REPORT #27

STORAGE REQUIREMENTS

and

SUPPLIES ABOVE BEAR LAKE

REPORT OF ENGINEERING COMMITTEE

to

BEAR RIVER COMPACT COMMISSION

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May 8, 1953

ACREAGE SUMMARY (Cont.)

(5) Rich County, Utah:

34,870 Lower Utah Compact acreage (Rep 23 page 12)
+ 2,151 Francis Lee & Bear River Canal land in Utah
− 1,884 B.Q. West side canal acreage in Wyo. (from maps)
35,137 Rich County excluding Chapman Canal lands.

(6) Wyoming state line to Cokeville, Wyo:

8,278 Compact acreage, lower Wyo. (Rep 23 pge 12)
+ 1,884 B.Q. West Side Canal acreage in Wyo.
10,162 - Total

(7) Cokeville to Border, Wyo:

5,323 Garrett canal to Richard Canal (Pixley to Border: Rep 23 page 7)
− 2,476 Cook Canal acreage in Idaho (from maps)
2,847 - Total

(8) Border to Stewart Dam, Idaho:

23,278 Border to Stewart Compact acreage (Rep 23, page 8)
+ 2,476 Cook canal acreage in Idaho (Maps)
25,754 - Total

SUMMARY
of [illegible]

[illegible] Utah

+80 [illegible] Transmountain plus Howarka (Rep. 23 p. 10)

+3 Utah [illegible] under Wright-Trans. } Never supplied by Bear R.
70 Wyo. " " } so incl. under Yellow Cr.

217 acres [illegible]g under Howarka Canal

(2) Hilliard Flats, Wyo:

2,644 Hilliard East Fork Canal (Rep. 23 page 10)
937 Lannon Canal " " "
2,072 Hilliard West Side Canal " " "
4,753 Bear Canal " " page 11
10,406 (10,900 shown in report from rep. 12 page 15 - in error)

(3) State Line to Myers Narrows

36,834 Upper Wyo. Compact Section (Rep. 23 page 12)
+ 5,663 HEF plus Lannon plus HWS Canals (" " 10)
- 10,900 Hilliard Flat acreage from rep. 27
- 15,439 Upper Wyo. land below Kneeder Canal (Rep 23 page 12)
- 7,889 Chapman Canal land in Utah " "
- 2,151 Francis-Lee & Bear River Canal land in Utah "
6,108 (Should be 6,602 since 10,900 is in error - see above)

(4) Myers Narrows to Utah line

7,889 Chapman Canal land in Utah (Rep. #23 page 12 corrected)
15,439 Myers #1 Canal to Lower Island plus 364 Fr. Lee & Bear R. Canals in Wyo.

MAIN STEM AND SMITHS FORK

	Adjud. Acreage	Planim. Acreage	Compact Planim.	Percent Division	State Line Planim.
UPPER DIVISION					
Upper Utah	6,221	6,133	480	0.6 %	217
Upper Wyo	36,645	36,834	42,487	49.3 %	32,447
Lower Utah	33,806	34,870	34,870	40.5 %	43,026
Lower Wyo	8,457	8,278	8,278	9.6 %	10,160
Total	85,129	86,115	86,115	100 %	85,850
CENTRAL DIVISION					
Wyoming	18,687	17,284	17,284	42.6 %	14,808
Idaho	22,664	23,278	23,278	57.4 %	25,754
Total	41,351	40,562	40,562	100 %	40,562

The above data from Rep. #23 with corrections for Chapman & Cook
If Lone Mt. ditch is included above (140 ac) resulting % = 49.42 & 40.42

Compact Division

Upper Division: Upper Wyoming includes 5,653 acres of Hilliard land adjudicated by Utah under the Hilliard East Fork, Lannon & Hilliard West Side Canals. Difference between 'Compact Planimetered' & 'State Line Planimetered' is land on Yellow Creek under Wright-Transmountain Canal which has not received Bear river water & should not be listed under Main Stem.

2,451 acres in Utah under Fr-Lee & Bear r. Canals adj. in Wyo.
1,884 acres in Wyo. under B.Q. West Side Canal adjud. in Utah

Central Division 2,476 acres in Idaho under Cook Canal adjud. in Wyo.

SUPPLIES & REQUIREMENTS
above
BEAR LAKE
May 8, 1953

At the last meeting of the Bear River Compact Commission, Jan. 9, 1953, the Engineering Committee was assigned a more detailed and complete study on upstream storage than had previously been made.

In general, the scope of the study was to include the following:

1. Tabulate irrigated acreage by source of water supply, and listed by sections on a State Line basis.
2. Compute supplemental requirements, by State Section, based on previous consumptive use studies and extended to include all tributaries. This would be shown as a supplemental supply required at the head of each section to fill headgate requirements within the section.
3. Study the limitations on potential storage to satisfy the above requirements by reason of storable supplies and/or available reservoir sites.
4. Include in the study of supplemental requirements on Smiths Fork, an estimated reduction in diversions resulting from Compact regulation, based on the sliding-scale division in the Central Division which was suggested by the Idaho Commissioner at the January 9th meeting.
5. Include in this study all irrigated acreage above Stewart Dam.

Table I summarizes the findings of this study relative to Acreages and Requirements. It was found in practically all areas having a supplemental requirement that storable supplies and available sites were adequate to meet the requirement. It was not necessary, therefore, to include a summary of limitations in Table I.

1953: HEF - 6cc cut about 4 cfs 6/30 and 6 cfs 7/3
HWS - " " " 13½ cfs from 27 cfs on 7/3 : on June 30 from 32 to 21 cfs

Diversions
Ac ft/acre

	HEF	~~HWS~~	~~Bear~~	Lannon
1953	1.12	1.59	1.66	3.85
1952	1.80			
1951	1.66			
1950	1.35			
1949				
1948	.85	1.77		2.68
1947	1.32	1.25	2.14	2.53
1946	1.14	1.94	1.29	2.78
1945	1.34	1.41	1.70	2.76
1944	.51 .71	1.55	1.60	1.49 2.68
ave	1.23	1.60	1.68	

1944 HEF diverts from Mill Creek early in season.

HEF - 2,644
HWS - 2,072
Lannon - 937
Bear - 4,753
10,406
- 937 Lannon
9,469
+ 260 - portion of Lannon at head of flats
9,649
+ 800 - willow
600 - sulphur
11,049

Total Main Stem Land Rep. 23 = 14,716
" " 27 = 14,451
265 lands transferred

As between Wyoming and Utah the following table summarizes the division of [illegible]e and requirement data:

	Acreage	Percent of Total	Requirement	Percent of Total
Utah	58,738	47%	24,680	64%
Wyoming	65,301	53%	14,000	36%
Total	124,039	100%	38,680	100%

This study with one exception is based on existing conditions of regulation [illegible] each State, and between States. The exception is Smiths Fork in the Central [illegible]on. In this section it was specifically requested that estimated effects [illegible]two proposals of Compact regulation be applied to the requirement studies. [illegible]ain Stem requirement data in the Upper Division are essentially as given in [illegible]#19, "Supplemental Storage Requirements above Bear Lake," which did not [illegible]to account possible effects of Compact regulation.

[illegible]upporting data for Table I is described in the detailed text and graphically shown on Plates 1 to 20, which follow.

SUMMARY OF REQUIREMENTS ABOVE BEAR LAKE

Area by State Section or source of Water Supply	Irrigated Acreage			Headgate Requirement (Ac.-ft. per Acre)			Total Headgate Requirement (Acre-feet)			Supplemental Supply Requirement (3) (Acre-feet)		
	Utah	Wyoming	Idaho	Utah	Wyoming	Idaho	Utah	Wyoming	Idaho	Utah	Wyoming	Idaho
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
MAIN STEM BEAR RIVER												
Summit County, Utah	217			2.0			430			0		
Hilliard Flats, Wyoming		~~10,900~~ 9766	*		2.1			~~22,900~~ 20500			0	
State Line to Myers Narrows		~~6,108~~ 7242			2.1			~~12,800~~ 15200			0	
Myers Narrows to Utah Line	(1) 7,889	15,439		2.0	2.5		15,800	38,600		0	4,500	
Rich County, Utah (except Chapman)	35,137			2.7			94,900			19,000		
Wyoming State Line to Cokeville		10,160			2.7			27,400		76%	6,600 24%	
Cokeville to Border		2,847			2.8			8,000			0	
Border to Stewart Dam		2,575			3.0			7,300				0
TRIBUTARIES												
Yellow Creek Drainage	192	1,070		2.5	2.5		480	2,700		80	420	
Mill Creek Drainage Rep. AB p. 39	344	1,900		2.1	2.1		720	4,000		0	0	
Sulphur Creek Drainage Adj. 1944 - Sulphur - Loo Maps 3 - Willow Sho		(2) 1,430			2.0			2,900			750	
Wahsatch Creek Drainage Adjudic. book	1,270			2.5			3,200			0		
Saleratus Creek Drainage Adjudic. book	(2) 2,550			2.7			6,900			0		
Woodruff Creek Drainage Adjudic. book	5,800			2.7			15,700			2,300		
Big Creek Drainage Adjudic. book	2,525			2.7			6,800			2,900		
Randolph Creek Drainage Adjudic. book	959			2.7			2,600			400		
Otter Creek Drainage Adjudic. book	(2) 1,380			2.7			3,700			0		
Six-Mile Creek Drainage Adjudic. book	474			2.7			1,300			0		
Twin Creek Drainage Field examination etc		2,900			2.7			7,800			1,800	
Misc. Tributaries - Twin Cr. to Border Adj. book etc		586			2.7			1,600			530	
Smiths Fork and Sublette Creek Rep. 23 p. 7	1514	11,961			3.0			35,900			0	
Thomas Fork Drainage (Maps) Rep. 8 p. 39			10,800			3.0			32,400			9,100
Total	58,738	65,301	36,554							24,680	14,000	9,100

(1) Chapman Canal land in Utah.
(2) Excludes Acreage receiving Supplemental Supply from Bear River
(3) Does not include reservoir losses.

*494 acre error plus 640 acres of common which should not be included on Hilliard.

MAIN STEM

Summit County, Utah

Two canals divert water from Main Stem headwaters for use in Utah. The Hovarka, diverting from East Fork, has a proposed adjudication to supply 217 acres. Not limited in time of application by supplies, it's average diversion for three years exceeded 5.0 acre-feet per acre. Consequently, there would be no indication of a supplemental requirement. The Wright-Transmountain Canal was designed to supplement Yellow Creek water for 193 acres in Utah and 70 acres in Wyoming. To the best of our knowledge, canal losses and other factors have prevented the use of any Bear River water on these lands. Therefore, for purposes of this study, this acreage is being included under Yellow Creek Drainage.

Hilliard Flats

Lands irrigated from Bear River on Hilliard Flats receive their supplies through four canals; three diverting above and one diverting below the Utah-Wyoming State Line. Most of the water diverted in these canals is used on Hilliard Flats. Their total supply would be the sum of the flow in the Hilliard East Fork Canal and the flow at the Bear River near Utah-Wyoming State Line gaging station.

The distribution of requirement is somewhat different from other Upper Wyoming lands due to the large amount of pasture irrigated throughout the season. Accordingly, an average diversion pattern, based on past diversions, was computed and plotted to equal 2.1 acre-feet per acre total headgate requirement. (Based on previous headgate requirement studies). Plates 1 and 2 show a comparison of this requirement with actual diversions and supplies for 1944 and 1946. In 1946 supplies fall below the requirement curve for a few weeks. However, in comparing this curve with actual diversions for both years, it appears that the requirement is greater than need be. This is probably due to the fact that return flows from water applied do not enter above the point of measurement of any lower diversions,

Measuring less water applied or diverted than is actually applied by measuring at the head.

and consequently, the requirement at the point of diversion from Bear River would be less than at the farm headgates. The headgate requirement curve is actually a supply requirement curve. Supplies for July and August for the remaining years of available record (1942-1952), were roughly checked against this requirement and for the most part exceeded it. Based on available records, therefore, Hilliard Flats would need no supplemental storage water. (Diverted at Source of Supply: 1953 - 1.6 ac-ft; 1954 - 1.1) [Should have included effects of Compact reg.] See opposite page

State Line to Myers Narrows

In Report #19, it was computed that 2.3 acre-feet per acre is the average headgate requirement for delivery of a full water supply between May 1 and July 15 in the Upper Wyoming Section. It was assumed that the average above Myers Narrows would be less, and below Myers Narrows would be more than this amount. It was estimated that 2.5 acre-feet per acre would be a logical requirement from Myers Narrows to Woodruff Narrows. Consequently, 2.1 acre-feet per acre is estimated for the land above Myers Narrows. The resulting headgate requirement is ~~12,800~~ 15,200 acre-feet. ~~12,540~~ 15,300 diverted in 1953 (Tropic to Knoder incl.) + 2/3 ac 10,700 " " 1954 (3 months) " "

Plates 3 and 4 show a graphical analysis of supplies and requirements for this section for 1944 and 1946. The requirement distribution is assumed to be as recommended for the Upper Wyoming Section in Report #19. The main source of supply for these lands is Bear River where it crosses the State Line, minus the diversion in the Bear Canal which irrigates Hilliard lands. Some additional supply, which has not been measured, enters the lower part of this section from Mill Creek. For 1944 and 1946 there would be no supplemental storage requirement, even without considering return flow and natural gain in the section. On the basis of available supply records at the Utah-Wyoming State Line (1943-1952), 1944 and 1946 represent about 90% of the 10-year average (June - Sept). The supply during July, 1946 is among the lowest for the 10-year period. Though an accurate total supply can be computed for only ~~two~~ four years because of records on Bear Canal, it is reasonable to assume that there would have been no supplemental storage requirement for the past 10 years.

Myers Narrows to Utah Line

In Report #19, dated Aug. 9, 1951, a comprehensive study of supplemental requirements was made for this section of the Main Stem, excluding Chapman Canal lands. An examination of these annual requirements indicate that with about 4,500 acre-feet supplemental supply, shortages would occur in three years of the 25-year period. This appears to be a reasonable requirement based on allowable frequency of shortages. This figure includes benefits from estimated return flows within the section, but does not allow for evaporation losses.

Irrigated lands under the Chapman Canal and Neponset reservoir, totalling 7,889 acres, receive their supply from Bear River through the Chapman Canal (storage and direct flow) and from Saleratus drainage. A portion of the latter supply in early spring is available for storage in Neponset reservoir. The headgate requirement here, as on Hilliard Flats, is actually a supply requirement since it is measured at the head. Consequently, the supply requirement would be less than the computed headgate requirement in the Woodruff area. If this requirement is estimated at 2.0 acre-feet per acre, the total requirement would approximate 16,000 acre-feet. Distribution throughout the irrigation season can be regulated by the existing reservoir. Diversion from Bear River since 1945 varies from about 10,000 to 13,000 acre-feet annually. This is supplemented by runoff from adjacent Basins whose annual contribution to reservoir storage is not known. On a basis of available data it is doubtful that there exists a supplemental need on present irrigated acreage.

A reservoir site on Sulphur Creek (Hilliard site) would supply needs from Myers Narrows to the Utah State Line. Supplies for this site were investigated in Report #18 and found to be sufficient in all years of record to satisfy this requirement.

Rich County, Utah and Wyoming State Line to Cokeville

In Report #19, supplemental storage requirements were computed for the section

from Woodruff Narrows to Cokeville, involving approximately 45,000 acres. For a 25-year period (1924-48), this requirement varied between 3,000 and 44,000 acre-feet annually (excluding two dry years). If the requirements were filled to the extent of about 25,000 acre-feet annually, there would have occurred 4 years of sizable shortages in the 25-year period. This frequency of shortage is comparable to the analysis on Upper Wyoming requirements. (Hilliard Site) $\frac{35,137}{45,300} \times 25,000 =$

On an acreage division, Utah's share of this requirement would be 19,000 acre-feet and the Wyoming requirement would be 6,000 acre-feet. This could be an unreliable method of division, however, due to location within the section of diversions, natural gains and return flows. The total average requirement for 1944, 1946, 1947 and 1948 is about 56% of the 25-year requirement of 25,000 acre-feet. Using this correlation, an approximate 25-year requirement can be determined for Wyoming acreage. Flows passing the Randolph gaging station (established 1944) comprise most of the supply to diversions in Wyoming, while the flow in the B. Q. West Side Canal at Kennedy Ranch supplies about 2,150 acres in Utah and 1,880 acres in Wyoming. Based on the headgate requirement and pattern of distribution recommended in Report #19, Plates 5 and 6 indicate an average supplemental requirement of 3,300 acre-feet for Wyoming lands for the four years. If this represents 56% of the long-time requirement, the latter would equal about 6,000 acre-feet, and would verify the division made on an acreage basis.

The Woodruff Narrows reservoir site could provide supplemental supplies for Rich County, Utah and Wyoming State Line to Cokeville. Supplies were also investigated in Report #18 for this site. The 25-year average storable flow (Oct. 1 - Apr. 30) at and above Woodruff Narrows was 47,500 acre-feet. Four years of the 1924-48 period were below 30,000 acre-feet. (See Rep. #26) Considering any holdover storage, supplies would in most years, adequately meet the supplemental needs for this area after deducting storage requirements at the Hilliard site and other upstream tributaries (Yellow Creek and Sulphur Creek).

Cokeville to Border (Main Stem)

This section consists of the land irrigated from the Garrett Canal to the J. R. Richards Canal, excluding acreage in Idaho under the Cook Canal. Supply consists, mainly, of Smiths Fork flow to Bear River plus the flow passing Bear River above Sublette Creek gaging station. Only short-time records are available on supplies. However, in Report #19, it is noted that in the Woodruff-Randolph area, 1946 and 1948 supplies are below the 25-year mean. Storage requirements for these years were above average and were exceeded in only five other years. Plate 7 shows the 1946 and 1948 supply hydrographs, the 1944-48 average diversions and an average diversion requirement for 2.8 acre-feet per acre (estimated from Report #19). It is rather evident that, except perhaps in extremely dry years, there would be no supplemental storage requirement in this section.

Border to Stewart Dam

For years of available diversion records, supplies during the 1947 and 1950 irrigation season were comparatively large and probably adequate enough to use as a diversion distribution pattern for this section. Plate 8 shows the headgate requirement hydrograph based on this distribution pattern and made to equal 3.0 acre-feet per acre (estimated from previous studies). The actual diversions in these two years equalled about 3.2 acre-feet per acre (including Cook Canal to Idaho). Supplies for 1946 and 1948 are shown to be above the requirement curve throughout the year. They represent about the lowest available supplies since the dry year of 1940. An examination of years prior to 1940, in the 25-year period, indicates that if the four or five drier years are excluded, supplies are sufficient to fill requirements; especially, considering the benefits of return flows and of increased supplies due to Compact regulation. It may be noted that in Report #8, dated June 15, 1949, supplemental requirements were determined under two different plans of delivery in Upper Idaho for 1944, 1946 and 1947. This study also indicated that there would have been no supplemental need. Consequently, it may be reasonably

concluded that, except for about five dry years in the 25-year period, there would have been no supplemental storage requirement.

TRIBUTARIES

Yellow Creek Drainage

Supply records are available for 1944, 1945 and 1950-52 on Yellow Creek. Diversion records were collected only in 1944 and 1945. Hydrographs for the latter two years are shown on Plate 9. The Headgate Requirement graph is based on studies in Report #19 and is equal to 2.5 acre-feet per acre. During June and July, apparently all available water is diverted. The relatively large area between diversions and supplies during this period would represent usable gain and return flow in the section.

The following table summarizes requirement data for years of record:

Year	Supplemental Headgate Requirement	Usable Gain During Period	Supplemental Supply Requirement
1944	420 ac. ft.	185 ac. ft.	235 ac. ft.
1945	1,200	680	520
1950	300	200 est.	100
1951	740	390 est.	350
1952	380	240 est.	140
		Average	270 ac. ft.

see hydrographs in supplemental data file for this Report

Irrigation season flows in the Upper Bear River for the above years are about double the 25-year mean (1924-48). It is estimated that a 25-year requirement would be about 500 acre-feet.

Two available sites on Yellow Creek have been studied for relatively large amounts of storage by diversion from Bear River. Yellow Creek supplies, however, would be adequate to meet the supplemental requirement for these lands.

Mill Creek Drainage

Plates 10 and 11 show Mill Creek hydrographs for 1944 and 1945. Plotted are Supplies, Diversions and an estimated Headgate Requirement based on studies

in Report #19. It is apparent that there would be no supplemental requirement in 1944 and 1945. The hydrographs indicate a relatively high benefit from return flows. Supplies would appear to be adequate, even in below-average years. Records corresponding to approximate supplies above diversions are also available in 1950, 1951 and 1952. An examination of these supplies substantiate the findings in 1944 and 1945.

Sulphur Creek Drainage

This section comprises about 800 acres irrigated from Willow Creek and about 600 acres from Sulphur Creek. Plate 12 shows hydrographs covering available data on Willow Creek. Based on a pattern of diversions similar to Hilliard Flats, this area in 1944 and 1945 would have needed about 750 acre-feet. A rational analysis on lands irrigated from Sulphur Creek proper cannot be made since some of the land receives water from both Bear River and Sulphur Creek. There would also be indeterminate supply gains from return flows of Bear River Canals. It appears reasonable to conclude, based on Hilliard Flat studies, that there would be no supplemental storage requirement on this land.

One or two small reservoir sites are available on Willow Creek. Though records on supplies are available only during the irrigation season, it is estimated that supplies are adequate and potential storage space available to meet the supplemental requirement.

Wahsatch Creek Drainage

Practically no information is available on supplies for Wahsatch Creek lands, which, according to proposed adjudication records, total 1,270 acres. An existing reservoir (Crane) has a capacity of about 700 acre-feet. Lacking further information, it is assumed that there would be no additional storage requirement.

Saleratus Creek Drainage

According to recent State surveys for adjudication purposes, rights are proposed for about 2,550 acres under Saleratus Creek and it's tributaries. This

excludes land receiving Bear River or Woodruff Creek water. About 1,800 acres are listed under Saleratus and the remaining acreage under Home Canyon and other tributaries. This acreage is considerably in excess of acreage shown on available Land Use Maps (800 acres), which do not, however, extend over about 600 acres of the upper land which is listed for adjudication. A field examination of this land indicates that it is largely sub-irrigated pasture.

The only available data on supplies consists of a few miscellaneous measurements made during the irrigation season in 1944 and 1945. These indicate that the supply from Saleratus, Home and Meacham Creeks, varies from about 4 cfs in May to practically 0 in August. According to local sources, in average years after drying up in the fall there is no flow until the spring flush, which is usually of short duration. Though there is undoubtedly a large supplemental requirement on this acreage, the available supplies for storage are relatively minor. This is especially true in view of the fact that much of the contributing drainage area is below existing or potential reservoir sites. It is difficult to estimate, without supporting data, the average available storable flows. There are several existing reservoirs with a total capacity of about 500 acre-feet on Saleratus Creek. It is doubtful that much, if any, additional water is available for storage.

As time did not permit a detailed examination of irrigated acreage, the results of the adjudication survey are being used. It is questionable, however, if more than perhaps half of this amount should be classified as irrigated acreage when compared with classification of similar lands in other sections.

Since there is a question on acreage,and supply rather than requirement is the governing factor on this drainage, no attempt has been made to estimate a supplemental requirement.

Woodruff Creek Drainage

The distribution of headgate requirement on Woodruff Creek would be somewhat different than the recommended requirement in Report #19 for lands served under a

Woodruff Narrows reservoir. Diversion records were collected only in 1944 and 1945. Supplies were not sufficient in either year to define a requirement distribution pattern. However, in 1952 supply records were obtained, measuring the natural supplies, plus releases from the newly constructed reservoir. Though diversion records were not obtained, the seasonal supply, supplemented by storage, apparently was adequate according to reports from local water officials. There was some hold-over in reservoir contents last fall. An approximate pattern of headgate requirement can be determined from the supply hydrograph in 1952, knowing the period of storage draft from a study of Birch Creek flows. (Supply equals Woodruff Creek plus Birch Creek). The requirement graph based on this pattern was made to equal 2.7 acre-feet per acre. Plates 13 and 14 show 1944 and 1945 hydrographs and the supply graph for 1952. Assuming all available water was diverted in 1944 and 1945, the difference between supplies and diversions would represent the usable gain and return flow. Apparently, less than half results from return flows since points of diversion are such that only about 25% of the diversions can contribute return flows beneficial to lower diversions. Supply records on Woodruff Creek proper (South Fork) are available for 1938, 1940-1943. Adjusting this supply for Birch Creek contribution makes possible the use of supply records for 10 years. This period includes some very poor and some very good water years. Supplies were plotted for only 1944, 1945 and 1952; however, requirements were computed in a like manner for other years using estimated gain and return flows for the period of storage need.

The following table summarizes supplemental requirements after adjusting for the newly constructed reservoir:

	Supplemental Headgate Requirement	Usable Return Flow	Supplemental Storage Provided	Additional Storage Requirement
1938	5,800 ac. ft.	1,400 ac. ft.	2,500 ac. ft.	1,900 ac. ft.
1940	12,700	2,900	2,500	7,300
1941	10,600	1,900	2,500	6,200
1942	8,300	1,700	2,500	4,100
1943	4,400	900	2,500	1,000
1944	5,300	600	2,500	2,200
1945	3,700	850	2,500	350
1950	1,400	500	2,500	0
1951	3,100	700	2,500	0
1952	900	900	0	0
Average	5,600			2,300

Two sites have been investigated on Woodruff Creek for various amounts up to 10,000 acre-feet. Average runoff (14 years) from Oct. 1 to Apr. 30, is about 6,000 acre-feet. This would adequately supply the Woodruff Creek supplemental requirement in each of the 14 years.

Big Creek Drainage

Plate 15 shows Supply and Diversion data for 1944 and 1945. Location of diversions with respect to most of the irrigated acreage would indicate practically no benefit from return flows between the upper and lower diversions. There is, however, a relatively large natural gain in this reach of the section. From a study of the hydrographs in these two years it appears that all available water is diverted, with the diversions averaging about 124% of the supplies. Since return flows contribute relatively little to this gain, it probably would vary only a small amount with increased water application. For purposes of this

this excludes acreage receiving water from both Big and Randolph Creeks, which has been included in the total acreage and supplemental requirement under Big Creek.

*Under a diversion pattern similar to Smith Fk. Supply req't = headgate 2000.

analysis, it may be estimated at 700 acre-feet annually. Records of supply are available for 10 years (1939-45, 1950-52). There is an extreme variation in supplies during this period, ranging from less than 500 acre-feet to 15,000 acre-feet in the May - September period. The following summary is based on the 1944-45 correlation of supplies with diversions using a headgate requirement of 2.7 acre-feet per acre (6,800 acre-feet).

Year	Total Supply May - Sept.	Beneficial Supply	Supply Needed for Headgate Requirement *	Supplemental Supply Requirement
1939	2,180 ac.ft.	2,180 ac.ft.	6,100 ac.ft.	3,920 ac.ft.
1940	460	460	6,100	5,640
1941	540	540	6,100	5,560
1942	680	680	6,100	5,420
1943	4,990	4,990	6,100	1,110
1944	2,540	2,540	6,100	3,560
1945	2,670	2,670	6,100	3,430
1950	14,940	6,100	6,100	0
1951	13,090	6,100	6,100	0
1952	15,500	6,100	6,100	0
*1953	7,350	6,100	6,100	
1954	4,040	4,040	6,100	
			Average	2,900

* Headgate requirement adjusted for gain.

One site has been investigated for capacities from 1,000 to 3,600 acre-feet. Average runoff (15 years) from Oct. 1 to Apr. 30 is about 4,400 acre-feet. This would meet supplemental needs fully in 11 of the 15-year period (1938-52).

Randolph Creek Drainage

In the Utah proposed determination of Water rights, there are listed 959 acres irrigated exclusively from Randolph or Little Creek and it's tributaries. This excludes acreage receiving water from both Big and Randolph Creeks, which has been included in the total acreage and supplemental requirement under Big Creek.

An existing reservoir, capacity 614 acre-feet, serves land above, by exchange, and approximately 400 acres below the reservoir. Diversion records are available below the reservoir for 1944 and 1945, but are not available for land above the reservoir. Records of supplies entering the reservoir have been obtained since 1950. No records have been collected on supplies above all diversions, but in 1944 this was estimated to be about 1,100 acre-feet, based on one or two miscellaneous measurements.

Based on 2.7 acre-feet per acre, the lower land would require about 1,100 acre-feet annually. In 1944 and 1945, diversions below the reservoir averaged 1,400 acre-feet annually. Since 1950 supplies entering the reservoir, plus existing storage would also adequately meet this requirement. It would appear that existing supplies would usually be adequate for the lower land if the acreage receiving part supply from Big Creek is excluded.

Based on the same duty of water, land above the reservoir would require about 1,500 acre-feet annually. Upper users report a definite shortage in most years. Based on interviews with upper users and the meager data available, an estimate of 400 acre-feet supplemental supply requirement is being made.

The existing reservoir on Randolph Creek could be enlarged to meet supplemental requirements above by further exchange storage. Off-season supplies are not known but, undoubtedly, would be sufficient to meet the estimated requirement.

Otter Creek Drainage

According to recent surveys made in connection with proposed adjudications, 1,378 acres are irrigated exclusively from Otter Creek. In addition, approximately 1,350 acres below the Randolph-Woodruff Canal receive water from Otter Creek and Bear River. The latter acreage has, in past storage requirement studies, been included with land irrigated from Bear River. Therefore, the supplemental requirement computed for the Lower Utah Section in Report #19 and listed under Main Stem land in this report, applies in part to this lower acreage. Since segregation

cannot be made and to avoid duplication, only that land above the Randolph-Woodruff Canal, comprising 1,378 acres, is listed herein as Otter Creek land.

As indicated on Plate 16, Otter Creek flow is well sustained with small seasonal variation. In general, supplies from May to September can all be considered beneficial with no excessive peak flows which cannot be beneficially diverted.

A gaging station, situated below about half of the diversions, was in operation from 1939 to 1945. Diversion records were collected in 1944 and 1945 and records of supplies above diversions are available since 1950. A study of individual diversions in 1944 and 1945 indicates that fairly adequate supplies were available for upper users. In 1944 and 1945 the three upper users irrigating about 1,125 acres diverted an average of 2.73 acre-feet per acre. These years were about normal for the 1939-45 period of record on Otter Creek. Magnitude of flow passing the gaging station varied relatively little in the six-year period. It is known that lower supplies are generally inadequate for lands situated below the Randolph-Woodruff Canal which have been included with Bear River acreage, and for which supplies cannot be ascertained.

It appears reasonable to conclude that present irrigated land above the Randolph-Woodruff Canal is adequately supplied (2.7 acre-feet per acre) from Otter Creek in most years. However, there may be a distribution problem among the upper users.

Six-Mile Creek Drainage

Utah proposed adjudication records list 474 acres irrigated from Six-Mile Creek. Supply records are not available. A reservoir of approximately 500 acre-feet capacity now exists above 376 irrigated acres. Apparently, additional supplemental requirements on this drainage, if any, would be minor and for purposes of this study are assumed to be negligible.

Twin Creek Drainage

Supply and diversion data are very meager on Twin Creek with practically no records above Sage. The Wyoming book of adjudications lists 2,290 acres below Sage and 2,472 acres above, including all tributaries, or a total of 4,762 acres. However, much of the adjudicated land was abandoned many years ago. To arrive at a more reliable acreage, the P.M.A. and S.C.S. offices at Kemmerer were consulted and a field investigation made with available land use maps. Most of the users on Twin Creek were consulted with respect to irrigated acreage, supplies, and supplemental needs. Based on land use maps, adjudicated water right listing and field coordination, there are about 1,800 acres of irrigated land below Sage, and 1,100 acres above Sage. Headgate requirement for this drainage is estimated at 2.7 acre-feet per acre (from Report #19,) giving a total requirement of 7,800 acre-feet.

Flows passing the Twin Creek gaging station are practically equivalent to the supply for the 1,800 acres below Sage. Type of crops would indicate a seasonal distribution pattern similar to Smiths Fork. The following table, based on the monthly distribution pattern of Smiths Fork and a requirement of 2.7 acre-feet per acre, summarizes the supplemental supply needed in each year of the 10-year period of record, 1943-52.

See note opposite page.

Year	Supplemental Requirement acre-feet	Year	Supplemental Requirement acre-feet
1943	2,470	1948	1,740
1944	1,850	1949	1,960
1945	2,220	1950	0
1946	2,160	1951	1,260
1947	950	1952	0
		Average	1,460

Above Sage there are about 300 acres irrigated on Rock Creek, principal tributary of Twin Creek. During the irrigation season most of the flow in Twin Creek is supplied from Rock Creek. According to users, supplies are adequate except in extremely dry years.

There are about 260 acres being irrigated on South Fork of Twin Creek. Of this, 115 acres are now adequately supplied from existing storage aggregating 250 acre-feet. A supplemental supply of one acre-foot per acre is estimated for remaining South Fork land. Field examination and discussion with water users would indicate that the remaining Twin Creek land may require about 200 acre-feet supplemental supply.

The total annual supply requirement for Twin Creek would be about ~~800~~ 1800 acre-feet. Sites and supplies are adequate on Rock Creek and at smaller sites on the south side tributaries to fill this requirement.

Miscellaneous Tributaries - Twin Creek to Border

Approximately 590 acres are irrigated from Antelope, Leeds, Birch and Chalk Creeks. Existing storage capacity for this acreage totals 159 acre-feet. The following table summarizes estimates and available data:

Stream	Irrig. Acreage	Average irrig. season flow	Existing Storage Cap.	Total Supply	Requirement (2.7 a.f./ac)	Suppl. Req't.
Antelope	80 est.	230 est.	2 a.f.	232 a.f.	215 a.f.	0 a.f.
Leeds	100 est.	240	30	270	270	0
Birch	204	300	97	397	550	153
Chalk	202	135	30	165	545	380
Total	586	905	159	1,064	1,580	533

Data is not available relative to available sites and supplies to satisfy the supplemental requirement on Chalk Creek. The existing reservoir is in a relatively steep canyon. If economic aspects are not considered, it is estimated that the supplemental requirements could be filled on these tributaries.

Smiths Fork

Plates 17 and 18 show a graphical picture of supplies, diversions and requirements for the Smiths Fork drainage as defined in the tentative Draft.

Studies in Report #19 would indicate that about 3.0 acre-feet per acre should be an adequate headgate requirement. The average distribution of diversions under this requirement is based on actual diversion patterns for 1944, 1946, 1947 and 1948 (supplies apparently were adequate). On Plate 17 is shown the four-year average supply above diversions plotted on 10-day mean flows. Average diversions (actual) are likewise plotted. It is noted that the supply curve stays well above the Headgate Requirement curve throughout the season for these four years. Comparison with available records (1942-52) at Smiths Fork near Border gaging station would indicate that this supply curve is about 90% of the 11-year normal.

In studying the probable effects of Compact regulation on Smiths Fork it is noted that of the years of available diversion records (1944-48), 1948 diversions would have been reduced by the greatest amount under a Compact. Accordingly, Plate 18 has been prepared to show the effect of regulation on 1948 diversions under the present Draft division of 43% - 57%, and also under the proposed sliding scale division suggested at the last Commission meeting. A maximum diversion rate of 1 cfs per 50 acres is shown being applicable when the flow at Border drops below 400 cfs. It is apparent from these graphs that even under Compact regulation and without considering the benefit of return flows, there would be no need for supplemental storage in these years.

Since the Average Supply curve, consisting of the flows in Smiths Fork near Border, Howland, Grade, Pine, Spring and Sublette Creeks remains above the requirement curve it would not be necessary to compute usable return flows and natural gain in the section. However, a rather detailed analysis of this gain was made from available data. Results would indicate that probably half the applied water returns to the system.

From available information it can be reasonably concluded that, excepting unusually dry years, Smiths Fork would not have a supplemental need for storage on present irrigated acreage.

etermination of Supply, Thomes Fork

re ft distributed over season by 10 day
based on Upper Idaho Pattern of diversion
e years. Corresponding flow for these
eriods was considered to be the maximum
which could be used beneficially. Total
available following May high water were
less than this pattern and hence beneficial
supplies were computed by increasing (by
age based on previous records) the
f Thos Fork Geneva & Salt Creek or the
at State line in recent years.

stimated gain and return flow computed
- analysis of gains in 1944 & 1945 Hydrometric
t:

1944

Total Supply	Diversions above Raymond Station	Passing Raymond	Gain cfs	Gain A.F.
8285 cfs	5579 cfs	4383 cfs	1677	3320
- 16,557 cfs	11,714 cfs	11227 cfs	6,384	12,700 (summer rains)

Gain = Diversions + Outflow - Supply

There are a
studies in Report
headgate requirem
seasonal requirem
and Diversion re
1.3 and 2.4 acre

Fairly acc
1940-1952. The
quirements for t
amount that coul
beneficial supp

Year	Su
1940	
1941	
1942	
1943	
1944	
1945	
1946	
1947	
1948	
1949	
1950	
1951	
1952	

* c

A rese
10,000 acre-
and a 5,000

Thomas Fork Drainage

There are approximately 10,800 acres irrigated from Thomas Fork. Results of studies in Report #19 and other consumptive use studies would indicate an average headgate requirement of about 3.0 acre-feet per acre for this land. The total seasonal requirement, then, would be 32,400 acre-feet. Plates 19 and 20 show Supply and Diversion records for 1944 and 1945. Diversions in these two years equalled 1.3 and 2.4 acre-feet per acre respectively.

Fairly accurate computations of supplies can be made for the 13-year period, 1940-1952. The following table summarizes beneficial supplies and supplemental requirements for this period. Total supplies were reduced, usually in May, by the amount that could not be beneficially diverted, and the remainder classified as beneficial supply. (Based on Upper Idaho pattern of diversions in adequate years)

Year	Beneficial * Supply (May - Sept)	Est. Usable gain * and return flow	Supplemental Supply Requirement
1940	5,200 ac. ft. (Total May-Sept)	2,000 ac. ft.	25,200 ac. ft.
1941	14,300	5,000	13,100
1942	13,900	5,000	13,500
1943	19,100	5,000	8,300
1944	16,900	5,000	10,500
1945	26,600	5,000	800
1946	17,000	5,000	10,400
1947	23,000	5,000	4,400
1948	19,600	5,000	7,800
1949	17,600	5,000	9,800
1950	27,600	5,000	0
1951	21,800 — 34,500	5,000	5,600
1952	18,400	5,000	9,000
		Average	9,100

* See note opposite page. 18,500

A reservoir site on Thomas Fork has been studied for capacities of 5,000 and 10,000 acre-feet. A 9,000 acre-foot reservoir would fill in 8 of the past 12 years, and a 5,000 acre-foot reservoir would fill in all years.

24000 U
9000 W

Active Capacity 33,000 A.F. — dead storage 1000
$1,700,000 54 yrs

43,900 acres 34,100 Ut — 9,800 Wyo.

Hilliard 11,000 active Cap. Suppl. 12,800 acres.
↳ Not feasible on Bureau Standards –

Family size units must be larger than now permitted

	Narrows	Hilliard
Average storable flows	U – 17,100	
	W – 7,000	W – 10,100
	24,100	10,100
Total storage & return flow	U – 32,500	
	W – 11,700	W – 15300

Irrigators could pay annually $31,600 for Narrows
54 yrs.

126400
158000
1,706,400

Bureau Studies 25 & 29.

Increase in water supply attributable to project 32,500 – U A.F.
11,700 – W.

[illegible] – [illegible] [illegible] [illegible] 22,121
[illegible] – [illegible] 7,[illegible] = 31 % × ~~[illegible]~~ 17,750 = 3400 [illegible]
[illegible] 9.1 / 41,[illegible]
1288

OTTER CREEK (Report # 27)

There are a few qualifications in the findings of this Engineering Committee report which I think should be well understood before a quick judgment is made of the conclusions relative to Otter Creek lands.

(1) The acreage below the Randolph - Woodruff canal, for which there are supplemental rights, had been included in an earlier study with other Bear River land which could be served by a Woodruff Narrows reservoir. This acreage, therefore, was not included in the Otter Creek study.

(2) Supplies, May - September, in 1944 and 1945 check closely the mean supplies measured, 1950 - 56, and averages about 4,000 acre-feet above all diversions during this period. Allowing no credit whatever for return flows of water applied in the upper part of the area, this supply would still allow 2.9 acre-feet per acre on 1,378 acres listed in the proposed adjudication above the Randolph - Woodruff canal.

(3) Diversion records in 1944 and 1945 indicated that 3.0 acre-feet per acre was applied to acreage on Otter Creek above the Randolph - Woodruff canal.

(4) A headgate requirement of about 2.7 acre-feet per acre has been used for this section of Utah as a basis for computing supplemental water requirements. The Bureau of Reclamation in their present study in connection with the Woodruff Narrows reservoir is using 2.63 acre-feet per acre.

1944 All Canals (acre-feet)

May	June	July	Aug.	Sept.
1,000	959	799	757	765

General

Former Bureau studies show diversion requirement of 2.6 af/ac at Woodruff, May 25 - Sept. 10 (Lowry-Johnson).

Report # 19 shows headgate requirement of 2.7 af/ac.

Present Bureau studies for project use 2.63 af/ac.

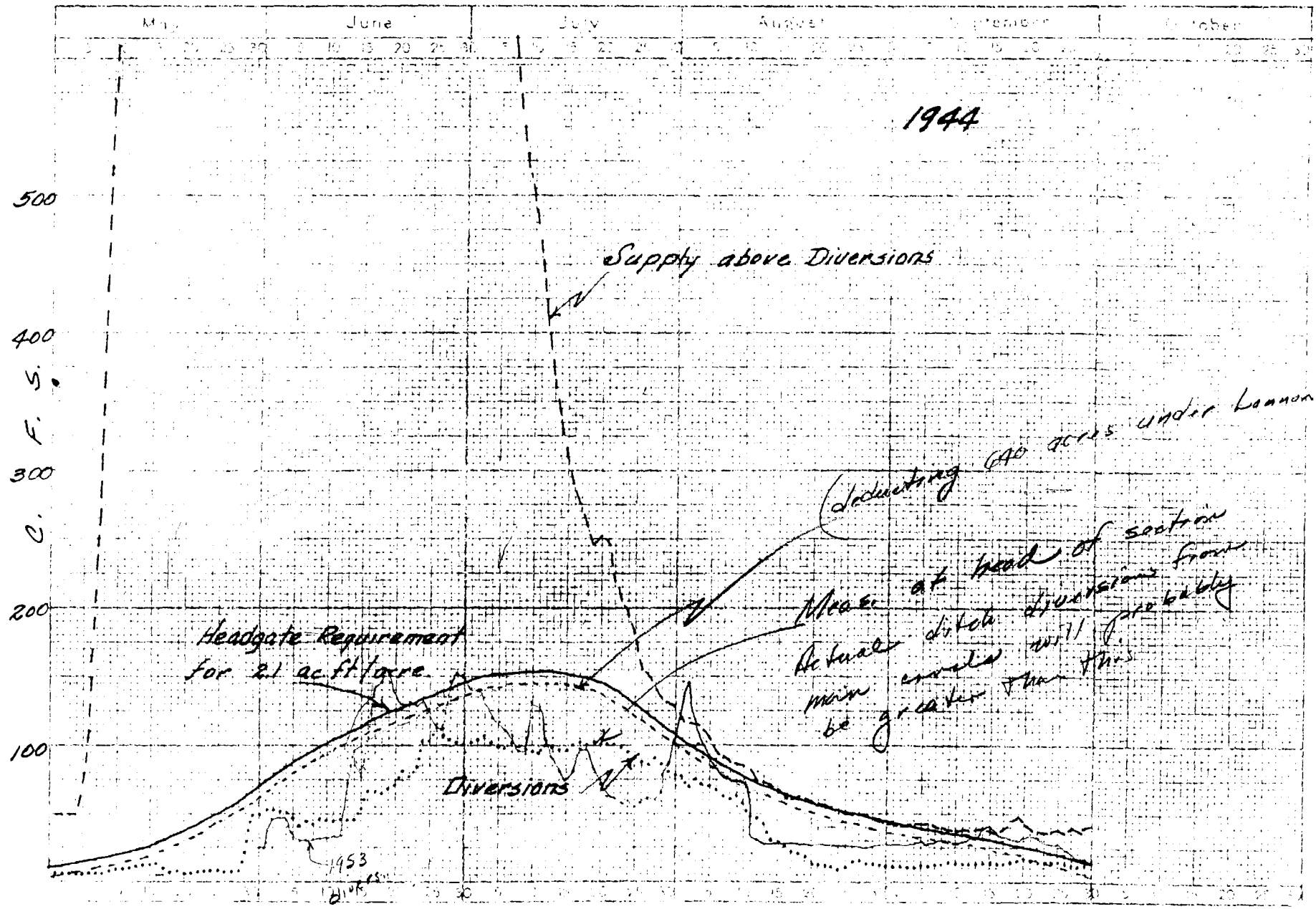
Headgate efficiency coefficient = $\frac{\text{consumptive use}}{\text{water applied}}$ = about 50%.

May 1-July 15 period of demand in Utah Section (report # 19).

Possibility of some exchange storage with Upper Wyoming in connection with Francis-Lee and Bear River canals. (page 13, report 26, about 2,000 ac. ft.)

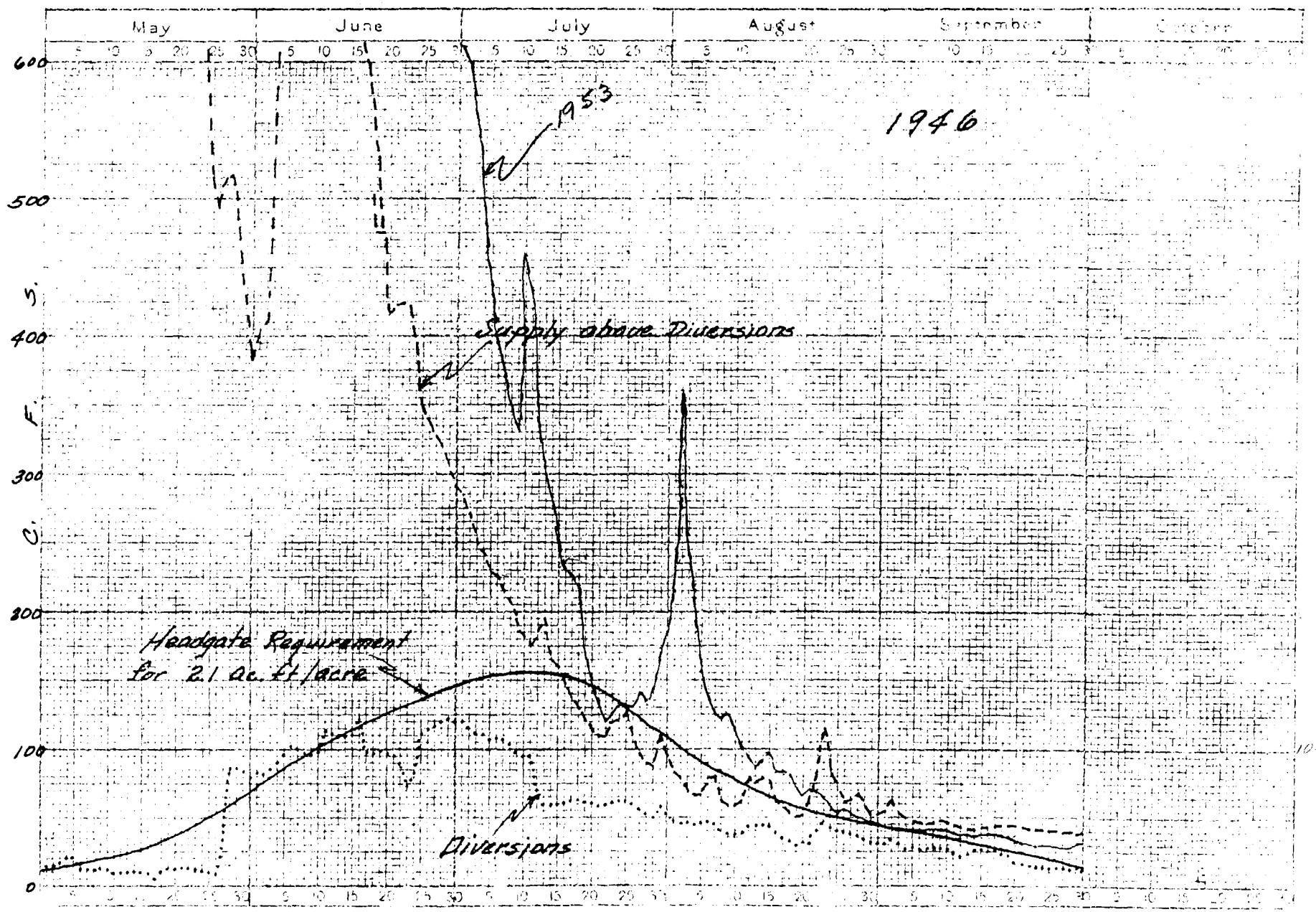
UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

HILLIARD FLATS



9-270-C UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

HILLIARD FLATS



UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY WATER RESOURCES BRANCH

UTAH-WYOMING STATE LINE TO MYERS NARROWS — MAIN STEM

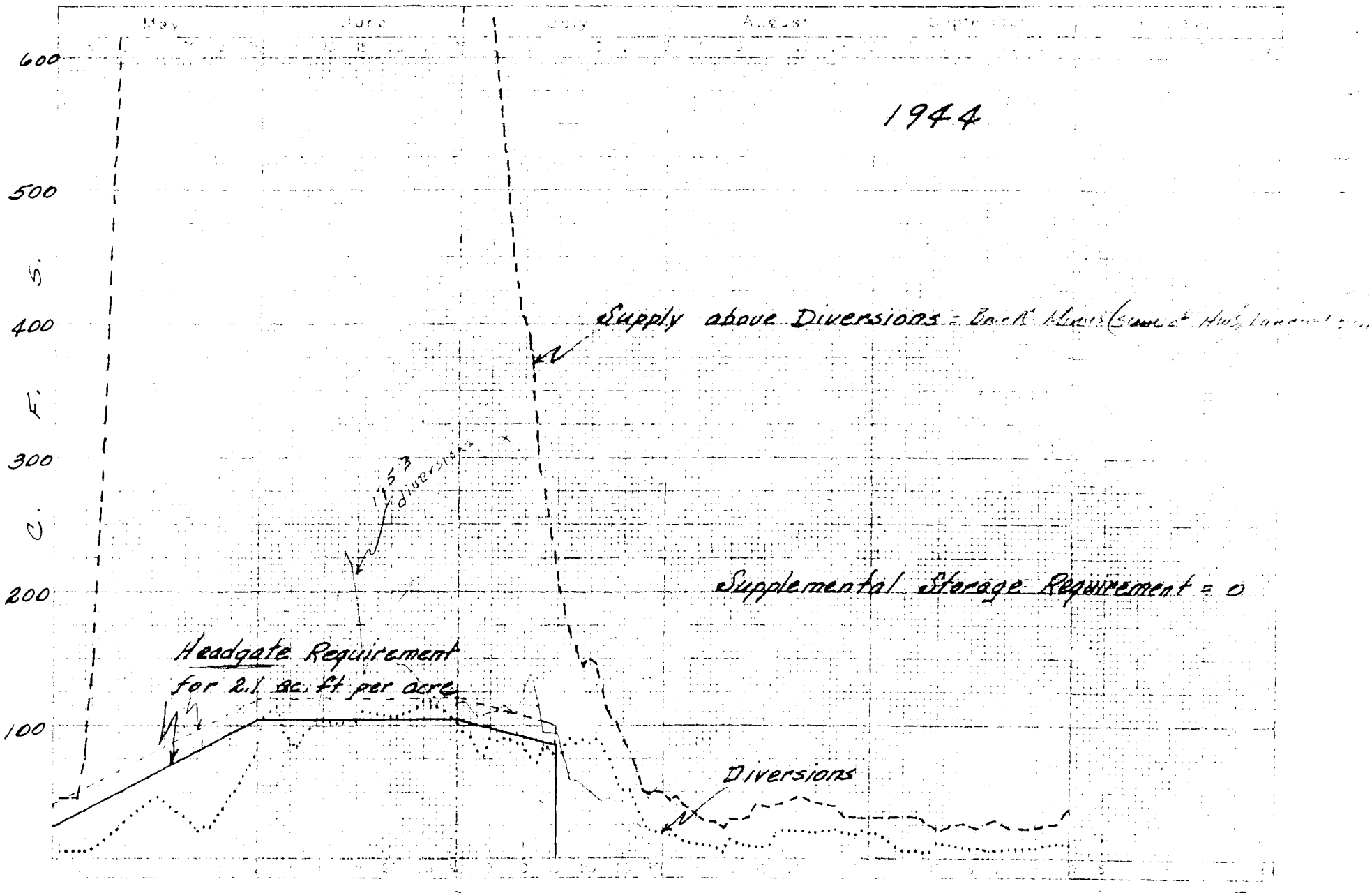


PLATE NO. 3

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

UTAH-WYOMING STATE LINE TO MYERS NARROWS — MAIN STEM

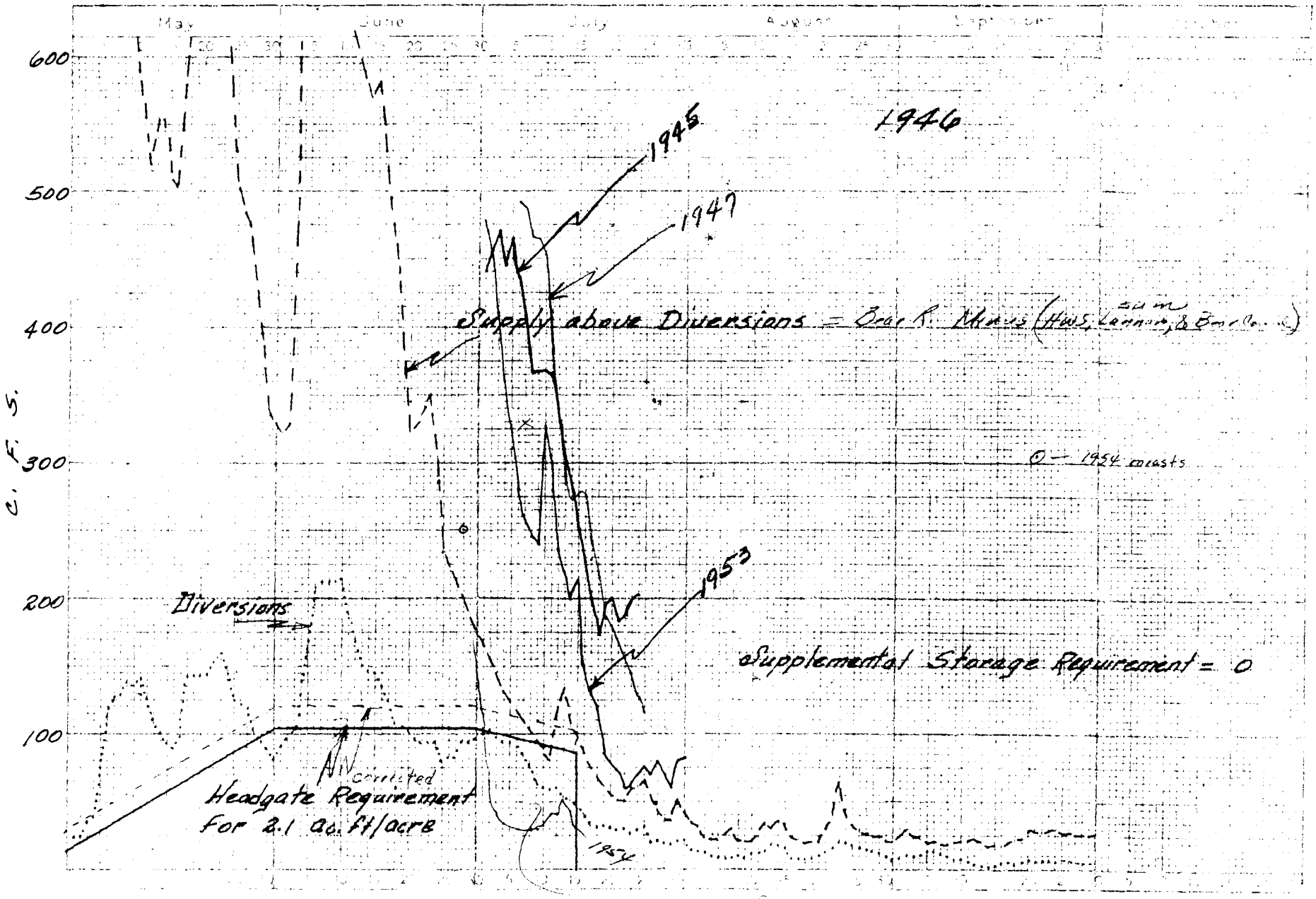
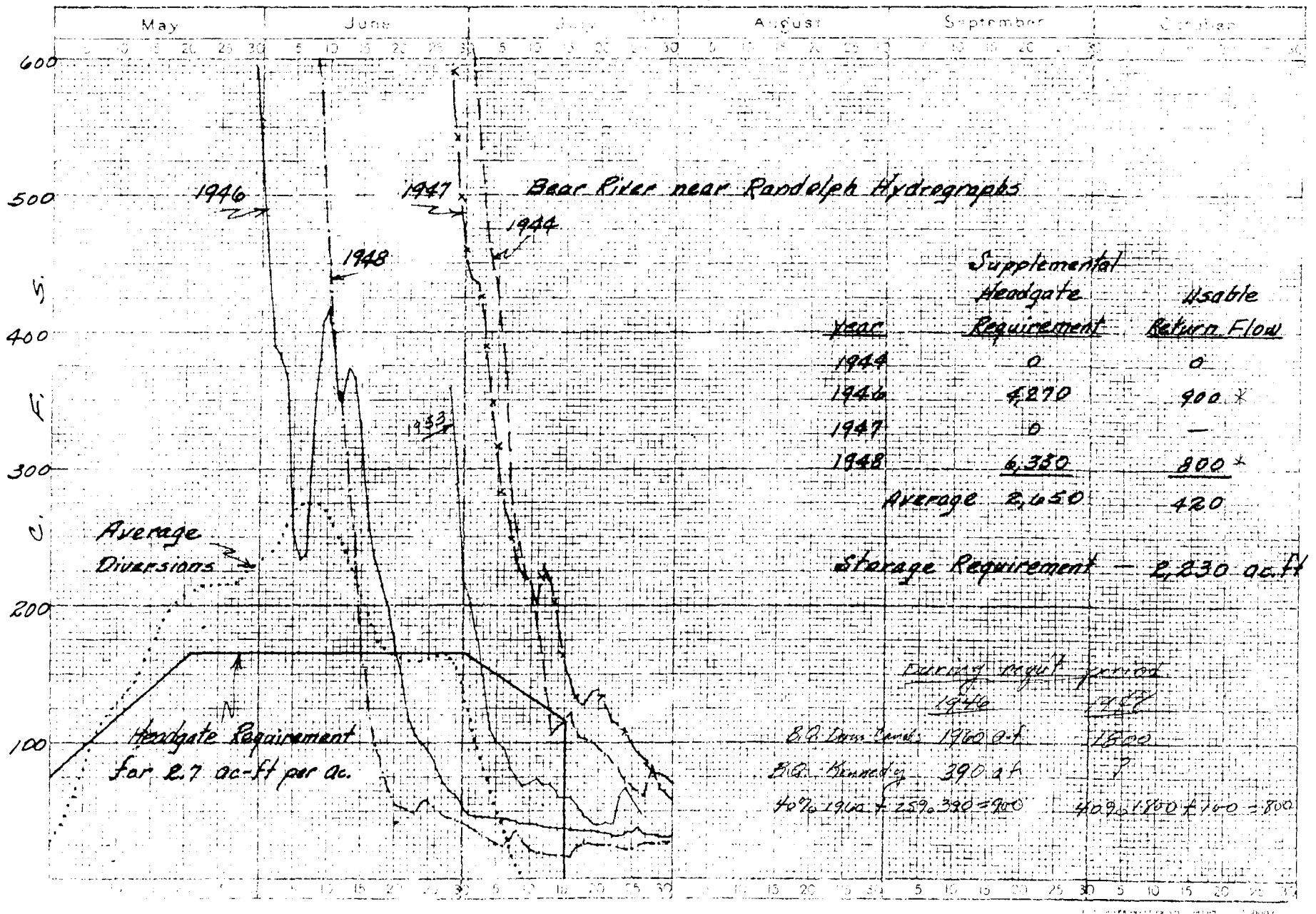


PLATE NO. 4

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

Wyoming State Line to Cokeville (Excluding land under B.Y. West Side Canal)



Bear River near Randolph Hydrographs

Year	Supplemental Headgate Requirement	Usable Return Flow
1944	0	0
1946	4,270	900 *
1947	0	—
1948	6,350	900 *
Average	2,650	420

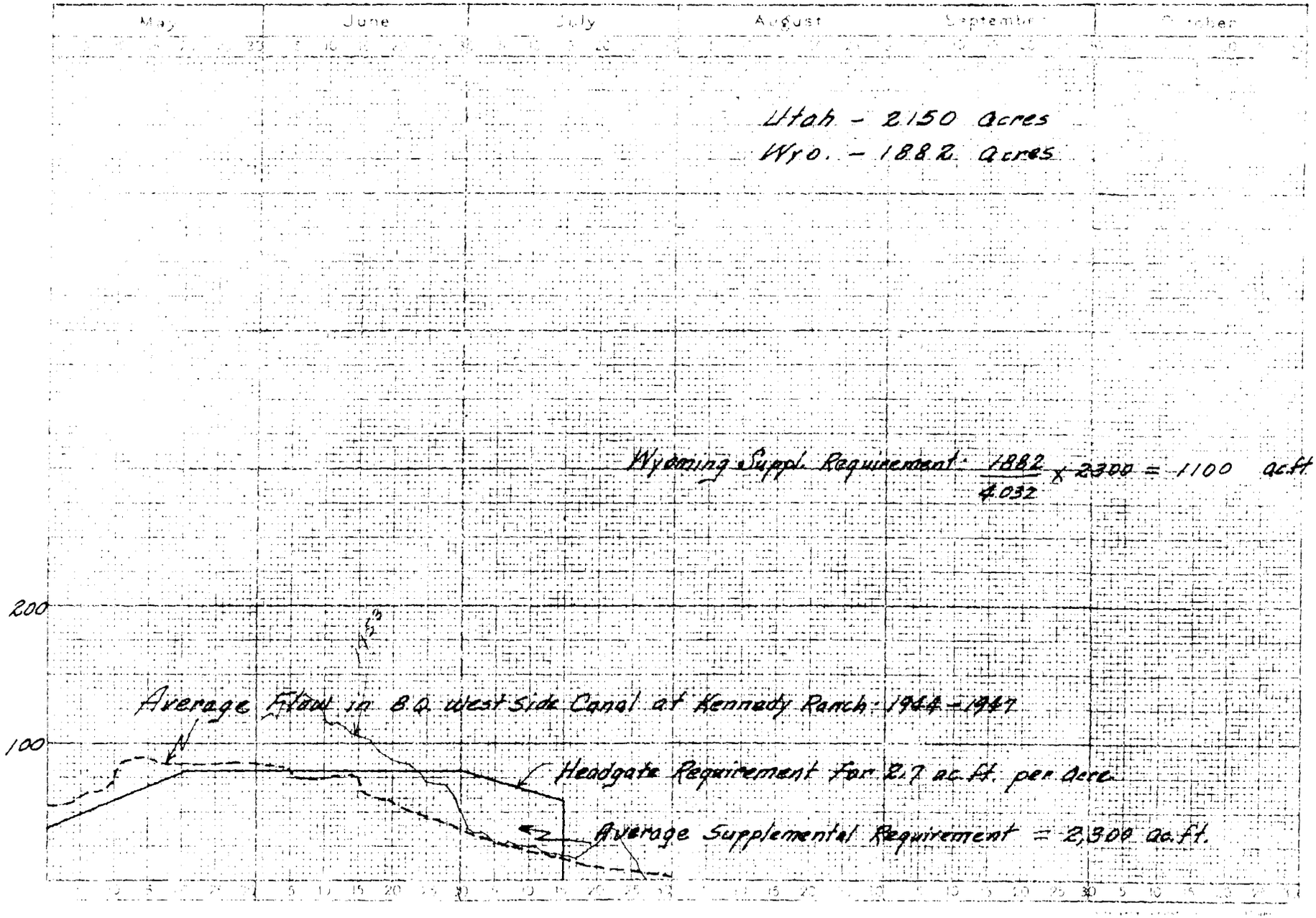
Storage Requirement — 2,830 ac.ft

	During irrigation season 1946	acc
BC Dam Res.	1760 a-f	1800
BC Kunzler	290 a-f	"
40% 1900 + 25% 330 = 900		40% 1800 + 100 = 800

Page No. 5

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

B.O. West Side Canal Land Below Control Line (Kennedy Ranch)



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

COKEVILLE TO BORDER — MAIN STEM

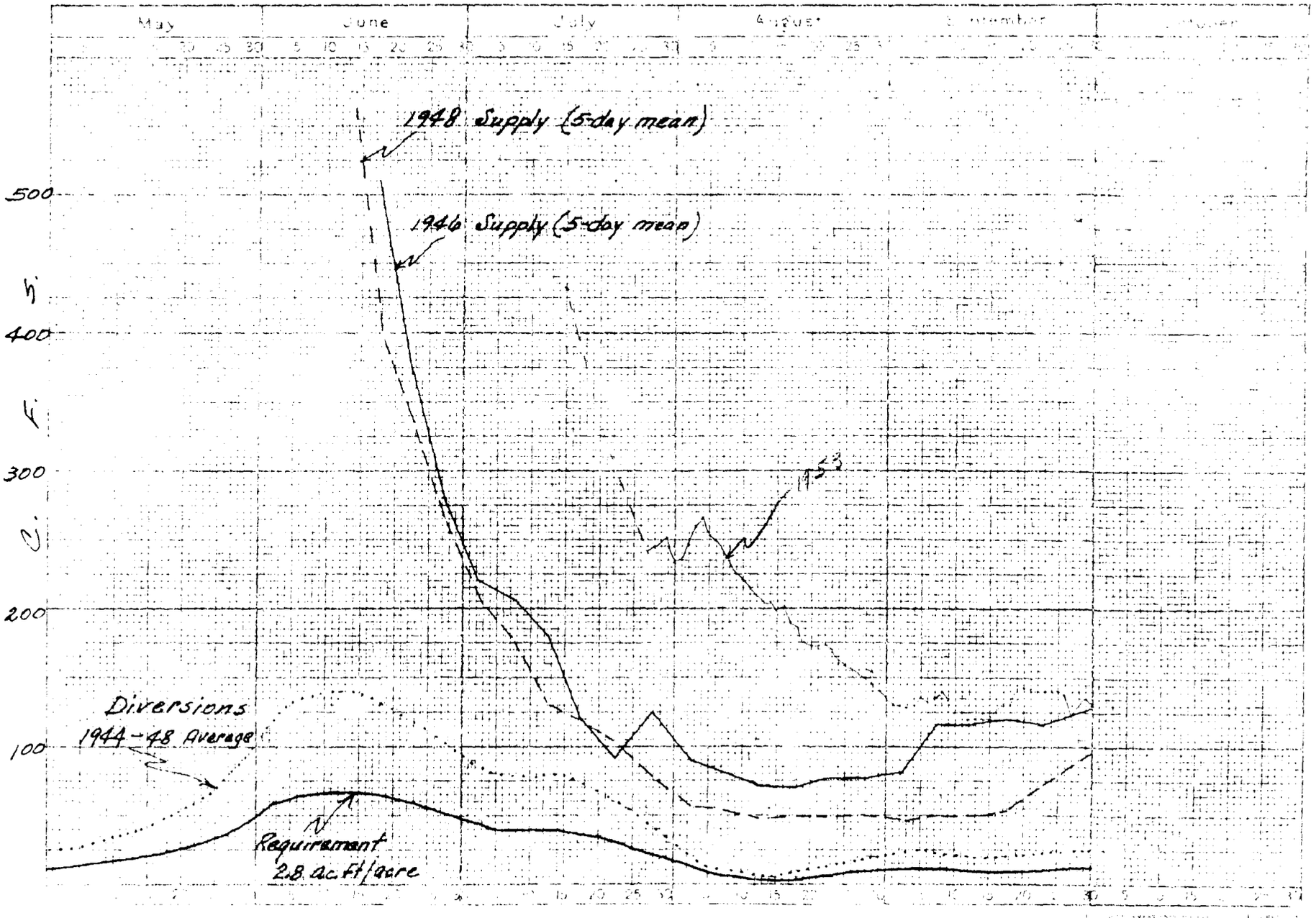


PLATE No. 7

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

Border To Stewart Dam

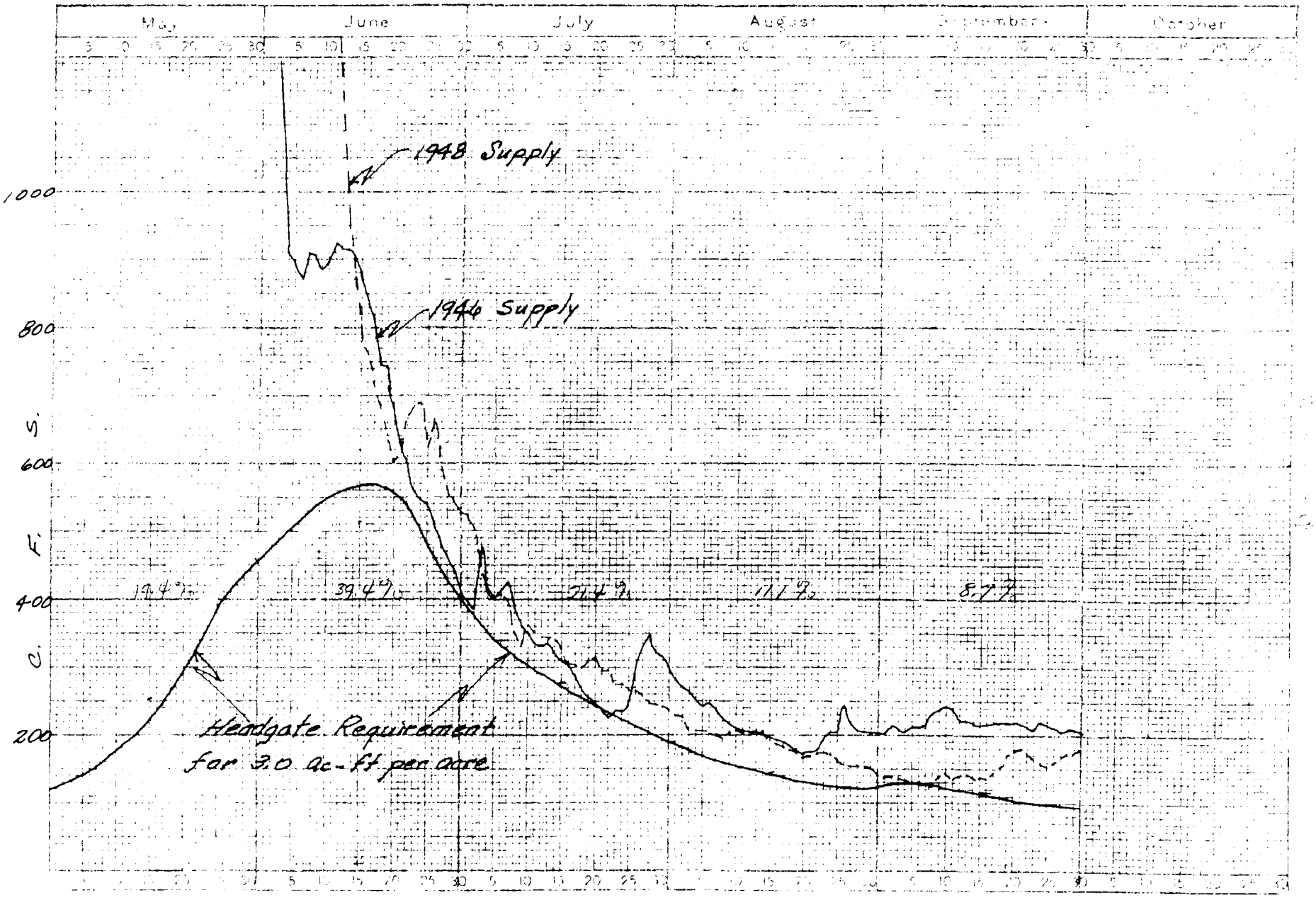
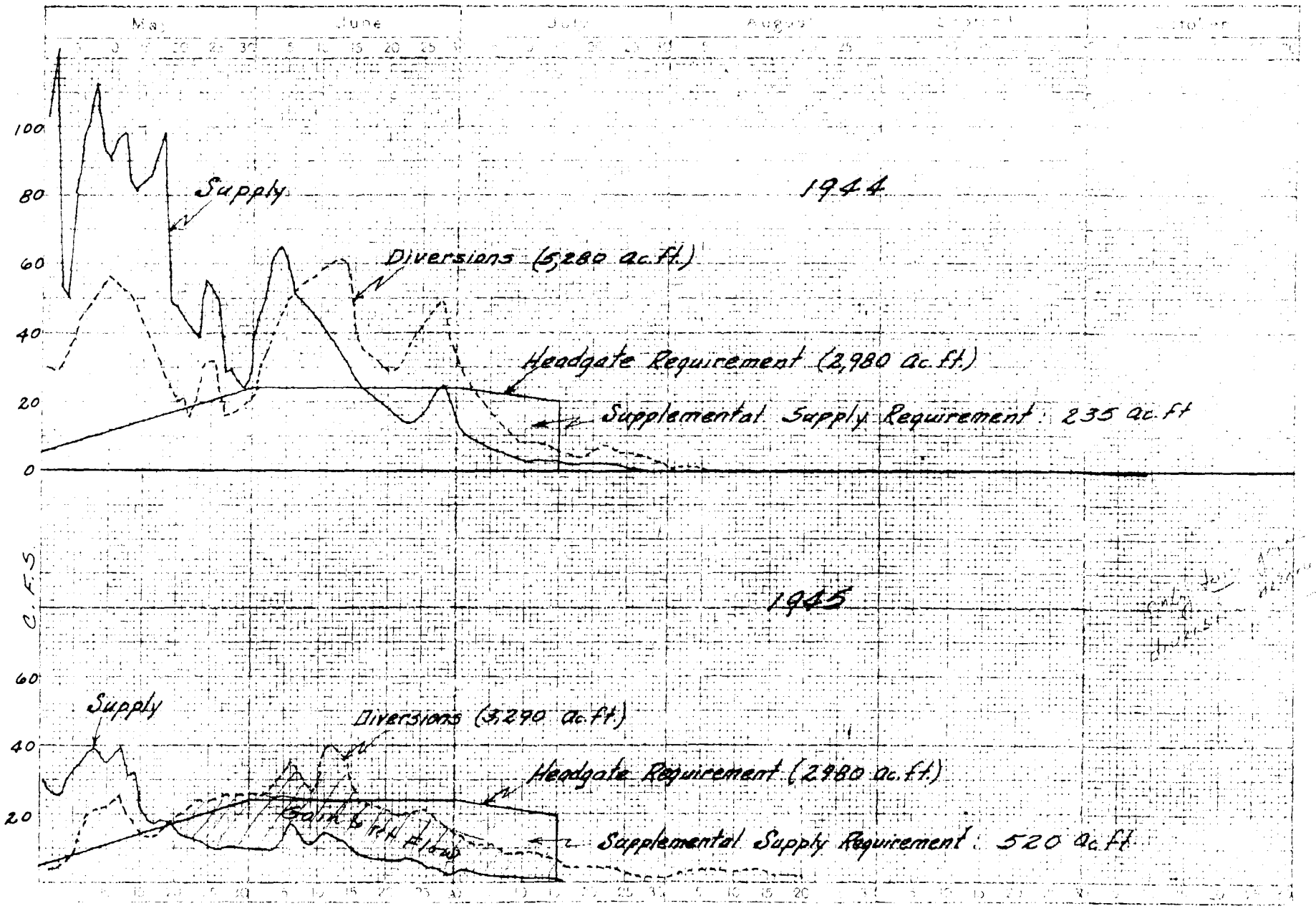


Chart No. 8

YELLOW CREEK 1944 & 1945



9-279-1 UNITED STATES DEPARTMENT OF THE INTERIOR GEOLOGICAL SURVEY (WATER RESOURCES BRANCH)

MILL CREEK — 1944

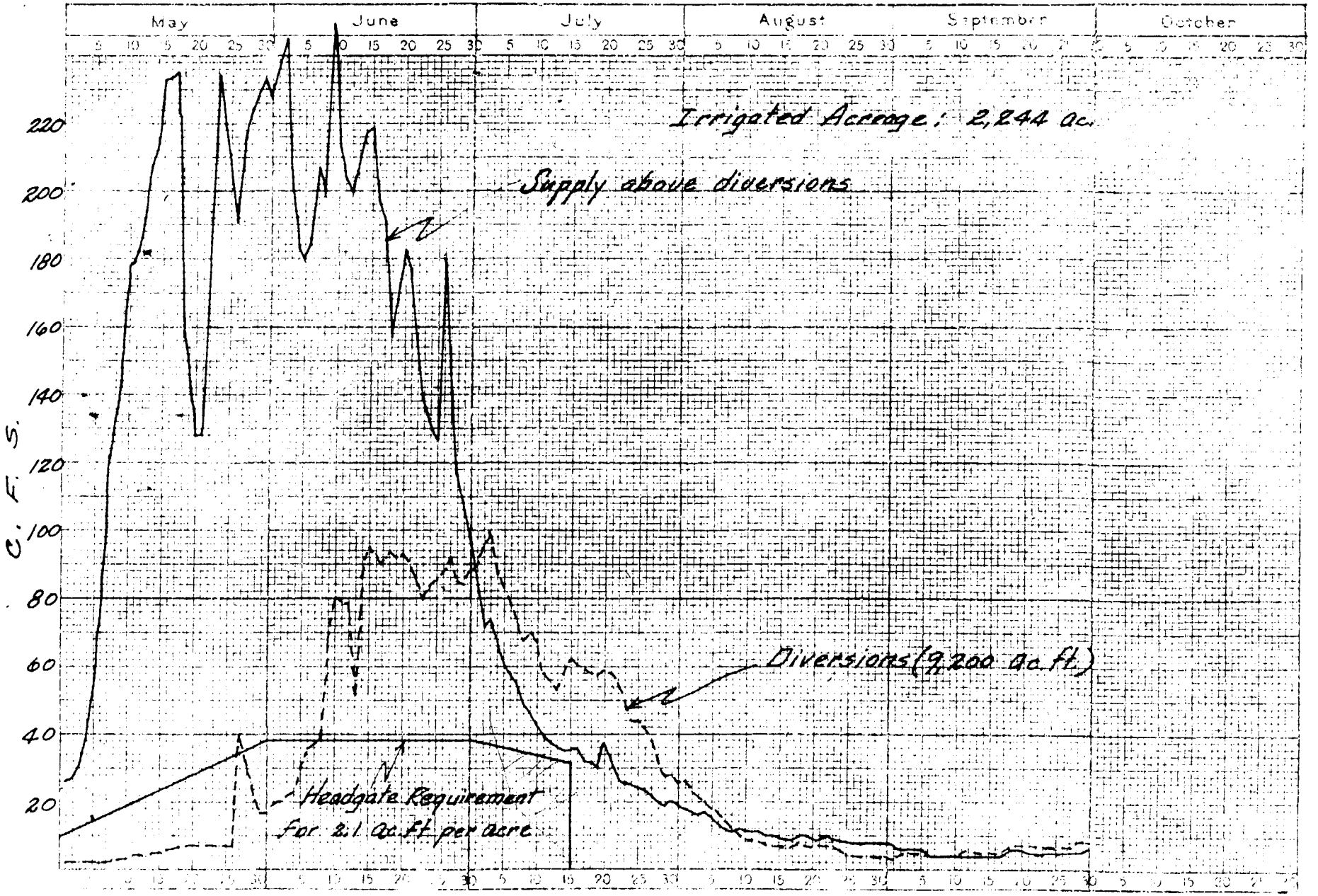


PLATE No. 10

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

Mill Creek — 1945

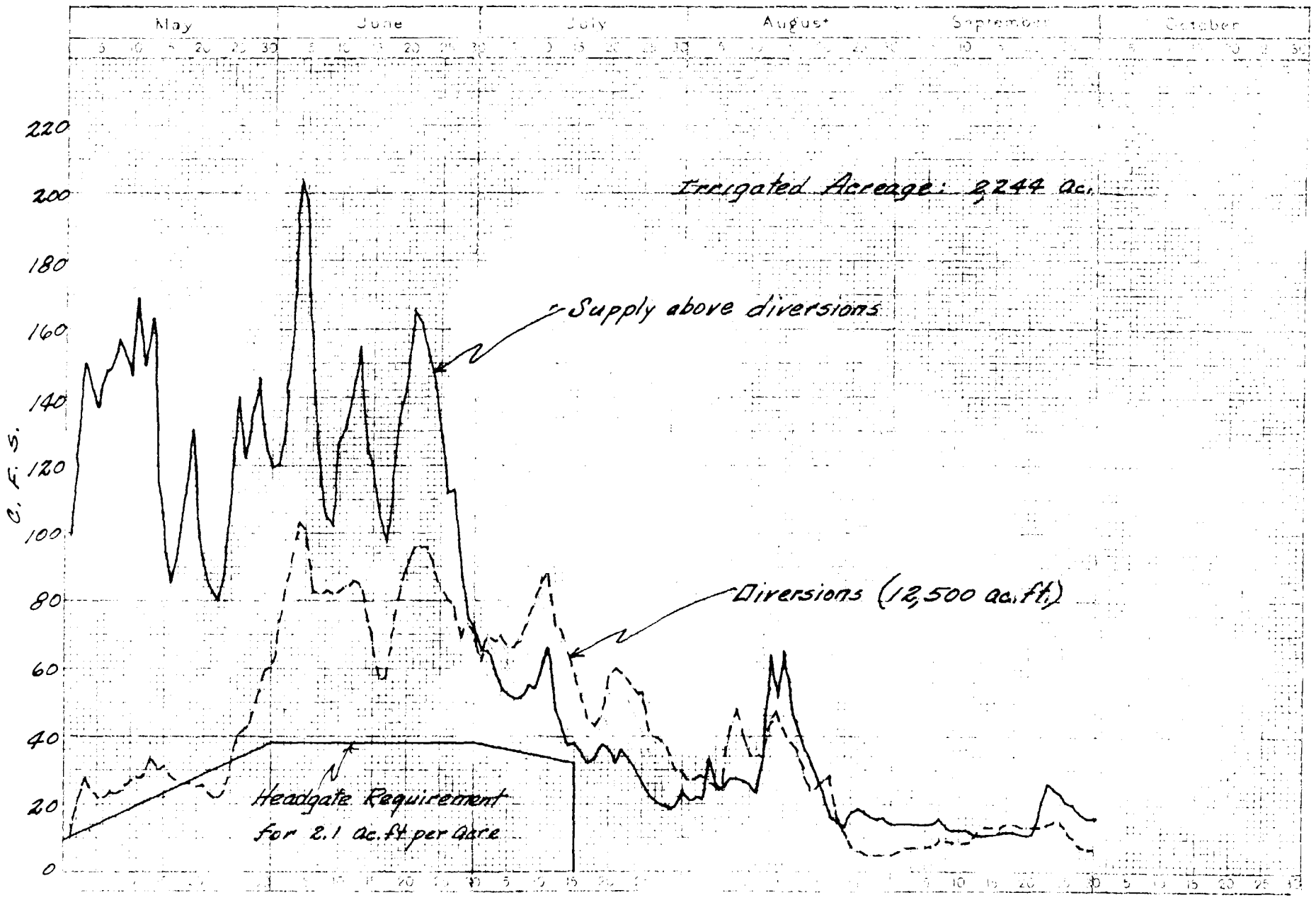


Plate No. 11

9-279-C

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

Willow Creek (Tributary to Sulphur Creek)

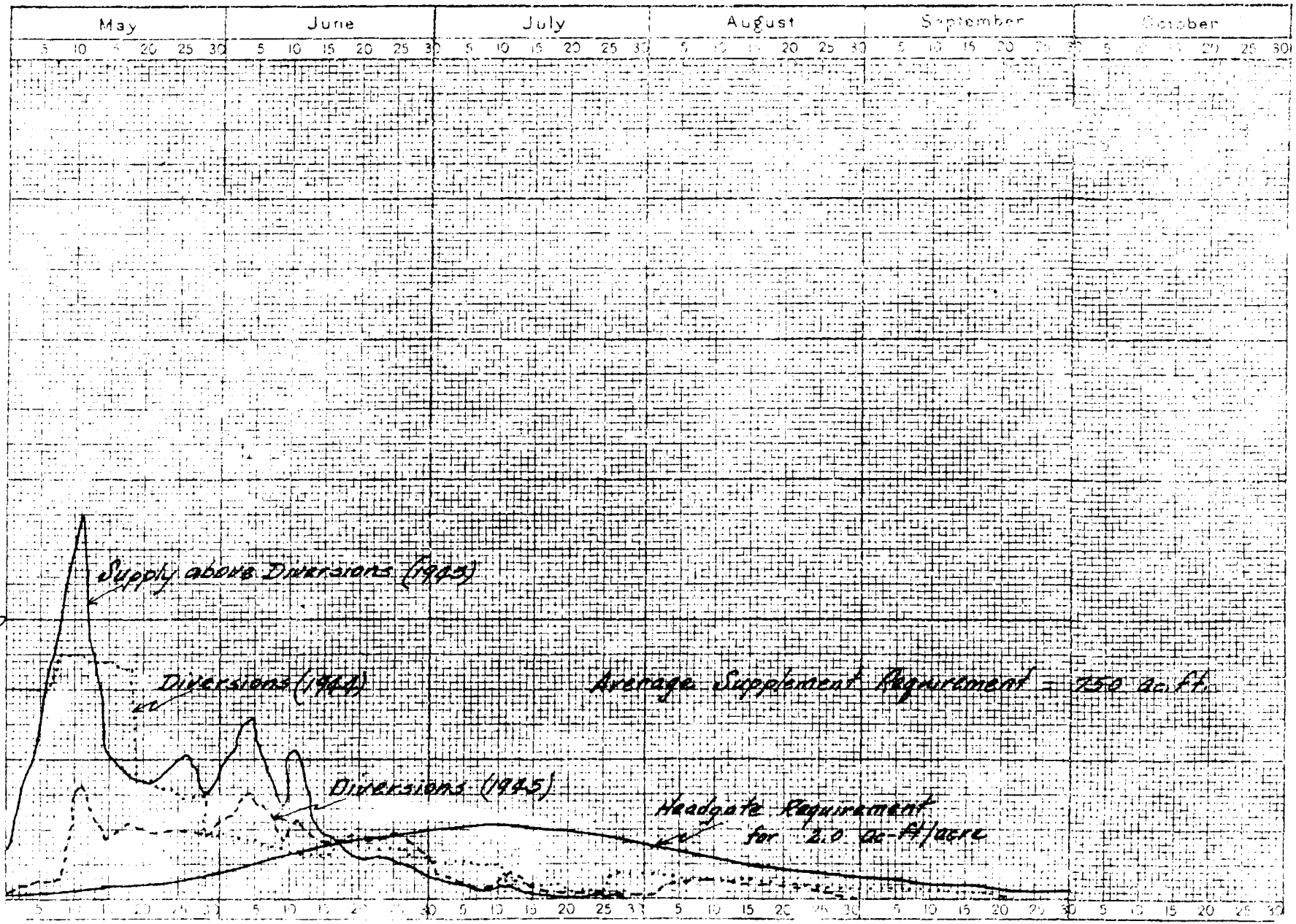


PLATE No. 1.

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

WOODRUFF CREEK — 1944

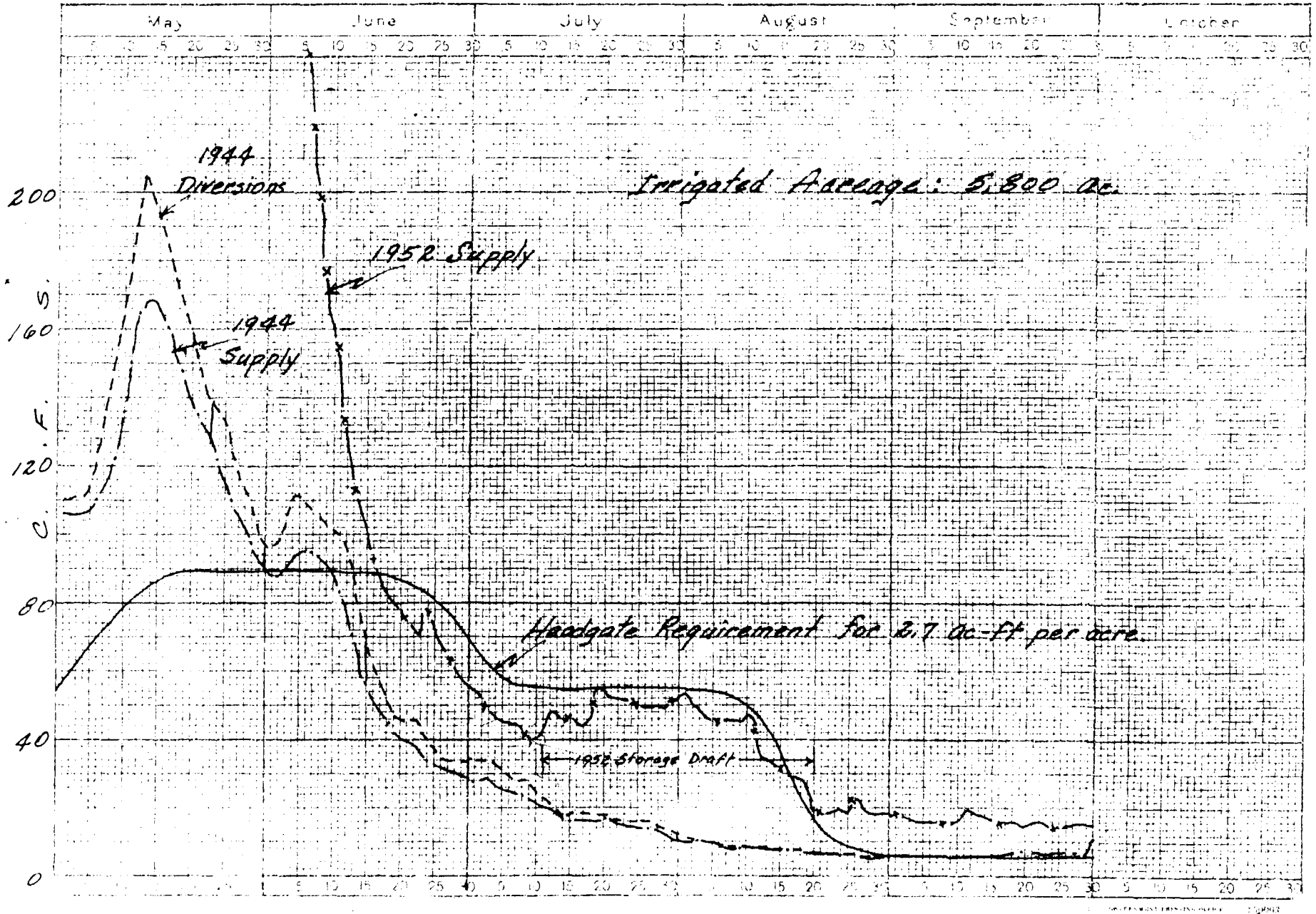


PLATE No. 13

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

WOODRUFF CREEK — 1945

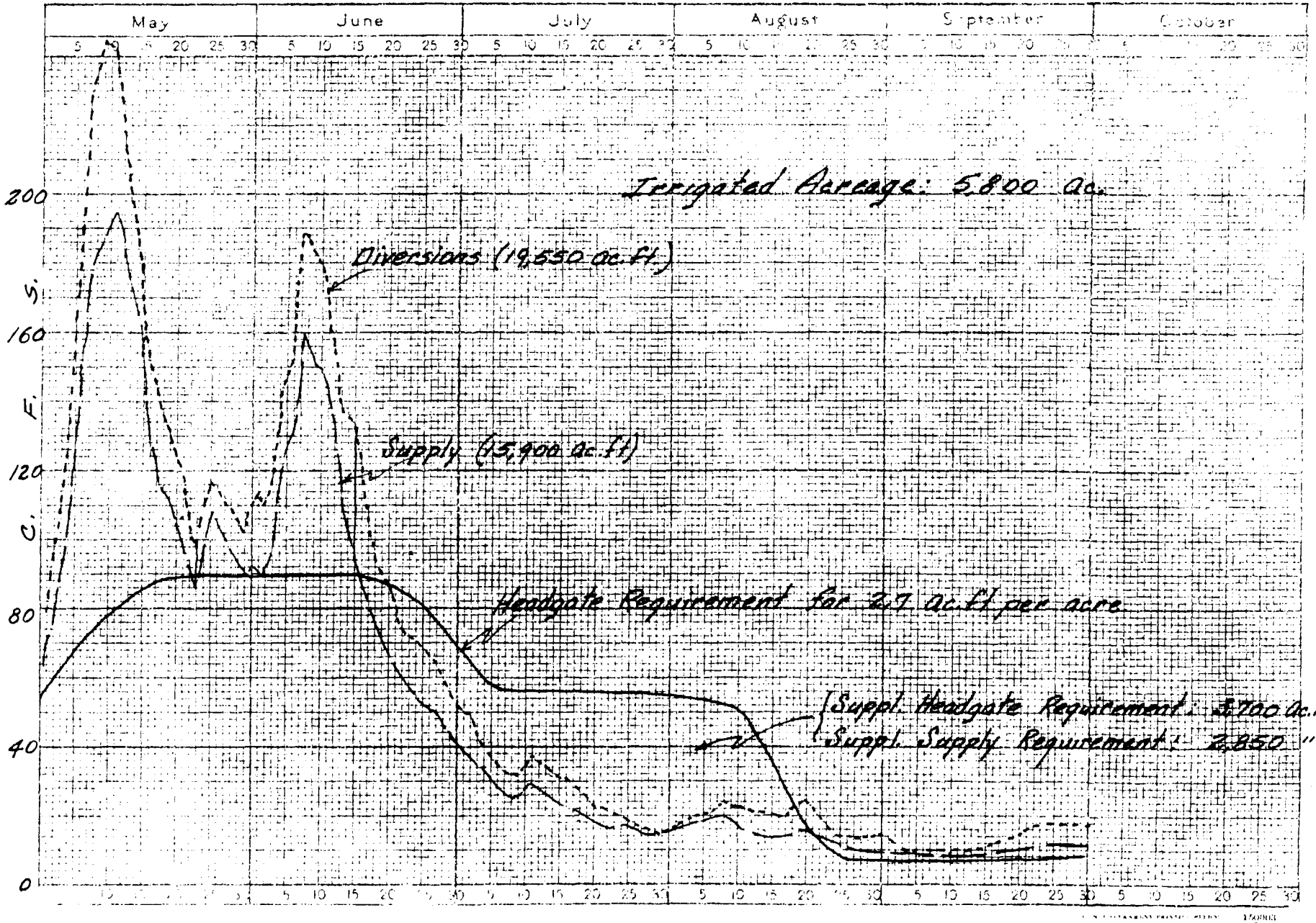


PLATE No 14

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

BIG CREEK - 1944 - 1945

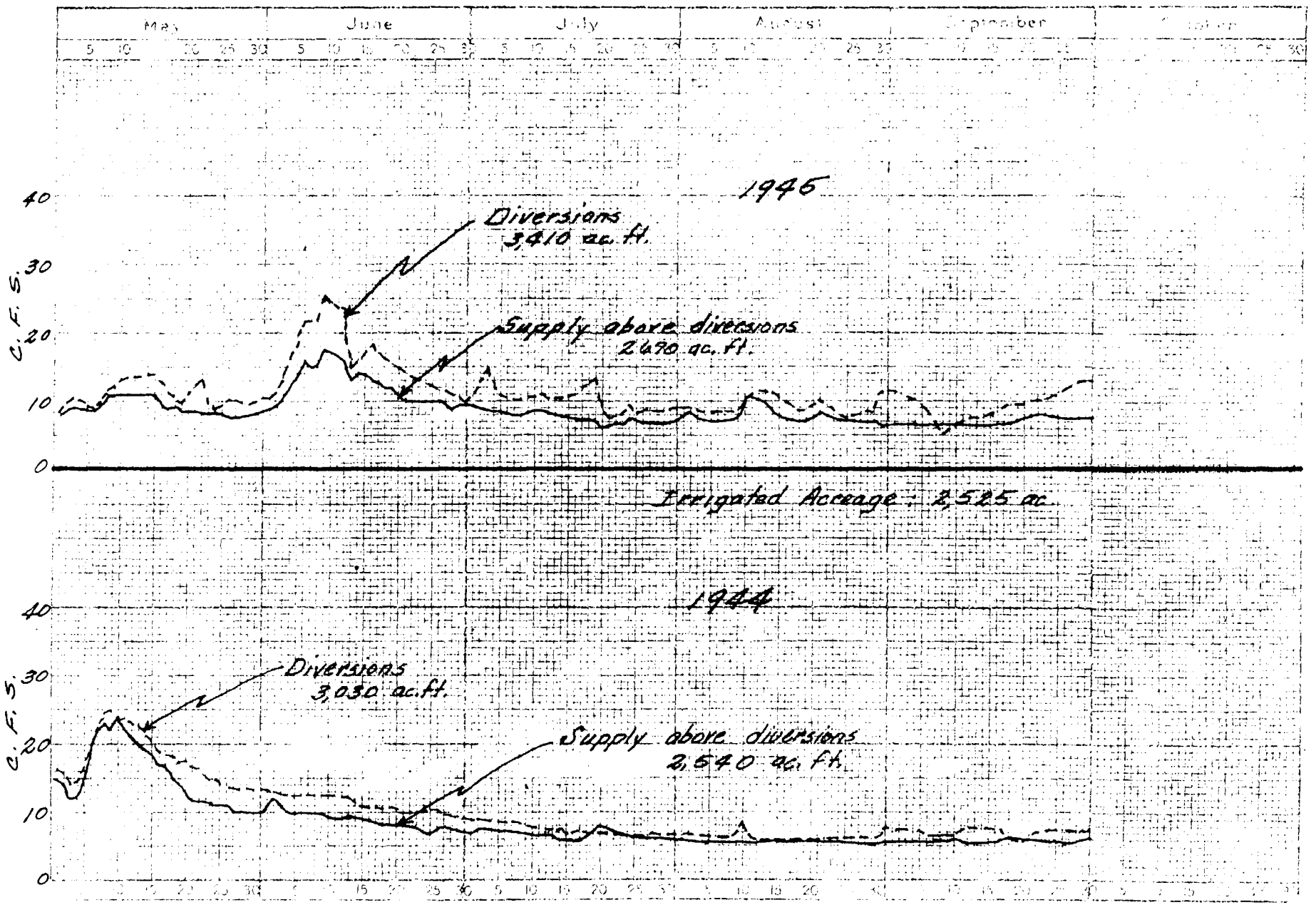
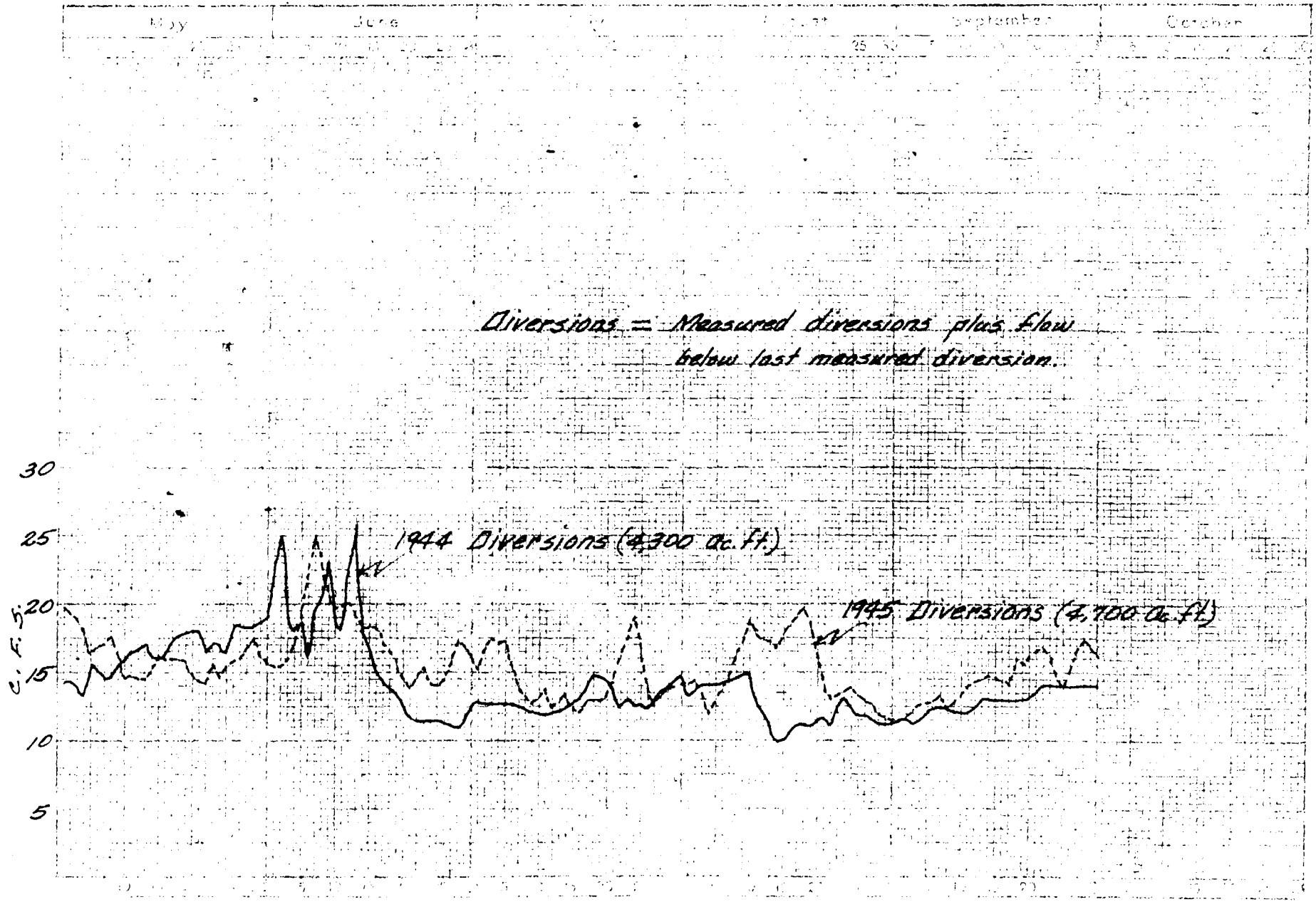


PLATE No. 15

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

Otter Creek – 1944 & 1945



9-279-f (Sept. 1952)

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

Smiths Fork

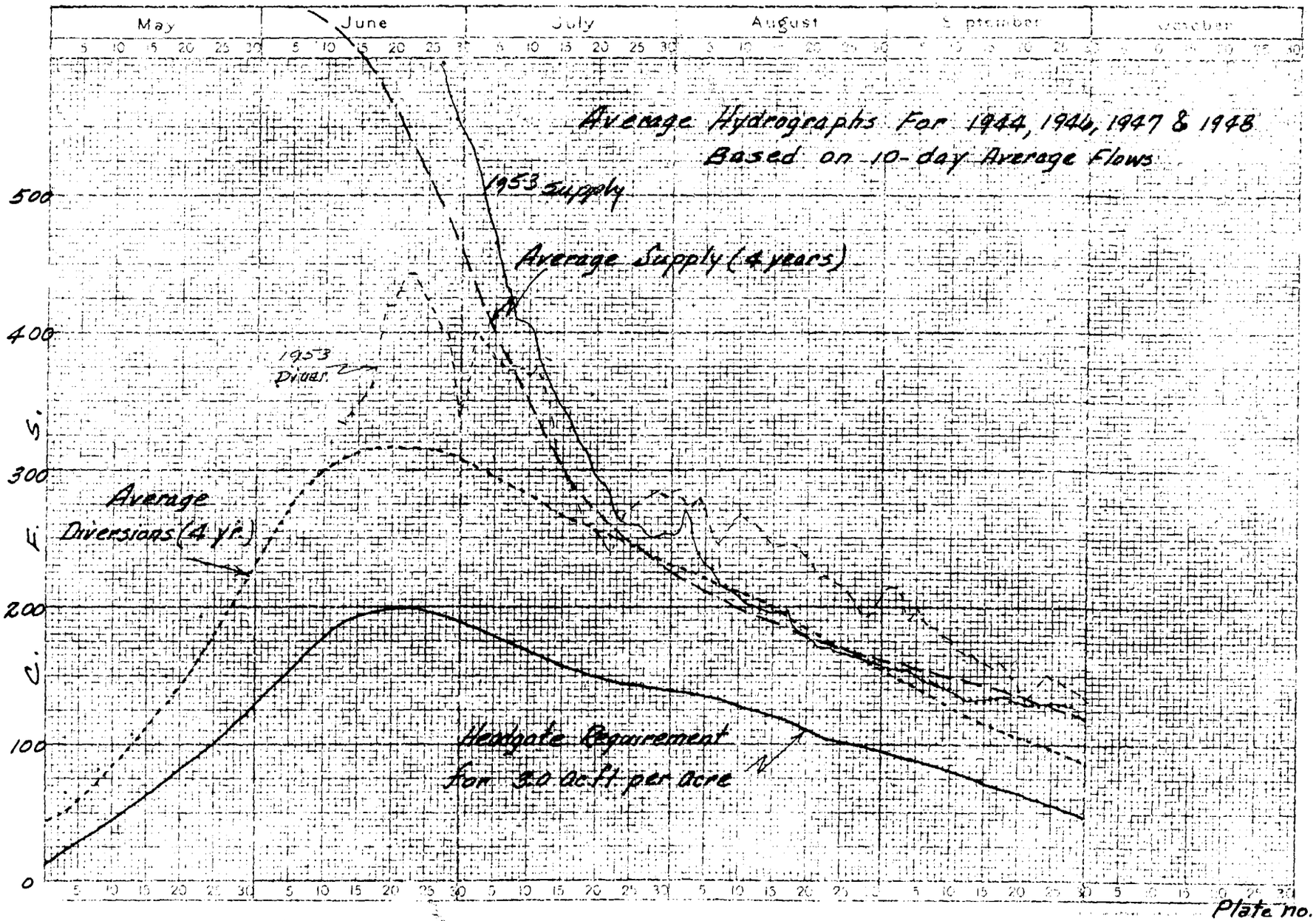


Plate no. 17

9-279-f (Sept. 1950)

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

Smiths Fork

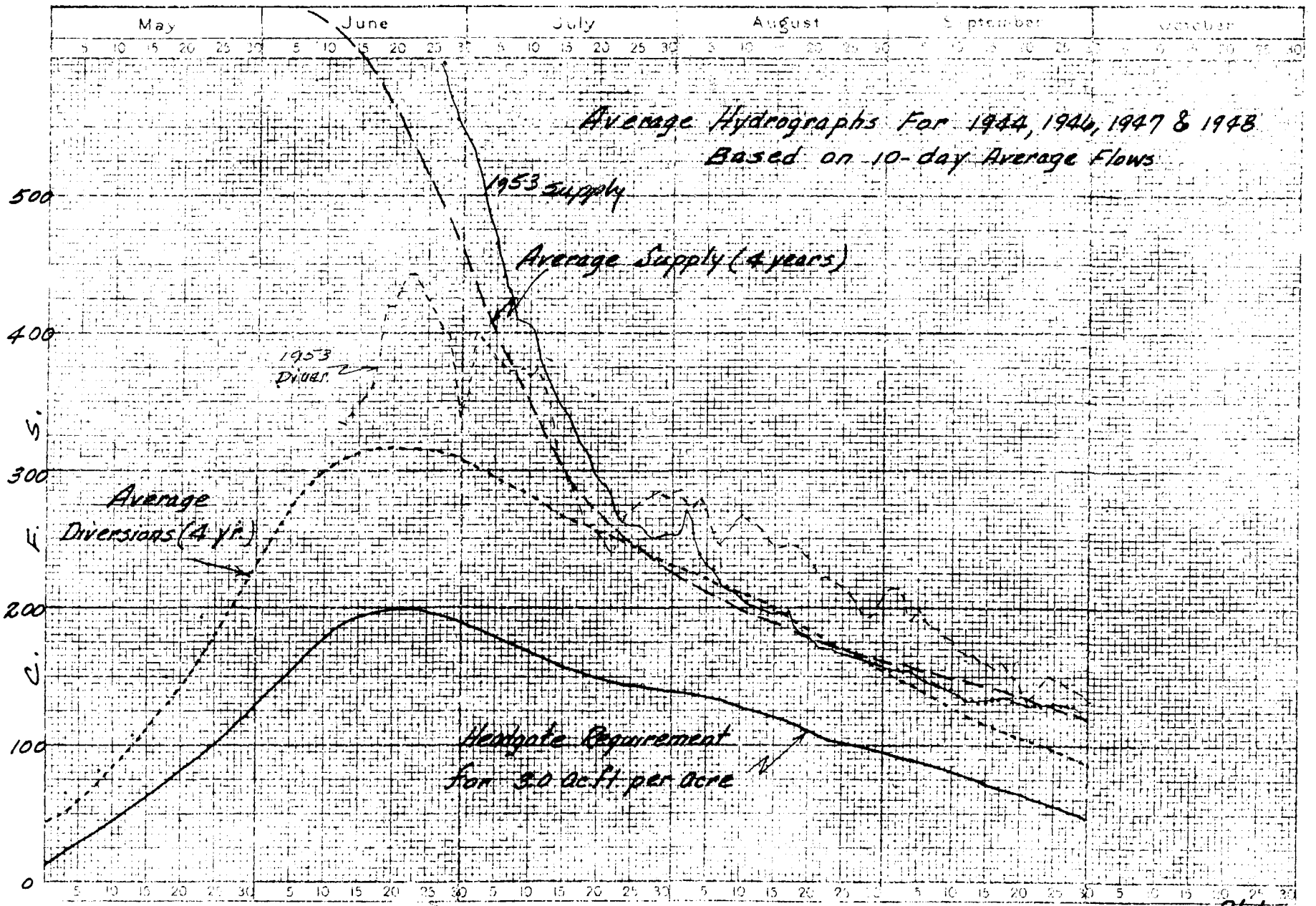


Plate no. 17

SMITHS FORK

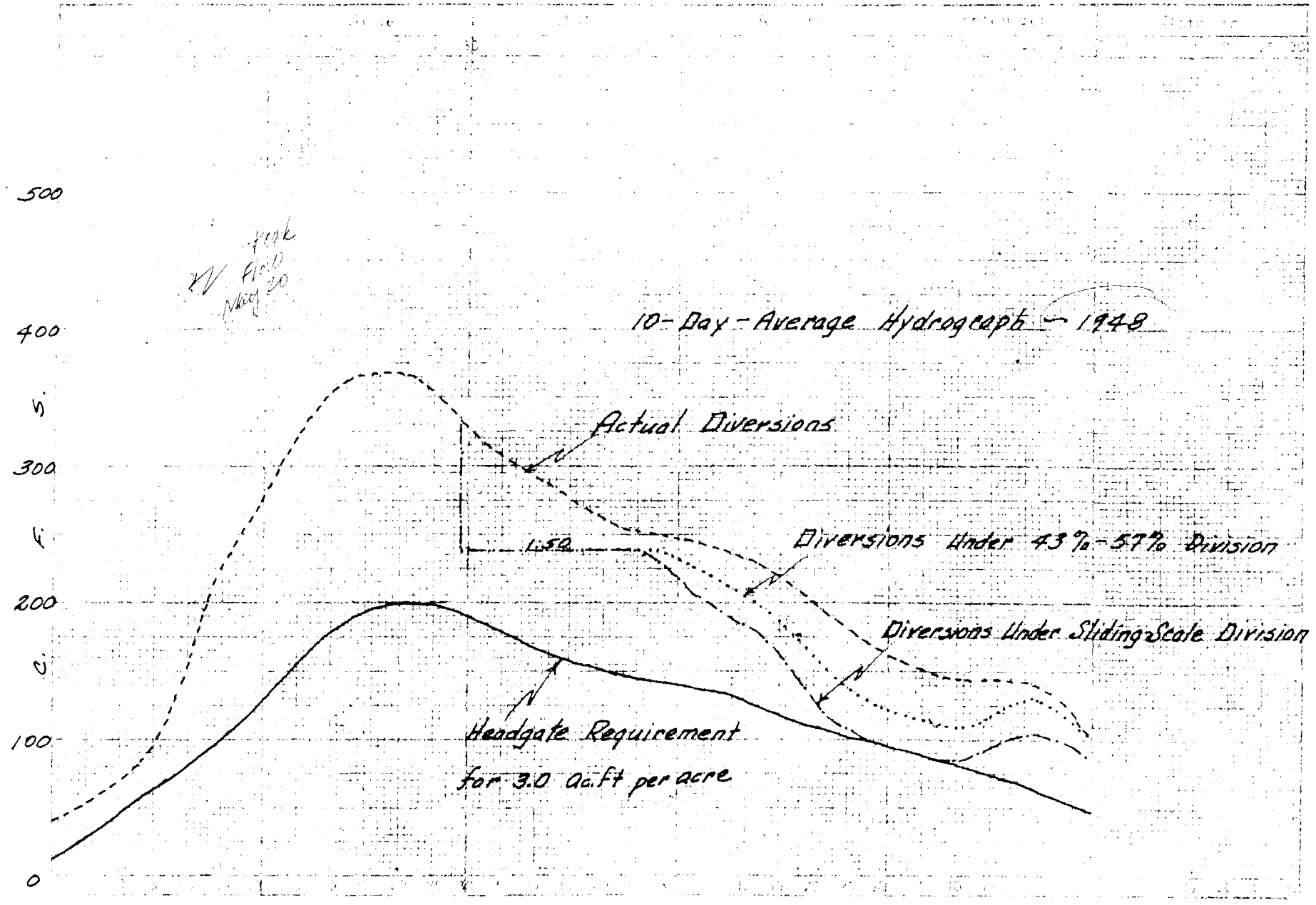


PLATE No. 18

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

THOMAS FORK — 1944

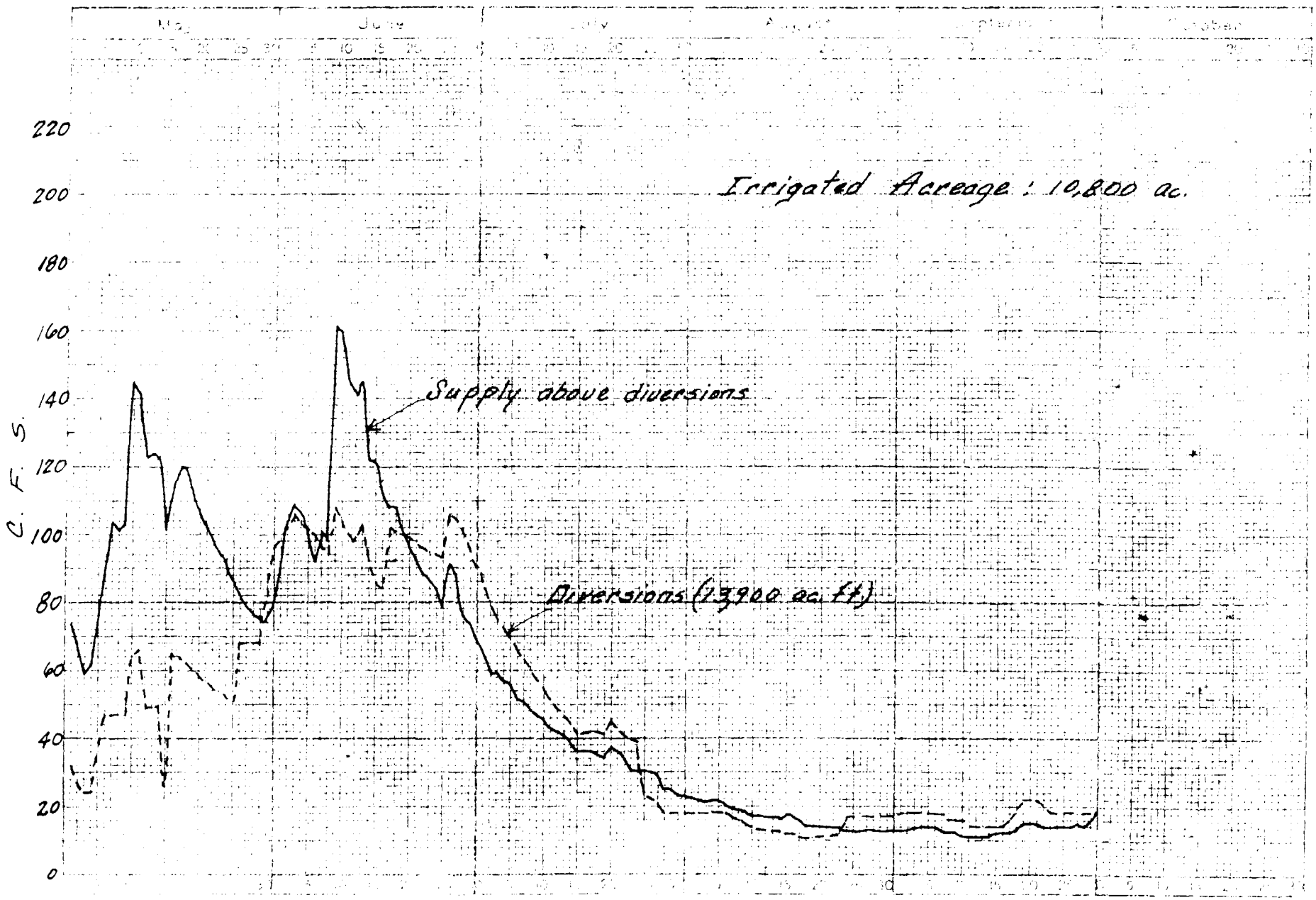


PLATE No 19

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

THOMAS FORK — 1945

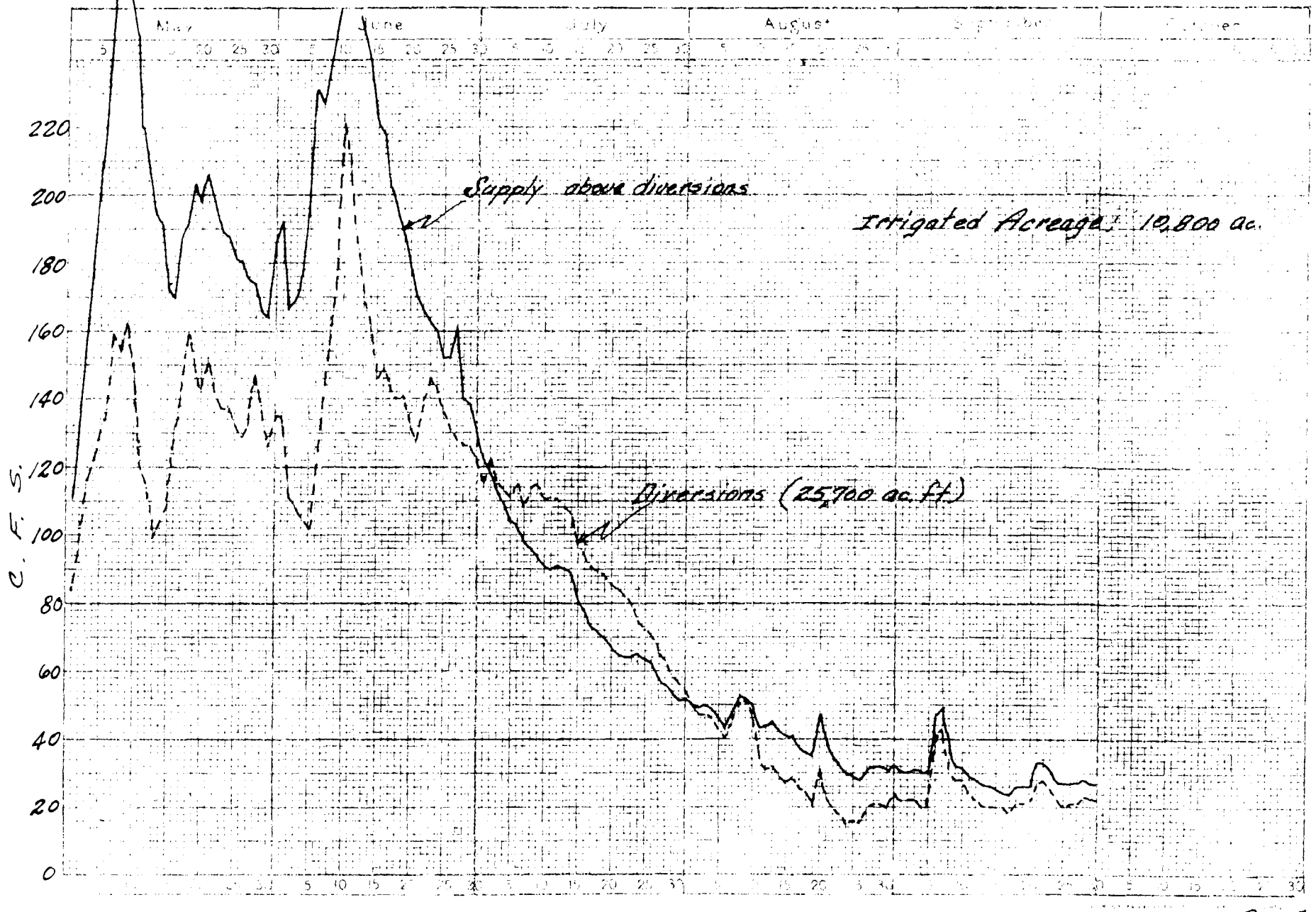


PLATE No. 2(

Main Stem	Acres
Main Stem above Stewart Dam	25,754
~~Thomas Fork~~	~~10,800~~
Budge and Johnson	1,373
Last Chance	39,736
Gentile Valley	3,9[illegible]
Smith-Bosen	29[illegible]
Riverdale etc	2,087
West Cache	18,541
Cub River Pumps (Bear River Water) (11,000 rep. by Van Orden)	6,317
Total Main Stem	98,081
	+5
	103,000