The slope in the valley floor and water surface in the river is about three feet per mile along the axis of the valley. It is surprising to note the rather small range in seasonal water levels and that most of this range occurs within the rather tight top soil. If this condition exists over a major portion of the valley, the net amount of ground-water which would feed to the river, as the water table drops, would be relatively small. This may account for the relatively moderate amount of river channel gain in the Woodruff-Randolph section following the irrigation periods.

<u>Groundwater as it would affect Consumptive Use Determinations</u>

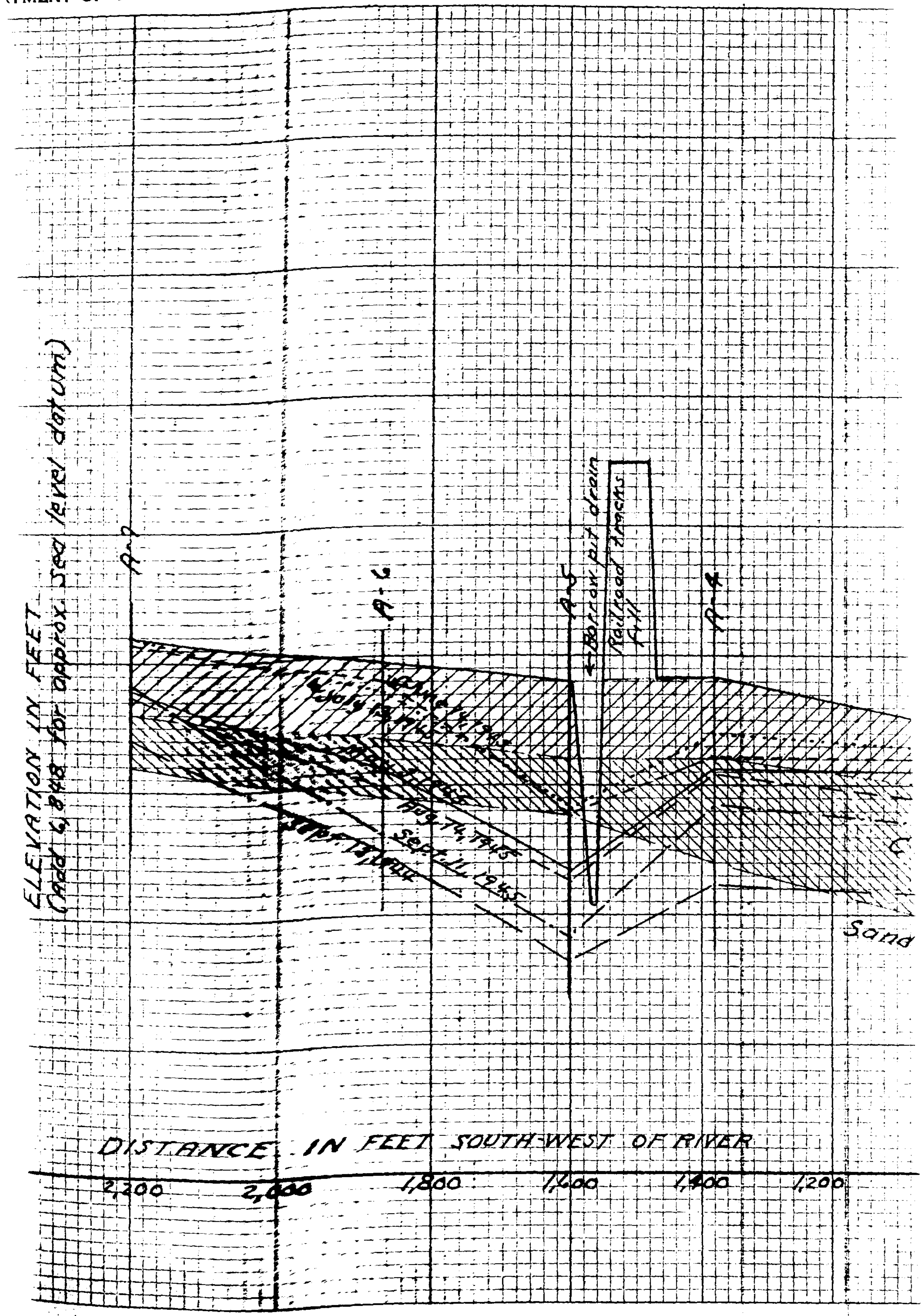
Ground-water inflow into a valley area, decrease in ground-water storage under valley area, and decrease in soil moisture between May 1 and September 30 would constitute a source of supply in the determination of consumptive use. The reverse of these conditions would likewise have an opposite effect.

It is to be noted that in general, the ground-water levels as illustrated on Plates 1 to 3 are higher at the time of the first reading in May than at the time of the last reading in September. It is believed part of the higher May elevation may have resulted from irrigation between May 1 and the date of the reading but it is more probable that it results from local snowmelt and rainfall prior to May 1. This unmeasured supply source may represent a quantity which will lead to a gross error in the determination of consumptive use. For the time being, however, it will be assumed to be negligible with the thought that the final analysis will prove it to be so or clearly indicate that it should be taken into account.

Soil moisture existing on May 1 would also be greater than on September 30. This may prove to be an additional element for which some adjustment should be made in the consumptive use determinations.

In the Bear River Hydrometric Reports for each of the years 1944 to 1947, daily hydrographs are plotted showing the total diversions and river gains in the various valley sections. These graphs indicate that the excess water applied in irrigation rapidly returns to the stream channels with the gain hydrographs closely following the hydrographs of the water applied. The excess water applied in irrigation rapidly builds up the water table under the irrigated areas. This increase in ground-water storage is temporary and is either consummed by vegetation, surface evaporation, or drains to the stream channels so that it is entirely dissipated by September 30.

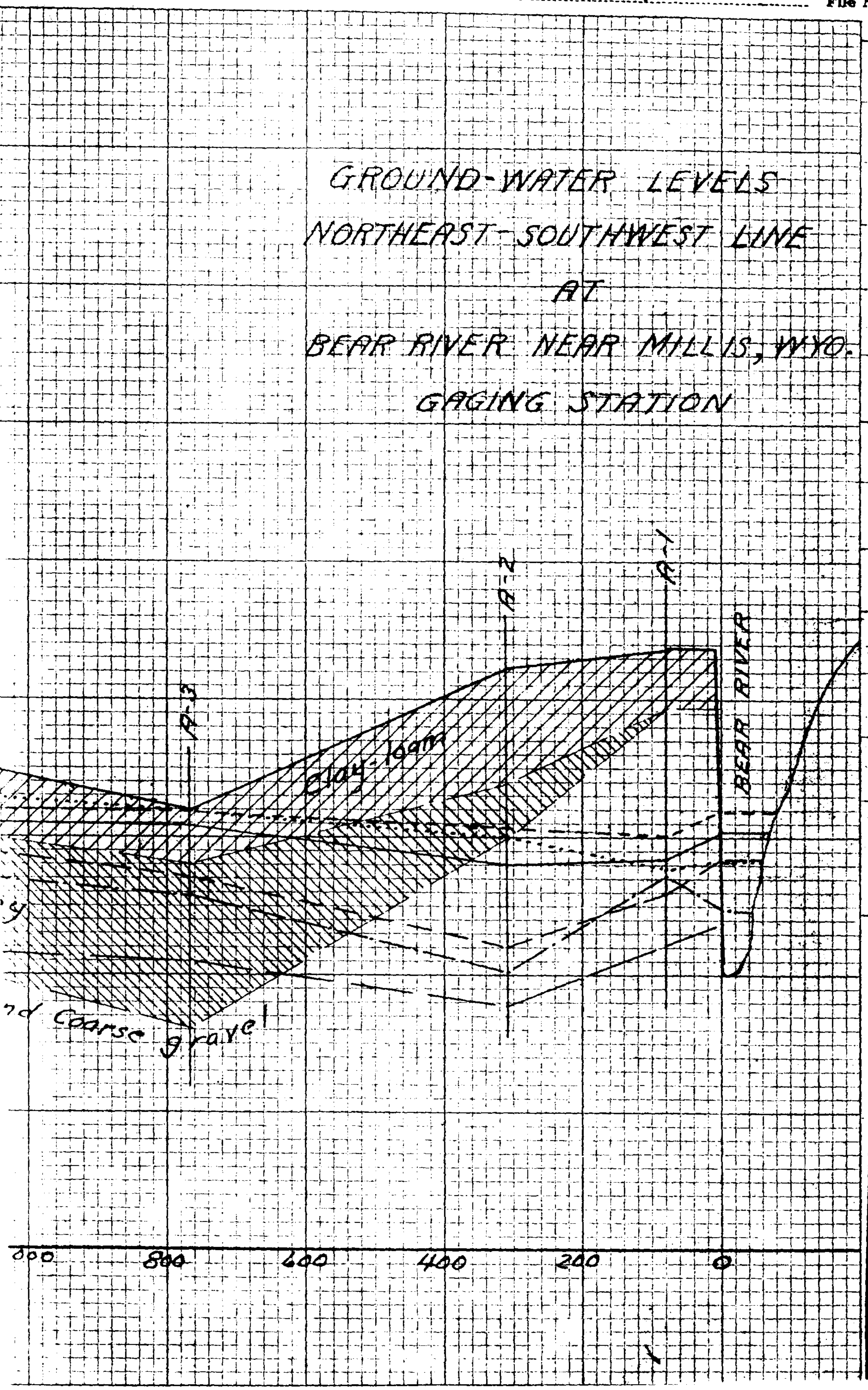
RTMENT OF THE INTERIOR—GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)



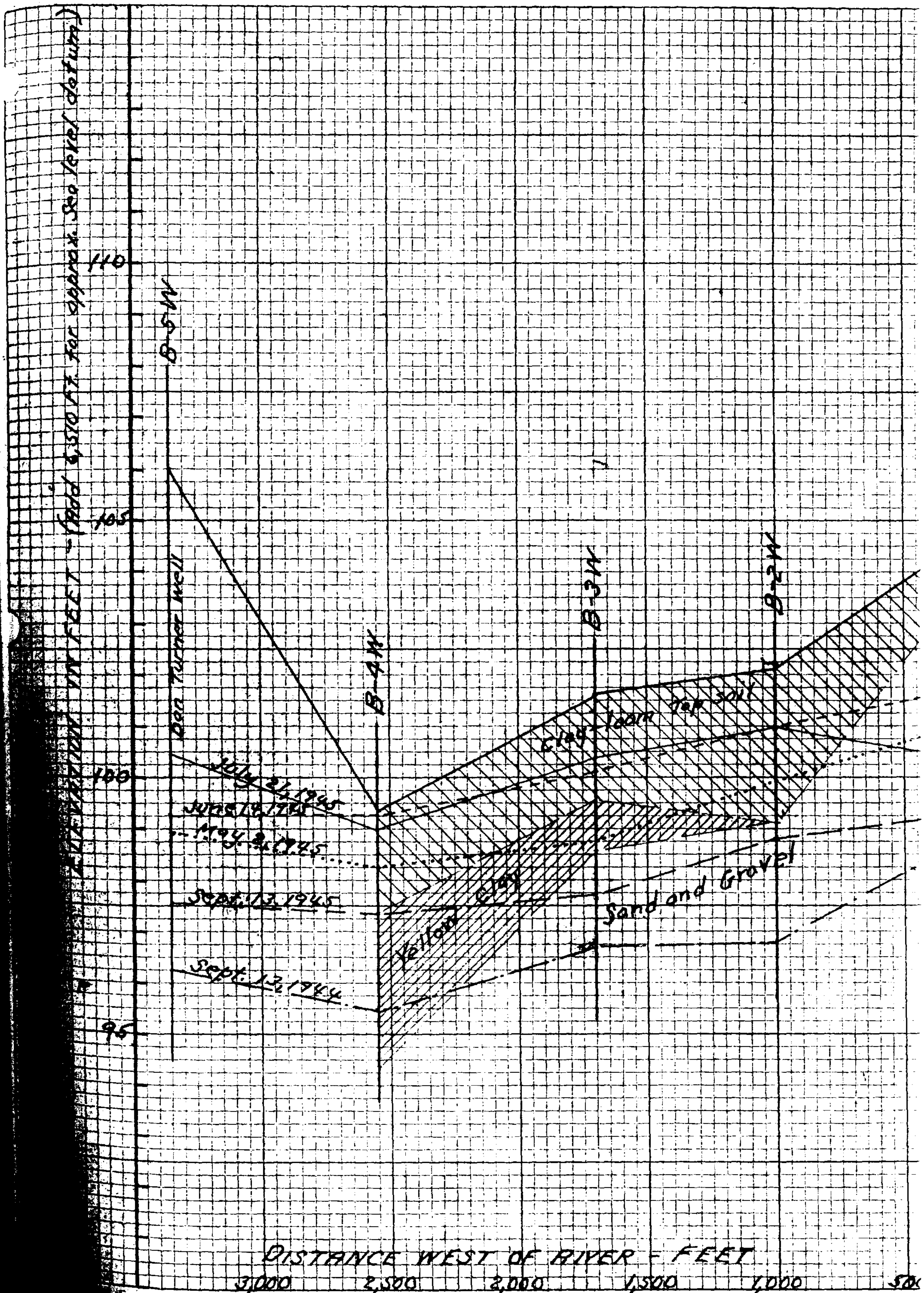
DISCHARGE IN SECOND-FEET

PLATE 1

File

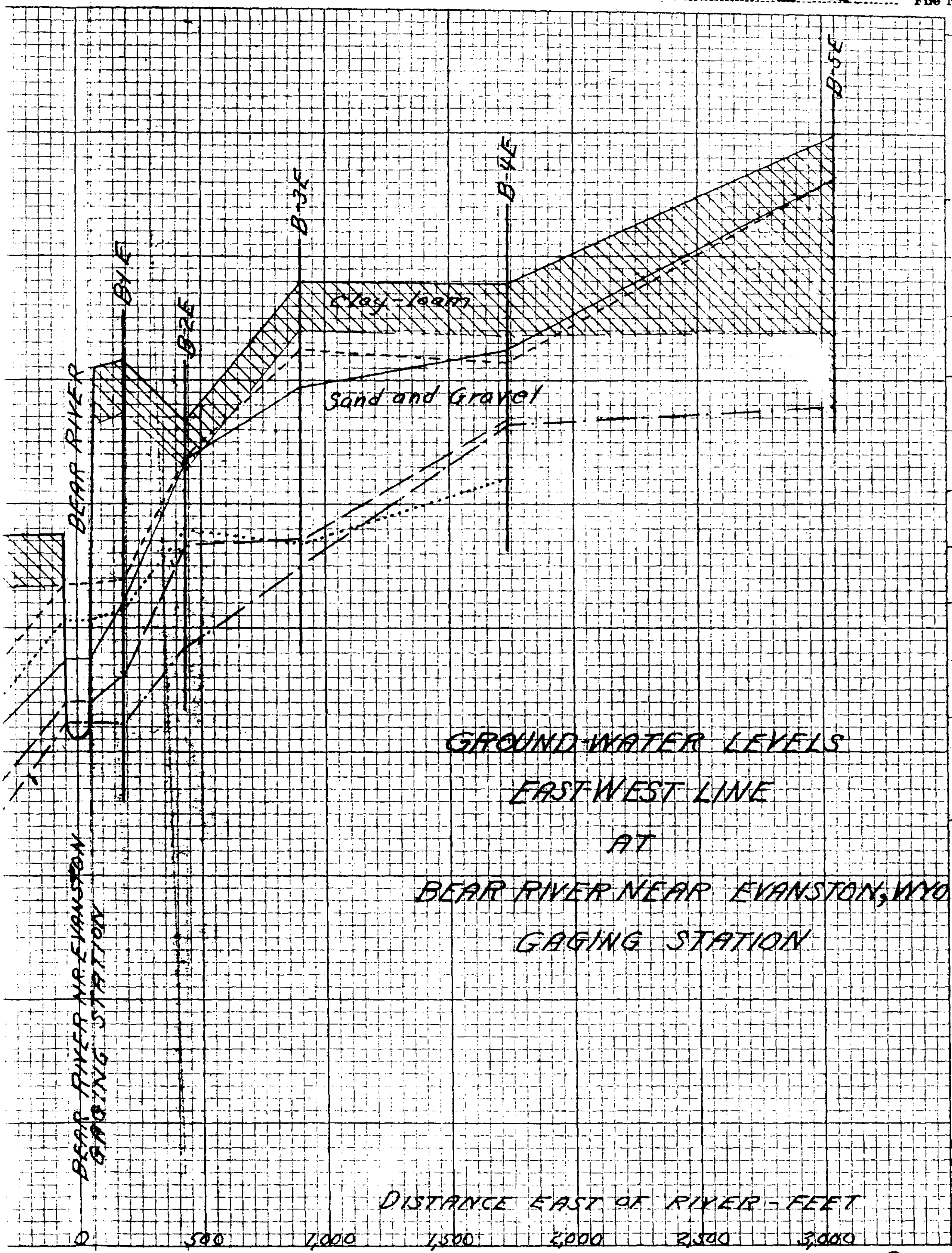

GROUND-WATER LEVELS
NORTHEAST-SOUTHWEST LINE
AT
BEAR RIVER NEAR MILLIS, WYO.
GAGING STATION
A-1
A-2
A-3
BEAR RIVER
Clay loam
nd Coarse gravel
800
600
400
200
0

UNITED STATES DEPARTMENT OF THE INTERIOR—GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

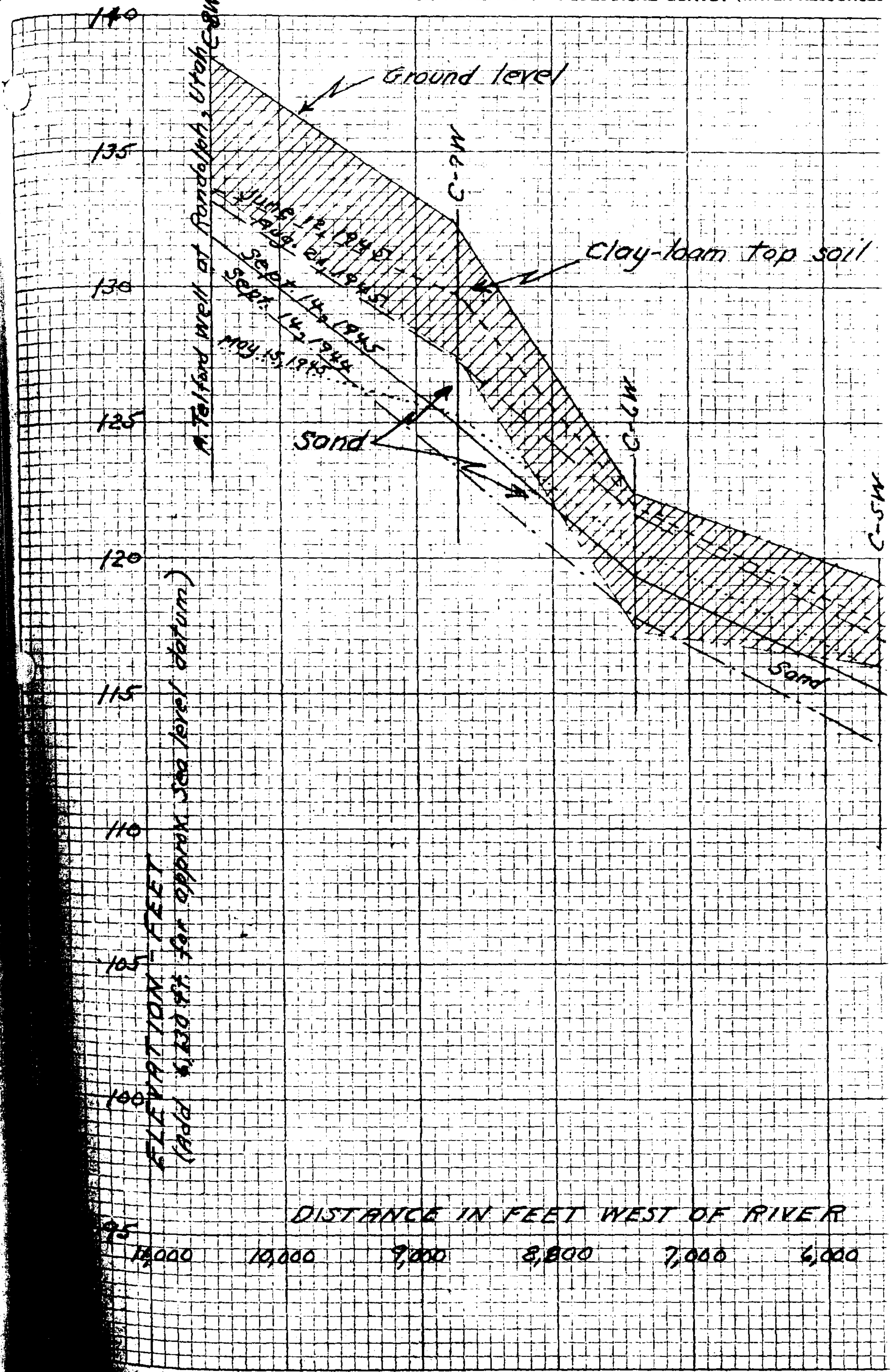


DISCHARGE IN SECOND-FEET

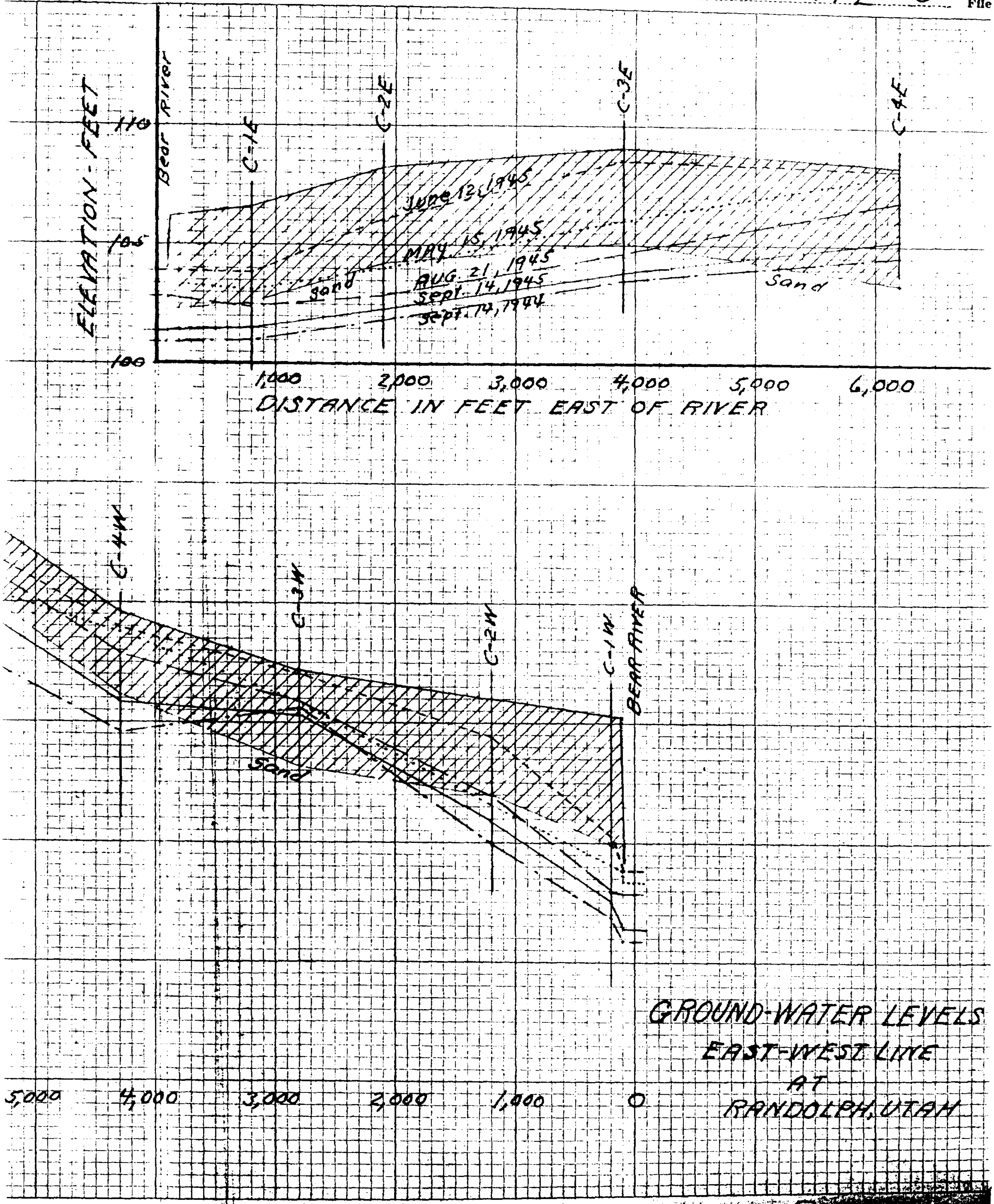
PLATE 2



GROUND-WATER LEVELS
EAST-WEST LINE
AT
BEAR RIVER NEAR EVANSTON, WYO
GAGING STATION
B-1E
B-2E
B-3E
B-4E
B-5E
Clay-loam
Sand and Gravel
BEAR RIVER
BEAR RIVER NR. EVANSTON GAGING STATION
DISTANCE EAST OF RIVER - FEET
0
500
1,000
1,500
2,000
2,500
3,000



DISCHARGE IN SECOND-FEET



GROUND-WATER LEVELS
EAST-WEST LINE
AT
RANDOLPH, UTAH

GENERAL DISCUSSION OF CONSUMPTIVE USE IN THE UPPER BASIN

As previously defined, the valley consumptive use is the sum of valley stream flow depletion and precipitation on the surface, considering ground-water and soil moisture supplies and changes as negligible. Hedke, Blaney, Criddle and other investigators, have made extensive studies and devised empirical equations showing the relation between available heat and crop consumption. These equations may well be utilized in testing the computed valley consumptive uses as determined for consistency and to explain the season to season variations in the stream flow depletions.

For this comparison the Blaney-Criddle method has been selected with factors limited to meet the conditions and data available. For the purpose of this study the equation is expressed mathematically and defined as follows:

$$U = K F$$

U = Valley consumptive use $K = \frac{U}{F}$

= Stream flow depletion + precipitation

F = Sum of monthly use factors

= Sum of the products of the mean monthly temperature and monthly percent of annual daytime hours for that portion of the "irrigation-growing period" beginning May 1 or the day following extreme freezing temperatures, whichever is the later and the day irrigation ceases plus 14 days, or the day of the first extreme frost in the fall, whichever is the earlier. WVI defin

K = Valley coefficient for irrigation period

t = Mean monthly temperatures in degrees Fahrenheit

p = Monthly percent of daylight hours of the year

f = $\frac{t \times p}{100}$ - Monthly consumptive use factor

k = Monthly valley coefficient

u = k f = Monthly consumptive use

The lands in the upper basin are all situated between 41 degrees 10 minutes and 42 degrees 10 minutes latitude. The monthly percent of daylight hours of the year corresponding to 42 degrees latitude, which can be used as an average are as follows:

Month	Percent
May	10.14
June	10.21
July	10.35
August	9.62
Sept.	8.40

The Weather Bureau maintains climatological stations in the upper basin at Evanston, Wyoming; Woodruff, Utah; Sage, Wyoming and Border, Wyoming. The precipitation and temperature records for some of these, especially the Evanston station may not be representative of the entire valley area in which they are located. However, it is believed that comparative results will be obtained if the Evanston station is used for the upper Wyoming section; the Woodruff station for the Woodruff-Randolph section; and an average of the Sage and Border stations for the Randolph to Border section.

The crops in the separate State sections above Bear Lake are practically the same sofar as the river bottom lands, which make up the major portion are concerned, being principally native grasses and wild hay. For these perennial type of crops, growth starts as soon as the maximum temperature stays well above freezing and growth continues throughout the season in spite of later freezes. Some of the water users in the basin begin applying water early in the spring before any growth starts. However, it has been observed that this is practiced only by a few and most of the water users do not begin applying water until after extreme freezing stops, which is usually after May 1. Streamflow normally does not begin to increase much until after the extreme freezing ceases and the available supply is not sufficient for many to adopt the practice of early irrigation.

In the upper areas of the Bear River basin the pattern of runoff has very definite effect on the length of the period during which water can be diverted for irrigation. In 1946 the river rose rapidly after May 1 and had receeded to practically zero by the end of June, the period of irrigation being thus limited to about 60 days. In other years the supply lasted 15 to 30 days longer.

The pattern of flow in Smiths Fork is considerably different from that of the main river. This stream has a considerably steadier flow and maintains a substantial supply throughout the irrigation season. Consequently, lands under this stream usually continue to divert water late in the irrigation season.

In the application of the consumptive use equation it is necessary to define the irrigation-growing period during which consumptive use occurs as limited by growth retarding or growth killing temperatures and irrigation supply. The following general rules have been devised as being applicable to the several river sections, consistent with the application of the equations and the time that general irrigation can be said to be over in relation to dwindling supply.

Upper Wyoming Section.- The "irrigation-growing period" is that portion of the period May 1 to September 30, beginning May 1 or the day following extreme freezing temperatures, whichever is the later and the day the discharge at the Bear River near Utah-Wyoming State line gaging station falls below 100 cubic feet per second plus 14 days, or the day of the first extreme frost in the fall, whichever is the earlier.

Woodruff-Randolph Section.- The "irrigation-growing period" is that portion of the period May 1 to September 30, beginning on May 1 or the day following extreme freezing temperatures, whichever is the later and the day the discharge at the Bear River near Woodruff gaging station falls below 100 cubic feet per second plus 14 days, or the day of the first extreme frost in the fall, whichever is the earlier.

Randolph to Border Section.- It is difficult to set up a definition of irrigation-growing period for this section due to the over-lapping of areas irrigated from the river and from Smiths Fork. The lands irrigated from Bear River above the mouth of Smiths Fork usually cease irrigation about July 5. The lands irrigated from the river below Smiths Fork stop irrigating about mid July, and after completion of haying turn on again for irrigation of the hay lands for pasture. Lands irrigated from Smiths Fork draw water throughout the season. As a rough estimate, about fifty percent of the lands are on the May 1 to July 5 schedule while the other fifty percent divert water throughout the irrigation season. There are large areas of swamp lands south of Cokeville in which the water stands at practically the ground surface or in tule filled ponds throughout the year. These conditions considerably complicate the determination of the consumptive use factor.

UPPER WYOMING SECTION

General Characteristics

The Upper Wyoming Section consists of the irrigated lands in the main river valley extending upstream from Woodruff Narrows to the mouth of West Fork; the tributary valley of Mill Creek from its mouth to the Utah-Wyoming State line; the portion of the Sulphur Creek drainage included in Hilliard Flats and the irrigated lands on Willow Creek; and the irrigated land on Yellow Creek from its mouth upstream to the mouth of Spring Creek in sec. 32, T. 5 N., R. 8 E., Salt Lake Meridian.

The 36,000 acres of irrigated lands in this section can be best segregated and described as follows:

1. Bear River and Mill Creek bottom lands between the Utah-Wyoming State line and Myers Narrows comprising approximately 9,400 acres. These lands are situated between 7,200 feet and 7,800 feet elevation. The river falls at a rate of about 35 feet per mile. The top soil is generally quite shallow, being underlain with cobbles and gravel. There are considerable areas of quaking aspen, willow and cottonwoods, in the upper areas of Mill Creek. Heavy growths of willow and cottonwoods line the river and Mill Creek channels. Bottom lands are principally devoted to irrigated pastures and native hay. There are some small areas of alfalfa.

2. Hilliard Flats and Willow Creek irrigated areas comprising approximately 10,900 acres.

   These lands are situated between 7,200 feet and 7,700 feet elevation. There is very little willow or tree growth on the Hilliard Flats and the land is devoted largely to irrigated pasture, although considerable wild hay is also raised. The Willow Creek irrigated lands are more rolling with hay lands in the bottom areas and pasture lands on the rolling hills.

3. Bear River bottom lands and bench lands between Myers Narrows and Woodruff Narrows embracing about 14,800 acres of irrigated lands.

   This long narrow valley is between 6,400 feet and 7,100 feet elevations. Heavy willow and cottonwood growths line the river channel. The bottom lands are devoted to irrigated pastures and wild hay while some alfalfa is raised on the bench lands, which have satisfactory drainage. The river falls at a rate of about 26 feet per mile between Myers Narrows and Evanston and at about 9 feet per mile between Evanston and Woodruff Narrows.

4. Yellow Creek irrigated bottom lands consisting of about ~~900~~ 1000 acres.

   The elevation of these lands range between 6,700 feet and 7,000 feet elevation. The soil along Yellow Creek is quite clayey. Due to the low open hills making up the headwaters of this stream, runoff occurs early and the supply decreases to practically nothing by mid June.

Inflow, Outflow and Depletion

There are 870 square miles in the drainage basin above Woodruff Narrows. Of this total area approximately 56 square miles are under irrigation. Gaging stations located on Bear River, Mill Creek, Sulphur Creek and Yellow Creek, the principal inflow sources, record the inflow from approximately 400 square miles. Surface runoff during the May to September period from the remaining 414 square miles is quite small. A measure of this is indicated in the runoff records of Coyote Creek, which is representative of the 415 square miles, and on which records were obtained in 1943 to 1945. This stream has a drainage area of 25 square miles and had a runoff per square mile during the May to September period in 1943 of 2.4 acre-feet in 1944 of 8.0 acre-feet, and in 1945 of 0.5 acre-feet. This would amount to only 1.9 percent of the total measured inflow in 1944 and 0.1 percent in 1945, however, adjustments which includes this ungaged inflow are later explained.

The supply from the Bear River source is that recorded at the Bear River near Utah-Wyoming State line gaging station and the Hilliard East Fork Canal gaging station. The supply from the Mill Creek source is equal to that recorded at the Mill Creek near Evanston gaging station plus the Hilliard Mill Creek Canal, Goodman-Cunnington Canal, and John Goodman Canal gaging stations, which divert above the main creek station. The supply from Yellow Creek is that recorded at the Yellow Creek near Evanston gaging station.

The supply from Sulphur Creek source is taken as that recorded at the Sulphur Creek near Evanston gaging station. Gaging stations were maintained on Sulphur and Willow Creeks above diversions only in 1945. Between the sites of these stations and the Sulphur Creek near Evanston gaging station considerable inflow occurs, a portion of which consists of return flow from Bear River and Mill Creek waters applied in irrigation on Hilliard Flats. As the return flow is known to be relatively small compared to the total flow at the Sulphur Creek near Evanston station it is believed more accurate to use that station as a measure of the Sulphur and Willow Creek supplies than to attempt to estimate supplies above diversions and adjust for the intermediate runoff.

Records of discharge were not collected at all of the inflow stations in 1946 and 1947. Coefficients based on 1944 and 1945 records are used to convert runoffs of various key stations into total inflow for 1946 to 1949.

The average time interval for movement of moderate and high flows from the inflow stations to the outflow stations is about two days. Allowance is made for this by using calendar month runoffs for the inflow stations and a lag of two days in computing monthly runoffs at the outflow stations.

Computation of Depletion in Upper Wyoming Section

The following Tables 1 to 6 show the computations of inflow, outflow and stream flow depletions in the Upper Wyoming section for the years 1944 to 1949.

TABLE 1

UPPER WYOMING SECTION

Stream Flow Depletion Acre-Feet - 1944

	May	June	July	Aug.	Sept.	Total
Bear R. nr. Ut.-Wyo. St. Line	42,790	58,460	23,990	3,870	2,090	131,200
Hilliard East Fk. Canal	0	0	536	551	273	1,360
Total Bear River	42,790	58,460	24,526	4,421	2,363	132,560
Mill Creek nr. Evanston	9,740	8,850	988	382	265	20,225
Hilliard Mill Creek Canal	155	1,183	543	0	0	1,881
Goodman Cunnington Canal	0	119	95	22	0	236
John Goodman Canal	13	24	98	28	30	193
Total Mill Cr.Ut.St.Line	9,908	10,176	1,724	432	295	22,535
Sulphur Creek near Evanston	7,020	2,930	392	48	24	10,414
Yellow Creek near Evanston	3,520	733	76	13	12	4,354
Total Inflow	63,238	72,299	26,718	4,914	2,694	169,863
Bear River nr. Woodruff	66,710	56,760	9,300	52	0	132,822
Chapman Canal at St. Line	960	4,342	653	0	0	5,955
Total Outflow	67,670	61,102	9,953	52	0	138,777
Depletion	-4,432	11,197	16,765	4,862	2,694	31,086

TABLE 2

UPPER WYOMING SECTION

Stream Flow Depletion Acre-Feet - 1945

	May	June	July	Aug.	Sept.	Total
Bear R. nr. Ut.-Wyo. St. Line	32,690	40,110	22,490	8,890	4,200	108,380
Hilliard East Fk. Canal	0	642	1,371	1,027	499	3,539
Total Bear River	32,690	40,752	23,861	9,917	4,699	111,919
Mill Creek nr. Evanston	6,690	5,970	1,790	1,460	685	16,595
Hilliard Mill Creek Canal	505	814	26	81	8	1,434
Goodman Cunnington Canal	102	173	73	1	0	349
John Goodman Canal	290	247	75	55	20	687
Total Mill Cr.Ut.St.Line	7,587	7,204	1,964	1,597	713	19,065
Sulphur Creek near Evanston	2,680	2,520	1,040	1,350	165	7,755
Yellow Creek near Evanston	1,370	501	43	79	0	1,993
Total Inflow	44,327	50,977	26,908	12,943	5,577	140,732
Bear River nr. Woodruff	38,350	35,510	8,910	8,570	2,250	93,590
Chapman Canal at St. Line	1,996	3,852	1,338	621	86	7,893
Total Outflow	40,346	39,362	10,248	9,191	2,336	101,483
Depletion	3,981	11,615	16,660	3,752	3,241	39,249

TABLE 3

UPPER WYOMING SECTION

Stream Flow Depletion Acre-Feet - 1946

	May	June	July	Aug.	Sept.	Total
Bear R. nr. Ut.-Wyo. St. Line	38,940	35,670	8,930	3,640	2,350	89,530
Hilliard East Fk. Canal	170	1,040	996	510	285	3,001
Mill Creek nr. Evanston	6,990	3,410	842	610	413	12,265
Sulphur Creek nr. Evanston	2,040	567	198	55	41	2,901
Total	48,140	40,687	10,966	4,815	3,089	107,697
Coefficient for Total Inflow	1.06	1.03	1.02	1.01	1.01	1.035
Total Inflow (Unadj.)	51,000	41,900	11,150	4,860	3,130	111,200
Total Inflow (Adj.)	50,500	41,600	11,130	4,850	3,120	111,200
Bear River near Woodruff	39,390	21,060	380	20	0	60,850
Chapman Canal at State Line	2,935	2,558	2	0	0	5,495
Total Outflow	42,325	23,618	382	20	0	66,345
Depletion	8,175	17,982	10,748	4,830	3,120	44,855

TABLE 4

UPPER WYOMING SECTION

Stream Flow Depletion Acre-Feet - 1947

	May	June	July	Aug.	Sept.	Total
Bear R. nr. Ut.-Wyo. St. Line	55,570	52,190	23,510	6,480	3,270	141,020
Hilliard East Fork Canal	0	470	1,408	986	632	3,496
Mill Creek near Evanston	11,100	6,490	979	747	577	19,893
Sulphur Creek near Evanston	3,570	5,610	1,040	1,030	98	11,348
Total	70,240	64,760	26,973	9,243	4,577	175,757
Coefficient for Total Inflow	1.06	1.03	1.02	1.01	1.01	1.035
Total Inflow (Unadj.)	74,500	66,600	27,500	9,330	4,620	182,000
Total Inflow (Adj.)	74,200	66,400	27,450	9,330	4,620	182,000
Bear River near Woodruff	59,980	53,410	11,400	2,916	1,177	128,883
Chapman Canal at State Line	4,197	3,499	0	44	30	7,770
Total Outflow	64,177	56,909	11,400	2,960	1,207	136,653
Depletion	10,023	9,491	16,050	6,370	3,413	45,347

TABLE 5

UPPER WYOMING SECTION

Stream Flow Depletion Acre-Feet - 1948

	May	June	July	Aug.	Sept.	Total
Bear R. nr. Ut.-Wyo. St. Line	51,810	34,410	6,150	3,380	1,890	97,640
Hilliard East Fork Canal	0	966	946	310	24	2,246
Mill Creek near Evanston	10,410	2,650	541	364	249	14,214
Sulphur Creek near Evanston	3,740	1,230	128	24	13	5,135
Total	65,960	39,256	7,765	4,078	2,176	119,235
Coefficient for Total Inflow	1.06	1.03	1.02	1.01	1.01	1.035
Total Inflow (Unadj.)	70,000	40,500	7,850	4,120	2,200	123,600
Total Inflow (Adj.)	69,600	40,300	7,780	4,120	2,200	124,000
Bear River near Woodruff	61,080	21,930	249	10	0	83,269
Chapman Canal at State Line	2,720	2,208	3	0	0	4,931
Total Outflow	63,800	24,138	252	10	0	88,200
Depletion	5,800	16,162	7,528	4,110	2,200	35,800

TABLE 6

UPPER WYOMING SECTION

Stream Flow Depletion Acre-Feet - 1949

	May	June	July	Aug.	Sept.	Total
Bear R. nr. Ut.-Wyo. St. Line	34,630	51,240	15,750	4,710	2,570	108,900
Hilliard East Fork Canal	109	1,299	1,200	347	99	3,054
Mill Creek near Evanston	(No record May to Sept., runoff, 14.6% of Bear River)					15,900
Sulphur Creek near Evanston	3,080	1,980	1,040	73	47	6,220
Total	-	-	-	-	-	134,074
Coefficient for Total Inflow	-	-	-	-	-	1.035
Total Inflow (Unadj.)	-	-	-	-	-	139,000
Total Inflow (Adj.)	-	-	-	-	-	139,000
Bear River near Woodruff	45,350	42,710	7,530	119	125	95,834
Chapman Canal at State Line	5,623	3,881	584	20	0	10,108
Total Outflow	50,973	46,591	8,114	139	125	105,942
Depletion	-	-	-	-	-	33,058

Water Diverted for Irrigation

Records were collected on canals diverting from the m[illegible] Bear River during the irrigation season for the years 1944 to 19[illegible] also for canals diverting from the tributaries in 1944 and 1945.

Table VII shows the May to September diversions in acre-feet and in acre-feet per acre of the Bear River Canals. The total water diverted from tributaries are also shown.

Figures given for Chapman Canal include only Wyoming lands and water diverted to Wyoming lands.

TABLE 7

Irrigation Diversion in Upper Wyoming Section

NAME OF CANAL	Acres Irrig.	DIVERTED ACRE-FEET May to Sept.				ACRE-FEET PER ACRE			
Bear River Canals	(a)	1944	1945	1946	1947	1944	1945	1946	1947
Hilliard East Fork (b)	2,644	1,360	3,539	3,001	3,496	.51	1.34	1.14	1.32
Lannon	936	1,400	2,588	2,592	2,371	1.50	2.76	2.77	2.53
Hilliard West Side	2,072	3,204	2,907	4,028	2,589	1.54	1.40	1.94	1.25
Bear	4,753	7,627	8,086	6,140	10,174	1.60	1.70	1.29	2.14
Tropic	584	168	287	456	441	.29	.49	.78	.76
Danielson	400	1,302	1,708	1,124	2,215	3.26	4.27	2.81	5.54
Pine Grove	2,236	4,438	3,735	4,206	4,348	1.98	1.67	1.88	1.94
McGraw & Big Bend	1,013	2,535	5,476	5,577	5,922	2.50	5.41	5.51	5.85
Homer	107	331	646	813	870	3.09	6.04	7.60	8.13
Lewis	822	460	1,356	1,466	1,473	.56	1.65	1.78	1.79
Lewis & Blanchard	207	719	822	1,197	824	3.47	3.97	5.78	3.98
Myers No. 2	654	1,102	2,932	963	1,788	1.69	4.48	1.47	2.73
Hare	151	1,617	1,440	1,429	1,240	10.71	9.54	9.46	8.21
Coffman	234	973	1,564	1,033	1,420	4.16	6.69	4.41	6.07
Knoder	194	346	872	599	412	1.78	4.49	3.09	2.12
Myers No. 1	258	592	704	199	426	2.29	2.73	.77	1.65
Myers Irrigation	232	1,535	1,710	1,572	1,050	6.62	7.37	6.78	4.53
Booth	800	299	613	1,115	1,381	.37	.77	1.39	1.73
Anel	332	2,081	2,185	1,753	1,264	6.27	6.58	5.28	3.81
Corneilson	76	644	2,302	1,833	2,862	8.47	30.29	24.12	37.66
Evanston Water Supply	528	1,611	2,110	1,361	1,965	3.05	4.00	2.58	3.72
Anderson	407	899	841	830	1,037	2.21	2.07	2.04	2.55
Knight No. 1	170	0	479	271	73	-	2.82	1.59	.43
Knight No. 2	270	121	352	241	285	.45	1.30	.89	1.06
Evanston Water	1,527	5,296	5,360	3,873	6,269	3.47	3.51	2.54	4.11
Barton	148	701	756	604	638	4.74	5.11	4.08	4.31
Faulkner	118	1,821	2,322	1,515	1,720	15.43	19.68	12.84	14.58
Rocky Mtn. Blythe	833	3,830	3,012	2,499	2,499	4.60	3.62	3.00	3.00
Fife	20	35	43	27	3	1.75	2.15	1.35	.15
Johnson Narramore	66	37	17	32	92	.56	.26	.48	1.39

TABLE 7 (Cont'd.)

Irrigation Diversion in Upper Wyoming Sec

NAME OF CANAL	Acres Irrig.	DIVERTED ACRE-FEET May to Sept.				[illegible] PER ACRE			
Bear River Canals	(a)	1944	1945	1946	1947	[illegible]	[illegible]	1946	1947
Bruce Barton	196	240	202	266	300	[illegible]	[illegible]	1.36	1.53
A. W. Sims	252	547	978	883	889	[illegible]	[illegible]	3.50	3.53
John Anderson	30	8	41	50	187	[illegible]	[illegible]	1.67	6.23
Crompton No. 2	212	252	718	389	419	[illegible]	[illegible]	1.83	1.98
Fearne	48	653	762	318	517	[illegible]	[illegible]	6.62	10.77
Saxton-Turner	30	142	413	121	276	[illegible]	[illegible]	4.03	9.20
Saxton Irrigation	288	990	1,340	984	3,769	[illegible]	[illegible]	3.42	13.09
John Sims	194	788	1,472	803	792	[illegible]	[illegible]	4.14	4.08
Southern Pacific	288	667	1,201	761	368	[illegible]	[illegible]	2.64	1.28
Heward	72	2,910	219	123	22	[illegible]	[illegible]	1.71	.31
Saxton-Thomas	92	1,260	1,781	1,467	1,527	[illegible]	[illegible]	15.95	16.55
Ramsey	819	2,538	3,565	2,256	3,210	[illegible]	[illegible]	2.75	3.92
Almy	76	1,073	304	252	654	[illegible]	[illegible]	3.32	8.61
Sims, Blythe, Turner	428	681	1,115	690	1,364	1.59	[illegible]	1.61	3.19
Bowns	76	450	377	252	210	5.92	4.96	3.32	2.76
Russell	20	40	109	94	173	2.00	5.45	4.70	8.65
Turner	200	437	600	387	365	2.18	3.00	1.94	1.82
Upper Morris	271	3,417	1,630	1,952	3,459	12.61	6.02	7.20	12.76
Chapman (Wyoming lands)	1,176	3,380	5,906	4,043	4,653	2.88	5.02	3.44	3.96
Lower Morris	1,283	359	385	576	768	.28	.30	.45	.60
Bruce Bowns	364	1,181	1,108	982	2,424	3.24	3.04	2.70	6.66
Tunnel	759	2,096	3,053	1,636	1,976	2.76	4.02	2.16	2.60
Fowkes	237	321	345	183	293	1.35	1.46	.77	1.24
Christensen	161	258	221	260	524	1.60	1.37	1.61	3.25
pper Island	256	644	1,044	853	680	2.52	4.08	3.33	2.66
light Irrigation	616	533	1,342	1,199	1,348	.87	2.18	1.95	2.19
cock & Cowlishaw	287	193	209	768	1,287	.67	.73	2.68	4.48
ower Island	269	1,666	1,700	583	1,238	6.19	6.32	2.16	4.60
ill Creek Canals	d 1,900	e 7,744	e 10,775)	)		3.08	4.85	-	-
ulphur & Willow Creek Canals	d 1,430	e 3,392	e 1,965)	c 14,000)	c 15,000	2.37	1.37	-	-
ellow Cr. Canals	900	5,009	3,509)	)		5.89	3.89	-	-
Totals	36,022	90,953	109,153	89,480	109,839	2.53	3.04	2.48	3.05

) Planimetered on land use maps.
) Includes only supplemental supply from Bear River - Balance obtained from Mill Creek.
) Estimated
) Excludes lands receiving supplemental supply from Bear River
) Includes supplemental supplies for lands also served by Bear River Canals.

Computation of Consumptive Use in Uppe[illegible]

Tables 8 to 12 show the data for and comput[illegible] The precipitation recorded at Evanston, Wyoming is as[illegible] over the irrigated lands and all precipitation between May [illegible] consider- ed as making up the supply from this source.

In the Bear River Hydrometric Data reports graphs are [illegible] the water applied and gain in the section above Woodruff Narrows[1]. These [illegible] are on daily basis, the area between the "total diverted" [illegible] and the "gain," graph would represent the depletion in the section. It is to be noted [illegible] May the gain curve is in most cases higher than the total diverted curve. This is caused by intermediate runoff from melting snow on the irrigated lands present on May 1 and runoff from the ungaged areas in the basin. An approximate adjustment can be determined for such unmeasured supply by sketching on the graphs a probable unaffected gain curve in May and converting the area between this curve and the gain curve into acre-feet. Adjustments determined in this manner are given in Table 10.

TABLE 8

Precipitation at Evanston, Wyoming in Inches

Month	1944	1945	1946	1947	1948	1949
Oct.	1.28	.44	.97	2.94	1.29	.61
Nov.	.15	1.22	2.76	1.08	1.51	1.35
Dec.	.62	.30	.94	.77	1.02	1.50
Jan.	.59	.14	.50	1.50	.71	.91
Feb.	.72	1.33	.63	.87	[illegible]	.55
Mar.	2.16	1.13	1.45	1.54	2.09	.87
Apr.	1.84	1.07	1.60	1.65	2.57	.06
May	1.07	1.37	1.75	1.51	.29	2.03
June	2.28	2.19	.37	4.02	1.53	.71
July	.59	.63	.20	.07	.13	.66
Aug.	00	3.13	.42	.57	[illegible]	.40 **
Sept.	1.45*	.61	.16	1.09	.17	.30 **

* 1.22 inches occurred on Sept. 30 (excluded in consumptive use determinations)

** Estimated on basis of Woodruff, Utah record.

(1) Bear River Hydrometric Data 1944-Plate 100; 1945-Plate 89; 1946-Plate 95; 1947-Plate 92.

TABLE 9

Precipitation Supply in Acre-fee[illegible]

Month	1944	1945	1946	[illegible]	[illegible]	[illegible]
May	3,210	4,110	5,250	[illegible]	[illegible]	[illegible]
June	6,840	6,570	1,110	12,[illegible]	[illegible]	[illegible]
July	1,770	1,890	600	[illegible]	[illegible]	[illegible]980
Aug.	0	9,390	1,260	1,[illegible]	[illegible]	[illegible]
Sept.	690	1,830	480	3,[illegible]	[illegible]	[illegible]900
Total	12,510	23,790	8,700	21,78[illegible]	[illegible]	[illegible],300

TABLE 10

Adjustment for Intermediate Supply - [illegible]cre-Feet

Month	1944	1945	1946	1947	1948	1949
May	11,300	2,400	850	1,800	?	?
June	0	0	0	0	0	0
July	0	0	0	0	0	0
Aug.	0	0	0	0	0	0
Sept.	0	0	0	0	0	0
Total	11,300	2,400	850	1,800	?	?

4530
1800
10020
16350

TABLE 11

Valley Stream Flow Depletions Acre-Feet
(From Tables 1 to 6)

Month	1944	1945	1946	1947	1948	1949
May	-4,430	3,980	8,180	10,020	5,800	-
June	11,200	11,620	17,980	7,490	16,160	-
July	16,760	16,660	10,750	15,050	7,530	-
Aug.	4,860	3,750	4,830	6,370	4,110	-
Sept.	2,690	3,240	3,120	3,410	2,200	-
Total	31,080	39,250	44,860	45,340	35,800	33,060

May 1 to Sept 30

TABLE 12

Valley Consumptive Use in Acre-F
(~~Combined~~ Sum of Tables 9, 10, and 11)

Month	1944	1945	1946	1947	[illegible]	[illegible]
May	10,080	10,490	14,280	16,350	[illegible]	-
June	18,040	18,190	19,090	19,550	[illegible]	-
July	18,530	18,550	11,350	16,260	[illegible]	-
Aug.	4,860	13,140	6,090	8,090	[illegible]	-
Sept.	3,380	5,070	3,600	6,680	[illegible]	-
Total	54,890	65,440	54,410	68,920	44,[illegible]*	[illegible]5,360*

* Does not include adjustment for intermediate runoff [illegible] might have occurred in May.

Irrigation-Growing Period and Available Heat (Consumptive Use Factor)

The day extreme freezing ceases is determined by inspection of daily maximum and minimum temperatures. The exact date is often hard to select because of subsequent low minimum temperatures which may retard, but do not entirely stop the growth of vegetation. The general rule followed is to use the date when minimum temperatures, usually in the twenties, rise above 32 degrees and for the most part remain above freezing. In most years this time is quite evident but in years like 1945 and 1948 considerable low temperatures occur after the dates selected but the maximum daily temperatures were quite high. The selection of the date is more or less one of judgment.

Tables 13 to 16 show irrigation growing-periods, mean monthly temperatures, monthly consumptive use factors and summation of consumptive use factors for the irrigation-growing periods.

TABLE 13

Irrigation-Growing Period

Year	Date following end of hard freezing in spring	Date first hard freezing in fall	Date end of Irrigation: Bear R. at Ut.-Wyo. St. Line drops below 100 c.f.s.	Date end of Irrigation: Date plus 14 days	[illegible] Period: Be[illegible]	[illegible] Period: [illegible]	[illegible] Period: Days
1944	May 8	Sept. 15	Aug. 4	Aug. 18	May [illegible]	[illegible]	103
1945	May 3	Sept. 8	Aug. 28	Sept. 11	May [illegible]	[illegible]	129
1946	May 12	Sept. 18	July 25	Aug. 9	May [illegible]	[illegible]	90
1947	Apr. 28	Sept. 11	Aug. 16	Aug. 30	May [illegible]	[illegible]	122
1948	May 14	Sept. 7	July 12	July 26	May [illegible]	[illegible]	74
1949	May 2	Sept. 12	July 29	Aug. 12	May [illegible]	[illegible]	103

This [illegible] comparable to the 5 months [illegible] which [illegible] computed

TABLE 14

Monthly Percent of Daytime Hours of the Year and Monthly Mean Temperatures in Degrees Fahrenheit at Evanston, Wyoming

Month	Daytime hrs. Monthly Percent p	Mean Monthly Temperatures - t: 1944	1945	1946	1947	1948	1949
May	10.14	49.0	48.7	45.0	49.6	47.5	48.3
June	10.21	52.3	50.6	54.8	50.3	55.0	53.8
July	10.35	61.3	63.2	63.4	61.6	60.6	61.6
Aug.	9.62	60.2	62.1	61.3	59.4	61.1	59.0*
Sept.	8.40	53.4	49.3	52.2	52.9	54.2	52.0*

* Estimated based on temperatures at Woodruff, Utah

TABLE 15

Monthly Consumptive Use Factor = $\frac{t \times p}{100} = F$

Month	1944	1945	1946	1947	1948	1949
May	4.97	4.94	4.56	5.03	4.82	4.90
June	5.34	5.17	5.60	5.14	5.62	5.49
July	6.34	6.54	6.56	6.41	6.27	6.38
Aug.	5.79	5.97	5.90	5.71	5.88	5.68
Sept.	4.49	4.14	4.38	4.44	4.55	4.37
	26.93	26.76	27.00	26.73	27.14	26.82

TABLE 16

Summation of Monthly Consumptive Use
Irrigation-Growing Period

Year	Irrigation-Growing Period Begin	Irrigation-Growing Period End	May	June	July	Total = F
1944	5/8	8/18	3.85	5.34	6.34	19.01
1945	5/3	9/8	4.62	5.17	6.54	23.40
1946	5/12	8/9	2.94	5.60	6.56	16.81
1947	5/1	8/30	5.03	5.14	6.41	22.11
1948	5/14	7/26	2.80	5.62	5.26	13.68
1949	5/2	8/12	4.74	5.49	6.38	18.81

Much shorter period than the 6 months

$K = \frac{U}{F}$ 5 mos. / 100 days

54,890 / 26.93

18.3 / 26.93

TABLE 17

18.5 / 26.9 0.69

Summary Table

Measured

Year	Irrigation-Growing Period Days	Consumptive Use Factor F	Water Applied in Irrigation Ac.-Ft.	Consump. Use Ac.-Ft.	Consump. Use In. per Acre U	Consump. Use Coeff. $K = \frac{U}{F}$
1944	103	19.01	90,953	54,890	18.3	.96
1945	129	23.40	109,153	65,440	21.8	.93
1946	90	16.81	89,480	54,410	18.1	1.08
1947	122	22.11	109,839	68,920	23.0	1.04
1948	74	13.68	-	44,950	15.0	1.10
1949	103	18.81	-	45,360	15.1	.80

.68 5 mo's

111.3 | 18.5

6/51

Graphs of Relation

On Plates 4 to 8 are plotted graphs showing relation between consumptive use and water applied in irrigation, days in irrigation growing period, and consumptive use factor or available heat on valley and acre basis. A graph showing relation of total inflow and total outflow is also shown. It is to be noted that most years are fairly consistant except 1949, which is believed to plot off because of the unmeasured intermediate inflow, which was not taken into account.

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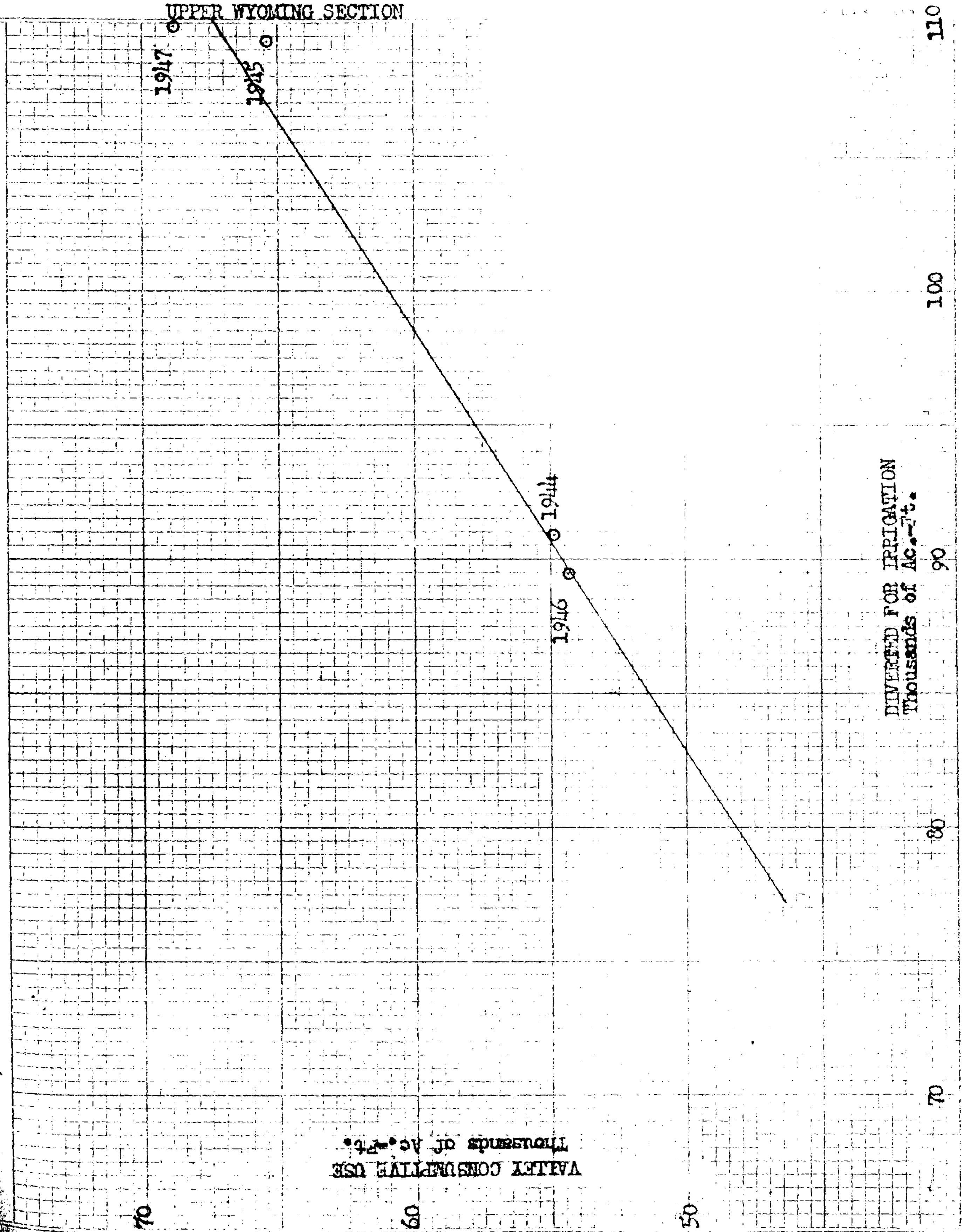
PLATE 4

WATER APPLIED AND VALLEY CONSUMPTIVE USE

UPPER WYOMING SECTION



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WATER RESOURCES BRANCH

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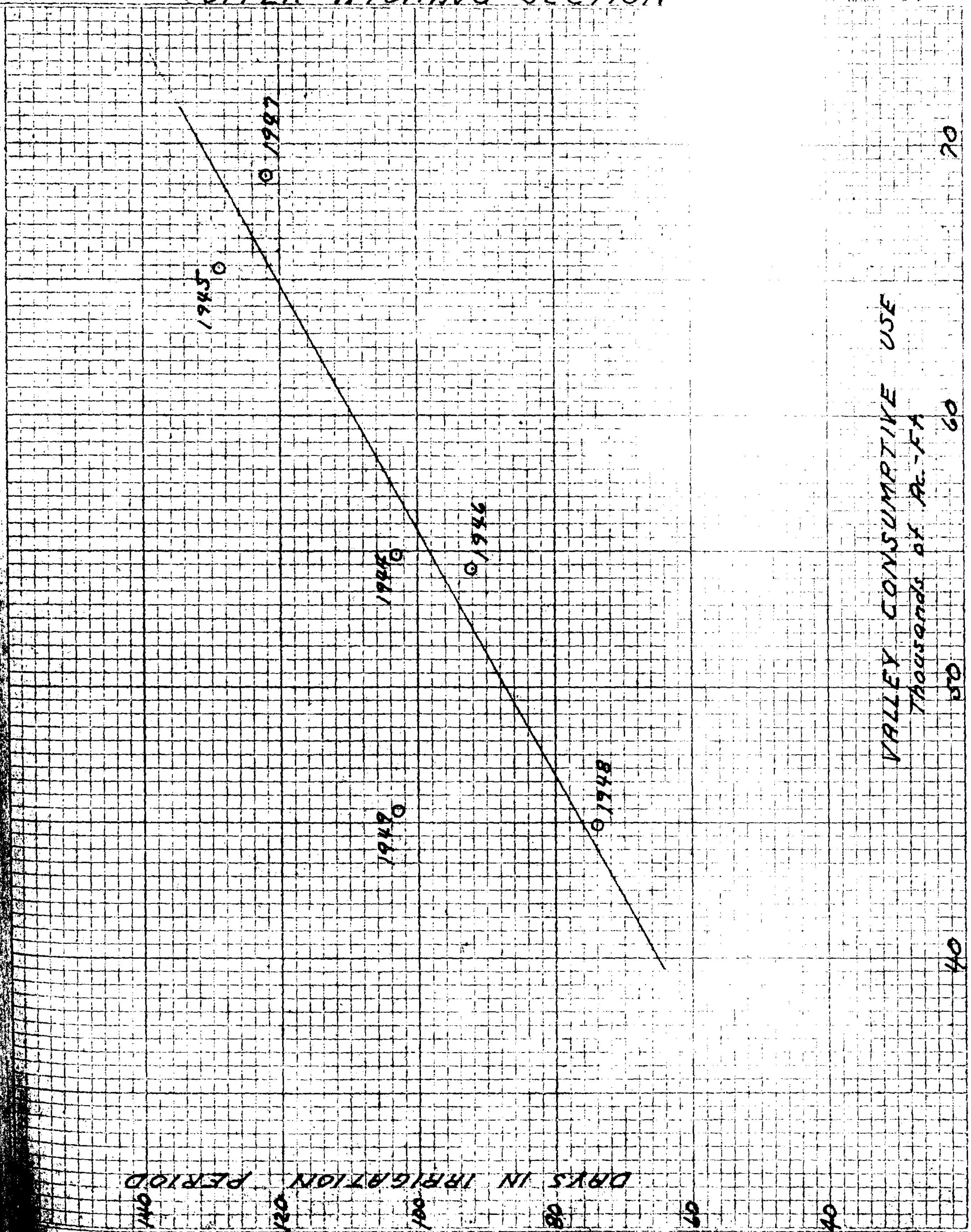
PLATE 5

IRRIGATION-GROWING PERIOD AND CO... ...IVE USE
UPPER WYOMING SECTION



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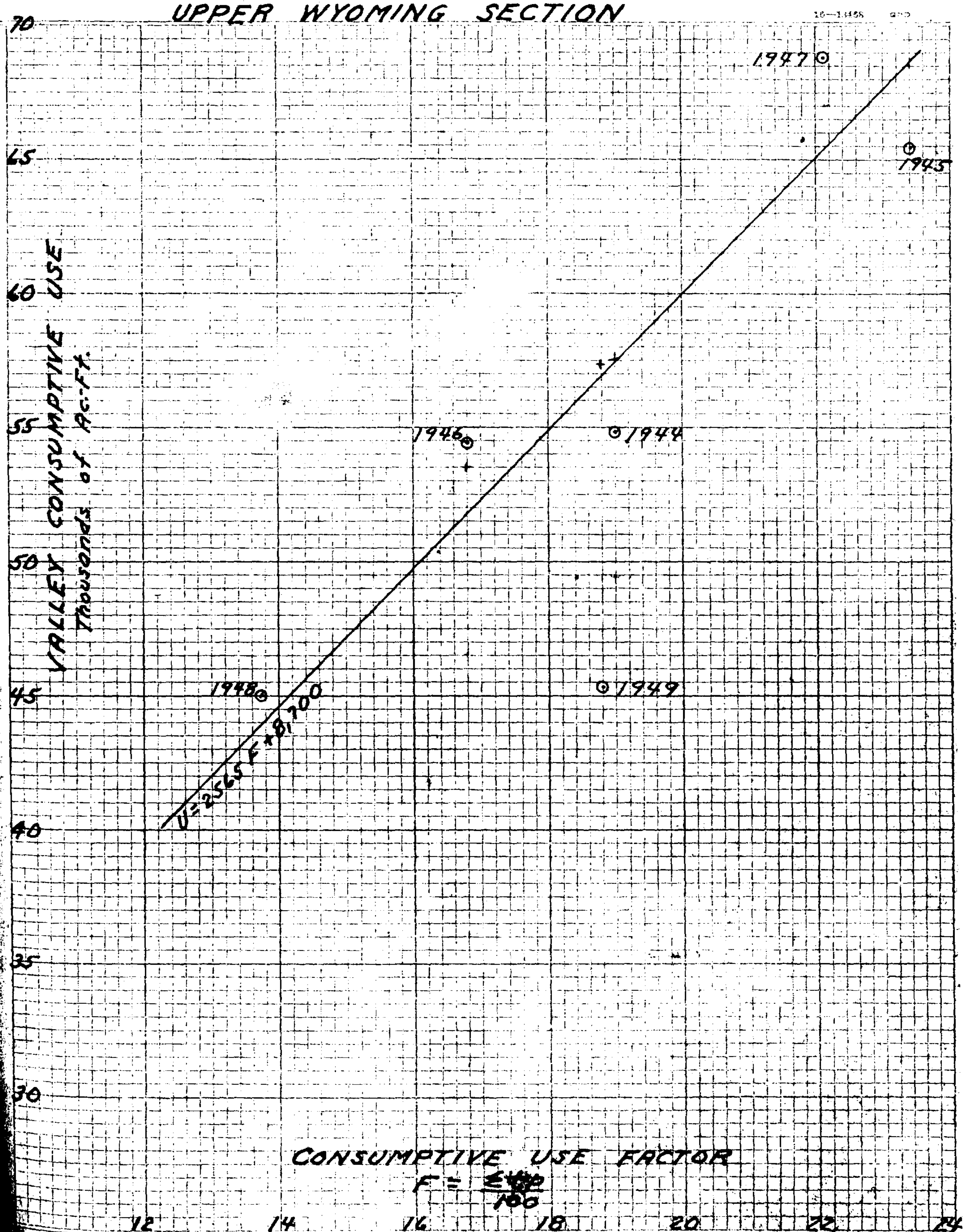
File Number | Washington ______ | District PLATE 6

VALLEY CONSUMPTIVE USE COEFFICIENT

UPPER WYOMING SECTION



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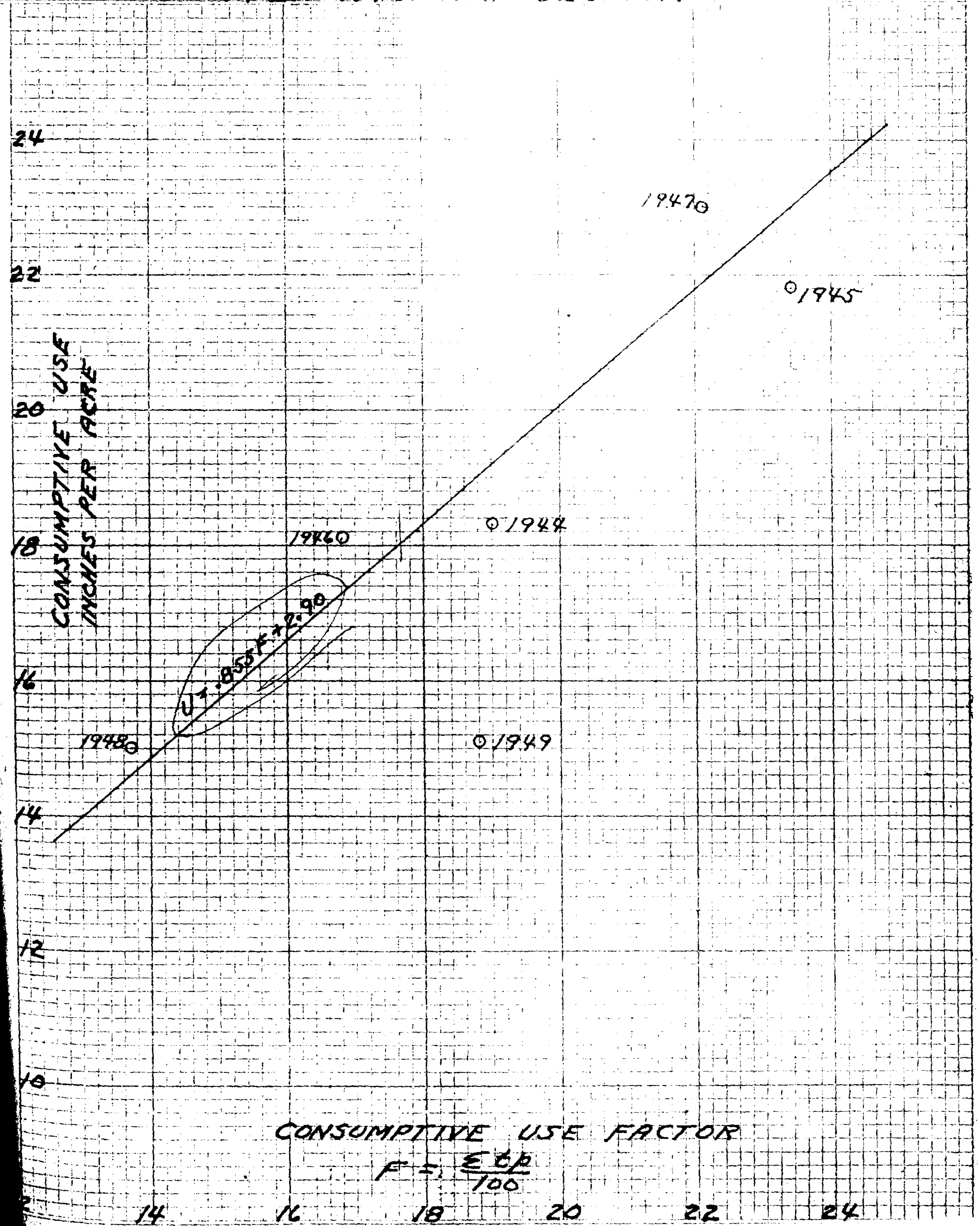
WATER RE[...]

CONSUMPTIVE USE COEFFICIENT PLATE 7
UPPER WYOMING SECTION



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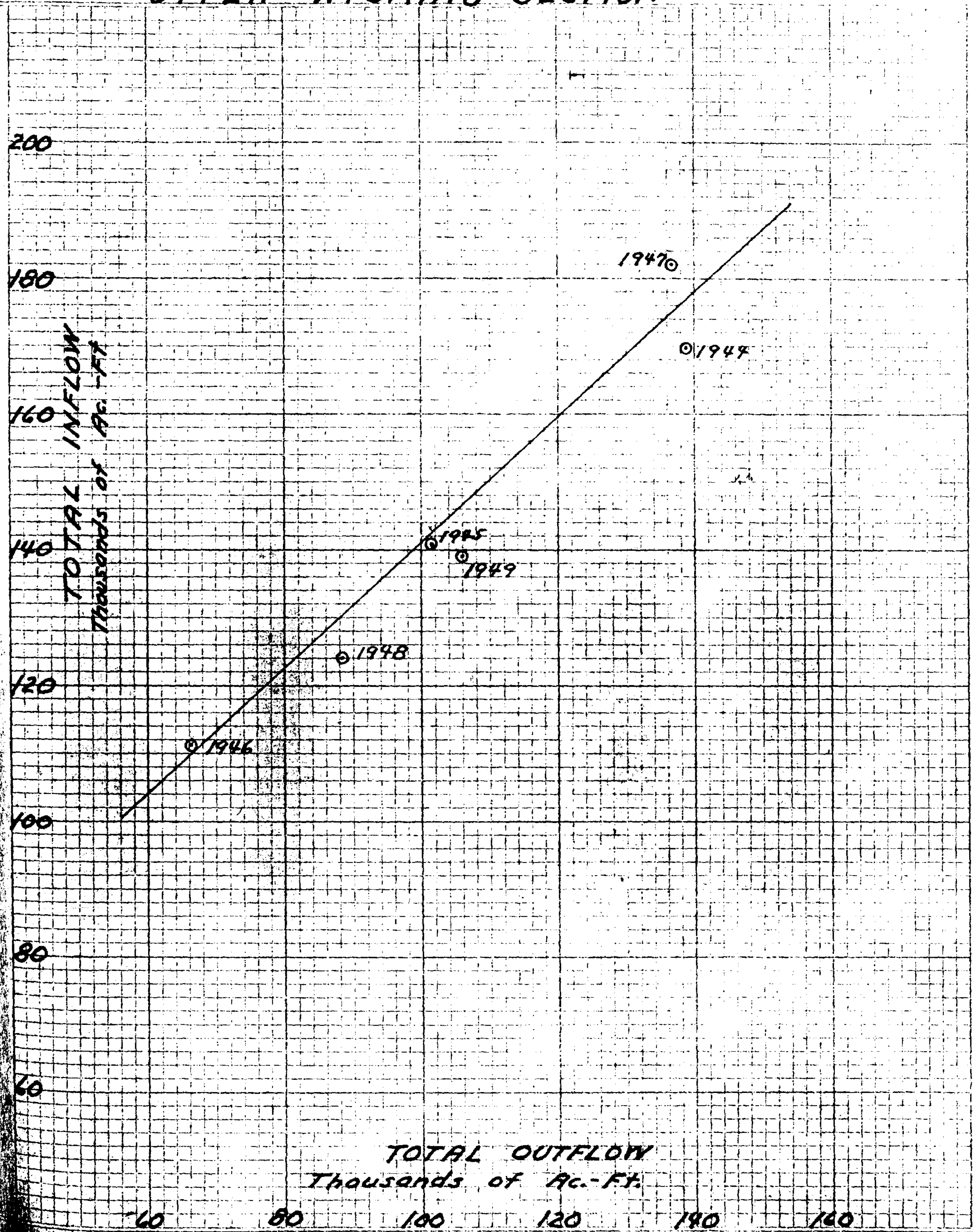
INFLOW - OUTFLOW PLATE 8

UPPER WYOMING SECTION



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BEAR RIVER VALLEY WOODRUFF-RANDOLPH SECTION

General Characteristics

The Woodruff-Randolph section of the Bear River Valley consists of the irrigated lands in the main river valley from Woodruff Narrows downstream to the Randolph control line, which is an east-west line passing through the center of Sec. 7, T. 12 N., R. 8 E., Utah; the irrigated lands in Saleratus basin; and the irrigated lands on Woodruff, Big, Randolph and Otter Creeks.

Excluding the drainage area above Woodruff Narrows there are 770 square miles of drainage tributary to this valley section. Of this total approximately 80 square miles are under irrigation in the valley bottom, about 300 square miles are included in the drainage area of the west side creeks and 390 square miles are low foothill drainage from which there is practically no surface runoff.

The following tabulation shows the approximate acreage irrigated from each source of supply.

Bear River	33,300	acres
Saleratus Basin	7,820	"
Woodruff Creek	5,700	"
Big and Randolph Creeks	2,500	"
Otter Creek	2,500	"
Total	51,820	"

Practically all irrigated lands are situated between 6,220 feet and 6,350 feet elevation. For the most part the top soil is clayey loam from three to five feet in depth. Underlying the top soil is sand and gravel of unknown depth. On the alluvial fans of the tributary streams the top soil grades to sandy loam and in some places is quite shallow and gravely. Some alfalfa is grown on these areas which have greater slope and good drainage. Some of the bottom lands are water logged and produce only coarse swamp grass. As the water table is high during the irrigation season, flushing by heavy a[illegible] to keep the lands from being extremely alkaline.

Stream flow records of inflow and [illegible] this area during the period May to September as follows:

	1944	[illegible]	1946	1947	1948	1949	1950
Inflow							
Bear River nr. Woodruff	x	x	x	x	x	x	x
Chapman Canal at Wyo.-Utah State Line	x	x	x	x	x	x	x
Woodruff Creek	x	x					x
Big Creek	x	x					x
Otter Creek	x	x					x
Outflow							
Bear River near Randolph	x	x	x	x	x	x	x
B.Q. West Side Canal at Control Line	x	x	x	x			x

A gaging station was maintained on Woodruff Creek (sometimes called So. Fork Woodruff) during the years 1938 to 1943, at a site about 5 miles upstream from the mouth of Birch Creek. Flow at that site is practically the same as the flow at the site of the Woodruff Creek gaging station established in the fall of 1949. The 1950 records indicate the total May to September flow of Woodruff Creek and Birch Creek is approximately 115 percent of the flow in Woodruff Creek. In 1944 and 1945 a staff gage station was maintained on Woodruff Creek below the mouth of Birch Creek. Records of this station plus Putnam-Cornia, Cornia No. 2, and Huffaker Canals are equivalent to the total flow of Woodruff and Birch Creeks. On Plate 9 is plotted a correlation curve of total supply from Woodruff and Birch Creeks as computed from the records available and Blacksmith Fork above Utah Power & Light Co's. dam near Hyrum, Utah. While this correlation is admittedly not good, it was the best correlation obtainable from several streams investigated and forms the best basis for determining runoff in 1946, 1947 and 1948.

A gaging station was operated on Big Creek from April 1939 to September 1944 and May to September 1945. This station was below two small diversions. In

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Correlation Curve Blacksmith Fork above U.P.&L.Co. Dam
and Woodruff Creek total supply
May to September Period

16—13168 GPO

PLATE 9

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9-173-A
(October 1939)

UNITED STATES DEPARTMENT OF THE INTERIOR
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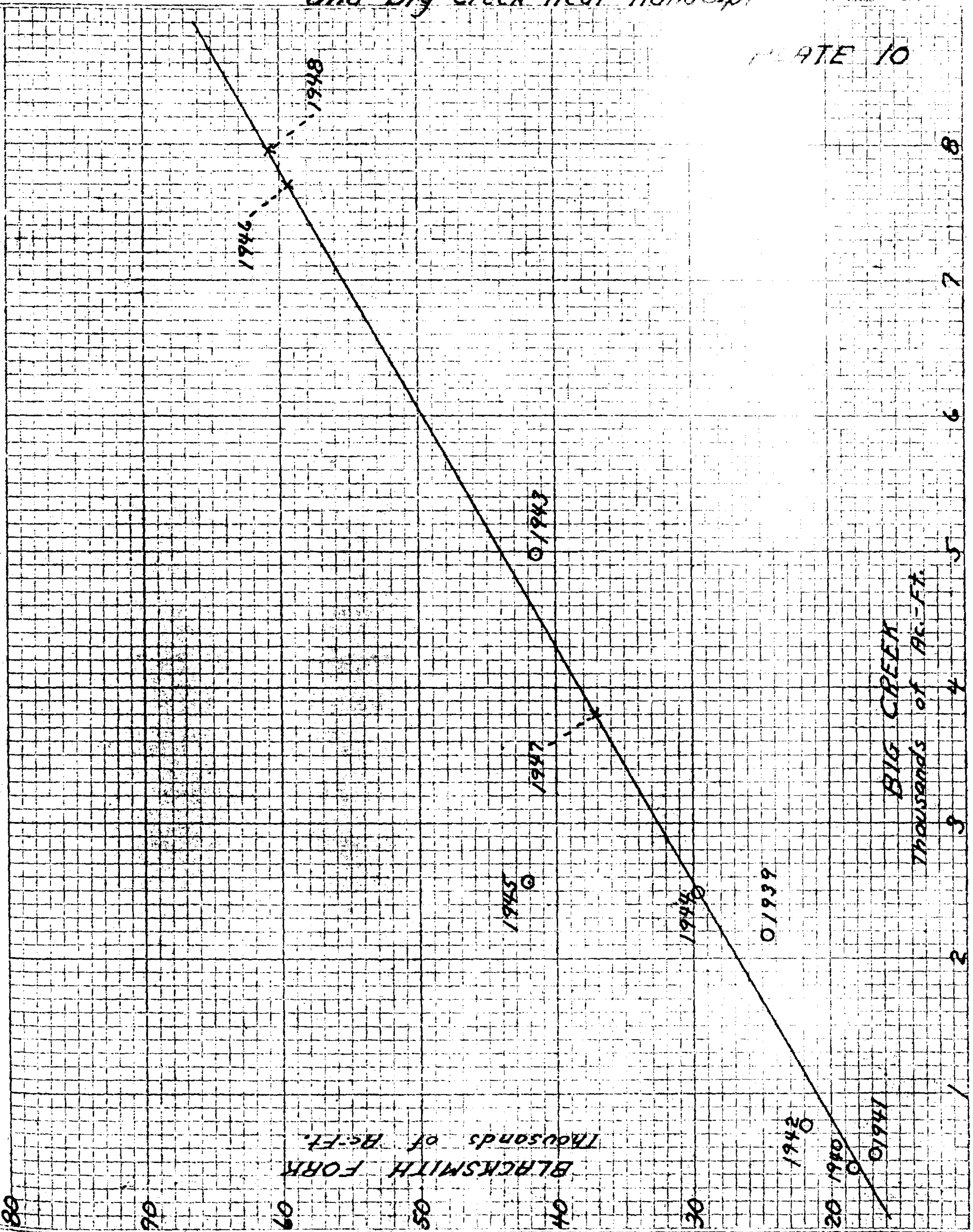
Correlation Curve - Blacksmith Fork above U.P. & L. Dam
and Big Creek near Randolph

PLATE 10



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October 1949 the station was reestablished above the diversions. On Plate 10 is shown a correlation curve of Big Creek and Blacksmith Fork above Utah Power & Light Co's. Dam near Hyrum, Utah. This correlation, like the one for Woodruff Creek, is not good but furnished the best basis for determining runoff in 1946, 1947 and 1948.

Gaging stations were maintained on the outflow from Randolph Creek reservoir in 1944 and 1945. On the basis of these two years of record the runoffs for 1946 and 1947 were estimated.

Irrigated lands extend some distance up each of the three branches of Otter Creek. These streams apparently receive the major portion of their flow from deep seated springs, especially during the May to September period. A study of the discharge at a gaging station below the junction of the three forks, which was operated prior to 1945, and miscellaneous measurements made above diversions, indicate the total supply in the three branches to be close to 12 cubic feet per second. This may be argumented some by surface runoff in good water years, but for the years 1944 to 1947, the average discharge previously noted is considered a reliable figure on which to base runoff.

Salteratus basin is a low drainage area of approximately 200 square miles aralleling the east side of the Wasatch range. Observations made in 1944 and 1945 howed the surface stream flow to be almost negligible. The Wasatch range proably intercepts most of the precipitation from the moisture-bearing winds, which ome predominately from the west, before reaching the drainage basin. Precipitaion is probably very light over the basin, which would account for the apparent ack of runoff. However, the surface precipitation may infiltrate to the groundter table and there may be considerable groundwater movement down the valley. actically all of the supply for irrigation in the basin is derived from Bear ver through the Chapman Canal. During the non-irrigation season water is divert- from the river and stored in Neponset Reservoir. This stored supply is argumented by additional diversion during the irrigation season. In determining the seasonal supply it has been assumed the Neponset Reservoir contained 6,000 acre-feet on May 1 of each year. This 6,000 acre-feet plus the discharge of Chapman Canal at the Utah-Wyoming State line, during the period May to September, is taken as the total seasonal supply for this basin.

The average time interval for movement of moderate and high flows from the inflow stations to the outflow stations is about three days. Allowance is made for this by using calendar month runoffs for the inflow stations and a lag of three days in computing the monthly runoffs at the outflow stations.

The following Tables 18 to 22, show computations of inflow, outflow and stream flow depletions in the Woodruff-Randolph section during the May to September period for the years 1944 to 1948.

TABLE 18
Woodruff Randolph Section
Stream Flow Depletion Acre-Feet - 1944

	May	June	July	Aug.	Sept.	Total
Inflow						
Bear River nr. Woodruff	64,260	59,390	12,150	74	0	135,874
Chapman Canal at Wyo-Ut. St. Line	718	4,310	936	0	0	5,964
Neponset Reservoir	0*	1,313*	4,687*	0*	0*	6,000*
Woodruff Creek	8,518	3,656	976	434	352	13,936
Big Creek	938	520	410	333	344	2,545
Randolph Creek	100	340	475	329	209	1,453
Otter Creek	740*	720*	740*	740*	720*	3,660*
Total inflow	75,274	70,249	20,374	1,910	1,625	169,432
Outflow						
Bear River nr. Randolph	45,350	43,660	8,670	2,430	1,610	101,720
B.Q. West Side Canal at Control Line	4,859	3,760	545	0	0	9,164
Total Outflow	50,209	47,420	9,215	2,430	1,160	110,884
Depletion	25,065	22,829	11,159	-520	15	58,548

*Estimated or computed on basis of partial records and miscellaneous discharge measurements.

TABLE 19
Woodruff Randolph Section
Stream Flow Depletion Acre-Feet - 1945

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Woodruff	37,470	36,480	10,140	7,950	2,220	94,260
Chapman Canal at Wyo.-Ut. State Line	1,789	3,903	1,480	634	86	7,892
Neponset Reservoir	0*	1,790*	4,210*	0*	0*	6,000*
Woodruff Creek	7,395	5,185	1,346	794	584	15,304
Big Creek	665	729	472	480	424	2,770
Randolph Creek	201	243	297	261	177	1,179
Otter Creek	740*	720*	740*	740*	720*	3,660*
Total inflow	48,260	49,050	18,685	10,859	4,211	131,065
Outflow						
Bear River nr. Randolph	13,630	22,860	6,610	8,570	3,790	55,460
B.Q. West Side Canal at Control Line	4,959	3,659	687	3	0	9,308
Total outflow	18,589	26,519	7,297	8,573	3,790	64,768
Depletion	29,671	22,531	11,388	2,286	421	66,297

* Estimated or computed on basis of partial records and miscellaneous discharge measurements.

TABLE 20
Woodruff Randolph Section
Stream Flow Depletion Acre-Feet - 1946

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Woodruff	41,500	22,380	454	31	0	64,365
Chapman Canal at Wyo.-Ut. State Line	2,960	2,710	0	0	0	5,670
Neponset Reservoir	-	-	-	-	-	6,000**
Woodruff Creek	-	-	-	-	-	26,500*
Big Creek	-	-	-	-	-	7,700*
Randolph Creek	-	-	-	-	-	2,000*
Otter Creek	-	-	-	-	-	3,670*
Total inflow	-	-	-	-	-	115,905
Outflow						
Bear River nr. Randolph	34,605	12,220	2,240	2,000	1,760	52,825
B.C. West Side Canal at Control Line	3,910	1,807	135	0	0	5,852
Total outflow	38,515	14,027	2,375	2,000	1,760	58,677
Depletion						57,228

* Computed by correlation curves of runoff, principally Blacksmith Fork.
** Estimated.

TABLE 21
Woodruff Randolph Section
Stream Flow Depletion Acre-Feet - 1947

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Woodruff	58,950	54,110	11,040	2,880	1,200	128,180
Chapman Canal at Wyo.-Ut. State Line	3,980	3,750	0	44	30	7,804
Neponset Reservoir	-	-	-	-	-	6,000**
Woodruff Creek	-	-	-	-	-	15,000*
Big Creek	-	-	-	-	-	3,800*
Randolph Creek	-	-	-	-	-	1,500*
Otter Creek	-	-	-	-	-	3,670*
Total inflow	-	-	-	-	-	167,454
Outflow						
Bear River nr. Randolph	37,580	52,000	9,480	4,390	2,860	106,310
B.Q. West Side Canal at Control Line	6,029	4,901	1,749	178	0	12,857
Total outflow	43,609	56,901	11,229	4,568	2,860	119,167
Depletion						48,287

* Computed by correlation curves of runoff, principally Blacksmith Fork.
** Estimated.

TABLE 22
Woodruff Randolph Section
Stream Flow Depletion Acre-Feet - 1948

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Woodruff	-	-	-	-	-	85,778
Chapman Canal at Wyo.-Ut. State Line	-	-	-	-	-	4,947
Neponset Reservoir	-	-	-	-	-	6,000**
Woodruff Creek	-	-	-	-	-	27,500*
Big Creek	-	-	-	-	-	8,000*
Randolph Creek	-	-	-	-	-	1,500*
Otter Creek	-	-	-	-	-	3,660*
Total inflow	-	-	-	-	-	137,385
Outflow						
Bear River nr. Randolph	-	-	-	-	-	68,616
B.Q. West Side Canal at Control Line	-	-	-	-	-	9,200*
Total outflow	-	-	-	-	-	77,816
Depletion						59,569

* Computed by correlation curves of runoff, principally Blacksmith Fork.
** Estimated.

Water Diverted for Irrigation

Records were collected on canals diverting from the main stem of the river for the years 1944 to 1947 and on canals diverting from the tributary streams in 1944 and 1945.

Table 23 shows the May to September diversions of the Bear River canals in acre-feet and in acre-feet per acre. Total water diverted from the tributaries are also shown.

Figures given for Chapman Canal and Neponset Reservoir are for Utah lands, for which there is estimated to be an annual supply of 6,000 acre-feet from Neponset Reservoir plus May to September discharge of Chapman Canal at Wyoming-Utah State line gaging station. The B.Q. West Side Canal delivers water to 3,809 acres north of the Randolph control line. These deliveries amounted to 9,547 acre-feet in 1944, 9,465 acre-feet in 1945, 6,077 acre-feet in 1946, and 13,304 acre-feet in 1947. With these adjustments applied to the totals of Table 23, the following tabulation shows the irrigation water applied in the Woodruff-Randolph section.

Water Applied in Acre-Feet

Total Acreage	1944	1945	1946	1947
51,819	124,704	137,734	116,572	131,579

TABLE 23

Irrigation Diversions in Woodruff-Randolph Sectio

NAME OF CANAL OR STREAM	Acres Irrig. (a)	DIVERTED ACRE-FEET May to Sept. 1944	1945	1946	1947	ACRE-FEET PER ACRE 1944	1945	1946	1947	1950
Francis Lee	673	4,090	5,836	3,346	5,389	6.08	8.67	4.97	8.01	7.05
Bear River	1,838	7,247	8,474	5,079	8,526	3.94	4.61	2.76	4.64	5.18
Neville	~~[illegible]~~	0	0	0	~~0~~					
Rees Land & Livestock	412	3,347	4,506	2,004	3,289	8.12	10.91	4.86	7.98	13.6[illegible]
Booth	307	1,288	1,074	814	3,154	4.20	3.50	2.65	10.27	10.[illegible]
Randolph-Woodruff	9,550	26,459	29,932	19,676	31,616	2.77	3.01	2.06	3.31	2.73
Crawford-Thompson	5,635	12,941	17,323	11,094	14,028	2.30	3.08	1.97	2.49	3.37
Dykens	1,298	2,824	1,820	1,683	4,070	2.18	1.40	1.30	3.14	6.15
Randolph-Sage Creek	9,380	15,970	13,140	10,518	15,853	1.70	1.40	1.12	1.69	1.61
McMinn	1,382	4,200	1,160	621	2,588	3.04	.84	.45	1.87	1.47
Enberg	820	2,314	1,955	1,436	1,806	2.82	2.38	1.75	2.20	1.78
B.Q. West Side	5,813	19,620	25,007	14,413	16,343	3.38	4.38	2.48	2.81	3.71
Chapman Canal and Neponset Reservoir (Utah Lands)	7,820	11,964	13,892	11,670	13,804	1.53	1.78	1.49	1.77	
Woodruff Creek (c)	b 5,700	13,936	15,304	26,500	15,000	2.45	2.68	4.65	2.64	
Big and Randolph Creeks (c)	b 2,500	3,998	3,949	9,900	5,300	1.60	1.58	3.96	2.22	
Otter Creek (c)	b 2,500	3,670	3,670	3,670	3,670	1.43	1.43	1.43	1.43	
Totals	55,628	133,868	147,042	122,424	144,436	2.40	2.64	2.20	2.60	

37,108

(a) Planimetered on land use maps except as noted.

(b) Areas not entirely mapped. Acreage determined from partial maps, field reconniassiance, and water users claims.

(c) Total supply diverted.

Computation of Consumptive Use in Woodruff-Randolph Section

Tables 24 to 27 show the data for and computation of consumptive use in the Woodruff-Randolph section. Precipitation recorded at Woodruff, Utah is assumed to occur evenly over the irrigated lands and all precipitation between May 1 and September 30, is considered as making up the supply from this source.

Study of the return flow and gain hydrographs in the Bear River Hydrometric Data Reports[2] shows the return flow from water applied in irrigation closely follows the pattern of daily diversions for irrigation. These hydrographs treat only supplies, diversions and return flows in the main stem of the river and allow for a time interval of three days in the reach. Tributary supplies and diversions are not included in the computations but the return flows from tributary sources contribute to the river gain. Peak irrigation on the tributaries precede that for the river since tributary runoff comes earlier. Peak irrigation from the west side tributaries would occur at the same time as peak stream flow as all of the flow in the tributaries is diverted for irrigation. In 1944 stream flow from west side creeks reached its peak about May 10 and 1945 on May 11. The gain hydrographs indicate that the peak groundwater flows resulting from the tributary irrigation reached the river about June 2 in 1944 and June 4 in 1945. The time interval is thus indicated to be about 24 days for movement of groundwater from the irrigated tributary lands to the main stem of the river.

Normally the irrigated bottom lands in this section of the river are bare of snow long before May 1 and little or no intermediate runoff occurs. Consequently, no intermediate supply correction need be applied for the early months of the irrigation season as were found necessary in the Upper Wyoming section.

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(2) Bear River Hydrometric Data; 1944 - Plate 111; 1945 - Plate 100; 1946 - Plate 100; 1947 - Plate 97.

TABLE 24

Precipitation at Woodruff, Utah in Inches

Month	1944	1945	1946	1947	1948
Oct.	1.10	1.70	0.94	3.23	.52
Nov.	.12	.41	1.38	.92	.76
Dec.	.49	.10	.35	.57	.45
Jan.	.32	.03	.08	.68	1.75
Feb.	.40	.91	.24	.38	.40
Mar.	1.65	.45	1.37	.75	.63
Apr.	1.39	.28	.67	.92	.06
May	.76	1.57	1.88	1.62	.55
June	2.41	1.37	.28	3.19	.35
July	.87	1.37	.30	.33	.83
Aug.	.17	3.29	.50	1.73	.84
Sept.	.15	.47	.15	1.43	.72
Total	9.83	11.95	8.14	15.75	7.36

TABLE 25

Precipitation Supply in Acre-Feet on 51,820 Acres

Month	1944	1945	1946	1947	1948
May	3,280	6,780	8,120	7,000	2,380
June	10,410	5,920	1,210	13,780	1,510
July	3,760	5,920	1,300	1,430	3,580
Aug.	730	14,210	2,160	7,470	3,630
Sept.	650	2,030	650	6,180	3,110
Total	18,830	34,860	13,440	35,860	14,210

TABLE 26

Valley Stream Flow Depletions in Acre-Feet
From Tables 18 to 21

Month	1944	1945	1946	1947	1948
May	25,060	29,670	-	-	--
June	22,830	22,530	-	-	-
July	11,160	11,390	-	-	-
Aug.	- 520	2,290	-	-	-
Sept.	20	420	-	-	-
Total	58,550	66,300	57,230	48,290	59,570

TABLE 27

Valley Consumptive Use in Acre-Feet
(Combined Tables 24 and 25)

Month	1944	1945	1946	1947	1948
May	28,340	36,450	-	-	-
June	33,240	28,450	-	-	-
July	14,920	17,310	-	-	-
Aug.	210	16,500	-	-	-
Sept.	670	2,450	-	-	-
Total	77,380	101,160	70,670	84,150	72,780

Irrigation-Growing Period and Available Heat
(Consumptive Use Factor)

The same comments as noted in the previous general discussion and for the Upper Wyoming section apply to this section in the determination of the irrigation-growing period, available heat and consumptive use factors. Tables 28 to 32 show irrigation-growing periods, mean monthly temperatures, monthly consumptive use factors and summation of consumptive use factors for the irrigation-growing periods.

TABLE 28

Irrigation-Growing Period

			Date End of Irrigation		Irrigation-Growing Period		
Year	Date following end of hard freezing in spring	Date first hard freezing in fall	Bear R. nr. Woodruff drops below 100 c.f.s.	Date plus 14 days	Begin	End	Days
1944	May 7	Sept. 15	July 14	July 28	May 7	July 28	83
1945	May 5	Sept. 19	Aug. 27	Sept. 9	May 5	Sept. 9	128
1946	May 7	Sept. 9	June 27	July 10	May 7	July 10	65
1947	Apr. 30	Sept. 11	July 22	Aug. 4	May 1	Aug. 4	96
1948	May 14	Sept. 6	June 28	July 11	May 14	July 11	59

5 (431 (86

TABLE 29

Monthly Percent of Daytime Hours of the Year and Monthly Mean Temperature in Degrees Fahrenheit at Woodruff, Utah

Month	Daytime hrs. Monthly Percent p	1944	Mean Monthly Temperatures = t 1945	1946	1947	1948
May	10.14	48.6	48.4	44.4	50.3	46.8
June	10.21	52.4	50.2	55.5	52.0	55.6
July	10.35	60.6	62.5	63.2	61.6	60.5
Aug.	9.62	58.5	61.5	61.8	59.4	59.0
Sept.	8.40	51.2	48.9	50.8	52.6	53.0

TABLE 30

Monthly Consumptive Use Factor = $\frac{t \times p}{100}$

Month	1944	1945	1946	1947	1948	
May	4.94	4.90	4.50	5.10	4.74	49
June	5.35	5.13	5.67	5.31	5.68	51
July	6.28	6.47	6.55	6.37	6.26	92
Aug.	5.62	5.91	5.94	5.70	5.68	80
Sept.	4.30	4.10	4.26	4.32	4.45	81
	26.49	26.51	26.92	26.80	26.81	353

26.71 ave.

TABLE 31

Summation of Monthly Consuptive Use Factors in Irrigation-Growing Period

Year	Irrigation-Growing Period Begin	End	May	June	July	Aug.	Sept.	Total = F
1944	5/7	7/28	3.98	5.35	5.67	0	0	15.00
1945	5/5	9/9	4.26	5.13	6.47	5.91	1.37	23.14
1946	5/7	7/10	3.63	5.67	2.12	0	0	11.42
1947	5/1	8/4	5.10	5.31	6.37	.74	0	17.52
1948	5/14	7/11	2.75	5.68	2.22	0	0	10.65

1. oo f. w.s.

TABLE 32

Summary Table

Year	Irrigation-Growing Period Days	Consumptive Use Factor	Water Applied in Irrigation Ac.-Ft.	Consump. Use Ac.-Ft.	Consump. Use In. per Acre U	Consump. Use Coeff. K = U/F
1944	83	15.00	124,700	77,380	17.9	1.19
1945	128	23.14	137,730	101,160	23.5	1.02
1946	65	11.42	116,570	70,670	16.4	1.43
1947	96	17.52	131,580	84,150	19.6	1.12
1948	59	10.65	-	72,780	16.9	1.59
					943	
				5	18.9	$\frac{18.9}{26.71} = .71$

Graphs of Relation

On Plates 11 to 15 are plotted graphs showing relation between consumptive use and water applied in irrigation, days in irrigation growing period, and consumptive use factor or available heat on valley and acre basis. A graph showing relation of total inflow and total outflow is also shown.

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WATER APPLIED AND VALLEY CONSUMPTIVE USE
WOODRUFF-RANDOLPH SECTION

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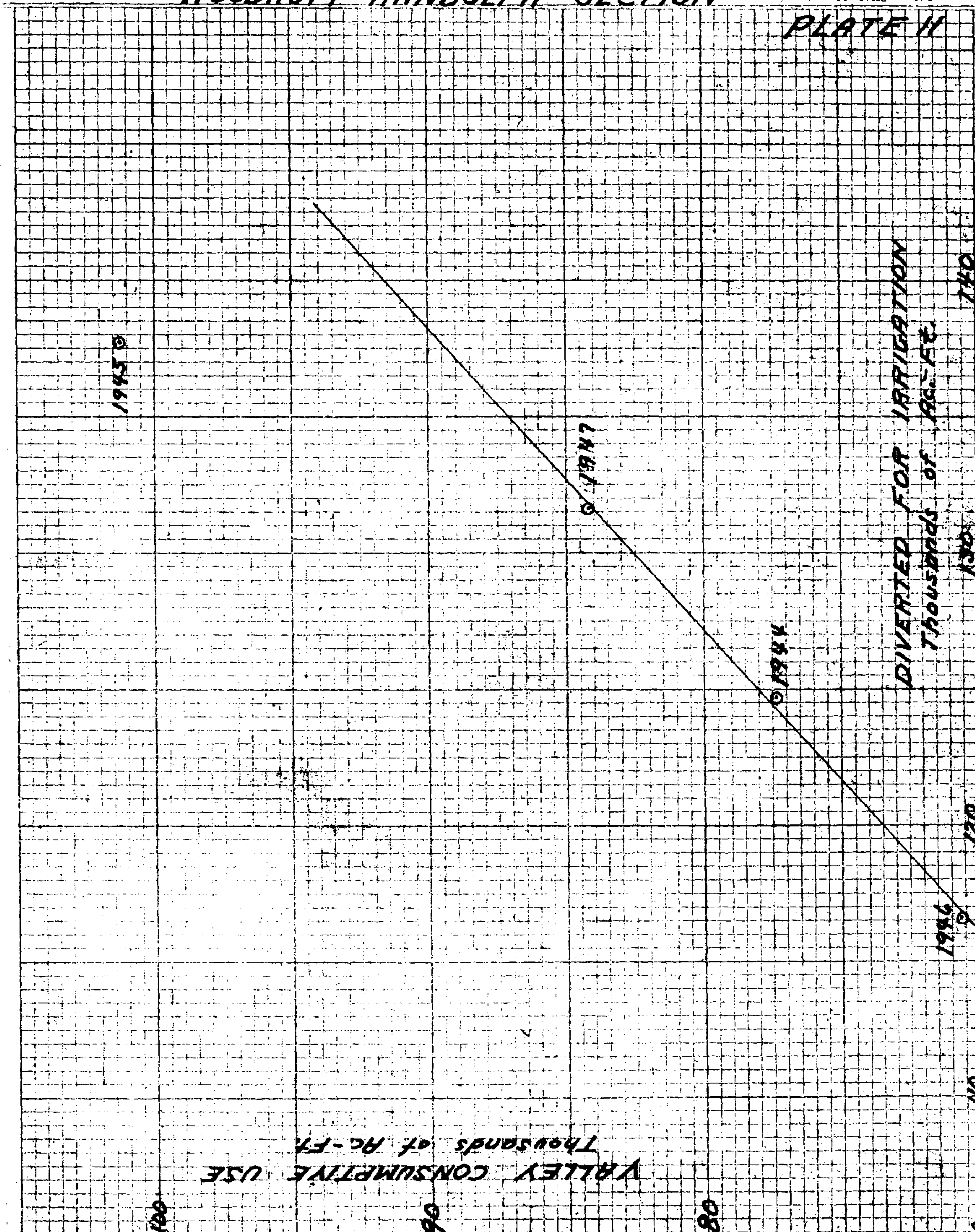
PLATE II



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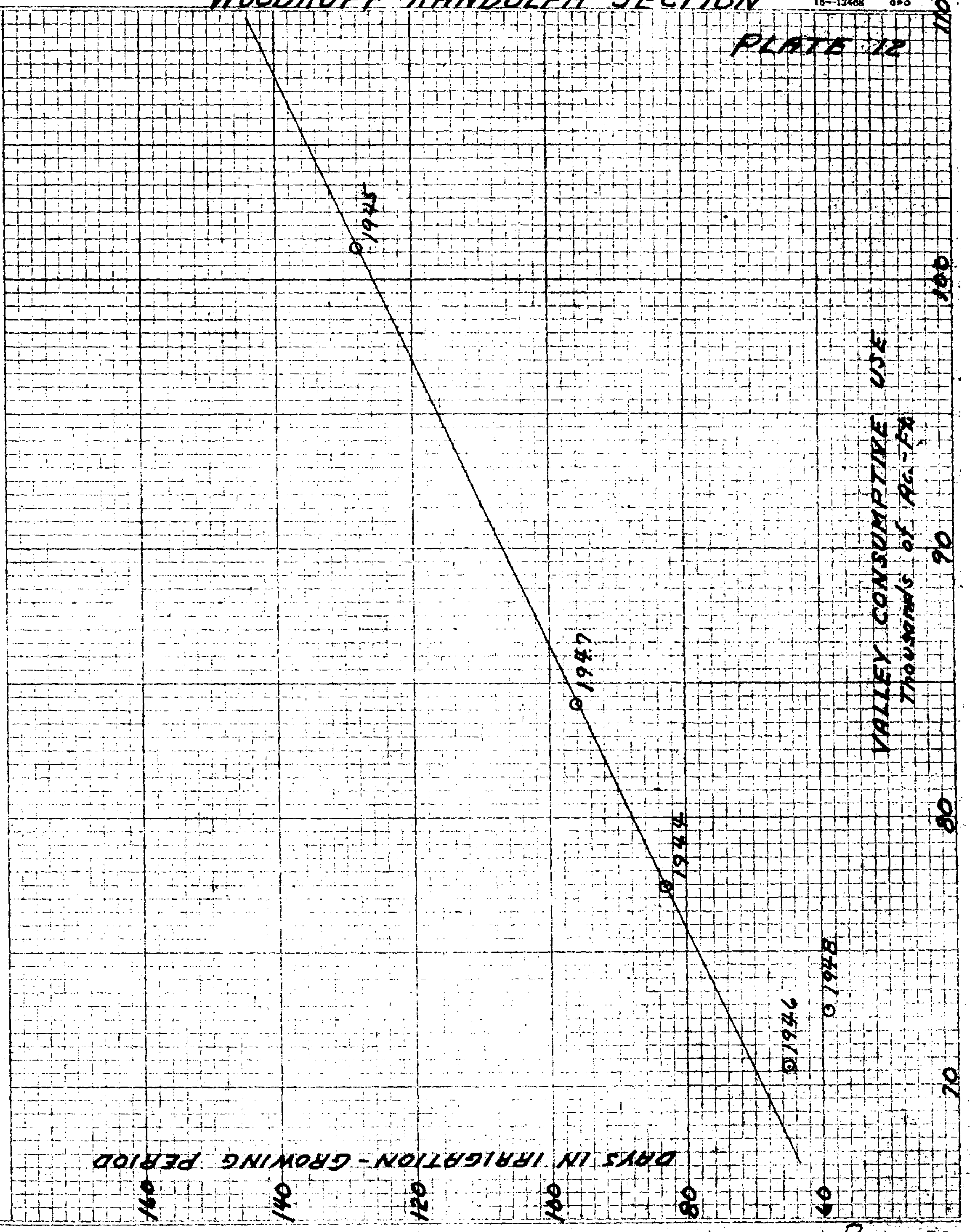
IRRIGATION-GROWING PERIOD AND CONSUMPTIVE USE
WOODRUFF-RANDOLPH SECTION

16—12468 GPO



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VALLEY CONSUMPTIVE USE COEFFICIENT
WOODRUFF-RANDOLPH SECTION

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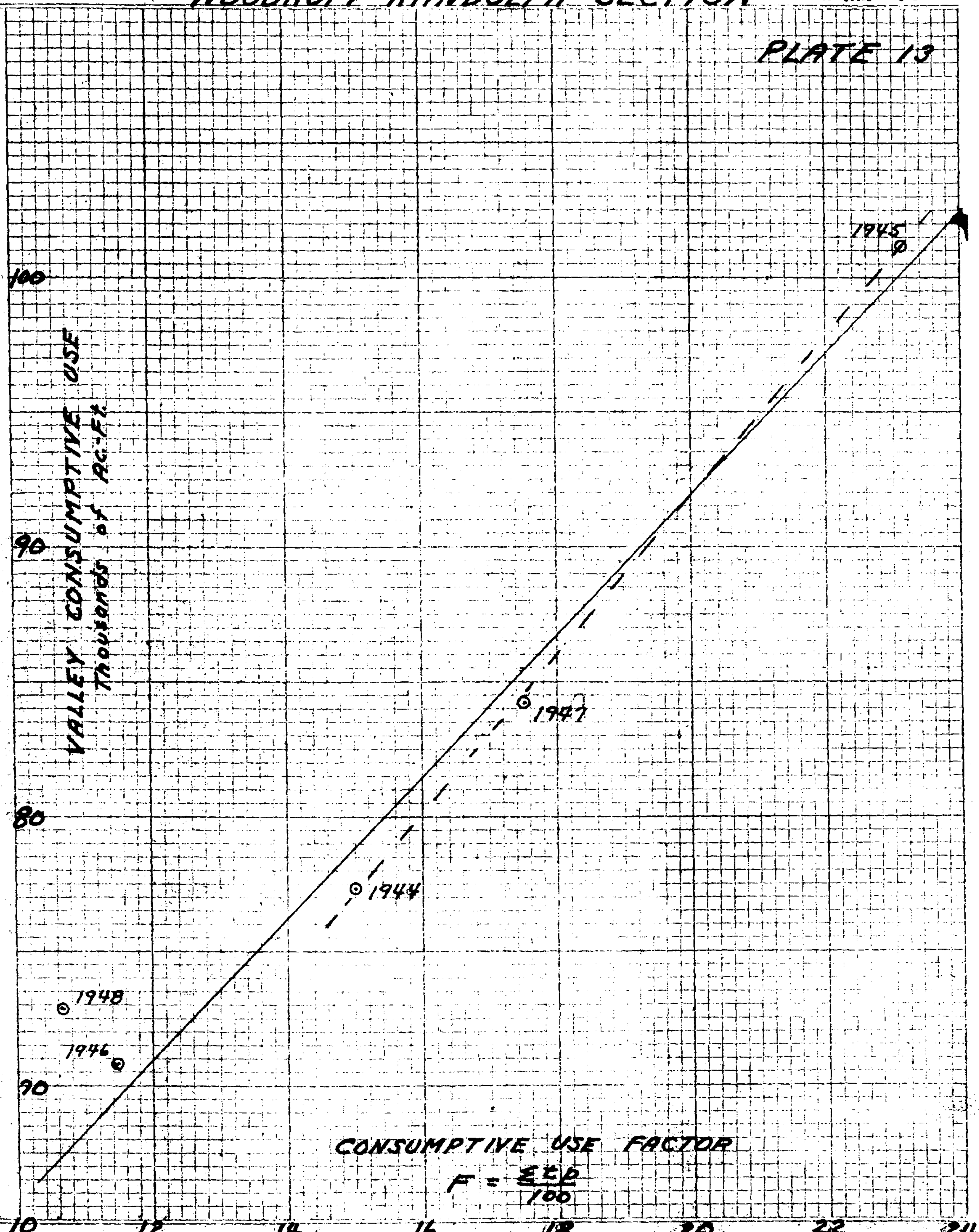

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CONSUMPTIVE USE COEFFICIENT
WOODRUFF-RANDOLPH SECTION

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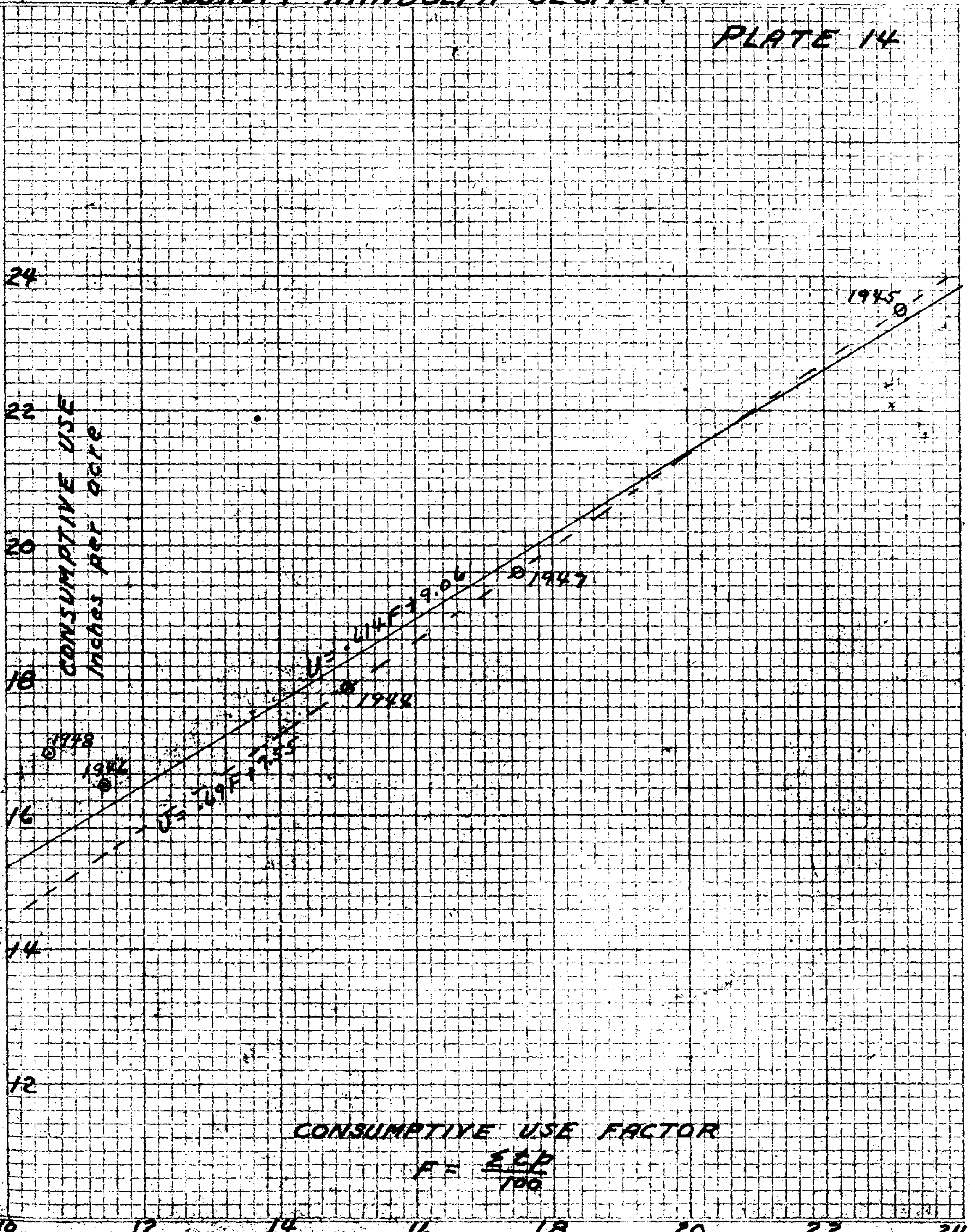

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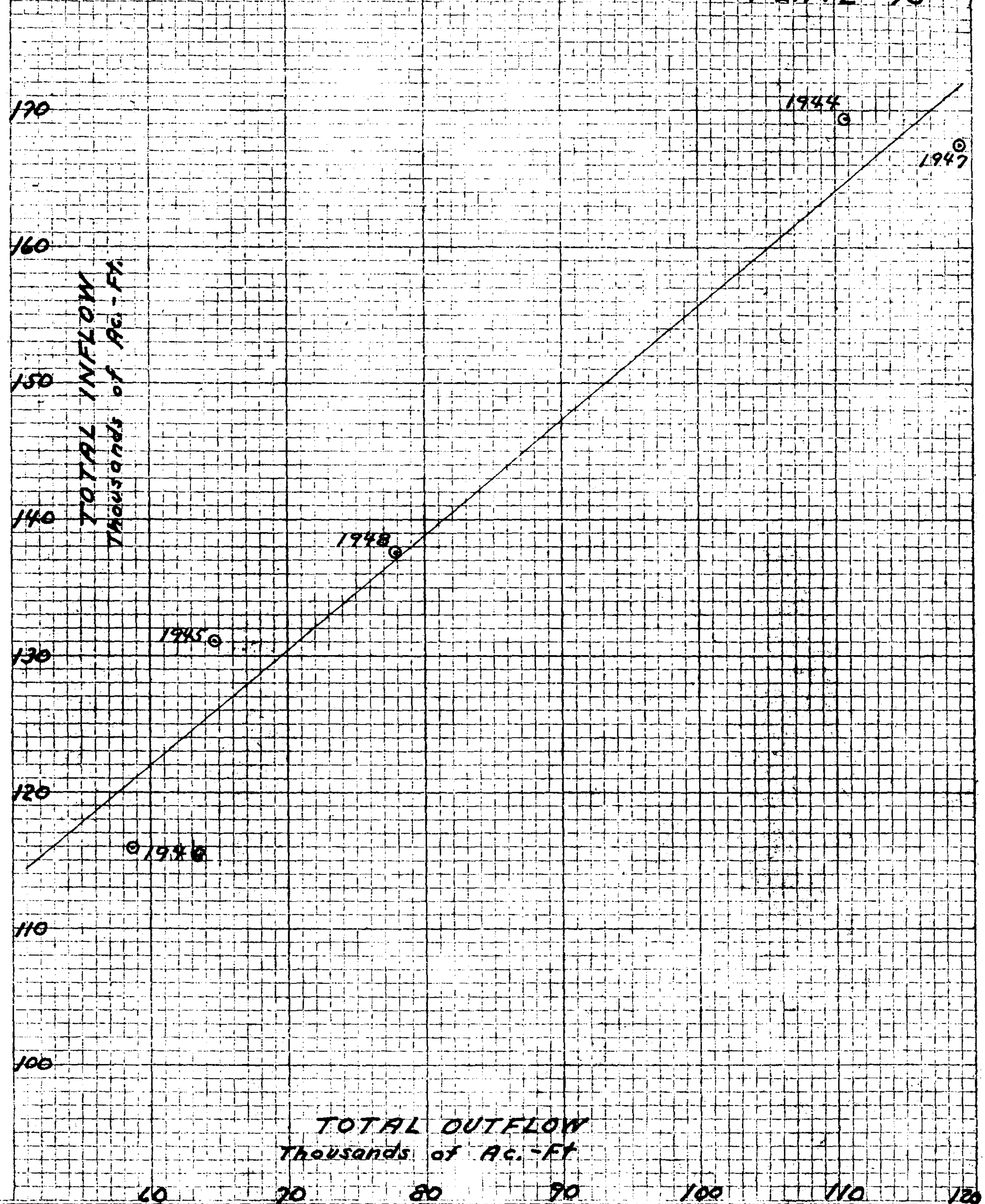
INFLOW - OUTFLOW

WOODRUFF-RANDOLPH SECTION

PLATE 15



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RANDOLPH TO BORDER INCLUDING SMITHS FORK SECTION

General Characteristics

This section of the Bear River Valley extends from the Randolph Control line to Border Wyoming and includes the irrigated lands on Smiths Fork.

The following tabulation shows the approximate irrigated acreage from each source of supply.

Bear River above Smiths Fork	12,090
Bear River below Smiths Fork (Less Cook Canal)	2,550
Twin Creek below Sage	1,100
Grade Creek	300
Pine Creek	800
Sublette Creek	670
Smiths Fork	9,800
Total	27,310

Irrigated lands in the main river valley are situated between 6,100 feet and 6,210 feet elevation and irrigated lands on Smiths Fork are between 6,200 and 6,600 feet elevation. Top soil in the river bottom lands is clayey loam and that on Smiths Fork is mostly silty loam mixed in places with gravel.

Excluding the drainage area above the Randolph Control line, there are approximately 850 square miles tributary to this valley section. Of this total area stream flow from approximately 480 square miles is gaged, 100 square miles lies in the valley bottom, and the remaining 270 square miles is low foothill drainage from which there is practically no surface runoff except early in the spring, usually before May 1. Of the valley bottom lands approximately 46 square miles are under irrigation.

Stream flow records of the inflow and outflow are available for this area during the period May to September as follows:

Inflow	1944	1945	1946	1947	1948
Bear River near Randolph	x	x	x	x	x
B.Q. West Side Canal at Control Line	x	x	x	x	
Twin Creek at Sage	x	x	x	x	x
Sucker Springs		Misc. Measurements			
Smiths Fork near Border	x	x	x	x	x
Howland Creek	x	x	x	x	x
Grade Creek	x	x	x	x	x
Pine Creek	x	x	x	x	x
Sublette Creek	x	x			
Outflow					
Bear River at Border	x	x	x	x	x
Cook Canal	x	x	x	x	x

Sucker Springs maintains an almost constant flow of 5 second feet. Missing records for Sublette Creek have been computed on the basis of correlation with Howland and Grade Creeks. The correlation curve for May to September runoff is shown on Plate 16. The missing record for B. Q. West Side Canal at Control Line was estimated for 1948.

The average time interval for movement of moderate and high flows from the inflow stations to the outflow stations is about three days. Allowance is made for this by using calendar month runoffs for the inflow stations and a lag of three days in computing the monthly runoffs at the outflow stations.

The following Tables 32 to 37 show stream flow depletions in this section during the May to September period for the years 1944 to 1948.

TABLE 33

Randolph to Border Section
Stream Flow Depletion Acre-Feet - 1944

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Randolph	43,540	45,750	11,670	2,590	1,610	105,160
B.Q. West Side Canal at Control Line	4,723	4,100	724	0	0	9,547
Twin Creek nr. Sage	1,970	4,550	433	305	275	7,533
Sucker Springs	307*	298*	307*	307*	298*	1,517*
Smiths Fork nr. Border	20,180	31,600	15,060	8,330	5,990	81,160
Howland Creek	575	591	315	208	134	1,823
Grade Creek	400*	416	299	207	151	1,473
Pine Creek	1,075	1,140	1,095	1,041	966	5,317
Sublette Creek	400*	415	242	181	121	1,359
Total inflow	73,170	88,860	30,145	13,169	9,545	214,889
Outflow						
Bear River at Border	67,960	74,820	23,620	8,990	6,660	182,050
Cook Canal	1,126	2,314	2,227	308	225	6,200
Total outflow	69,086	77,134	25,847	9,298	6,885	188,250
Depletion	4,084	11,726	4,298	3,871	2,660	26,639

* Estimated on basis of discharge measurements or correlation with nearby streams.

TABLE 34

Randolph to Border Section
Stream Flow Depletion Acre-Feet - 1945

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Randolph	13,650	22,140	8,110	8,360	4,100	56,360
B.Q. West Side Canal at Control Line	4,586	3,989	855	35	0	9,465
Twin Creek nr. Sage	590	862	312	1,380	294	3,438
Sucker Springs	307*	298*	307*	307*	298*	1,517*
Smiths Fork nr. Border	25,360	35,440	19,430	10,150	7,170	97,550
Howland Creek	508	625	390	239	156	1,918
Grade Creek	334	468	376	244	170	1,592
Pine Creek	879	1,051	1,142	1,083	1,000	5,155
Sublette Creek	396	349	245	252	176	1,418
Total inflow	46,610	65,222	31,167	22,050	13,364	178,413
Outflow						
Bear River at Border	35,060	54,010	23,820	19,080	14,340	146,310
Cook Canal	669	3,369	1,829	505	25	6,397
Total outflow	35,729	57,379	25,649	19,585	14,365	152,707
Depletion	10,881	7,843	5,518	2,465	-1,001	25,706

* Estimated on basis of discharge measurements or correlation with nearby streams.

TABLE 35

Randolph to Border Section
Stream Flow Depletion Acre-Feet - 1946

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Randolph	39,050	14,360	2,330	2,020	1,740	59,500
B.Q. West Side Canal at Control Line	3,712	2,189	176	0	0	6,077
Twin Creek nr. Sage	2,250	717	369	591	485	4,412
Sucker Springs	307*	298*	307*	307*	298*	1,517*
Smiths Fork nr. Border	34,460	29,310	13,690	8,440	6,350	92,250
Howland Creek	1,016	473	313	235	179	2,216
Grade Creek	600*	306	278	198	153	1,535
Pine Creek	1,372	1,200	1,130	1,061	1,004	5,767
Sublette Creek	600*	310*	280*	200*	150*	1,540*
Total inflow	83,367	49,163	18,873	13,052	10,359	174,814
Outflow						
Bear River at Border	75,370	33,670	14,190	10,330	10,910	144,470
Cook Canal	696	2,774	1,690	147	41	5,348
Total outflow	76,066	36,444	15,880	10,477	10,951	149,818
Depletion	7,301	12,719	2,993	2,575	-592	24,996

* Estimated on basis of discharge measurements or correlation with nearby streams.

TABLE 36

Randolph to Border Section
Stream Flow Depletion Acre-Feet - 1947

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Randolph	35,200	52,950	11,600	4,480	2,890	107,120
B.Q. West Side Canal at Control Line	5,881	5,105	2,122	196	0	13,304
Twin Creek nr. Sage	1,720	2,110	589	741	682	5,842
Sucker Springs	307*	298*	307*	307*	298*	1,517*
Smiths Fork nr. Border	48,370	38,210	19,270	11,030	7,110	123,990
Howland Creek	1,351	607	402	291	196	2,847
Grade Creek	700*	378	304	218	162	1,762
Pine Creek	1,279	1,206	1,163	1,101	1,071	5,820
Sublette Creek	700*	500*	400*	220*	160*	1,980*
Total inflow	95,508	101,364	35,157	18,584	12,569	264,182
Outflow						
Bear River at Border	82,920	90,910	28,230	16,870	13,330	232,260
Cook Canal	1,981	2,255	1,378	246	0	5,860
Total outflow	84,901	93,165	29,608	17,116	13,330	238,120
Depletion	10,607	8,199	6,549	1,468	-761	26,062

* Estimated on basis of discharge measurements of correlation with nearby streams.

TABLE 37

Randolph to Border Section
Stream Flow Depletion Acre-Feet - 1948

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Randolph	47,270	21,000	1,540	1,870	1,560	73,240
B.Q. West Side Canal at Control Line	5,000*	4,000*	200*	0*	0*	9,200*
Twin Creek nr. Sage	2,890	1,440	506	392	273	5,501
Sucker Springs	307*	298*	307*	307*	298*	1,517*
Smiths Fork nr. Border	41,190	33,770	14,090	8,370	5,920	103,340
Howland Creek	1,128	603	345	243	172	2,491
Grade Creek	900*	503	313	235	167	2,118
Pine Creek	1,543	1,450	1,305	1,196	1,100	6,594
Sublette Creek	800*	500*	300*	200*	130*	1,930*
Total Inflow	101,028	63,564	18,906	12,813	9,620	205,931
Outflow						
Bear River at Border	89,700	46,030	13,880	8,490	7,260	165,360
Cook Canal	443	2,891	1,435	612	214	5,595
Total Outflow	90,143	48,921	15,315	9,102	7,474	170,955
Depletion	10,855	14,643	3,591	3,711	2,146	34,976

* Estimated on basis of discharge measurements or correlation with nearby streams.

Subdivision of Randolph to Border Section

In the spring of 1948 a gaging station was installed on Bear River above the mouth of Sublette Creek. This station is below all lands irrigated from Bear River above the mouth of Smiths Fork and also below about sixty-five percent of the lands irrigated by the Covey Canal system which derives its water from Smiths Fork. An east-west control line through this station would subdivide the Randolph to Border Section into two areas. The river valley bottom at this point is restricted in width due to out-wash from Sublette Creek on the east and Boyd Creek on the west. Irrigation on the Sublette alluvial fan would tend to produce a groundwater dam on the east side but there may possibly be down valley groundwater movement through the Boyd Creek fan on the west side.

Records were not obtained on the water delivered by the Covey canals to lands south of Sublette Creek. Although these lands comprise sixty-five percent of the total Covey lands, it is not believed they would receive more than forty to fifty percent of the total Covey water because of limited capacity of the main inverted siphon crossing Sublette Creek.

In Table 38 are shown the computations of stream flow depletion for 1948 for the section between the Randolph Control line and Sublette Control line. By deducting this depletion from that previously determined for the Randolph to Border section a determination is also obtained for the section from Sublette Control line to Border including Smiths Fork.

Irrigated acreage south of Sublette Control line	15,680	acres
Irrigated acreage north of Sublette Control line	11,630	"

TABLE 38

Randolph to Sublette Section
and
Sublette to Border Section
Stream Flow Depletion Acre-Feet - 1948

Inflow	May	June	July	Aug.	Sept.	Total
Bear River nr. Randolph	47,270	21,000	1,540	1,870	1,560	73,240
B.Q. West Side Canal at Control Line	5,000*	4,000*	200*	0*	0*	9,200*
Twin Creek nr. Sage	2,890	1,440	506	392	273	5,501
50% of Covey Canal system	1,950	2,907	2,970	2,077	1,623	11,527
Total Inflow	57,110	29,347	5,216	4,339	3,456	99,468
Outflow						
Bear R. above Sublette	47,500	22,690	4,220	2,720	2,410	79,540
Depletion - Randolph to Sublette (1 day time interval)	9,610	6,657	996	1,619	1,046	19,928
Computed Randolph to Border (Table 37)	10,885	14,643	3,591	3,711	2,146	34,976
Net Sublette to Border including Smiths Fork	1,275	7,986	2,595	2,092	1,100	15,048

Water Diverted for Irrigation

Table 39 shows the May to September diversions in acre-feet and in acre-feet per acre of the Bear River, Smiths Fork and tributary stream canals in the Randolph to Border section. This tabulation does not include some minor diversions from small intermittant tributary streams around the periphery of the valley or diversions from Twin Creek above the gaging station at Sage, Wyoming. For the tributaries shown total irrigation diversion is given instead of listing each individual canal.

The totals in this table do not reflect the actual acreage irrigated or water applied in the valley section for which the stream flow depletion has been computed. However, with adjustments to the totals as noted in the following brief discussion the total acreage and total water applied can be determined.

1. There are 1,378 acres irrigated from Bear River above the mouth of Smiths Fork, the supply for which could not be measured. This supply is derived from overflow and backwater from Pixley Dam and waste water from B. Q. East Side, McFarland and Twin Creek canals. Since the amount of water involved in the overflow and backwater is relatively small, an approximate adjustment can be made by increasing the acreage by 1,378 acres without increasing the water diverted.
2. 3,809 4037 acres of land north of the Randolph Control line receives water from the B. Q. West Side Canal which diverts in the Woodruff-Randolph section. This canal delivered past the control line 9,547 ac.-ft. in 1944, 9,465 ac.-ft. in 1945, 6,077 ac.-ft. in 1946, 13,304 ac.-ft. in 1947 and an estimated 9,200 ac.-ft. in 1948. The totals would need be increased by these amounts.
3. The acreage irrigated and water diverted by the Quinn Bourne Canal on Smiths Fork would be deducted as the lands are upstream from the Smiths Fork near Border gaging station.
4. Return flow from the Cook Canal lands would not return to the river above the Bear River near Border gaging station, therefore this canal's acreage and water would be deducted from the totals.

The total given in Table 39 with these adjustments result in the following net figures.

Acreage	Water applied in irrigation, Ac.-Ft.				
Irrigated	1944	1945	1946	1947	1948
27,313	106,530	113,716	103,447	106,257	112,022

TABLE 39

Irrigation Diversion Randolph to Border Section

NAME OF CANAL Bear River Randolph Control Line to Sublette	Acres Irrig. (a)	DIVERTED ACRE-FEET May to Sept. 1944	1945	1946	1947	1948	ACRE-FEET PER ACRE 1944	1945	1946	1947	1948
B. Q. West Slough	1,882	6,673	10,101	7,715	3,009	3,056	3.55	5.54	4.10	1.60	1.62
McFarland	300	1,149	1,223	675	577	360	3.83	4.08	2.25	1.92	1.20
B. Q. East Side	2,104	9,704	13.139	13,013	8,518	8,752	4.61	6.24	6.18	4.05	4.17
Pixley	2,614	8,347	4,858	2,626	8,331	3,453	3.19	1.86	1.00	3.19	1.32
Total	6,900	25,873	29,321	24,029	20,435	15,621	3.75	4.25	3.49	2.95	2.26
Bear River Sublette to Border											
Garrett	217	1,301	1,281	1,629	869	990	0.00	5.91	7.51	4.00	4.56
Sights	705	1,939	2,570	2,469	1,811	1,937	2.75	3.65	3.50	2.57	2.76
Wyman (East)	234	2,462	2,203	912	1,121	1,850	10.52	9.40	3.90	4.79	7.91
Wyman (West)	369	5,172	5,180	3,182	3,229	3,239	14.02	14.04	8.62	8.75	8.78
Snyder	351	3,969	4,503	4,640	4,257	4,282	11.31	12.82	13.22	12.13	12.20
Rocky Point	256	723	1,749	1,438	1,554	2,890	2.82	6.83	5.62	6.07	11.30
Cook	2,925	6,102	6,407	5,363	5,843	5,584	2.08	2.19	1.83	2.00	1.91
J. R. Richards	419	1,422	463	586	3,158	2,102	3.39	1.10	1.40	7.54	5.02
Total	5,476	23,090	24,356	20,219	21,842	22,874	4.21	4.45	3.70	4.00	4.18
Smiths Fork											
Quinn Bourne	354	262	1,175	249	1,293	932	.74	3.32	.70	3.66	2.64
Button Flat	241	862	458	263	0	102	3.57	1.90	1.09	0	.42
Perry Partridge	263	346	270	377	0	320	1.31	1.02	1.43	0	1.22
Progress	218	634	602	760	456	581	2.91	2.76	3.48	2.09	2.67
Emelle	659	2,646	3,107	3,566	4,323	5,097	4.02	4.72	5.42	6.66	7.75
Cooper	414	1,440	891	1,040	2,062	2,192	3.48	2.15	2.51	4.99	5.30
Wheelock (Upper)	175	302	308	1,314	598	1,668	1.72	1.76	7.52	3.41	4.60
Wheelock (Lower)	189	973	1,392	726	585		5.15	7.35	3.84	3.10	
Covey, Mau, & Collett	4,396	16,611	13,245	15,542	14,117	23,059	3.77	3.02	3.53	3.22	5.25
Tanner, Hunt, Garrett	288	1,644	1,864	2,161	2,701	2,465	5.71	6.48	7.51	9.38	8.58

(Continued on next Page)

TABLE 39 (Cont'd.)

Irrigation Diversion Randolph to Border Section

NAME OF CANAL	Acres Irrig.	DIVERTED ACRE-FEET May to Sept.					ACRE-FEET PER ACRE				
Smiths Fork (Continued)	(a)	1944	1945	1946	1947	1948	1944	1945	1946	1947	1948
Whites Water	915	5,826	8,293	7,548	6,129	6,805	6.37	9.07	8.25	6.70	7.43
Martin	149	350	118	85	0	160	2.35	.79	.57	0	1.07
Bourne	117	1,939	1,640	1,801	1,573	1,432	16.58	14.00	15.40	13.45	12.25
Forgeon	210	1,366	1,264	937	1,196	1,467	6.51	6.03	4.47	5.70	6.99
Stoner	369	1,221	2,700	1,492	1,874	3,025	3.31	7.32	4.04	5.08	8.23
Morgan	144	1,490	2,343	1,949	1,629	1,989	10.35	16.27	13.55	11.32	13.81
Cokeville	69	613	652	833	741	629	8.88	9.45	12.09	10.75	9.13
Tanner 1 & 2	110	1,152	886	1,118	1,412	1,746	10.49	8.06	10.15	12.85	15.87
Smiths Fork Canal	142	1,056	1,824	1,568	1,015	1,268	7.44	12.85	11.03	7.16	8.93
South Branch 1 & 2	737	4,803	5,509	5,109	5,006	5,099	6.51	7.47	6.94	6.80	7.01
Total Smiths Fork	10,159	45,536	48,541	48,438	46,710	60,036	4.50	4.80	4.79	4.62	5.97
Tributary Streams	7,646										
Twin Creek	(b) 1,100	1,560	1,616	2,400(c)	2,800(c)	2,400(c)	1.42	1.47	2.18	2.54	2.18
Grade Creek	(b) 300	1,272	1,592	960	1,122	1,414	4.25	5.31	3.20	3.75	4.72
Pine Creek	(b) 800	4,775	4,989	5,396	5,200	5,063	5.97	6.23	6.75	6.50	6.34
Sublette Creek	(b) 670	1,241	1,418	1,540 (c)	1,980 (c)	1,930(c)	1.86	2.12	2.30	2.96	2.88
Total Tributaries	2,870	8,848	9,615	10,296	11,102	10,807	3.08	3.35	3.59	3.87	3.77
GRAND TOTAL Randolph to Border	25,405	103,347	111,833	102,982	100,089	109,338	4.07	4.40	4.06	3.94	4.31

(a) Planimetered on land use maps except as noted.
(b) Estimated.
(c) Estimated on basis of supply.

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Computation of Consumptive Use in Randolph to Border, including Smiths Fork Section

Tables 40 to 43 show the data for and computation of consumptive use in the Randolph to Border section. This section also includes Smiths Fork and the lands irrigated from Smiths Fork.

The lands irrigated from Bear River above the mouth of Smiths Fork usually have a short season water supply and the practice of heavy irrigation starting about May 1 and then turning off about July 5, seems to have been established even though in some years the supply lasts beyond this date. Lands irrigated from Smiths Fork use water from early in May until late in September, and since a good portion of these lands are located on benches and have adequate drainage, alfalfa makes up a good portion of the crops raised. Lands irrigated from the tributary streams use whatever water is available throughout the irrigation season.

These different patterns of water application in an area where the return flows cannot be segregated makes impossible a study similar to those made for the two upstream sections. However, for what it may be worth, similar data is given for this section.

Climatological data is available for two stations located near the north and south ends of the section. Average precipitation data based on the two stations are used in the following tables.

TABLE 40

Average Precipitation in Inches at Sage and Border, Wyoming

Month	1944	1945	1946	1947	1948	1949
May	1.00	2.29	1.54	1.96	.48	1.98
June	2.81	1.98	.41	3.18	1.48	2.12
July	.54	.48	.83	.48	.34	.92
August	.08	1.60	1.48	2.19	.36	.30
September	.40	1.03	.79	1.36	.72	.46

TABLE 41

Precipitation Supply in Acre-Feet on 27,310 Acres

Month	1944	1945	1946	1947	1948	1949
May	2,280	5,230	3,520	4,480	1,100	4,520
June	6,420	4,520	940	7,260	3,380	4,840
July	1,230	1,100	1,900	1,100	780	2,100
August	180	3,650	3,380	5,000	820	680
September	910	2,350	1,800	3,100	1,640	1,050
Total	11,020	16,850	11,540	20,940	7,720	13,190

TABLE 42

Valley Stream Flow Depletions in Acre-Feet
From Tables 33 to 37

Month	1944	1945	1946	1947	1948	1949
May	4,284	11,085	7,601	11,107	11,185	
June	11,911	8,194	13,009	8,299	14,793	
July	4,406	5,723	3,113	6,499	3,641	
August	3,940	2,513	2,625	1,548	3,761	
September	2,689	-977	-542	-671	2,216	
Total	27,230	26,538	25,806	26,782	35,596	

TABLE 43

Valley Consumptive Use in Acre-Feet
(Combined Tables 41 and 42)

Month	1944	1945	1946	1947	1948	1949
May	6,564	16,315	11,121	15,587	12,285	
June	18,331	12,714	13,949	15,559	18,173	
July	5,636	6,823	5,013	7,599	4,421	
August	4,120	6,163	6,005	6,548	4,581	
September	3,599	1,373	1,258	2,429	3,856	
Total	38,250	43,433	37,346	47,722	43,316	

Irrigation-Growing Period and Available-Heat (Consumptive Use Factor)

Because of the extreme difference in time that water is applied to the lands irrigated from the main stem of the river above the mouth of Smiths Fork and the time that water is applied to lands served principally from the Smiths Fork source of supply, it is necessary to use two "irrigation-growing" periods. In general, each would be applicable to about fifty percent of the irrigated lands in the section. The following definition serves for each:

> The "irrigation-growing period" is that portion of the period May 1 to September 30, when the total water applied becomes greater than 100 c.f.s. or the day following the end of extreme freezing temperatures, whichever is the later and the day the water being applied decreases below 100 c.f.s. plus 14 days, or the day of the first extreme frost in the fall, whichever is the earlier.

It may be that the water table under the river bottom lands remains high in the root zone and furnishes plant moisture for a longer period than this definition provides.

In tables 44 to 49 are shown the data and determination of the consumptive use factors. The factor for the river lands is designated F_1 and the factor for the Smiths Fork lands is designated F_2.

TABLE 44

Irrigation-Growing Period Bear River above Mouth of Smiths Fork

Year	Date following end of hard freezing in spring	Date first hard freezing in fall	Date begin of Irrig. above 100 cfs.	Date end of Irrig.		Irrigation-Grow. Period		
				Date below 100 cfs.	Date plus 14	Begin	End	Days
1944	5/7 (a)	9/15 (a)	5/13	7/6	7/20	5/13	7/20	69
1945	5/5 (a)	9/19 (a)	5/9	7/8	7/22	5/9	7/22	75
1946	5/7 (a)	9/9 (a)	5/3	6/30	7/14	5/7	7/14	69
1947	4/30 (a)	9/11 (a)	5/7	6/29	7/13	5/7	7/13	68
1948	5/7 (b)	9/6 (a)	5/9	6/25	7/8	5/9	7/8	61

(a) Woodruff, Utah temperatures used.

(b) Border, Wyoming temperature used.

TABLE 45

Irrigation-Growing Period Lands Served from Smiths Fork Source of Supply

Year	Date following end of hard freezing in spring	Date first hard freezing in fall	Date begin of Irrig. above 100 cfs.	Date End of Irrig.		Irrigation-Grow. Period		
				Date below 100 cfs.	Date plus 14	Begin	End	Days
1944	5/7	9/16	5/18	9/30	9/30	5/18	9/16	122
1945	5/4	9/19	5/8	9/9	9/23	5/8	9/19	135
1946	5/5	9/18	5/15	9/4	9/18	5/15	9/18	127
1947	5/3	9/15	5/10	9/8	9/22	5/10	9/15	128
1948	5/7	9/6	5/14	9/30	9/30	5/14	9/6	116

Border, Wyoming temperatures used.

TABLE 46

Monthly Percent of Daytime Hours of the Year and Monthly Mean Temperatures in Degrees Fahrenheit averaging Sage and Border Wyoming Records

Month	Daytime hrs. Monthly Percent	Mean Monthly Temperatures 1944	1945	1946	1947	1948
May	10.14	48.8	47.3	46.2	49.8	48.6
June	10.21	51.6	50.7	57.6	51.8	57.8
July	10.35	60.2	63.2	64.8	62.6	61.0
Aug.	9.62	57.6	62.2	62.8	60.1	61.4
Sept.	8.40	50.5	51.6	51.4	55.4	52.9

TABLE 47

Monthly Consumptive Use Factor $\frac{t \times p}{100}$

Month	1944	1945	1946	1947	1948
May	4.95	4.80	4.69	5.05	4.94
June	5.28	5.19	5.89	5.30	5.96
July	6.24	6.55	6.70	6.49	6.31
Aug.	5.54	5.98	6.04	5.77	5.90
Sept.	4.24	4.34	4.31	4.65	4.44

TABLE 48

Summation of Monthly Consumptive Use Factor in Irrigation-Growing Period for Bear River Lands above Mouth of Smiths Fork

Year	Irrigation-Growing Period Begin.	End	May	June	July	Aug.	Sept.	Total = F_1
1944	5/13	7/20	3.03	5.28	4.14	0	0	12.45
1945	5/9	7/22	3.56	5.19	4.65	0	0	13.40
1946	5/7	7/14	3.78	5.89	3.02	0	0	12.69
1947	5/7	7/13	4.07	5.30	2.72	0	0	12.09
1948	5/9	7/8	3.66	5.96	1.63	0	0	10.98

TABLE 49

Summation of Monthly Consumptive Use Factor in Irrigation-Growing Period for lands served from Smiths Fork Source

Year	Irrigation-Growing Period Begin.	End	May	June	July	Aug.	Sept.	Total = F_2
1944	5/18	9/16	2.24	5.28	6.24	5.54	2.12	21.42
1945	5/8	9/19	3.72	5.19	6.55	5.98	1.73	23.17
1946	5/15	9/18	2.57	5.89	6.70	6.04	1.87	23.07
1947	5/10	9/15	3.58	5.30	6.49	5.77	2.64	23.78
1948	5/14	9/6	2.70	5.96	6.31	5.90	.74	21.61
								22.6 ave F.

SUMMARY

Because the stream flow depletions cannot be segregated for the two areas having different lengths of irrigation periods, correlation curves cannot be prepared for this area as was done for the upper two sections. The following summary table has been prepared by averaging the days in the irrigation growing periods and the consumptive use factors and computing the values of "K" on this basis.

TABLE 50

Summary Table

Year	Average Irrig. Growing Period	Average Consumptive Use Factor F	Water Applied in Irrigation	Consumptive Use Ac.-Ft.	Average Consump. Use in. Per Ac. U	Consumptive Use Coeff. K = $\frac{U}{F}$
1944	86	16.94	106,530	38,250	16.8	0.99
1945	105	18.28	113,716	43,433	19.1	1.04
1946	98	17.88	103,447	37,346	16.9	.91
1947	98	17.94	106,257	47,722	21.4	1.16
1948	88	16.30	112,022	43,316	19.0	1.17

93.2

5) 18.6

$$\text{Coef.} = \frac{\text{Depletion} + \text{PRECIP.}}{\text{Headgate Div.} + \text{PRECIP}}$$

$$\text{CONSUMPTIVE USE} = U = \text{DEPL.} + \text{PRECIP.}$$

$$\text{HEADGATE DIVERSION REQUIREMENT} = \frac{U}{\text{COEF.}} + \text{PRECIP.}$$

<u>Example #1</u>

DIVERSIONS = 8,000 A.F. DEPLETION = 5000 A.F.

RAINFALL = 1000 A.F.

$$\text{Coef.} = \frac{5000 + 1000}{8000 + 1000} = 66.7\%$$

$$U = 5000 + 1{,}000 = 6{,}000 \text{ A.F.}$$

$$\text{Headgate div. Requir't} = \frac{6000}{66.7} + 1{,}000 = 8{,}000$$

<u>Example # 2</u>

If all rainfall consumed then on year of zero rainfall, depletion will Increase by amount of rainfall in 1st example.

$$\text{coef.} = \frac{6000}{8000} = 75\%$$

$$U = 6000 + 0 = 6000$$

$$\text{Headgate Req.} = \frac{6000}{.75} + 0 = 8{,}000$$