FLUSHING OPERATIONS OF WARSAK RESERVOIR SEDIMENT

BY

Muhammad Rashid Chaudhry (*)

SUMMARY

1. The Warsak Dam is located on Kabul River 19 miles North-West of Peshawar. Messrs. H.G. Acres were the Consulting Engineers for this project. The contract was awarded for the project to Messrs. Augus Robertson Limited of Canada in August 1955. This project was completed in 1960 under the Colombo Plan.

2. The gross storage capacity of Warsak Reservoir is 136,000 acre ft. and the live storage capacity is only 25,300 acre ft. The catchment area is 26,000 sq.miles and out of this 20,000 sq. miles lies in Afghanistan.

3. This is a concrete gravity type of Dam with a length of 460 feet and height 259 ft. There are nine spillway gates each 40 feet wide. The top elevation of the dam is 1290 and the spillway crest level is 1230 with a pond level of 1270. The maximum flood discharge capacity of the spillway is 540,000 cusecs. The length of the Reservoir is 26 miles which ends at the Pakistan-Afghanistan border. The Power Tunnel is 39 feet dia and can take discharge upto 24,000 cusecs for operating six units of 40,000 KW each. Initially four units of 40,000 KW each were installed in 1960 but two more units of 40,000 KW each have been added in February 1981.

4. The Warsak Reservoir was almost silted upto the pond level of 1270 upstream of the Dam leaving only about 200 ft. wide

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iv)	Top elevation of the Dam	= 1290
v)	Spillway crest level	= 1230
vi)	Pond level	= 1270
vii)	Max. discharge capacity of spillway.	= 540,000 cusecs.
viii)	Gross storage (fig.2)	= 136,000 acre ft.
ix)	Live Storage	= 25,300 acre ft.
x)	Catchment area	= 26,000 sq.miles.
xi)	Irrigation tunnel (3½ miles, 10 ft. dia for 100,000 acres) discharge capacity.	= 500 cusecs.
xii)	Length of Reservoir	= 26 miles.
xiii)	Power tunnel (39 ft. diameter) discharge.	= 24,000 cusecs.
xiv)	Power units - 4 Nos. (initial) each 40,000 KW.	= 160,000 KW.
xv)	Power units - 2 Nos. 40,000 KW each installed in Feb. 1981.	= 80,000 KW

2.0 CATCHMENT AREA

2.1 The Kabul River rises in the Noth Central Afghanistan and provides drainage for the Eastern portion of that country. Through one of its tributaries, it also drains the state of Chitral in Northern Pakistan. The total drainage area above the Warsak Dam Site is approximately 26,000 square miles.

2.2 Kabul, the capital city of Afghanistan, is situated on the River, about 60 miles from the source. From Kabul the river flows Eastward, dropping several thousand feet in elevation into the Jalalabad valley and thence to the border between Afghanistan and Pakistan. The river then meanders and turns through the hills of the Sofed Koh Range, then flows

mainly Eastward until it debouches on the flat land of the valley of Peshawar at Warsak Dam.

2.3 The Kabul River and its tributaries, the Kunar (sometimes called the Chitral), the Alingar, the Panjir, the Logar and the Sarkhab, drain an area of approximately 26,000 square miles. This drainage area, located mostly in Afghanistan except for some 5800 square miles in Pakistan on the upper Kunar, is surrounded by high mountains on all sides, the narrow gorge extending through the Safed Koh Range from the Jalalabad Valley to Warsak being the only low level outlet. The mountain ranges to the North, part of the Hindu Kush, rise to elevation of the order of 20,000 feet and have permanent snow fields at the higher elevations.

2.4 These mountains are tertiary formations as are the Alps in Europe and the rocky mountains of North America. Because of the general sparseness of vegetation, soil and loose decaying rock are easily eroded. Consequently, little over-burden exists on the rock hills and mountains of the catchment area and alluvial deposits are confined to stretches of flat river valleys where the rivers lose their bed-load carrying capacity. The catchment area will, therefore, probably have little underground storage either in overburden or in rock.

3.0 DISCHARGE & SEDIMENT MEASUREMENTS.

3.1 Discharge Measurements

The Discharge Measurements of the Kabul River were carried out at Warsak for 10 years from 1961 to 1970. The mean annual runoff of the Kabul River at Warsak for ten years of record (1961-70) is 17,600,000 Acre feet. The river has

perennial flow with a minimum of 3,060 cusecs recorded on 10th March, 1961. The peak flow during the period of record was 151,000 cusecs on 19th April, 1965. It is snow-fed river and has a relatively smooth peak flow generally occuring in May or June. The principal volume of runoff occurs during the months April-May-June and July-August-September, due to melting of now and rainfall in the catchment respectively.

3.2 Sediment Measurements

Sediment samples were obtained using the D-49 deptch-integrating sampler from Michni Bridge. The first sediment sample was obtained on 3rd August 1960. Altogether, 17 samples were taken in 1960, 20 in 1961, 24 in 1962, 12 in 1963, 25 in 1964, 20 in 1965, 15 in 1966, 17 in 1967, 25 in 1968, 26 in 1969, 25 in 1970, and 5 in 1971. Of the samples taken, particle size analysis by bottom-withdrawal tube and pipette methods was made for 6 in 1961, 3 in 1962, 4 in 1963, 9 in 1964, 10 in 1965, 6 in 1966, 2 in 1967, 7 in 1968, 6 in 1969, 5 in 1970 and nil in 1971.

3.3 The sediment yield for the following years is detailed in Table 1.

TABLE -1 Discharge & Suspended Sediment

Year	Total Runoff 10^3 acre ft.	Max. Disch. Cs.	Min. Disch. Cs.	Million short tons	By wt. %	By Vol. %	Max. PPM	Min. PPM.
1	2	3	4	5	6	7	8	9
1961	18,200	84,000	3,060	10.8	.044	.046	2,900	19
1962	12,600	67,700	3,640	3.9	.023	.024	743	10
1963	16,900	107,000	3,210	17.7	.077	.081	2,240	9
1964	16,200	90,700	4,320	14.6	.066	.070	19,200	13

1	2	3	4	5	6	7	8	9
1965	23,800	151,000	4,430	43.9	.136	.144	3,070	19
1966	19,200	116,000	6,080	20.1	.077	.081	2,350	24
1967	18,200	130,000	5,360	18.4	.074	.078	2,090	7
1968	20,300	107,000	6,560	24.0	.087	.092	6,910	9
1969	17,100	80,200	6,850	14.0	.067	.064	13,000	33
1970	13,400	55,260	4,900	6.5	.033	.030	10,600	33
MEAN	17,600							

3.4 At average discharge the suspended sediment consists at approximately 12% sand, 60% silt and 28% clay. At high flows, sand concentration goes upto about 15% and clay is 20% by weight. At low flows, the water is very clear with sediment content seldom exceeding 50 ppm by weight. Practically whole of the suspended sediment is carried by the river during the six months - April to September. Unit weight of fresh deposits of this sediment is about 59 lbs. per cft.

3.5 The average annual sediment load at Warsak was 17.4 million short tons from 1961 to 1970, according to the measurement by surface water Hydrology Project as givenin Table No.1.

The Warsak Dam was commissioned in May 1960 and the measurements upto about 1965 are affected by the sediment deposit within the reservoir as the observations were taken about two miles downstream of the Dam. For an average year the total volume of sand and silt (excluding clays and dissolved material) is 4.6×10^7 cubic feet and 17.5×10^5 cubic feet respectively.

3.6 The sediment measurements carried out in the period

1955-57 at Dam site and about 2 miles downstream indicated very high rates of sediment transport i.e. upto 0.4 per cent by weight of the water flow in high flow periods and total sediment per year was 63 million tons approximately.

The quantity of sediment deposited during the first year of operation was approximately 1×10^9 cubic feet which was found to be nearly equal to the quantity of coarse and medium sand carried by the flow. The annual deposits as worked out by M/s. Acres are as follows:

Table -2 Annual Deposits

1960	1.1 ($10^9 \times ft^3$)
1961	.2
1962	.4
1963	.3
1964	.4
1965	- .1
1966	.4
1967	- .2
1968	- .4
1969	.8
1970	.1
1971	0
1972	0
1973	0

The history of accumulation of sediment for the above noted period has been plotted in Figure No.3.

Most of the sediments were carried by the River during the period from April to September as per sediment appraisal carried out by Surface Water Hydrology Project of Wapda and detailed in Table 1.

4.0 CONSULTANTS Measures to check silt entry into the Powerhouse.

4.1 M/s. H.G. Acres of Canada, the Consultants for this project had thought that the Warsak Reservoir will get

filled upto the crest level of spillway i.e. 1230 elevation within a few years after the commissioning of the project. To reduce the sediment entry in the Power House a skimming wall 40 ft. high located at a distance of 80 ft. from the power intake openings was constructed. The top of this wall is at elevation 1240 against the pond level of 1270 and spillway crest level of 1230. No provision was made for flushing of the sediment by keeping sluices in the Dam. The sediment deposit reached upto the elevation of 1240 i.e. top of the skimming wall in the year 1965 and then aggravated the erosion damage to the turbines. By 1970 a condition of cyclic equilibrium appears to have reached with seasonal variations in sediment level occuring but with little net change from year to year.

5.0 A UNIQUE IDEA FOR FLUSHING OF RESERVOIR

5.1 Condition of Reservoir before flushing

The idea of carrying out flushing operations of Warsak Reservoir sediment came to the mind of the Author after the first official visit to the Project in June 1976. It was observed that Warsak Reservoir was almost silted upto the pond level of 1270 upstream of the Dam leaving only about 200 feet wide and 20 feet deep channel near the right bank. The live storage as well as flood discharge capacity had decreased considerably.

5.2 The Flushing idea inspired by flushing of Barrages.

The flushing of silt from the pockets of Barrages through the undersluices has always been practised. At Rasul Barrage, WAPDA had to construct a stone spur in the year 1970 which was located 1000 feet upstream of the Barrage in order

to correct oblique flow entering the Head Regulator of Rasul-Qadirabad Link Canal. There was about 10 feet of silt deposit on the bed of the river where stone spur was to be constructed. This silt deposit was removed by raising the pond to full supply level and flushing was carried out through the under-sluices by gradually lowering the pond level to the lowest possible. This helped in removing the overburden of silt from the site of the spur. With this background in the mind, the Author was hopeful that flushing operation of sediment deposited in the Warsak Reservoir could be possible because of narrow reservoir (Figure.1) and using spillway for the removal of the sediment.

6.0 MODEL STUDIES

6.1 It was decided to carry out model studies at Irrigation Research Institute, Nandipur where Warsak model had already been prepared for determining the silt entry into the powerhouse. The model study for carrying out flushing operations was done in July 1976 on this model with the cooperation of Irrigation Research Institute. The model of Warsak Dam spillway, power tunnel and reservoir upto 2 miles upstream of spillway was set up on 1/36 of natural scale. The model was run to visulise the effect of lowering the pond level for flushing of sediment with a discharge of 65,000 cusecs. The spillway gates were uniformally opened upto 6 feet. It was observed that with the normal pond level of 1270 the flow upstream of the spillway did not follow the natural course of the river. The flow from upper bend crossed over to the right bank below the protuberance at R.D. 1800 (upstream of spillway) forming a very large bend which results in formation of large sand bar on inside of the bend with top level varying from 1250 to 1270. The lowest bed level of the approach channel for the power intake was at elevation 1250.

The skimming wall upstream of the power intake with top elevation 1240 was burried and the area in between the skimming wall and the power intake was silted up except some opening taking the flow into the power tunnel.

6.2 The pond level was then lowered to elevation 1265 by increasing the gate openings uniformaly to 6.5 feet. The power tunnel was closed and the model was run for two hours which is equivalent to 12 hours on the prototype. The pond level was further lowered to a level of 1259 by manipulation of gates at a uniform opening of 7 feet and the model was run for another two hours. The bed contours at the end of four hours model run are shown in Figure 4 whereas the cross sections at 200, 500 and 1000 feet upstream of the spillway for three pond levels tested on the model are compared in Figure 5 & 5.1. The study of these figures indicated that:

i) The area in between the power intake and skimming wall got cleared almost upto elevation 1210 where floor level is 1200.

ii) The bed level of the approach channel to the power intake got lowered by about 10 feet on the average.

iii) The embayment above the protuberance in the right bank came into action and the protuberance acted as a spur with the result that the flow conditions above the spillway showed a marked improvement. The bed level of channel downstream of protuberance along right bank was at R.L. 1240 and its width was 250 feet.

iv) The top level of the skimming wall upstream of power intake was flush with the bed of the approach channel.

7.0 FLUSHING OPERATIONS

The various methods for removal of sediment from Warsak Reservoir could be :

7.1 Dredging

It was not possible because of high hills on both sides of the reservoir. The dredged material could only be thrown downstream of the Dam through a pipeline which would reduce the efficiency of dredging as the dredging proceeds upstream from the Dam.

7.2 Air Lift

The compressed air is used for lifting the sediment alongwith water. The discharge could be done only on downstream of the Dam involving very long pipeline and thus effecting the efficiency of this operation. This system can be used for small areas where the disposal of the sediment could be done at a short distance.

7.3 Flushing the Reservoir by lowering the Pond level and manipulation of spillway gates

This method was considered the best for removal of sediment from the Warsak Reservoir as it was practically feasible.

i) First Flushing

The first flushing operation of Warsak Reservoir sediment was carried out from 6th to 9th August, 1976. The flushing operation was started on 6th August at 20.00 hours by lowering the pond level from 1270. The discharge passing through the spillway was 41,000 cusecs. The gate openings were increased and the discharge rose to 53,550 cusecs when the pond level was lowered to 1265 at 2400 hours. Then pond level was lowered to elevation 1260 on 7th August at 1100 hours and the discharge was 50,100 cusecs. The pond was

again lowered to 1255 at 2200 hours when the discharge was 51000 cusecs. Then finally it was lowered to elevation 1250.5 on 8th August at 0700 hours. The pond was lowered to minimum elevation 1250.5 in four stages as shown in figure 6. The flushing operation was finally closed on 9th at 0600 hours. The total flushing time was 58 hours as detailed below:

Stage No.	Pond Level	Time
First	1270-1265	11 hours
Second	1265-1260	11 hours
Third	1260-1255	9.5 hours
Fourth	1255-1250.5	26.5 hours

The Powerhouse remained closed during the flushing operation from 1430 hours on 7th August because of cavitation danger when the generation went below 10 M.W. for each unit and the pond level was 1260. The intake gates of Power and Irrigation Tunnels were not lowered because of the fear that the same will get jammed in silt and it may be difficult to raise them again. Therefore part of the outlet gate of Irrigation Tunnel was kept open so that some flow continues in the tunnel in order to avoid choking of the tunnel with sediment. The water was run into escape channel at the outlet gate as no water was required for irrigation due to rains.

ii) Second Flushing

The second flushing operation was carried out from 25th to 29th August 1977 as detailed in Figure 7. The total period of this flushing was 82.5 hours. The pond was lowered to minimum elevation 1245 in the various stages as given below:

Stage No.	Pond level	Time
First	1270-1259	16 hours
Second	1259-1255	28 hours
Third	1255-1250	13.5 hours
Fourth	1255-1250	27 hours
Fifth	1264-1245	18 hours

iii) Third Flushing

The third flushing operation was carried out from 15th to 18th June 1978 as detailed in Figure 8. The total period of this flushing was 63 hours. The pond was lowered to minimum elevation of 1245 in the various stages as detailed below:

Stage No.	Pond Level	Time
First	1270-1260	14.0 hours
Second	1260-1255	14.0 hours
Third	1255-1250	17.5 hours
Fourth	1250-1245	17.5 hours

iv) Fourth Flushing

The fourth flushing operation was carried out from 27th July to 31st July 1978 as detailed in Figure 9. The total period of this flushing was 86 hours. The pond was lowered to minimum elevation of 1242 in the various stages as given below :

Stage No.	Pond Level	Time
First	1270-1245	42 hours
Second	1245-1242	26 hours
Third	1246-1242	18 hours

v) Fifth Flushing

The fifth flushing operation was carried out from 12th to 20th August 1979 as detailed in Figure 10. The total period of this flushing was 181 hours. The pond was lowered to minimum possible elevation of 1242 in various stages as detailed below:

Stage No.	Pond Level	Time
First	1270-1245	90.5 hours
Second	1260-1242	44.0 hours
Third	1261-1242	46.5 hours

It was observed during flushing operation that maximum sediment was washed when pond level was at the lowest level. When the depth of water was upto about 10 feet waves were formed. The velocities also increased at the lowest pond level because of high level in the upper reach. This operation induced higher velocities upstream of the spillway and the sediment started washing from upstream and was carried by water downstream of the spillway. The photographs taken during the flushing operation and showing the removal of sediment from the banks may be seen on pages 263, 264 & 265.

8.0 SURVEY RESULTS

The survey upto two miles upstream of the Dam was carried out after completing each flushing operation.

8.1 The survey data is plotted in the form of cross sections of the Reservoir from R.D. 500 to RD 10,000 (Figures 11-18). The survey results have been plotted for the years 1976, 1977 and 1979. During 1976 flushing operation it was estimated that approximately 40 million cubic feet of

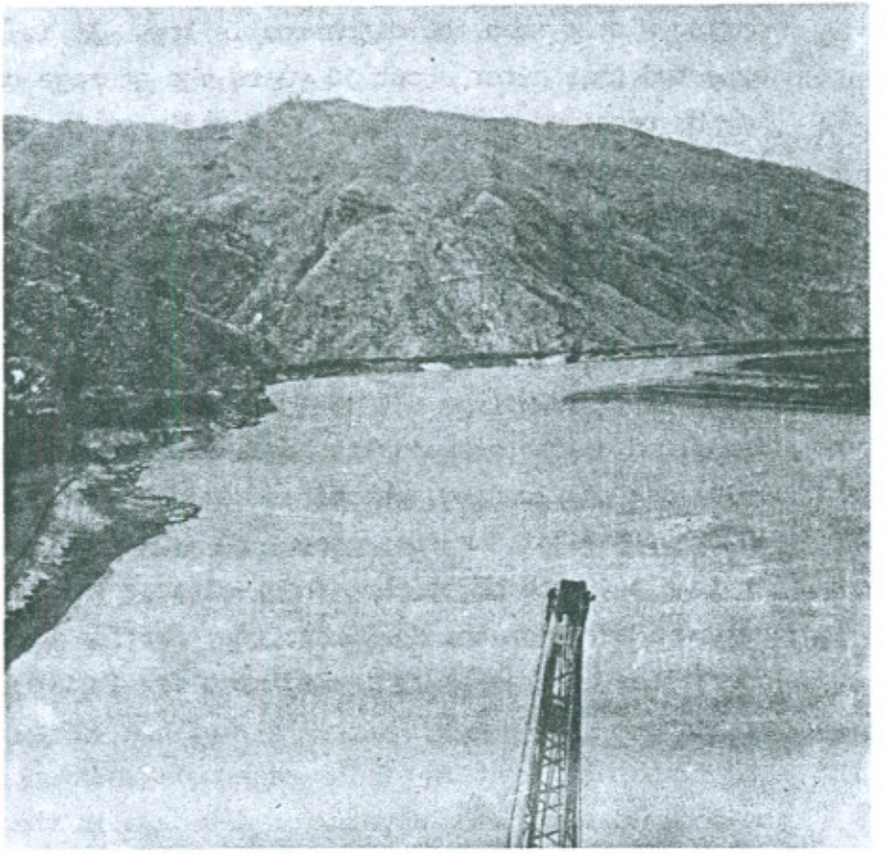


Photo No.1 : View of Reservoir looking upstream from the Dam during flushing operation.

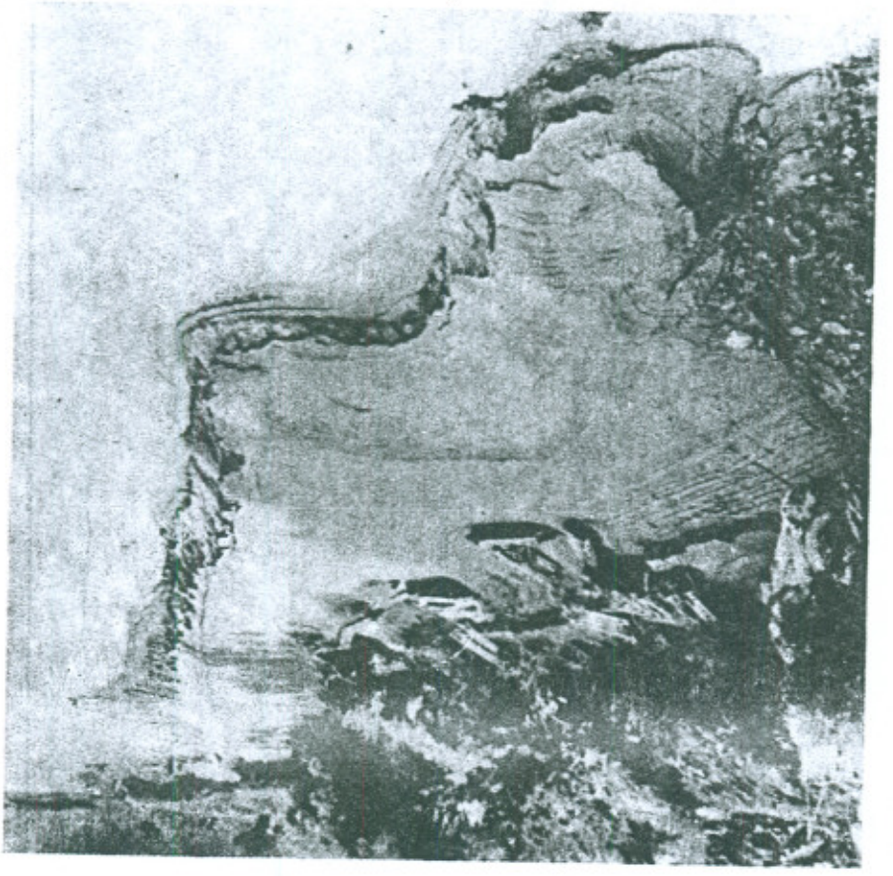


Photo No.2 : View of right bank of Reservoir upstream of Dam during flushing operation.



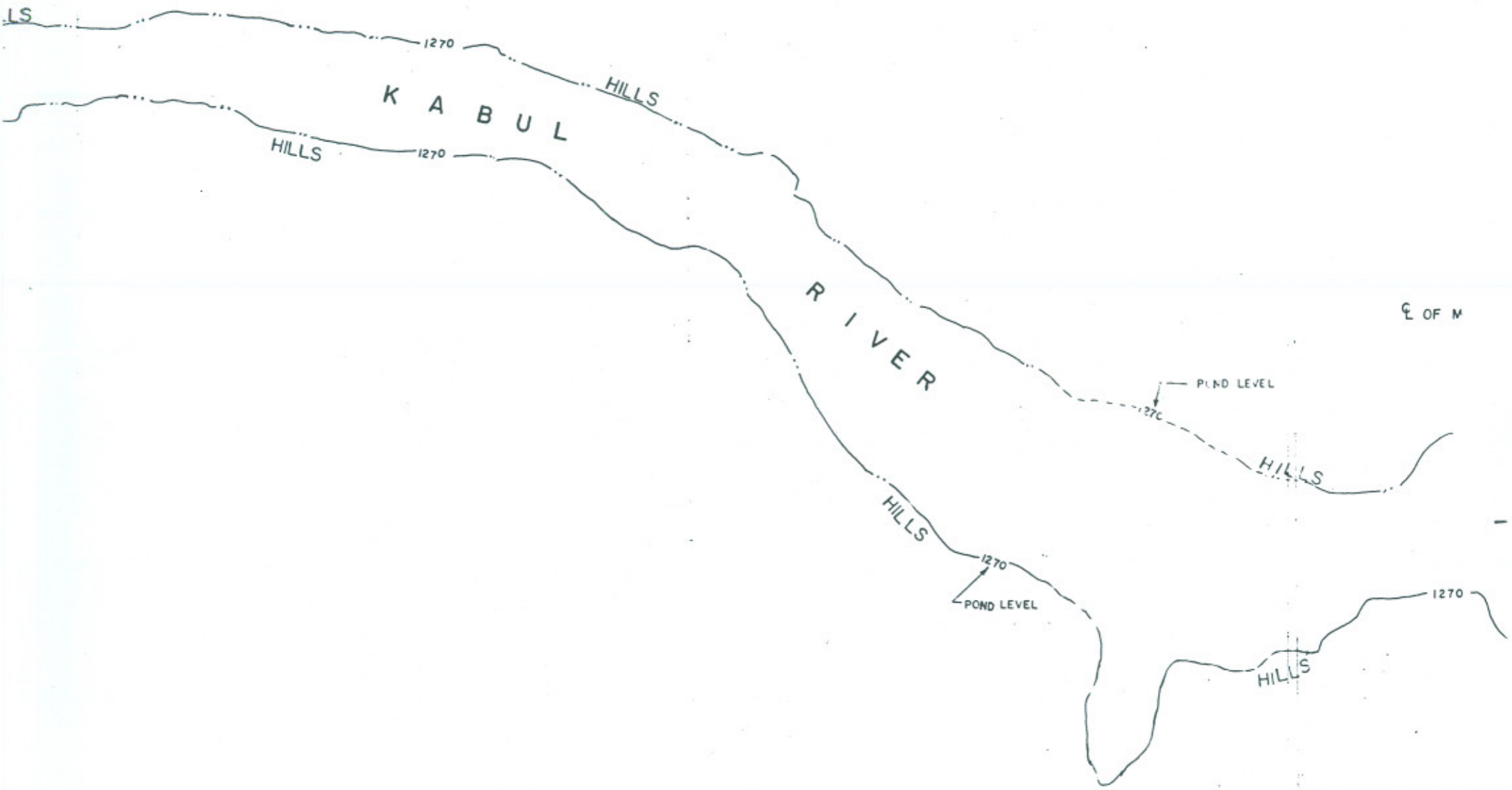
Photo No. 3 : View of left bank of Reservoir upstream of Dam during flushing operation.

FLUSHING OPERATIONS OF WARSAK RESERVOIR SEDIMENT

(Paper No. 455)

LIST OF FIGURES

FIG. NO.	T I T L E
1	Plan of Warsak Reservoir
2	Reservoir Capacity U/S of Warsak Dam
3	Warsak Reservoir Storage Changes 1960-1973
4	Warsak Dam Reservoir Bed Configuration after 4 hrs.
5	Warsak Dam Reservoir Cross Sections.(500 ft.U/S of Gate Line)
5.1	Warsak Dam Reservoir Cross Sections.(1000 ft.U/S of Gate Line)
6	Flushing Operations of Warsak Reservoir Sediments Aug.76
7	Flushing Operations of Warsak Reservoir Sediments Aug.77
8	Flushing Operations of Warsak Reservoir Sediments June 1978
9	Flushing Operations of Warsak Reservoir Sediments July 1978
10	Flushing Operations of Warsak Reservoir Sediments Aug. 1979
11	Warsak Reservoir X-Section Line 2 (RD.500)
12	Warsak Reservoir X-Section Line 6 (RD. 1500)
13	Warsak Reservoir X-Section Line 8 (RD.2000)
14	Warsak Reservoir X-Section Line 12 (RD. 3000)
15	Warsak Reservoir X-Section Line 18 (RD.4500)
16	Warsak Reservoir X-Section Line 16 (RD.4000)
17	Warsak Reservoir X-Section Line 22 (RD.10,000)
18	Warsak Reservoir X-Section Line 20 (RD.5000)

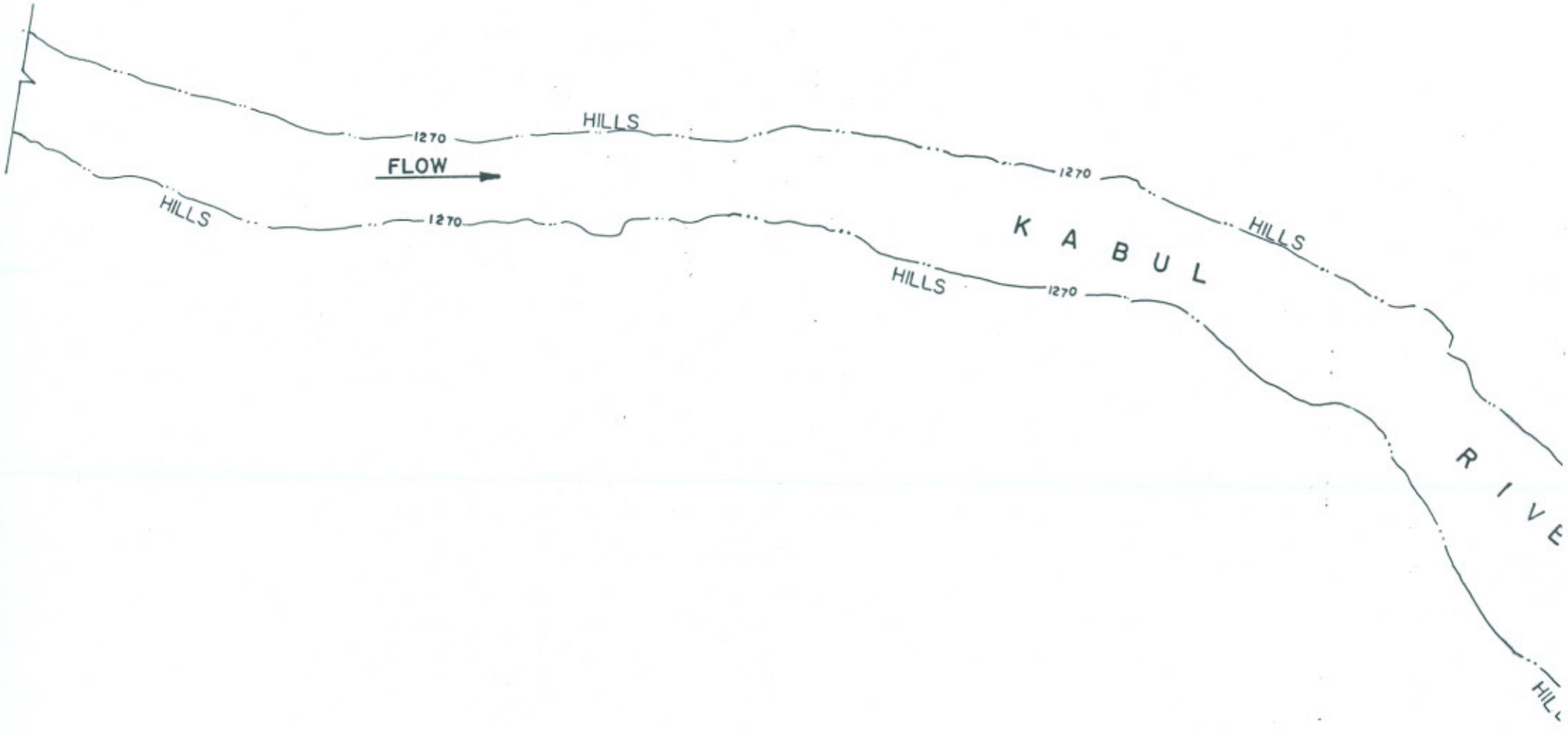


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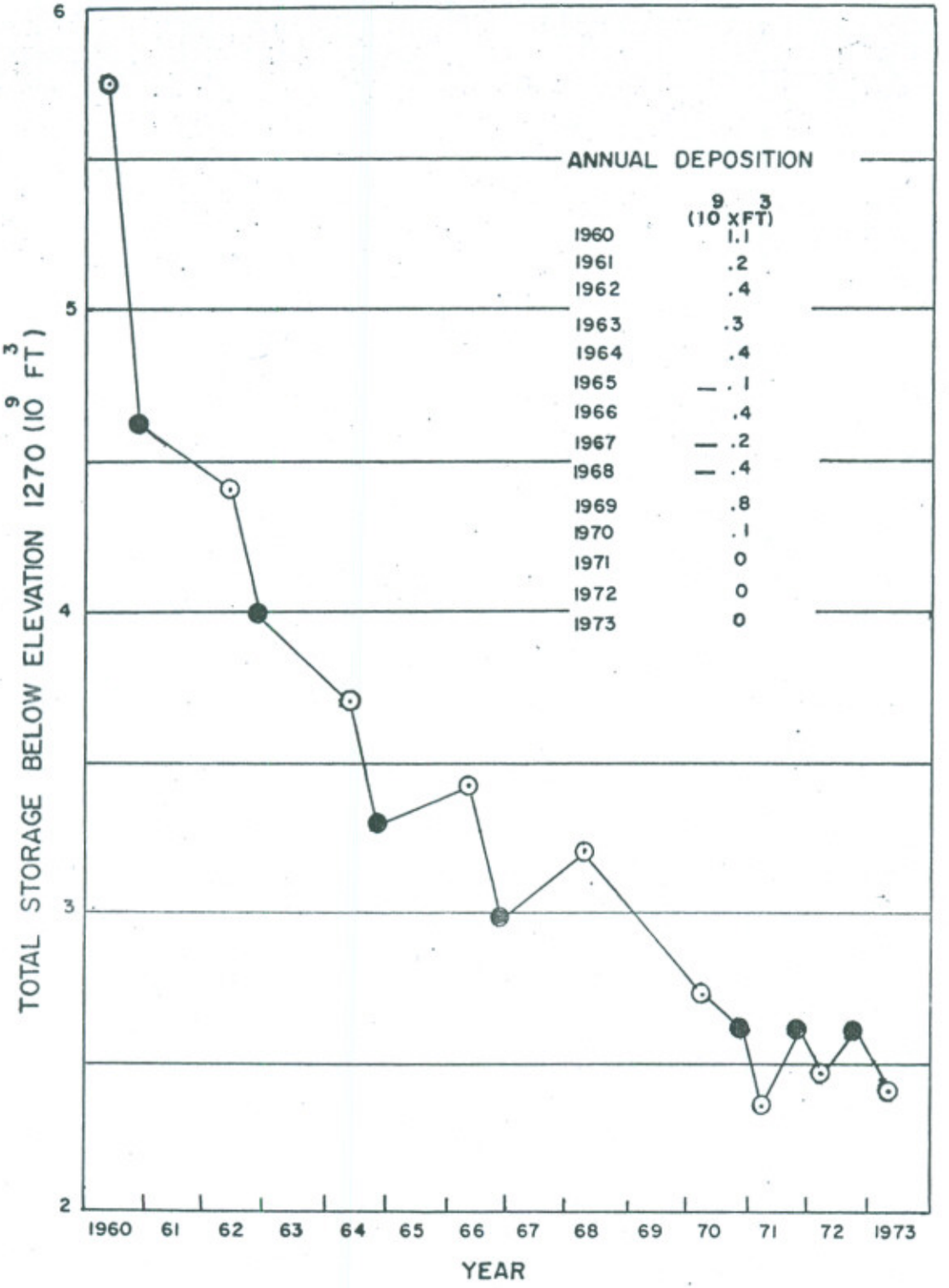
SCALE :- 1"

TOTAL LENGTH OF RESERVOIR = 26 MILES



TOTAL LENGTH O

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WARSAK RESERVOIR STORAGE CHANGES 1960-1973

FIG. 3

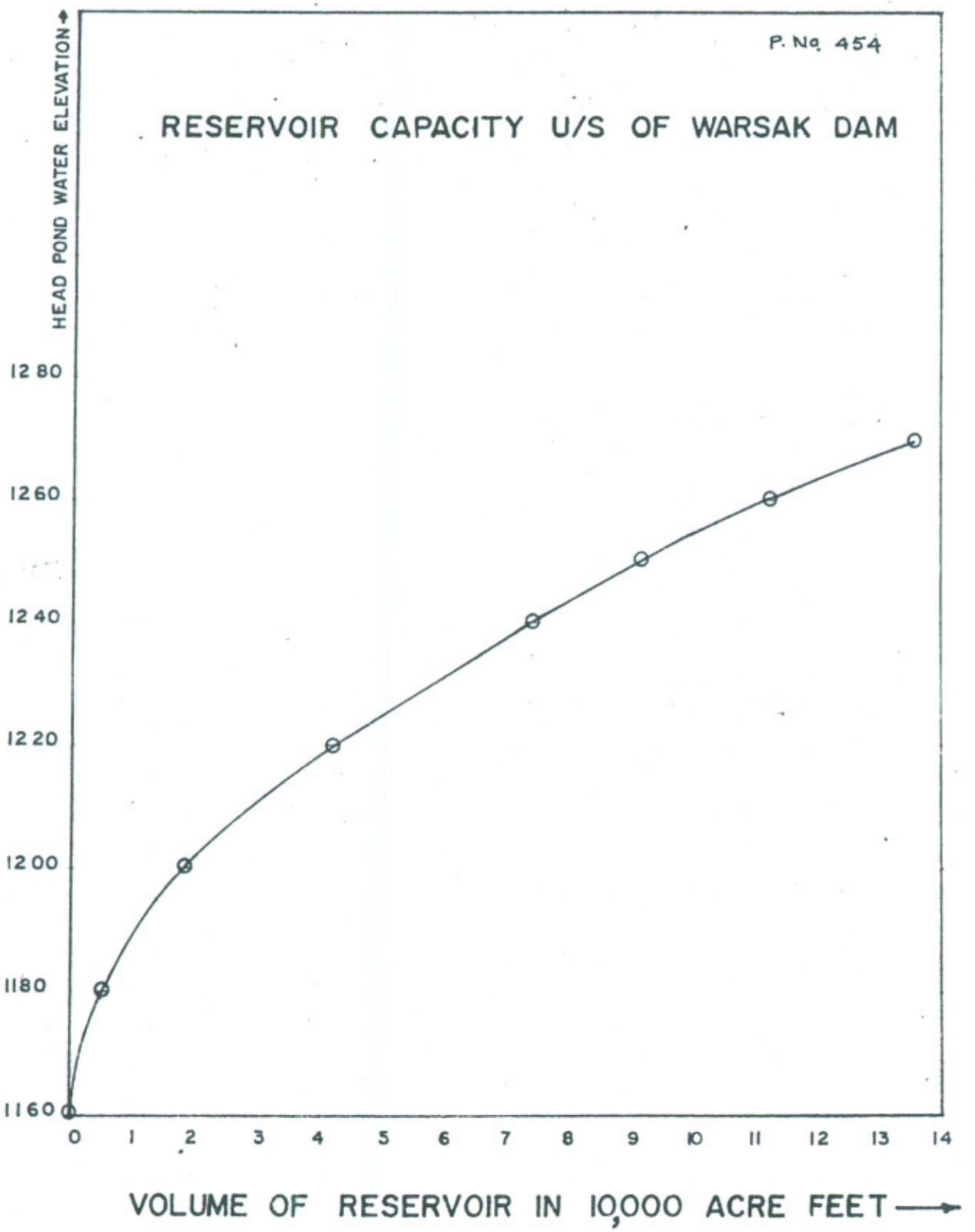
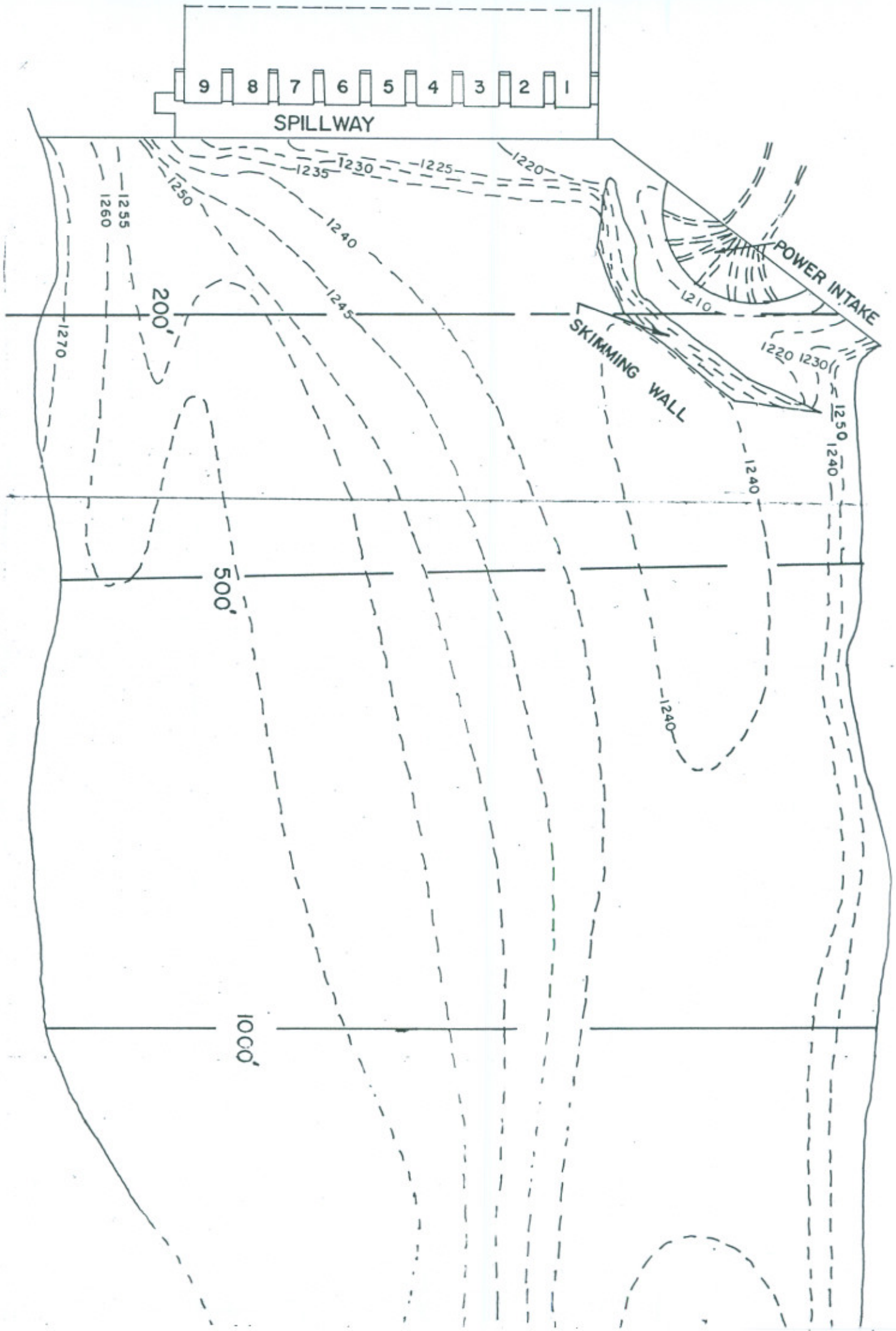
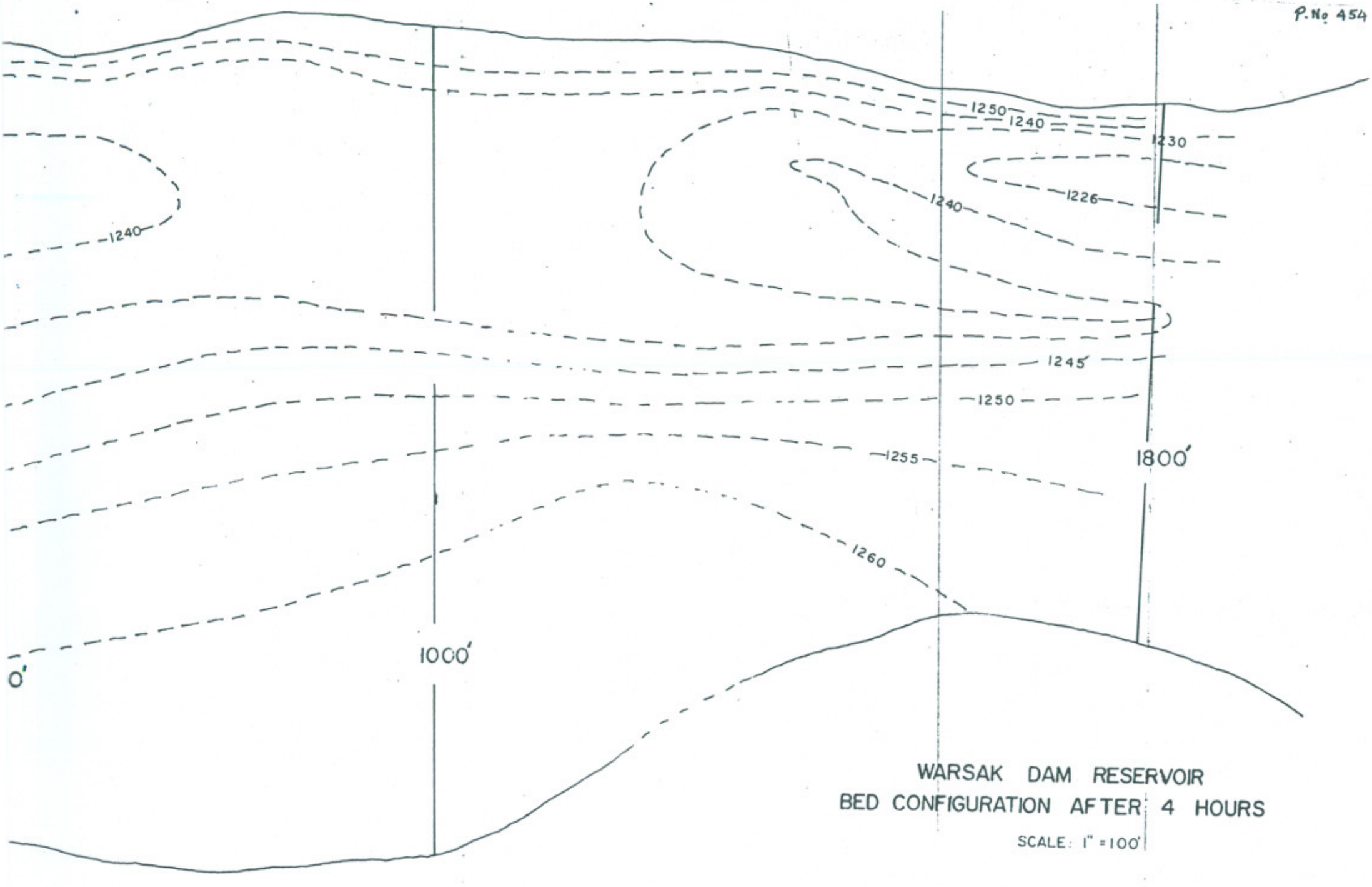

P. No. 454
RESERVOIR CAPACITY U/S OF WARSAK DAM
HEAD POND WATER ELEVATION
1280
1260
1240
1220
1200
1180
1160
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
VOLUME OF RESERVOIR IN 10,000 ACRE FEET

FIG.2

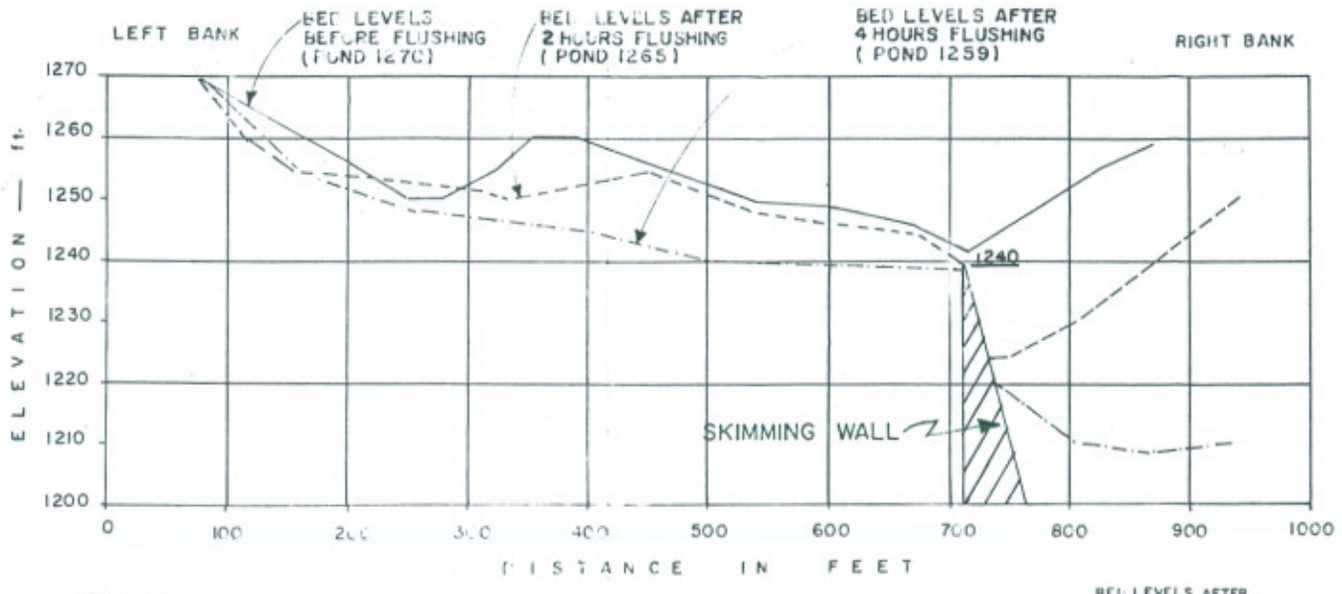

9
8
7
6
5
4
3
2
1
SPILLWAY
1220
1225
1230
1235
1250
1240
1255
1260
1270
1245
1210
POWER INTAKE
SKIMMING WALL
1220
1230
1250
1240
1240
1240
200'
500'
1000'



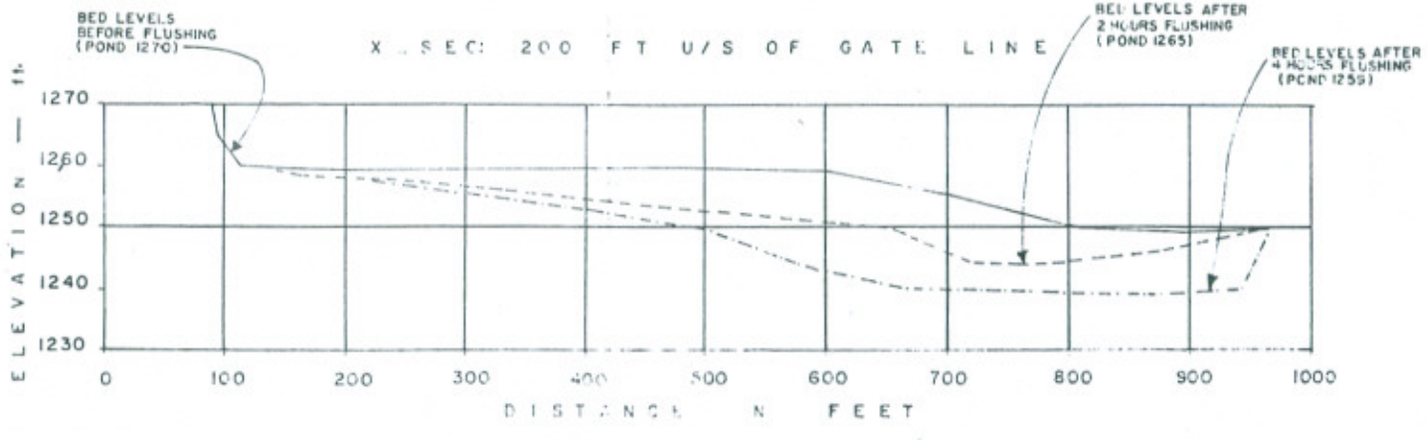
WARSAK DAM RESERVOIR
BED CONFIGURATION AFTER 4 HOURS

SCALE: 1" = 100'

FIG. 4



X-SEC: 200 FT U/S OF GATE LINE



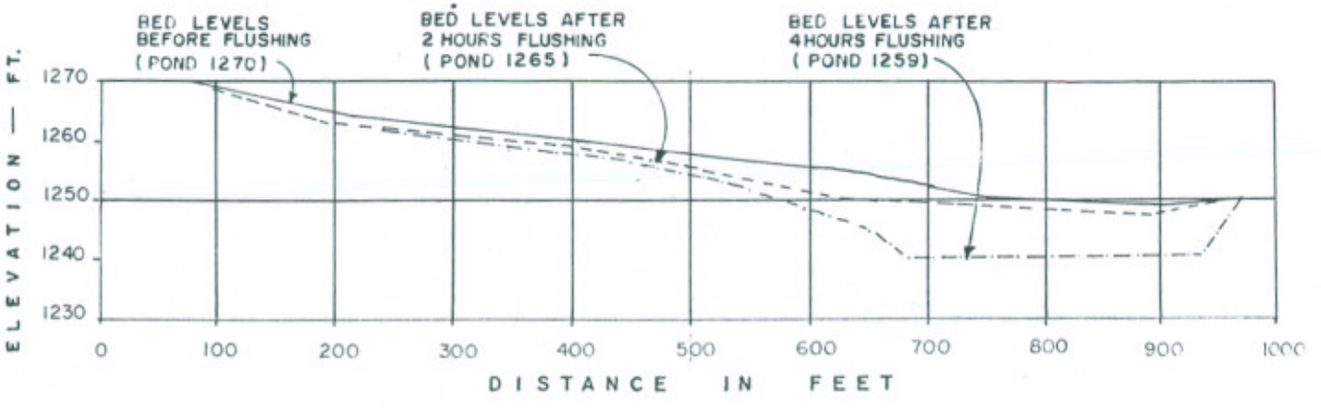
X-SEC: 500 FT U/S OF GATE LINE

WARSAK DAM RESERVOIR

CROSS SECTIONS

FIG. 5

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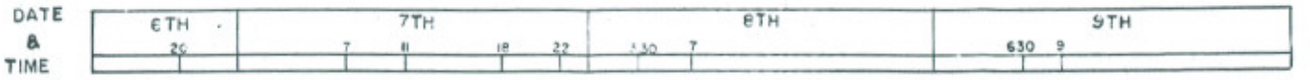
X-SEC: 1000 FT U/S OF GATE LINE

WARSAK DAM RESERVOIR

CROSS SECTIONS

FIG. 5.1

FLUSHING OPERATIONS OF WARSAK RESERVOIR SEDIMENTS
AUGUST, 1976



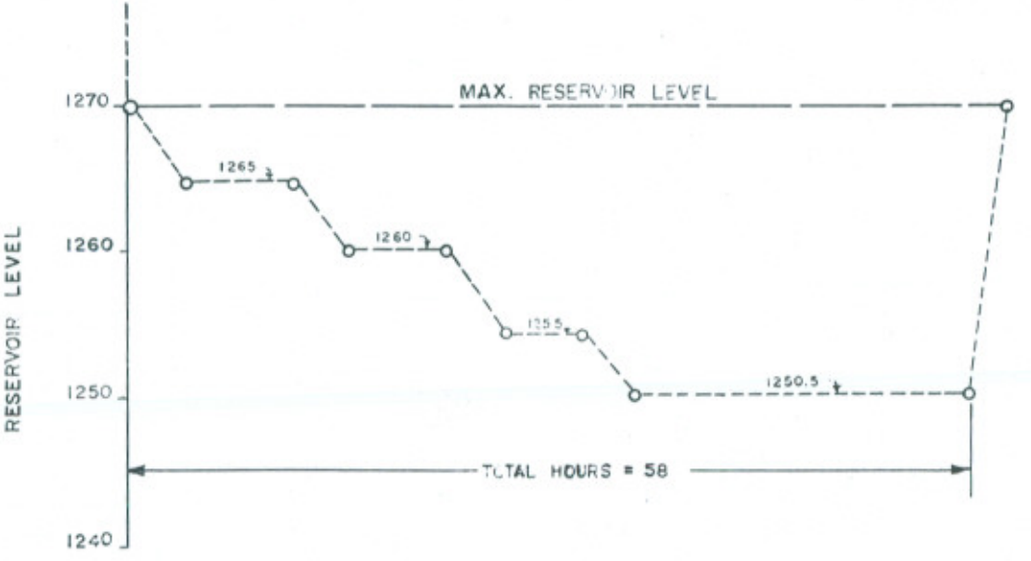


FIG: 6

FLUSHING OPERATIONS OF WARSAK RESERVOIR SEDIMENTS

AUGUST, 1977

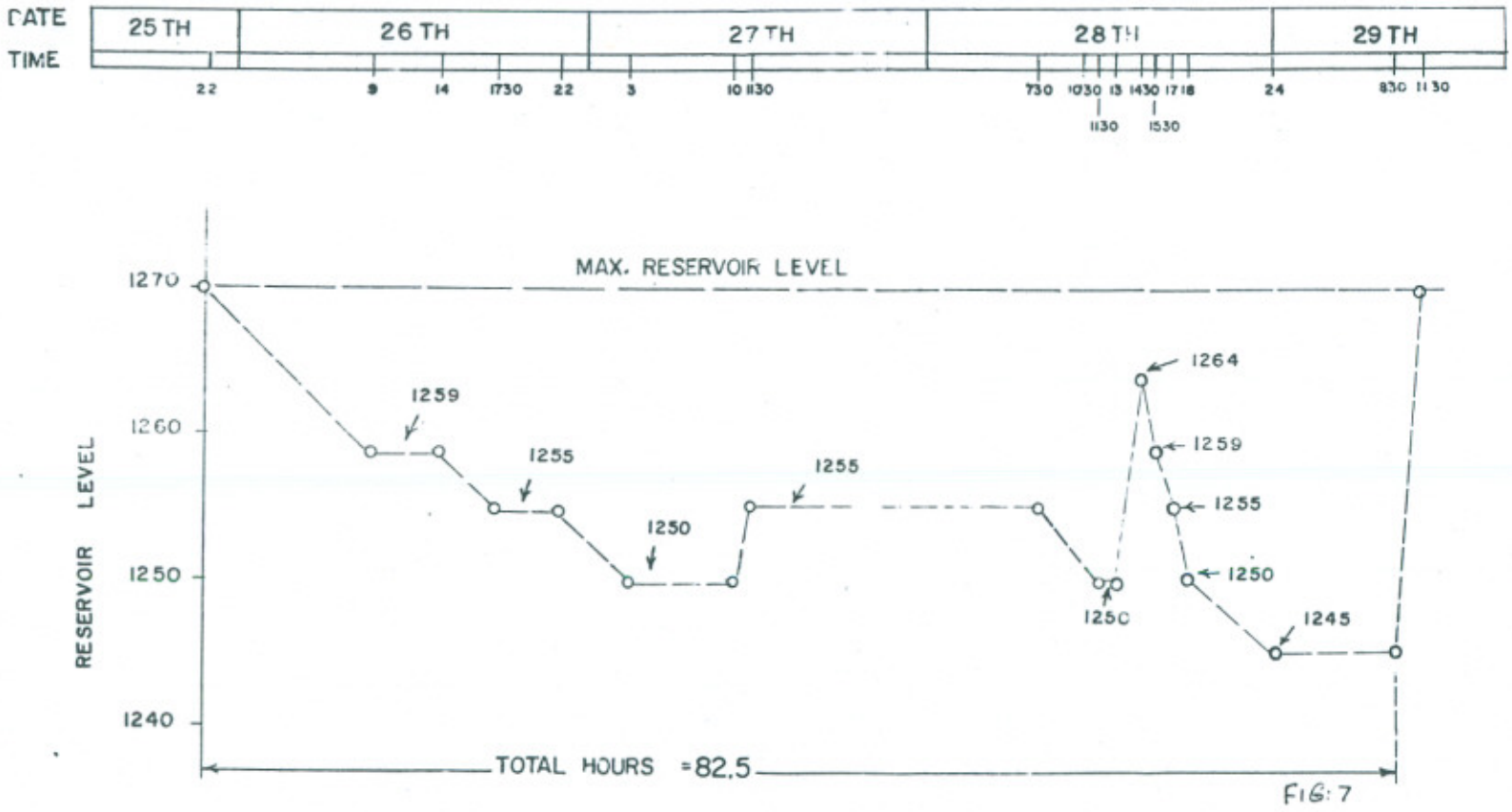


FIG: 7

FLUSHING OPERATIONS OF WARSAK RESERVOIR SEDIMENTS

FOR JUNE, 1978



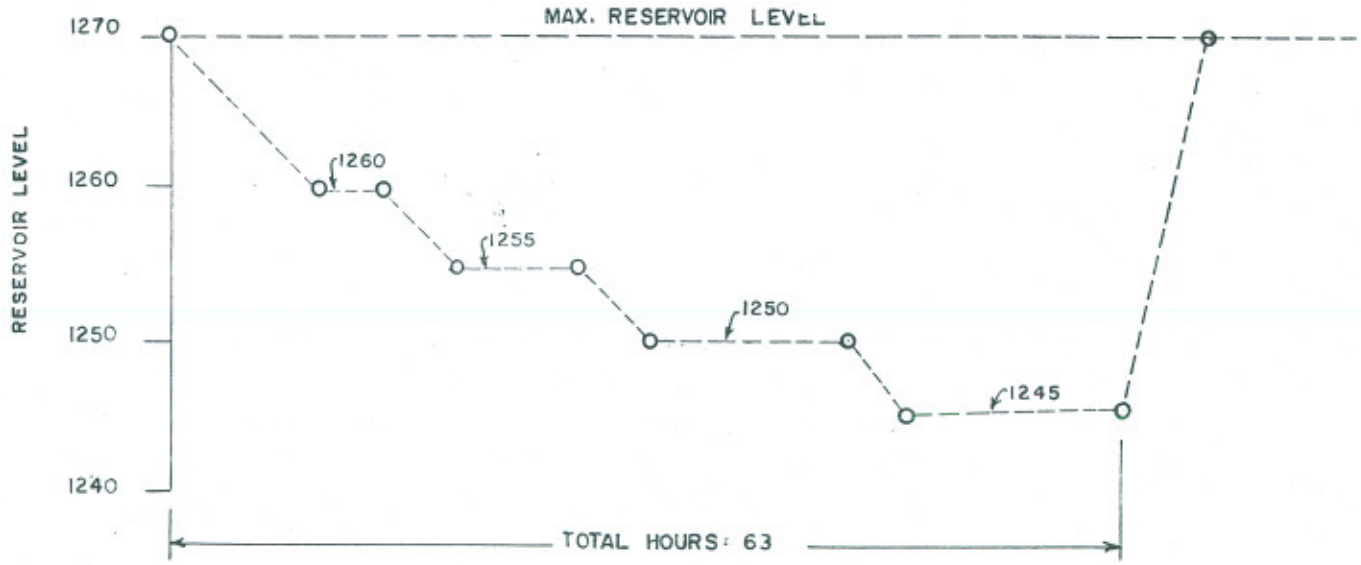
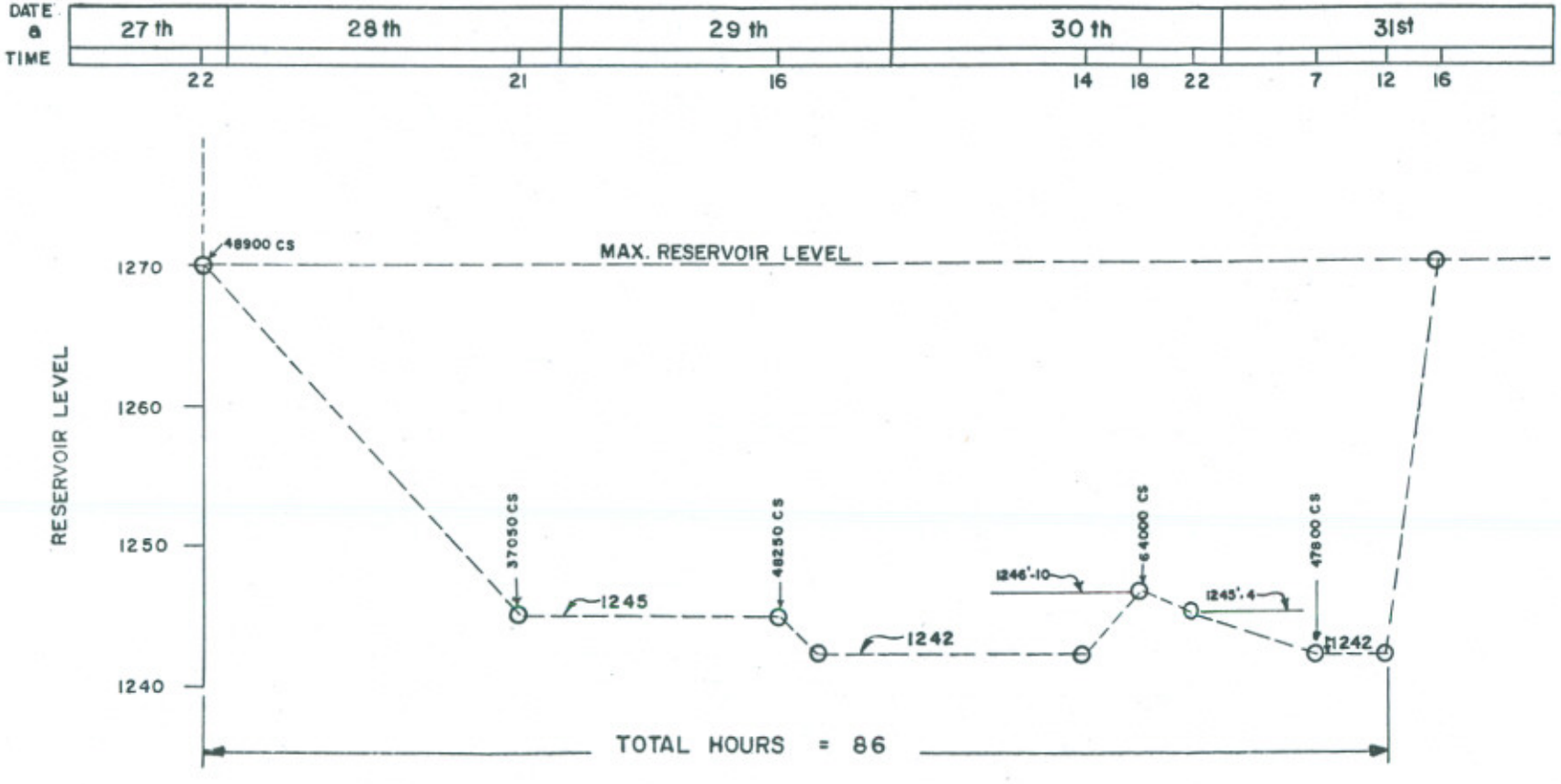
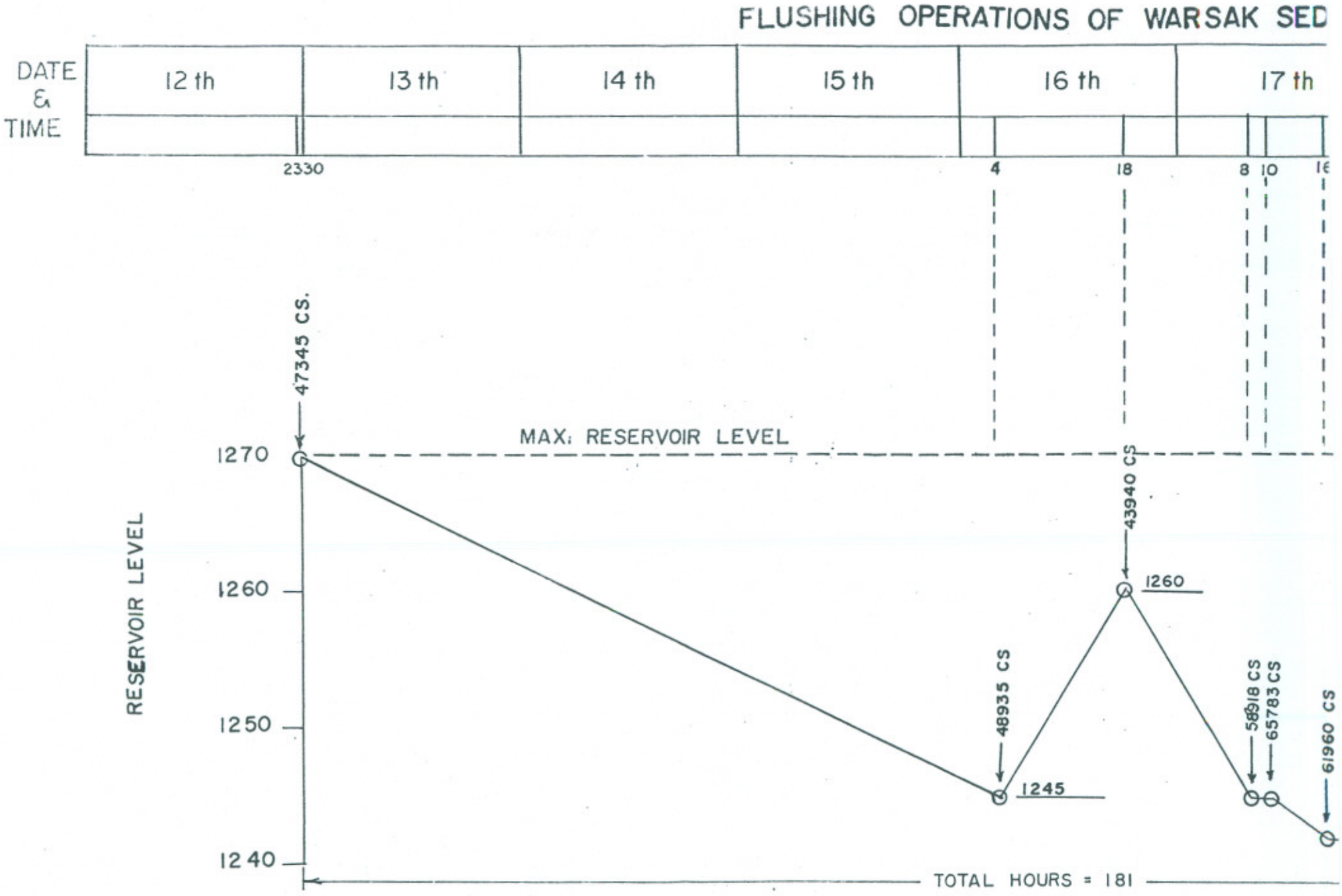


FIG: 8

FLUSHING OPERATIONS OF WARSAK RESERVOIR SEDIMENTS

JULY, 1978




FLUSHING OPERATIONS OF WARSAK SED
DATE & TIME
12 th
13 th
14 th
15 th
16 th
17 th
2330
4
18
8
10
47345 CS.
MAX: RESERVOIR LEVEL
1270
1260
1250
1240
RESERVOIR LEVEL
43940 CS
1260
48935 CS
1245
58918 CS
65783 CS
61960 CS
TOTAL HOURS = 181

FLUSHING OPERATIONS OF WARSAK SEDIMENTS AUGUST, 1979

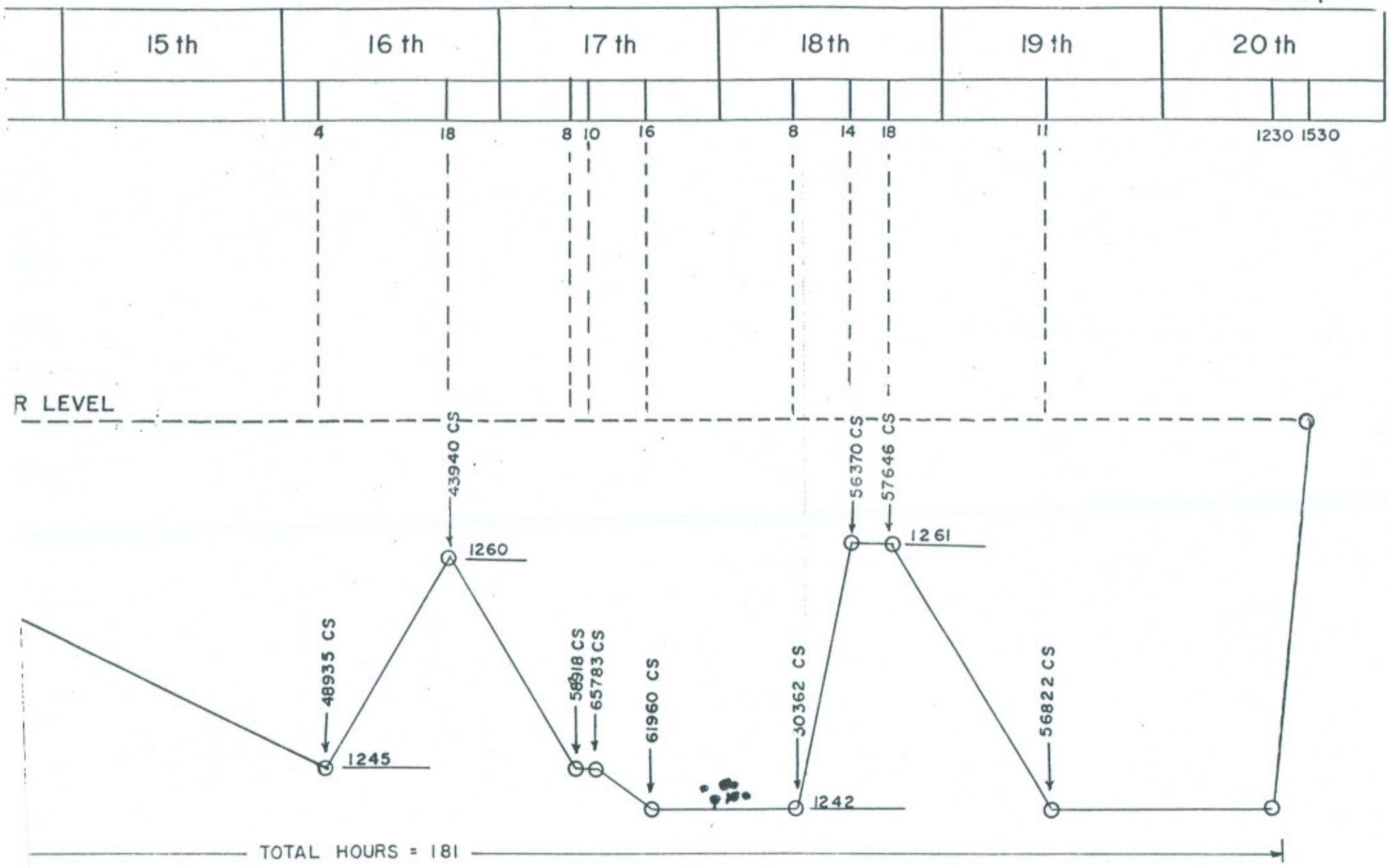
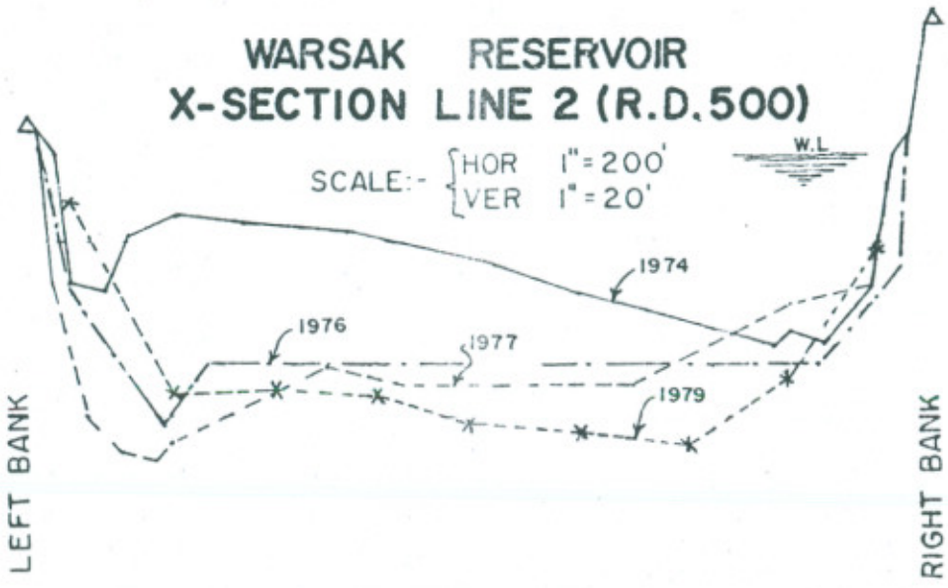


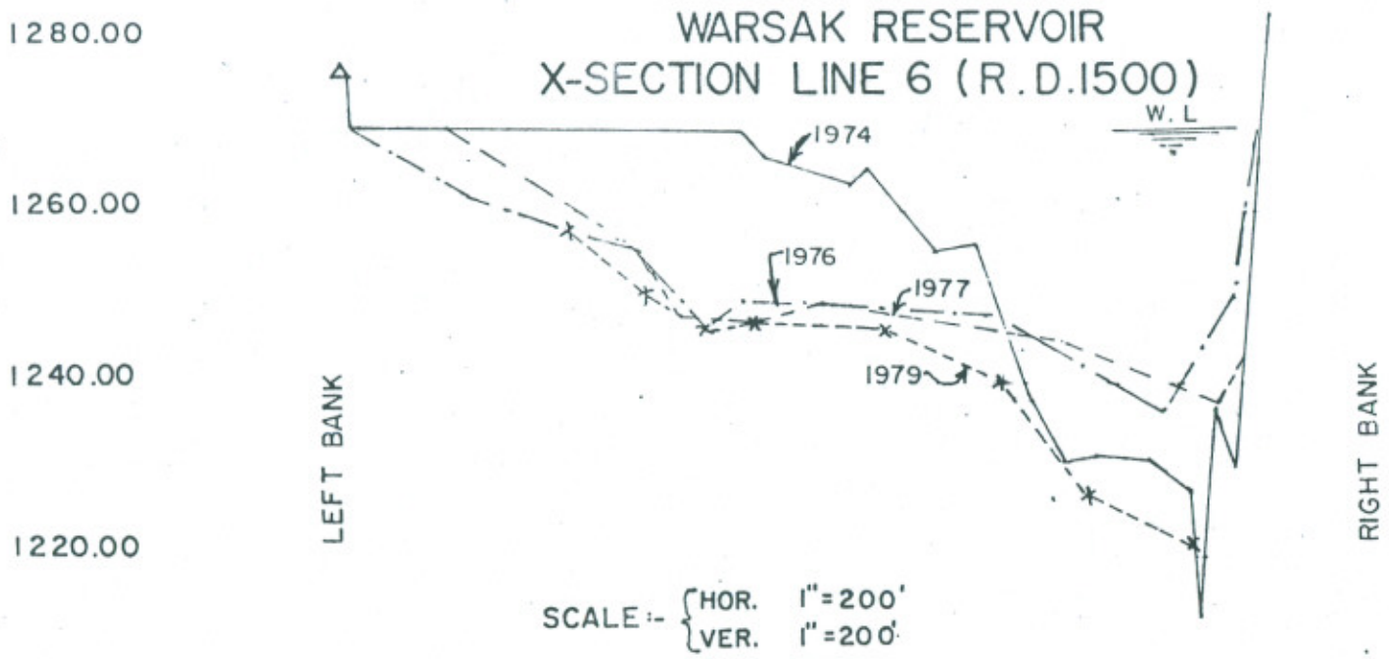
FIG:10



R.D	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
R.L 1974	1272.7	1257.50	1262.50	1262.0	1261.00	1258.50	1254.0		1246.00	1248.50	1254.50		
R.L 1976		1252.0	1240.5	1246.0						1250.00	1272.00		
R.L 1977			1236.90		1245.90			1243.90		1252.90	1254.90		
R.L 1979		1254.90	1242.70	1243.20	1242.70	1239.70	1238.70		1237.20	1244.7	1259.70		

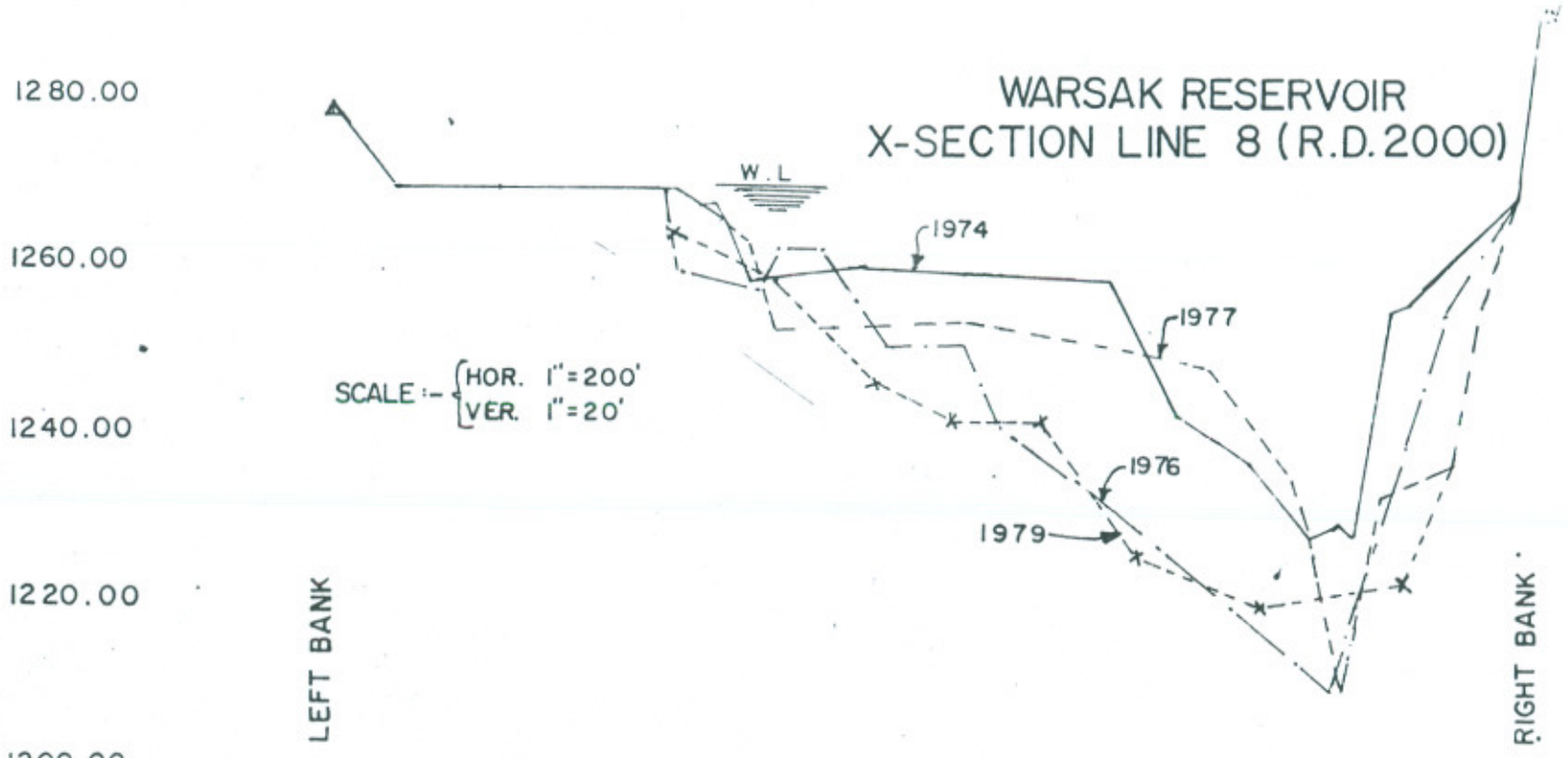
1280.00
1260.00
1240.00
1220.00
1200.00

FIG: II



R.D	0	100	200	300	400	500	600	700	800	900	1000	1100	1200
R.L.1979	1270.00			1257.90		1247.20	1246.70		1240.70	1227.70	1221.70		
R.L.1977			1270.00		1250.70							1237.50	1269.80
R.L.1976		1262.20		1258.40	1256.50	1250.00	1249.50	1255.80	1248.00	1245.00	1237.50	1250.00	1270.00
R.L.1974		1270.00			1246.50	1269.50	1263.30	1266.80	1264.80	1231.00	1231.30	1237.80	1269.80
						1266.30	1264.90		1238.80	1231.80	1227.80	1213.30	

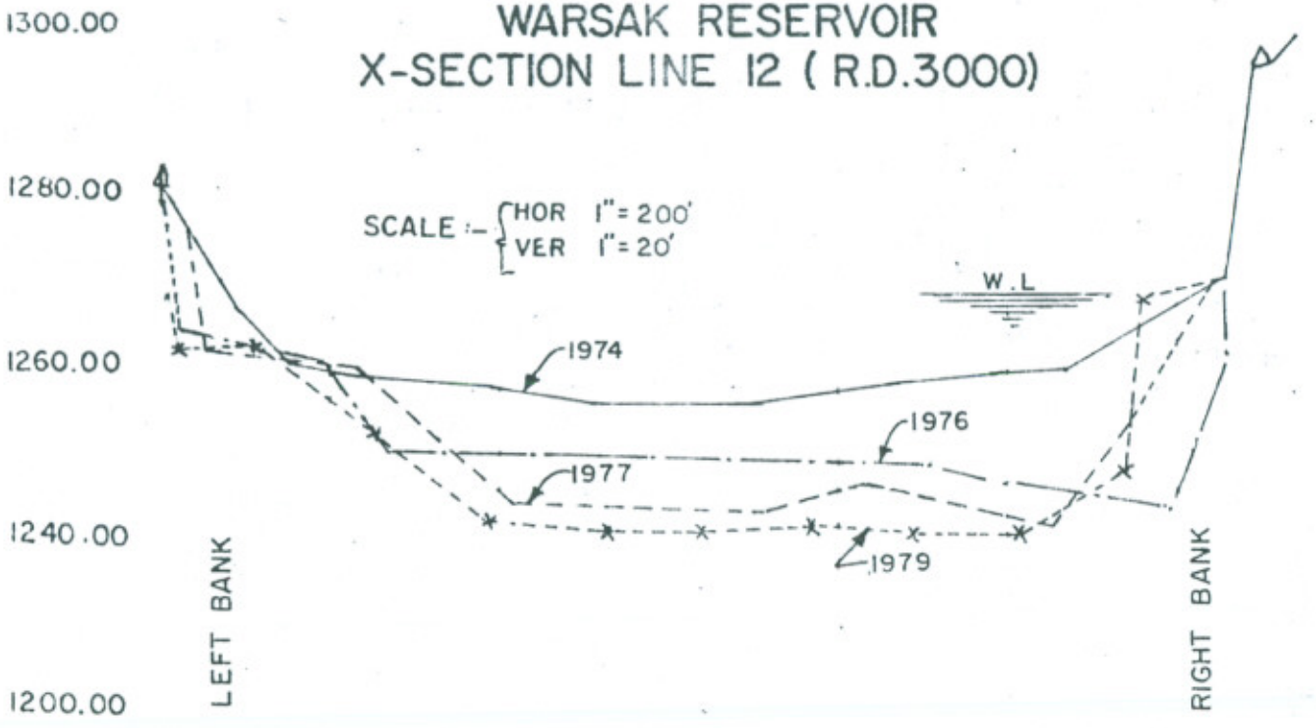
FIG. 12



R.D	0	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500
R.L.1974				1269.80		1266.30 1259.80	1260.80		1259.80	1259.30	1243.30	1236.80	1228.30		1262.30	
R.L.1976					1260.00	1258.00 1263.50	1263.00	1251.50		1235.00			1215.00		1256.50	1270.00
R.L.1977						1253.90			1253.90			1250.40	1229.90		1237.40	
R.L.1979					1264.70	1259.70		1247.70	1242.70	1242.70	1226.70	1220.70		1223.70		

FIG: 13

WARSAK RESERVOIR
X-SECTION LINE 12 (R.D.3000)



R.D	0	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300	1400
R.L.1974	1281.20	1267.70	1261.70	1260.70	1258.70	1257.70		1256.70		1259.70	1260.20	1261.20	1245.00	1272.00	1296.30
R.L.1976	1265.00	1262.50	1263.50	1261.50	1251.50					1250.00	1248.00			1263.00	
R.L.1977		1262.70		1260.70		1247.70		1247.20		1247.70		1242.70	1255.20		
R.L.1979	1269.70 1263.70		1263.70		1253.70		1243.70	1242.20	1242.70	1243.70	1242.70 -	1242.20	1249.70 1269.70		

FIG: 14

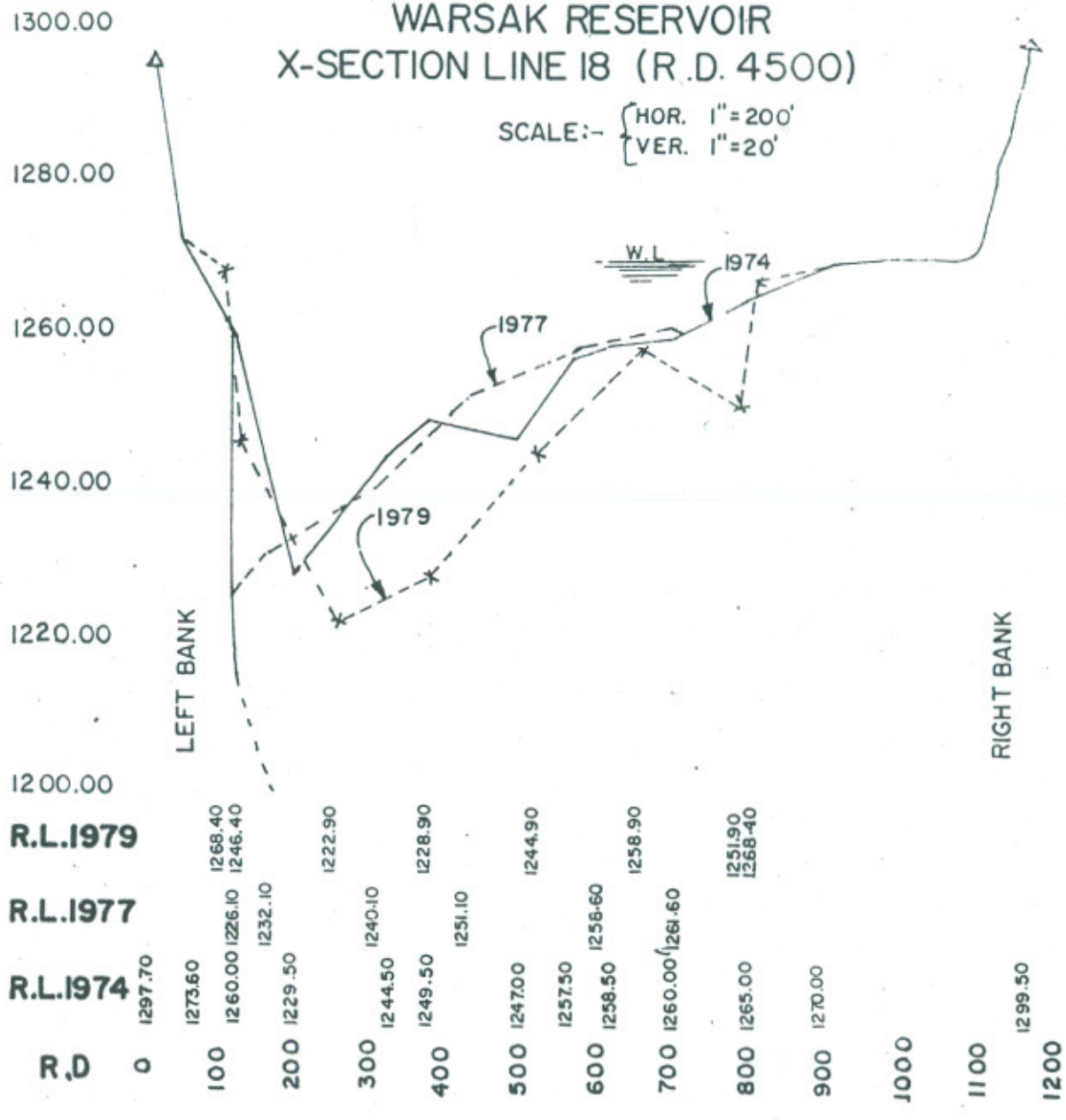

WARSAK RESERVOIR
X-SECTION LINE 18 (R.D. 4500)
SCALE:- HOR. 1"=200'
VER. 1"=20'
1300.00
1280.00
1260.00
1240.00
1220.00
W.L
1974
1977
1979
LEFT BANK
RIGHT BANK
R.L.1979
R.L.1977
R.L.1974
R.D
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1297.70
1273.60
1268.40
1246.40
1260.00
1226.10
1232.10
1229.50
1222.90
1244.50
1240.10
1249.50
1251.10
1228.90
1247.00
1244.90
1257.50
1258.60
1258.50
1258.90
1260.00
1261.60
1265.00
1251.90
1268.40
1270.00
1299.50

FIG: 15

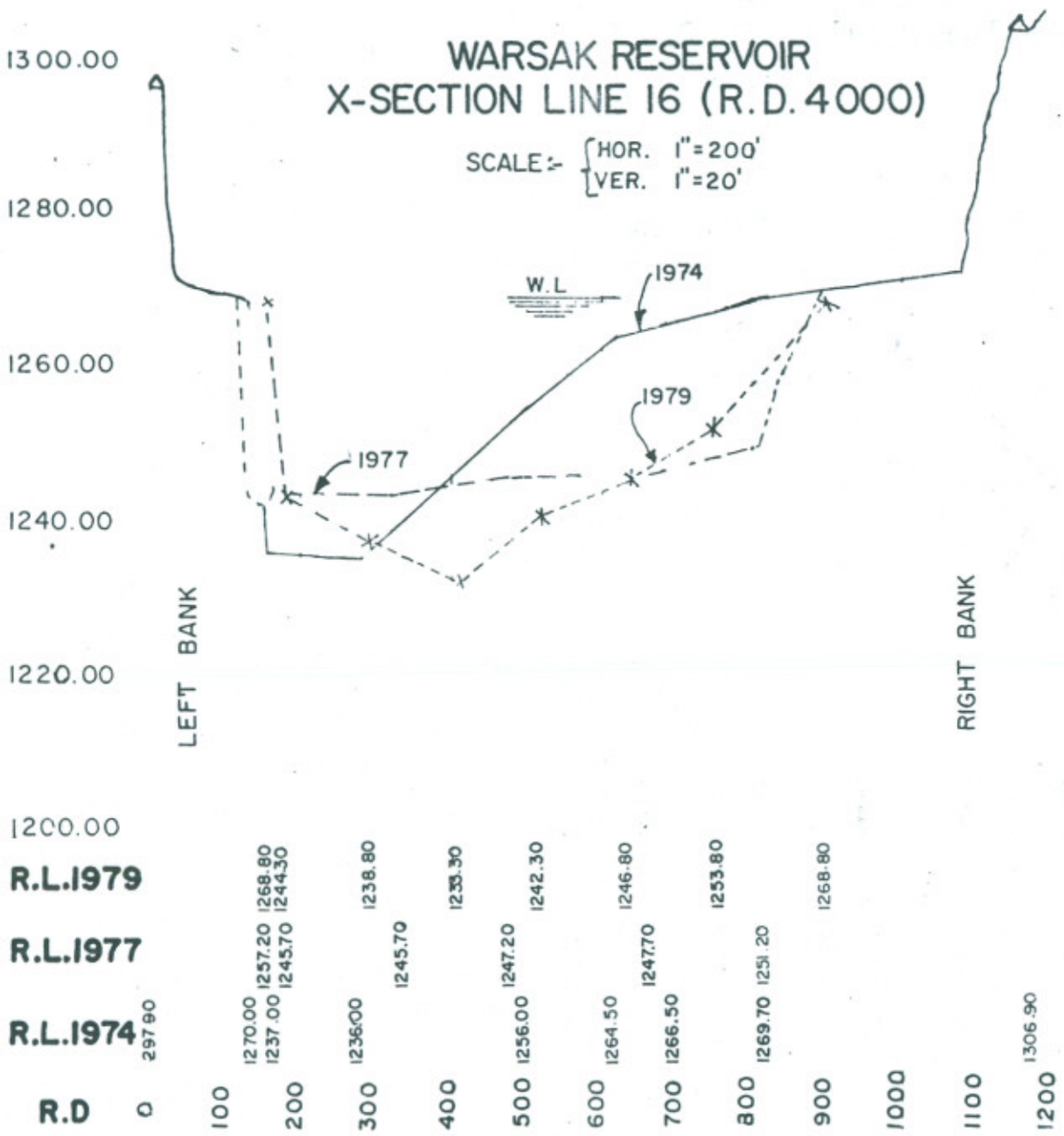
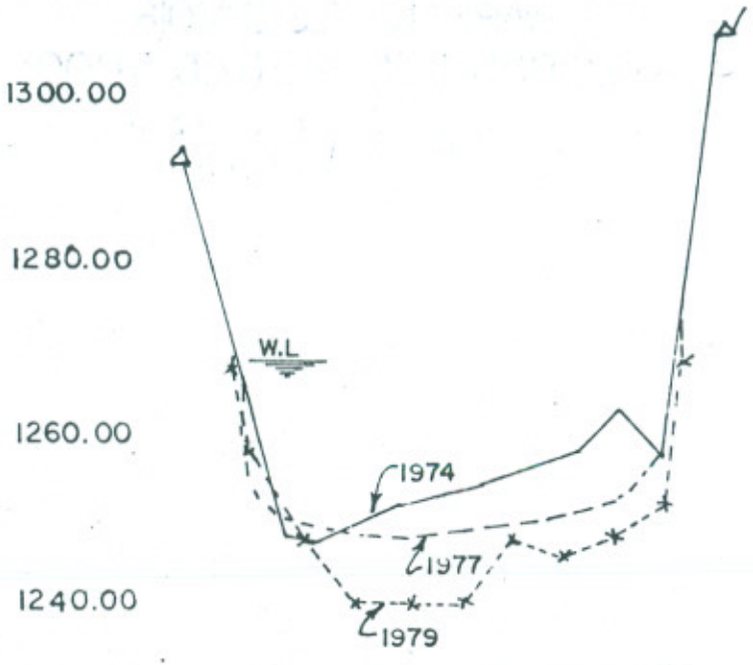

WARSAK RESERVOIR
X-SECTION LINE 16 (R.D.4000)
SCALE :- HOR. 1"=200'
VER. 1"=20'
1300.00
1280.00
1260.00
1240.00
1220.00
1200.00
W.L
1974
1979
1977
LEFT BANK
RIGHT BANK
R.L.1979
R.L.1977
R.L.1974
R.D
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
297.90
1270.00
1237.00
1236.00
1256.00
1264.50
1266.50
1269.70
1306.90
1257.20
1245.70
1245.70
1247.20
1247.70
1251.20
1268.80
1244.30
1238.80
1233.30
1242.30
1246.80
1253.80
1268.80

FIG: 16

WARSAK RESERVOIR
X-SECTION LINE 22 (R.D.10,000)

SCALE :- HOR. 1"=200'
VER. 1"=20'



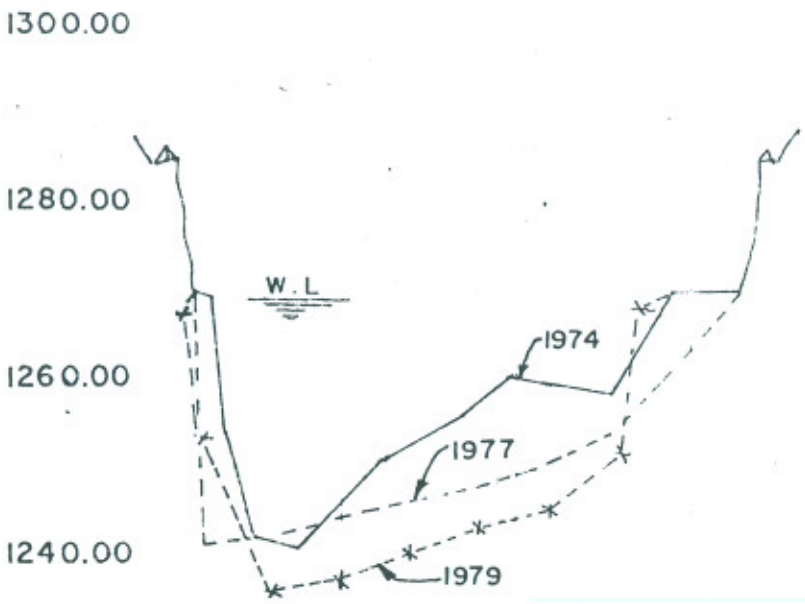
R.D	0	100	200	300	400	500	600	700	800
R.L.1979		1269.00 1259.80							
R.L.1977		1258.50	1251.00	1248.80	1249.00	1241.30	1249.00	1240.80	1240.80
R.L.1974	1299.10	1262.70	1249.70	1248.70	1252.70		1255.70	1250.00	1248.80

R.D	800								
R.L.1979									
R.L.1977	1240.80	1251.50	1246.80	1253.00	1248.80	1256.00	1252.80 1269.80		
R.L.1974		1259.20		1254.70		1258.70		1310.80	

FIG: 17

WARSAK RESERVOIR
X-SECTION LINE 20 (R.D.5000)

SCALE :- HOR. 1" = 200'
VER. 1" = 20'



R.D	0	100	200	300	400	500	600	700	800
R.L.1979	1268.60	1237.60	1238.60	1241.60	1244.10	1246.10	1252.60	1268.60	
R.L.1977	1220.00	1243.10	1243.60	1245.10	1246.60	1248.60	1251.60	1256.10	1286.80
R.L.1974	1254.60	1261.00	1243.50	1242.00	1252.00	1257.00	1261.00	1259.50	1270.00

FIG:18