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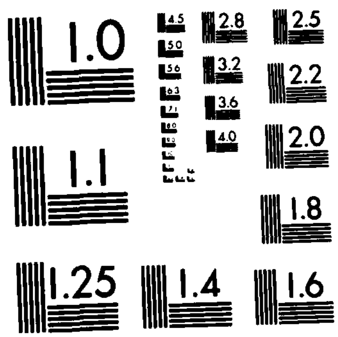

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NATIONAL BUREAU OF STANDARDS-1963-A

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US Army Corps
of Engineers
Memphis District

CHANNEL STABILIZATION STUDY

Potamology Program (P-I)

Report 3

Prepared by

U. S. Army Engineer District, Memphis
B314 Clifford Davis Federal Building
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Prepared for

U. S. Army Engineer Division, Lower Mississippi Valley
P. O. Box 80, Vicksburg, Miss. 39180

December 1982

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER Report 3	2. GOVT ACCESSION NO. AD-A124 515	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) CHANNEL STABILIZATION STUDY		5. TYPE OF REPORT & PERIOD COVERED Final report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Rick Wells		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U. S. Army Engineer District, Memphis B314 Clifford Davis Federal Building Memphis, Tenn. 38103		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Potamology Program (P-1)
11. CONTROLLING OFFICE NAME AND ADDRESS U. S. Army Engineer Division, Lower Mississippi Valley P. O. Box 80, Vicksburg, Miss. 39180		12. REPORT DATE December 1982
		13. NUMBER OF PAGES 52
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Channel stabilization
Mathematical models
Mississippi River
Potamology

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this study was to determine, by review and analysis of prototype data and appropriate use of mathematical model, the effect of channel stabilization features on water surface profiles, channel alignment, and geometry development, and to use this information for future analysis of problem areas and design of stabilization features. The study reach selected was the Merriwether-Cherokee Reach, Mile 877 to Mile 860, on the Mississippi River.

(Continued)

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20. ABSTRACT (Continued).

An attempt was made to establish certain hydraulic characteristics in the study reach for pre- and post-dike construction years. An effort was then made to compare these characteristics and determine if there were changes and how stabilization features contributed to these changes. Additional goals of the study were to answer questions of whether the dikes achieved their intended purpose, how long did it take for the dikes to show an effect, and has the river stabilized since the construction of the dikes.

The investigation indicated certain trends concerning the effectiveness of dike systems, which are as follows:

a. The effect of dike systems on the water surface is negligible at stages over midbank (Q=400,000 cfs). At lower flows, a 4- to 5-ft rise in stage occurred over a period of five years, then a steady decline has taken place. This decline is seen at other stations downstream and would lead one to believe the effects of the dike system have diminished and other controls have taken over.

b. Although the overall effect of the dike systems on the Thalweg profile is one of significant beneficial depths, it can be seen that at locations where a smooth transition is not maintained a deposition problem may occur. This may result in the need for dredging at low flows.

c. This reach indicates that the effects of dike systems on channel geometry are negligible immediately upstream or downstream of the dikes. However, channel areas opposite the dike fields have more than doubled at some sections for extreme low flow conditions. In most cases there is degradation in the channel and aggradation in the dike fields. Dikes have been successful in improving the channel, as well as the alignment.

d. A dike field not immediately preceded by another dike field may take an extended period of time before changes are seen, with effects still being seen for some seven or eight years after construction. Dike fields following within a mile or two of another dike field begin showing changes right away and effects seem to slow significantly after three or four years.

PREFACE

The study reported herein is a component of the Potamology Program (P-1) of the Lower Mississippi Valley Division. The Potamology Program is conducted under the direction of the Commander, Lower Mississippi Valley Division, and is a comprehensive study of physical forces which influence the flood carrying capacity and navigability of the lower Mississippi River. The purpose of the Potamology Program is to define cause-and-effect relationships that result in short-term and long-term changes in the the lower Mississippi River's stage-discharge relationships and to develop improved design concepts and criteria for construction of channel stabilization works which will improve flood control and navigation along the lower Mississippi River.

The Potamology Program is composed of two major components: Sedimentation, Mississippi River Basin; and Aggradation and Degradation, Mississippi River. This study is one item under the Aggradation and Degradation, Mississippi River component.

The study reported herein was the responsibility of the U. S. Army Engineer District, Memphis, Tennessee. The study was conducted during the period 1981-1982.

ACKNOWLEDGMENTS

This study was conducted under the direction of Mr. Andy Lowery. Mr. Rick Wells was responsible for compiling the data and preparation of the report.

Colonel William H. Reno and Colonel John F. Hatch, Jr. were District Engineers during the preparation of this report.

CONTENTS

CHANNEL STABILIZATION STUDY

I. INTRODUCTION

Purpose

1. This study is a unit study within Study I (Aggradation-Degradation Investigations, Mississippi River) of the (P-1) Program. The study reach selected was the Merriwether-Cherokee Reach, Mile 877 to Mile 860. The objective of the study was to determine, by review and analysis of prototype data and appropriate use of mathematical model, the effect of channel stabilization features on water surface profiles, channel alignment, and geometry development, and to use this information for future analysis of problem areas and design of stabilization features.

2. An attempt was made to establish certain hydraulic characteristics in the study reach for pre- and post- dike construction years. An effort was then made to compare these characteristics and determine if there were changes and how stabilization features contributed to these changes. Additional goals of the study were to answer questions of whether the dikes achieved their intended purpose, how long did it take for the dikes to show an effect, and has the river stabilized since the construction of the dikes?

Description

3. The Merriwether-Cherokee Reach includes two complete bendways located near Tiptonville, approximately 130 miles upstream of Memphis (see Plates 1

and 2). The reach is immediately preceeded by a moderately sinuous channel with no dikes. The nearest upstream dikes are the Kentucky Point Dikes some ten miles upstream. The upper portion of the reach is a right to left crossing as it approaches Merriwether Bend, which is a six mile long bendway with a 12,000-15,000 foot radius. The channel then crosses again as it approaches Little Cypress Bend. Little Cypress Bend is a bendway to the left approximately 4 miles long with a 10,000-12,000 foot radius. The river continues on a sinuous alignment downstream of the study reach.

This situation, prior to dike construction, resulted in a meandering channel which narrowed in the bendways and caused wide, shallow crossings. These conditions contributed to an inefficient navigation channel at low stages. Low water channel widths before dike construction average around 2,000 feet, while an average channel width after dike construction was about 2,300 feet. Further inspection showed a slight decrease in width at the crossings from pre-construction to post-construction and about a twenty percent increase in width in the bendways. Low and high water slopes through the reach for pre-dike construction years average 0.60 to 0.53 feet per mile, respectively. Post-dike construction years show average low and high water surface slopes through the reach of 0.55 and 0.49 feet per mile, respectively.

History of Construction

4. At the upstream end of the study reach there was an active bank caving problem on the right bank which was endangering the controlling levee. In 1952 and 1953 bank stabilization was completed on approximately 2 miles of shoreline from Mile 877 to Mile 875. At Mile 875 the channel begins an approximately 6

mile long bendway to the right, where active caving was beginning to produce an undesirable alignment. In 1934 bank stabilization was begun at Mile 872 and extended downstream. By 1961 the stabilization had extended downstream to Mile 867 and by 1973 it had extended upstream to Mile 874. Continuing downstream the channel crosses from left to right and begins a bend to the left, Little Cypress Bend. Active caving in this bendway was threatening distortion of the curvature of this bend which would have resulted in an undersirable alignment. In 1957 the majority of the bank in this bendway was stabilized from Mile 865 to Mile 862. By 1965 the bank from Mile 866 to Mile 859 had been stabilized.

5. In 1931 two right bank pile dikes had been constructed between Mile 875 and Mile 874 as an attempt to correct an undesirable alignment that was developing in this reach. In 1956 the Ruddles Point Dikes were completed to improve the alignment and to further develop the existing channel. In 1967 three of these pile dikes were stone filled and an additional stone dike was constructed just downstream of these dikes to hold the existing alignment and to improve the navigation channel at low flows.

6. After the construction of the Ruddles Point Dikes an undesirable channel was developing downstream near Stewart Towhead. Three Stewart Towhead pile dikes were constructed near Mile 872 and Mile 871 in 1959 to improve the navigation channel. By 1967 these three dikes had been improved and stone filled. One additional stone dike at Mile 870 was built in 1967. Dikes five and six were completed downstream of the above mentioned dikes in 1969. (See Plate 2)

7. The Below Cherokee Dikes, consisting of two left bank stone dikes, were built in 1969 as a feature of the Channel Improvement Program to stabilize the crossing from the Merriwether Cherokee Revetment to the Little Cypress Revetment.

II. COMPARISON OF PRE AND POST DIKE CONSTRUCTION YEARS

Channel Roughness

8. The period examined covered 22 years, from 1957 through 1978, and begins prior to the construction of stone dikes in this reach. Using hydrographic surveys, water surface vs. river mile was ploted for each year used in the study to produce an actual water surface slope profile. This profile represented the actual water level at the time of the survey with a given flow condition. This flow was determined by establishing a lag time relationship between the Hickman Gage at Mile 922 and the Tiptonville Gage at Mile 872. This was done by plotting stage vs. time for both gages and comparing the peaks and valleys. It could be seen that there was approximately a one day lag from the Hickman Gage to the Tiptonville Gage. By knowing the discharge at Hickman for a certain date, a discharge could then be found for Tiptonville which is near the middle of the study reach.

9. Sections from the hydrographic surveys were then coded into the HEC 2 backwater model. The same flows as those found on the survey dates for each year were used in the model with the only variable being the Manning's roughness coefficient. These coefficients were adjusted wherever necessary until the computed water surface profile matched the prototype to within one tenth of a

foot. For the purpose of comparison a weighted average of these roughness coefficients was calculated for each year. These values were plotted against time in years as shown on Plate 3 and against discharge as shown on Plate 3A.

10. In years prior to dike construction there seemed to be a relatively smooth, slightly increasing trend in roughness coefficients with an average value around 0.029. Post construction years show an erratic but still increasing trend with an average around 0.032. The most notable feature of the graph is the increase in erratic behavior during and after dike construction. Further study shows the more significant increases in roughness values occur at lower discharges. A look at the roughness values vs. only high discharges shows a smoother, only slightly increasing trend.

Specific Gage Records

11. One method for observing changes in water surface for various discharges is to plot the specific gage records. At the Tiptonville Gage a stage-discharge curve was plotted for each year from 1952-1980. Stages were read from these curves for different discharges and plotted for each year (see Plate 4). These plots showed that for higher flows (Q=400,000 cfs) there has been no significant change in water surface levels. For lower flows there was a continuous rise in water surface levels for about 5 years after dike construction. Then there seems to be a continuous decline in the extreme low flow condition, with a decline and a leveling off in the medium low flow case.

Thalweg Profile

12. The Thalweg was plotted for each year of the study. An average profile for the years 1959-1963 was determined and used for comparison purposes as an average pre-dike construction condition. The same was done for years 1967 and 1968 and this was used as an average during construction condition. The latest available survey was used as a post-dike construction condition and all three conditions were plotted on the same graph, showing the bendways, crossings, and dikes in the study reach. (Plate 5)

13. A deepening of the bendways is an obvious occurrence over the twenty years of study. By looking at pre- and post- dike construction years only, one might contribute this deepening to the building of dikes. By plotting another profile representing the Thalweg at the time of dike construction, it can be seen that the channel had done some deepening before the actual construction of the dikes. While the dike fields seem to have improved the depth of the channel both entering the bendway and exiting the bendway, reveting the outside bank of the bendway has probably contributed to this improved depth as much as the dike fields. None of the stabilization measures seems to have had much affect on the Thalweg profile in the crossings.

14. Plates 6 thru 28 show a comparison of the pre-dike construction, channel cross-section to the post-dike construction, channel cross-section. Each plate has a table showing various hydraulic parameters for each cross-section, for both an LWRP elevation and a -10 stage. As one follows the sections downstream,

the channel has no significant changes until you reach the Ruddles Point Dike Field. An improved channel, in width as well as depth, can be seen all the way through the dike field with an average increase of almost 20 percent in the area at the LWRP elevation and an average increase of over 70 percent in area at -10 stage. Plates 29 and 30 show the change in area through the reach from pre-dike construction to post-dike construction for both the LWRP elevation and the -10 stage.

15. The improving channel continues downstream into the Stewart Towhead Dike field. Much improved widths and depths are seen through Mile 870. From Mile 870-868.5 the channel has widened but has apparently lost some depth. The resulting channel area has still increased slightly for LWRP but has decreased at a -10 stage. The channel seems to have stabilized through the remainder of Stewart Towhead Dike field and begins a quicker crossing from left bank to right bank as a result of the Below Cherokee Dike field. As the channel is shifted to the outside bank, it continues to improve in both width and depth until it gets below Mile 865. From this area to the downstream limit of the study reach the channel seems to have stabilized.

16. Plates 31 thru 37 show a more detailed plot of the sections that showed a significant change. The purpose here was to determine what type of change took place, a gradual or a sudden change. In general it appeared that the channel in the upstream half of the study reach reacted for a period of 7 to 8 years, while the reactions in the downstream half of the study reach slowed considerably after 3 to 4 years.

III. DISCUSSION AND CONCLUSIONS

Discussion

17. An effort was made using a practical (using actual prototype data), rather than a theoretical, approach to determine whether the construction of dikes has affected the water surface levels in the study reach. The Manning's roughness value analysis showed an increase in value for post-construction years. Looking at this and the specific gage record graphs for the Tiptonville gage, you can possibly conclude the following:

a. For medium range flows (400,000 cfs - 600,000 cfs) the average stage for a given flow has risen approximately one foot.

b. For flows greater than 600,000 cfs there is no significant change.

c. For flows less than 400,000 cfs there was a significant 3-4 foot rise in stage for 5-7 years after dike construction, then a continuing decline right up to present time.

These increases in stage are understandable since the construction of these dike fields causes a constriction in flow as well as a rougher channel bottom at low stages. The decreasing trend that begins around 1976 for extreme low flows should be noted. This trend is seen in other downstream gages; but has not shown up to the Hickman gage, some 50 miles upstream.

18. The channel has shown a noticeable improvement in depth thoughout the study reach. In years preceeding the construction of the pile dikes at Ruddles Point and Stewart Towhead, the channel depths through the bendway were not adequate for navigation and dredging was necessary. After the pile dike

construction, depths improved as much as 10-15 feet. In 1967, the conversion of these dikes to stone dikes and further revetment have improved the depth of the channel as much as 10 feet and have held the desired alignment. The last two dikes of the Stewart Towhead dike field, in conjunction with the Below Cherokee Dikes, have improved the depths of the crossing from Mile 868-866, but there is still some deposition between Mile 866 and Mile 865 which may be caused by the sharp curvature of the channel at the entrance to this bendway. From Mile 865 through the remainder of the study reach, channel depths have improved significantly and channel alignment has held as designed. The significance of this well stabilized reach, from a channel depth standpoint, can be seen by the fact that no dredging has been done in this reach since dike construction, with the exception of one year, at the above mentioned location in the vicinity of mile 866.

19. Pre-dike construction and post-dike construction sections taken at locations immediately upstream and downstream of the dike fields show that there is no appreciable affect in widths, depths, or alignment outside of the dike fields. Improved widths and depths begin appearing at a section taken at Dike 1A of Ruddles Point Dikes. This trend continues through the dike field with increased channel areas and with deposition in the dike fields. Around Mile 870 the channel takes a little more abrupt turn and causes some deposition as shown by sections at Mile 870.1 and Mile 869.3. At times of extreme low flow this could be a small problem area. Beginning at the section taken at Mile 866.4 one can see the affect of the Below Cherokee Dikes in moving the channel to the right which will allow a smoother curve back to the left. The remaining sections show a slightly improved channel area, and a much improved channel alignment.

20. A close analysis of Plates 31-37 indicates that the majority of dikes show a continuing, scouring affect on the channel for up to 8 years after construction. A somewhat balanced state seems to have taken place after this period of time. Except for the section at Mile 874.2, affects from the dikes start showing immediately after construction, and continue gradually until this balanced state is reached. No significant changes occur at Section 874.2 for the first five years after construction, but a balanced state is still reached after approximately eight years. The success of this well stabilized reach is further demonstrated by realizing that these sections have experienced three high water years after apparent stabilization and have maintained their improved shape as evidenced by the 1978 sections.

Conclusions

21. The investigation has indicated certain trends concerning the effectiveness of dike systems, which are as follows:

a. The effect of dike systems on the water surface is negligible at stages over midbank (Q=400,000 cfs). At lower flows a four to five foot rise in stage occurred over a period of five years, then a steady decline has taken place. This decline is seen at other stations downstream and would lead one to believe the effects of the dike system have diminished and other controls have taken over.

b. Although the overall effect of the dike systems on the Thalweg profile is one of significant beneficial depths, it can be seen that at locations where a smooth transition is not maintained a deposition problem may occur. This may result in the need for dredging at low flows.

c. This reach indicates that the effects of dike systems on channel geometry are negligible immediately upstream or downstream of the dikes.

However channel areas opposite the dike fields have more than doubled at some sections for extreme low flow conditions. In most cases there is degradation in the channel and aggradation in the dike fields. Dikes have been successful in improving the channel, as well as the alignment.

d. A dike field not immediately preceded by another dike field may take an extended period of time before changes are seen, with affects still being seen for some seven or eight years after construction. Dike fields following within a mile or two of another dike field begin showing changes right away and affects seem to slow significantly after three or four years.

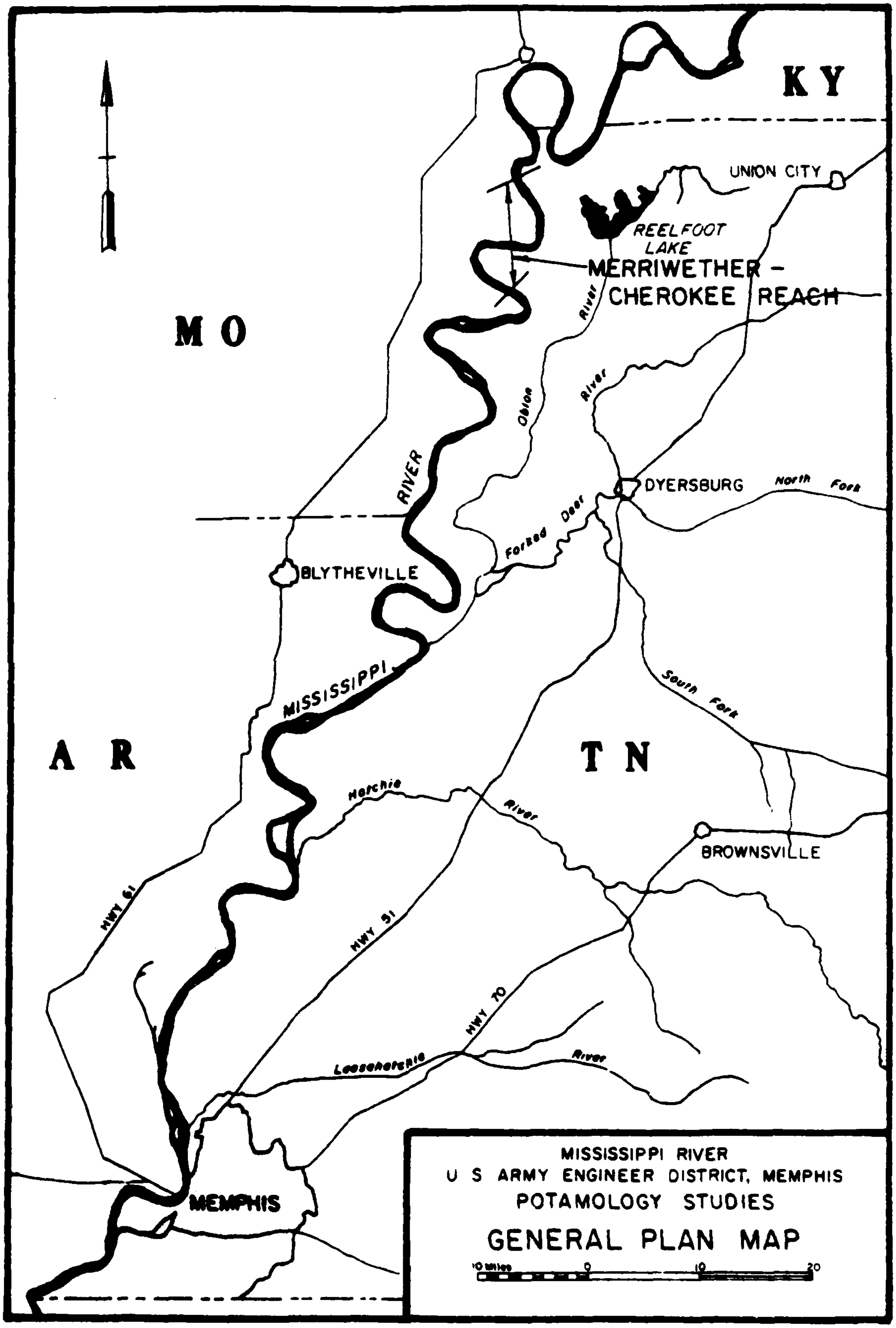

KY
UNION CITY
REELFOOT LAKE
MERRIWETHER - CHEROKEE REACH
MO
Obion River
River
RIVER
DYERSBURG
North Fork
Forked Deer
BLYTHEVILLE
MISSISSIPPI
South Fork
A R
T N
Hatchie River
BROWNSVILLE
HWY 61
HWY 51
HWY 70
Loosahatchie River
MEMPHIS
MISSISSIPPI RIVER
U S ARMY ENGINEER DISTRICT, MEMPHIS
POTAMOLOGY STUDIES
GENERAL PLAN MAP
10 Miles 0 10 20

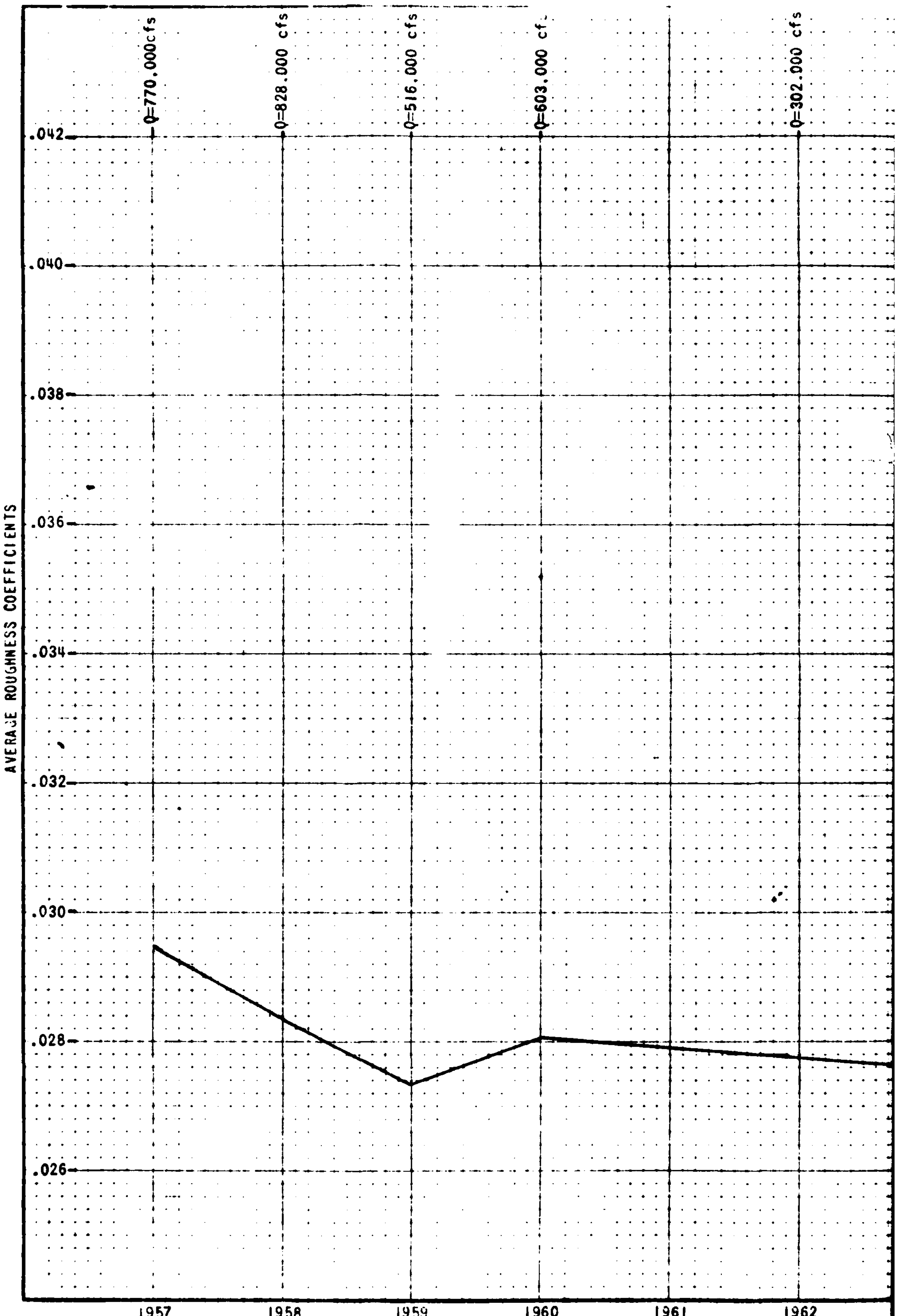
PLATE 1

MISSISSIPPI RIVER

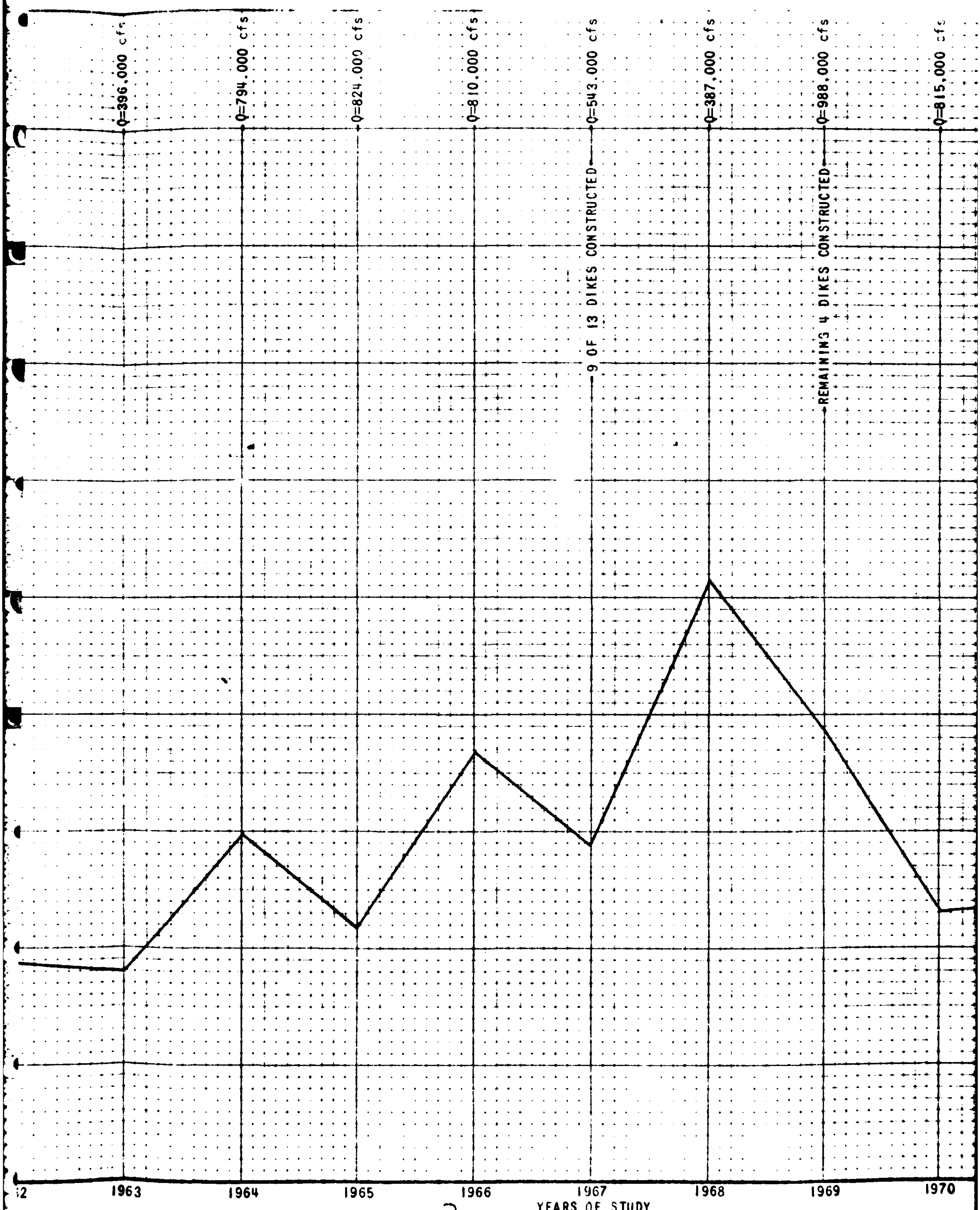
U. S. ARMY ENGINEER DISTRICT, MEMPHIS

POTAMOLOGY STUDIES

MERRIWETHER — CHEROKEE REACH



Q=770,000cfs
Q=828,000 cfs
Q=516,000 cfs
Q=603,000 cf.
Q=302,000 cfs
AVERAGE ROUGHNESS COEFFICIENTS
.042
.040
.038
.036
.034
.032
.030
.028
.026
1957
1958
1959
1960
1961
1962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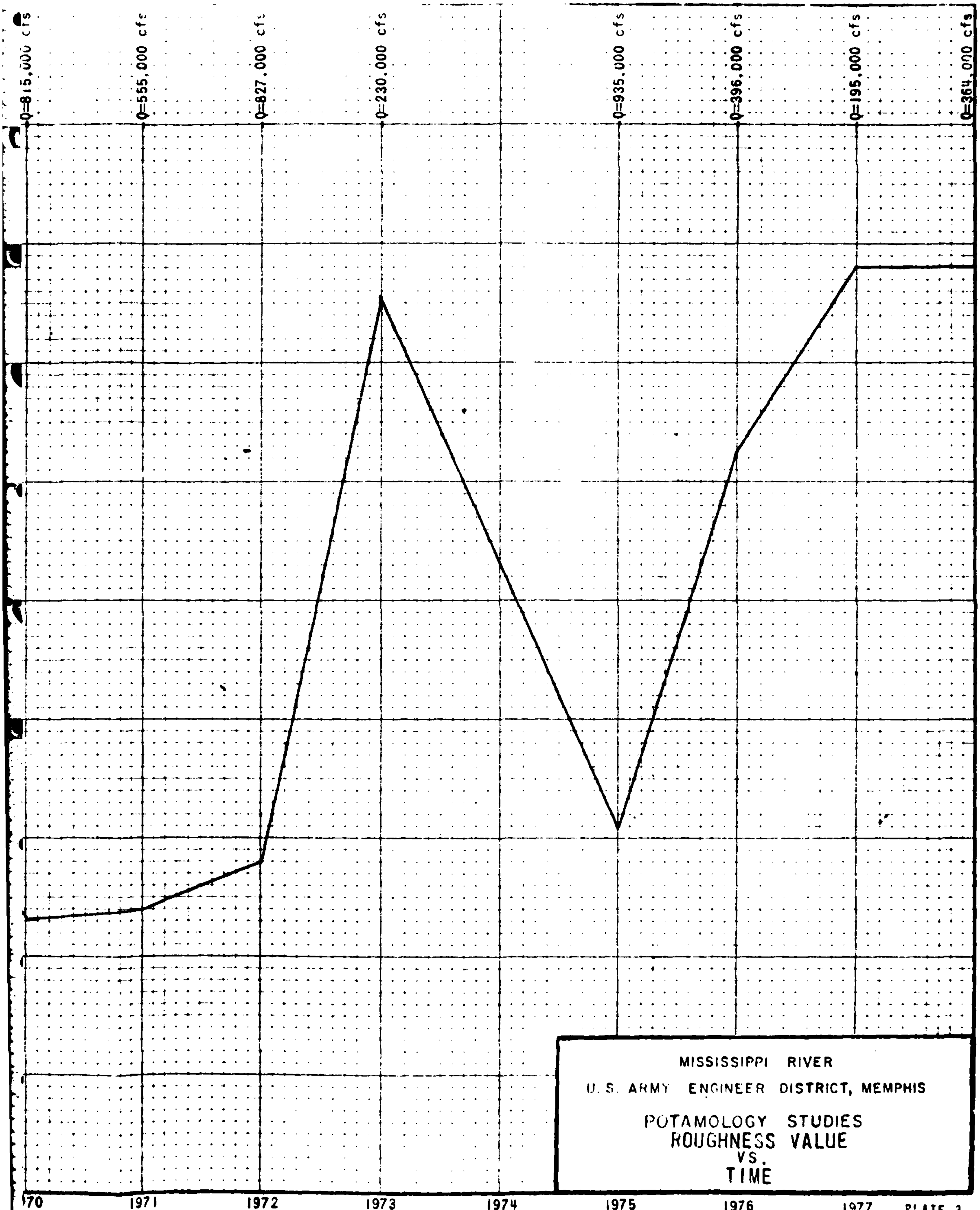
Q=794,000 cfs
Q=824,000 cfs
Q=810,000 cfs
Q=543,000 cfs
Q=387,000 cfs
Q=988,000 cfs
Q=815,000 cfs
9 OF 13 DIKES CONSTRUCTED
REMAINING 4 DIKES CONSTRUCTED
1963
1964
1965
1966
1967
1968
1969
1970
YEARS OF STUDY



MISSISSIPPI RIVER

U. S. ARMY ENGINEER DISTRICT, MEMPHIS

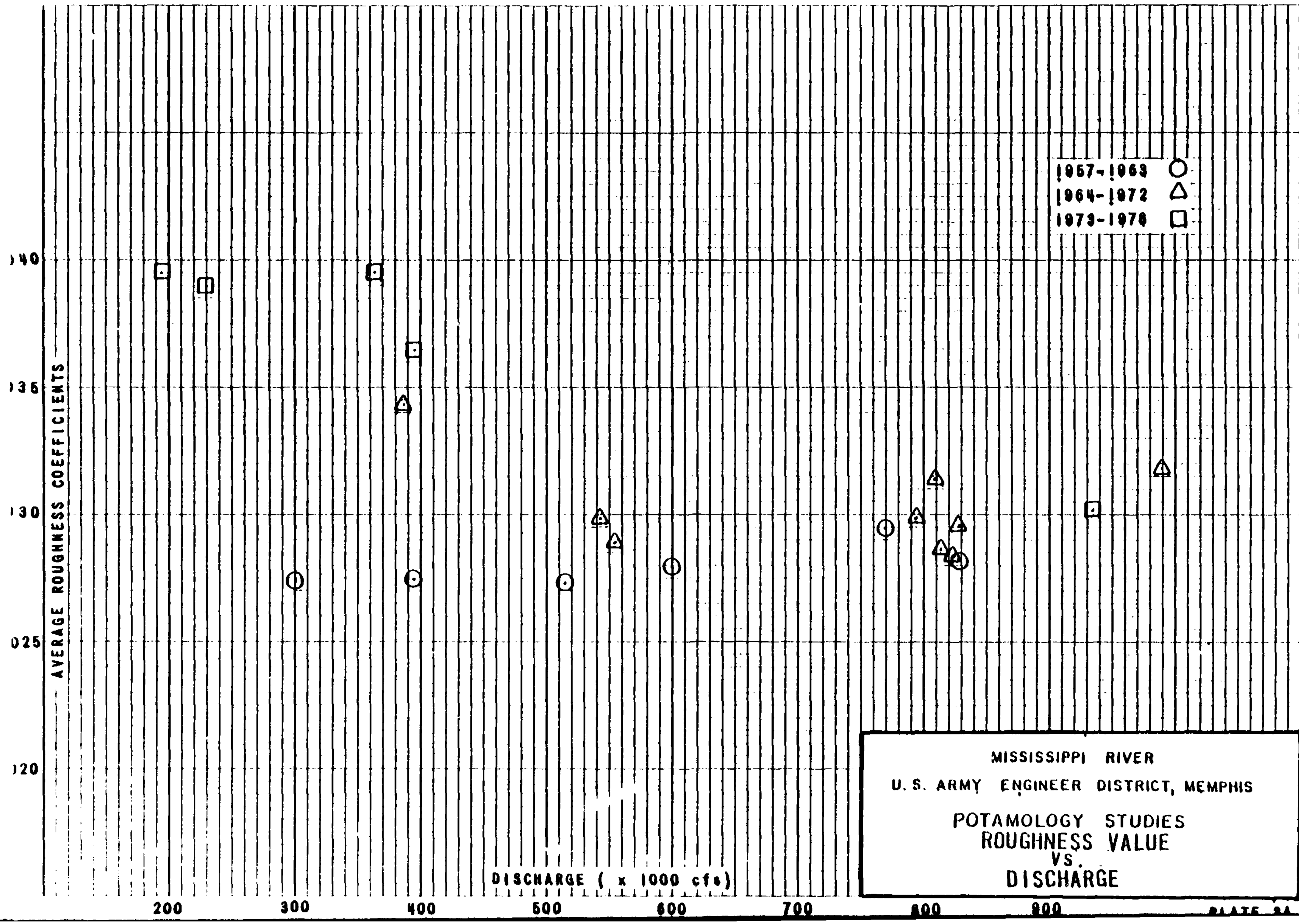
POTAMOLOGY STUDIES

ROUGHNESS VALUE

VS.

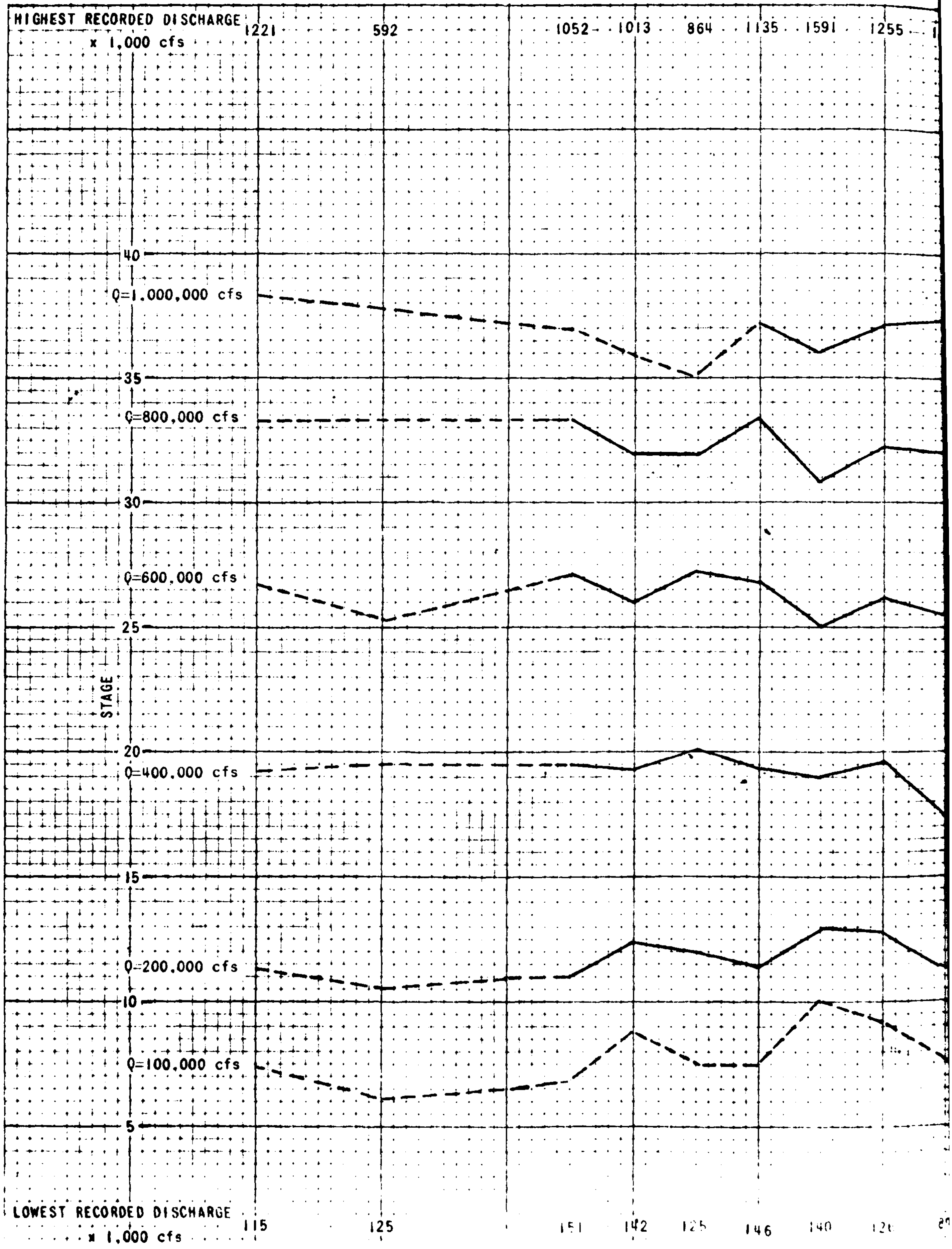
TIME

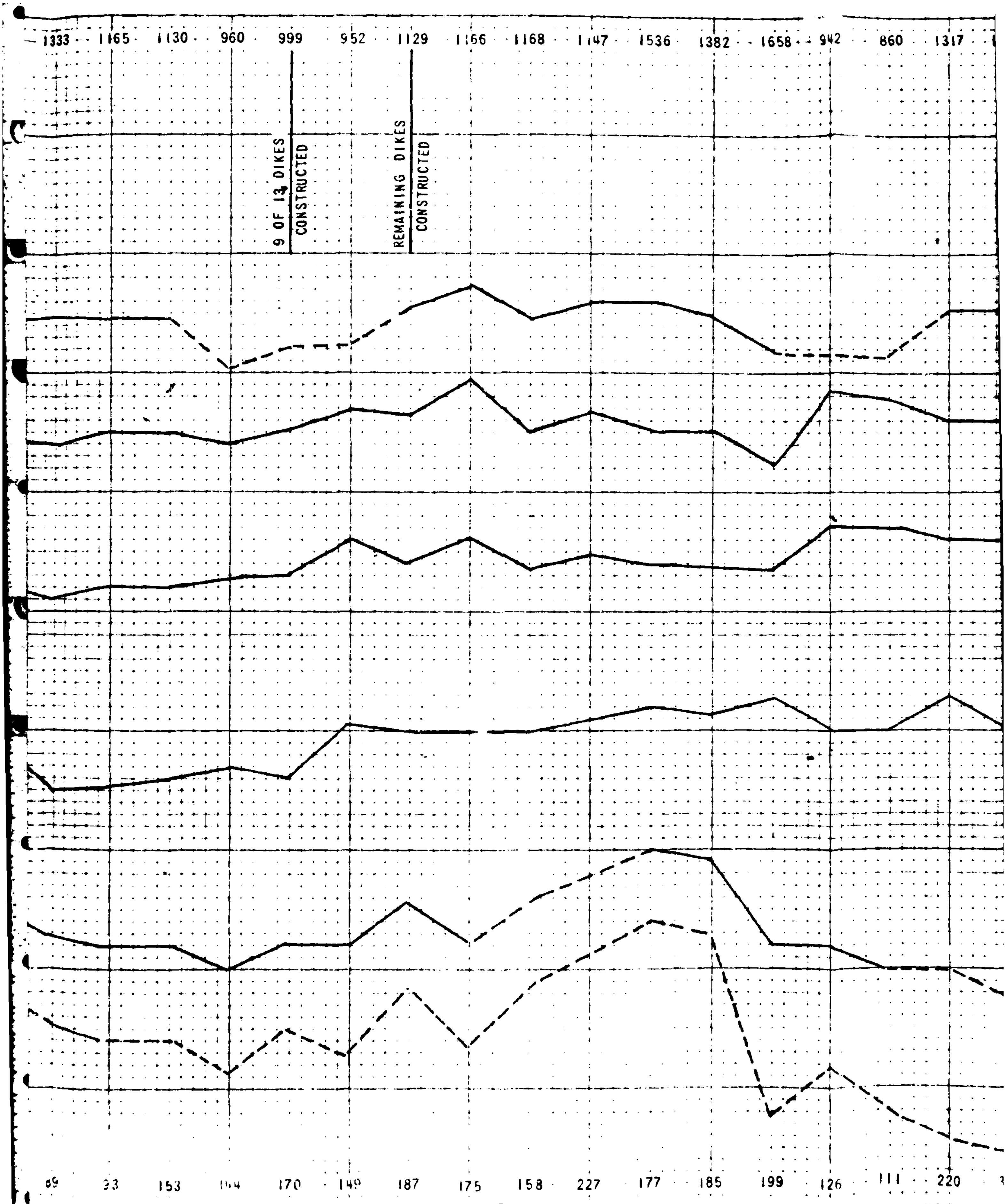
PLATE 3



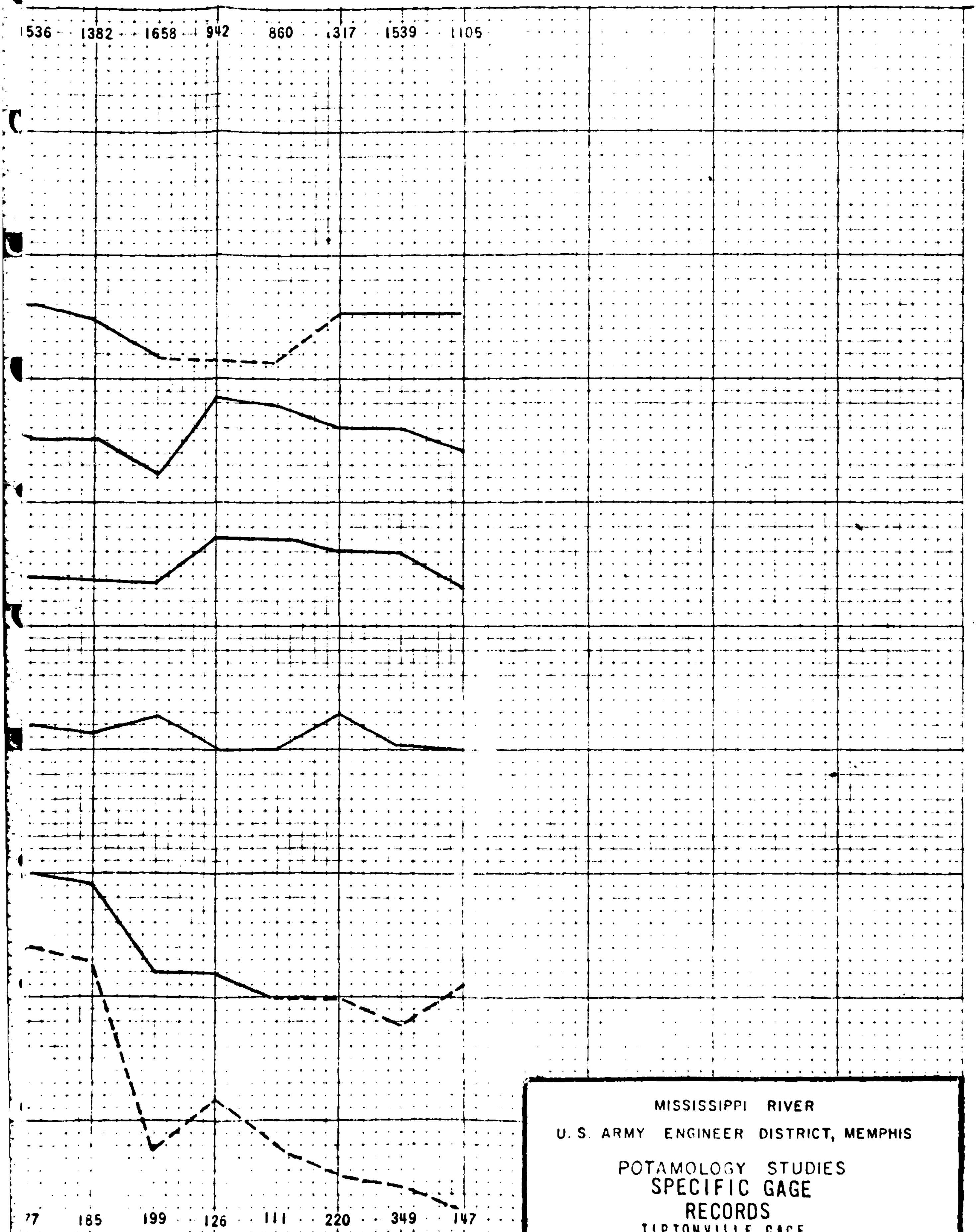
MISSISSIPPI RIVER
U.S. ARMY ENGINEER DISTRICT, MEMPHIS

POTAMOLOGY STUDIES
ROUGHNESS VALUE
VS.
DISCHARGE


HIGHEST RECORDED DISCHARGE x 1,000 cfs
1221
592
1052
1013
864
1135
1591
1255
40
Q=1,000,000 cfs
35
Q=800,000 cfs
30
Q=600,000 cfs
25
STAGE
20
Q=400,000 cfs
15
Q=200,000 cfs
10
Q=100,000 cfs
5
LOWEST RECORDED DISCHARGE x 1,000 cfs
115
125
151
142
125
146
140


1333 1165 1130 960 999 952 1129 1166 1168 1147 1536 1382 1658 942 860 1317
9 OF 13 DIKES CONSTRUCTED
REMAINING DIKES CONSTRUCTED
93 153 170 187 175 158 227 177 185 199 126 111 220

2



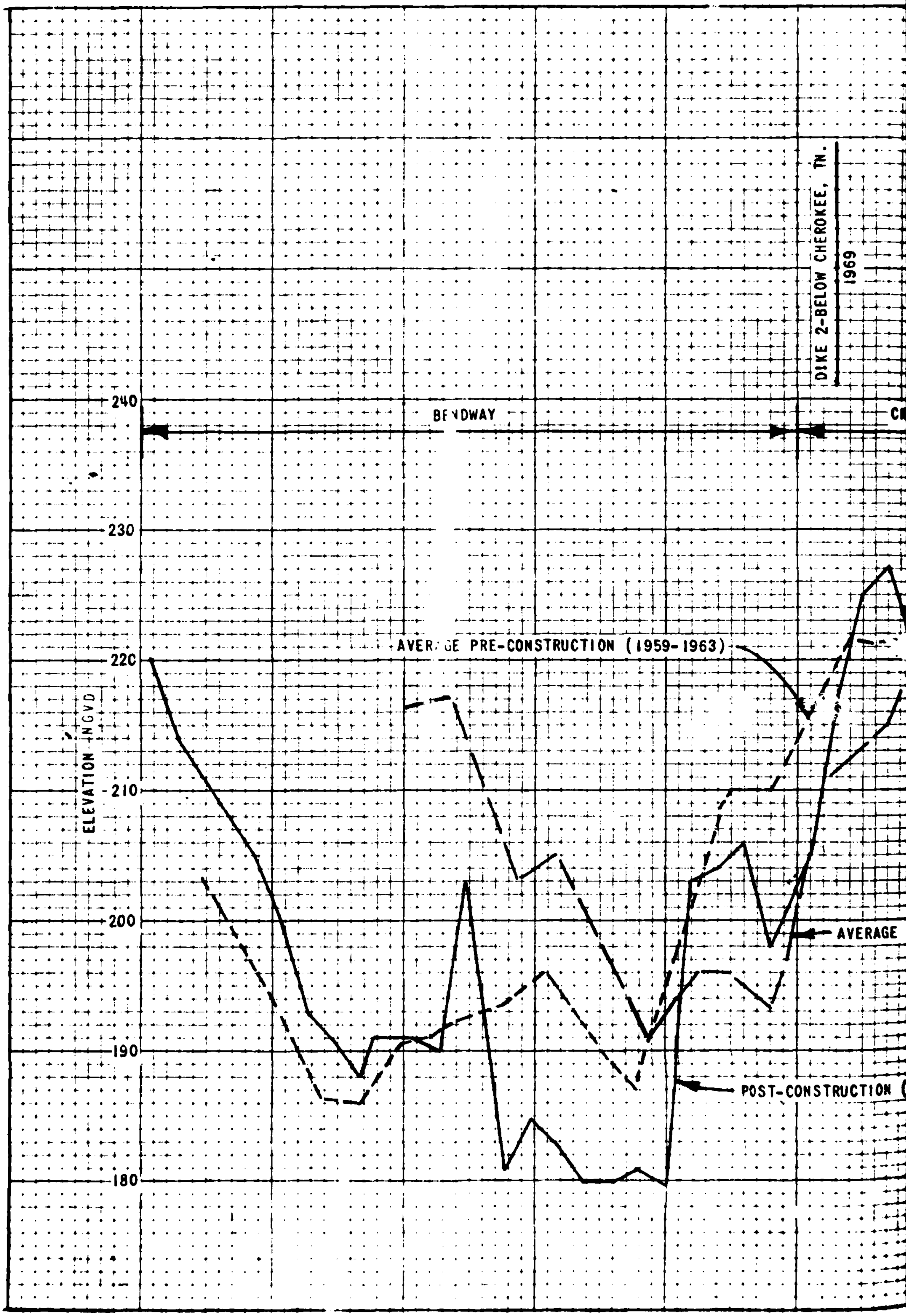
MISSISSIPPI RIVER

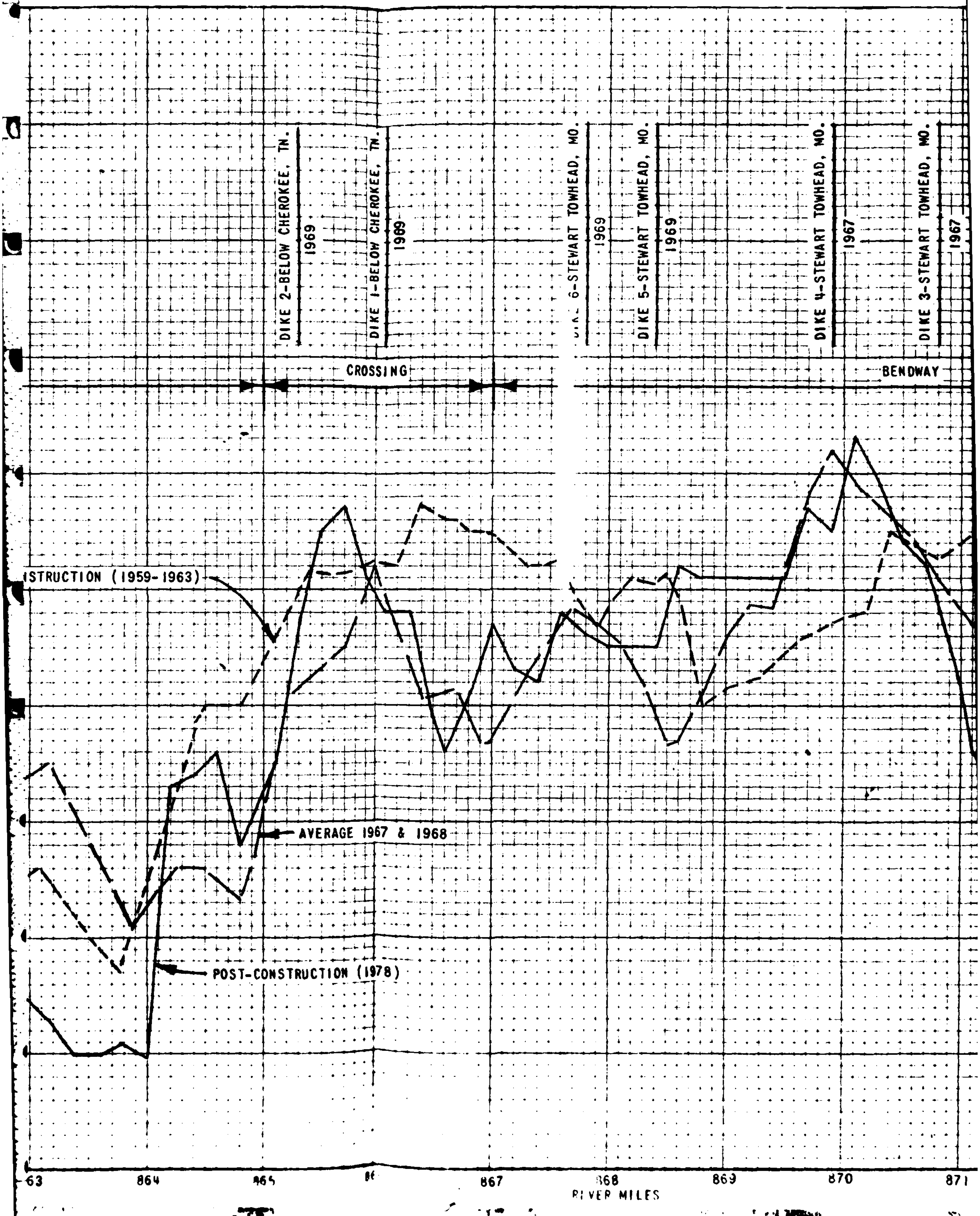
U. S. ARMY ENGINEER DISTRICT, MEMPHIS

POTAMOLOGY STUDIES

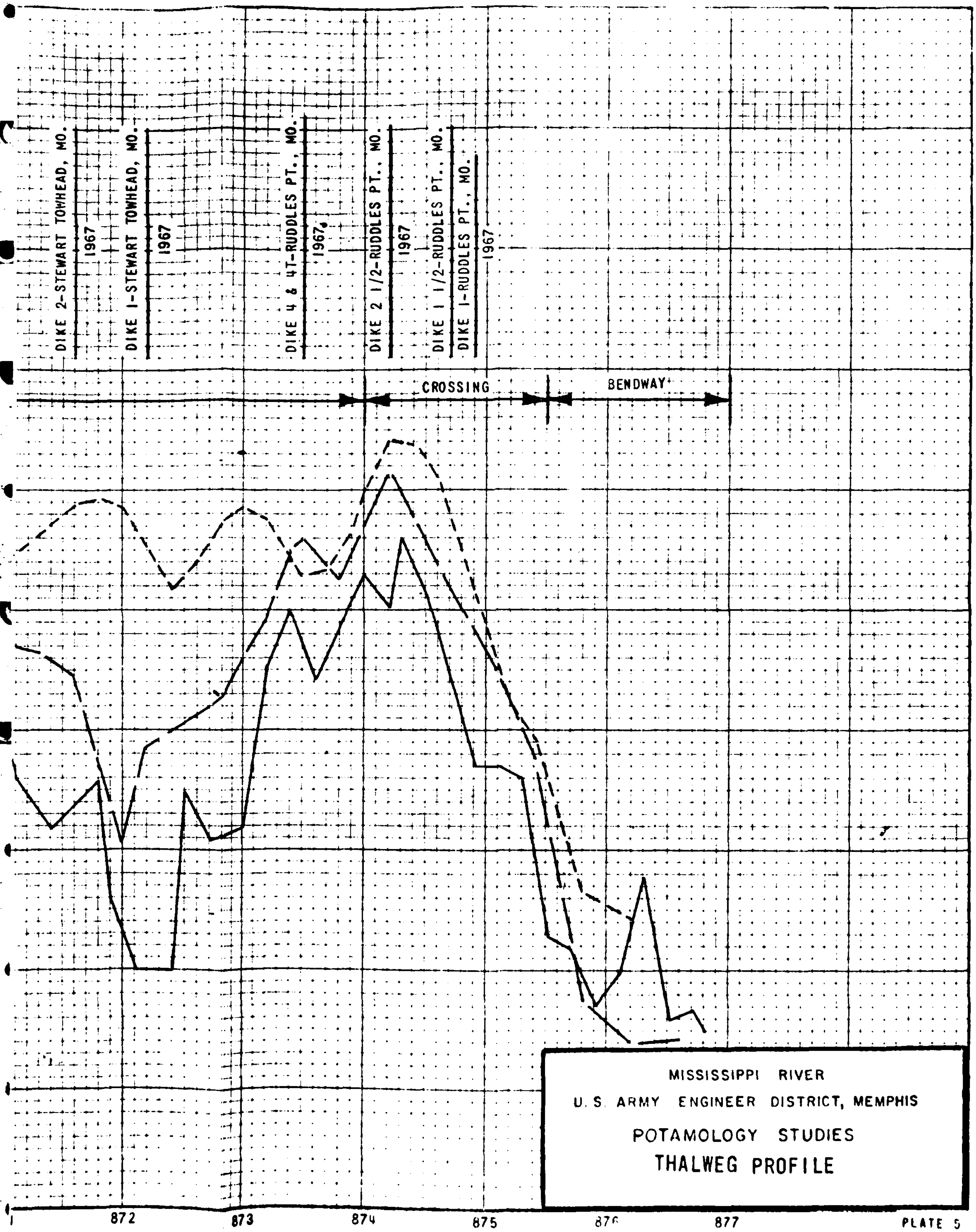
SPECIFIC GAGE RECORDS

TIPTONVILLE GAGE


DIKE 2-BELOW CHEROKEE, TN.
1969
BENDWAY
AVERAGE PRE-CONSTRUCTION (1959-1963)
AVERAGE
POST-CONSTRUCTION
ELEVATION IN GVD
240
230
220
210
200
190
180
860
861
862
863
864
865



DIKE 2-BELOW CHEROKEE, TN. 1969
DIKE 1-BELOW CHEROKEE, TN. 1969
6-STEWART TOWHEAD, MO. 1969
DIKE 5-STEWART TOWHEAD, MO. 1969
DIKE 4-STEWART TOWHEAD, MO. 1967
DIKE 3-STEWART TOWHEAD, MO. 1967
CROSSING
BENDWAY
ISTRUCTION (1959-1963)
AVERAGE 1967 & 1968
POST-CONSTRUCTION (1978)
-63
864
867
868
869
870
871
RIVER MILES



MISSISSIPPI RIVER

U. S. ARMY ENGINEER DISTRICT, MEMPHIS

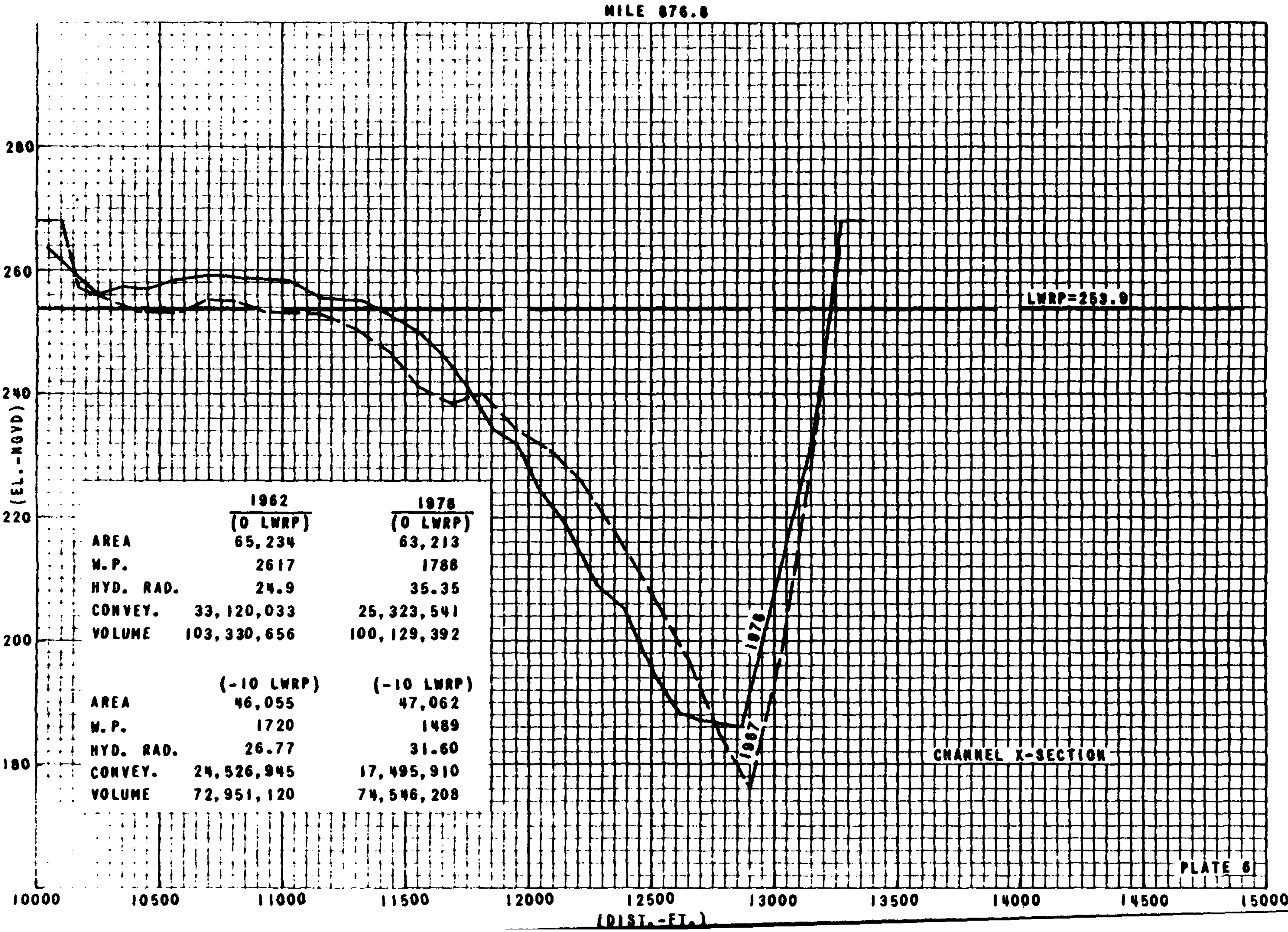
POTAMOLOGY STUDIES

THALWEG PROFILE

PLATE 5

K·E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0703

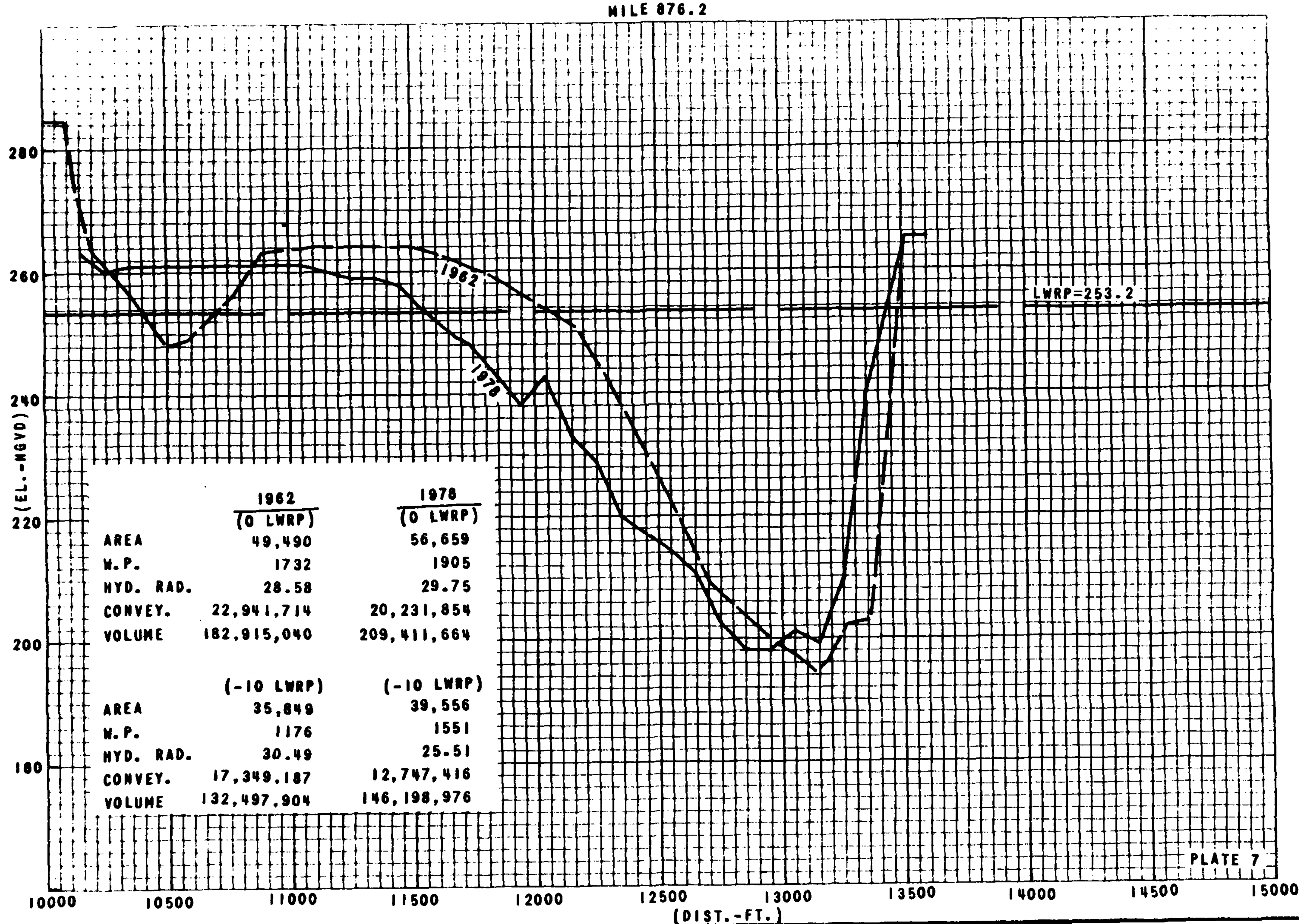


	1962 (0 LWRP)	1978 (0 LWRP)
AREA	65,234	63,213
W.P.	2617	1788
HYD. RAD.	24.9	35.35
CONVEY.	33,120,033	25,323,541
VOLUME	103,330,656	100,129,392
	(-10 LWRP)	(-10 LWRP)
AREA	46,055	47,062
W.P.	1720	1489
HYD. RAD.	26.77	31.60
CONVEY.	24,526,945	17,495,910
VOLUME	72,951,120	74,546,208

PLATE 6

46 0703

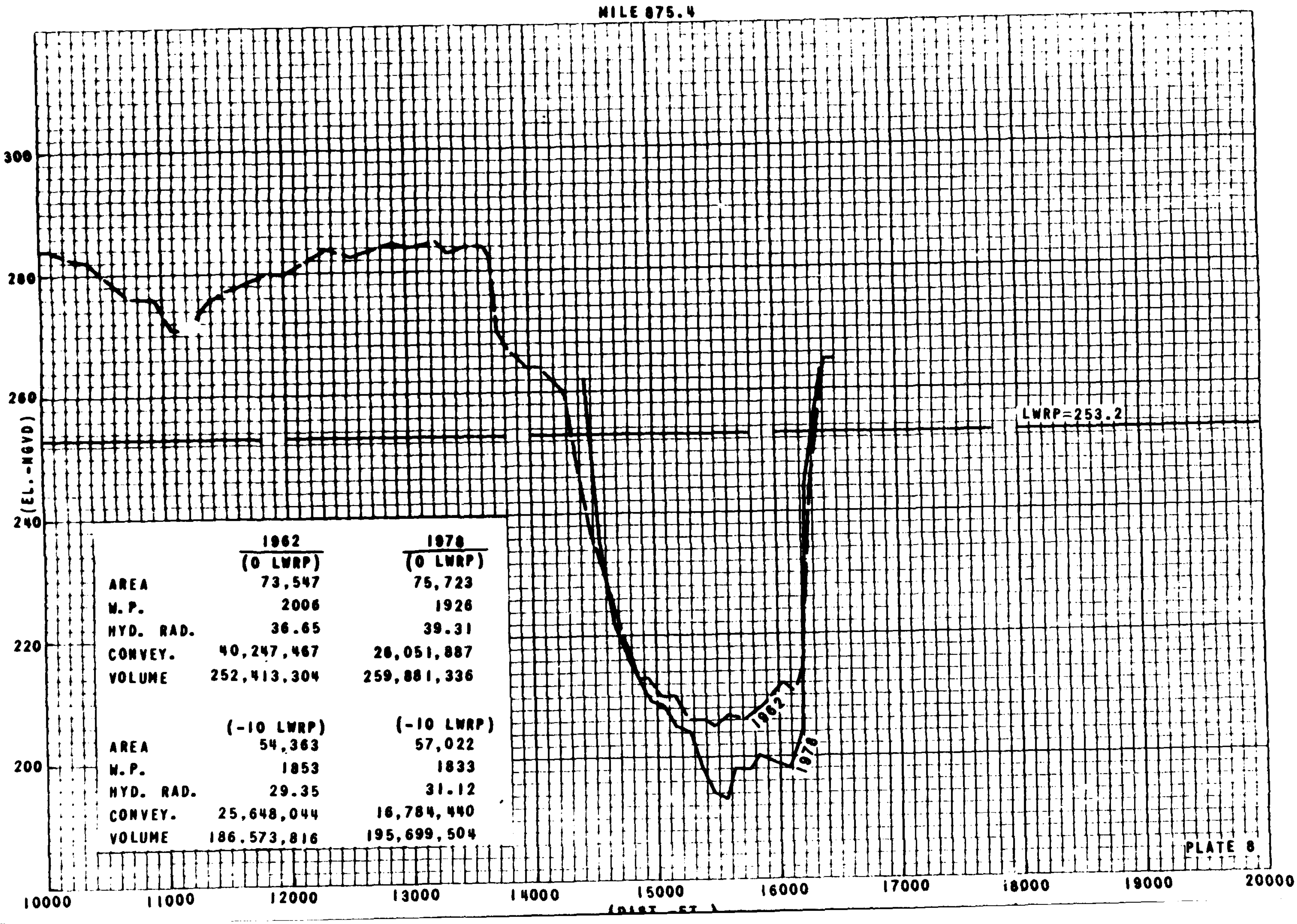
MILE 876.2



	1962 (0 LWRP)	1978 (0 LWRP)
AREA	49,490	56,659
W.P.	1732	1905
HYD. RAD.	28.58	29.75
CONVEY.	22,941,714	20,231,854
VOLUME	182,915,040	209,411,664
	(-10 LWRP)	(-10 LWRP)
AREA	35,849	39,556
W.P.	1176	1551
HYD. RAD.	30.49	25.51
CONVEY.	17,349,187	12,747,416
VOLUME	132,497,904	146,198,976

PLATE 7

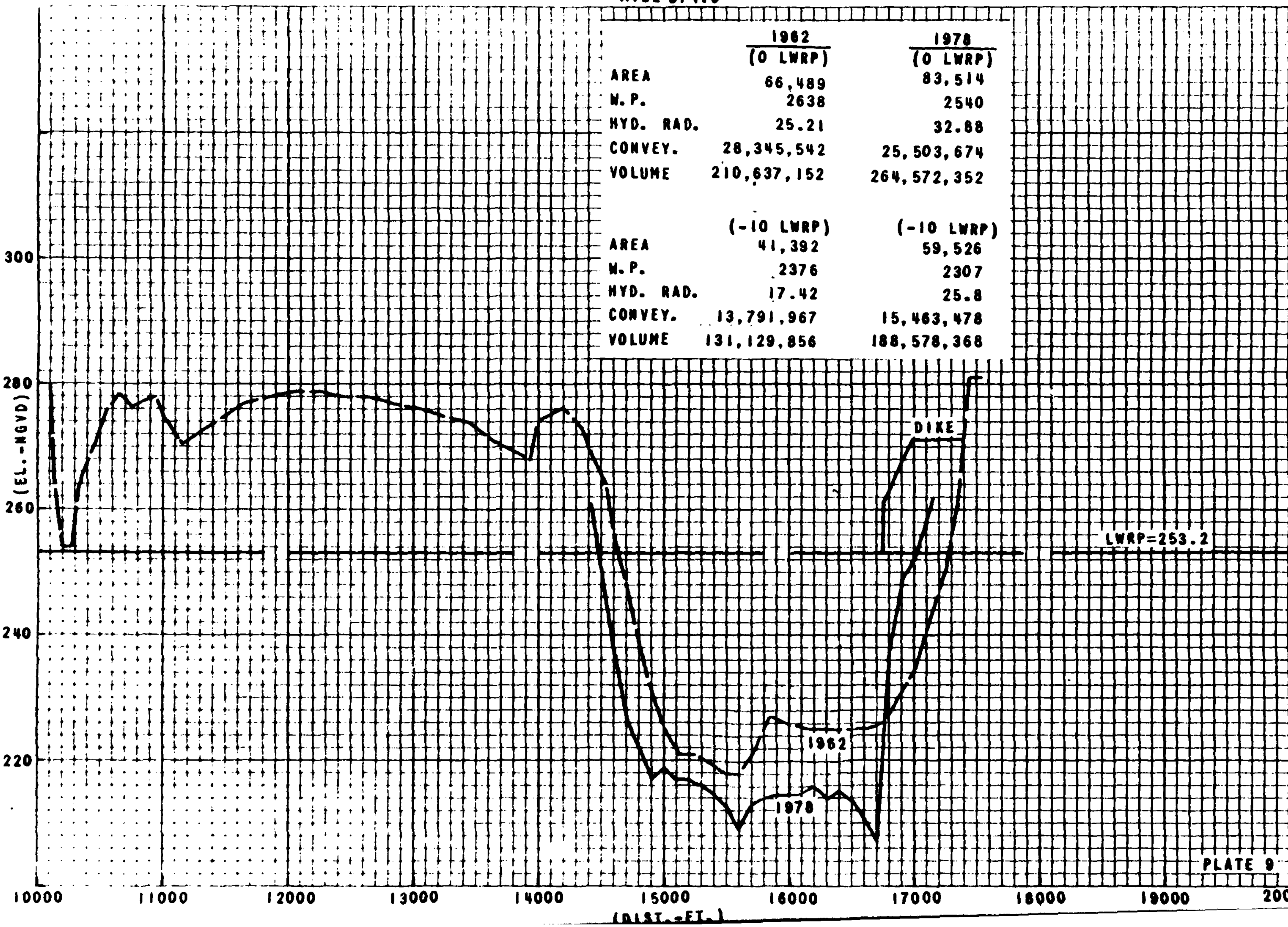
46 0703



	1962 (0 LWRP)	1978 (0 LWRP)
AREA	73,547	75,723
W.P.	2006	1926
HYD. RAD.	36.65	39.31
CONVEY.	40,247,467	26,051,887
VOLUME	252,413,304	259,881,336
	(-10 LWRP)	(-10 LWRP)
AREA	54,363	57,022
W.P.	1853	1833
HYD. RAD.	29.35	31.12
CONVEY.	25,648,044	16,784,440
VOLUME	186.573,816	195,699,504

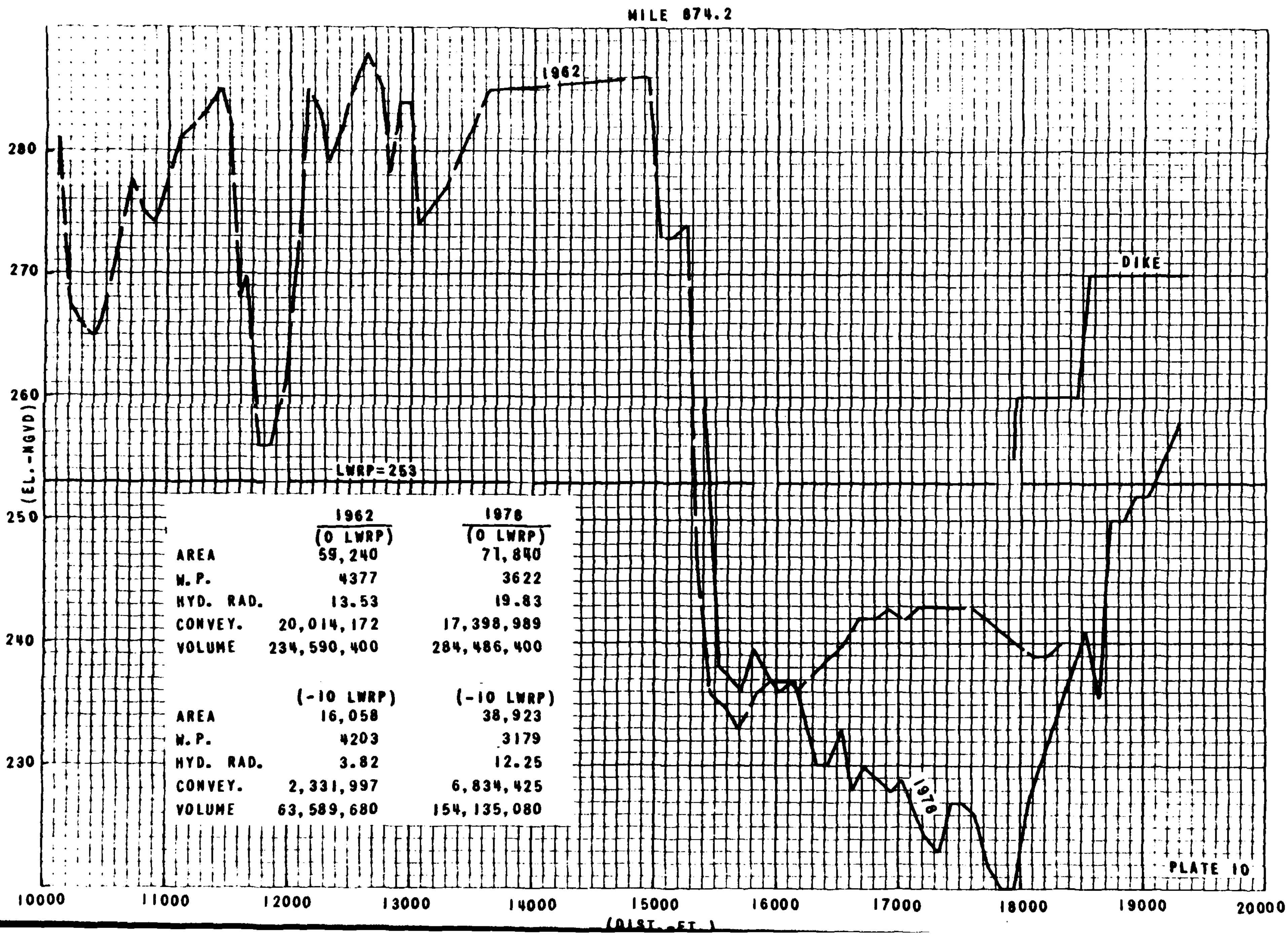
PLATE 8

MILE 874.9



	1962	1978
	(0 LWRP)	(0 LWRP)
AREA	66,489	83,514
W.P.	2638	2540
HYD. RAD.	25.21	32.88
CONVEY.	28,345,542	25,503,674
VOLUME	210,637,152	264,572,352
	(-10 LWRP)	(-10 LWRP)
AREA	41,392	59,526
W.P.	2376	2307
HYD. RAD.	17.42	25.8
CONVEY.	13,791,967	15,463,478
VOLUME	131,129,856	188,578,368

PLATE 9

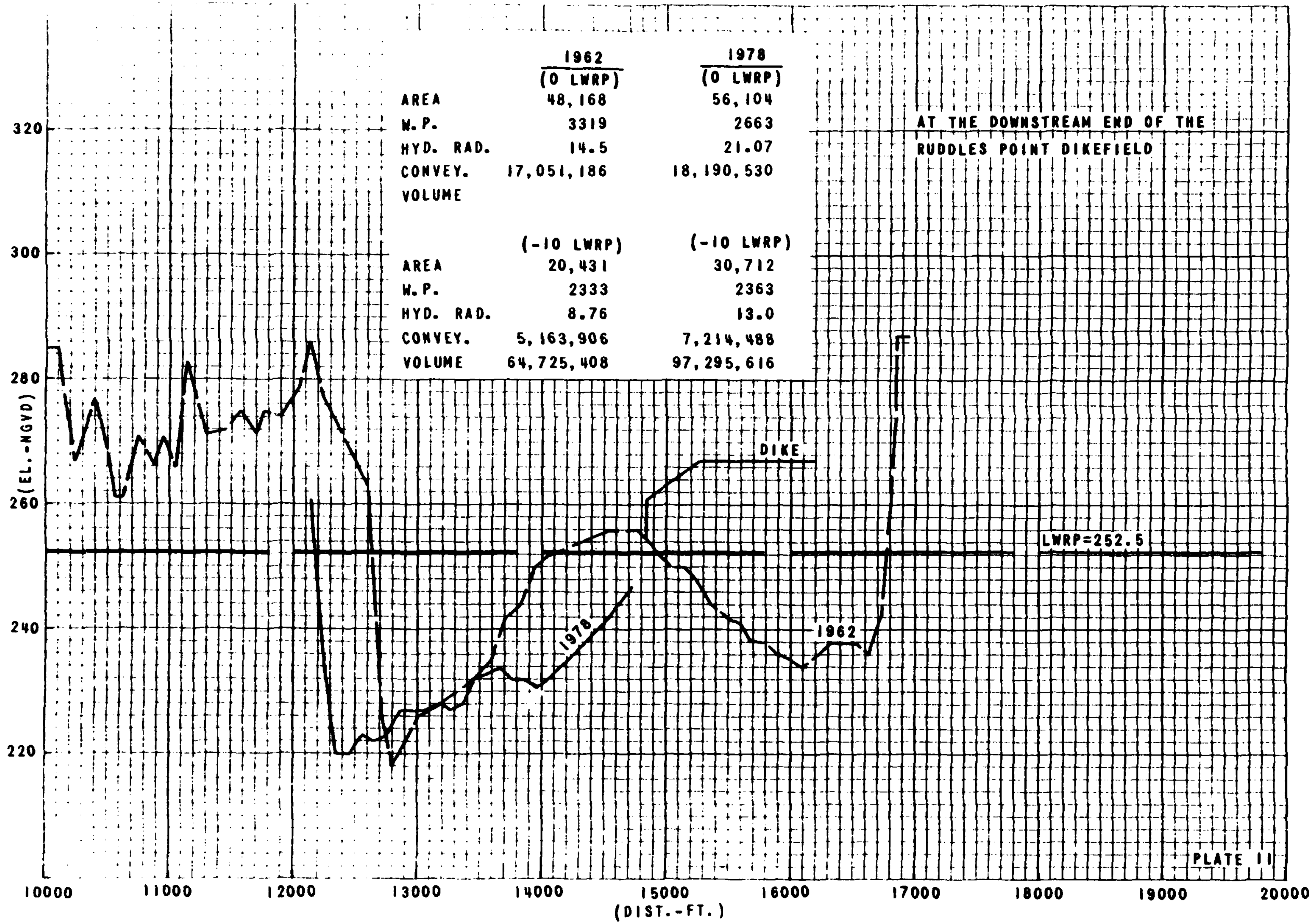


	1962 (0 LWRP)	1978 (0 LWRP)
AREA	59,240	71,840
W.P.	4377	3622
HYD. RAD.	13.53	19.83
CONVEY.	20,014,172	17,398,989
VOLUME	234,590,400	284,486,400

	1962 (-10 LWRP)	1978 (-10 LWRP)
AREA	16,058	38,923
W.P.	4203	3179
HYD. RAD.	3.82	12.25
CONVEY.	2,331,997	6,834,425
VOLUME	63,589,680	154,135,080

46 0703

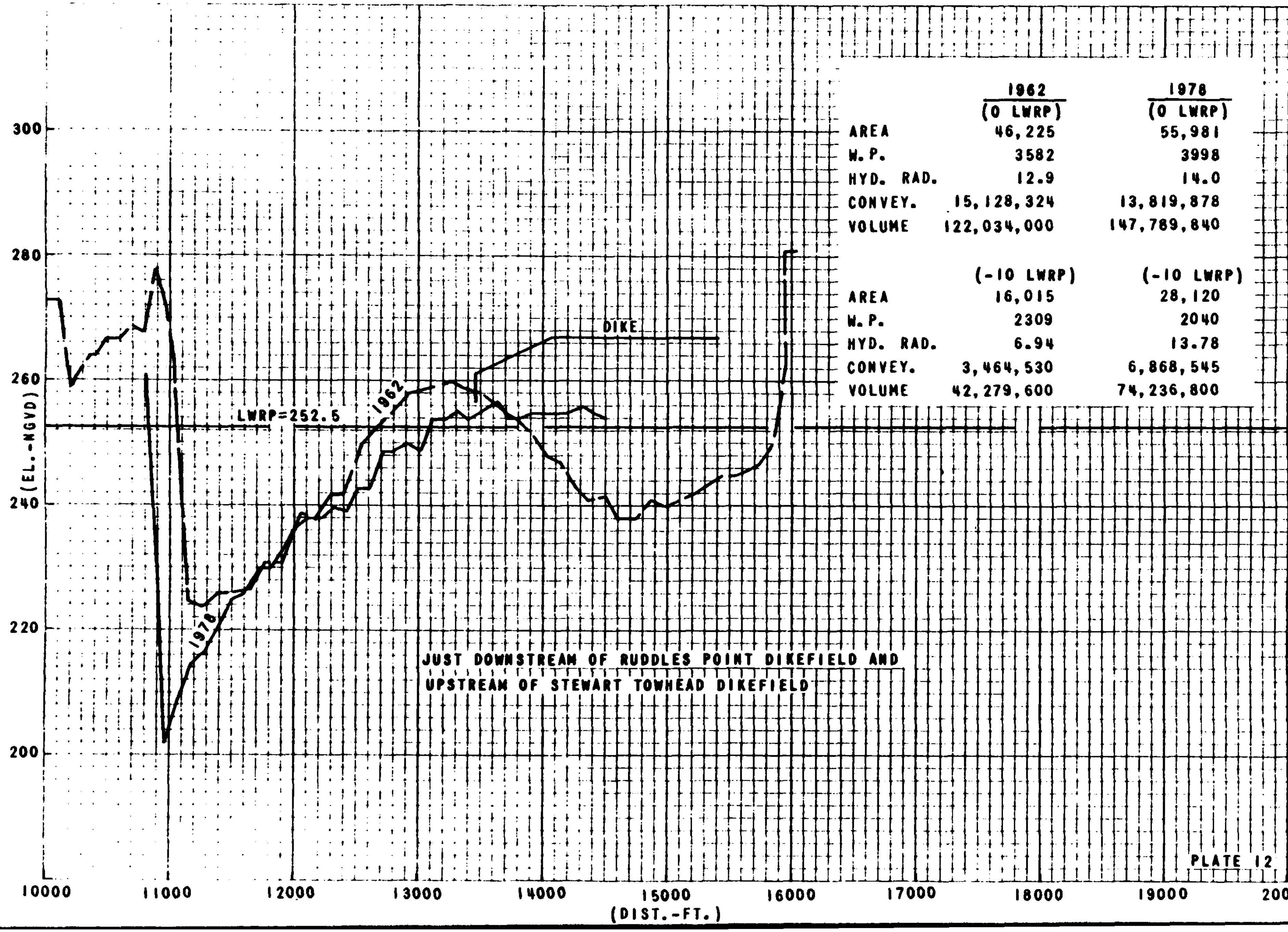
MILE 873.4



	1962	1978
	(0 LWRP)	(0 LWRP)
AREA	48,168	56,104
W.P.	3319	2663
HYD. RAD.	14.5	21.07
CONVEY.	17,051,186	18,190,530
VOLUME		
	(-10 LWRP)	(-10 LWRP)
AREA	20,431	30,712
W.P.	2333	2363
HYD. RAD.	8.76	13.0
CONVEY.	5,163,906	7,214,488
VOLUME	64,725,408	97,295,616

PLATE 11

MILE 873.0

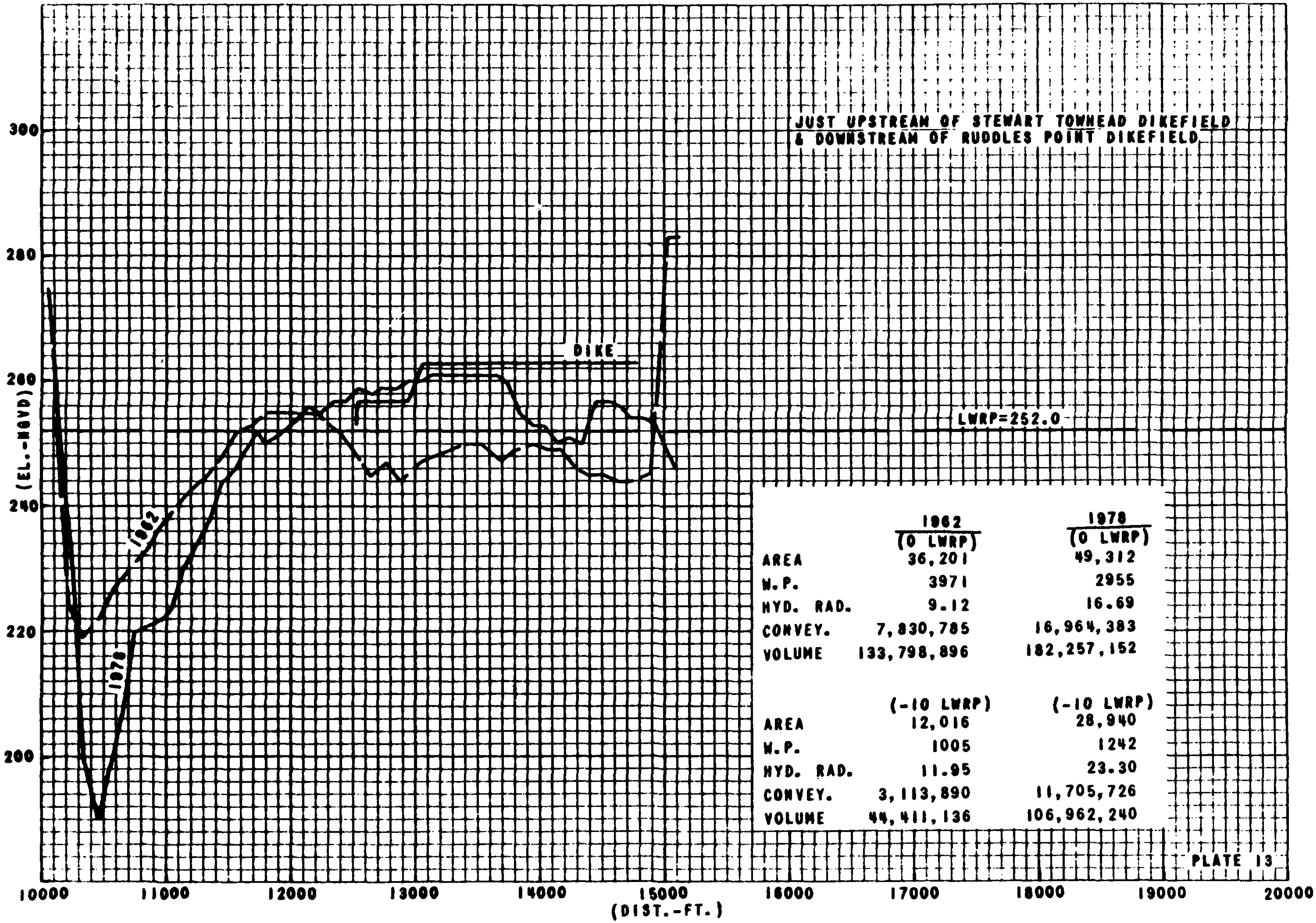


	1962	1978
	(0 LWRP)	(0 LWRP)
AREA	46,225	55,981
W.P.	3582	3998
HYD. RAD.	12.9	14.0
CONVEY.	15,128,324	13,819,878
VOLUME	122,034,000	147,789,840
	(-10 LWRP)	(-10 LWRP)
AREA	16,015	28,120
W.P.	2309	2040
HYD. RAD.	6.94	13.78
CONVEY.	3,464,530	6,868,545
VOLUME	42,279,600	74,236,800

PLATE 12

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0703

MILE 872.4



	1962 (0 LWRP)	1978 (0 LWRP)
AREA	36,201	49,312
W.P.	3971	2955
HYD. RAD.	9.12	16.69
CONVEY.	7,830,785	16,964,383
VOLUME	133,798,896	182,257,152
	(-10 LWRP)	(-10 LWRP)
AREA	12,016	28,940
W.P.	1005	1242
HYD. RAD.	11.95	23.30
CONVEY.	3,113,890	11,705,726
VOLUME	44,411,136	106,962,240

PLATE 13

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0703

MILE 871.6

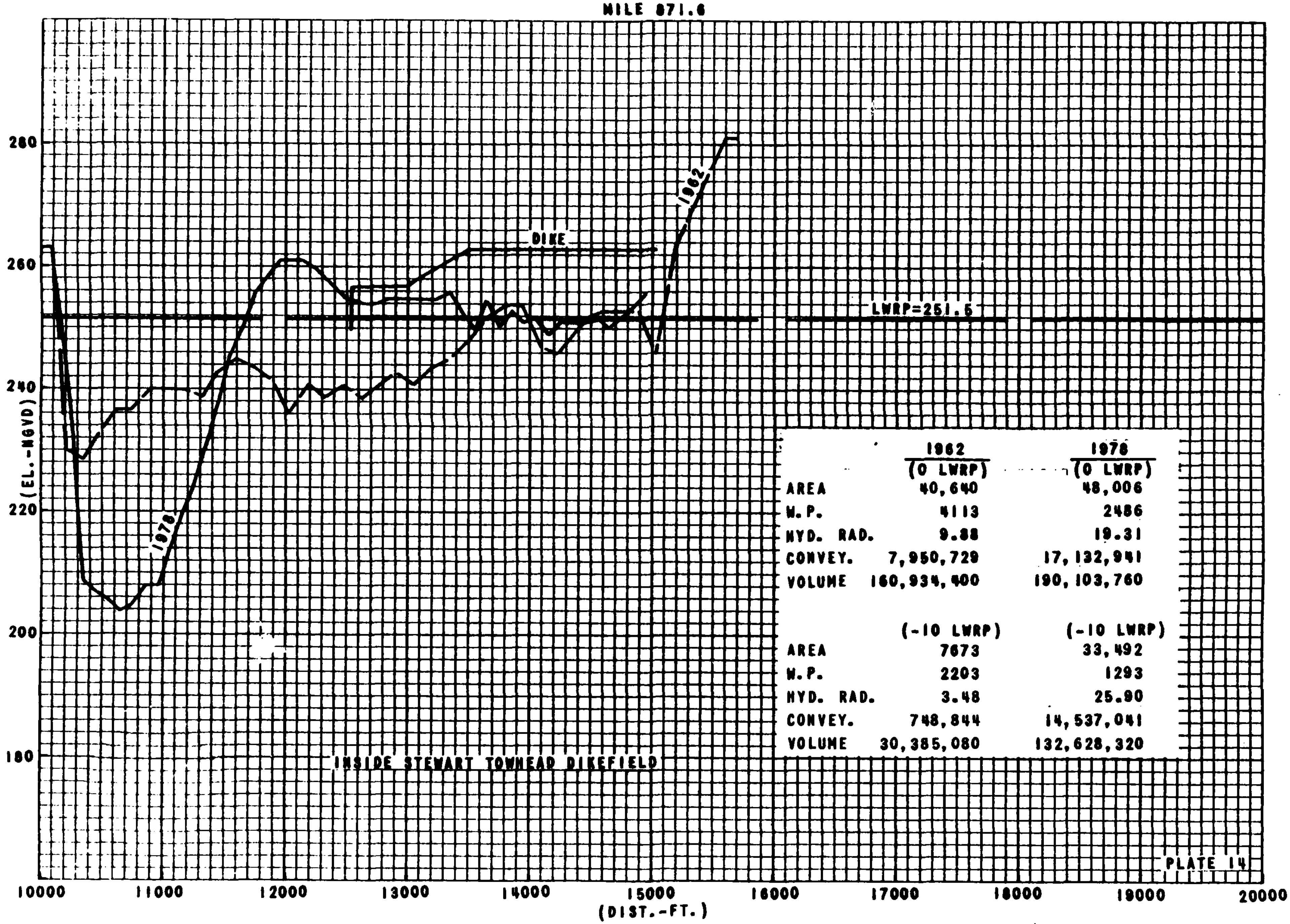
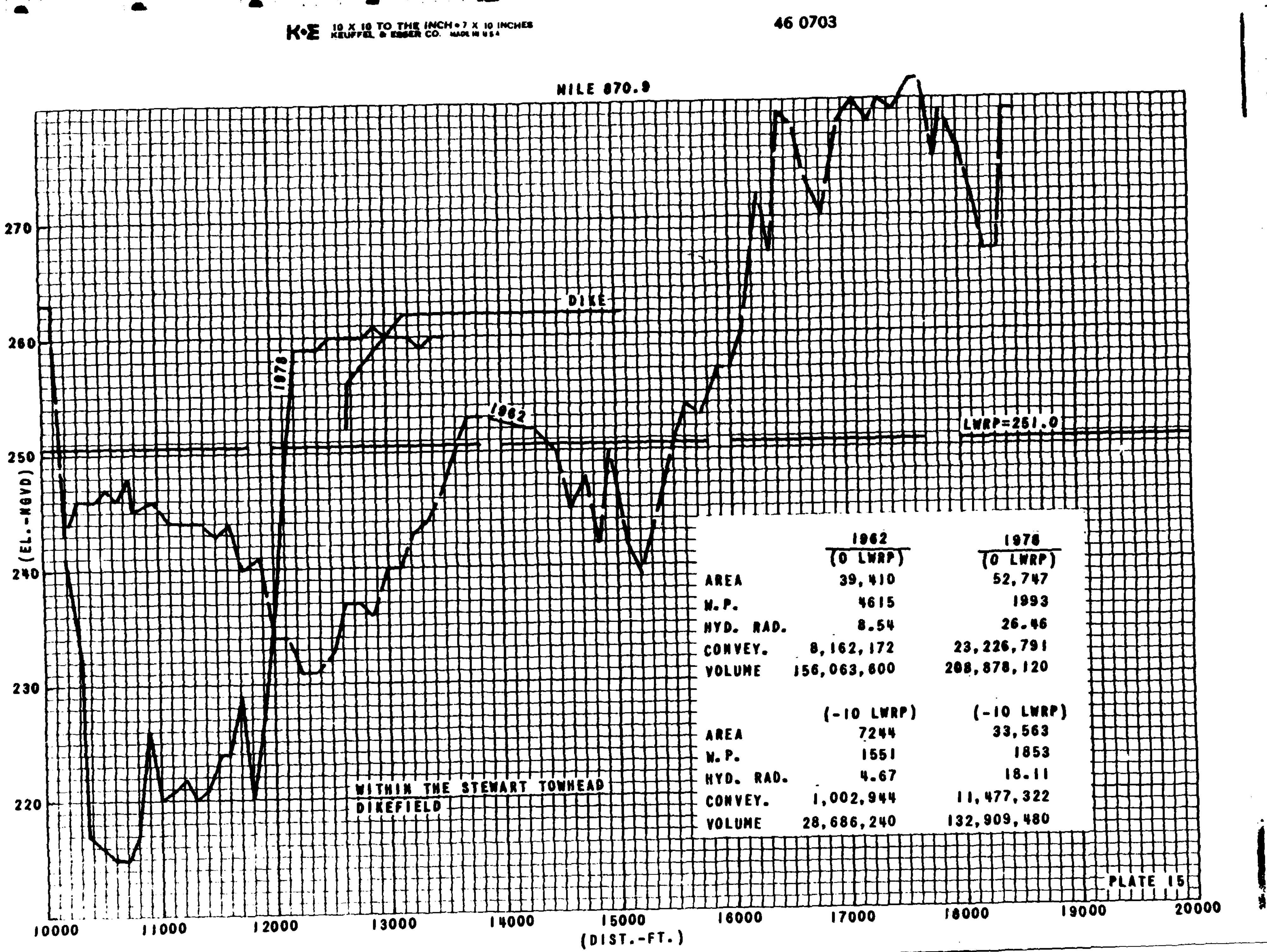


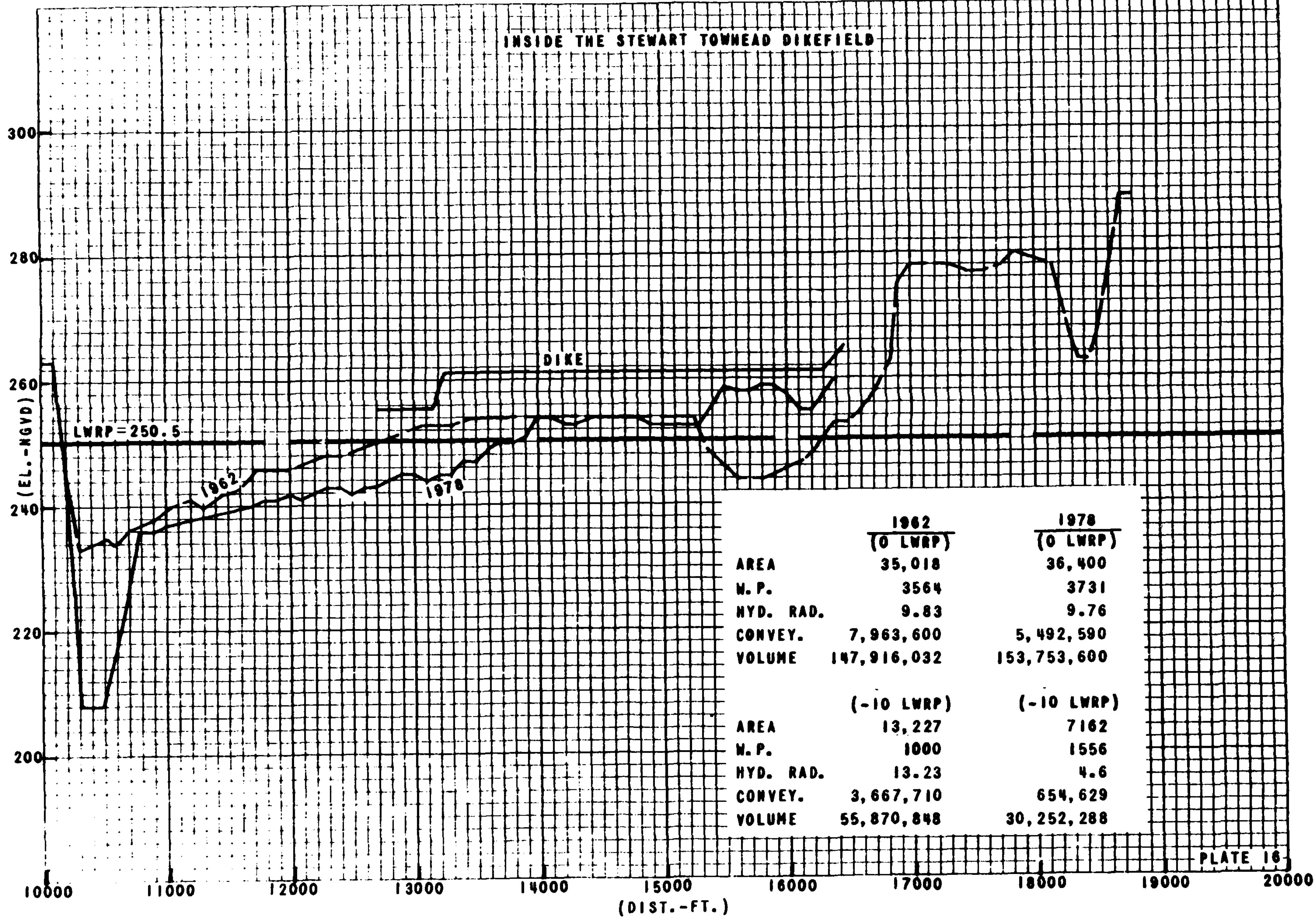
PLATE 14


K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.
46 0703
MILE 870.9
DIKE
1978
1962
LWRP=251.0
270
260
250
240
230
220
(EL.-NGVD)
10000
11000
12000
13000
14000
15000
16000
17000
18000
19000
20000
(DIST.-FT.)
WITHIN THE STEWART TOWHEAD DIKEFIELD
	1962 (0 LWRP)	1978 (0 LWRP)
AREA	39,410	52,747
W.P.	4615	1993
HYD. RAD.	8.54	26.46
CONVEY.	8,162,172	23,226,791
VOLUME	156,063,600	208,878,120
	(-10 LWRP)	(-10 LWRP)
AREA	7244	33,563
W.P.	1551	1853
HYD. RAD.	4.67	18.11
CONVEY.	1,002,944	11,477,322
VOLUME	28,686,240	132,909,480
PLATE 15

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0703

MILE 870.1

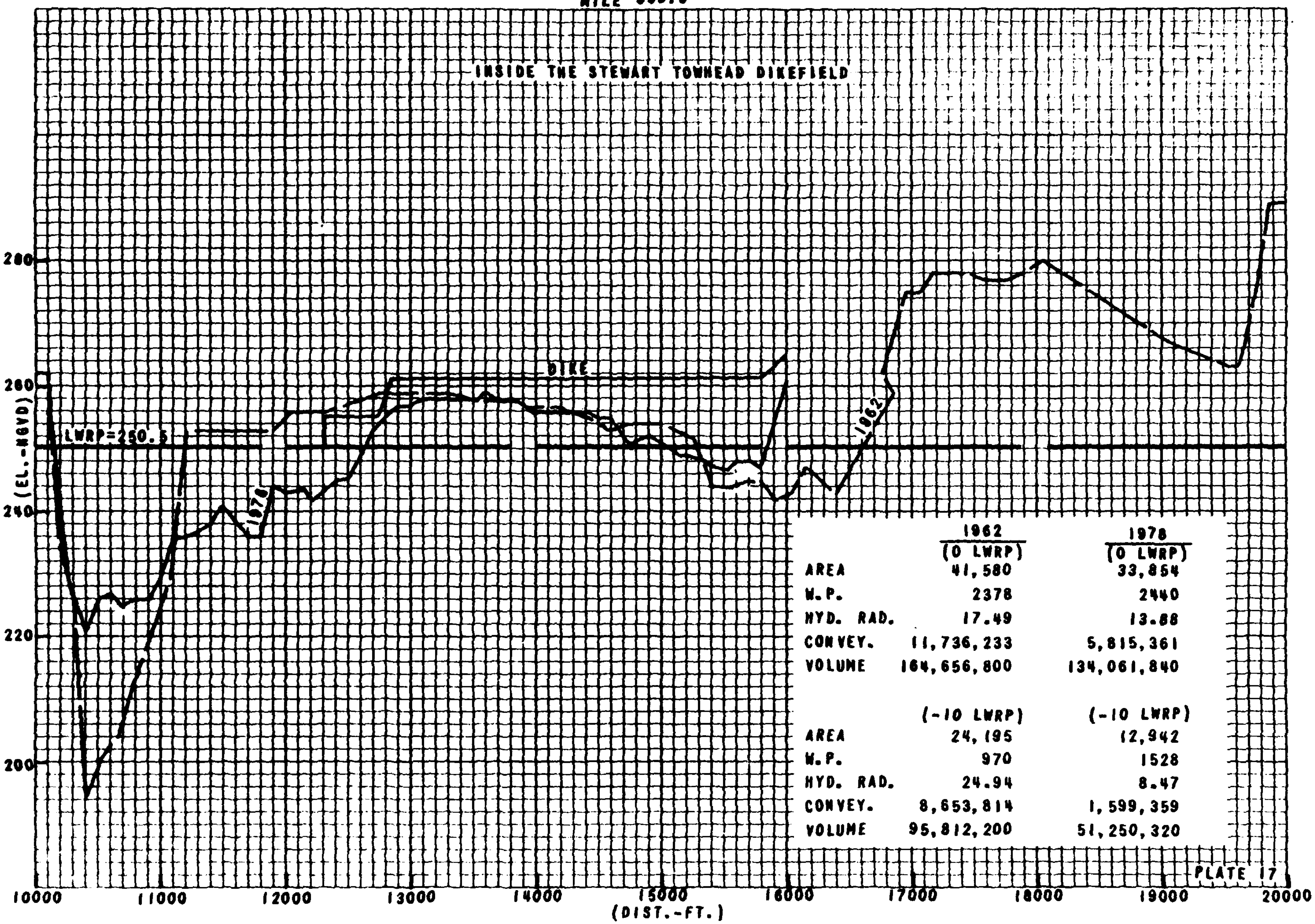
INSIDE THE STEWART TOWHEAD DIKEFIELD



	1962 (0 LWRP)	1978 (0 LWRP)
AREA	35,018	36,400
W.P.	3564	3731
HYD. RAD.	9.83	9.76
CONVEY.	7,963,600	5,492,590
VOLUME	147,916,032	153,753,600
	(-10 LWRP)	(-10 LWRP)
AREA	13,227	7162
W.P.	1000	1556
HYD. RAD.	13.23	4.6
CONVEY.	3,667,710	654,629
VOLUME	55,870,848	30,252,288

PLATE 16

MILE 869.3



	1962	1978
	(0 LWRP)	(0 LWRP)
AREA	41,580	33,854
W.P.	2378	2440
HYD. RAD.	17.49	13.88
CONVEY.	11,736,233	5,815,361
VOLUME	164,656,800	134,061,840
	(-10 LWRP)	(-10 LWRP)
AREA	24,195	12,942
W.P.	970	1528
HYD. RAD.	24.94	8.47
CONVEY.	8,653,814	1,599,359
VOLUME	95,812,200	51,250,320

PLATE 17

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

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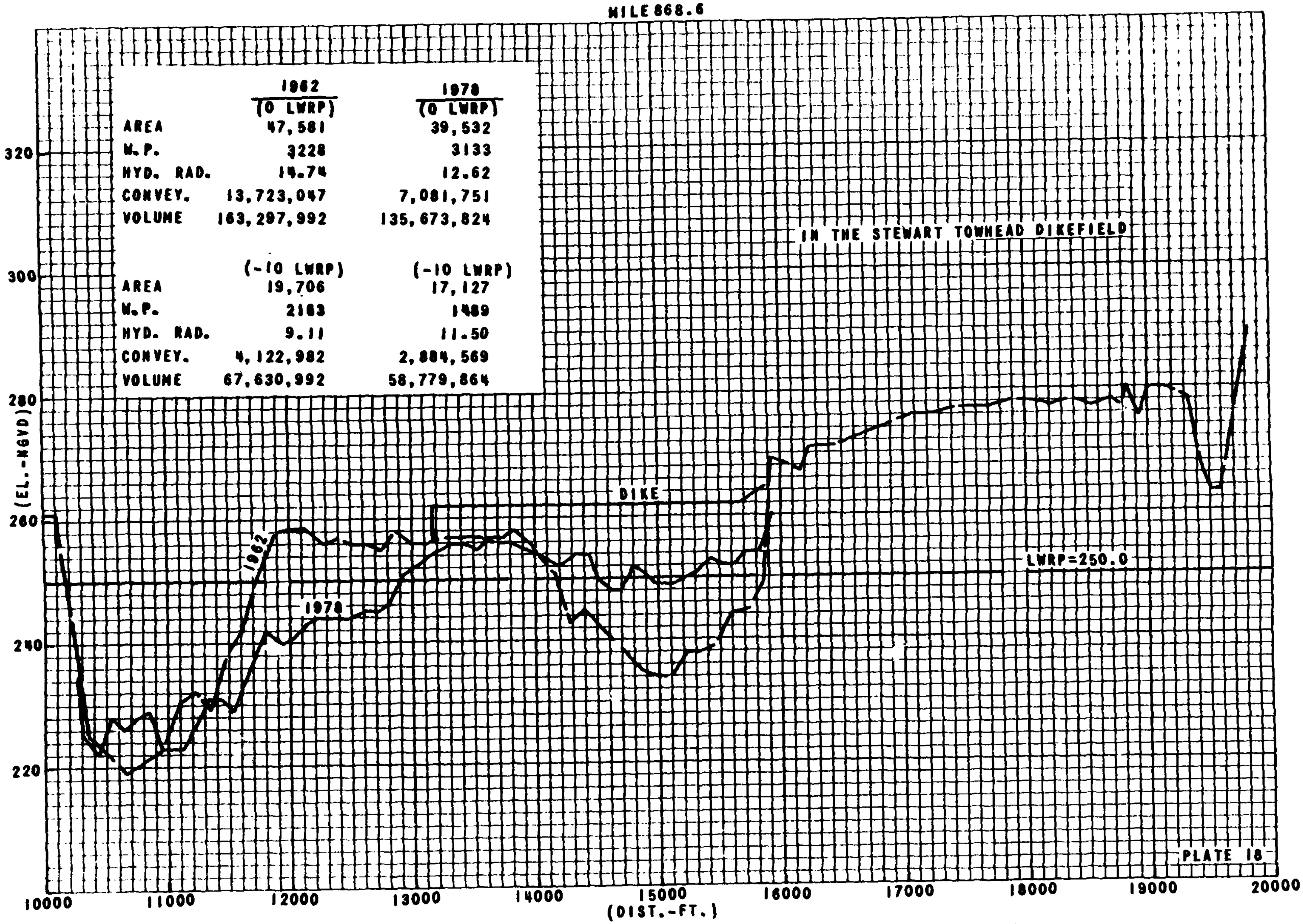
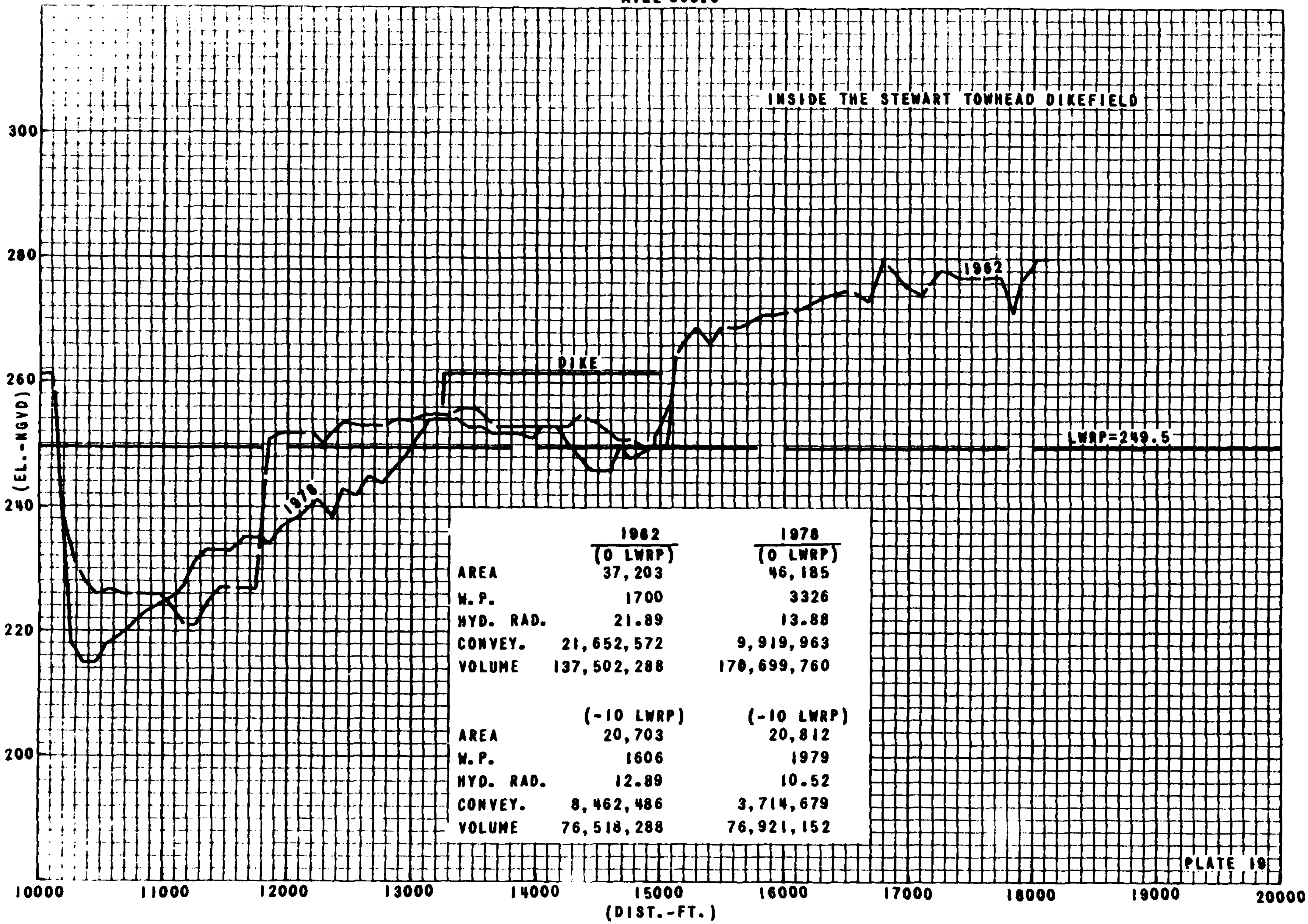


	1962 (0 LWRP)	1978 (0 LWRP)
AREA	47,581	39,532
W.P.	3228	3133
HYD. RAD.	14.74	12.62
CONVEY.	13,723,047	7,081,751
VOLUME	163,297,992	135,673,824

	(-10 LWRP)	(-10 LWRP)
AREA	19,706	17,127
W.P.	2163	1489
HYD. RAD.	9.11	11.50
CONVEY.	4,122,982	2,884,569
VOLUME	67,630,992	58,779,864

MILE 868.0

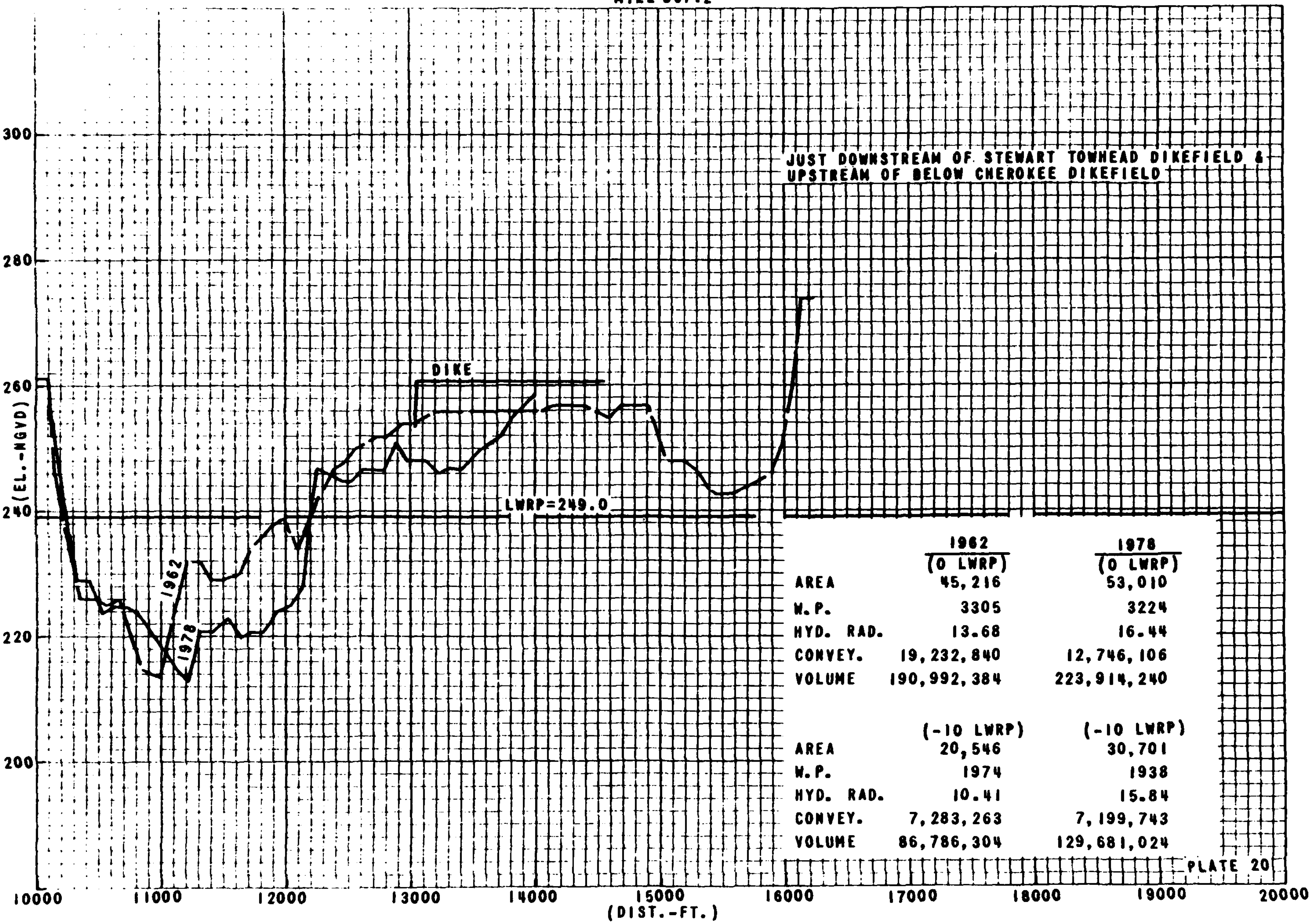


	1962 (0 LWRP)	1978 (0 LWRP)
AREA	37,203	46,185
W.P.	1700	3326
HYD. RAD.	21.89	13.88
CONVEY.	21,652,572	9,919,963
VOLUME	137,502,288	170,699,760
	(-10 LWRP)	(-10 LWRP)
AREA	20,703	20,812
W.P.	1606	1979
HYD. RAD.	12.89	10.52
CONVEY.	8,462,486	3,714,679
VOLUME	76,518,288	76,921,152

PLATE 19

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0703

MILE 867.2



	1962 (0 LWRP)	1978 (0 LWRP)
AREA	45,216	53,010
W.P.	3305	3224
HYD. RAD.	13.68	16.44
CONVEY.	19,232,840	12,746,106
VOLUME	190,992,384	223,914,240
	(-10 LWRP)	(-10 LWRP)
AREA	20,546	30,701
W.P.	1974	1938
HYD. RAD.	10.41	15.84
CONVEY.	7,283,263	7,199,743
VOLUME	86,786,304	129,681,024

PLATE 20

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

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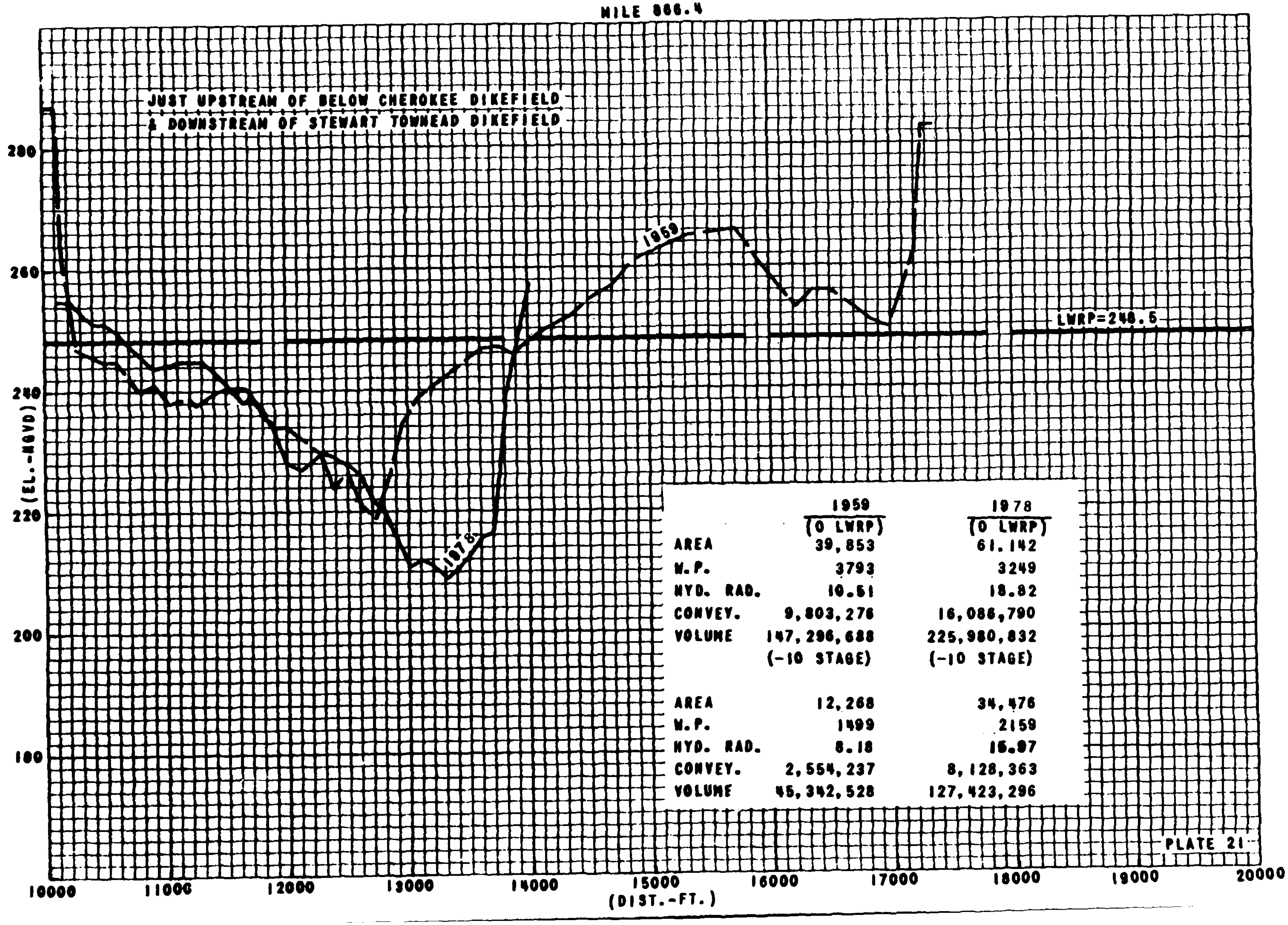
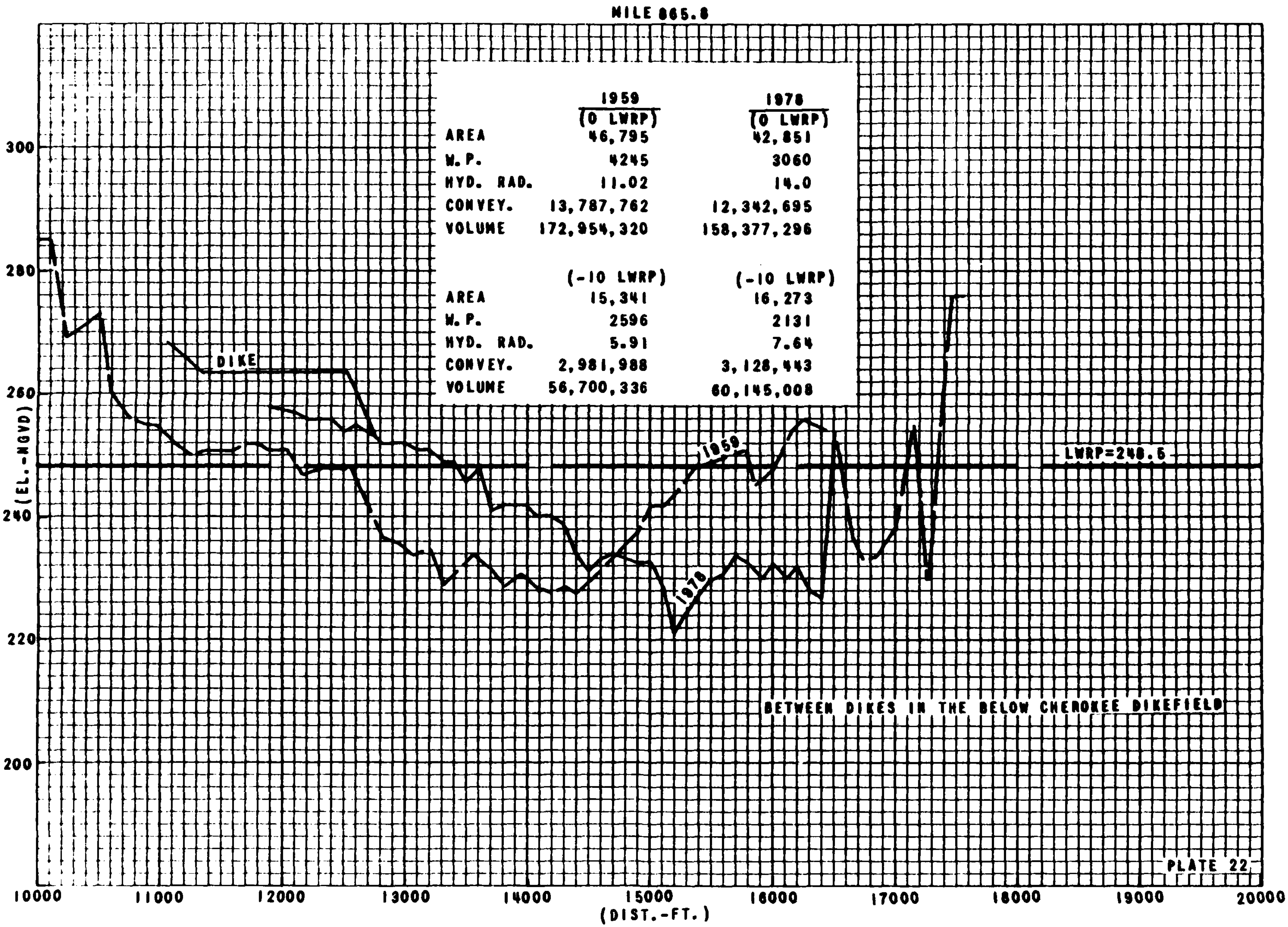
MILE 886.4



	1959 (0 LWRP)	1978 (0 LWRP)
AREA	39,853	61,142
W.P.	3793	3249
HYD. RAD.	10.51	18.82
CONVEY.	9,803,276	16,086,790
VOLUME	147,296,688	225,980,832
	(-10 STAGE)	(-10 STAGE)
AREA	12,268	34,476
W.P.	1499	2159
HYD. RAD.	8.18	15.97
CONVEY.	2,554,237	8,128,363
VOLUME	45,342,528	127,423,296

PLATE 21

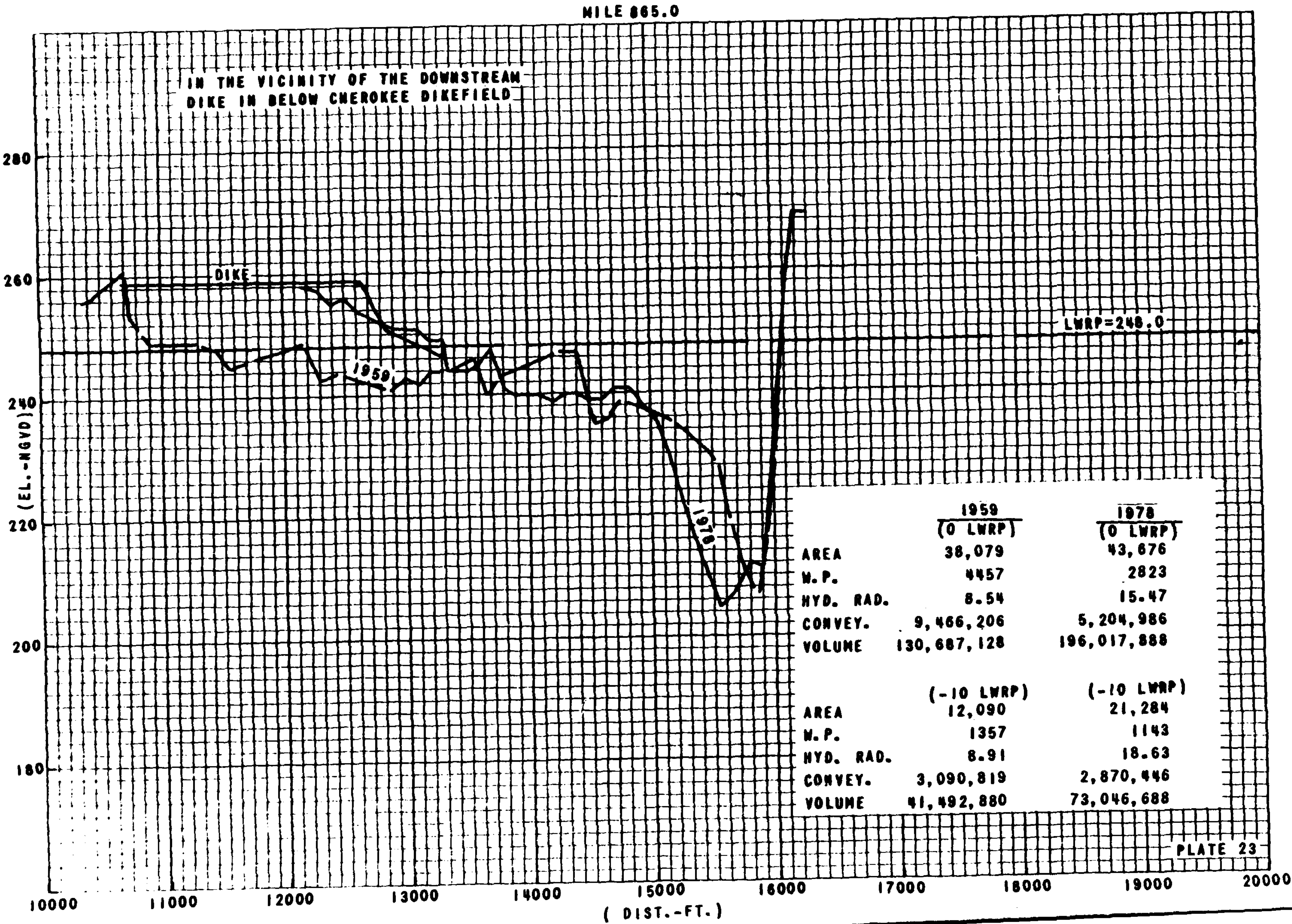
K·E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0703



	1959	1978
	(0 LWRP)	(0 LWRP)
AREA	46,795	42,851
W. P.	4245	3060
HYD. RAD.	11.02	14.0
CONVEY.	13,787,762	12,342,695
VOLUME	172,954,320	158,377,296
	(-10 LWRP)	(-10 LWRP)
AREA	15,341	16,273
W. P.	2596	2131
HYD. RAD.	5.91	7.64
CONVEY.	2,981,988	3,128,443
VOLUME	56,700,336	60,145,008

PLATE 22

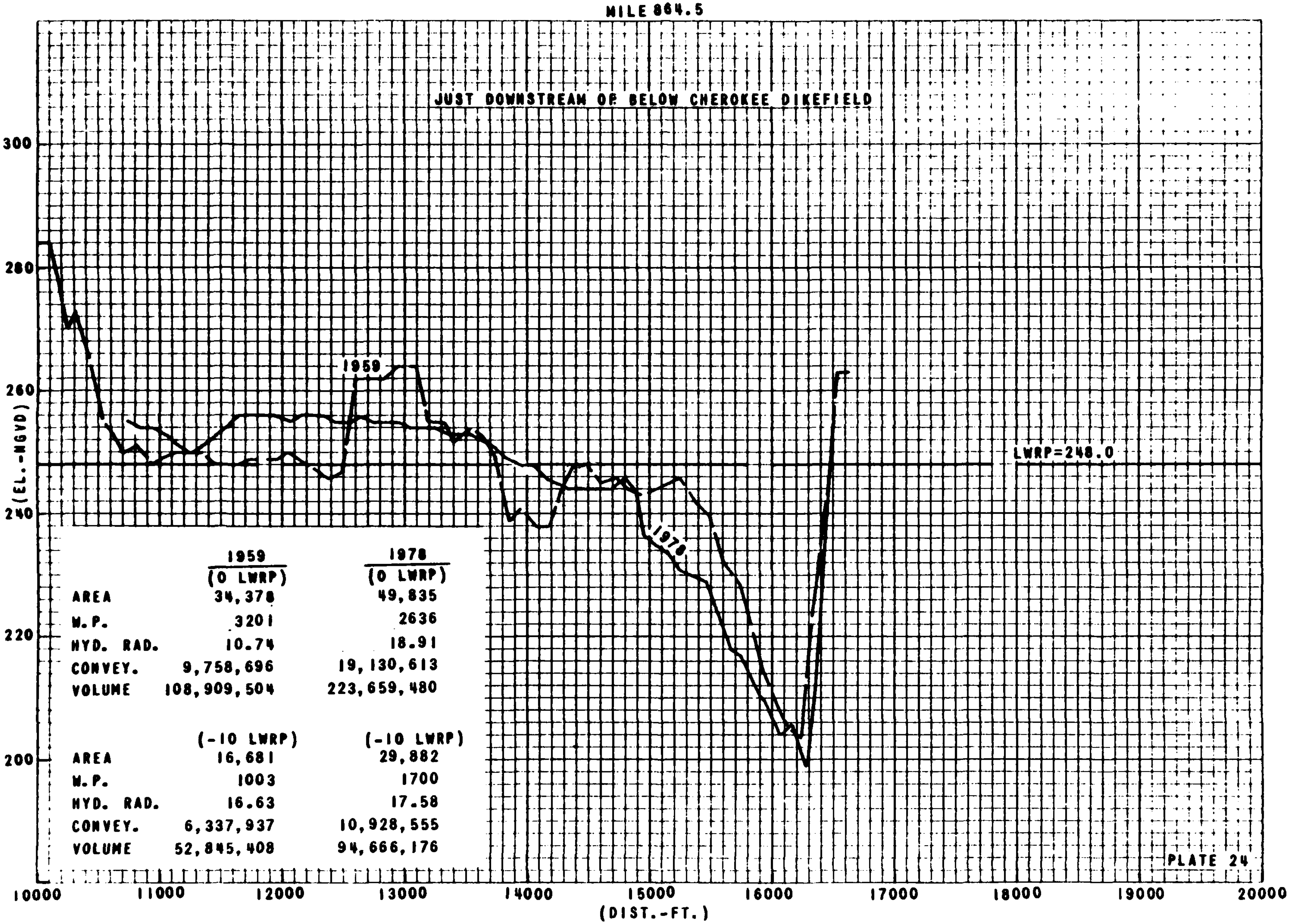
MILE 865.0



	1959 (0 LWRP)	1978 (0 LWRP)
AREA	38,079	43,676
W.P.	4457	2823
HYD. RAD.	8.54	15.47
CONVEY.	9,466,206	5,204,986
VOLUME	130,687,128	196,017,888
	(-10 LWRP)	(-10 LWRP)
AREA	12,090	21,284
W.P.	1357	1143
HYD. RAD.	8.91	18.63
CONVEY.	3,090,819	2,870,446
VOLUME	41,492,880	73,046,688

PLATE 23

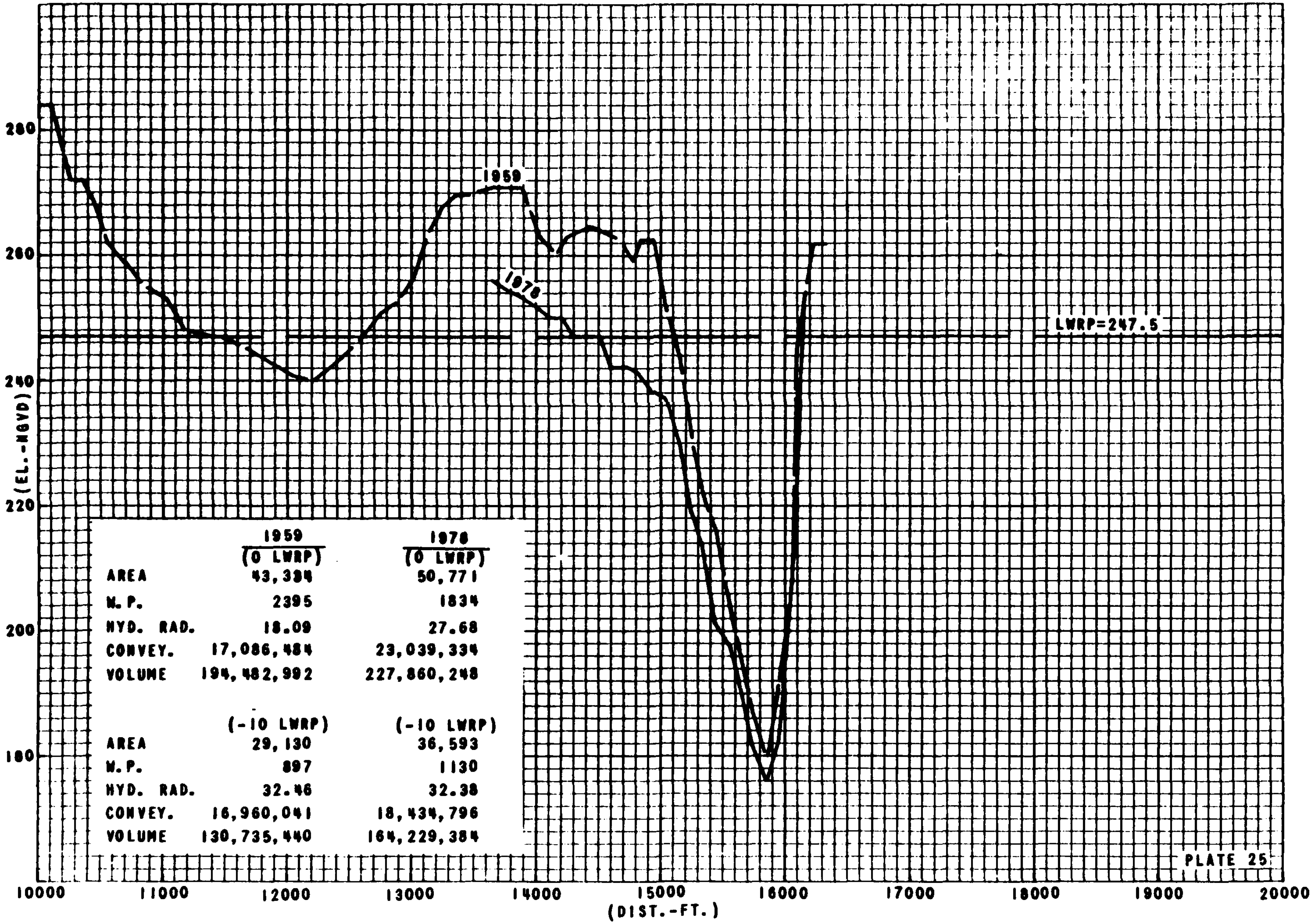
46 0703



	1959 (0 LWRP)	1978 (0 LWRP)
AREA	34,378	49,835
W.P.	3201	2636
HYD. RAD.	10.74	18.91
CONVEY.	9,758,696	19,130,613
VOLUME	108,909,504	223,659,480
	(-10 LWRP)	(-10 LWRP)
AREA	16,681	29,882
W.P.	1003	1700
HYD. RAD.	16.63	17.58
CONVEY.	6,337,937	10,928,555
VOLUME	52,845,408	94,666,176

PLATE 24

MILE 863.8

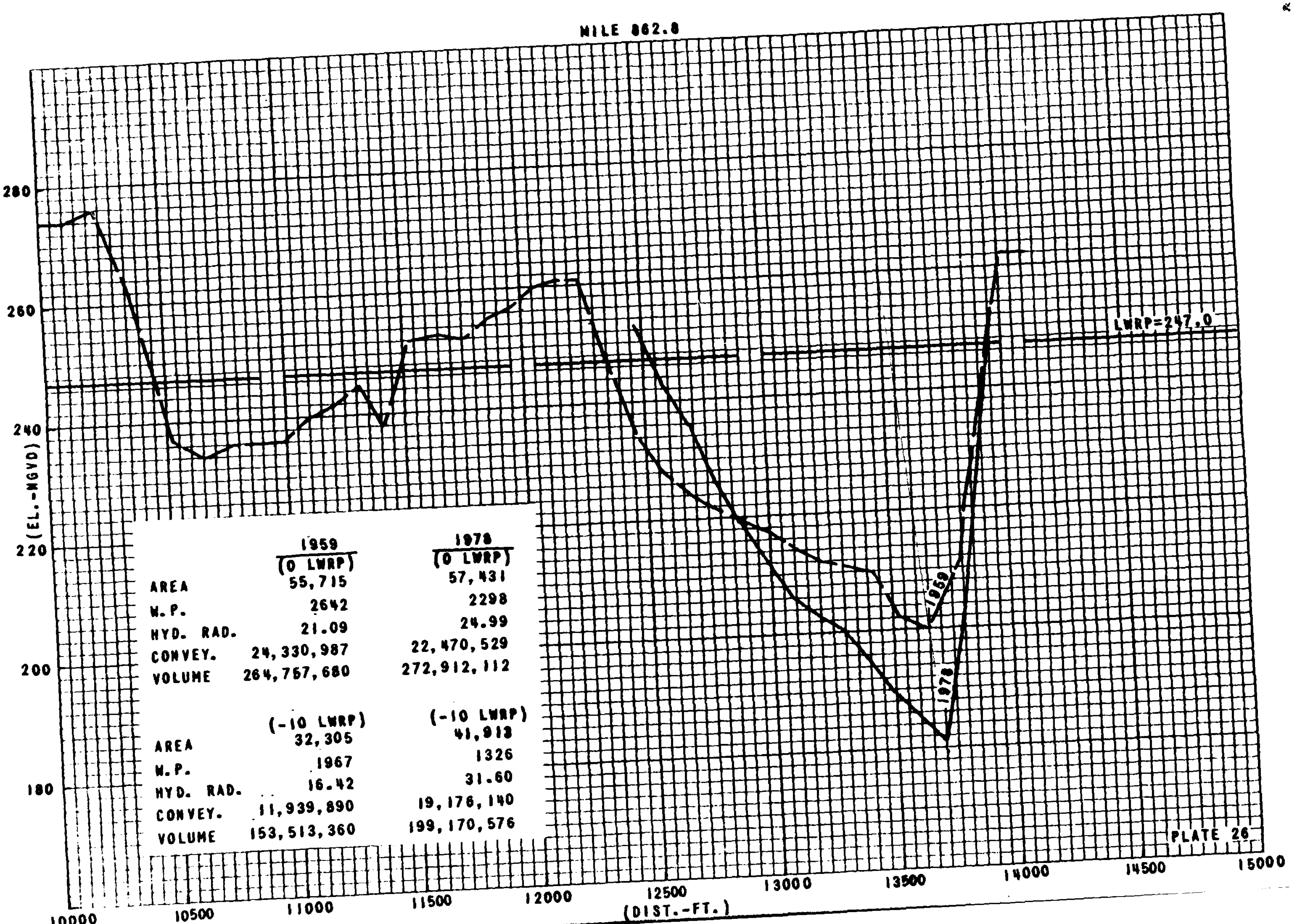


	1959 (0 LWRP)	1978 (0 LWRP)
AREA	43,384	50,771
W.P.	2395	1834
HYD. RAD.	18.09	27.68
CONVEY.	17,086,484	23,039,334
VOLUME	194,482,992	227,860,248
	(-10 LWRP)	(-10 LWRP)
AREA	29,130	36,593
W.P.	897	1130
HYD. RAD.	32.46	32.38
CONVEY.	16,960,041	18,434,796
VOLUME	130,735,440	164,229,384

PLATE 25

46 0703

K+E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

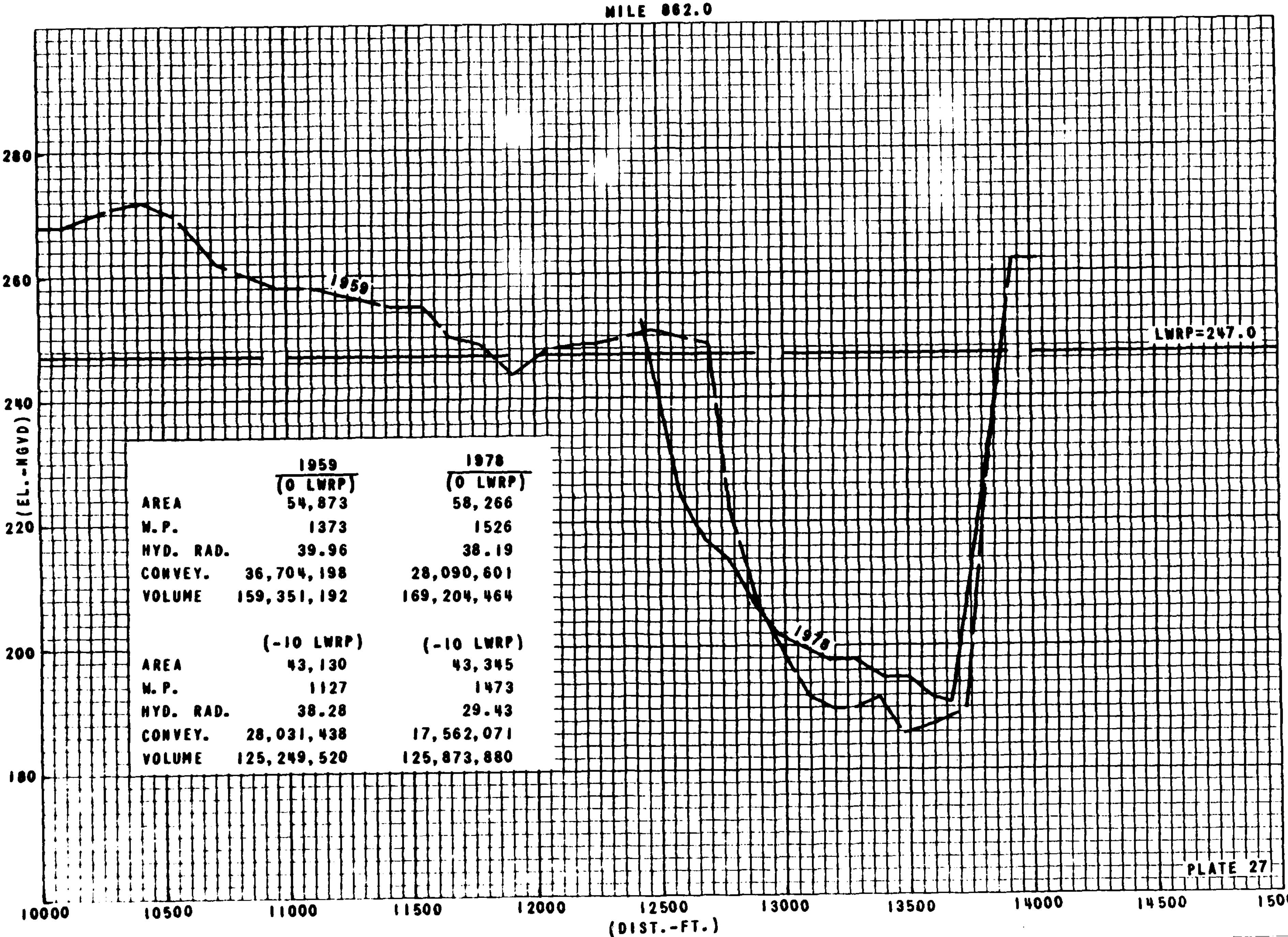


	1959 (0 LWRP)	1978 (0 LWRP)
AREA	55,715	57,431
W.P.	2642	2298
HYD. RAD.	21.09	24.99
CONVEY.	24,330,987	22,470,529
VOLUME	264,757,680	272,912,112
	(-10 LWRP)	(-10 LWRP)
AREA	32,305	41,913
W.P.	1967	1326
HYD. RAD.	16.42	31.60
CONVEY.	11,939,890	19,176,140
VOLUME	153,513,360	199,170,576

PLATE 26

46 0703

MILE 862.0

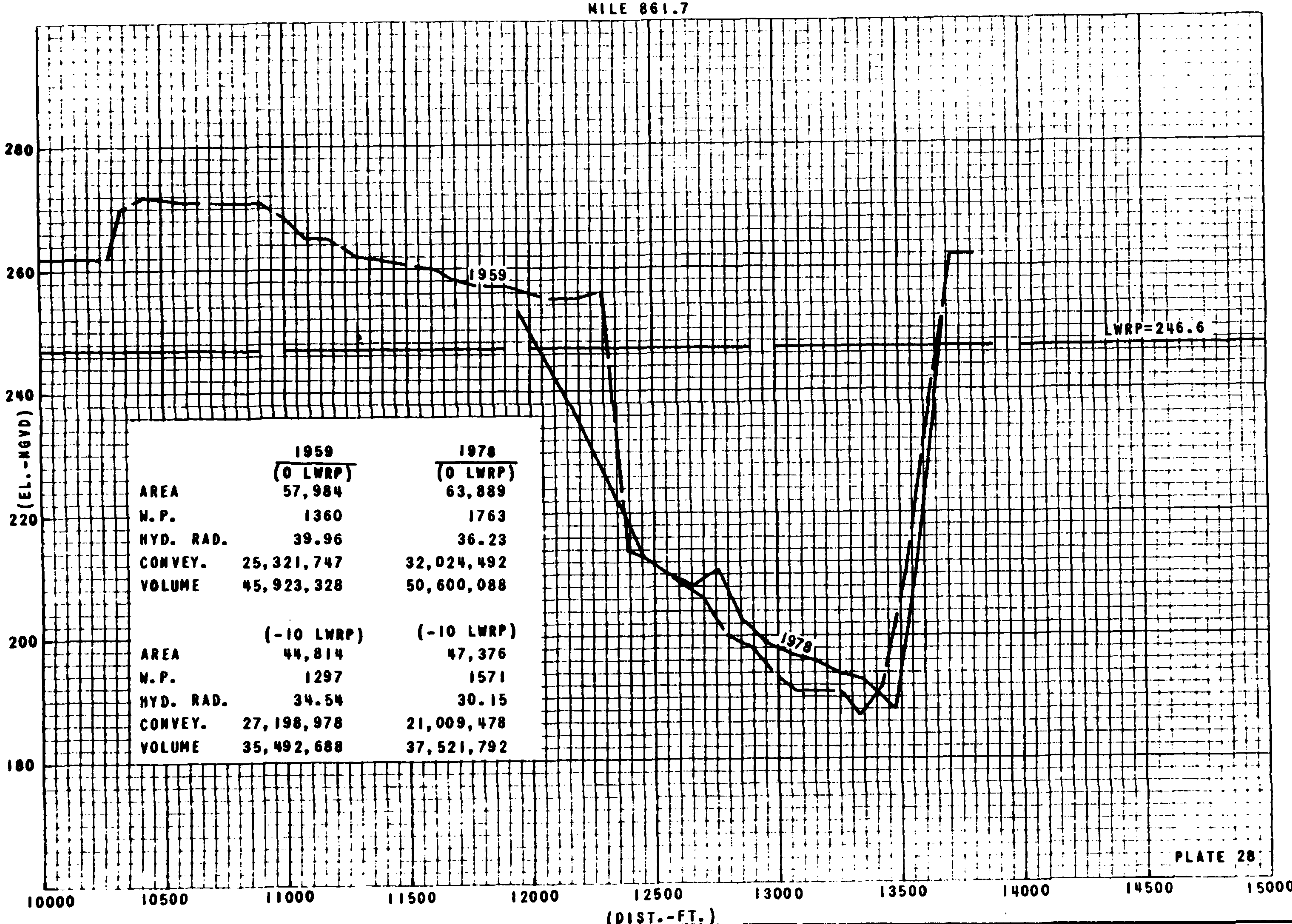


	1959 (0 LWRP)	1978 (0 LWRP)
AREA	54,873	58,266
W.P.	1373	1526
HYD. RAD.	39.96	38.19
CONVEY.	36,704,198	28,090,601
VOLUME	159,351,192	169,204,464
	(-10 LWRP)	(-10 LWRP)
AREA	43,130	43,345
W.P.	1127	1473
HYD. RAD.	38.28	29.43
CONVEY.	28,031,438	17,562,071
VOLUME	125,249,520	125,873,880

PLATE 27

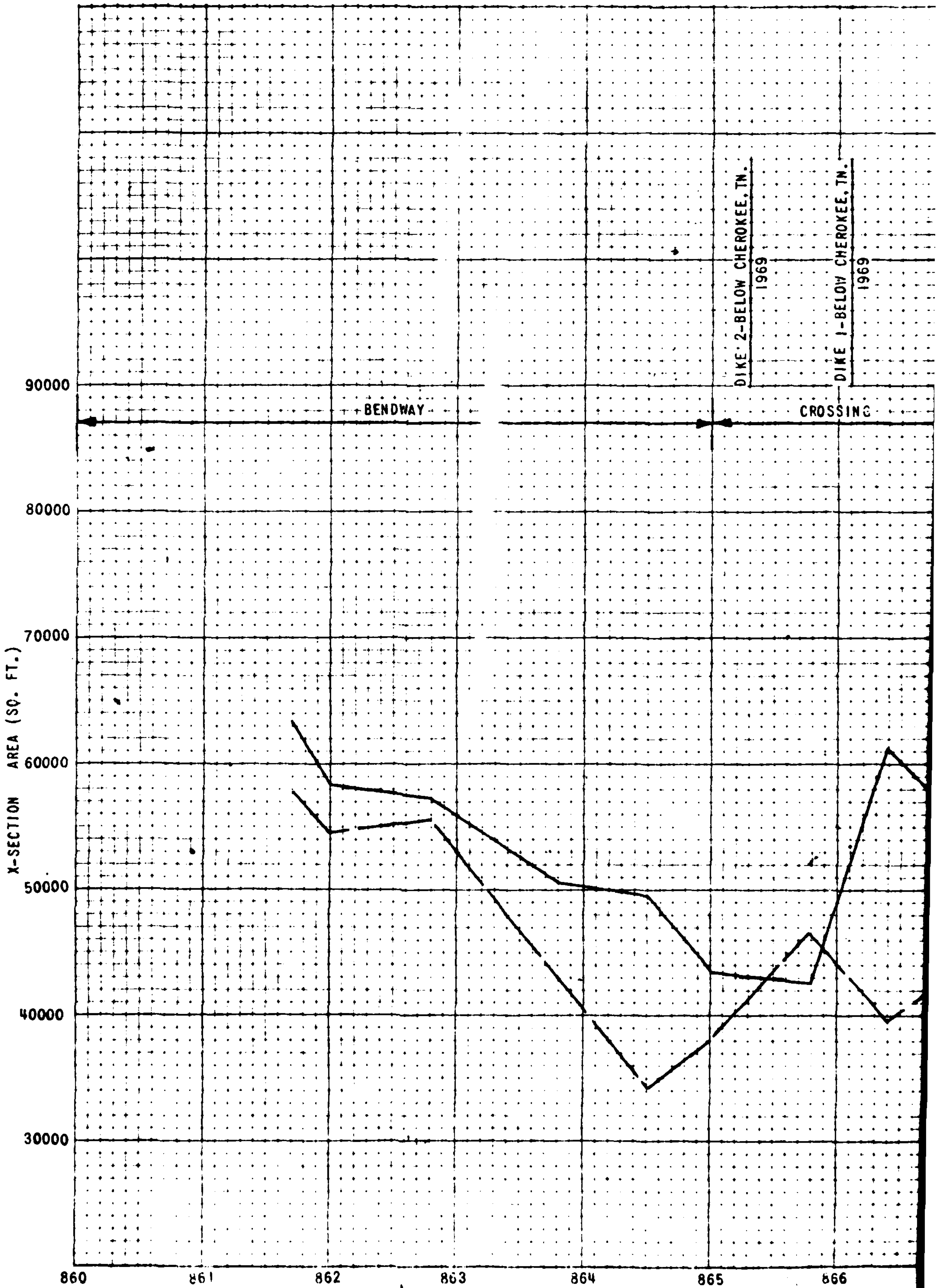
46 0703

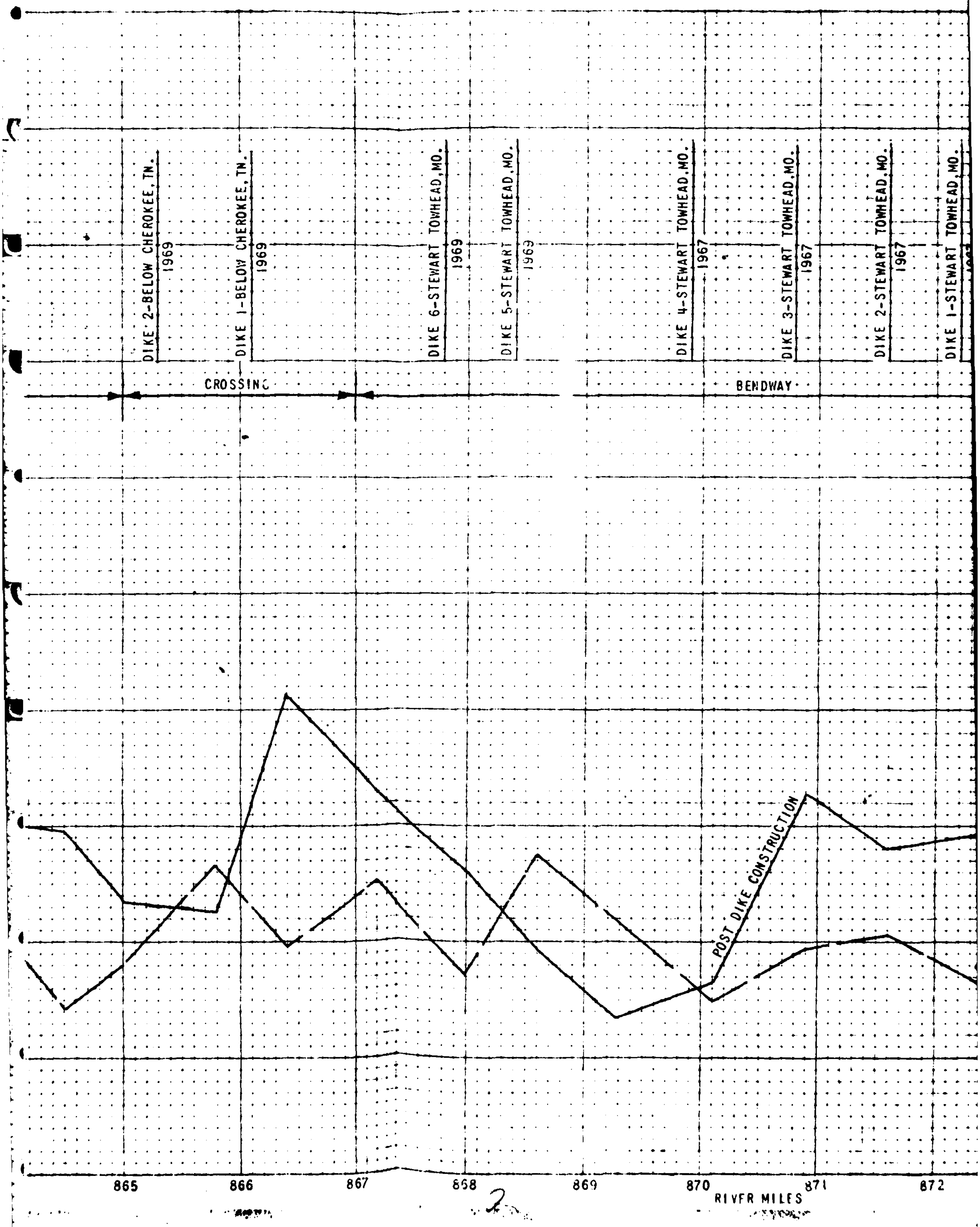
MILE 861.7



	1959	1978
	(0 LWRP)	(0 LWRP)
AREA	57,984	63,889
W.P.	1360	1763
HYD. RAD.	39.96	36.23
CONVEY.	25,321,747	32,024,492
VOLUME	45,923,328	50,600,088
	(-10 LWRP)	(-10 LWRP)
AREA	44,814	47,376
W.P.	1297	1571
HYD. RAD.	34.54	30.15
CONVEY.	27,198,978	21,009,478
VOLUME	35,492,688	37,521,792

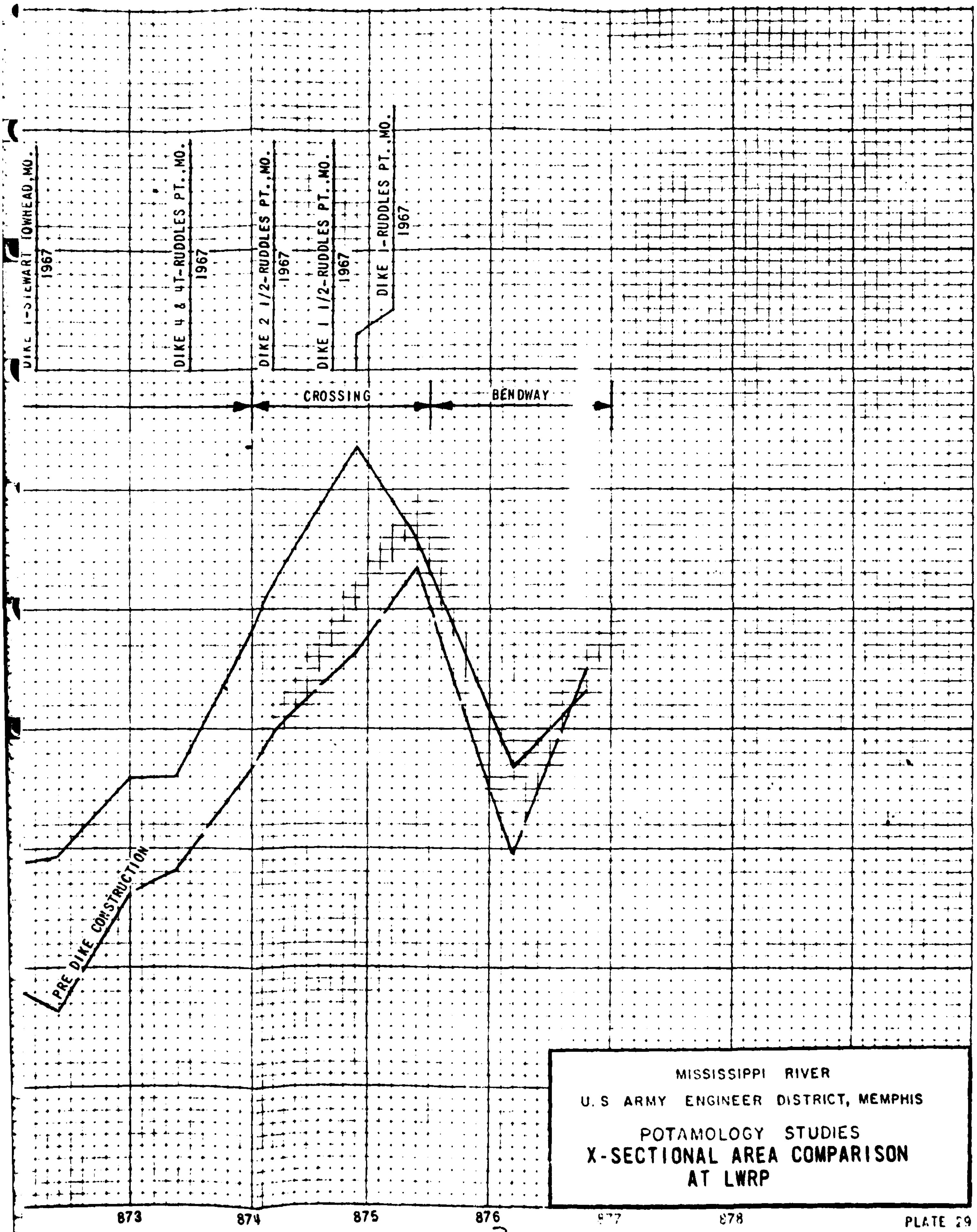
PLATE 28


DIKE 2-BELOW CHEROKEE, TN.
1969
DIKE 1-BELOW CHEROKEE, TN.
1969
BENDWAY
CROSSING
90000
80000
70000
60000
50000
40000
30000
X-SECTION AREA (SQ. FT.)
860
861
862
863
864
865
866



DIKE 2-BELOW CHEROKEE, TN.
1969
DIKE 1-BELOW CHEROKEE, TN.
1969
DIKE 6-STEWART TOWHEAD, MO.
1969
DIKE 5-STEWART TOWHEAD, MO.
1969
DIKE 4-STEWART TOWHEAD, MO.
1967
DIKE 3-STEWART TOWHEAD, MO.
1967
DIKE 2-STEWART TOWHEAD, MO.
1967
DIKE 1-STEWART TOWHEAD, MO.
CROSSING
BENDWAY
POST DIKE CONSTRUCTION
865
866
867
868
869
870
871
872
RIVER MILES

2

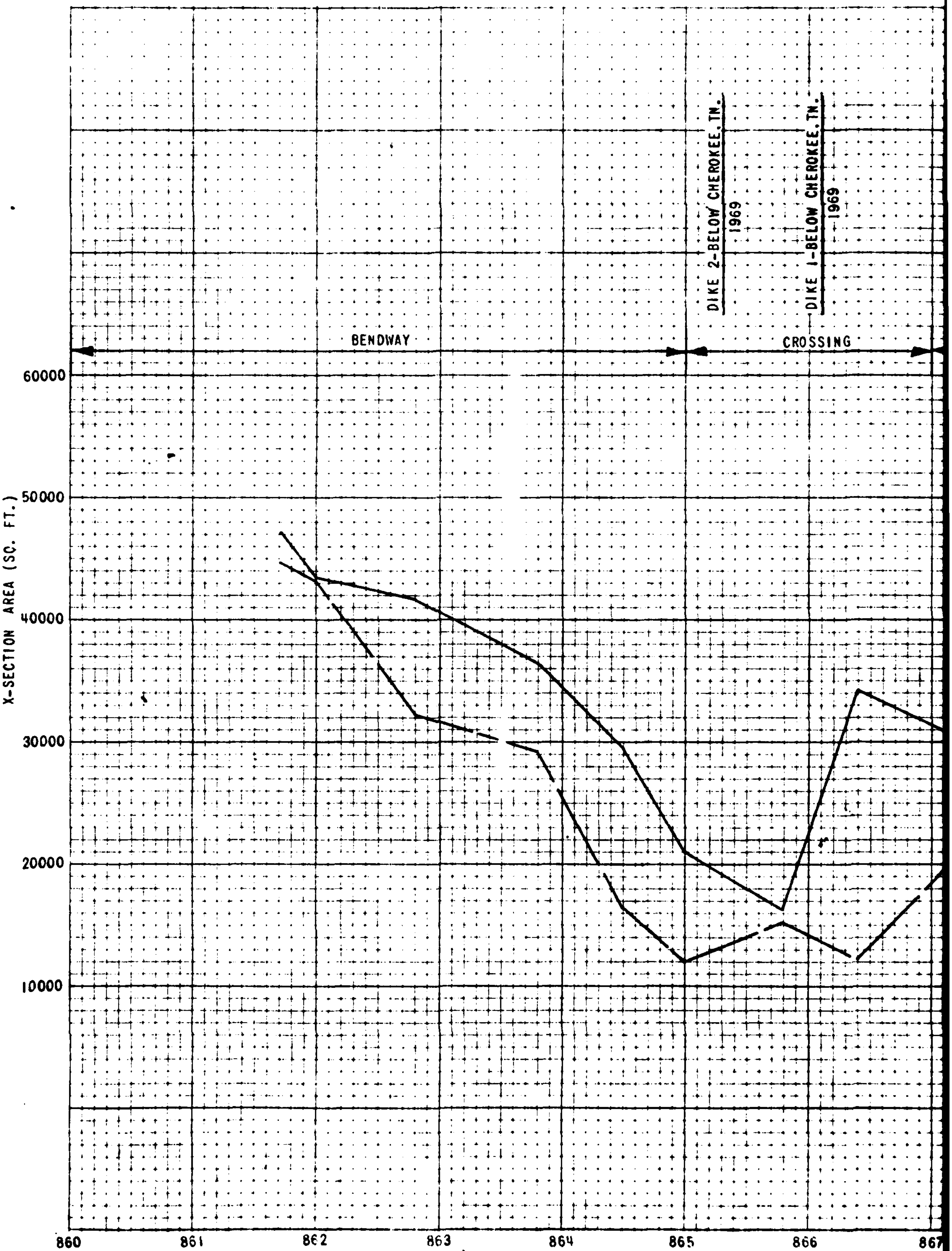


MISSISSIPPI RIVER

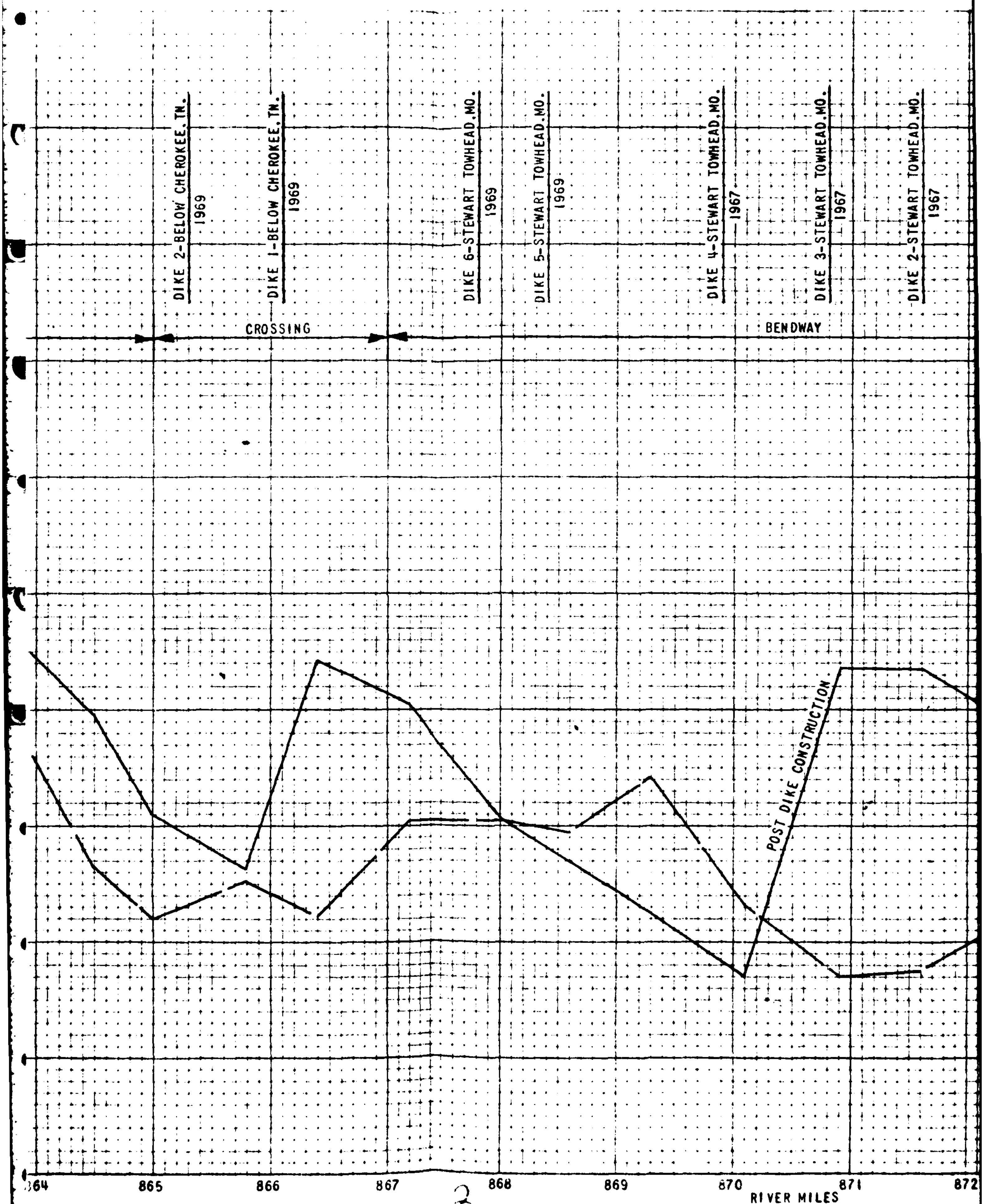
U. S ARMY ENGINEER DISTRICT, MEMPHIS

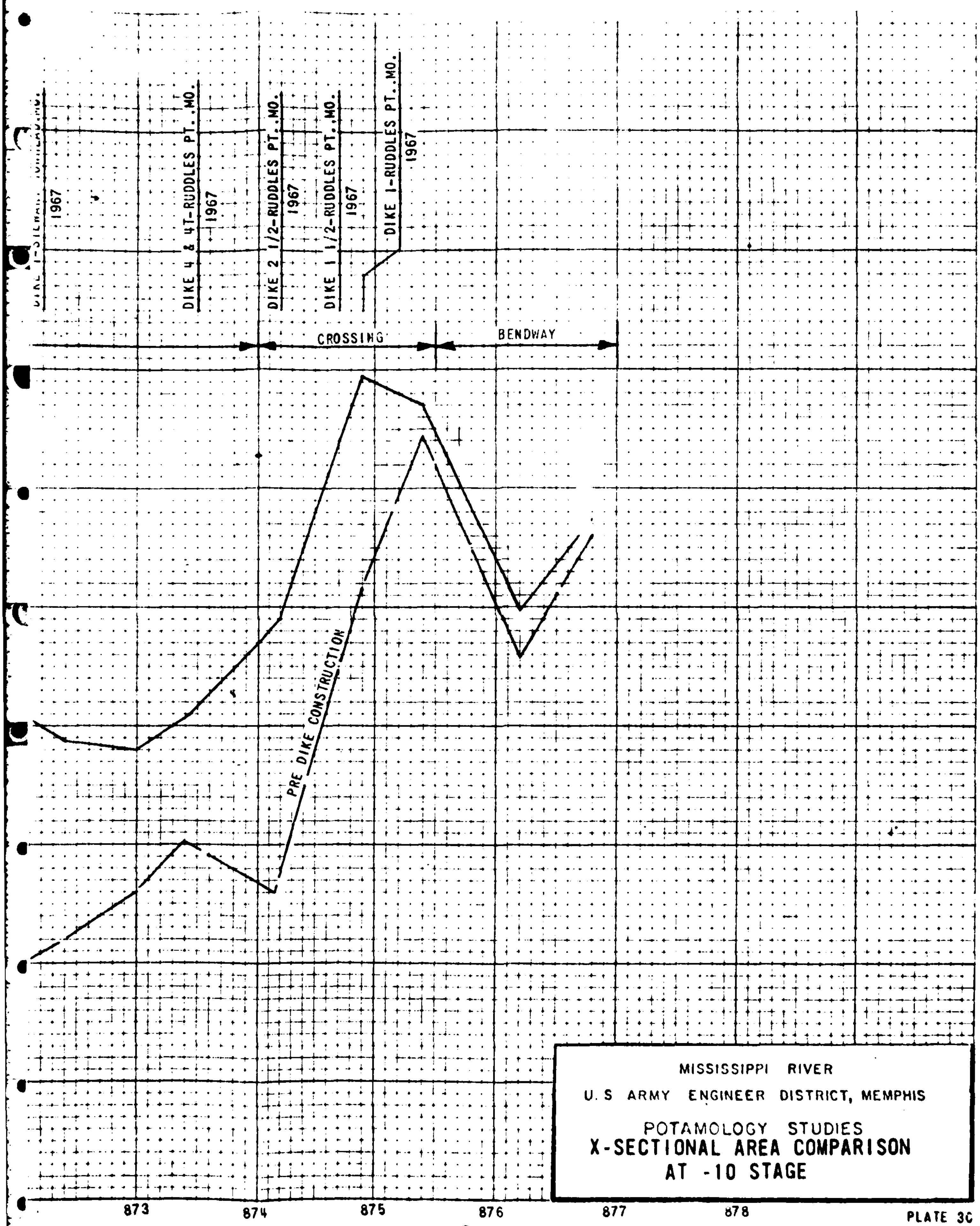
POTAMOLOGY STUDIES

X-SECTIONAL AREA COMPARISON AT LWRP



DIKE 2-BELOW CHEROKEE, TN.
1969
DIKE 1-BELOW CHEROKEE, TN.
1969
BENDWAY
CROSSING
X-SECTION AREA (SQ. FT.)
60000
50000
40000
30000
20000
10000
860
861
862
863
864
865
866
867


DIKE 2-BELOW CHEROKEE, TN. 1969
DIKE 1-BELOW CHEROKEE, TN. 1969
DIKE 6-STEWART TOWHEAD, MO. 1969
DIKE 5-STEWART TOWHEAD, MO. 1969
DIKE 4-STEWART TOWHEAD, MO. 1967
DIKE 3-STEWART TOWHEAD, MO. 1967
DIKE 2-STEWART TOWHEAD, MO. 1967
CROSSING
BENDWAY
POST DIKE CONSTRUCTION
864
865
866
867
868
869
870
871
872
RIVER MILES



MISSISSIPPI RIVER

U.S ARMY ENGINEER DISTRICT, MEMPHIS

POTAMOLOGY STUDIES

X-SECTIONAL AREA COMPARISON AT -10 STAGE

PLATE 3C

K·E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

46 0703

MILE 874.2

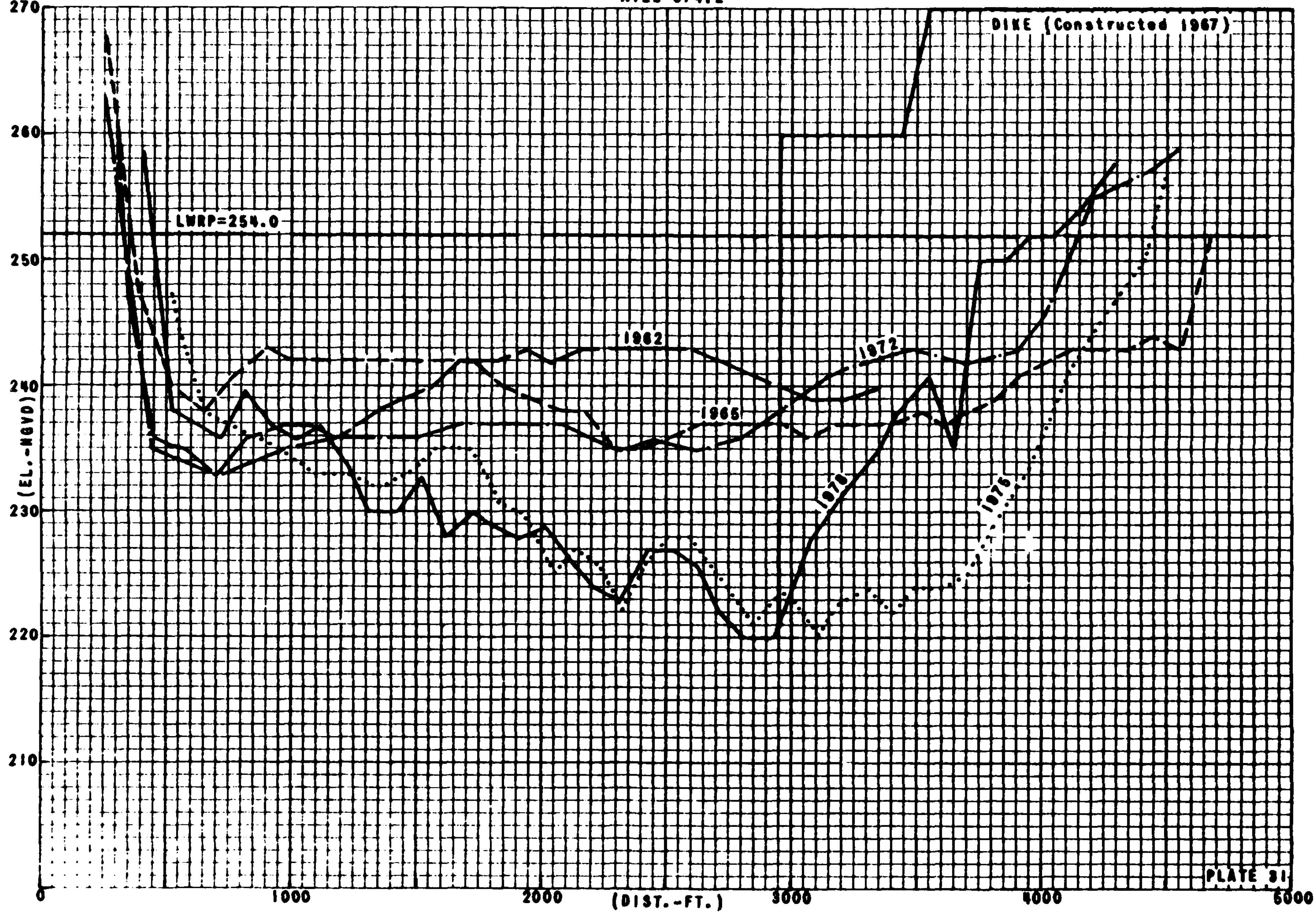


PLATE 31

46 0703

MILE 871.6

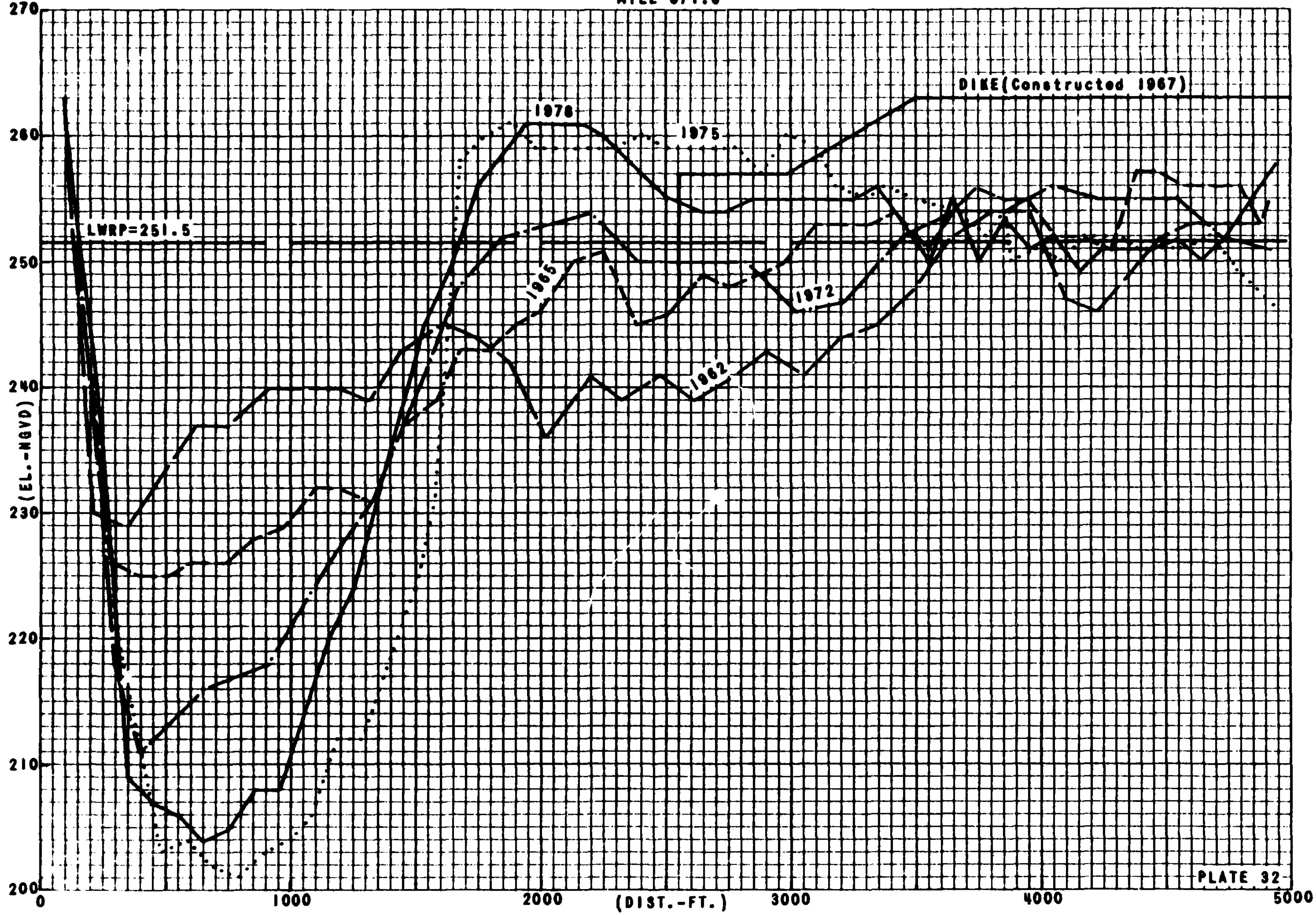


PLATE 32

46 0703

PLATE 33

MILE 870.1

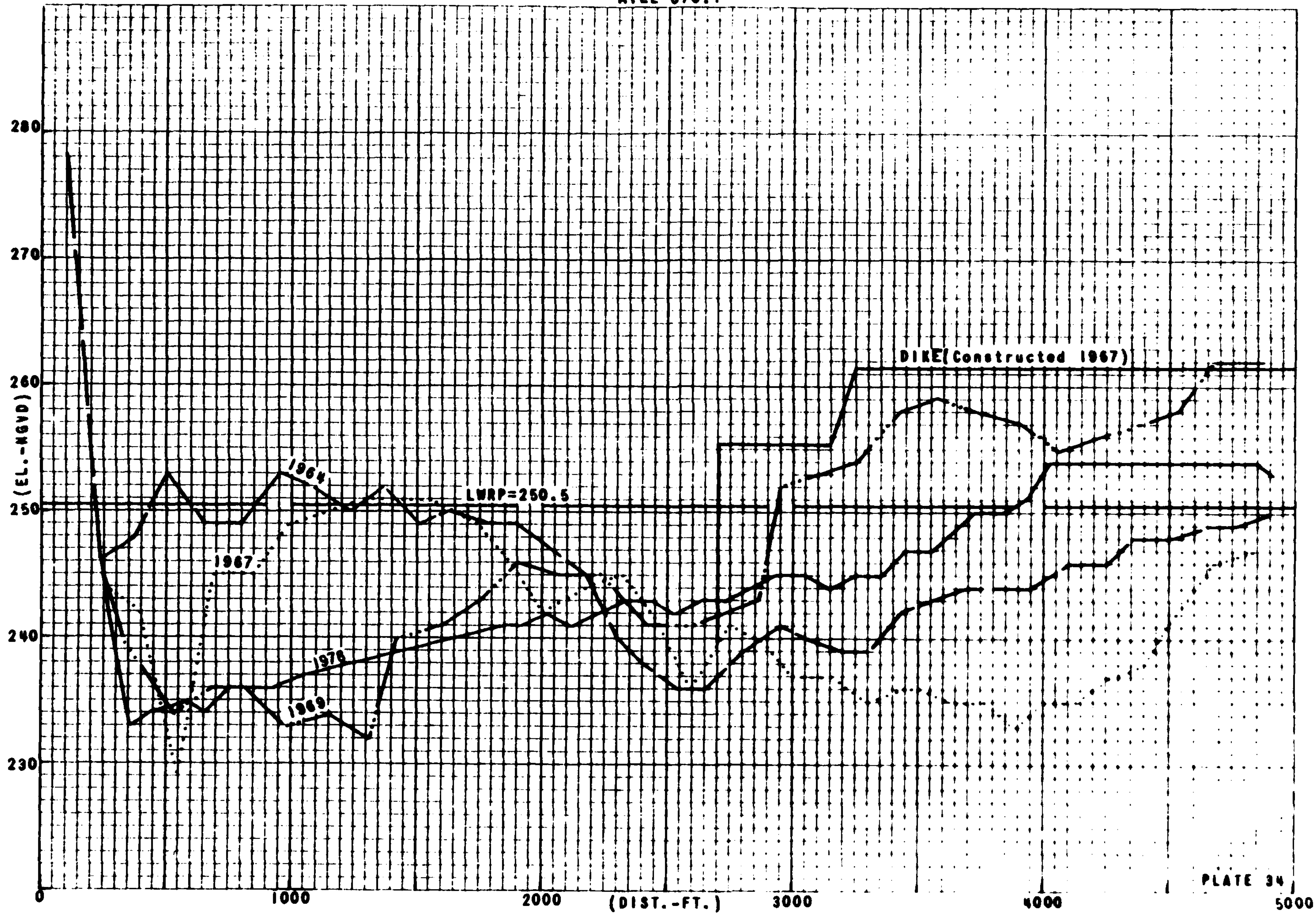


PLATE 34

K•E 10 X 10 TO THE INCH • 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 0703

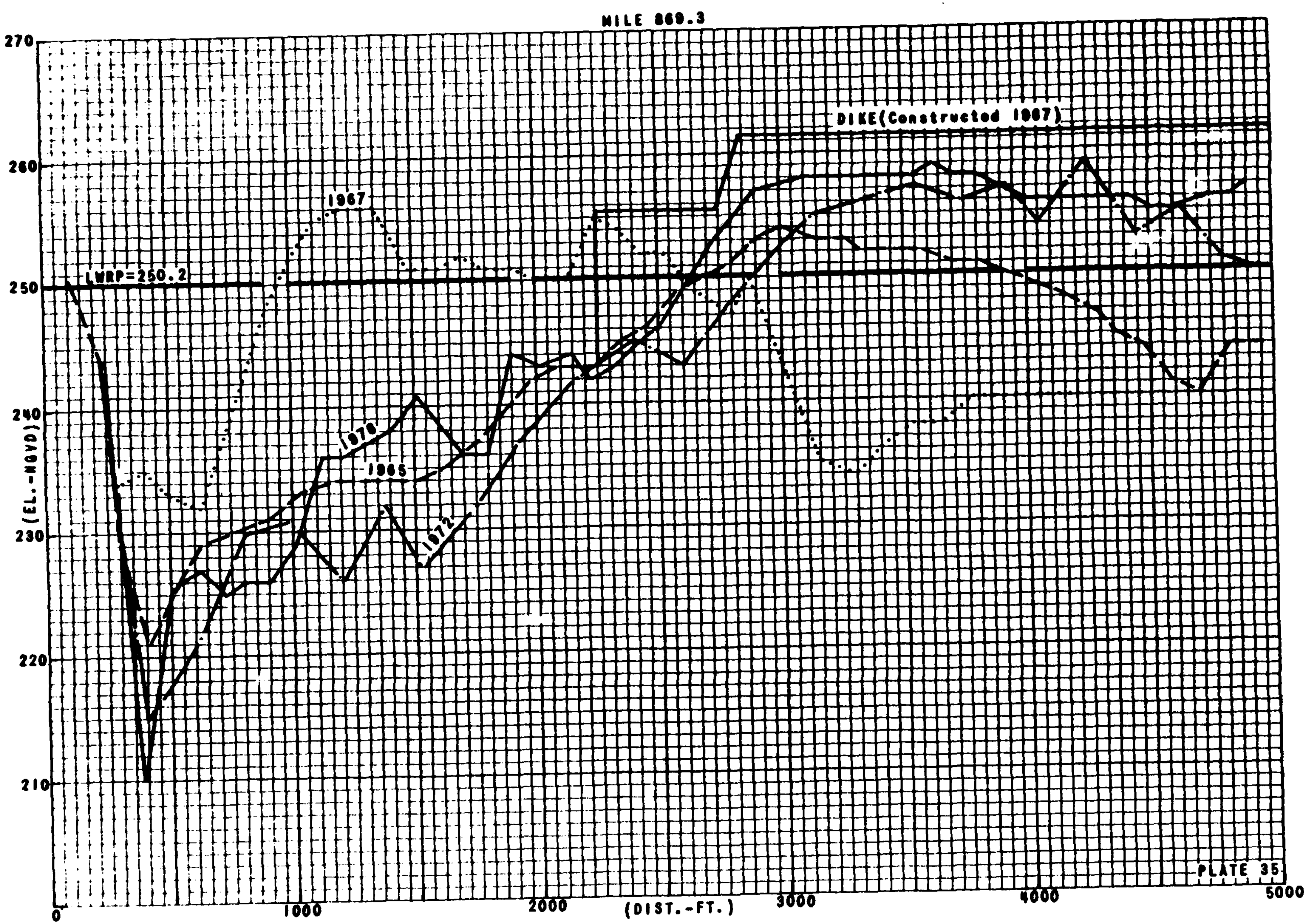
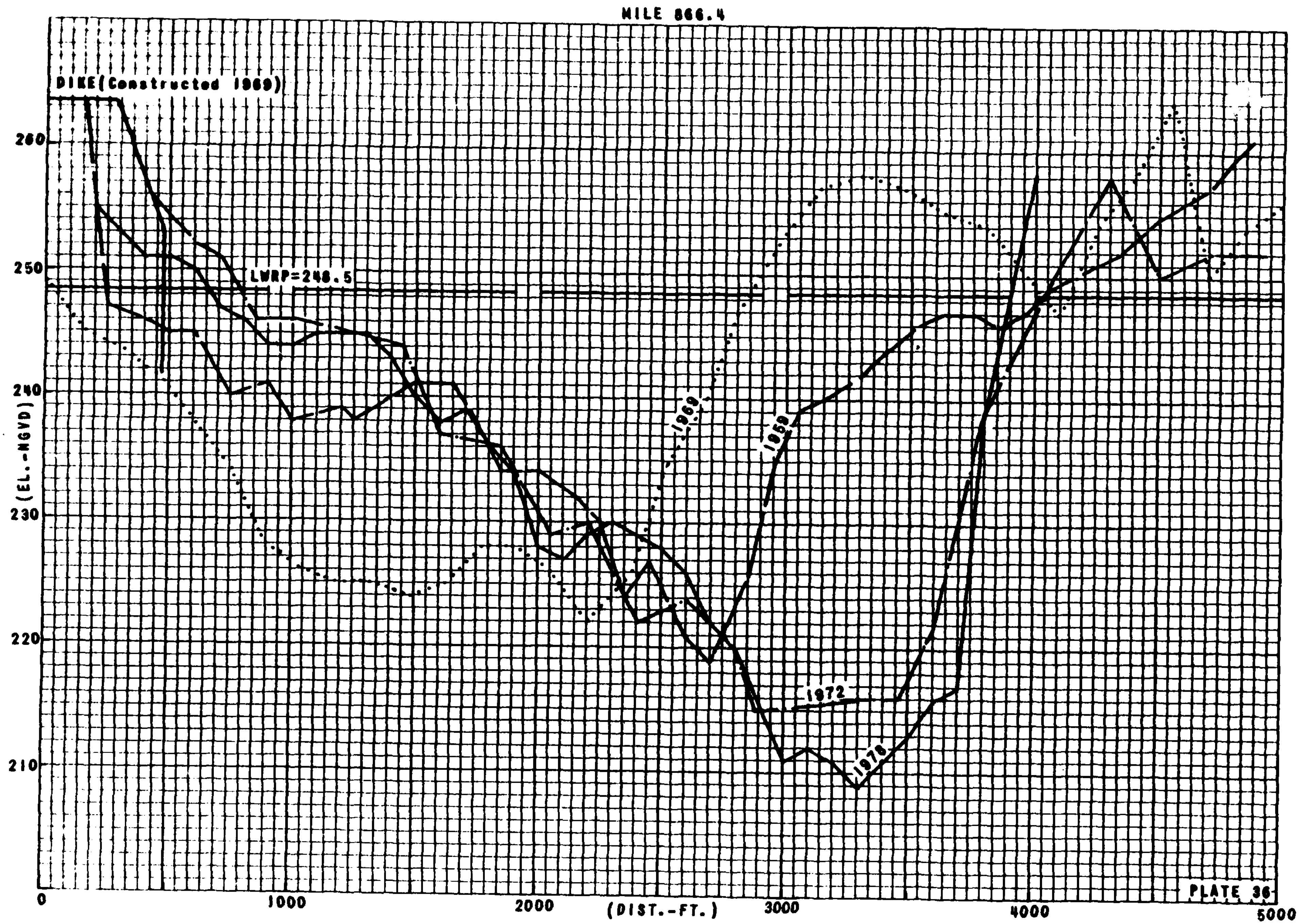


PLATE 35


MILE 866.4
DIKE (Constructed 1969)
LWRP=248.5
1969
1959
1972
1978
(EL.-NGVD)
260
250
240
230
220
210
0
1000
2000
3000
4000
5000
(DIST.-FT.)
PLATE 36

MILE 865.8

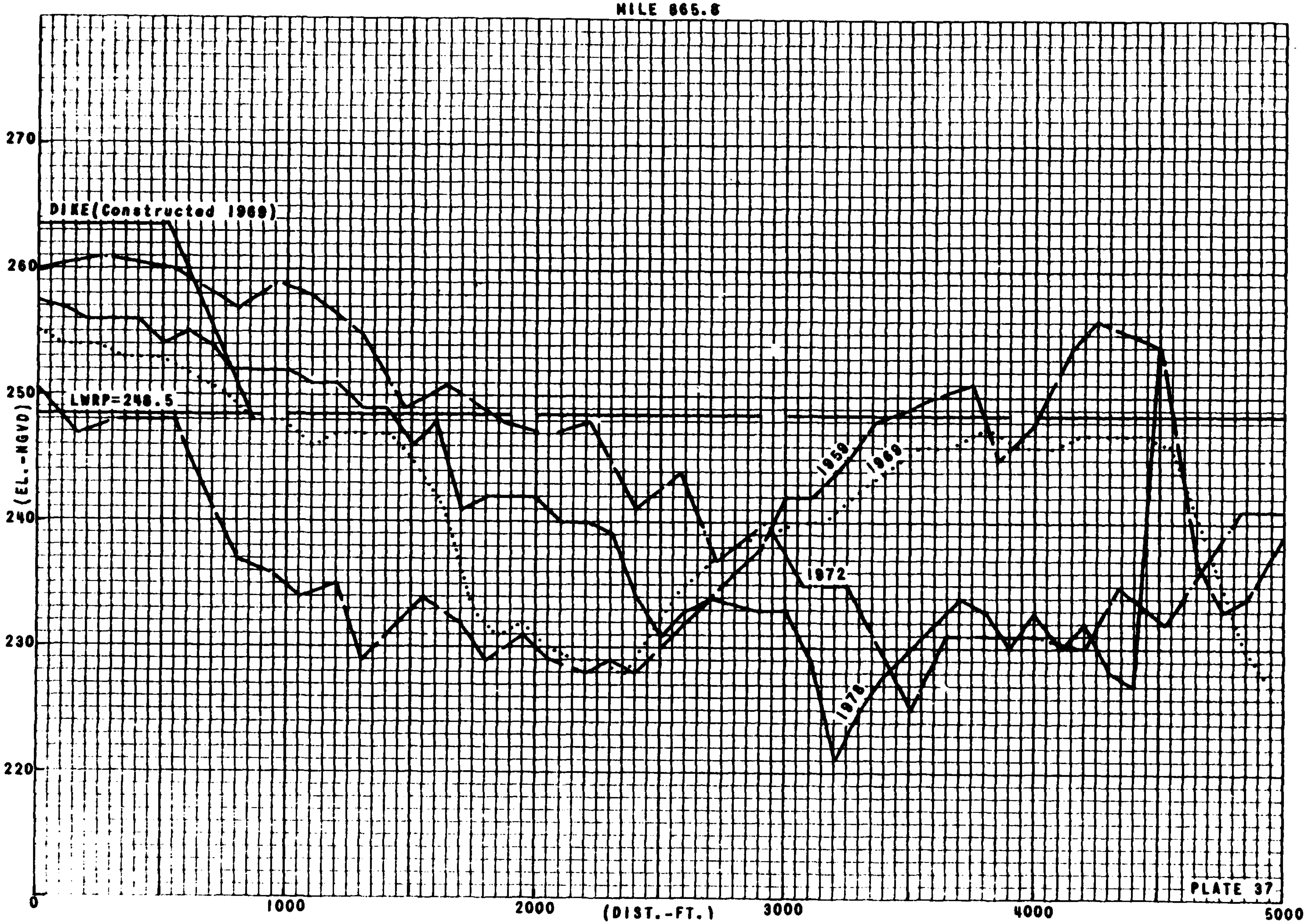


PLATE 37

END

FILMED