WORKSHOP

ON

RESERVOIR SEDIMENTATION ASSESSMENT USING REMOTE SENSING DATA

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Module 6

Rate of Siltation of Reservoirs

in

Andhra Pradesh - Case Studies

BY

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RATE OF SILTATION OF RESERVOIRS IN ANDHRA PRADESH — CASE STUDIES

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SYNOPSIS

Assessment of sediment rate to a fair degree of accuracy is of utmost importance for planning a reservoir in order to determine their useful and economic life span.

This paper presents the observations in the rate of siltation obtained by conducting hydrographic surveys in some of the Major and Medium Irrigation reservoirs of Andhra Pradesh and discussed the variation of sediment deposition with respect to Khosla's Theory. It was found that very large variation of values of rate of sediment was observed over and above the designed values in Nizam Sagar Project and other medium reservoirs.

It was found that, though the rate of siltation is high in the initial years it trend slow down over the subsequent period. This paper further high light the usage of sophisticate equipments for obtaining a realistic data on reservoir sedimentation. Experience gained from use of such sophisticated equipment in conducting the hydgropahic surveys of Tungabadra Reservoir highlighting the advantages of using the precise instruments for ensuring high degree of horizontal controls.

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INTRODUCTION

Andhra Pradesh is the fifth largest state in India with a large network of large and small rivers. Several major and medium reservoirs have been constructed across these seasonal rivers to impound water for catering irrigation and power and other needs of the community. There are 9 major and about 92 medium reservloirs are existing in Andhra Pradesh in addition to several minor irrigation projects.

One of the most important problems in the development and maintenance of storage reservoirs is the loss of storage capacity due to silting. Silting of reservoirs is a matter of vital concern to any design engineer. The life of reservoir depend on the rate of silt accumulating in it. Sediment inflow into a reservoir originates from up stream and is influenced by several factors like type of soil, vegitation, gradient and intensity of rainfall etc., as per the existing design norms, the rate of siltation is calculated as per the Khosla's Theory which recommends a vlaue of 3.57 Ham / 100 Sq. Km / Year as arrived from the Khosla's recommendations.

Hydrographic surveys were conducted in major and medium reservoirs and the rate of siltation was assessed. Repeat surveys of some of the reservoirs were also conducted and the trend in the rate of sedimentation over a period of time was observed.

In this paper the hydrographic suveys conducted in the different major and medium irrigation reservoirs were explained and the data collected from these reservoirs was presented variation of the rate of sediment observed in these reservoirs with the designed values were discussed. The critical study made with regard to the trends in the rate of sedimentation in some of the reservoirs from which repeat surveys are conducted was also discussed. The rates of siltation on the studies conducted in few reservoirs are showed in a Table-I. The paper furhter highlights the surveys conducted in Tungabhadra Dam using sophisticated equipment and compared with data obtained with conventional methods. (Fig-3)

A set of 2 major and 3 medium irrigation reservoir having a considerable quantity of silt deposition were selected for making the subject of study for this paper (FIG. 1)

OBSERVATIONS

The major projects considered are Nizam Sagar Project and Singur Project constructed across Manjira River and further studies are conducted in Tungabhadra reservoir which is a joint venture of Andhra Pradesh and Karnataka States. The capacity of the reservoirs selected for study is ranging from 15.96 M.cum to 847.0 M.cum and the areas of catchment range varies from 194.41 Sq. km to 18,523.00 Sq. km. the catchment for rivers like Musi, Pampa and Upper Manair etc., has predominantly red soils, whereas Nizam Sagar and Singur reservoirs have thick clayey soils. The period of observations stretches from 10 years to 62 years in the cases of Singur project and Nizam Sagar project respectively.

2. METHODOLOGY

Soundings were taken by the echo-sounder along the range lines. The horizontal distance interval at which the successive depths were taken were observed by a distance log.

Whenever the water level in the reservoir below the FRl, ground surveys were conducted from the existing water level to the FRL.

The depths obtained from Hydrographic surveys were reduced and plotted on the respective lines. Contours were then drawn with 2 m interval and the capacity was worked out as per the prismoidal formula.

2.1 NIZAM SAGAR

Nizam Sagar project was constructed during the years 1923-30 on the Manjira river which is a major tributory of the river Godavari. Capacity surveys were conducted by Andhra Pradesh Engineering Research Laboratories part of the programme of the centrally sponsored Research scheme applied to river valley project by the CBIP in the year 1967 and 1975. The surveys of 1967 revealed that 52% of capacity was lost due to siltation during the period of 1975, the same has been observed as 57%. Due to high rate of siltation the capacity of the reservoir reduced abnormally therefore in the year of 1978 the FRL of the reservoir was raised by 1.38 m (from 426.87 m to 428.25 m) to compensate the loss in capacity.

The repeat hydrographic survey was also taken up in the year 1992 after reservoir received some inflow when the water level was at +422.58M.

Since the FRL has been raised by 1.38 M, new monuments were constructed wherever necessary. Ground surveys were also conducted to fix the position of the new range monuments while tracing the correct FRL contour. An FRL plan to a scale I cm=96m showing the range lines was prepared. The entire reservoir area was fully covered by taking 23 range lines. The range lines were set parallel to the dam wherever possible and normal to the flow direction in valleys.

Since the FRL has been raised, the capacity corresponding to the old FRL was taken into consideration for the study in this paper. The capacities worked out based on the surveys carried out in the years 1961, 1967, 1975 and 1992 are given in Table-I Graph showing the elevation vs capacity observed from the above surveys are shown in Figure - 2.

2.2 SINGUR RESERVOIR

The Singur reservoir is another Major project constructed across river Manjira which is a tribute to Godavari river about 130 km in the upstream of Nizamsagar reservoir. Singur project is having similar catchment characteristics like Nizamsagar reservoir. Hydrographic surveys of the reservoir were conducted in 1997 first time. The reservoir water spread area of 1654 sq. km was divided in to 79 ranges and echo-sounding were done on these ranges at an interval of 30 m on each range line. Based on the levels contours were drawn and capacity worked out.

The hydrographic surveys were started in Singur reservoir during 10/97 when the water level was +519.12m, 4.48 m. below the FRL of +523.60m. The reservoirs has vast water spread area, some of the range lines are as long as 10 kms. It is felt very difficult to see the respective monument from one flank to the other. To follow the range line for taking soundings, intermediate reference points have been established by planting thermocole bouys in case of long ranges. After establishing straight range line, soundings were taken on each range line at interval of 30 M. The entire work of taking soundings on all the 69 range lines was completed. When the reservoir level was at + 519.035 M. Where the water levels are below the FRL, ground surveys extending the range line from the present water level to FRL on both flanks have been carried out to get the entire cross section.

The FRL plan is prepared to a scale of 1:12500 based on the ground surveys conducted by the APERL. The levels obtained from the soundings were plotted on each range line with the observed interval between them. Everyday the water level in the reservoir was noted from the gauge fixed to the masonry dam, and taken as datum. To observe the level while doing the hydrographic survey in the upstream of the reservoir a gauge was fixed on pulkurthy bridge. Contour at 1.0 m interval from elevation +505.00 m to +523m were marked in the plan and their areas were determined with a planimeter. Capacities were computed by using the prismoidal formulae.

The capacities obtained from the above studies are given in Table - I.

2.3 UPPER MANAIR RESERVOIR

Upper Manair reservoir was constructed across Manair river, the main tributory of river Godavari during the year 1950 with a storage capacity of 84.97 M.cum. Capacity surveys were conducted during the year 1986 and the capacity was found to be 61.0937 M.cum and the rate of sedimentation workout to 8.531 Hectare meter / 100 sq. km / year.

Based on the sedimentation studies of the Upper Manair reservoir the capacity of the reservoir at FRL 451.865 mt. was 61.0937 M.cum as against the original capacity of 84.870 M.cum at this level and the observation are given in Table I & II.

2.4 MUSI RESERVOIR

The Musi reservoir was built across the river Musi in the year 1966 with a storage capacity of 143.0726 M.cum the catchment area upto dam site is 9091 sq. km of which 2057 sq. km is a free catchment Hydrographic surveys were conducted during the year 1988 and the annual loss found as 0.2417% and the rate of siltation calculated to 1.6818 HM / 100 sq. km / year.

Based on the sedimentation surveys of the Musi reservoir the capacity of the reservoir at FRL +196.60 m was 135.4616 M.cum as against the original capacity of 143.0726 M.cum.

2.5 PAMPA RESERVOIR

Pampa project was constructed across Pampa river which is a tributory of Godavari in 1977 with a gross storage of 15.96 M.cum at PRL +32.004 m. Surveys were conducted in 1982 and 1990 & capacity worksout 15.316 and 14.84 M.cum respectively. It is found that the rate of siltation which was at 6.68 Hm/100 Sq.km / year during 1982 has been reduced to 4.43 Hm/100 sq. km / year during 1980. The data thus obtained is given in Table - I.

3.0 DISCUSSION OF RESULTS

3.1 As per the hydrographic surveys of Nizamasagar, results are available for four repeat surveys. Table-I indicate the rate of sedimentation in the period between successive repeat surveys which have a decreasing trend. The rate of sedimentation at the time of first surveys 1961 was 6.67 Hm/100 Sq. km / year, has come down to 2.783 Hm / 100 sq. km / year during the fourth repeat surveys of 1992.

3.2 The original capacity of Singur reservoir at FRL +534.60m was reported to be 847.M.cum. The present capacity as per the hydrographic survey of 1997 for the FRL +523.60m worked out to 800 M.cum (28.27 TMC).

Considering the present capacity of 800.6 M.cum (28.27 TMC) the loss in capacity comes to 46.42 M.cum (1.64 TMC) the average annual loss for 10 years (1987-1997) comes to (0.16 TMC) which works out to 0.55% of the original capacity.

Considering the free catchment area of 8679 Sq. km and 25% of the intercepted catchment of 7418 sq. km the rate of deposition comes to 5.59 Ham / 100 sq. km / year.

3.3 It may be seen from the result obtained by the hydrographic surveys in some of the medium reservoirs that there is variation in the rate of siltation with compare to designed value.

3.4.1. Hydrographic surveys of Tungabhadra reservoir having water spread area of 378 Sq. km were conducted jointly by the A.P. Engineering Research Labs and Karnataka Engineering Research Station using Digital Distance Measuring Unit (DDMU) having high frequency microwave trisponder systems. Horizontal measurements along 89 00 The range line are as long as 15.00 km. and it was found very convenient to get horizontal measurements even on these long ranges with the above equipment. The data obtained with regard to the areas of water spread are compared with those obtained in earlier surveys with conventional instruments. Which were found

to be in consistent (FIG. - 3).

3.4.2. Due to lack of proper horizontal control of the positioning of the boat, taking of soundings is in accurate by using conventional equipment. On the other hand positioning of the boat can be done precisely by using the DDMU. It is difficult to take soundings at closer intervals using the conventional equipment whereas the DDMU facilitates taking of soundings at closer intervals, which gives a fairly realistic picture of the bed profile. Though the cost of the conventional equipment is less, the results are not so accurate, whereas even though the cost of the entire HYDAC system is exhobbitant, a better cost effectiveness can be obtained by coupling its dynamic positioning system with the conventional system and a high degree of accuracy can be obtained. The conventional equipment may be used for smaller reservoir whereas for obtaining more realistic results a combination with the HYDAC positioning system may be better prospect. Moreover keeping in view the meager financial resources of the research stations under State Governments all over India, the acquisition of HYDAC system at exhorbitant costs by each state may not be viable. Hence based on the experiences of this study it is opined that if a positioning system which relatively costs-less is acquired by all the states and used in conjunction with the conventional equipments more accurate and realistic data may be obtained which may go a long way in monitoring our scant water resources.

CONCLUSION

4:1 The data indicated that the rate of sedimentation for reservoirs have much variation with the design value. It is therefore necessary to adopt the value as per the observed value of the respective catchment in the design of the reservoir.

4:2 It may be concluded from the above study that the rate of sedimentation in reservoir though found to be high in the early periods of their operation declines with the period of time.

4:3 It is concluded that the realistic and logical results can be obtained by using sophisticated equipment having precise horizontal and vertical controls like DDMU.

4:4 It is recommended to conduct the repeat Hydrographic survey at every 5 years to know the behavoir of sediment and to assess the capacity of reservoir.

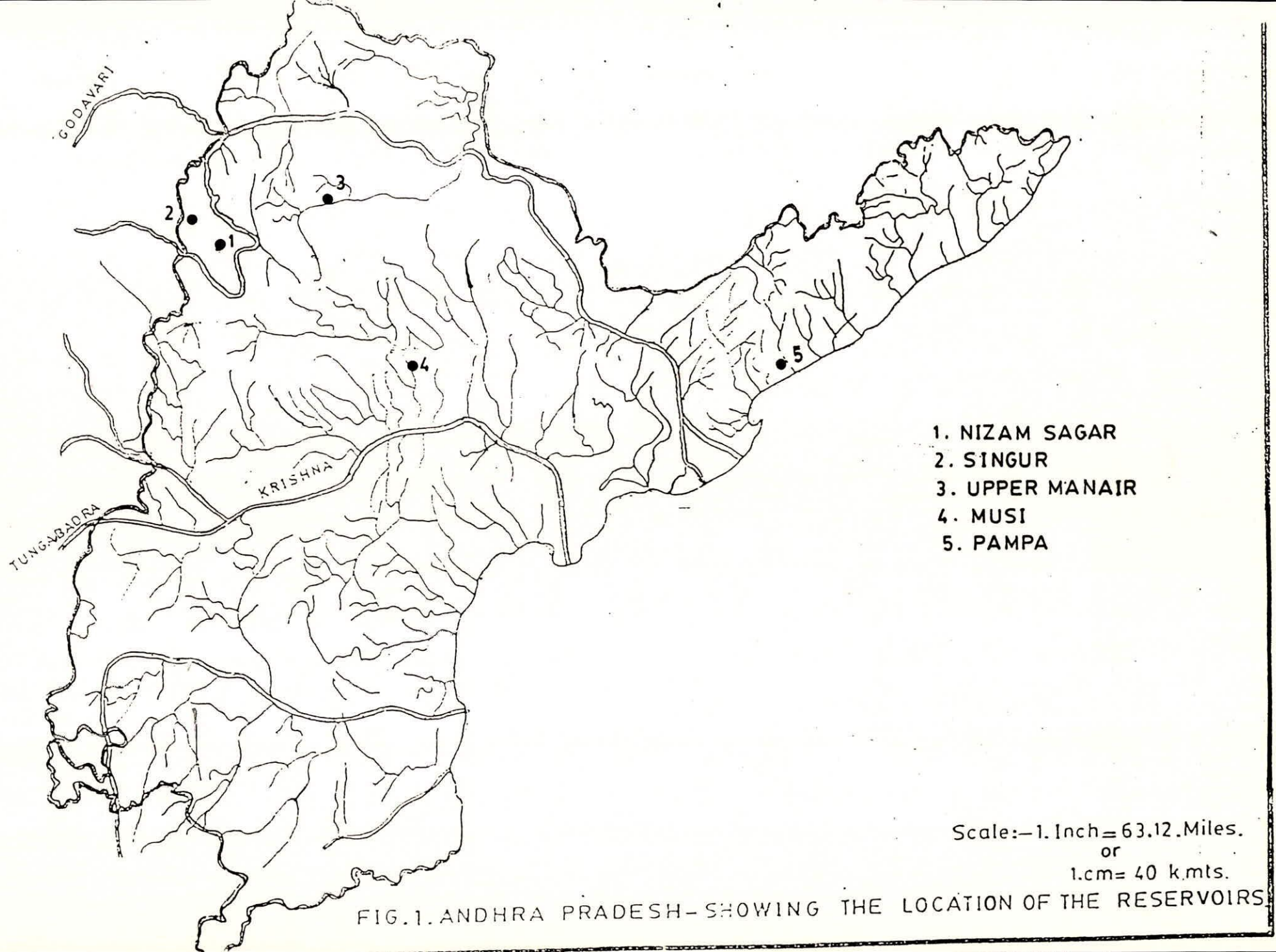

FIG. 1. ANDHRA PRADESH – SHOWING THE LOCATION OF THE RESERVOIRS

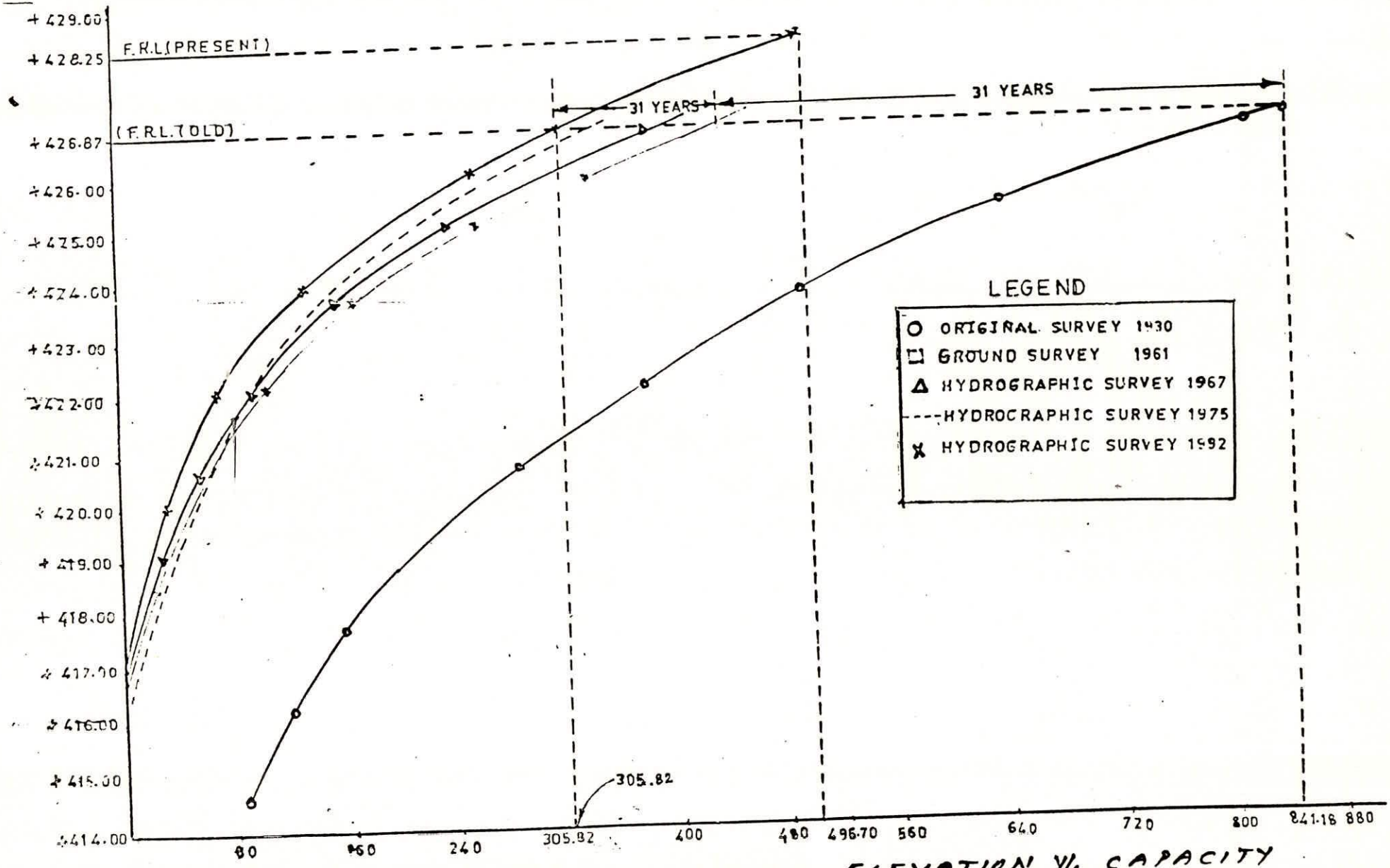

FIG: 2. NIZAM SAGAR RESERVOIR – ELEVATION V/S CAPACITY

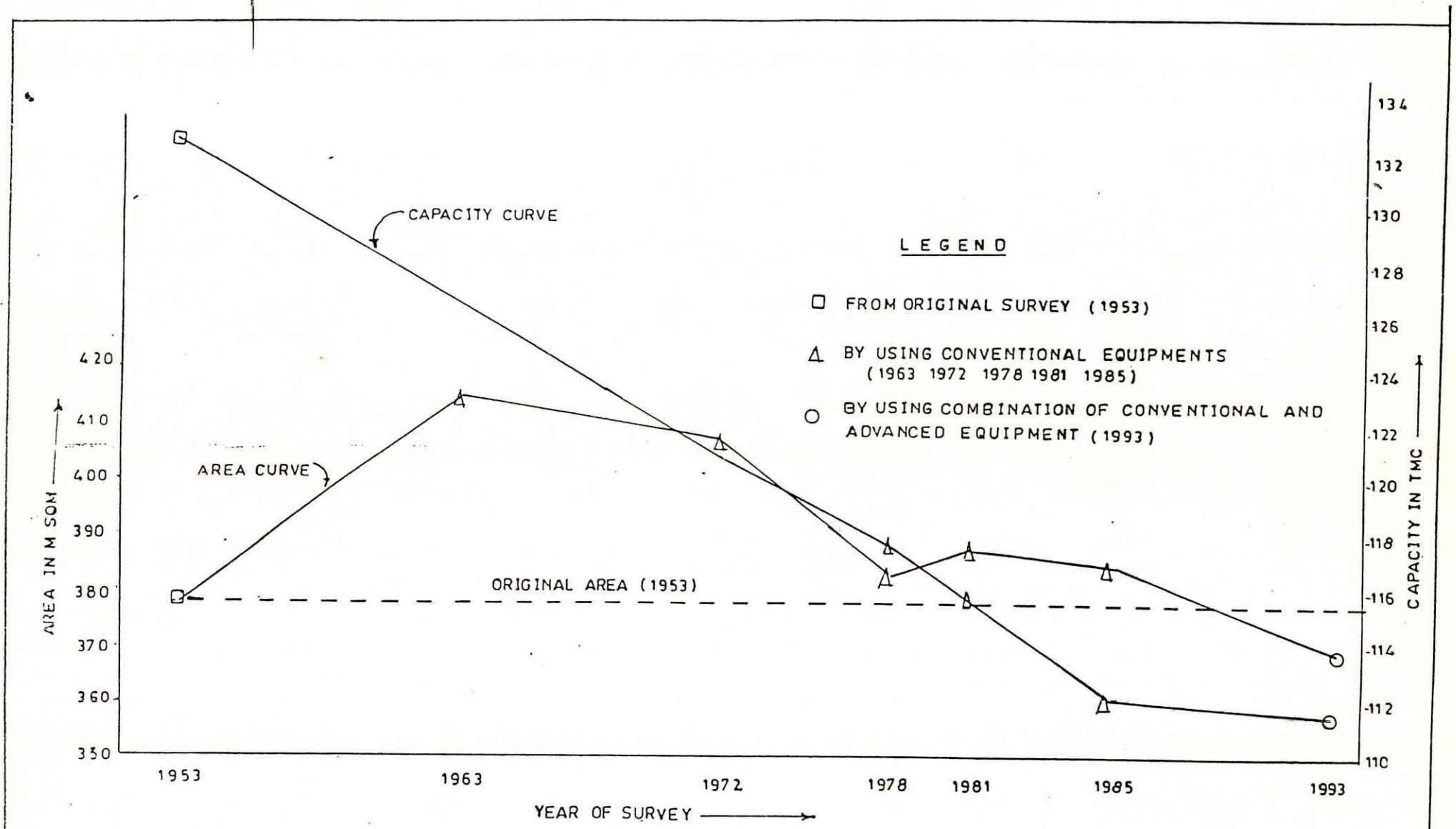

FIG. 3. TUNGABHADRA RESERVOIR – GRAPH SHOWING THE AREAS AND CAPACITIES OBTAINED FROM DIFFERENT REPEAT SURVEYS.

TABLE-I

Rate of Siltation observed from successive repeat surveys in some of the reservoirs of Andhra Pradesh

Sl. No.	Name of Reservoirs	Original Capacity in M.Cum. and year	Capacity in M.Cum. as per the hydrographic Surveys and year				Rate of Sedimentationin Hm/100 Sq.km. per year and number of year				Area of catchment Survey
			First Survey	second Survey	Third Survey	Fourth Survey	First Survey	second Survey	Third Survey	Fourth Survey	
1	2	3	4	5	6	7	8	9	10	11	12
1.	Nizam Sagar Reservoir	841.81 (1930)	451.67 (1961)	402.91 (1967)	362.40 (1975)	305.82 (1992)	6.670 (31)	6.370 (6)	5.740 (8)	2.783 (17)	18,523
2.	Signur Reservoir	847 (1987)					5.49 (10)				16,096
3.	Upper Manair Reservoir	84.97. (1950)	61.09 (1987)				5.531 (37)				2,174
4.	Musi Reservoir	142.31 (1954)	135.00 (1978)	134.15 (1982)	133.31 (1985)		1.580 (5)	1.417 (4)	1.320 (3)		2,056
5.	Pampa Reservoir	15.96 (1977)	15.32 (1982)	15.00 (1986)	14.84 (1990)		5.680 (5)	5.000 (4)	4.430 (4)		355

TABLE-II

RESERVOIR'S CONSIDERED FOR THE STUDY

Sl. No.	Name of Reservoir	Catachment area in Sq. km.	Capacity in M. cum.	Period of study years	Rate of sedimentation Ha.M/100Sq.km/ years	Dead Storage Lost %	Live Storage Lost %
1.	Upper Manair	777	61	1950-87 (37)	8.531	89.76	20.69
2.	Lower Manair	6465	672	1985-91 (6)	3.470	4.38	0.91
3.	Nizamsagar	21694	403	1930-92 (62)	4.225	99.03	54.28
4.	Kinnersani	1333	238	1970-85 (15)	0.613	3.20	1.21
5.	Kanigiri	163	181	1910-87 (77)	3.895	-	42.47
6.	Musi	2057	143	1966-88 (22)	1.682	29.55	4.10
7.	Thandava	451	140	1974-91 (17)	5.800	21.07	0.88
8.	Gajuladinne	1274	127	1978-92 (14)	9.530	100.00	8.98
9.	Tammileru	611	85	1977-87 (10)	8.050	0.31	2.58
10.	Kaddam	2656	78	1958-91 (33)	5.619	50.24	13.28
11.	Araniar	448	52	1958- 94 (36)	9.250	8.41	2.70
12.	Swarna	290	42	1977-87 (10)	6.199	13.68	2.15
13.	Mehadrigadda	352	33	1977-93 (16)	15.720	14.41	10.23
14	Konam	171	24	1975-92 (17)	11.190	51.13	9.50
15.	Pampa	352	16	1977-90 (13)	4.430	76.67	9.50
16.	Pocharam	673	13	1922-92 (70)	9.972	91.15	28.52
17.	Lower Sagileru	467	7	1957-93 (36)	0.920	95.11	16.66

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