A PRELIMINARY DESIGN REPORT
ON
THE KULIKHANI PROJECT
NEPAL

OVERSEAS TECHNICAL COOPERATION AGENCY

TOKYO, NOVEMBER 1963

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PREFACE

On the occasion of the royal visit of His Majesty the King of Nepal to Japan in April 1960, the premier of Japan expressed to the vice premier of Nepal, in response to the request, the willingness that the Japanese Government was prepared to render technical assistance. It was afterwards concluded that it was desirable to render the technical assistance in the field of the multipurpose water power development on a small scale. Along this line, the technical investigation teams were sent to Nepal twice, in 1960 and 1962, and good results were achieved. In succession to the above, the Survey Team for the Kulikhani Project was dispatched this year.

The Kulikhani Project was originally explored in 1956 by the Swiss-Nepal Forward Team, and have since been noticed as a promising development plan in the central Nepal. Recently it was keenly felt that the development of this project was necessary due to the growth of power demand in the Kathmandu area as well as in Hitaura area, new industrial center. Under these circumstances, His Majesty's Government expressed its desire to seek assistance from Japan for the implementation of the survey of this project. The Government of Japan, in response to this desire, entrusted the Overseas Technical Cooperation Agency with the task of dispatching the necessary personnel. The Agency organized the Survey Team for the Kulikhani Project and dispatched it to Nepal.

The Team consisted of the following members.

Takao Ichimiya, Chief of the Team, Civil engineer,	Nippon Koei Co., Ltd.
Masanobu Sakaita, Geologist	Nippon Koei Co., Ltd.
Yoshiro Murano, Erosion control engineer,	Technical Research Institute, Ministry of Construction
Motoo Okada, Mechanical engineer,	Kawasaki Heavy Industry Co., Ltd.
Kazuyo Iwabuchi, Civil engineer	Nippon Koei Co., Ltd.
Kazuo Koike, Boring engineer	Kawai Boring Co., Ltd.

The field investigation by the Team was carried out from February to May 1963. In close association with the Electricity Department of the H.M.G. of Nepal, the Team could accomplish all the field works necessary for the preparation of the Preliminary Design Report during its stay in Nepal, and the works for the preparation of the Preliminary Design Report were entrusted to Nippon Koei Co., Ltd. The works were completed in November 1963 under the leadership of Mr. Yutaka Kubota, the President of the same firm, cooperated in the main by the Team members.

The Kulikhani Project has its main purpose in the power generation. This Project will sufficiently meet the future increase in power demand in the central Nepal. Moreover, there are more possibilities of power generation development on its lower reaches. Therefore, this Project is worthy of recommendation as an initial development.

In general, the mountain areas in Nepal are rather in seriously devastated condition, but no investigation has ever been made. The works carried out by the Team in this aspect are compiled in the same Report as the first treatise ever submitted to Nepal on this serious problem deducing from the Kulikhani basin.

ACKNOWLEDGEMENTS

The cooperation to the Japanese Survey Team during its stay in Nepal provided by Mr. Ram Prasad Nepal, Chief Engineer, Department of Electricity, and by the members of the same Department especially Mr. Purna Prasad Adhikari, Acting Division Engineer, Division 3 of the same Department, are gratefully acknowledged.

We are indebted to Mr. Deniel Emil Havelka, Hydraulic Engineer, United States Aid Mission to Nepal, for the assistance he provided in connection with the discharge measurement and also to Mr. Alf de Spindler, Diplomatic Civil Engineer F.U.H.T. and the then Project Manager of Karnali Project from the United Nations, and to the Swiss Federal Institute of Technology for their works which preceded ours especially for the topographic maps of the project area they prepared.

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CONTENTS

PRECIS

The Kulikhani project area is located about 30 kilometers to the Southwest of Kathmandu city, the capital of the Kingdom of Nepal. The Kulikhani river is a tributary of the Bagmati river which drains the Kathmandu valley and flows down southwards to the Indian border. About 5 kilometers to the south of Kulikhani river, there flows another river, the Rapti river, which belongs to the Gandak river system. The main purpose of the Kulikhani project is the power generation by diverting the run-off of the Kulikhani river through a short-cut tunnel to the Rapti river and utilizing the available drop inbetween.

The Kathmandu valley including Kathmandu city is the most densely populated area in Nepal with some half a million of heads. This area already has a total power generation capacity of 4,800 kilowatts against the present peak demand, estimated at some 6,000 kilowatts. For this shortage of power, the unavoidable adjustment have to be made at the existing power stations by dropping the voltage. Under such circumstances, it is prohibited to cater to new consumers though a good many people want the electricity. Thus the peak demand including the latent demand will easily exceed 10,000 kilowatts even at the present stage.

In the Kathmandu valley and its vicinity, several power schemes are proposed. The leading projects are Trisuli hydroelectric project (18,000 kilowatts) and Panauti hydroelectric project (2,400 kilowatts), both of which are under construction.

The Hitaura area, about 60 kilometers to the southwest of Kathmandu en route to the Indian border, is designated as an industrial center by the Government, and various factories and mills are proposed here of which plannings are all finished and the construction is to be started soon. But there is no power source now, hence a diesel power station of 4,500 kilowatts in capacity is proposed.

In addition, the construction of transmission line connecting Kathmandu to Hitaura and further to Birganj (Indian border) is proposed. If everything goes smoothly, according to the above plans, both old and new power stations, about 22,000 kilowatts in total capacity, will be connected by one transmission line in 1965.

According to our demand forecast, however, this capacity will soon run short most probably in around 1968 because both the general and industrial demands will remarkably increase in response to the increase of the power source.

Accordingly in planning the Kulikhani project, it is essential to utilize the potentiality as fully as possible. In this sense, the project became larger than it was thought before. Not only the main stream but also two adjoining tributaries are diverted. The following is the outline of this power scheme.

(1) Water source

Basin	Catchment area(km^2)	Run-off (m^3/sec)	
		Annual mean	Minimum
Kulikhani river	120	3.2	0.9
Chakhel river	30	0.8	0.2
Sim river	7	-	0.2
Total:	157		

(2) Reservoir

H.W.L. : EL. 1,570 m

L.W.L. : EL. 1,533 m

Drawdown : 37 m

Capacity : Gross 40,600,000 m^3

Dead 8,500,000 m^3

Effective 32,100,000 m^3

Regulated firm continuous discharge from reservoir: 3.3 m^3/sec.

(3) Main dam

Type : Rockfill

Crest elevation : 1,573 m

Crest length : 190 m

Crest width : 6 m

Height : 85 m

Dam volume : 1,550,000 m^3

Type of spillway : Side spillway

Capacity of spillway : 1,200 m^3/sec at H.W.L.

(4) Waterway system

* From Chankhel Khola : 1.2 km long tunnel, 2.5 m dia. with intake structures

Main tunnel : 4.7km long tunnel, 2.5 m dia.

From Sim Khola : Vertical shaft with intake structures

Surge tank : Restricted orifice type, 8 m dia.

Penstock : Tunnel penstock, 1 line, 843 m long

(5) Power generation

Rated head : 440 m

Maximum discharge : 7.6 m^3/sec

Type of turbine : Vertical shaft Pelton

* Installed capacity : 26,000 kW (2 x 13,000 kW)
Firm output : 11,000 kW
Possible energy output : 116,100,000 kWh at station terminal

(6) Transmission line
Extension : 30 km to Kathmandu
22 km to Hitaura
Substation : at Kathmandu and Hitaura

The total construction cost is estimated at 16.55 million U.S. Dollars equivalent for the dam and power generation feature, and 1.65 million U.S. Dollars equivalent for the transmission feature.
Hence the construction cost per kilowatt-hour excluding the transmission feature becomes 14.3 Cents. Supposing the interest rate of the introduced fund is 5.5 per cent and the yearly amortization rate 1.38 per cent together with the operation cost, the power cost is calculated at 1.09 Cents per kilowatt-hour. As present power cost at Kathmandu is about 5 Cents per kilowatt-hour mainly due to the imported fuel, this cost can be judged very cheap.

For the purpose to just meet the future demand and to reduce the initial investment, it is recommended to divide the whole construction works into two stages. The first stage development excludes one unit of turbine and generator and the Chakhel Khola intake and tunnel (marked with *). The construction cost for the first and second stage developments are 14.55 and 2 million U.S. Dollars equivalent respectively.

As the whole construction works (or for the first stage development) including the preparatory works will take 4 years it is recommended to commence the first stage development in 1964 or at the latest in 1965 so as to overcome the shortage of power which may appear in around 1968 and to commence in 1970 the second stage development which needs about one full year.

The Rapti river downstream from the power station site to Hitaura has a head of more than 600 meters. Therefore it is possible to develop the power on this river with an aid of diverted discharge from Kulikhani river. By a series of another two power projects, it is possible to develop the additional installed capacity of 44,000 kilowatts with a total construction cost of some 19 million U.S. Dollars equivalent and the possible annual output of some 195 million kilowatt-hours will be available. Then the overall construction cost including the Kulikhani project becomes as cheap as 11.4 Cents per kilowatt-hour on an average.

Prior to the present investigation, it was presumed that the silting of Kulikhani river was very serious. But upon investigation, it was found that the silting had no serious problem. Therefore, the life of the dam is considered to be very long.

The Rapti basin is in a state of so serious devastation that it is desirable to take necessary countermeasures. This report gives in Appendix II a sample design of Sabo scheme (comprehensive erosion control scheme) for Khani Khola near Bhimphedi from which the general countermeasure can be deduced.

As for the transmission line it is recommendable to utilize the route of the old rope-way but without utilizing the old structures, because such is the best way to minimize the construction cost. (Refer to Appendix I).

Concerning this project, there is a possibility to improve the traffic problem between Hitaura and Kathmandu. But this needs a great amount of construction cost separately. Therefore, it will be difficult to realize it as an incidental work of the Kulikhani project. However, the construction machinery or temporary installations for the Kulikhani project after its completion will become a great help to the realization of this problem (Refer to Appendix I).

Thus it is concluded that this Kulikhani project is an excellent project worthy of realization.

CHAPTER 1

INTRODUCTION

1.1 Nepal is situated inland in the Asian continent between India and Chinese Tibet. It is somewhat parallelogram in shape extending from northwest to southeast approximately 800 kilometers long and 180 kilometers wide. With a total area of 140,700 square kilometers, Nepal is located between east longitude 80° and 88° 15' and north latitude 26° 30' and 30° 15'. Nepal has a population of about 9 millions.

1.2. Nepal is world famous mountainous country. In parallel with the direction of longitudinal axis of the country, three mountain ranges run, namely the Siwalik, the Maha Bharat and the Himalaya from south to north. By these mountain ranges, Nepal is divided into four typical regions.

The Kathmandu valley is situated just north of the Maha Bharat mountain range and at about one third point from the east end of the longitudinal axis. This Kathmandu valley, about 600 square kilometers within its watershed border, forms the center of Nepal where three cities of Kathmandu, Patan and Badgaon are swarming like one city with a population of some half a million.

1.3 The Kulikhani project area is located some 30 kilometers southwest of Kathmandu. The Kulikhani river is a tributary of the Bagmati river which drains the Kathmandu valley, reaches south to the Indian border and finally joins to the Ganges. The catchment basin of the Kulikhani river, approximately 120 square kilometers at the proposed dam site, lies adjacent to the Kathmandu valley on its southwest side.

At about 6 kilometers southwest of the proposed dam site, there is Bhimphedi town along the Rapti river. The Rapti river belongs to the other river system of the Gandak which drains the central part of Nepal and joins also to the Ganges.

Between the river bed elevations of the Kulikhani river at the proposed dam site and the Rapti river near Bhimphedi town, there is a difference of height by some 350 meters.

1.4 About 30 kilometers from Bhimphedi town, a new town of Hitaura lies. Hitaura is situated in a valley between the Maha Bharat and Siwalik mountain ranges. This area is designated as an industrial center of Nepal. Various factories and mills such as cement, paper, soap, textile, sawing and so forth are proposed here. Their planning is almost completed and construction work is expected to start soon.

1.5. Nearly the whole area of Nepal is occupied by high and irregular mountains in heaps, hence the communications and inner traffics in Nepal have been put to extreme inconvenience. The means of traffic is generally footpaths and roads, only for pedestrians and pack animals. But a few exceptions are seen mainly in central Nepal in such an example as the paved road called the "Tribhuban Rajpath Road" from Kathmandu to Bhainse Dobhan, the road from Bhainse Dobhan to Bhimphedi and the road from Bhainse to Birganj (Indian border) which are motorable and two lines of old and new long ropeways to Kathmandu, the old one starting from Dharsing and the new one from Hitaura, as well as a small scale railway in the southern plain. Thus Bhimphedi town is accessible by car both from Kathmandu and the Indian border.

1.6 Nepal as a whole is formed of steep mountain area which are subjected to serious erosion. Added to this, the inhabitants of not only the Kulikhani basin but of the whole Nepal generally have little understanding of the forest. Farming and stockbreeding are performed on the areas which ought to be preserved in a form of forest. The consequence is as follows.

1) Unfavourable condition of river flow, mainly unfavourable for the hydroelectric power and irrigation developments.

2) Frequent disasters which are often serious and irreparable caused by the landslide, landslip or mud flow. The recent example was seen at Trisuli.

3) Instability of river bed and river course due to the discharging of sand and gravel from these head erosion, landslide and landslip. The damage by flood is accelerated by them. This example is seen near Adhamar village near Hitaura on the Rapti river.

This unfavourable consequence is still progressing, but neither treatment nor investigation have ever been made.

1.7 The Kulikhani project was originally explored by the Swiss-Nepal Forward Team in 1956. This Team prepared a map of the project area on the scale of 1 on 10,000 and drew out its plan based on this map. This plan intended to develop two power stations to utilize the total available head, and a part of the waterway tunnel was to serve also as the traffic tunnel to open a highway to Kathmandu which has not been accessible by car from India at that time. The planned installed capacities of these two power stations were 2,900 kilowatts (upper stage) and 6,600 kilowatts (lower stage) totalling 9,500 kilowatts.

By this planning, the Kulikhani project has since been noticed as a prominent development plan in the central Nepal.

1.8 The main purpose of the Kulikhani project is power generation. As more than twelve years have passed since the original plan of the Kulikhani project has proposed, the demand for the electric power has now grown remarkably. Therefore, the Japanese Team treated this project from a little different viewpoint, mainly aiming at utilizing the maximum of potentiality.

The layout of the proposed scheme is as follows. (Drawing No.1 and 2 may be referred).

1) To create a reservoir by constructing a high dam on the Kulikhani river. This reservoir is capable of the run-off regulation throughout the year. The run-off of the two adjoining tributaries are also taken.

2) To divert the regulated discharge to the Rapti river, and generate power. The available head is about 440 meters for the first stage, but there is additional head of about 600 meters in the lower reaches in two more stages. Thus the total head of more than 1,000 meters is available.

3) To transmit the generated power to the Kathmandu area and Hitaura area which are both situated near the project area.

1.9 The field survey by the Japanese Survey Team for the Kulikhani project was performed from the beginning of February 1963 to the beginning of May 1963, closely associated with the Electricity Department of the H.M.G. of Nepal.

The Team consisted of six members in total, two civil engineers, one erosion control engineer, one mechanical engineer, one engineering geologist and one boring engineer. The team could complete all the field surveys necessary for the preparation of the preliminary design report during its stay in Nepal. The following is the outline of the works which they have done in Nepal.

1.10 Topographic survey: The field survey was made on the basis of the 1 on 10,000 topographic map initiated by the Swiss-Nepal Forward Team in 1956 which was found to be very accurate by the survey of this time. The Team executed necessary levellings, topographic survey of the proposed structure sites and river profile survey of relevant portions of the Kulikhani river and Rapti river. The main results are compiled in Appendix III.

1.11 Geological survey: By the engineering geologist, the geological reconnaissance was carried out all over the project area. The test drillings by the boring engineer were executed at 5 points namely, two on the upper dam site, two on the lower dam site, and one on the then proposed power station site.

The total depth of the above boring amounts to 41.4 meters. The results are drafted in the columnar sections and compiled in Appendix III.

1.12 Erosion control survey: By the erosion control engineer, the reconnaissance was carried out on the wide areas given below.

1) All the catchment basin of the Kulikhani river upstream from the dam site and downstream from the dam site down to the confluence with the Bagmati river.

2) The catchment basin of the Rapti river down to Bhainse Dobhan.

At the beginning of the above work, it was presumed that the silting of the Kulikhani river would be very serious, but upon the reconnaissance it was found that the silting in the upper reaches had no serious problem. Hence, after the reconnaissance the survey was made on the huge landslide area near Chisapani Garhi for the purpose of preparing an example of the comprehensive erosion control works, (Sabo works).

The results of the reconnaissance are compiled in Appendix III, and the general recommendations on the erosion control with an example design are compiled independently in Appendix II as a first report treating of this problem in Nepal.

1.13 Transmission line survey: The reconnaissance and survey along the proposed route of the transmission line from Hitaura to Kathmandu were performed by the Team. This route was selected almost on the route of the old ropeway for the purpose to compare two alternatives, - one to construct newly on this route and the other to improve the existing structures of the old ropeway for the transmission line when the old ropeway is substituted by the new ropeway. For the latter, precise study on the existing structures of the old ropeway was also performed. The recommendations are compiled in Appendix I.

1.14 Collection of data: The team collected necessary data such as meteorologic and hydrologic data required for the project planning, existing bibliography on the relevant lines, information about the existing power generation, irrigation and communication facilities. The collected data, on the whole, are not to the amount expected before.

Some of these data directly necessary for the project planning are compiled in Appendix IV.

1.15 Preparation of report: After the Team completed the field investigation, all the works necessary for the preparation of this report was carried out mainly by the Nippon Koei Co., Ltd., a consultant firm in Tokyo, under the direction of Mr. Yutaka Kubota the President, with the cooperation of the Team members.

1.16 In addition, as a merit derived indirectly from the Kulikhani project, there is a possibility to open a new highway along the former main footpath from Bhimphedi to Kathmandu. As the Tribubgan Rajpath road is not satisfactory in its function, this proposed highway will remarkably improve the traffic condition to Kathmandu. This proposal is included in Appendix I.

CHAPTER 2

GEOLOGY AND HYDROLOGY

2.1 The Kulikhani river has its source in the mountains in the Maha Bharat mountain range by which the Kulikhani basin adjoins the basin of the Bagmati river (Kathmandu valley), the Trisuli river and the Rapti river. And, this river has no glacier source like the other big river systems in Nepal. Consequently, the run-off is directly influenced only by the rainfall in the catchment basin which is 120 square kilometers at the proposed dam site.

2.2 The catchment basin, which forms part of the Maha Bharat mountain range, consists of shale, slate, sandstone, chert, schist, formations of sandstone-slate alternates and granite which intrudes into it.

The intrusions of sulphite ore are often seen along the bedding plane in the thin-bedded slate and it forms the copper deposits at several locations in the catchment basin where mining works were made before. In some villages near such deposits, some traces of smelting in a primitive process are still seen.

The reconnaissance was made on some of the deposits expecting that these deposits might be exploited profitably when the hydropower will be developed and the traffic condition improved. But these deposits were in poor grade everywhere and ore reserve is very small, therefore it would be almost impossible to develop them economically.

The geological details on each structure sites are given in the relevant paragraphs.

2.3 The vegetation in the catchment area is generally poor as a result of artificial deforestation for a long time, but the erosion of mountain slopes are comparatively not very serious.

A footpath runs through the catchment area. Before the completion of the Tribhuban Rajpath road some ten odd years ago, this route was the main road connecting Kathmandu to Bhimphedi and further to the Indian border. This route runs along the proposed sites for structures of this project such as dams, penstock and power station. Today, however, this route is used only by few pedestrians and pack animals.

2.4 As to the meteorology in the Kulikhani basin, no observations were ever made before, and accordingly nothing is known on this matter. But in view of its propinquity and similarity in altitude and latitude to the Kathmandu valley, it is possible to consider that the meteorology in this basin closely resembles that in the Kathmandu valley.

At Kathmandu, meterologic observations have been made to some extent. Figure 2.4.1 shows the temperature and relative humidity there. These areas are considered to have a continental subtropical climate under the influence of the monsoon.

2.5 At Kathmandu, the observation of rainfall was continued for about 60 years. Although not all of the detailed data was available, the Team could collect a good deal of data enough to get an idea of the trend of precipitation. These data are compiled in the Appendix IV together with other necessary data, and the known mean monthly precipitations are as in Table 2.5.1.

Fig.2.4.1.

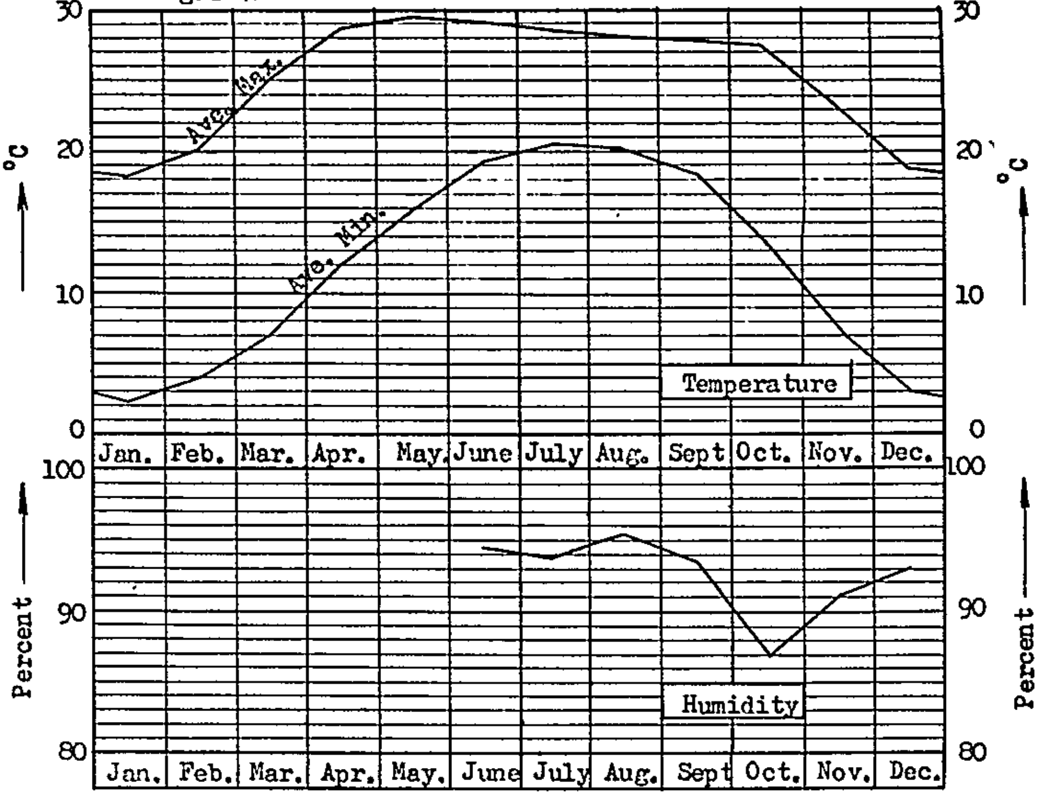


Table 2.5.1.

(Unit: mm)

Month	Average of 29 years ending 1940	Average of 40 years ending 1940
Jan.	25	27
Feb.	22	6
Mar.	28	33
Apr.	49	49
May	102	105
June	234	226
July	379	352
Aug.	372	373
Sept.	187	152
Oct.	58	51
Nov.	4	4
Dec.	8	4
Total:	1,468	1,382

As seen in this table the monsoon usually lasts for 5 months from May to September. This period is the rainy season and the remaining 7 months are the dry season. The rainy season precipitation accounts for more than 85 per cent of the total yearly precipitation.

2.6 At Kulikhani dam site, the run-off measurement has been executed since December 1962 by the Electricity Department with an automatic water gauge and periodical discharge measurement with a current meter. The availed data are fully dependable.

Besides, there are some records of the discharge measurements made in and around the Kathmandu valley, covering the latter half of 1952 at 9 stations such as Chabar, Sundarijal, etc.

These data afford good reference, when it is assumed that the hydrology in the Kulikhani basin resembles that in the Kathmandu basin, even though they are insufficient in the period covered for establishing an excellent plan of hydro power-project, for which discharge records covering good many years are indespensable.

2.7. It is easily supposed that about 80 per cent of the annual run-off of the Kulikhani river is concentrated in the 5 months of the rainy season, and that the run-off becomes small and constant in the dry season because the run-off of dry season solely depends upon the underground water of the mountains whose holding capacity of the underground water is constant. Hence, it is reasonable to consider that the obtained discharge data of the Kulikhani river, which was actually measured in the dry season of this year, stand for the minimum run-off in every dry season. The driest monthly mean discharge is around 0.9 cubic meter per second.

Therefore, it is essential to estimate the monthly mean discharge of the rainy months in a normal year.

2.8 The following Table 2.8.1 shows the discharge records around Kathmandu valley measured in the latter half of 1952 computed into the specific run-off from 100 square kilometers. The locations of these gauging stations are shown on Fig. 2.8.1.

Table 2.8.1.

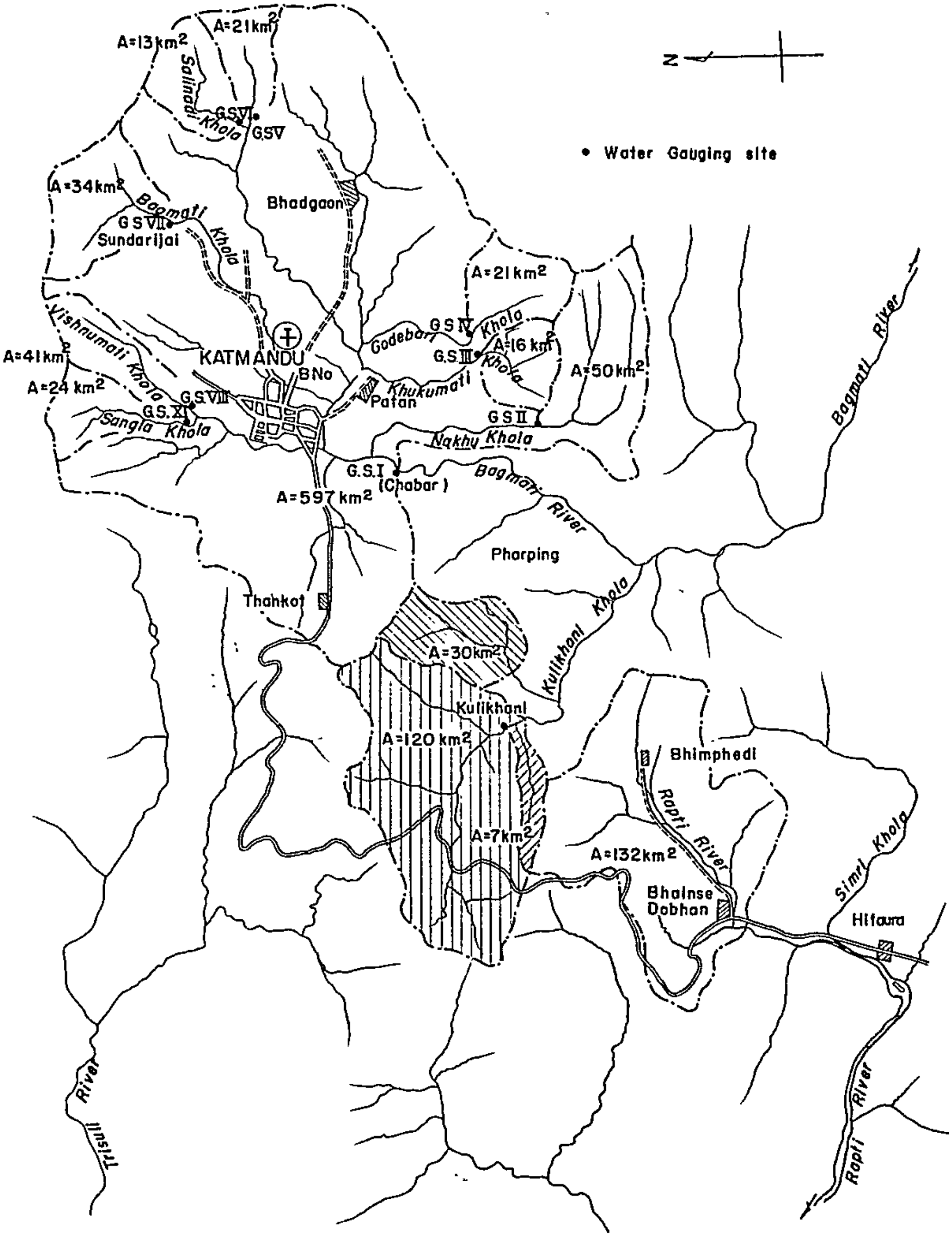
(Unit: $m^3/sec/100\ km^2$)

Station No.		I [1]	II	III	IV	V	VI	VII [2]	VIII	IX
Catchment area (km^2)		597.0	49.9	16.2	21.4	20.7	13.0	33.7	41.4	24.6
	June	1.61			2.92		2.48	3.35		
Run-off	July	7.62			4.36	4.05	7.34	14.15	4.76	6.22
in	Aug.	11.19		11.99	9.67	7.54	17.38	28.33	7.34	14.96
	Sept.	9.41	12.04	8.46	7.85	9.52	16.69	25.28	5.75	9.59
1952	Oct.	2.53	4.64	3.11	2.50	2.19	4.70	7.63	1.83	2.91
	Nov.	1.81	2.18	2.06	1.08	1.65	2.90	3.80	1.01	1.41
	Dec.	0.63	1.87	1.85	0.89	1.19	1.98	2.54	0.50	0.74
Location		← Southern part in Kathmandu valley →				← Northern part in Kathmandu valley →				

[1] at Chabar

[2] at Sundarijal

Fig. 2. 8. 1.


N
• Water Gauging site
A=13km²
A=21km²
Salinadi Khola
G.S.VI
G.S.V
Bhadgaon
A=34km²
Bagmati Khola
G.S.VII
Sundarijal
A=21km²
Godebari Khola
G.S.IV
G.S.III
A=16 km²
Khola
A=50km²
Vishnumati Khola
A=41km²
A=24 km²
KATMANDU
B.No
G.S.VIII
G.S.XI
Sangla Khola
Khukumati
Patan
G.S.II
Nakhu Khola
G.S.I
(Chabar)
A=597 km²
Bagmati River
Bagmati River
Pharping
Thahkot
Kulikhani Khola
A=30km²
Kulikhani
A=120 km²
A=7km²
Bhimphedi
Rapti River
A=132km²
Bhainse Dobhan
Simri Khola
Hitaura
Rapti River
Trisuli River

The monthly rainfall in 1952 which corresponds to the above is as in Table 2.8.2.

Table 2.8.2.

(Unit: mm)

Year	Month	Monthly Rainfall	Accumulation
1952	Jan.	4	4
	Feb.	9	13
	Mar.	56	69
	Apr.	80	149
	May	116	265
	June	170	435
	July	287	722
	Aug.	327	1,049
	Sept.	220	1,269
	Oct.	0	1,269
	Nov.	7	1,276
	Dec.	0	1,276

2.9. Out of the 9 stations in Table 2.8.1, station No.1 at Chabar is considered to most resemble to Kulikhani in the pattern of run-off because the catchment areas of the other stations is very small. And from Table 2.8.1, it is found that the run-off from northern part of the Kathmandu valley is greater than that from southern part. And the run-off at station No.1 contains both of them.

For the purpose to make the run-off pattern at station No.1 more like that at Kulikhani, an adjustment is preferably made by means of the proportional allotment by area of catchment basin. The following table show thus adjusted values of station No.1

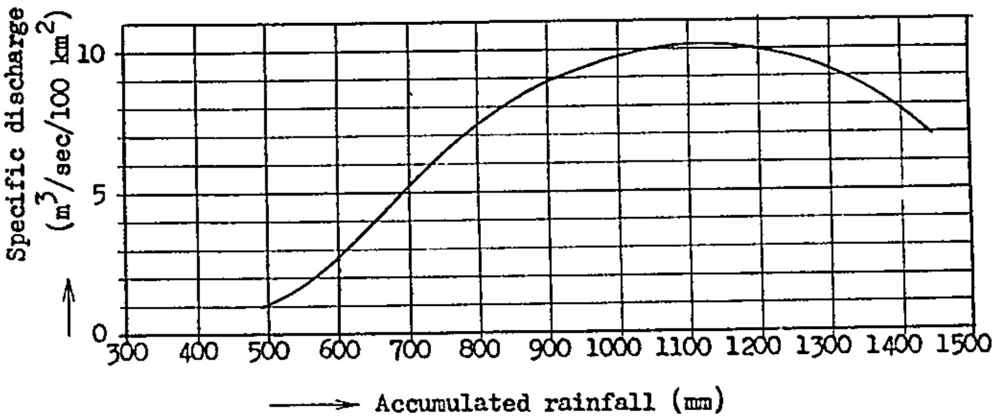
Table 2.9.1.

(Unit: $m^3/100\ km^2$)

Year	Month	Adjusted monthly mean discharge
1952	June	1.46
	July	7.70
	Aug.	10.06
	Sept.	8.27
	Oct.	2.16
	Nov.	1.71
	Dec.	0.80

Assuming that the values in the above table stand for the monthly mean discharges at Kulikhani, the relation between these values and the accumulated rainfall is graphed as follows.

Fig. 2.9.1.



2.10. Next, it is necessary to assume the precipitation in the normal year. In our case, it is reasonable to find the most frequent value (which has 50 per cent frequency of appearance) of the monthly rainfall in each month, and to establish an assumed year having these values as the respective monthly rainfalls. And the following is the monthly rainfall of thus established normal year.

Table 2.10.1

(Unit: mm)

Month	Monthly rainfall	Accumulation
Jan.	9	9
Feb.	12	21
Mar.	25	46
Apr.	25	71
May	94	165
June	173	338
July	325	663
Aug.	302	965
Sept.	127	1,092
Oct.	19	1,111
Nov.	0	1,111
Dec.	0	1,111

2.11 The following table shows the monthly mean discharges of the Kulikhani river at Kulikhani (120 square kilometers in catchment area) together with those of the adjoining tributary Chakhel Khola at the proposed intake site (30 square kilometers in catchment area), in the established normal year of precipitation.

Table 2.11.1

(Unit: m^3/sec)

Month	Monthly mean discharge	
	Kulikhani river	Chakhel Khola *
Jan.	1.1	0.4
Feb.	1.0	0.3
Mar.	1.0	0.3
Apr.	0.9	0.2
May	1.3	0.3
June	1.5	0.4
July	5.6	1.4
Aug.	13.0	3.2
Sept.	6.4	1.6
Oct.	3.2	0.8
Nov.	1.8	0.5
Dec.	1.4	0.4
Yearly mean	3.2	0.8

* Khola: River in Nepalese

For the dry months, the actual data were used, and for the rainy months, readings on the graph in Fig. 2.9.1 by the accumulated rainfall in Table 2.10.1 were used. And for the transient months inbetween, further reasonably adjusted values were taken.

These values are used for the project planning later. Now it must be noticed that these values might show some difference from the real values when run-off measurement for many years are performed. But this, if happens, have to be attributed to the insufficiency of data available this time.

2.12 As to the probable flood discharge necessary for the design of spillway of the dam, it is impossible to directly estimate the value due to insufficiency of the discharge data and absolute lack of the daily rainfall data. But by the following reasons, the value is indirectly estimated at 1,200 cubic meters per second.

1) The past flood mark of the Kulikhani river at Kulikhani village was indicated by the old villagers there. At the same time, the cross section of the river at the respective point and the slope of the river were measured. Basing on these data, the past maximum flood discharge can be calculated but the estimated value cannot but fluctuate according to the values of the coefficient of roughness. The estimated value is at most 1,000 cubic meters per second.

2) The above value must have been the largest flood in the past several decades that are covered by the memory of the old villagers. Accordingly, the value 1,200 cubic meters per second including some surplus on the above value is considered to be the largest value in a period several times the length of the above period.

3) On the other hand, 1,200 cubic meters per second from 120 square kilometers of basin give a specific flood run-off of 10 cubic meters per second per square kilometer. This value of specific run-off is considered adequate in view of the size of the basin, land aspect in the basin and the shapes of mountains of the basin.

CHAPTER 3

FUTURE POWER DEMAND IN CENTRAL NEPAL

3.1. The hydro-electric power development scheme was originally proposed by the Swiss-Nepal Forward Team around in 1956. The original plan proposed two power stations to utilize the total available head but it was not on a scale to fully develop the potentiality.

This time, however, this scheme has to be treated from a little different viewpoint, as stated before, for the purpose to fully utilize the potentiality because of the recent development of social situation in Nepal, and the consequent rapid growth of demand for the electric power.

3.2. In the Kathmandu valley which contains some half-a-million population, there are already several small power stations, of which the total installed capacity is about 4,800 kilowatts as listed below.

Table 3.2.1.

Classification	Name of power station	Installed Capacity (kW)
Hydro	Sundarijal	900
	Pharphing	500
Diesel	Kathmandu	1,688
	Teku	500
	Lainchaur	500
	Naksol	500
	Bhaktapur	250
Total:		4,838

In Hitaura, the proposed industrial center, there is no power source at present. In Birganj, the town on the Indian border, there is a diesel power station of 50 kilowatts only.

3.3. On the other hand, in the central Nepal, some power projects are proposed and some of them are already under way. They are summarized in the following table.

Table 3.3.1.

Location	Name	Classification	Installed capacity (kW)	Remarks
Kathmandu	Trisuli	Hydro	9,000 (3 x 3,000)	Under construction
Valley and vicinity	Panauti	"	2,400 (wet season) 1,600 (dry season)	
"	Patan	Diesel	1,470	Proposed
"	Taro Khola	Hydro	500	Planned only
Hitaura	Hitaura	Diesel	4,410 (3 x 1,470)	Proposed
"	Birganj	"	500	"

Trisuli power project, about 50 kilometers from Kathmandu is now under construction with the Indian aid. The construction works of the Panauti project have also commenced recently with the aid of U.S.S.R. It is said that both projects will be brought into operation in 1965 when everything goes smoothly.

On the other hand, a transmission line connecting Hitaura with Kathmandu is proposed and its field survey was almost finished, and it is said that a part of construction work will be commenced soon.

3.4. In Kathmandu area, the total installed capacity of the generating facilities at present is some 4,800 kilowatts as aforementioned. On the contrary, the peak demand is estimated at 6,000 kilowatts, though officially expressed to be 3,200 kilowatts. Hence, the unavoidable adjustment for the lack of generating capacity has to be made at the power station side by dropping the voltage. In consequence, it is prohibited to cater to the new consumers though good many people want electric power. Including these latent demands, the demand in the Kathmandu area alone will easily exceed 10,000 kilowatts even at the present stage.

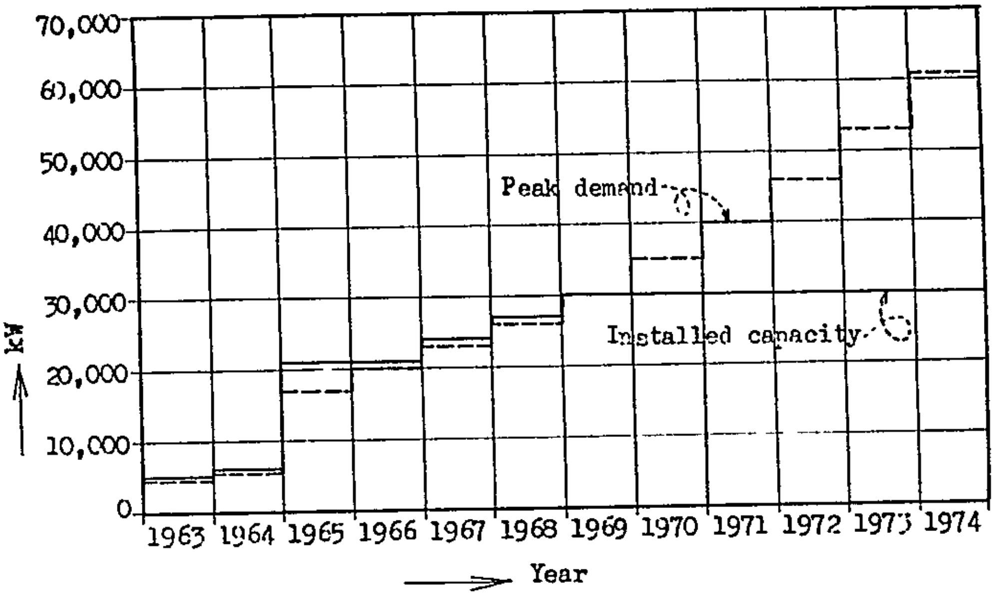
In the Hitaura industrial center, the power demand is estimated as listed in the table below after the completion of these factories and mills of which planning is almost completed and the construction works are expected to start soon.

Table 3.4.1.

Description	Power demand (kW)
Cement factory	6,000
Paper factory	1,000
Soap factory	100
Saw mill	500
Textile mill	1,000
Total:	8,600

3.5. As the situation is as aforementioned, the relation between supply and demand in the central Nepal is at present considered to be not systematized yet. Therefore it is rather difficult to forecast the exact relation between the peak demand and supply of the future. But the relation will grow, more or less, as illustrated below, provided that all plans of power development and factory construction are carried out as on schedule.

Fig. 3.5.1. Future relation of peak demand and installed capacity in central Nepal



In 1965, three power stations at Trisuli, Panauti and Hitaura will be completed, and the transmission line connecting two big consuming centers in the Kathmandu valley will also be completed. Hence, the total generating capacity of about 22,000 kilowatts will be connected by the transmission line.

Keeping pace with the above, the factories and mills in the Hitaura area will partly be put to operation in the same year, and the power demand from them together with the general demand will increase remarkably.

In 1967, 1968 and 1969, the capacity of the Trisuli power station will be increased by 3,000 kilowatts each.

3.6. The tendency toward shortage of the generating capacity is likely to appear as early as in 1966, because a part of the then existing capacity, especially of the old diesel units, will have to be reserved as a stand-by capacity. And the lack of the generating capacity will become obvious in 1969.

Therefore, it is necessary to complete the Kulikhani project in 1969 at the latest.

Exact forecast of power consumption and supply is hardly possible when almost no data are available as in the present case. Nevertheless, it may be allowed to judge that the future trend of consumption and supply will be much the same as the aforementioned trend of the peak demand and supply.

CHAPTER 4

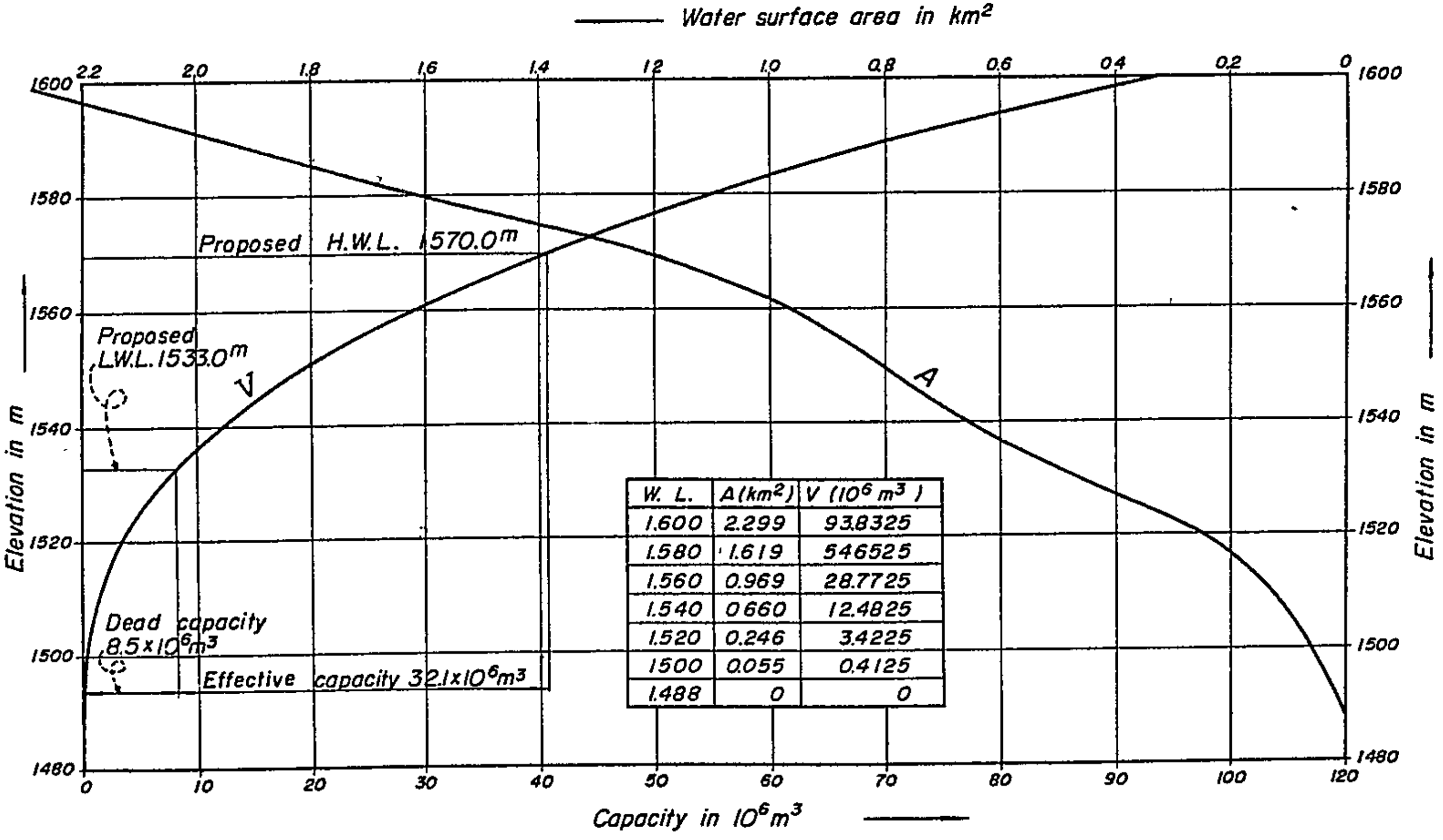
POWER GENERATION SCHEME

4.1 Under the above circumstances, it is essential to establish a planning of the Kulikhani project on a principle to utilize the potentiality as fully as possible, and to prepare further plan of power development for the successive stage to be undertaken before the total generating capacity including the Kulikhani project is overtaken by the demand. For the latter, the run-off diverted from the Kulikhani river to the Rapti river together with the flow of the Rapti river itself and the downstream topography of the Rapti river are capable of good deal of power developments.

4.2 Previously only the main stream which has a catchment area of 120 square kilometers was considered to be the water resource. But it was found later that this project would become more favourable if it is so planned to utilize the flow of the two adjoining tributaries, namely the Sim Khola and Chakhel Khola, with 7 and 30 square kilometers of catchment area respectively, both of which join the Kulikhani river at downstream points from the proposed dam site. Hence, the planning can be much larger than it was expected before.

4.3 As already stated in Paragraph 2.11, the yearly mean run-off of tl Kulikhani river and the Chakhel Khola is 3.2 and 0.8 cubic meters per second respectively, totalling 4.0 cubic meters per second in the norm year of precipitation. It may be ideal to fully utilize this run-off throughout the year, but it must be brought into consideration that th are drier years than the normal year with an occurrence frequency of

Fig. 4. 4. 1



W. L.	A (km^2)	V (10^6 m^3)
1.600	2.299	93.8325
1.580	1.619	546525
1.560	0.969	28.7725
1.540	0660	12.4825
1.520	0.246	3.4225
1500	0.055	0.4125
1.488	0	0

Table 4.4.1 (Unit; m^3/sec)

Month	Inflow to reservoir			Regulation by reservoir					Intake from		Total intake discharge
	Kulikhani river Δ	Chakhel Khola Δ	Total	Available capacity	Regulation	Waste	Water level	—do—	Reservoir	Sim Khola	
Oct.				12.4			H.W.L	1570.0			
Nov.	1.8	0.5	2.3	11.6	0.8	0		1568.2	3.1	0.2	3.3
Dec.	1.4	0.4	1.8	10.3	1.3	"		1565.4	"	"	"
Jan.	1.1	"	1.5	8.7	1.6	"		1561.9	"	"	"
Feb.	1.0	0.3	1.3	6.9	1.8	"	down	1557.6	"	"	"
Mar.	1.0	"	"	5.0	1.9	"		1554.5	3.2	"	3.4
Apr.	0.9	0.2	1.1	2.9	2.1	"		1545.4	"	"	"
May	1.3	0.3	1.6	1.3	1.6	"		1538.8	"	"	"
June	1.5	0.4	1.9	0	1.3	"	L.W.L	1533.0	"	"	"
July	5.6	1.4	7.0	2.3	0	2.3	up	1543.0	4.7	0	4.7
Aug.	13.0	3.2	16.2	12.4	"	10.1	H.W.L	1570.0	"	"	"
Sept.	6.4	1.6	8.0	"	"	0	"	"	"	"	"
Oct.	3.2	0.8	4.0	"	"	"	"	"	4,0	0.2	4.2

Note; Δ The estimated values in the paragraph 2.11

Table 4.4.2 (Unit; m^3/sec)

Month	Inflow of Kulikhani river Δ	Regulation by reservoir					Intake from		Total intake discharge
		Available capacity	Regulation	Waste	Water level	—do—	Reservoir	Sim Khola	
Oct.		12.4			H.W.L	1570.0			
Nov.	1.8	11.4	1.0	0		1567.8	2.8	0.2	3.0
Dec.	1.4	10.0	1.4	"		1564.8	"	"	"
Jan.	1.1	8.3	1.7	"		1561.0	"	"	"
Feb.	1.0	6.5	1.8	"	down	1556.6	"	"	"
Mar.	1.0	4.7	1.8	"		1551.5	"	"	"
Apr.	0.9	2.8	1.9	"		1545.0	"	"	"
May	1.3	1.3	1.5	"		1538.9	"	"	"
June	1.5	0	1.3	"	L.W.L	1533.0	"	"	"
July	5.6	2.8	0	2.8	up	1545.0	"	"	"
Aug.	13.0	12.4	"	9.6	H.W.L	1570.0	"	"	"
Sept.	6.4	"	"	0	"	"	"	"	"
Oct.	3.2	"	"	0	"	"	"	"	"

Note; Δ The estimated values in the paragraph 2.11

50 per cent. Therefore it is reasonable to utilize 90 per cent of the yearly run-off of the normal year.

For the purpose to regulate the natural run-off and to utilize 90 per cent of the annual run-off in the normal year, the necessary effective storage capacity of reservoir is calculated at about 32 million cubic meters.

4.4 From the capacity curve (refer to Fig. 4.4.1), the said effective storage can be obtained by setting the high and low water levels at elevation 1,570 and 1,533 meters respectively with a drawdown of 37 meters. The gross and dead capacities are 40.6 and 8.5 million cubic meters and the effective storage is 32.1 million cubic meters. This effective capacity is equivalent to a monthly mean discharge of 12.4 cubic meters per second.

Then the intake discharge for the power generation is calculated as shown in Table 4.4.1. When the run-off of the Chakhel Khola is not taken in the reservoir, the intake discharge is calculated as shown in Table 4.4.2.

4.5 The proposed dam center line lies on the Kulikhani river between the government rest house and Kulikhani village. The dam is to be of rock-fill type to fully utilize the domestic material available abundantly in the vicinity and to minimize the importation and transportation of materials.

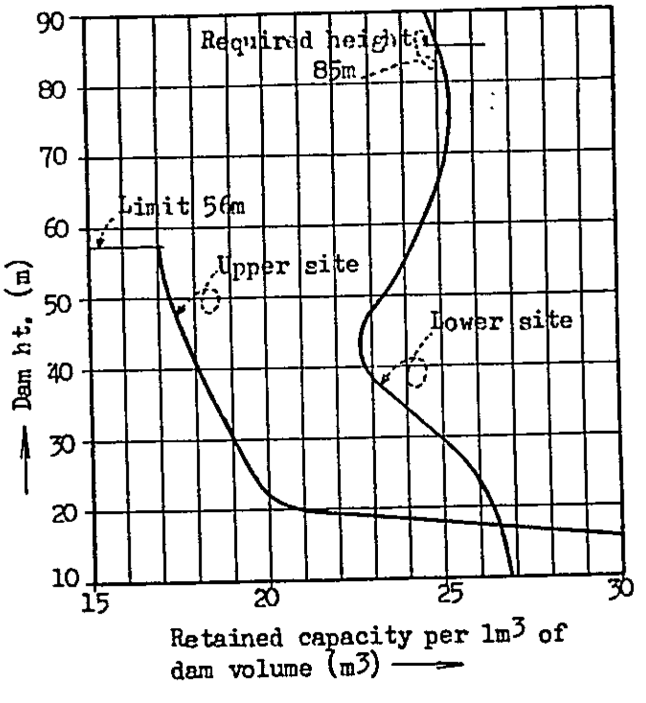
By providing a free board by 3 meters from the high water level, the dam crest is set at El. 1,573 meters. As the river bed elevation is 1,488 meters, the dam will be 85 meters high and the backwater will extend to about 7 kilometers behind the dam.

4.6 During its stay in Nepal, the Japanese Team surveyed two alternative dam sites and the lower site is selected. The reason is as follows.

(1) On the upper site, it is hardly possible to construct a dam more than 56 meters high owing to the topography. Therefore, it is impossible to construct a dam by which the required storage capacity can be secured.

(2) For reference, reservoir capacity per 1 cubic meter of dam volume is illustrated in Fig. 4.6.1 Obviously the lower site is superior.

Fig. 4.6.1



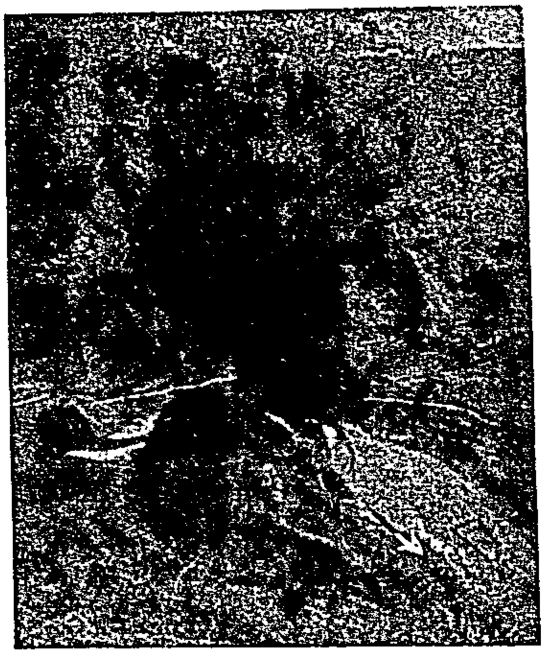


Photo 4.6.1 Upper dam site

Photo 4.6.2 Lower dam site, view looking downstream

Photo 4.6.3. Lower dam site view looking upstream

4.7 The geology of the dam site (lower site) consists of biotite schist, slate and sandstone and forms a simple inclined structure of N 20° - 30° W and 30° - 80° WE. This strike crosses the dam axis at an angle of about 45° and inclines towards the upstream part of the left bank. The left bank consists of biotite schist and the right bank consists of mainly slate and sandstone intercalated. As the former is stronger against weathering than the latter, the slope is very steep on the left bank and not very steep on the right bank reflecting the nature of structure. Therefore, the top soil is hardly seen on the left bank but the right bank is covered by rather thick, say several meters, top soil. The river bed is covered by rather thin layer of gravel deposit of which thickness is 4 to 5 meters, according to the results of borings.

4.8 On the left bank about 50 meters downstream from the dam axis, there is a fault, N 50° - W and 80° - NE, accompanied by some 3 meters thick fractured zone. This fault is assumed to cross the river bed diagonally and extends to the right bank, but this was not ascertained due to the thick top layer as mentioned before. This fault will not be a serious defect, when certain treatment is effected during the excavation of foundation.

This foundation rock is judged to be firm enough for either gravity concrete dam or rock-fill dam of proposed height. Prior to the dam construction, it is necessary to strip the top soil of the right bank to a depth of several meters.

4.9 The rockfill dam has an average surface slope of 1:2.5 and 1:1.5 on the up and downstream surfaces respectively. (refer to Drawing No.4)

The dam is 85 meters in height, 190 meters in crest length and 6 meters in crest width. The cross section consists of the inclined core zone and quarry run zones of which the size of the material gradually changes from coarse to fine from the outside to the inside.

The toe and heel portions of the dam are to be filled prior to the construction of the main dam body as the coffer dams for the purpose to unwater inbetween. The total volume of fill is calculated at 1,550,000 cubic meters.

To access the dam site, it is recommendable to improve the existing footpath from Okhargaon to Kulikhani for about 13.5 kilometers, so that the dam site becomes accessible by car.

4.10 As to the rock quarry for the fill materials, it is possible to utilize the accumulated formation of biotite schist or hard sandy slate cropping out on the slope of the left bank, 300 to 500 meters downstream from the dam site. But the schist and slate have a tendency to be broken into platy blocks in quarrying.

If this quarry is found inadequate, it is also possible to utilize the granite cropping out on the right bank, about 500 to 1,000 meters downstream from the dam site. As the impervious materials to be filled in the core zone of the dam, weathered soil of shaly rock is available on the slope of the right bank downstream from the dam site.

4.11 The dam is provided with a side spillway on the left bank which can discharge 1,200 cubic meters per second at the high water level when the overflow head is 6 meters. (refer to Drawing No.5)

For the purpose of diversion during the construction period, a line of diversion tunnel is to be driven on the left bank. This diversion tunnel is 505 meters long, 6 meters in inside diameter and capable of discharging 650 cubic meters per second. The side spillway is connected to this diversion tunnel by an inclined shaft so as to be able to utilize the latter half of the diversion tunnel.

This diversion tunnel will probably run through the mass of biotite schist. This formation will be somewhat difficult to excavate, but very stable excavation is expected, and is expected to be safe enough against high water pressure.

4.12 The run-off of the Chakhel Khola is taken in to the reservoir through a tunnel, 1.2 kilometers in length. The tunnel from the Chakhel Khola opens at about 1 kilometer upstream from the dam. The bottom elevation of this tunnel is 1,570 meters at the opening, same elevation as the high water level.

The regulated discharge is to be led through the main tunnel towards the power station. This main tunnel on its course, passed beneath a small tributary, the Sim Khola. This tributary has a catchment area of 7 square kilometers only, but the dry run-off is very rich owing to the water source near the Daman pass, as high as about 2,800 meters above sea level. In the driest month of April when the run-off of the Kulikhani river is around 1 cubic meter per second, the Sim Khola still flows out nearly 0.2 cubic meters per second. Therefore, to increase the intake discharge in the dry season, 0.2 cubic meter per second is to be taken to the main tunnel by an auxiliary intake and a shaft.

4.13 The main waterway tunnel starts from the intake located on the right bank of the dam. Behind the intake, an intake gate tower is arranged in a shaft. (Refer to Drawing No. 3 and 6). The main tunnel has a circular section of which diameter is 2.5 meters. As the maximum discharge is small, the size of the cross section is designed to be of the minimum size for the convenience of the construction.

At a point where the main tunnel runs under the Sim Khola, a shaft is provided to connect the tunnel with the auxiliary intake on the Sim Khola. At the end point of the tunnel, a restricted orifice type surge tank, 8 meters in inside diameter, is provided. From this point, the penstock begins and it runs down in the penstock tunnel, and branches into two lines with a spherical branch, just before entering the power station.

4.14 The first 450 meters of the main tunnel will run slightly diagonally to the direction of the formation of slaty shale or sandy slate and reaches the Chipla Khola. From this point, the tunnel will run through a zone of great mass of granite under the Sisagarhi pass on the watershed of Kulikhani and Rapti basins.

The main tunnel will run in the zone of quartzite or siliceous slate formation from the Sisagarhi pass. This formation continues to the slope beneath Sisagarhi.

From the Sisagarhi pass, the mountain is formed of pre-tertiary silicious slate, quartzite and sandstone. Generally silicious rock in this area abounds in cracks and seriously weathered resulting in vigorous supply of sediments to the gorge. The river bed near Bhimphedi town is thereby filled with this gravel deposit. In consequence, the major part of river water disappears from the river surface, flowing as the river bed water, and it is said that the shifting of the sediments in the rainy season is rather furious.

4.15 The power station is constructed underground for the following reasons. (Refer to Drawing No.7)

(1) Because the dam works are rather costly compared with the quantity of the intake discharge, it is preferable to take as much head as possible.

(2) The Rapti river is so steep that the river bed at the proposed opening of the tail race is lower than that at the bottom of the ridge of the old footpath by about 40 meters which is equivalent to 10 per cent of total head.

(3) For this layout, the underground type is better and cheaper than the usual open type owing to the topography of the mountain in the vicinity.

(4) When the development of the lower reaches is brought into consideration (Refer to Paragraph 4.19 and thereafter), this layout is favourable for the arrangement of the head race to the next power station in view of the elevation and the distance.

(5) The mountain in the vicinity is unstable as explained in Appendix II, but the underground type is independent of the surface erosion.

4.16 The tail water is discharged through the tail race tunnel, 450 meters in length, which opens on the right bank of the Rapti river in front of the downstream outskirt of Bhimphedi town. (Refer to Drawing No.7).

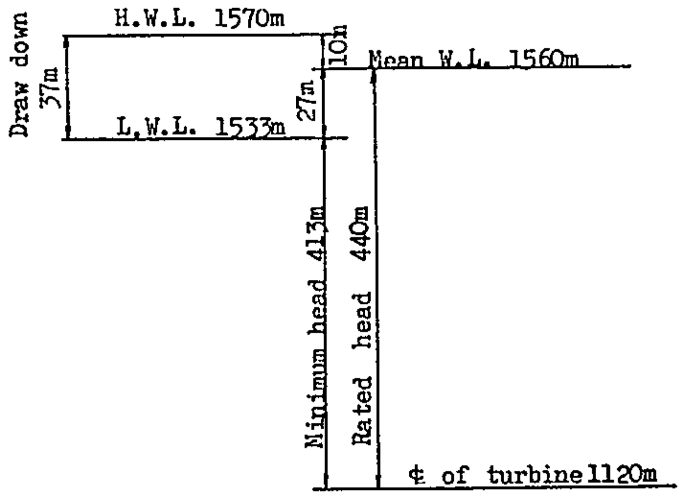
The power station chamber contains the turbine and generator rooms in the main, and the office and switch yard are located near the opening of the access tunnel.

The access tunnel, 340 meters long, is arranged for the access traffic, ventilation and power and other cables as well as for the hauling of the excavated material during the construction. The turbine center is set at elevation 1,120 meters.

The power station site is accessible by car as aforementioned, but the other structure sites are not. Therefore, for the construction use of the penstock and tunnel, a line of rope way up to the surge tank is necessary.

4.17 The gross head is illustrated as shown in Fig. 4.17.1. For the turbine of this power station, Pelton type with vertical shaft is to be adopted because of the high head.

Fig. 4.17.1



The firm continuous output is calculated as follows.

$$P_f = g\,(h - h_l)\ Q \cdot \eta_{T \times G}$$

$$= 9.8 \times (413 - 3.5) \times 3.3 \times 0.84$$

$$= 11{,}000 \text{ kW}$$

where, h ; head (m), h_l : loss of head (m), Q : discharge (m^3/sec)

$\eta_{T \times G}$: combined efficiency of turbine and generator (%)

As to the installed capacity, it is preferable to adopt a high yearly utility factor because there are diesel power stations separately which are capable of supplying the peak output. Therefore, it is decided to adopt the yearly utility factor of about 50 per cent. Then the installed capacity is calculated at 26,000 kilowatts. The maximum intake discharge for this output is calculated at 7.6 cubic meters per second and the firm continuous peak output becomes 24,000 kilowatts. Table 4.17.1 may be referred.

Table 4.17.1

$$P_p = 9.8 \times (440 - 23.8) \times 7.6 \times 0.84 \ \doteqdot\ 26{,}000 \text{ kW}$$

$$P_{fp} = 9.8 \times (413 - 23.8) \times 7.6 \times 0.84 \ \doteqdot\ 24{,}000 \text{ kW}$$

$$P_f \doteq 9.8 \times (413 - 3.5) \times 3.3 \times 0.84 \ \doteqdot\ 11{,}000 \text{ kW}$$

For the above installed capacity, 2 units of turbine and generator, 13,000 kilowatts each in capacity, are to be installed.

4.18 The possible power output in the normal year at the power station terminal is calculated as in Table 4.18.1.

Table 4.18.1

Month	Reservoir Water level El.m. Δ	Gross head m.	Effective head m.	Discharge m^3/sec Δ	Output kW	Energy output 10^3kWh
Nov.	1568.2	448.2	440.4	3.3	11,900	8,600
Dec.	1565.4	445.4	437.6	"	11,900	8,900
Jan.	1561.9	441.9	434.1	"	11,800	8,800
Feb.	1557.6	437.6	429.8	"	11,700	7,900
Mar.	1554.5	434.5	426.5	3.4	11,900	8,900
Apr.	1545.4	425.4	417.4	"	11,700	8,400
May	1538.8	418.8	410.8	"	11,500	8,600
June	1533.0	413.0	405.0	"	11,300	8,100
July	1543.0	423.0	411.4	4.7	15,900	11,800
Aug.	1570.0	450.0	438.4	"	17,000	12,600
Sept.	"	"	"	"	"	12,200
Oct.	"	"	440.0	4.2	15,200	11,300
Total						116,100

Note; Δ Refer to Table 4.4.1 for discharge and reservoir water level.

When the run-off of Chakhel Khola is not diverted to the Kulikhani reservoir, the possible power output is similarly calculated as in Table 4.18.2.

Table 4.18.2

Month	Reservoir Water level El.m. △1	Gross head m	Effective head m	Discharge m³/sec △1	Output kW	Energy output 10³kWh
Nov.	1567.8	447.8	440.6	3.0	10,900	7,800
Dec.	1564.8	444.8	437.6	"	10,800	8,000
Jan.	1561.0	441.0	433.8	"	10,700	8,000
Feb.	1556.6	436.6	429.4	"	10,600	7,100
Mar.	1551.5	431.5	424.3	"	10,500	7,800
Apr.	1545.0	425.0	417.8	"	10,300	7,400
May	1538.9	418.9	411.7	"	10,200	7,600
June	1533.0	413.0	405.8	"	10,000	7,200
July	1545.0	425.0	417.8	"	10,300	7,700
Aug.	1570.0	450.0	442.8	"	10,900	8,100
Sept.	"	"	"	"	"	7,800
Oct.	"	"	"	"	"	8,100
Totel						92,600

Note; △1 Refer to Table 4.4.2 for discharge and reservoir water level.

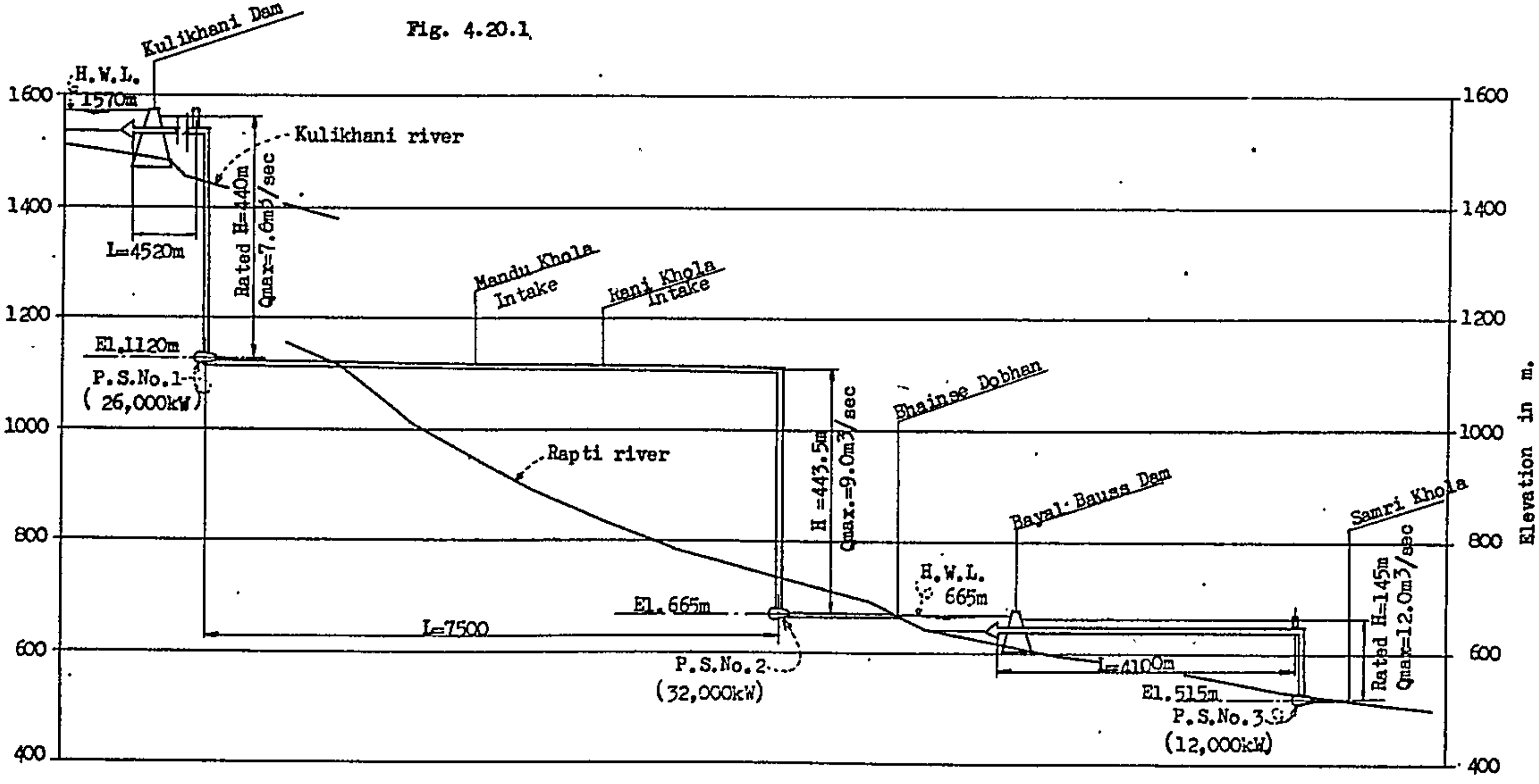
4.19 From Bimphedi to Hitaura, the Rapti river has as steep slope of river bed as 1 on 30. Namely, in a portion from Bimphedi down to the confluence of Simri Khola for 19.3 kilometers, the Rapti river falls down by as much as 636 meters. And the topography is suitable for the power development. By this river bed slope it is possible to plan out two power projects in series in this portion. Tentatively in this report, these projects will be called "The Rapti power project No.2 and 3" and accordingly the Kulikhani project itself No.1. (Refer to Fig. 4.19.1 and Drawings No.1 and 2)

4.20 Project No.2 is a "run-of-river type" power station project. By laying a waterway, probably consisting of partly open channel and partly tunnel, for about 7.5 kilometers from the tailrace of the power station No.1 to Bhainse Dobhan, a head of about 440 meters is available. Dry run-off of two tributaries in mid course of the waterway, Mandu Khola and Rani Khola, is to be taken, added to the discharge of the power station No.1. The power station is located underground near Bhainse Dobhan town with an installed capacity of 32,000 kilowatts. The annual output of 130 million killowatt hours will be available. The construction cost is roughly estimated at some 10 million U.S. Dollars equivalent.

4.21 Project No.3 is a "dam and head race type" power station project. Near the village of Bayal Bause, a narrow of gorge exists some 1 kilometer downstream from Bhainse Dobhan town. This narrow provides a good dam site. By constructing a rockfill dam about 60 meters in height and about 1 million cubic meters in fill volume, a reservoir, some 14 million cubic meters in gross capacity and some 10 million cubic meters in effective storage is obtained. The discharge from power station No.2 and the run-off from the remnant catchment basin or 130 square kilometers joins in this reservoir.

By a waterway of about 4.1 kilometers, a head of 145 meters is available. Power station is located near the confluence of Simri Khola with an installed capacity of 12,000 kilowatts. The annual output will be some 65 million kilowatt hours and the construction cost is estimated at some 9 million U.S. Dollars equivalent.

Fig. 4.20.1


Kulikhani Dam
H.W.L.
1570m
Kulikhani river
L=4520m
Rated H=440m
Qmax=7.6m3/sec
El.1120m
P.S.No.1
(26,000kW)
Mandu Khola
Intake
Hani Khola
Intake
Rapti river
H =443.5m
Qmax.=9.0m3/sec
Bhainse Dobhan
El. 665m
P.S.No.2
(32,000kW)
L=7500
H.W.L.
665m
Bayal·Bauss Dam
L=4100m
El.515m
P.S.No.3
(12,000kW)
Samri Khola
Rated H=145m
Qmax=12.0m3/sec
1600
1400
1200
1000
800
600
400
Elevation in m.

4.22 The above are summarized as follows.

Table 4.22.1

Project	Installed capacity (kW)	Annual output (10^6 kWh)	Construction cost (10^6 U.S. Dollar)
Kulikhani (No.1)	26,000	116	16.55 /1
No.2	32,000	130	10.00
No.3	12,000	65	9.00
Total	70,000	311	35.55

/1 Cost of transmission feature excluded.

Hence, the total construction cost per kilowatt hour is:

35.55/311 = 11.4 ¢ /kWh

Therefore, by the same way as given in paragraph 5.4, the overall power cost is calculated at as cheap as less than 1 Cent per kilowatt hour.

4.23 These downstream power projects are to be developed after the completion of the Kulikhani project because they owe more than half the discharge to the Kulikhani project. Anyway it can be concluded that the further growth of power demand in the central Nepal will be met by these developments for pretty long period of year.

The planning of these lower projects were, this time, made on the basis of the reconnaissance, so that the further field investigations shall have to be made. Now it is strongly recommended to start as soon as possible and to ceaselessly execute the observation of water level and run-off at essential points, for the purpose to establish further detailed plannings of these schemes.

CHAPTER 5

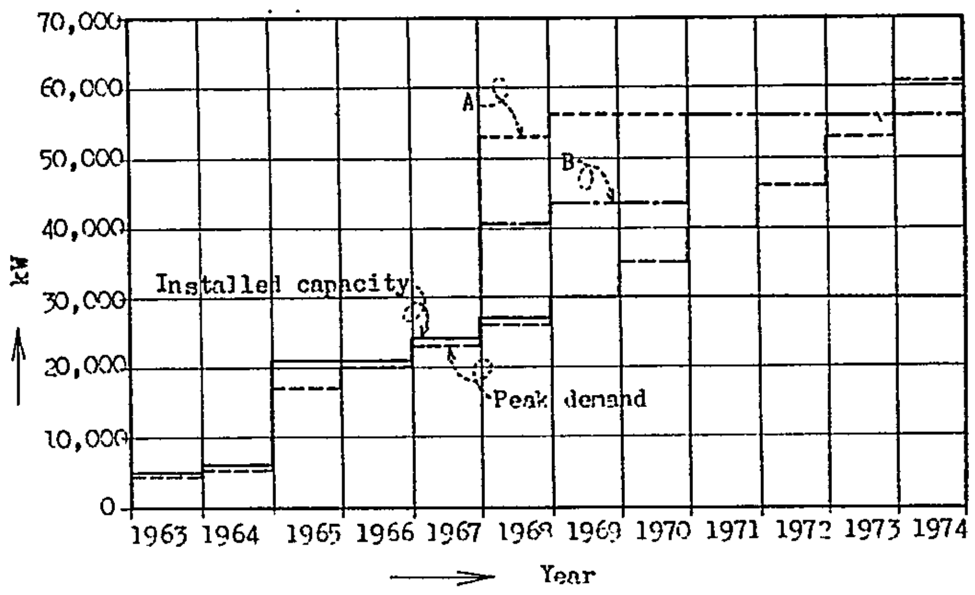
FEASIBILITY OF THE PROJECT

5.1 The preparatory works of the Kulikhani project will require one dry season prior to the commencement of the construction of main works. The main construction works will require a period of three years through three cycles of dry seasons.

Also prior to the main works, it is necessary to execute the detailed investigations for the detailed design which is indispensable for the main works. This detailed investigation on the field site will require also one dry season, but this can be performed in parallel with the preparatory works. And the succeeding office works necessary for the preparation of detailed design and specifications will require a little more than half a year. Therefore it is possible to start both the detailed investigation and preparatory works at the beginning of the dry season one year before the commencement of main works.

5.2 As mentioned and illustrated in Paragraph 3.5 the demand for power will overtake the generating capacity in 1968 or 1969. And the construction works including the preparatory works will require 4 years. Therefore, for the purpose to complete the Kulikhani project in 1968 or 1969 not to incur a shortage of supply in the market, it is recommendable to commence the construction in 1965, and to start the detailed investigations preferably in 1964 or at the latest in 1965.

Fig. 5.2.1



In case that the Kulikhani project is completed in 1968, the installed capacity will be as shown by line A in Fig. 5.2.1. Therefore, it is not necessary to complete all the power generation facilities in that year but to finish half the capacity. In this sense, it is recommended to divide the whole works into two stages. Namely,

(1) 1st stage development : All the works except for 1 unit of turbine and generator, and accordingly the Chakhel Khola intake and tunnel therefrom because the run-off of the Kulikhani river suffices the discharge for the power generation by 1 unit.

(2) 2nd stage development : The remaining works excepted in the 1st stage development.

The first stage development is to be completed in 1968 or 1969 and the second stage development is to be completed in 1971. Then the installed capacity will be as shown by line B in Fig. 5.2.1.

For the further shortage of power which may appear in 1974, the power project No.2 is to be considered.

5.3 The total construction is estimated as shown in the Table 5.3.1.

Table 5.3.1 CONSTRUCTION COST

I. Dam and Power Generation Features

Particular	Cost (in 1,000 U.S.$)
1. Dam feature	5,000
(1) Construction facilities	950
(2) Construction machinery and spare parts	1,500
(3) Dam embankment	1,800
(4) Spillway	300
(5) Diversion tunnel	450
2. Power generation feature	7,050
(1) Construction facilities	200
(2) Chakhel Khola intake and tunnel	350
(3) Intake, tunnel, Sim Khola intake and surge tank	1,400
(4) Penstock and penstock tunnel	1,100
(5) Power station structures and tail race tunnel	1,650
(6) Turbine and generator	2,100
(7) Access tunnel	250
3. General expense and engineering service	1,500
4. Contingency and interest	3,000
Total	16,550

II. Transmission Feature

Particular	Cost (in 1,000 U.S.$)
1. Transmission line	640
2. Substations in Kathmandu and Hitaura	760
3. General expense and engineering service	130
4. Contingency and interest	120
Total	1,650

The cost of the dam and power generation feature is divided into two stages. Namely,

Table 5.3.2

(Unit: 1,000 U.S.$)

1st stage development	14,550
2nd stage development	2,000
Total	16,550

It will not be necessary to appropriate the cost for the transmission line because its construction is to be started soon independently

5.4 As mentioned in Paragraph 4.18, the annual energy output is 116.1 million kilowatt-hours at the power station terminal. Hence, the construction cost per kilowatt-hour excluding the transmission lines and substations is:

16,550,000 $/116,100,000 kWh = 14.3 ¢ /kWh

Assuming the interest of the introduced fund to be 5.5 per cent, an ordinary rate like that of the International Bank for Reconstruction and Development, and the depreciation rate to be 1.38 per cent necessary for 30 years' depreciation, this value becomes:

$$14.3\ ¢\ /\text{kWh} \times (0.055 + 0.0138) = \underline{0.98\ ¢\ /\text{kWh}}$$

While the operation cost is estimated as follows.

Table 5.4.1

Salary, labour cost, maintenance and repair expenses per year : 130,000 $

Then

$$130{,}000\ \$/116{,}100{,}000\ \text{kWh} \doteqdot \underline{0.11\ ¢\ /\text{kWh}}$$

Totalling the above, the power cost becomes as follows.

$$0.98 + 0.11 = \underline{1.09\ ¢/\text{kWh}}$$

5.5 At present, the power cost in Kathmandu area is about 5 Cents per kilowatt hour on an average. Therefore, the power cost of the Kulikhani project 1.09 Cents per kilowatt hour can be judged much cheaper, say less than one quarter of the present cost. If a fund of which interest rate is lower is available, no matter of course the power cost can be cheaper accordingly.

Appendix I

TRANSMISSION LINE AND HIGHWAY

TRANSMISSION LINE

I.1. At present, there is no transmission line in Nepal except for one for the rope way use which are rather to be called the distributions. The Government of Nepal has a plan to construct a transmission line connecting Kathmandu to Hitaura and further to Birganj for the purpose to lay a network for the power projects in the Kathmandu valley and factories in Hitaura which are now under way (refer to Paragraph 3.2 and 3.3). This work is divided to the first stage work, in the southern part mainly on flat topography, and the second stage work, in the northern part in the hilly topography.

I.2. The first stage work covering from Simura to Bhainse Dobhan via Hitaura has the purposes, beside its original purpose, of supplying power for the new rope way and for the construction use of the Kulikhani project. The route survey of this part was finished by the hand of the Electricity Department.

The second stage work from Bhainse Dobhan to Kathmandu covers the difficult portion of the whole route. The Team made the reconnaissance of this portion, from Hitaura to Kathmandu, as a route of transmission line of the Kulikhani project.

I.3. The proposed route of the transmission line runs on the left bank of the Rapti river along the existing motor road from Hitaura to Bhainse Dobhan, and on the right bank along the existing motor road from Bhainse Dobhan to Dharsing, the terminal of the old rope way. At Dharsing the route is connected with the route of the old rope way, and runs to Kesepuree Jeela, the other terminal of the old rope way and further to Balaju in the northern outskirt of Kathmandu. The distance of this route is 22 kilometers from Hitaura to Bhimphedi and 30 kilometers from Bhimphedi to Balaju (Kathmandu) totalling 52 kilometers.

I.4. Bringing the conditions of the transmission program, topography, weather etc. into consideration, it is recommended to adopt the following specifications.

1) Normal voltage: 60 kV (max. voltage 69 kV)
2) Number of circuit: 1
3) Cycle: 50 c/sec
4) Conductor: 160 mm^2 ACSR
5) Overhead ground wire: 55mm^2 galvanized steel wire
6) Support: Square base type steel tower
7) Standard span: 270 m
8) Min. height from ground surface: 8 m in town, 6 m in general and 5 m in mountain
9) The worst condition: Temperature: -5°C to $+18^\circ$C
Wind velocity: 20 to 26 m/sec

Under the above specifications, the proposed transmission line from Hitaura to Kathmandu requires 230 towers, about 10 places of long span for 500 to 600 meters and maximum horizontal angle of about 60 degrees. Out of these towers, about one half numbers will become the strain type.

I.5 The old rope way of which route covers more than one half of the proposed transmission line, was completed in 1925 and was in service for 38 years. This old rope way covers 30 kilometers from Dharsing to Kathmandu has 9 intermediate stations and is supported by 152 steel towers of various types, heights and spans. The old rope way, double line circulation system, has a capacity of 8 tons per hour and is still in service.

The new rope way from Hitaura to Kathmandu is just completed and has a capacity of 25 tons per hour. When this new rope way is put to service, the old rope way will be abolished. Therefore it will be very convenient if all facilities of the old rope way could be reused for the transmission line. The Team, in this sense, investigated all of these old towers. Table I.5.1 gives the summary.

I.6. The total distance of the old rope way is classified by the span length as follows.

1) Span less than 200 meters

about 110 towers for about 10 kilometers

2) Span more than 200 meters

about 40 towers for about 20 kilometers

About one half of these towers are of low height of less than 10 meters. Therefore the structures of old rope way is digested as follows.

1) About two thirds of the towers are concentrated in a distance of 10 kilometers which cover rather gentle slopes and thickly settled areas.

2) In the mountainous areas, the spans are much longer than the span for the transmission line.

3) Necessary height for the transmission tower is not always obtained by the old tower.

I.7 It would be most convenient if every existing tower could be utilized for the transmission tower at each proper location. But owing to the

Table I.5.1 Investigation Data of the Old Rope Way Towers

Section		Station 1 - 2	Station 2 - 3	Station 3 - 4	Station 4 - 5	Station 5 - 6	Station 6 - 7	Station 7 - 8	Station 8 - 9	Station 9 - 10	Station 10 - Terminal	Total
Nos. of tower /1		10	6	10	7	20	3	23	6	19	48	152
Span	0 - 50^m	5	2	1	4	7	1	9	1	3	10	43
	50 - 100	1		3		4		4	2	5	11	30
	100 - 150	1		2	1			4	1	7	17	33
	150 - 200		1	2		2		2		2	5	14
	200 - 250	1	2	2			1	1	1		4	12
	250 - 300	1	1		1			1		1	2	7
	300 - 350					1				1		2
	350 - 400	1		1		2		1	2		1	8
	400 - 450	1				2	1			1		5
	450 - 500						1	1				2
	550 - 600				1			1				2
	700 - 750					1						1
	950 - 1000		1									1
	1150 - 1200				1	2						3
Height Of Tower	0 - 5^m	2		3	2	5	1	3	1	3		20
	5 - 10	5	5	5	3	3	1	8	2	5	14	51
	10 - 15	2	1	1	2	7	1	11	2	10	24	61
	15 - 20	1		1		3			1		6	12
	20 /					2		1		1	4	8
Shape of Tower /2	Type A										44	44
	Type B	7	6	9	3	13	2	22	5	17	1	85
	Type C	3		1		7		1	1	2		15
	Type D				4		1				3	8

/1 Terminal structures not included

/2 Refer to Fig. 7.8.1. Type D; Cube like special type abovementioned reasons, only less than 30 towers out of 152 can be utilized at their location.

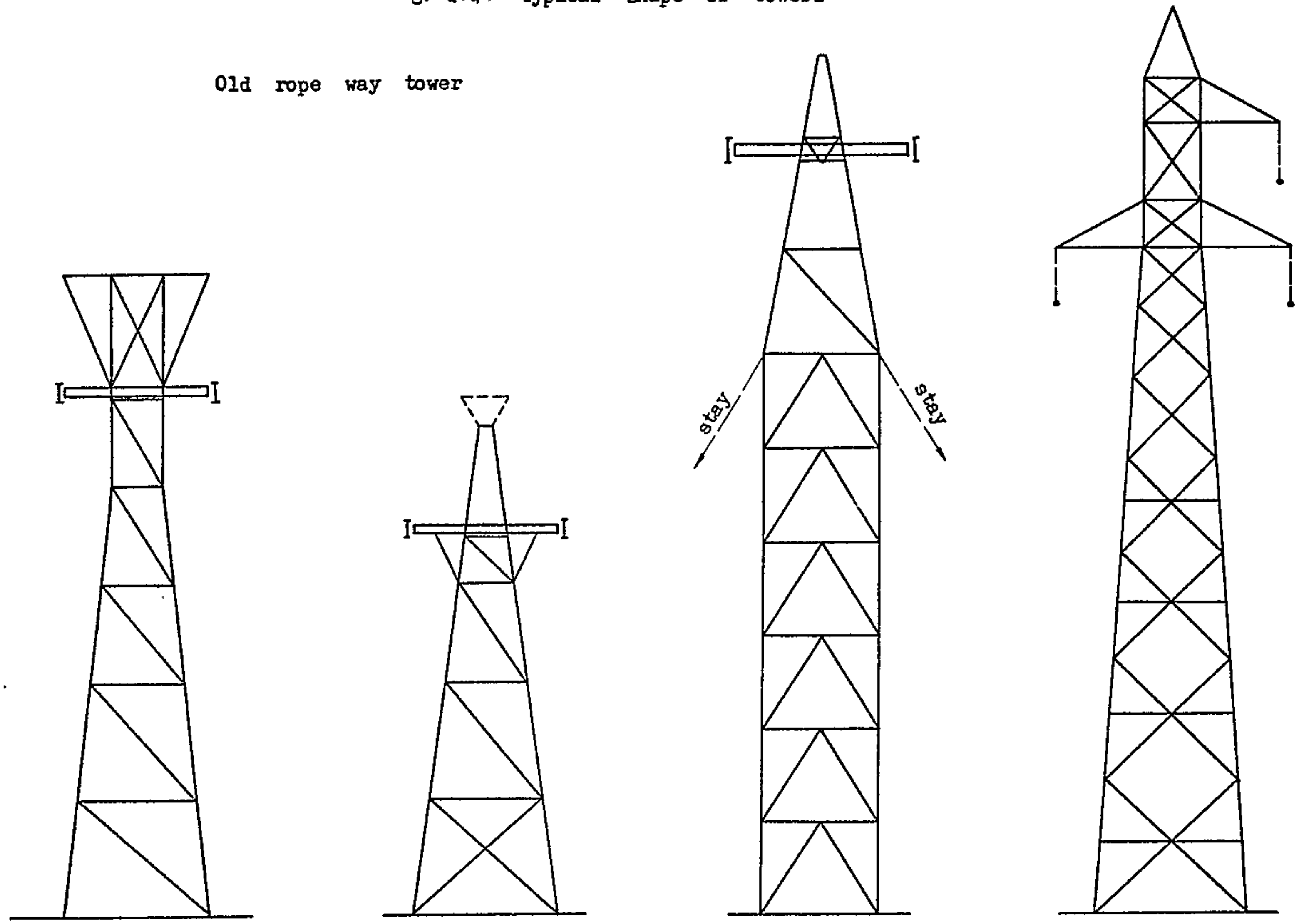
Moreover when considering the utilization of base blocks after removing the steel towers, there is a great difficulty of using them, because the distance between the base blocks and the anchor volumes are insufficient owing to a fact that these base blocks were prepared for the different purpose and different height of towers. Also it is difficult to know the underground shape of these blocks due to lack of the drawings.

I.8 Therefore, the problem to utilize the old towers can be confirmed to use them as the parts members by means of disjointing, refabricating and reassembling, though only a limited number can be used as they are. The comparison of transmission tower and the existing towers is illustrated on Fig. I.8.1.

In this connection, it is better and worth-while to relocate the facilities of the old rope way to utilize the transportation function itself, or to divert them for the structure of the other purpose as well as to decompose the existing base blocks to utilize them as the aggregate of the base for the transmission tower.

I.9 In the forest in the southern part of the project area, Sal tree which is used as a telephone pole is available amply. The Team brought the sample of this timber back to Japan and tested it. The results of this test, as appended in Appendix III, proved that this material has enough strength as a hard wood. But according to the results in India, this material is durable only for 15 years when it is not chemically treated. Hence, the steel is preferable to this material for the above reason together with the following reasons.

Fig. I.8.1 Typical shape of Towers



Old rope way tower

Type A

Type B

Type C

Transmission Tower

The wooden tower needs a stay wire which is not safe from a viewpoint of maintenance. Especially the proposed transmission line requires so many strain towers that the disconnection of conductor is considered when the stay wire snaps.

I.10 Consequently it is recommended to use the route of the old rope way under specifications in Paragraph 1.4 with new steel towers along the route shown on the Drawing 8. The substations at the both ends of the route are to be located at Hitaura and at Balaju in the northern outskirt of Kathmandu.

HIGHWAY

I.11 As mentioned in Paragraph 1.5, there is only one route from Kathmandu to the Indian border. The paved road from Kathmandu to Bhainse Dobhan is called "Tribubhan Rajpath" road which covers the hilly part of the route. But the Tribubhan Rajpath road has defects as mentioned below.

1) Due to undesirable location, the road includes many steep slopes and curves of small radius in continuity and combination. This defect results in more fuel consumption, wear and tear of vehicles, travelling time and fatique of drivers.

2) Due to unsatisfactory treatments of cross sectional slopes, the slopes easily collapse by a small rainfall, and traffic stoppage for about two weeks is regular in every rainy season. This means less reliability and security and more maintenance expenses.

3) This road crosses over several high passes, out of which the heighest one, the Daman pass, is some 2,800 meters above sea level. Due to thin air of such passes, trucks passing are only some 70 per

cent loaded. This means less capacity.

I.12 To solve the above defects, another route of better highway which makes the present road alternative is desired. When the industrial facilities of Hitaura are put to operation, this desire will become more serious than at present.

Concerning the Kulikhani project there is a possibility of this matter. That is to improve the old main footpath to a highway. This was also suggested in the original plan by the Swiss Nepal Forward Team. But in our case, the idea is a little different.

I.13 For the construction use of the Kulikhani project, a road for car is to be opened from Okhargaon to Kulikhani, so that Kulikhani will be accessible by car after the commencement of the main works. (Refer to Part A in Fig. I.13.1).

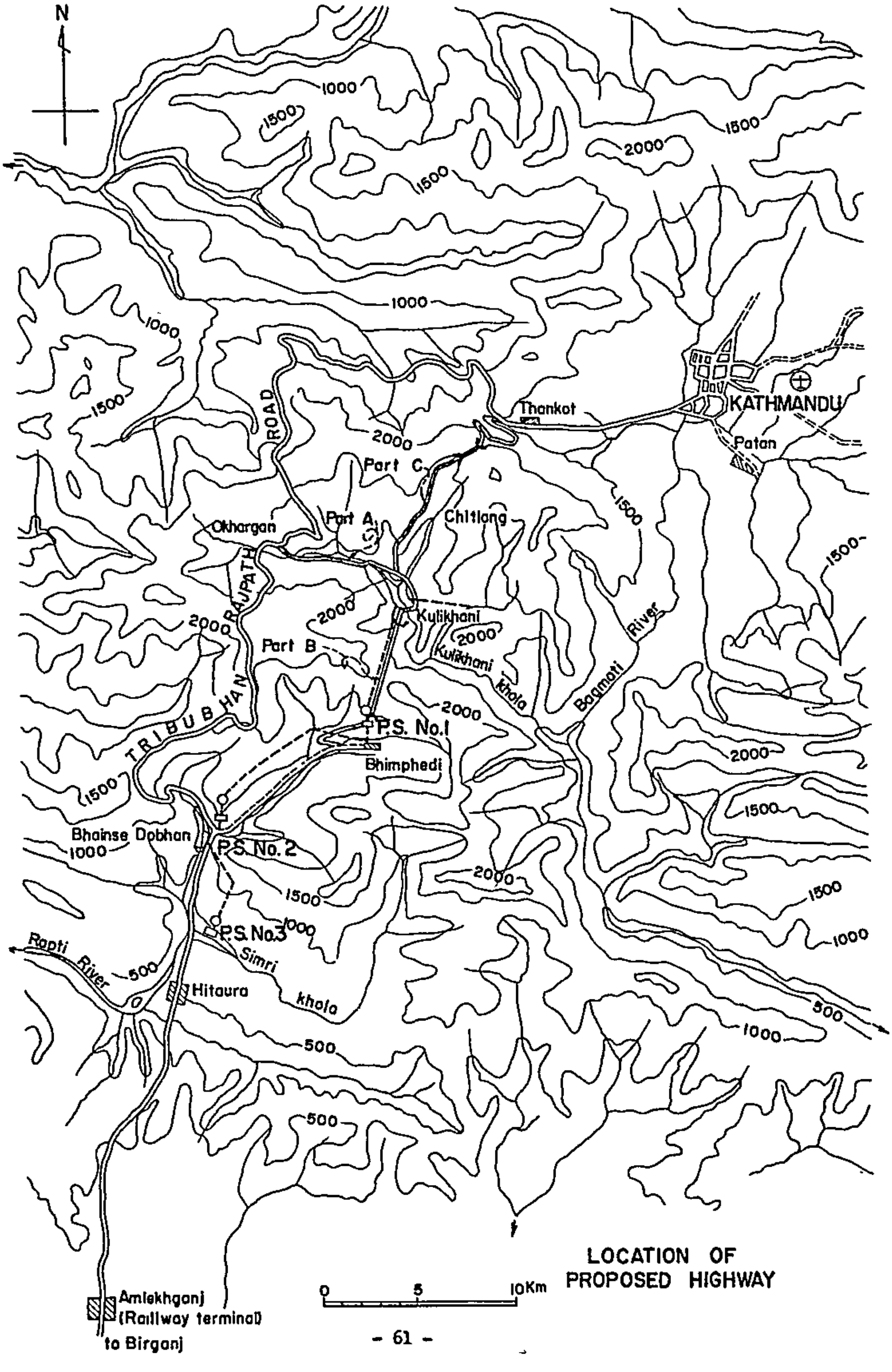
Therefore, by providing a tunnel for traffic through the pass beneath Chisapani Garhi and Sisagarhi and by connecting the both opening to Bhimphedi and to Kulikhani (Part B in the same Fig.), Kathmandu becomes accessible by car along the following course.

Hitaura - Bhainse Dobhan - Bhimphedi - Kulikhani -
Okhargaon - Tribubhan Rajpath road - Thankot - Kathmandu

This course does not pass through the Daman pass, therefore this route is in better condition than the present course.

I.14 For this traffic tunnel, two cases of construction are considered. One is to enlarge the cross section of waterway tunnel for the Kulikhani project and the other is to drive the other tunnel for the exclusive use

Fig. I. 13. 1



LOCATION OF PROPOSED HIGHWAY

of the traffics. The latter is more recommendable because the waterway tunnel have to lead the pressure flow and the discharge to flow through it became much more than it was thought before, accordingly the waterway have to occupy a pretty big portion in the combined tunnel resulting in the increase of the construction cost.

I.15 After the said route is opened, it is possible to further improve the route. That is, by opening another tunnel through the pass beneath Chandragiri and by connecting the both openings to Kulikhani and to Thankot, Kathmandu becomes accessible by car along the following route. (Refer to Part C in Fig. I.13.1).

Hitaura - Bhainse Dobhan - Bhimphedi - Kulikhani -
Chitlang - Thankot - Kathmandu

Then, necessary time for the car drive from Hitaura to Kathmandu will be remarkably shortened say within 3 hours.

I.16 The construction of Part B and C will require some 10 million U.S. Dollars equivalent. Therefore, it will be difficult to prepare necessary fund as an incidental work of the Kulikhani project. But this highway project will have the same importance to Nepal as the Kulikhani project.

The Kulikhani project is not to benefit this highway project directly. But indirectly, the machinery for the Kulikhani project after the completion will be diverted to this project and there will be, at that time, a good deal of experienced engineers and technicians with full confidence for the works of such kinds.

Appendix II

EROSION CONTROL

DEVASTATION OF MOUNTAIN AREA

II.1 For the purpose to know the present situation of devastation in the mountain area as well as to obtain the data to study the sedimentation qualitatively, the Team executed the investigation mainly in respect to the states of collapses as a source of sediment and of the devastation of rivers and streams in the catchment basins of this project.

The summary is given in a table and figure in the Appendix III showing the distribution of the collapses. This summary contains almost all the main collapses with carefull selection of reconnaissance course together with ample information from the inhabitants.

KULIKHANI BASIN

II.2 The erosion in the Kulikhani basin is active in the middle and lower reaches. In the basin, the flats are still remaining upstream from Okhargaon in Kulikhani Khola and in the middle and lower reaches on the main tributaries such as Tistung Khola, Bissingkhel Khola and Chitlang Khola. On these flats, the valleys which flow on them are shallow, and as a whole a basin like land form is shaped. On the contrary, at the lower end of the flats, both the main stream and tributaries have very steep slope of river beds and form deep valleys or hanging valleys.

However, in the basins of downstream tributaries such as Chakhel Khola, Rakas Khola and Kokte Khola, there are almsot no basin like flats except few which were already dissected and separated with the deep valleys. These features of the above-mentioned land form are illustrated showing profiles of river beds.

II.3 In short, the mountain in the Kulikhani basin is still in young stage, therefore the lowering of the river bed is remarkable in the lower reaches where the run-off is much. Especially the lower part of Kulikhani Kohla and the main stream Bagmati river form very deep gorge because these rivers enter the transverse valleys which cross the Maha Bharat mountain range.

On the other hand in the upper reaches, basin like flats are remaining because the erosion is not active yet. The head of the erosion reaches Okhargaon and the upper flats will be gradually eroded. Similarly on the tributaries, the lowering is active in portions near the confluence to Kulikhani Khola.

II.4 In the upper basin of Kulikhani Khola, the collapses are few except for one (Coll. 2) near Dwaugara Khola which is landcreep like collapse caused by a flood in 1954. This collapse is as large as 58,000 square meters and the debris from it is deposited widely on the lower flat. The depth of this collapse is assumed to be more than 20 meters and the already moved debris is only about 10 per cent of the total volume of the collapse, and the remainder is still remaining on the mountain side in an unstable state.

II.5 On Naukhanna Khola, a small tributary of Kulikhani Kohla, many collapses of small scale are seen. It is probably because the mean slope of the basin is extremely steep and the whole basin is covered with pasture.

The upper basins of Tistung Khola, Bissingkhel Khola, Chitlang Khola or Naliban Khola are covered by good forest, so that the collapses are very few there.

Downstream from the confluence of Chitlang Khola, there are collapses on the right bank of Kulikhani Khola such as Coll. 27, 31 and 34. Coll. 27 covering 60,000 square meters is big one, but it is so old that it has been almost restored naturally and the future yield of debris will be little. Coll. 31, in a area to be inundated in the reservoir, is showing a pretty amount of debris at present.

II.6 On both banks of the Kulikhani Khola near the confluence of Chakhel Khola, many collapses are concentrated. In this portion, Kulikhani Khola is meandering conspicuously and all the outer slopes of the curves have collapses. This meandering may have been caused by faults. The rock in this portion consists of clay slate in the main which have been disintegrated seriously.

In the downstream basin from the confluence of Chakhel Khola, collapses are few. But Coll. 72 and 73 on Rakas Khola must be noticed because they have a nature to become larger. On the lower reaches of Kokte Khola, there is coll. 84 covering 80,000 square meters. The cause of this collapse is assumed that the foot of hanging valley was abruptly eroded by the flood in 1954, thereby the river bed was lowered, and finally both banks caused collapse. Numerous huge boulders of granite which produced from this collapse have filled the river bed of Kokte Khola thickly.

RAPTI BASIN

II.7 The Rapti river basin is more devastated than the Kulikhani basin. Compared with the Kulikhani basin, number of collapse and quantity of materials deposited on the river bed are far more in this basin. In every case of tracing on the bed material upstream-wards, there exists the collapse as a supplying source of debris at the most upstream location.

II.8 In the upper reaches of Rapti river, river terrace is well developed on both sides. Especially on the left bank, there is a very long gravel terrace beginning from Bilauneghari, near the source of the left tributary Khari Khola, through Bhimphedi flat between Khari Khola and Lamo Khola down to Dharsing. The height of this terrace surface from the river bed is about 30 meters at Bilauneghari and about 40 meters near Bhimpehdi. The terrace scarp is collapsed at some places by the lateral and vertical erosion of Khari Khola and Rapti river.

II.9 The Rapti river downstream from the junction of Khari Khola and Lamo Khola is very wide. The river is often more than 200 meters wide. At many of the confluences of small tributaries from both sides, talus cones or alluvial fans are often seen. But downstream from the confluence of Pandrang Khola to Hitaura, the Rapti river crosses a branch of the Maha Bharat mountain range, accordingly valley walls on both sides are very steep. Especially in the portion up and downstream from the confluence of Bhainse Khola, the river channel is very narrow.

II.10 In Lamo Khola basin there are two big collapses, namely Coll. 13 on the right tributary Khani Khola and Coll. 15 on Sisney Khola. These two collapses are developing both from east and west sides like attaching Chisapani Garhi town on the watershed inbetween. Many collapses such as Coll. 1, 2, 17, 18 and 19 are all caused by the construction of the jeepable road.

II.11 In Khari Khola basin, there are many collapses on the mountain side of both sides as well as Coll. 25 and 35 and also many places which are in danger of collapsing newly. If no treatment is made the devastation will become more serious and more debris will be supplied to the Rapti river together with the washout of terrace scarps and movement of debris deposited on the river bed.

Suping Khola is a unique basin with a flat in the middle reaches and deep valley on it. But there is no collapse in this basin. Also in the basins of Mandu Khola and Rani Khola, there are very few collapses, because the forests in good condition.

II.12 In the lower reaches of Kalsing Khola and Pandrang Khola, there are several collapses. But the lower portion of these tributaries are deposited with especially great amount of sand and gravel. On Pandrang Khola, a great deposit as wide as 200 meters is seen.

In the Bhainse Khola basin, there are collapses such as Coll. 87, 88 and 91 on the right side tributary Okhe Khola which are comparatively big and have tendency to enlarge. Debris from these collapses are deposited on the river bed of lower portion of Okhe Khola. Moreover, there are several places where the excavated materials for the construction of Tribubhan Rajpath road were dumped. These dumped materials were washed in the rainy season to the river bed.

SEDIMENT DISCHARGE

II.13 The amount of sediment discharge is, as a matter of course, remarkably differs according to the various conditions of the basin. Therefor the definite method to estimate the sediment discharge is not establishe yet at the present stage.

However, according to the results of the reconnaissance on the basins of Kulikhani Khola and Rapti river, it is concluded that the mountain areas upstream from the proposed dam site is comparatively stable, and accordingly that it is not necessary to estimate much quantity of sedimentation in the Kulikhani reservoir.

II.14 It is favourable that the basin like flats exist on the upper reach of Kulikhani Khola and middle reaches of the main tributaries. It is because, even the collapses take place on the upper reaches, the major part of the debris will deposit on these flats and the sedimentation will be little on the lower reaches where the Kulikhani reservoir is to be created.

II.15 According to the Indian measurement △1 at Sapt Kosi at Sunakhambi Khola, the annual sediment discharge there is as follows.

Table II.15.1

(Unit: $m^3/km^2/year$)

Year	Annual sediment discharge
1948	1,700
1949	2,600
1950	1,600

Various conditions in the Kulikhani basin are of course much differ from those in the Sunakhambi basin. Hence, it is impossible to apply the above measured values to the Kulikhani basin. But it may be said that the sediment discharge at the Kulikhani dam site is about 1/4 to 1/5 of the above values.

/1 Annual Sediment Data for Sapt Kosi at Sunakambi Khola, by Central Water and Power Commission, Government of India.

II.16 In case the Kulikhani river is diverted to the Rapti river by the proposal of this report, it might be feared that the bed material on the Rapti river moves namely the river bed varies by the increased run-off. But this phenomenon will not occur at all, because the deposit on the Rapti river which is more than 200 meters wide near Bhimphedi is more than 10 meters thick and the increased discharge, at most 7.6 cubic meters per second, will all infiltrate into the deposit.

CONTROL OF MOUNTAIN AREA

II.17 The Sabo works which are the comprehensive erosion control works require a great amount of construction expenses, but in many cases the effect of the investment, by nature, can not be grasped as clearly as in case of the power generation, irrigation or highway.

It is usual that the Sabo works become to be necessary only after the land is highly utilized and accumulated capital on the land becomes much and thereby the amount of damage by the discharge and deposit of sand and gravel becomes notable. But it needs a great expense and long period of time to restore the devastated land to the former stable condition. Therefore, prevention measures must be taken before the situation is not very serious. In Nepal this matter must be especially noticed because she has already devastated mountain areas and moreover, every development plan is to be executed from now on.

II.18 The devastation of mountain areas is caused in many cases by the natural process but in some cases it is caused or at least promoted by the process of various human works done in the mountain areas. Therefore, it is also essential to control it strictly.

There is no use to say that it is expedient to select the best method of land utilization according to the nature or characteristics of the nature of land without any prevention measures may cause an unexpectedly serious disaster.

II.19 The Government of Nepal is very carefull to this matter, and instituted strict regulations for the integrity of land. In reality, however, lands which ought to be utilized as forest areas are utilized for the forming or the stockbreeding by the inhabitants owing to the lack of knowledge of the necessity for the farming operations.

In the basins of Kulikhani Khola and Rapti river, the control of mountain areas is insufficient, and there often seen the cases that the unnecessary deforestation has caused the devastations of mountain area. Therefore it is necessary to watch the following points.

II.20 The stockbreeding is an important industry of Nepal, and a great number of livestocks are bred. The inhabitants are utilizing even a very steep slope of mountain as a pasture. Therefore it is easily considered that a great quantity of sand and gravel is produced by the surface erosion and that these pastures let the landslides to take place easily.

Also there seen many cases that the inhabitants are pasturing the livestocks in the forests and accordingly the young forests are being all destroyed. Furthermore, it is a habit everywhere in Nepal to burn out the undergrowth or grass in the vicinity of villages in March or April for the purpose to let the growth of pasture grass in the next rainy season better. In consequence, growth of tree is disturbed and young trees or undergrowth are all dead and the devastation is more promoted.

II.21 In view of erosion control, these kinds of destruction of forest for the stockbreeding purpose must be prevented as soon as possible. But in executing the prevention measures, the method or procedure must be comprehensive after due consideration, investigation or study, because this matter will greatly influence on the lives of the farmers who predominate more than 90 per cent of whole Nepalese population.

II.22 As the Maha Bharat mountain range is still in young stage, many flats are still remaining near the watershed, and these flats are often seen cultivated rather recently owing to the growth of the population.

As an extreme example, there was a case to burn the primeval forest on a watershed more than 2,100 meters high above sea level for the cultivation purpose. On such a high altitude, much yield can not be expected and such cultivation will be almost nothing more than a cause of devastation of mountain area. Therefore, such cultivation should be prohibited as much as possible and an effort to make the unit yield more should be exerted instead.

II.23 As the demand for timber is not large in Nepal, and as the transportation road is not developed, most of the existing forest is kept as the primeval forest. But in near future, the timber demand will become large with progress of development and cutting of the forest active.

After cutting, the forest will, for the time being, be reproduced by the natural seeding or sprout, but it is essential to improve the present primitive forest management and to plant the forest positively by the artificial forestation in as near future as possible. Also the pastures on the steep slope must be forested artificially. Further on the river bank or in the areas which used to be suffered from the disasters of sand and gravel discharge by floods, it is better to surround these areas with forest belts of sufficient width. By this, it is possible to decrease the flood and sand disaster at a low cost.

II.24 No matter of course, the forest is not all mighty to prevent the production or discharge of sand and gravel. Therefore, it is necessary to execute the Sabo works positively on the areas which are in danger of sudden discharging of sand and gravel.

SABO SCHEME

II.25 The Sabo works are classified into two categories. One is the direct works which are to be executed on a area which is producing sand and gravel or in danger of doing so. The other is the indirect works which are to be executed for the purpose to prevent or to control the sudden discharge of sand and gravel when the execution of the direct works is very difficult or requires a pretty long period. According to the actual situation of devastation of mountain areas or the disasters caused by sand and gravel, the Sabo scheme is to be framed combining these two categories conventiently.

II.26 The attached drawing No.9 is a layout of Sabo scheme for the basins of Kulikhani Khola and upper Rapti river. The idea is as follows.

Because the sediment in the Kulikhani reservoir is not much, it may be permitted to let the upper basin as it is. But for better condition to add more life of the dam from the sedimentation, it is better to execute the direct works on the main Kulikhani river and on the lower reaches of the tributaries.

For the lower reaches from the dam, the direct works are to be executed on the existing collapses for the purpose to decrease the transportation of sediment load to the Bagmati river, though this will not effect directly to the Kulikhani project.

II.27 On the upper Rapti basin, it is necessary to prevent the disaster of sand and gravel which is in danger to occur near Bhimphedi and Bhainse Dobhan, and to control the transportation of sand and gravel to the lower Rapti river and Hitaura area. For these purposes, the direct works are to be executed on the seriously devastated stream such as Lamo Khola, Khari Khola and Bhainse Khola to prevent the discharge of sand and gravel from the collapses and to prevent the movement of bed material. Also the indirect works are to be executed on certain suitable locations on the main Rapti river and on the lower portions of the tributaries for the purpose to prevent or to control the sudden discharge of sand and gravel caused by the heavy rain.

II.28 On Khani Khola, there is a very large collapse (Coll. 13) originating near Chisapani Garhi town. This collapse is very large in scale and supplying a huge quantity of sand and gravel to the Rapti river and this might injure the security of the proposed power station. Hence, it may not be allowed to let this collapse as it is. The Team took up this case to draw up a Sabo scheme for the above reasons as well as to show a real example of scheme. The attached Drawing No.10 and 11 may be referred.

II.29 The slope direction of Coll. 13 is S 30° E and inclination is S 35° at the top and S 28° at the bottom. It covers a horizontal area of 45,000 square meters. The dip of bed rock approximately conforms with the surface slope. The rock consists of weathered silicious hornfels and the exfoliation of schistosity is remarkable. The top part of the collapse is covered by 4 meters thick soil. On this soil 4 lines of gully are running in a shape of opened palm of hand.

II.30 Debris from this collapse is thickly deposited on the lower portion of Khani Khola. To prevent the movement of this deposit, 3 Sabo dams are to be constructed. Sub dams are necessary for dam No.2 and No.3 because it is impossible to construct them on the rock foundation. When the downstream side of these sub dams are scoured, new dams are to be inserted at suitable locations downstream from the dam No.2 and No.3 to prevent the scouring by the sediment to be accumulated behind these certain suitable locations on the main Rapti river and on the lower portions of the tributaries for the purpose to prevent or to control the sudden discharge of sand and gravel caused by the heavy rain.

II.28 On Khani Khola, there is a very large collapse (Coll. 13) originating near Chisapani Garhi town. This collapse is very large in scale and supplying a huge quantity of sand and gravel to the Rapti river and this might injure the security of the proposed power station. Hence, it may not be allowed to let this collapse as it is. The Team took up this case to draw up a Sabo scheme for the above reasons as well as to show a real example of scheme. The attached Drawing No.10 and 11 may be referred.

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II.31 On the bottom of the collapse, Sabo dam No.3 is to be constructed. The hill side channel works are to be executed on every stream on the collapse. These channels are to be stifferred by the ground sills at every 15 meters of vertical distance.

The collapse surface is to be treated with the hill side cutting works, namely the uneveness of the surface is to be removed to a uniform slope of 30° to 45°. As for the hill side works there are variety of methods of execution, but in this case, the following method is suitable because the Nepalese is skilled in the masonry works and there are plenty of boulder material in Coll. 13. The hill side masonry works of 1 meter height are to be executed at every 15 meters of vertical distance. The intermediate portions inbetween are to be protected with the dry masonry stripe works of 0.5 meter height with a vertical interval of about 2 meters.

II.32 The spaces behind the hill side masonry works and the dry stone stripe works are to be backfilled with earth and the saplings are to be planted on them. Although the kind of plant suitable to the devastated place in this area is to be selected by the future investigations, yet the Leguminous and pine tree are recommendable as generally recommended. The saplings of these two kinds are to be planted alternately with an interval of 0.6 to 0.7 meters. As the fertilizer, straw bundle or chemical manure is to be mixed with the backfill earth.

II.33 The above-mentioned structures are summarized in the Tables below in which the construction costs are given to give a hint for the monetary measures. But these costs give only the direct expenses.

Table II.33.1

TORRENTIAL WORKS

Item	Height (m)	Length (m)	Crest width (m)	Surfaces slope Downstream	Surfaces slope Upstream	Volume (m^3)	Cost (U.S.$)
No.1 Dam	12.0	66.0	2.5	1 : 0.2	1 : 0.3	3,059	67,300
No.2 Dam	16.0	59.0	2.5	1 : 0.2	1 : 0.4	3,812	83,800
" Sub dam	9.0	49.0	2.5	1 : 0.2	1 : 0.1	1,406	39,400
No.3 Dam	12.0	67.0	3.0	1 : 0.2	1 : 0.2	2,716	67,900
" Sub dam	7.0	59.0	3.0	1 : 0.2	1 : 0.0	1,107	31,000
Revetment	5.6–7.0	94.0	-	1 : 0.3	-	587	18,200
Total						12,687	307,600

Table II.33.2

HILLSIDE CHANNEL WORKS

Item	Length of channel (m) a	b	c	d	e	Total	Nos. of ground sill A	B	Total cost (U.S.$)
1st stream	105	251	36	0	0	392	3	9	13,987
2nd "	80	275	108	0	0	463	2	11	16,295
3rd "	64	264	106	161	384	979	11	17	36,149
4th "	35	251	33	0	0	319	1	8	11,032
5th "	0	96	0	0	0	96	1	3	4,432
6th "	0	142	0	0	0	142	1	4	5,814
Other "	0	253	0	0	0	253	3	6	10,901
Total length	284	1,532	283	161	384	2,644	22	58	
Cost ($)	1,136	26,044	7,075	5,635	1,920	41,810	22,000	34,800	98,610

Table II.33.3

HILLSIDE MASONRY WORKS AND STONE STRIPE WORKS

Item	Q'ty	Cost (U.S.$)
Hillside cutting work	44,490 m^2	4,449
Hillside masonry works	2,400 m	9,600
Hillside stripe works	14,500 m	7,200
Total		119,909

The grand total of above three becomes 427,509 U.S. Dollars equivalent.

Kulikhani Khola basin

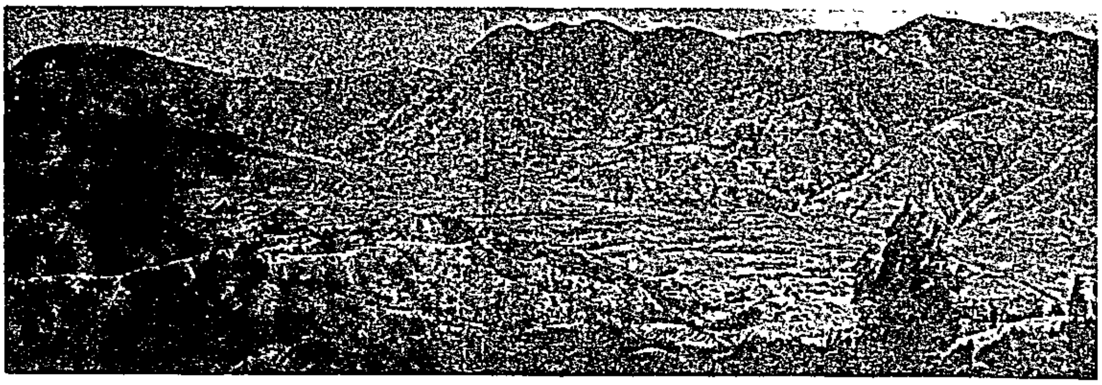


Photo II. 1. Kulikhani Khaola, water source mountains and basin-like flat.

Photo II. 2. Coll. 12 on Dwaugara Khola, still expanding.

Photo II. 3. Lower part of Dwaugara Khola, deposit of sediment from Coll. 2.

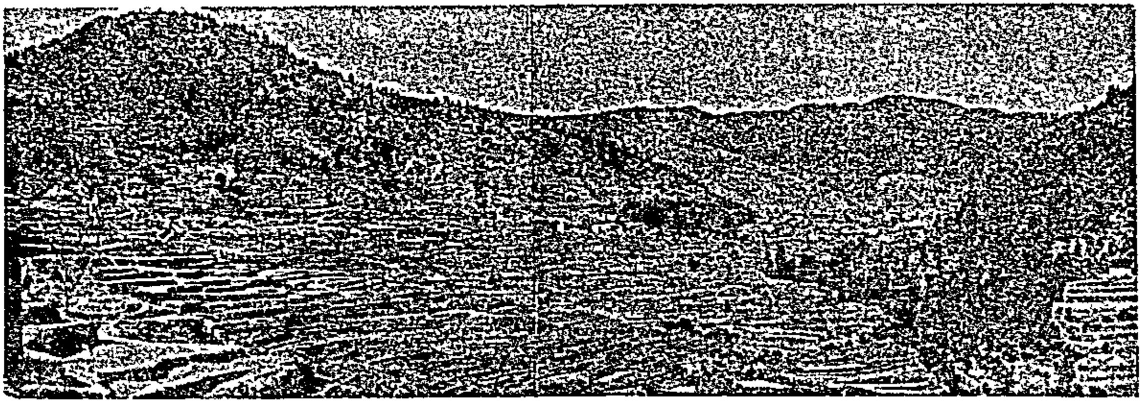


Photo II, 4. Basin-like flat in middle reaches of Chitlang Khola and water source mountains.

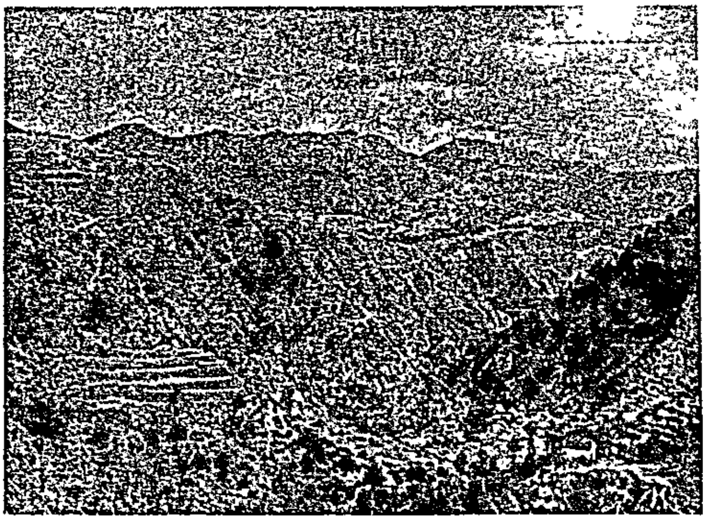


Photo II. 5. Downward view of Kulikhani Khola from Basantgaon. In lower part of basin-like flat, gorge is deep and both sides are very steep.

Photo II. 6. Waterfall on lower part of Chitlang Khola.

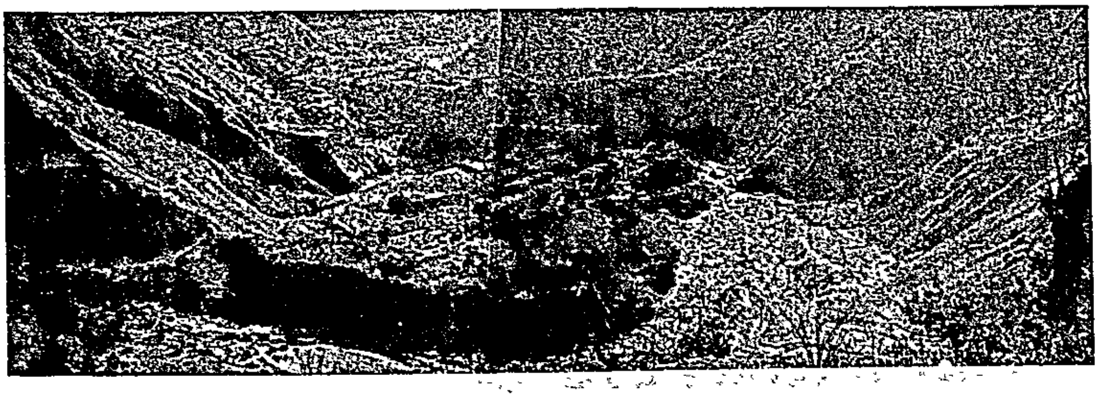
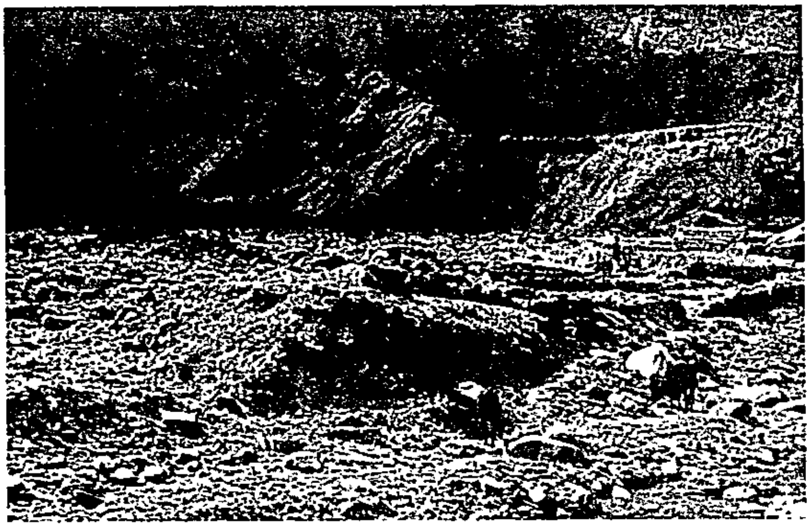


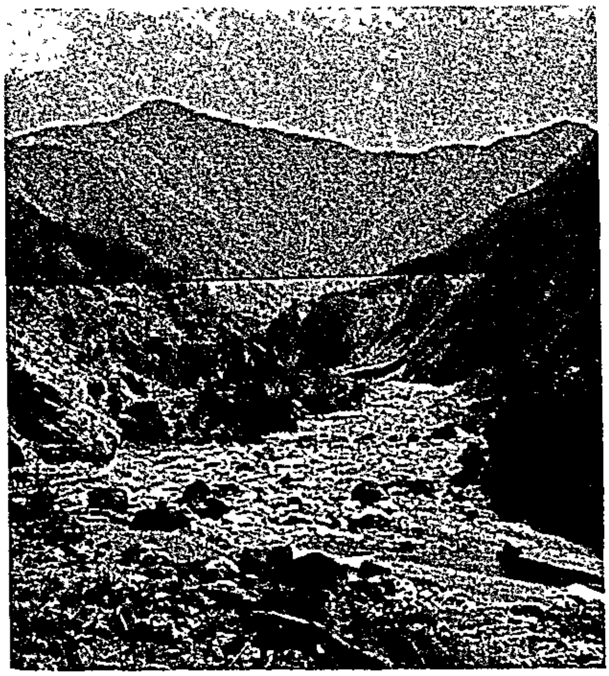
Photo II. 7. Meandering of Kulikhani Khola upstream from confluence of Chakhel Khola. Every outer sides of curves have collapsed.

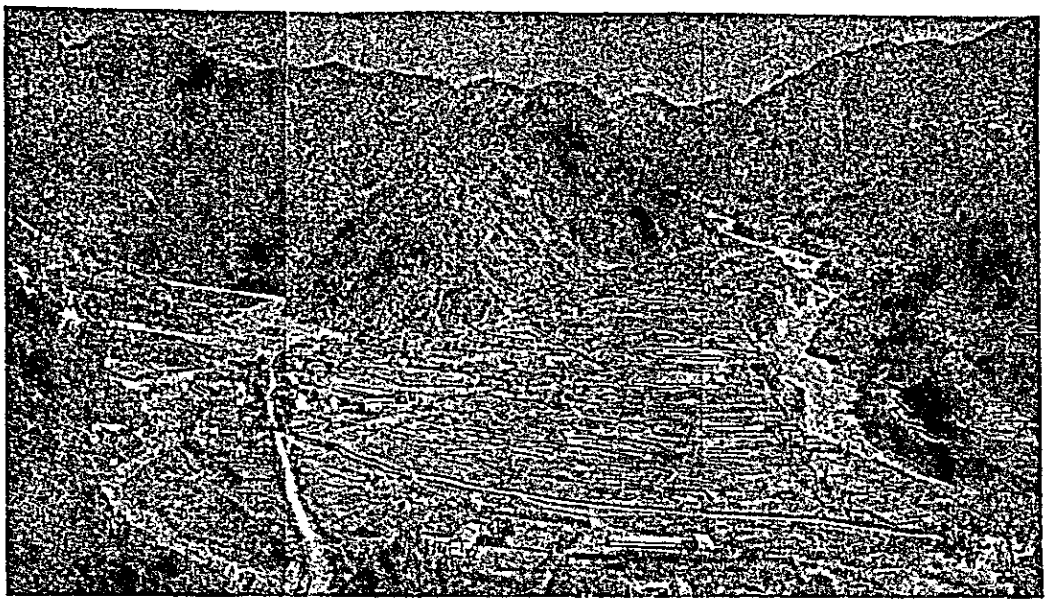


8. Kulikhani
confluence of
ola. River bed
with great
f sand and gravel.

Photo II. 9. Both side slopes of Kulikhani Khola upstream from confluence of Rakes Khola. (upward view)

Photo II. 10. Bagmati river downstream from confluence of Kulikhani Khola.





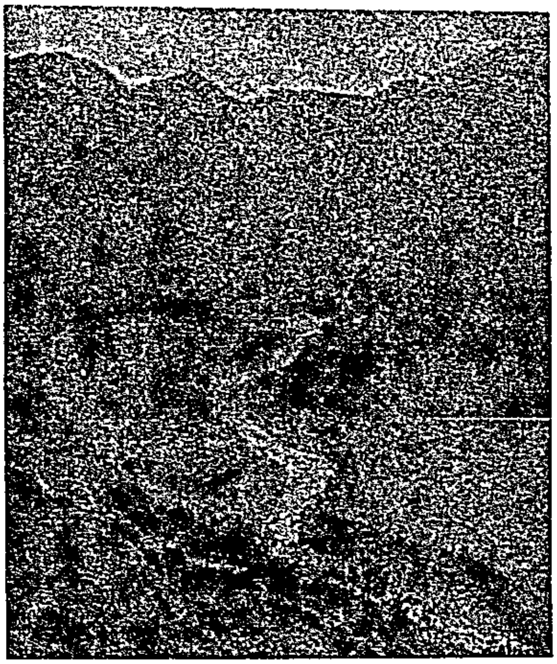
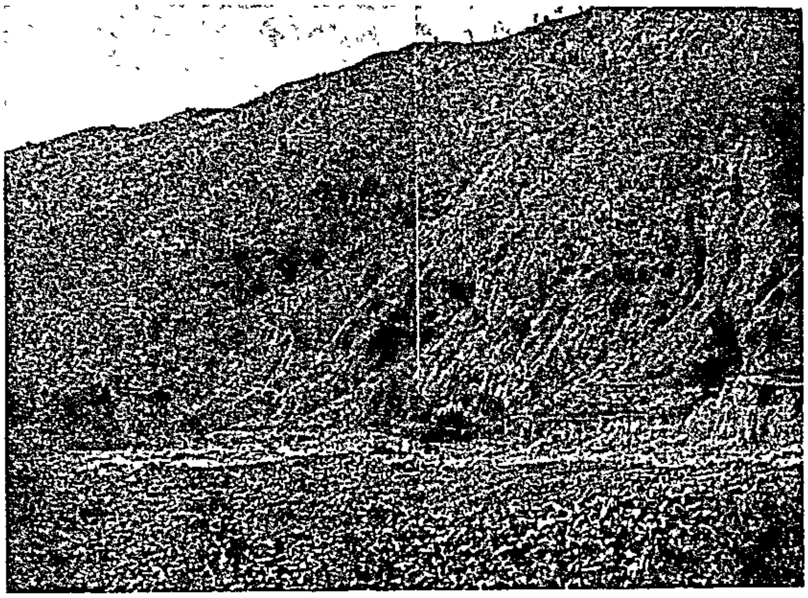


Photo II. 11. Flats of Bhimphedi. Right side is Khari Khola with well developed gravel terrace and left side is Lamo Khola with great quantity of sand and gravel deposit on river bed.

Photo II. 12. Source area of Khari Khola. Gravel terrace continues up to extremity.

Photo II. 13. Coll. 32 and 33 on Khari Khola. (downward view)



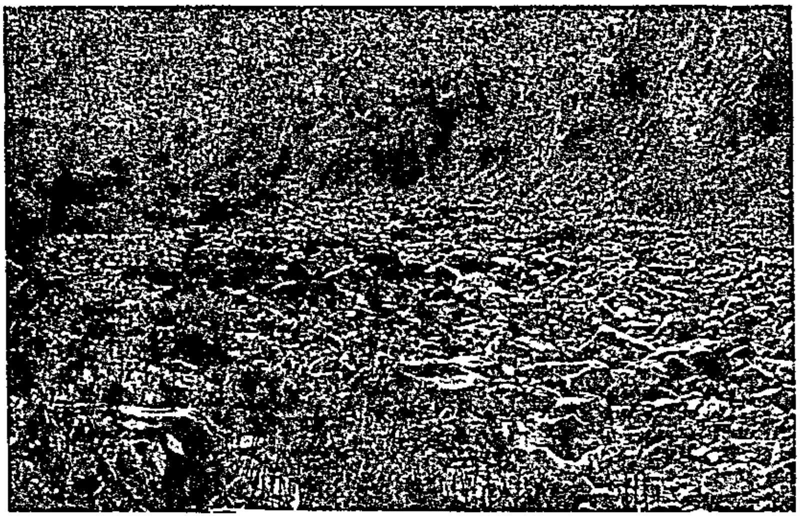


Photo II, 14. Washout of terrace scraps on lower reaches of Khari Khola. (Upstream view)

Photo II. 15. Panoramic view of Coll. 13

Photo II. 16. Part of Coll. 13

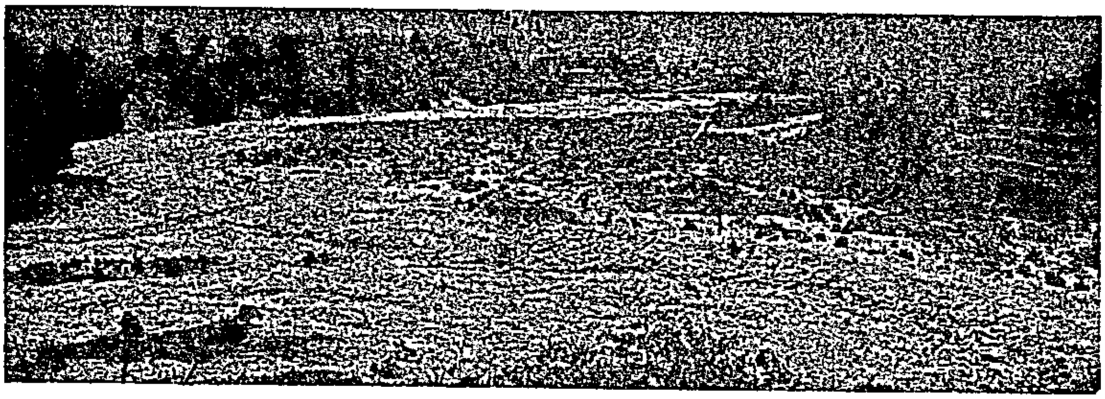


Photo II. 17. Confluence of Lamo Khola and Khani Khola. Width is more than 300 m, river bed is covered with great quantity of sand and gravel deposit. Houses of Bhimphedi are seen in right upper part.

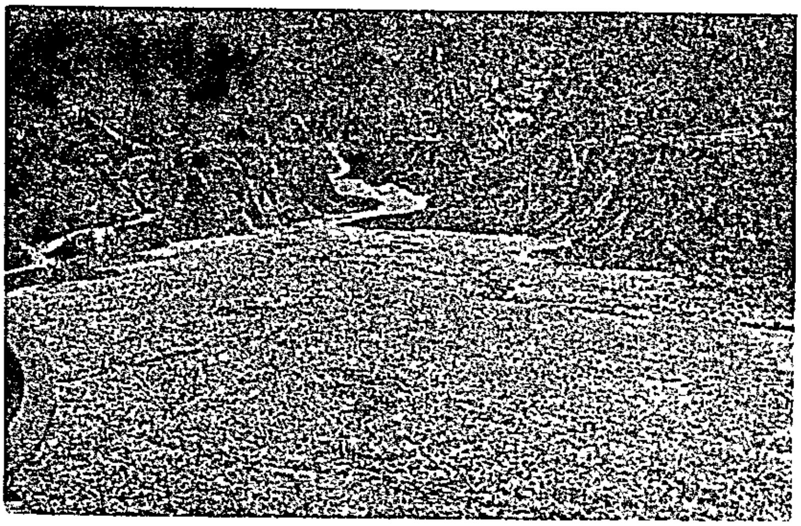
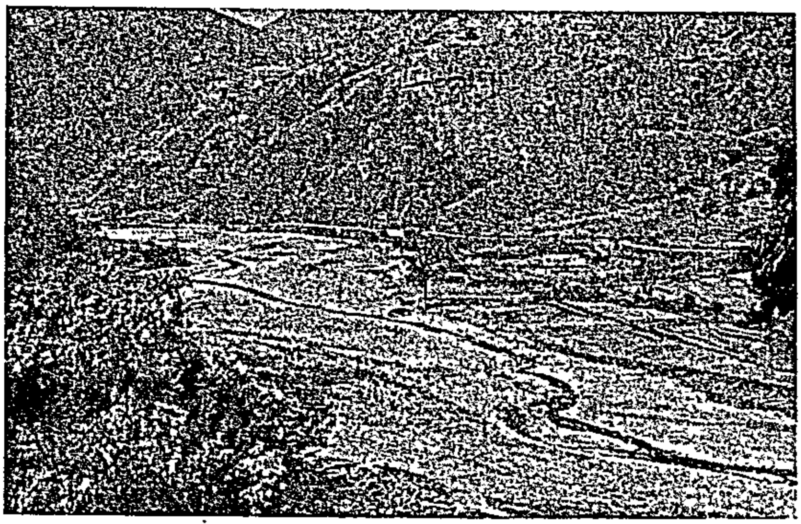


Photo II. 18.
Rapti river near Dharsing. River bed is covered with great quantity of sand and gravel deposit, and river water all flows in the deposit.

Photo II. 19.
Rapti river near Nibuwatar, (downstream view).



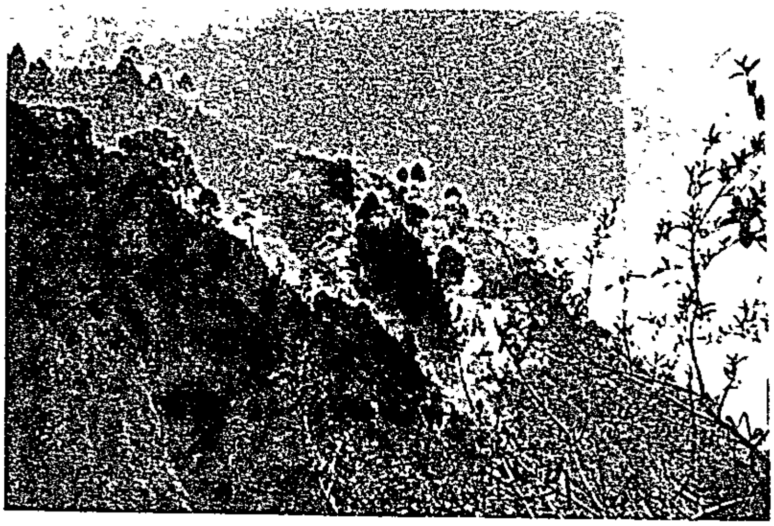


Photo II.20 Inhabitants are burning withered grass on mountain slope (seen near Bhimphedi in April)

Photo II.21 Reclaimed Khasro forest, on watershed of Sim Khola basin

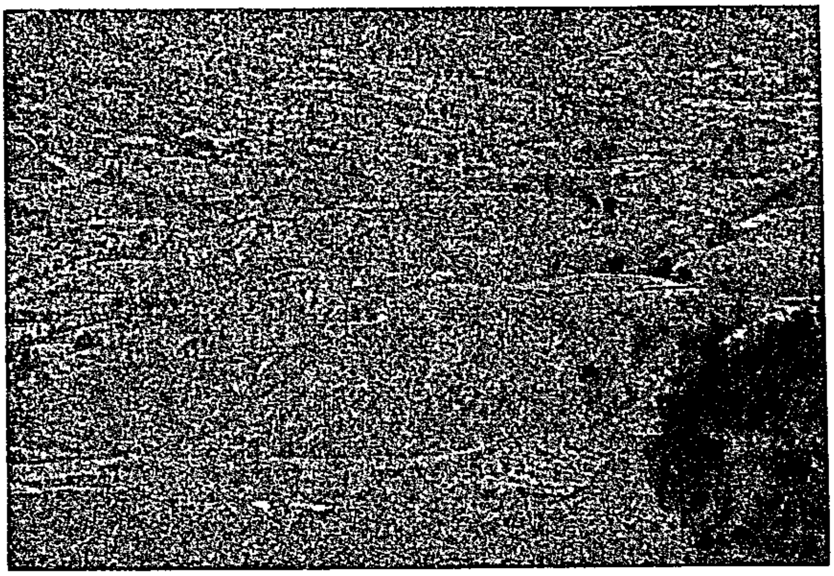


Photo II.22 Example of head erosion of pasture
(near Machhindragaon)

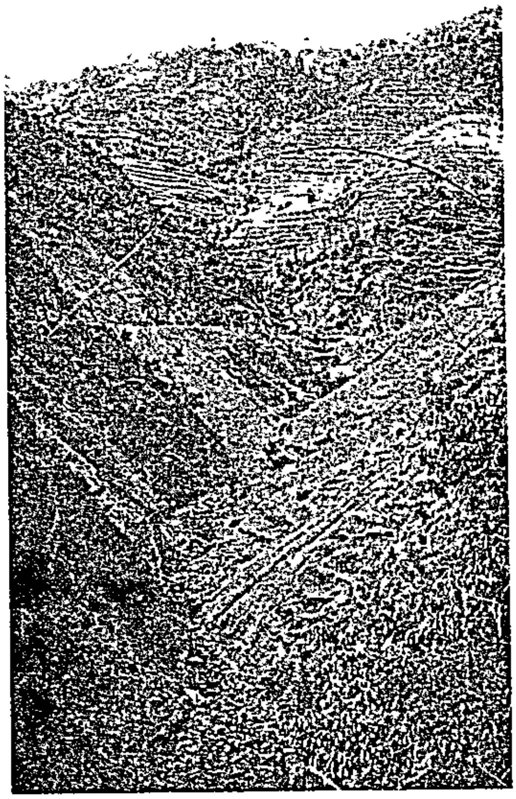


Photo II.23

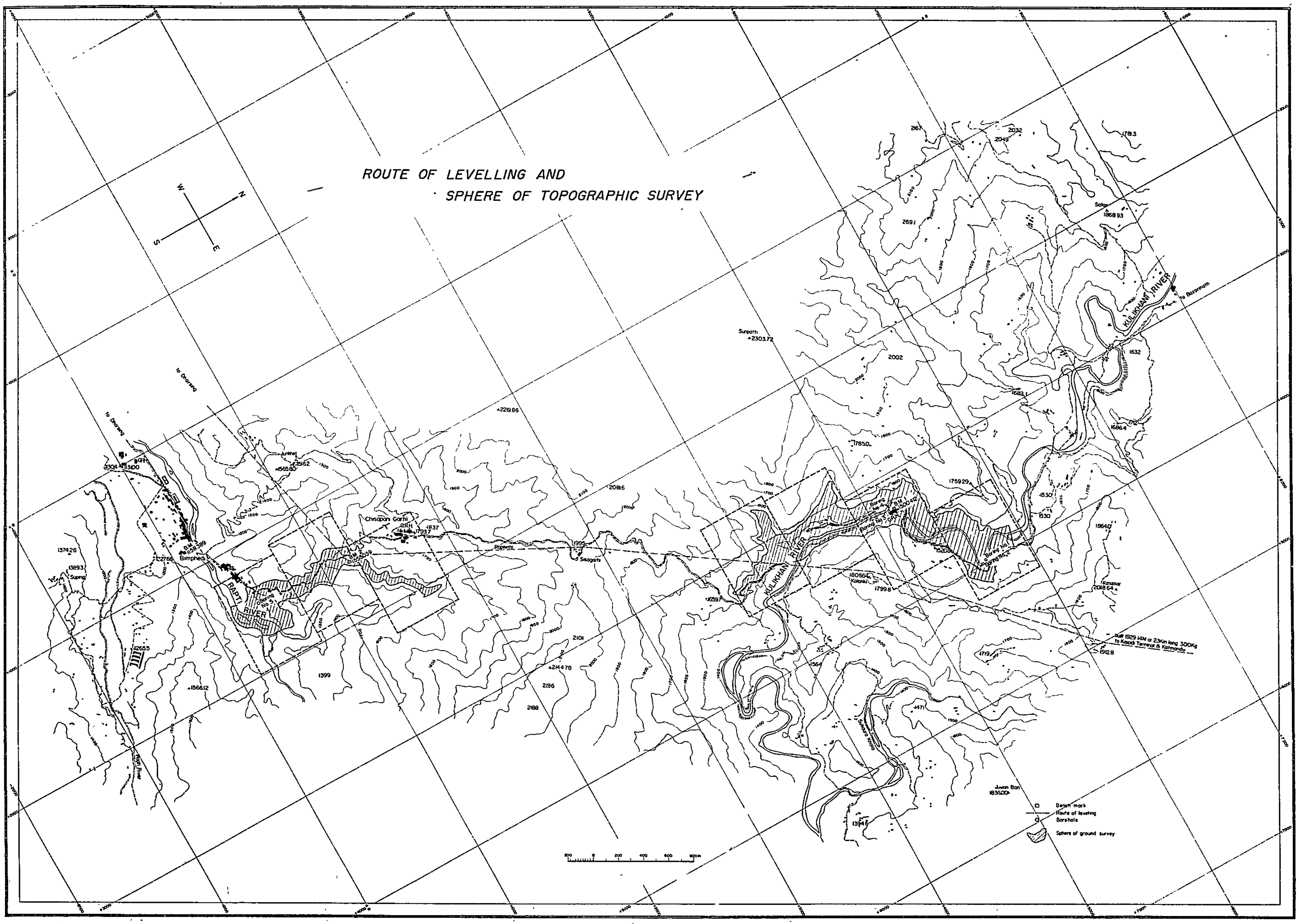
Dumped excavated material from
Tribubhan Rajpath road
(near Tistung Deorali)

APPENDIX III

RESULT OF INVESTIGATIONS

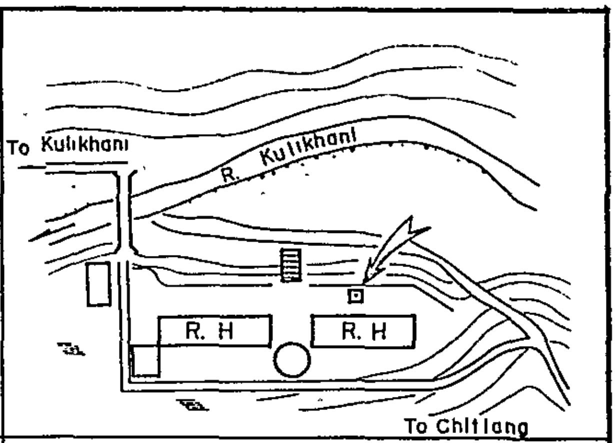
CONTENTS

ROUTE OF LEVELLING AND SPHERE OF TOPOGRAPHIC SURVEY



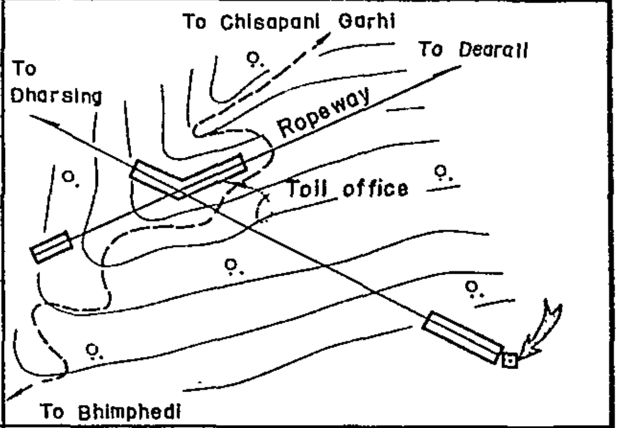
No.	B.M. 1
Elevation	1 500.412
Installed on	21. Mar. 1963
Location	Kulikhani

Note . In front of kulikhani rest house



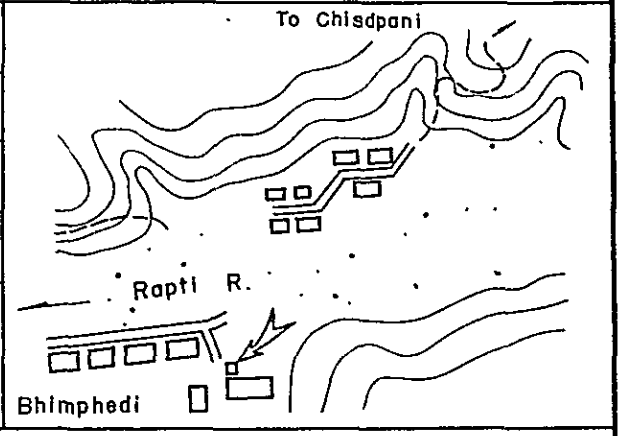
No.	B.M. 2
Elevation	1 555.039
Installed on	31. Mar. 1963
Location	Chisapani Garhi

Note , On the ropeway anchor block

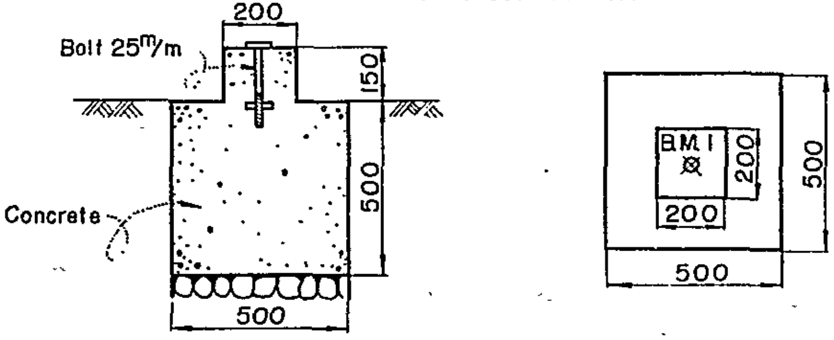


No.	B.M. 3
Elevation	1 158.389
Installed on	18. Apr. 1963
Location	Bhimphedi

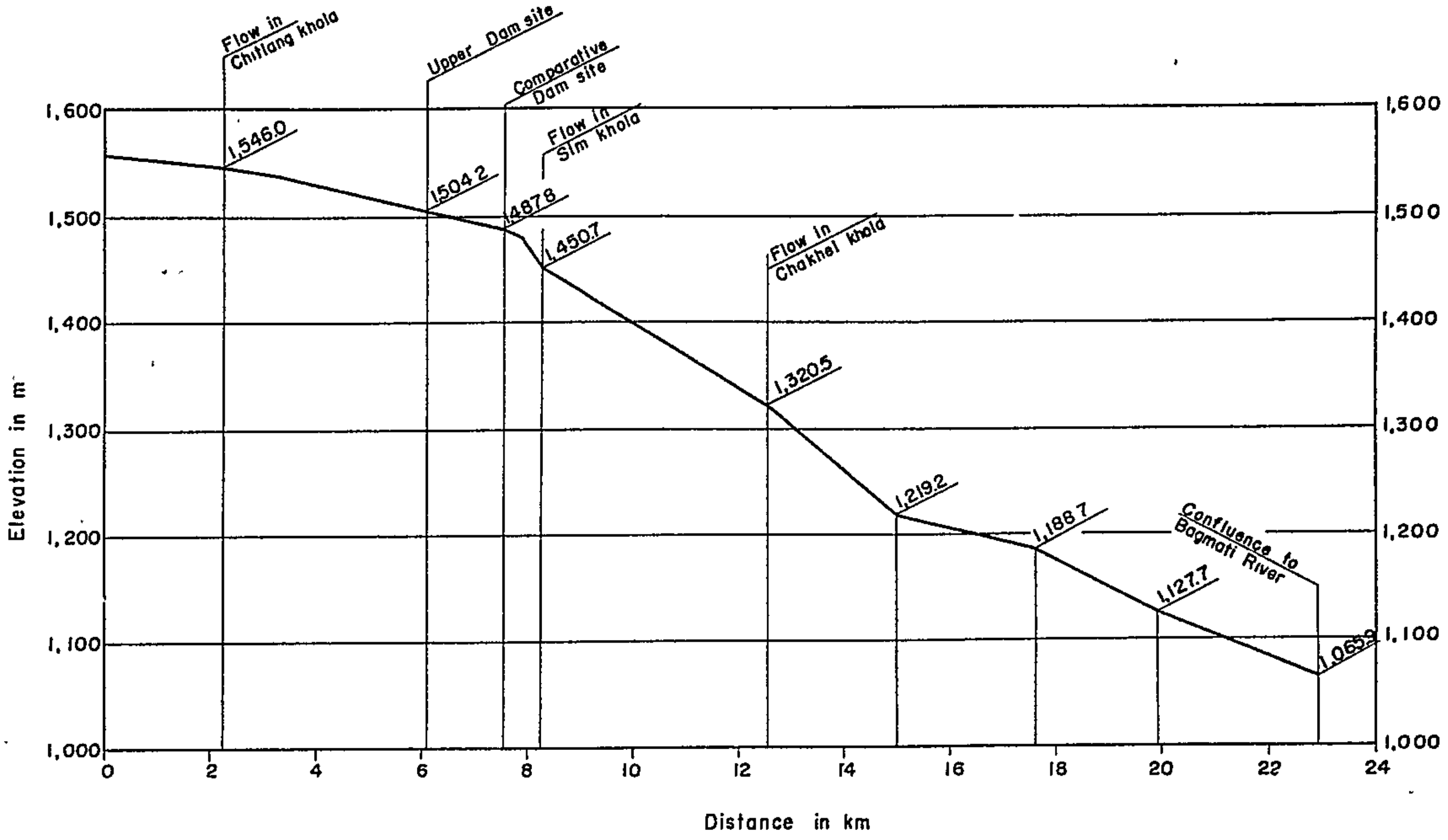
Note ; By the house commonly called "Elephant house "



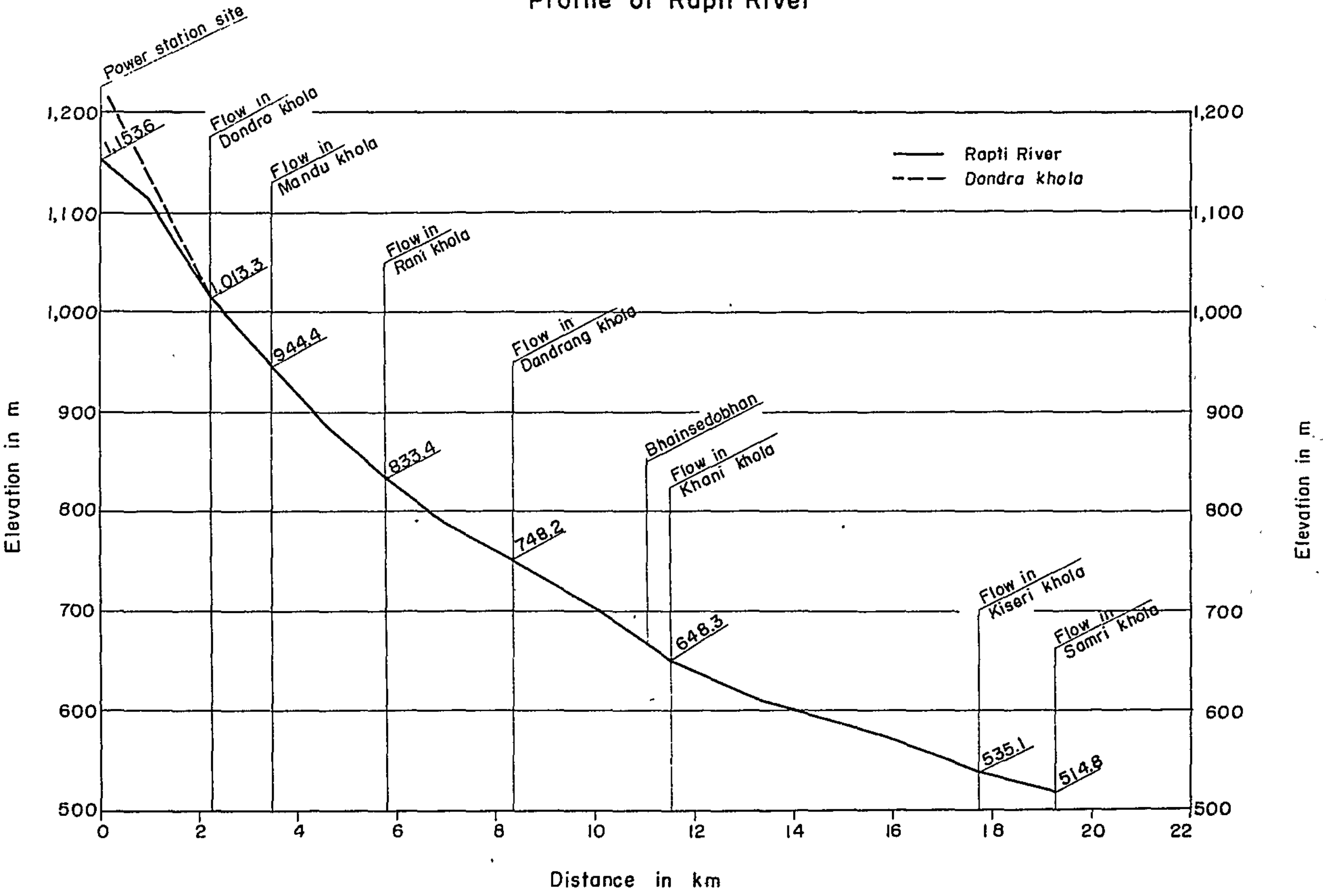
BENCH MARK



Profile of Kulikhani River

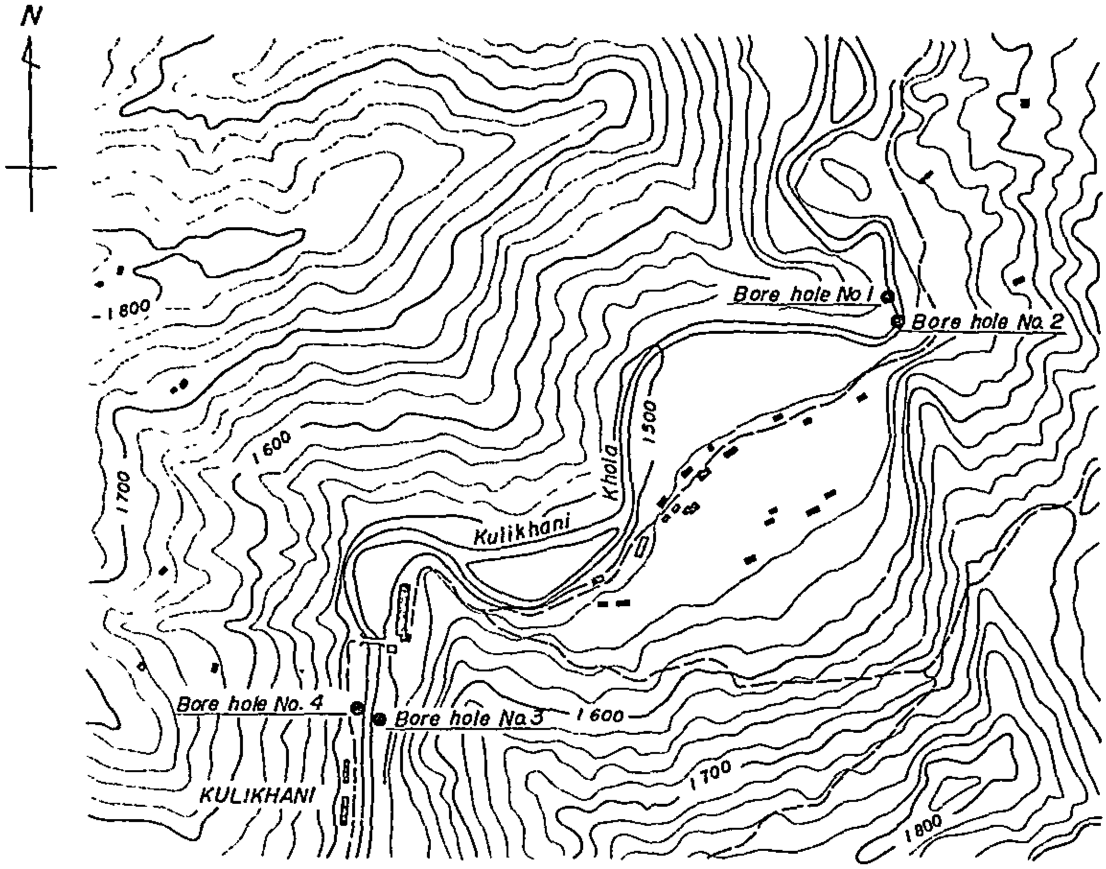


Profile of Rapti River

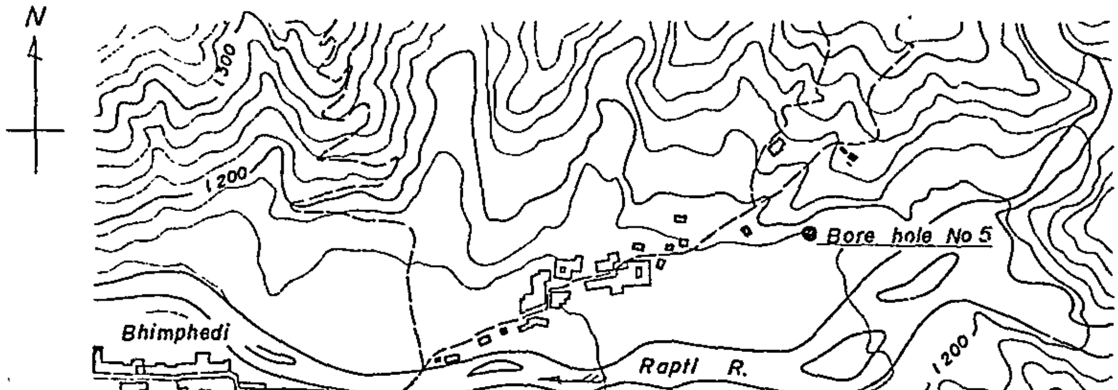


LOCATION OF BORE HOLE

(Scale 1: 10,000)



DAM SITES



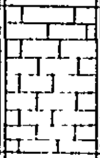
POWER STATION SITE

GEOLOGICAL RECORD OF BORE HOLE

HOLE NO. 1

PROJECT : Kulikhani
LOCATION : Upper site
DATE STARTED : Feb 26 '63
DATE COMPLETED : Mar 12 '63
DIAMETER OF HOLE : 85 $\overset{\text{MM}}{\sim}$ 46
MACHINE : UD-5

ELEVATION OF SURFACE 1504^{M}.2
ELEV. BOTTOM OF HOLE 1498^{M}.2
INCLINATION OF HOLE. vert.
DRLLED BY K. Koike
GEOL. LY LOGGED BY K. Koike

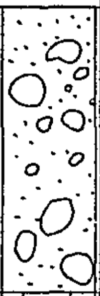
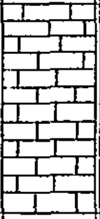
DATE	DEPTH	ELEV. TOP OF STRATUM	CLASSIFI-CATION OF ROCKS	COLUMNAR SECTION	THICKNESS OF STRATUM	ACCUMLATIVE TIHCKNESS OF STRATA	CORE RECOVERY	DESCRIPTION
	m	m			m	m	%	
3/2 3/7 3/8	1 2 3		Boulder Gravel and Sand		3.90	3.90	50 %	Driving pipe sunk down to 1.0m Casing pipe sunk down to 2.5 m Boulder is of granite and sandstone max. ϕ 15 ~20cm
3/10 3/11 3/12	4 5 6		Crystalline Limestone		2.10	6.00	25 %	Very cracky especially at 5.2 m
	7 8 9 10 11 12 13 14 15 16 17 18 19 20							

GEOLOGICAL RECORD OF BORE HOLE

HOLE NO. 2

PROJECT : Kulikhani
LOCATION : Upper site
DATE STARTED : Mar. 13, 1963
DATE COMPLETED : Mar 18 '63
DIAMETER OF HOLE : 85 $^{\text{MM}}$46
MACHINE : UD-5

ELEVATION OF SURFACE, 1504$^{\text{M}}$0
ELEV. BOTTOM OF HOLE, 1496$^{\text{M}}$9
INCLINATION OF HOLE, vert
DRLLED BY K. Koike
GEOL. LY LOGGED BY K. Koike

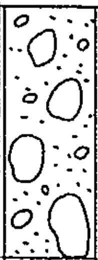
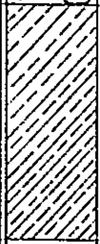
DATE	DEPTH	ELEV. TOP OF STRATUM	CLASSIFI-CATION OF ROCKS	COLUMNAR SECTION	THICKNESS OF STRATUM	ACCUMLATIVE TIHCKNESS OF STRATA	CORE RECOVERY	DESCRIPTION
	m	m			m	m	%	
3/15 3/16	1 2 3 4		Boulder Gravel and Sand		4.10	4.10	0 % 40 %	Driving pipe set down to 1.0 m. Casing pipe set down to 2.5 m Boulder is of Granite Sandstone and Limestone
3/17 3/18	5 6 7		Crystalline Limestone		3.00	7.10	60 %	Very cracky
	8 9 10 11 12 13 14 15 16 17 18 19 20							

GEOLOGICAL RECORD OF BORE HOLE

HOLE NO. 3

PROJECT : Kulikhani
LOCATION : Lower site
DATE STARTED : Mar 21 '63
DATE COMPLETED : Mar 26 '63
DIAMETER OF HOLE : 85 MM~46
MACHINE : UD-5

ELEVATION OF SURFACE, 1488 M.2
ELEV. BOTTOM OF HOLE, 1481 M.2
INCLINATION OF HOLE, vert.
DRLLED BY K. Koike
GEOL. LY LOGGED BY K. Koike

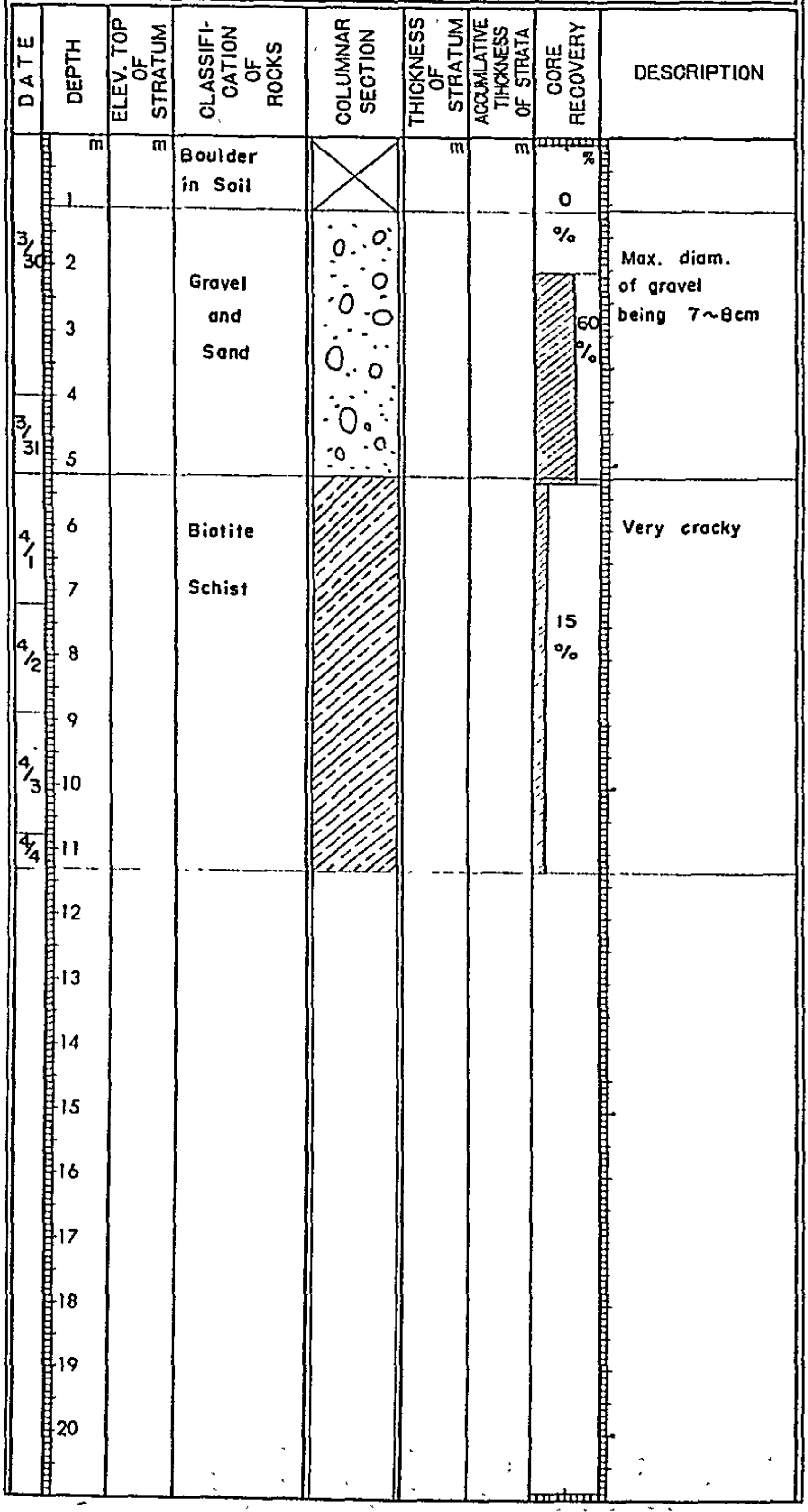
DATE	DEPTH	ELEV. TOP OF STRATUM	CLASSIFICATION OF ROCKS	COLUMNAR SECTION	THICKNESS OF STRATUM	ACCUMLATIVE TIHCKNESS OF STRATA	CORE RECOVERY	DESCRIPTION
	m	m			m	m	%	
3/23 3/24	1 2 3		Boulder gravel and Sand		3.65	365	0 % 65 %	Driving pipe set down to 1.0 m
3/25 3/26	4 5 6 7		Biotite Schist		3.35	7.00	50 %	with some cracks
	8 9 10 11 12 13 14 15 16 17 18 19 20							

GEOLOGICAL RECORD OF BORE HOLE

HOLE NO. 4

PROJECT : Kulikhani
LOCATION : Lower site
DATE STARTED : Mar. 27 '63
DATE COMPLETED : Apr. 4 '63
DIAMETER OF HOLE: $85^{MM}\sim46$
MACHINE : UD-5

ELEVATION OF SURFACE. $1427^{M}.1$
ELEV. BOTTOM OF HOLE. $1415^{M}.8$
INCLINATION OF HOLE. vert.
DRLLED BY K. Koike
GEOL. LY LOGGED BY K. Koike



DATE	DEPTH	ELEV. TOP OF STRATUM	CLASSIFI-CATION OF ROCKS	COLUMNAR SECTION	THICKNESS OF STRATUM	ACCUMLATIVE TIHCKNESS OF STRATA	CORE RECOVERY	DESCRIPTION
	m	m			m	m	%	
	0–1		Boulder in Soil				0 %	
3/30 3/31	1–5		Gravel and Sand				60 %	Max. diam. of gravel being 7~8cm
4/1 4/2 4/3 4/4	5–11		Biotite Schist				15 %	Very cracky

GEOLOGICAL RECORD OF BORE HOLE

HOLE NO. 5

PROJECT : Kulikhani
LOCATION : Bhimpedi P.S site
DATE STARTED ; Apr. 4 '63
DATE COMPLETED : Apr. 17 '63
DIAMETER OF HOLE; 85^{MM}~46
MACHINE ; UD – 5

ELEVATION OF SURFACE, 1177^{M}.6
ELEV. BOTTOM OF HOLE, 1167^{M}.6
INCLINATION OF HOLE, vert.
DRLLED BY K. Koike
GEOL. LY LOGGED BY K. Koike

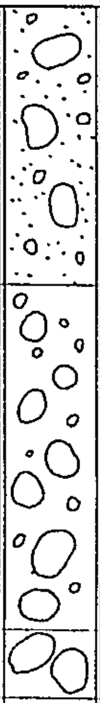
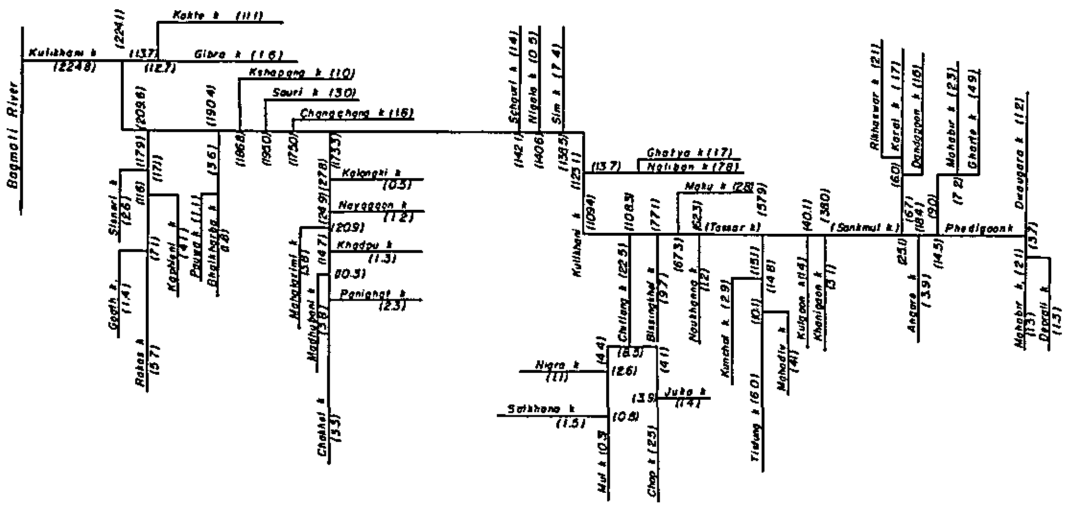
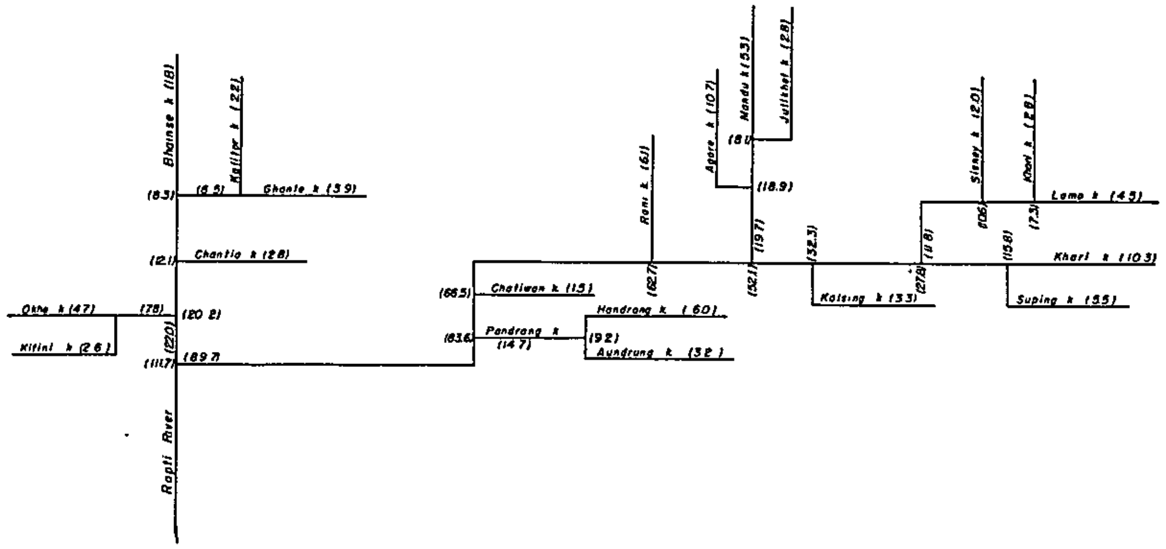
DATE	DEPTH	ELEV. TOP OF STRATUM	CLASSIFICATION OF ROCKS	COLUMNAR SECTION	THICKNESS OF STRATUM	ACCUMULATIVE THICKNESS OF STRATA	CORE RECOVERY	DESCRIPTION
	m	m			m	m	%	
4/10 4/11 4/12	1 2 3 4		Boulder Gravel and Sand					Driving pipe set down to 0.75m Boulder and gravel are of Sandstone, Quartzite, and Limestone
4/13 4/14 4/15	5 6 7 8 9		Boulder and Gravel					Boulder and gravel are of Quartzite only.
4/16	10							
	11 12 13 14 15 16 17 18 19 20							

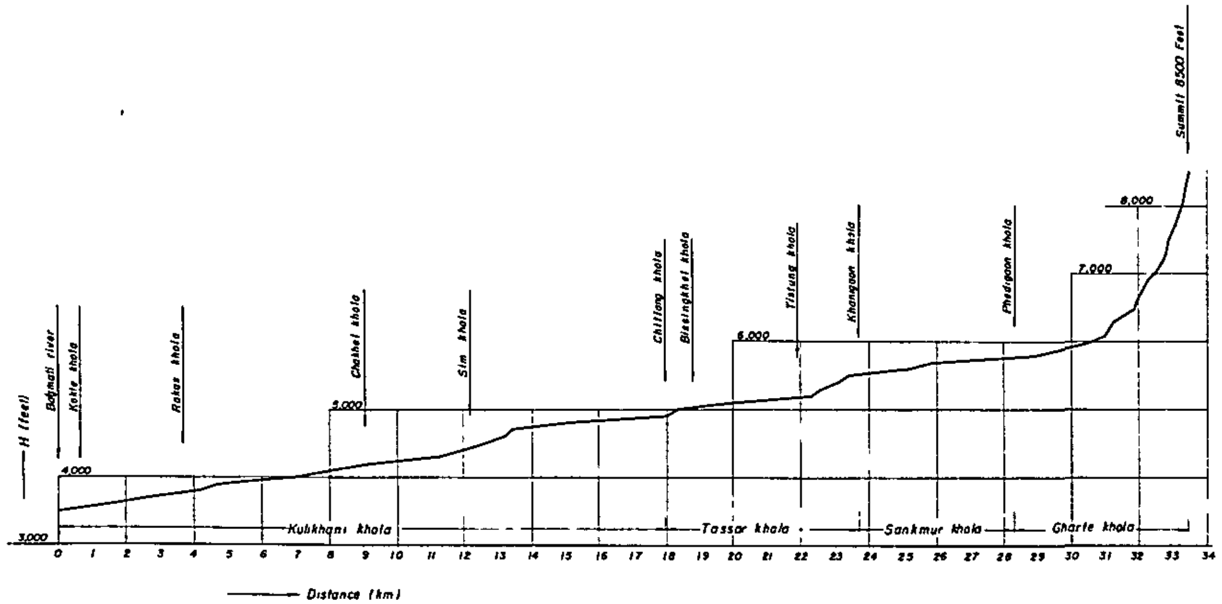
DIAGRAM OF RIVER SYSTEM AND PROFILE OF RIVER



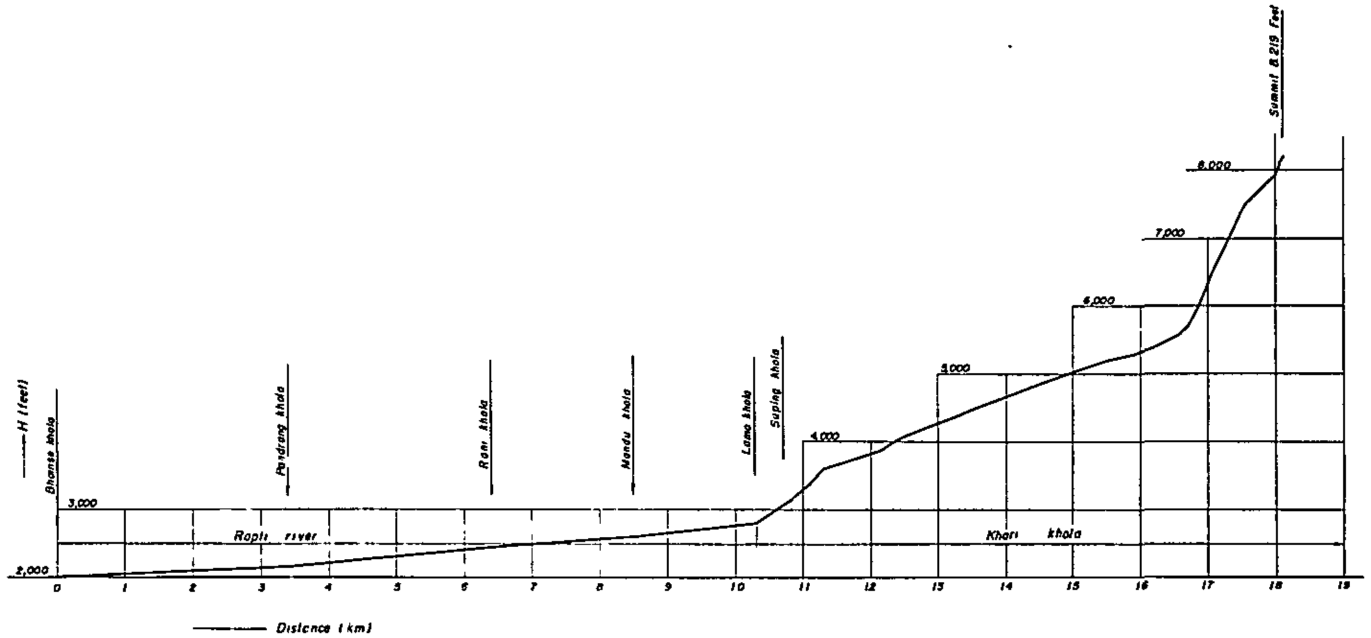
DRAINAGE SYSTEM OF KULIKHANI RIVER BASIN



DRAINAGE SYSTEM OF RAPTI RIVER BASIN



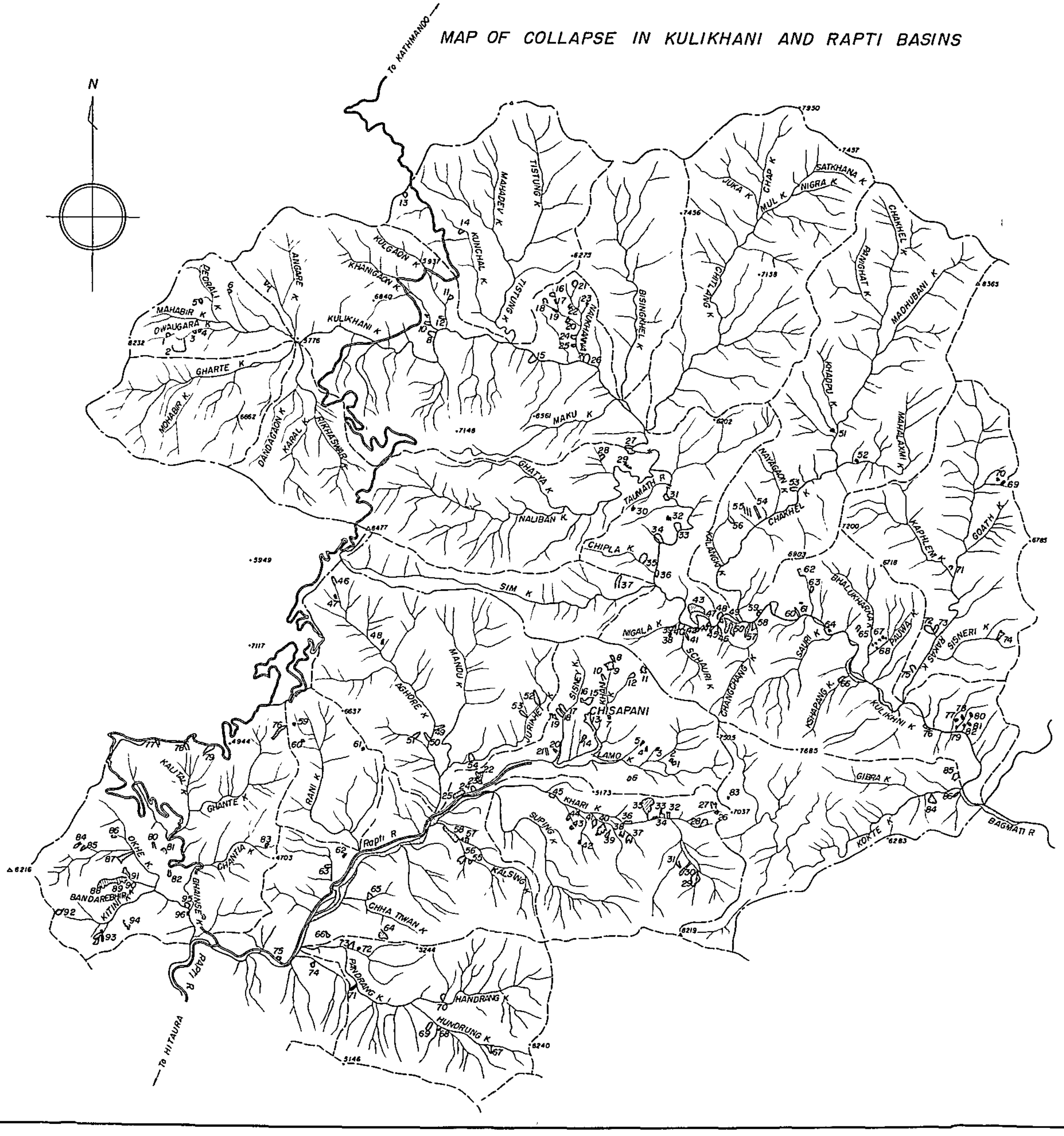
PROFILE



PROFILE

( ) shows drainage area (km²)

MAP OF COLLAPSE IN KULIKHANI AND RAPTI BASINS



Collapse on Kulikhani river basin

Coll. No.	River	Valley	Position	Direction of mountain slope	Area of collapse	Classification	Cause
1	Kulikhani	Dwangara	Bank	S 30° E	3,200 m^2	Earth fall	Vertical erosion
2	"	"	Bank Concave part of mountain side	N 24° W	58,000	Earth fall Land creep	Ground water
3	"	"	Bank	N 15° W	300	Earth and rock fall	Lateral erosion
4	"	"	"	N 15° E	250	"	"
5	"	Deorali	Spur	N 35° E	4,600	Rock fall	Vertical erosion
6	"	"	Mountain side	S 5° W	400	Soil exfoliation	Heavy rain
7	"	Angare	Bank	N 20° E	1,600	Land creep	Vertical erosion
	Total				68,350		
8	Kulikhani	-	Bank	S 55° E	2,000	Rock fall	Vertical erosion
9	"	Khanigaon	"	N 70° E	100	Earth fall	Lateral erosion
10	"	"	Concave part of mountain side Bank	N 45° E	900	"	"
	Total				3,000		
11	Kulikhani	Kulgaon	Bank	N 35° E	250	Earth fall	Lateral erosion
12	"	"	"	N 80° E	1,500	Earth and rock fall	Vertical erosion
	Total				1,750		
13	Tistung	Kunchal	Ridge Concave part of mountain side	S 40° E	1,600	Earth and rock fall	Head erosion
14	"	"	Bank	N 25° E	500	Earth fall	Lateral erosion
	Total				2,100		
15	Kulikhani	-	Bank	N 15° E	14,400	Rock fall	Lateral erosion
16	"	Naukhanna	"	N 70° E	4,000	Earth fall	"
17	"	"	"	N 45° E	1,300	"	"
18	"	"	Valley head	S 45° E	4,000	"	Head erosion

Coll. No.	River	Valley	Position	Direction of mountain slope	Area of collapse	Classification	Cause
					m^2		
19	Kulikhani	Naukhanna	Bank	N 45° E	400	Earth fall	Lateral erosion
20	"	"	"	N 10° E	2,000	Rock fall	"
21	"	"	Ridge, mountain side, Concave part of mountain side	S 5° W	3,700	"	Head erosion
22	"	"	Bank	N 60° E	1,300	Soil exfoliation	Vertical erosion
23	"	"	Concave part of mountain side ridge	S 50° E	250	Earth fall	Head erosion
24	"	"	Concave part of mountain side valley head	N 85° E	5,000	"	Lateral erosion
25	"	"	Bank	N 70° E	3,000	"	"
	Total				39,350		
26	Kulikahani	-	Concave part of mountain side	S 50° W	5,000	Earth fall	Head erosion
	Total				5,000		
27	Kulikhani	-	Ridge Bank	S 55° E	60,000	Earth and rock fall	Lateral erosion
28	Naliban	-	Bank	S 50° W	600	Earth fall	Lateral erosion
29	"		Mountain side	S 40° E	1,000	Soil exfoliation	Heavy rain
	Total				61,600		
30	Kulikahani	Taumath	Valley head	N 10° E	1,000	Earth fall	Head erosion
31	"	-	Concave part of mountain side	N 55° E	40,000	Rock fall	Lateral erosion
32	"	-	"	N 25° W	300	Soil exfoliation	Head erosion
33	"	-	Bank	S 25° E	330	Earth fall	Lateral erosion
34	"	-	"	S 85° E	8,000	Rock fall	Vertical erosion
35	"	Chipla	"	S 15° W	4,000	Earth fall	Lateral erosion
36	"	-	"	S 40° W	500	"	"

Coll. No.	River	Valley	Position	Direction of mountain slope	Area of collapse m^2	Classification	Cause
37	Sim	Chipla	Bank	S 30^o W	1,200	Rock fall	Vertical erosion Head erosion
	Total				55,330		
38	Kulikhani	Nigala	Bank	N 20^o E	7,500	Rock fall	Head erosion
39	"	"	"	N 30^o W	1,000	"	Vertical erosion
40	"	-	"	N 40^o E	14,000	"	Lateral erosion
41	"	Schauri	"	N 75^o W	400	"	"
42	"	-	"	N 15^o E	2,000	Earth fall	"
43	"	-	Concave part of mountain side Bank	S 15^o E	38,000	Rock fall	Vertical erosion Lateral erosion
44	"	-	Bank	N 75^o E	600	Soil exfoliation	Lateral erosion
45	"	-	"	N 25^o E	1,000	Rock fall	"
46	"	-	Mountain side Concare part of mountain side	N 15^o W	4,000	"	Head erosion
47	"	-	Spur	N 5^o W	200	Soil exfoliation	Head rain
48	"	-	Bank	S 50^o E	4,000	Rock fall	Lateral erosion
49	"	-	Concave part of mountain side	N 25^o E	26,300	"	Head erosion
50	"	-	"	N 35^o E	15,000	"	"
	Total				114,000		
51	Chakhel	Khadpu	Mountain side Convex part of mountain side	N 50^o E	150	Earth fall	Head erosion
52	"	Mehalarimi	Bank	S 25^o W	300	Earth and rock fall	Lateral erosion
53	"	-	Concave part of mountain side	N 60^o E	2,000	Rock fall	Head erosion
54	"	-	"	S 35^o E	750	Gully	Vertical erosion
55	"	-	"	S 25^o E	2,700	"	"
56	"	Kalangki	"	N 60^o W	2,500	Earth fall	Head erosion
57	Kulikhani	-	"	N 5^o E	900	Rock fall	"
58	"	Chang Chang	Concave part of mountain side	N 35^o E	6,500	Rock fall	Vertical erosion

Coll. No.	River	Valley	Position	Direction of mountain slope	Area of collapse	Classification	Cause
59	Kulikhani	Chang Chang	Bank	S 55° E	500m^2	Earth and rock fall	Lateral erosion
60	"	-	Concave part of mountain side	S 50° E	700	Gully	Vertical erosion Head erosion
61	"	-	"	S 80° E	400	Soil exfoliation	Heavy rain
62	"	-	"	N 70° E	8,000	Rock fall	Vertical erosion
63	"	-	Bank	S 25° W	500	"	"
64	"	-	"	S 40° E	1,200	Earth and rock fall	Head erosion
65	"	-	Concave part of mountain side	S 60° W	4,000	Earth fall	Heavy rain
66	"	Kshapang	Bank	S 60° E	10,000	Earth and rock fall	Lateral erosion
67	"	Bhalukharka	Mountain side	S 55° W	200	Soil exfoliation	Heavy rain
68	"	"	"	S 15° E	400	"	"
	Total				41,700		
69	Rakas	-	Mountain side	S 25° W	130	Soil exfoliation	Heavy rain
70	"	-	"	S 20° E	150	"	"
71	"	Kaphleni	Concave part of mountain side Bank	S 40° W	600	Rock fall	Lateral erosion
72	"	-	Bank Concave part of mountain side	N 60° E	31,000	"	Vertical erosion Head erosion
73	"	-	Bank	S 70° W	1,200	"	Vertical erosion
74	"	Sisneri	Concave part of mountain side	S 20° W	4,700	Earth fall	Vertical erosion Head erosion
75	"	-	"	S 40° E	700	"	Head erosion
	Total				38,480		
76	Kulikhani	-	Bank	N 40° E	2,500	Earth fall	Lateral erosion
77	"	-	Concave part of mountain side	S 25° W	1,100	Rock fall	Vertical erosion
78	"	-	Concave part of mountain side Bank	S 20° W	1,400	Earth and rock fall	Vertical erosion Head erosion

Coll. No.	River	Valley	Position	Direction of mountain slope	Area of collapse	Classification	Cause
79	Kulikhani	-	Bank	S 45° E	800 m^2	Earth fall	Head erosion
80	"	-	Concave part of mountain side	S 70° W	400	Rock fall	"
81	"	-	Bank	N 70° W	1,000	Earth fall	Lateral erosion
82	"	-	"	S 0°	1,000	Gully	Vertical erosion
	Total				8,200		
83	Kokte	-	Spur	N 10° E	100	Soil exfoliation	Heavy rain
84	"	-	Concave part of mountain side	N 10° W	80,000	Rock fall	Vertical erosion
85	"	-	"	S 25° W	200	"	"
86	Kulikhani	-	Spur	N 75° E	500	Earth and rock fall	Head erosion
	Total				80,800		
	Grand total				519,660		

Collapse on Rapti river basin

Coll. No.	River	Valley	Position	Direction of mountain slope	Area of Collapse	Classification	Cause
1	Lamo	-	Concave part of mountain side	S 70° W	800 m^2	Earth fall	Head erosion
2	"	-	"	S 40° W	200	"	"
3	"	-	"	S 25° E	300	Soil exfoliation	"
4	"	-	"	S 75° W	100	"	"
5	"	-	"	S 50° W	500	Earth and rock fall	"
6	"	-	"	N 5° E	100	Earth fall	"
	Total				2,000		
7	Lamo	Khani	Concave part of mountain side	S 20° E	1,200	Earth and rock fall	Head erosion
8	"	"	"	S 40° E	3,800	"	"
9	"	"	"	N 80° E	4,000	"	"
10	"	"	"	S 25° W	300	"	"
11	"	"	"	S 35° W	7,000	Rock fall	"
12	"	"	Spur	S 80° W	3,500	"	Vertical erosion
13	"	"	Concave part of mountain side	S 30° E	58,500	"	Head erosion
	Total				78,300		
14	Lamo	-	Concave part of mountain side	S 55° W	2,400	Rock fall	Head erosion
	Total				2,400		
15	Lamo	Sisney	Concave part of mountain side	S 55° W	21,600	Rock fall	Head erosion
16	"	"	Bank	S 20° W	1,500	"	Vertical erosion
17	"	"	Concave part of mountain side	S 45° E	3,000	"	Head erosion
18	"	"	"	S 30° E	4,300	"	"
19	"	"	"	S 55° E	700	"	"
20	"	"	"	S 65° E	500	Earth and rock fall	"
	Total				31,600		

Coll. No.	River	Valley	Position	Direction of mountain slope	Area of collapse	Classification	Cause
21	Lamo	-	Concave part of mountain side	S 15° E	1,500m^2	Gully	Vertical erosion
22	"	-	"	S 30° E	3,700	Rock fall	Head erosion
23	"	-	"	S 40° E	1,400	Earth fall	"
24	"	-	Bank	S 45° E	3,000	Earth and rock fall	Lateral erosion
25	"	-	"	S 40° E	8,000	Earth fall	"
	Total				17,600		
26	Khari	-	Concave part of mountain side	N 85° W	1,400	Rock fall	Head erosion
27	"	-		S 45° W	400	Soil exfoliation	"
28	"	-	Concave part of mountain side	S 65° W	1,000	Rock fall	"
29	"	-	"	N 30° E	38,400	Rock fall	Head erosion
30	"	-	"	N 35° E	1,800	"	Vertical erosion
31	"	-	"	N 20° W	1,500	"	Head erosion
32	"	-	Bank	S 15° W	3,800	"	Lateral erosion
33	"	-	"	S 15° W	4,900	"	"
34	"	-	"	S 5° E	700	Earth and rock fall	"
35	"	-	Concave part of mountain side	S 10° W	12,000	Rock fall	Head erosion
36	"	-	Bank	S 5° E	500	"	Lateral erosion
37	"	-	Concave part of mountain side	N 65° E	3,200	"	"
38	"	-	"	N 45° E	2,400	"	"
39	"	-	"	N 30° E	400	"	Head erosion
40	"	-	"	N 20° E	8,000	"	Vertical erosion
41	"	-	Bank	N 10° E	3,200	"	Head erosion
42	"	-	Concave part of mountain side	N 40° E	2,400	"	"
43	"	-	Bank	N 70° E	300	Earth and rock fall	Vertical erosion
44	"	-	Spur	N 5° E	2,400	"	"
45	"	-	Bank	N 65° E	4,000	Earth fall	Lateral erosion
	Total				92,700		

Coll. No.	River	Valley	Position	Direction of mountain slope	Area of collapse	Classification	Cause
46	Manau	Aghore	Concave part of mountain side	S 25° E	450	Earth fall	Head erosion
47	"	"	"	S 15° W	400	"	"
48	"	"	Bank	S 30° W	200	Earth and rock fall	Vertical erosion
49	"	"	Concave part of mountain side	S 65° W	1,500	Rock fall	Head erosion
50	"	"	"	S 70° E	800	Earth fall	"
51	"	"	"	N 25° W	500	Earth and rock fall	"
52	"	Jurikhet	"	S 30° E	2,500	Rock fall	"
53	"	"	Spur	S 50° E	300	Earth fall	"
54	"	"	Concave part of mountain side	S 15° E	500	"	Vertical erosion Head erosion
	Total				7,150		
55	Kalsing	-	Bank	N 5° E	1,800	Rock fall	Lateral erosion
56	"	-	Concave part of mountain side	N 65° E	5,600	"	Vertical erosion
57	"	-	Bank	S 45° W	1,400	"	"
58	"	-	Concave part of mountain side Bank	N 60° E	17,600	"	Lateral erosion
	Total				26,400		
59	Rani	-	Mountain side	S 70° E	300	Rock fall	Head erosion
60	"	-	Concave part of mountain side	S 80° E	200	Earth fall	"
61	"	-		N 70° W	400	Soil exfoliation	Vertical erosion Head erosion
	Total				900		
62	Rapti	-	Mountain side	S 30° W	500	Rock fall	Head erosion
63	"	-	Bank	S 80° E	100	Soil exfoliation	Vertical erosion
	Total				600		
64	Chhatiwan	-	Concave part of mountain side	N 60° W	3,500	Rock fall	Head erosion
65	"	-	Bank	S 10° E	600	"	Lateral erosion
	Total				4,100		

Coll. No.	River	Valley	Position	Direction of mountain slope	Area of collapse	Classification	Cause
66	Rapti	-	Concave part of mountain side	S 60° W	200 m^2	Earth fall	Head erosion
	Total				200		
67	Pendrang	Hundrung	Concave part of mountain side	N 35° W	4,000	Rock fall	Lateral erosion
68	"	"	"	N 80° E	500	"	Vertical erosion
69	"	"	"	N 5° E	5,000	"	Head erosion
70	"	Handrang	Bank	S 30° W	700	Earth fall	Vertical erosion
71	"	-	Concave part of mountain side	N 50° E	500	"	"
72	"	-	Bank	S 40° W	1,000	Rock fall	"
73	"	-	Concave part of mountain side	S 60° W	4,000	"	"
	Total				15,700		
74	Rapti	-	Concave part of mountain side	N 65° E	2,000	Rock fall	Vertical erosion
75	"	-	"	S 45° W	1,000	Earth and rock fall	"
	Total				3,000		
76	Bhainse	Ghante	Concave part of mountain side	S 60° W	2,500	Gully	Vertical erosion
77	"	Kalital	"	S 60° E	800	Rock fall	Head erosion
78	"	"	"	S 75° E	2,300	"	"
79	"	"	"	S 70° W	4,500	"	"
80	"	"	"	S 10° E	4,500	Earth and rock fall	"
81	"	"	"	S 5° W	10,000	Rock fall	Vertical erosion
82	"	"	Bank	N 5° W	1,000	Earth fall	Lateral erosion
83	"	Chantia	"	S 20° W	2,200	Rock fall	Head erosion
	Total				27,800		
84	Bhainse	Okhe	Concave part of mountain side	N 80° E	800	Earth and rock fall	Head erosion
85	"	"	"	N 60° E	800	Earth fall	"
86	"	"	Bank	N 15° E	1,600	Soil exfoliation	Lateral erosion
87	"	"	Concave part of mountain side	N 80° E	6,600	Rock fall	Head erosion

Coll. No.	River	Valley	Position	Direction of mountain slop	Area of collapse	Classification	Cause
88	Bhainse	Bandarebhir	Concave part of mountain side	N 80° E	13,200m^2	Rock fall	Head erosion
89	"	"		N 15° E	2,700	"	"
90	"	"	Concave part of mountain side Bank	N 25° E	1,000	"	Lateral erosion
91	"	"	Bank	N 20° E	6,800	"	Vertical erosion
92	"	Kitini	Concave part of mountain side	S 80° E	2,400	"	Head erosion
93	"	"		N 25° E	3,200	"	"
94	"	"	Concave part of mountain side	N 20° W	400	"	"
95	"	Okhe	Bank	S 20° W	4,000	"	Lateral erosion
	Total				43,500		
96	Bhainse	~~Okhe~~	Bank	N 80° E	3,200	Earth and rock fall	Lateral erosion
	Total				3,200		
	Grand total				357,150		

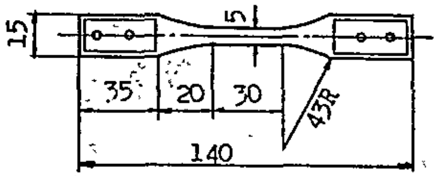
Mechanical Properties of Sal tree

No. of Test Piece	Tension			Bending (Span 100 mm)		
	Test Piece B^{m}/m x T^{m}/m	Tensile strength Kg	Breaking stress Kg/cm^2	Test Piece B^{m}/m x T^{m}/m	Breaking load Kg	Breaking stress Kg/cm^2
1	5.0 x 20.0	816	816	20.0 x 20.0	538	1008.7
2	"	1360	1360	"	526	986.2
3	"	1060	1060	20.1 x 19.8	552	1050.7
4	"	1010	1010	20.1 x 20.1	536	990.1
5	"	1126	1126	20.0 x 20.3	522	945.6
mean			1070			996

No. of Test Piece	Compression		
	Test Piece B^{m}/m x T^{m}/m	Breaking load kg	Breaking stress kg/cm^2
1	20.1 x 20.1	1950	482.6
2	20.4 x 20.1	2000	487.7
3	20.0 x 20.2	1750	433.1
4	20.0 x 20.1	1870	465.2
5	20.0 x 20.1	2100	522.3
mean			480

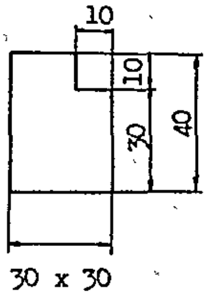
Remarks

1. Specific gravity is 0.89 - 0.93 (mean 0.90)
2. Water content is 15.1 - 16.2 % (mean 15.6)
3. Shape of tension test piece is as follows.



No. of Test Piece	Shear	
	Breaking stress kg/cm^2	
	Straight grain	Cross grain
1	157.6	136.2
2	174.4	141.9
3	189.3	163.4
4	156.8	149.1
5	197.4	155.5
6	160.1	141.3
mean	172.6	147.9

4. Shape of shearing test piece is as follows.



APPENDIX IV

METEOROLOGIC AND HYDROLOGIC DATA

CONTENTS

WATER LEVEL AND DISCHARGE

STATION *Kulikhani* Year *1962*

River system : *Bagmati* Name of stream : *Kulikhani* Drainage area (km²) : *120.0*

	Jan.		Feb.		Mar.		Apr.					
	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)
1	0.98	1.15	0.98	1.15	1.00	1.25	0.93	0.90				
2	0.98	1.15	0.98	1.15	1.01	1.30	0.93	0.90				
3	0.97	1.10	0.98	1.15	1.00	1.25	0.93	0.90				
4	0.96	1.05	0.98	1.15	1.00	1.25	0.92	0.85				
5	0.95	1.00	0.98	1.15	1.00	1.25	0.93	0.90				
6	0.99	1.20	0.97	1.10	1.04	1.50	0.92	0.85				
7	0.98	1.15	0.98	1.15	1.05	1.55	0.92	0.85				
8	0.98	1.15	0.98	1.15	1.02	1.35	0.92	0.85				
9	0.99	1.20	0.97	1.10	1.03	1.40	0.92	0.85				
10	0.99	1.20	0.98	1.15	1.09	1.80	0.92	0.85				
11	0.98	1.15	0.98	1.15	1.05	1.55	0.93	0.90				
12	0.98	1.15	0.98	1.15	1.01	1.30	0.93	0.90				
13	0.98	1.15	0.98	1.15	1.00	1.25	0.93	0.90				
14	0.99	1.20	0.98	1.15	1.00	1.25	1.10	1.90				
15	1.01	1.30	0.99	1.20	0.98	1.15	1.09	1.80				
16	1.03	1.40	1.00	1.25	0.98	1.15	1.04	1.50				
17	1.02	1.35			0.98	1.15	1.02	1.35				
18	1.00	1.25			0.97	1.10	1.01	1.30				
19	1.00	1.25			0.97	1.10	1.00	1.25				
20	0.99	1.20	N.R.	N.R.	0.97	1.10	0.98	1.15				
21	0.99	1.20			0.97	1.10						
22	0.99	1.20			0.98	1.15						
23	0.99	1.20			0.98	1.15						
24	0.99	1.20	0.98	1.15	0.97	1.10						
25	0.99	1.20	0.98	1.15	0.99	1.20						
26	0.98	1.15	0.99	1.20	1.01	1.30						
27	0.98	1.15	0.99	1.20	0.97	1.10						
28	0.98	1.15	1.00	1.25	0.95	1.00						
29	0.98	1.15			0.95	1.00						
30	0.97	1.10			0.94	0.95						
31	0.97	1.10			0.94	0.95						
TOTAL		36.55		24.40		38.00		21.65				
DAYS		31		21		31		20				
MEAN		1.18		1.16		1.23		(1.08)				
MAX.	1.03	1.40	1.00	1.25	1.09	1.80	1.10	1.90				
MIN.	0.95	1.00	0.97	1.10	0.94	0.95	0.92	0.85				

NB - Water level in meters arbitrary zero.

Arbitrary zero is_________meters above M.S L.

WATER LEVEL AND DISCHARGE

STATION *G.S.I (Chabar)* Year *1952*

River system : *Bagmati*
Name of stream : *Bagmati*
Drainage area (km²) : *597.0*

											June	
	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												0.849
19												2.52
20												2.01
21												0.736
22												1.08
23												0.396
24												14.8
25												32.0
26												40.0
27												8.29
28												4.16
29												7.85
30												10.2
31												
TOTAL												124.891
DAYS												13
MEAN												(9.59)
MAX.												40.0
MIN.												0.396

NB Water level in meters arbitrary zero.
Arbitrary zero is________ meters above M.S.L.

WATER LEVEL AND DISCHARGE

STATION G.S.I. (Chabar) Year 1952

River system: Bagmati
Name of stream: Bagmati
Drainage area (km²): 597.0

	July		Aug.		Sept.		Oct.		Nov.		Dec.	
	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)
1		152.0		28.5		48.2		17.4				
2		65.8		58.7		45.6		16.8				
3		63.4		72.2		80.6		11.7				
4		38.4		45.5		139.0						
5		199		434		71.9		16.0				
6		11.9		50.7				16.2				
7		140		1,000.0		32.6		16.8				
8		23.0		65.8		34.9		16.9				
9		16.1		70.7		29.6		17.7				
10		154				30.9		18.3		12.1		
11		8.60		48.1		81.8				10.8		4.87
12		8.32		63.8		50.1		15.5		9.54		5.13
13		26.9		56.9				15.5		11.4		
14		12.1		52.7		54.2		16.5		11.0		5.01
15		12.7		66.2		58.0		15.6		10.5		4.67
16		24.9				47.7		15.7				4.70
17		28.8		67.6		52.4		14.4		11.0		3.85
18		29.2		79.0		33.7				10.2		4.33
19		126.0		50.1		91.7				10.1		3.68
20		80.6		46.9						11.1		
21		105.0		62.1		48.3		14.9		10.8		3.43
22		39.4		115.0		43.6		15.3				3.28
23		63.8				79.1		14.1				3.28
24		75.0		59.6		64.3						3.17
25		116.0		157.0		41.6						3.51
26		39.8		67.0		30.6		13.2				3.06
27		39.6		124.0				13.1				
28		23.3		47.7				12.2				2.91
29		58.4		57.1				12.6				2.80
30		43.7						13.8				2.83
31		39.8		46.5				12.4				2.91
TOTAL		1421.82		1,802.8		1,290.4		362.6		118.54		67.42
DAYS		31		27		23		24		11		18
MEAN		45.5		(66.8)		(56.2)		(15.1)		(10.8)		(3.74)
MAX.		152.0		157.0		139.0		18.3		12.1		5.13
MIN.		8.32		28.5		29.6		11.7		9.54		2.80

NB Water level in meters arbitrary zero.
Arbitrary zero is ______ meters above M.S.L.

WATER LEVEL AND DISCHARGE

STATION G.S.I. (Chabar) Year 1953

River system: Bagmati Name of stream: Bagmati Drainage area (km^2): 597.0

	Jan.											
	W.L. (M)	DIS. (M^3/S)	W.L. (M)	DIS. (M^3/S)	W.L. (M)	DIS. (M^3/S)	W.L. (M)	DIS. (M^3/S)	W.L. (M)	DIS. (M^3/S)	W.L. (M)	DIS. (M^3/S)
1		3.22										
2		3.71										
3												
4		3.03										
5		3.43										
6		3.00										
7		3.22										
8		2.89										
9		2.66										
10												
11												
12												
13		3.09										
14		3.40										
15		3.54										
16		4.67										
17												
18		4.84										
19		3.76										
20		3.43										
21		3.43										
22		3.14										
23		3.94										
24												
25		3.57										
26		3.66										
27		3.46										
28		2.91										
29												
30												
31												
TOTAL		75.80										
DAYS		22										
MEAN		(3.44)										
MAX.		4.84										
MIN.		2.66										

NB Water level in meters arbitrary zero.
Arbitrary zero is ________ meters above M. S. L.

WATER LEVEL AND DISCHARGE

STATION G. S. II Year 1952-1953

River system : Bagmati
Name of stream : Nakhu
Drainage area (km^2) : 49.9

	Aug.		Spet.		Oct.		Nov.		Dec.		Jan.	
	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)
1				5.16		4.04				1.34		0.398
2				4.19		3.82				1.05		0.425
3				4.19		3.54				1.30		
4				11.1		3.03				1.09		0.340
5				5.58		3.00				1.16		0.340
6						3.00						0.374
7						3.06						0.283
8				3.74		2.61						0.346
9				3.79		2.52				1.03		0.354
10				4.28		2.49				1.44		
11				6.37				1.39		0.694		
12				4.59		2.24		1.20		0 765		0.325
13						2.18		1.10		0.710		
14				3.91		2.12		1.06		0.709		
15				4.28		1.98				0.708		
16				4.25		1.98		1.25		0.652		
17				4.33		2.01		1.01		0.652		
18				3.79				1.10		0.766		
19				7.31				0.963				
20								1.26				
21				7.03		1.84		1.02				
22				703		1.81						
23				8.60		1.64						
24				13.0				0.948				
25		10.2		8.38				1.03				
26		9.09		7.22		1.84		1.08				
27		9.97				1.73		1.02				
28		9.06				1.36		1.06				
29		8.19				1.39						
30						1.53		0.906				
31		14.8				1.39						
TOTAL		61.31		132.12		58.15		17397		14.066		3.185
DAYS		6		22		25		16		15		9
MEAN		(10 2)		(6.02)		(2.32)		(1.09)		(0.937)		(0.354)
MAX.		14.8		13.0		4.04		1.39		1.44		0.425
MIN.		8.19		3.74		1.36		0.906		0.652		0.283

NB Water level in meters arbitrary zero.
Arbitrary zero is ________ meters above M. S. L.

WATER LEVEL AND DISCHARGE

STATION G. S. III Year 1952

River system: Bagmati   Name of stream: Khukumati   Drainage area (km²): 16.2

			Aug.		Sept.		Oct.		Nov.		Dec.	
	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)
1						1.67		0.719				0.303
2						1.30		0.730				0.303
3				0.892		1.16		0.691				0.291
4				0.788		2.61						0.303
5				0.750		1.39		0.646				0.303
6				0.753				0.595				
7				0.549		0.715		0.555				
8				0.527		0.906		0.558				
9						0.816		0.552				
10				0.974		1.16		0.538				
11				1.05		1.24				0.291		
12				2.13		0.948		0.521		0.291		
13				1.22				0.524		0.291		
14				1.17		1.23				0.303		
15				0.912		1.18		0.470				
16						1.14		0.476		0346		
17				2.06		0.753		0.470		0.334		
18				1.54		0.659		0.481		0.379		
19				2.70		2.63				0.337		
20				1.58						0.331		
21				1.08		1.45				0.382		
22				0.986		1.01		0.467				
23						2.29		0.402		0.382		
24				1.01		2.53		0.396		0.303		
25				5.58		1.40				0.309		
26				1 70		1.23		0.391		0 303		
27				4.73				0 391		0.379		
28				5.72				0.388				
29				3.22				0.388				
30								0.382		0.379		
31				4.87				0.354				
TOTAL				48.491		31.417		12.085		5.340		1.503
DAYS				25		23		24		16		5
MEAN				(1.94)		(1.37)		(0.503)		(0.334)		(0.300)
MAX.				5.72		2.61		0.730		0.382		0.303
MIN.				0.527		0.659		0.354		0 291		0.291

NB Water level in meters arbitrary zero.
Arbitrary zero is_________meters above M. S L.

WATER LEVEL AND DISCHARGE

STATION G. S. IV Year 1952

River system: Bagmati

Name of stream: Gode bari

Drainage area (km²): 21.4

											June	
	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16												
17												
18												
19												
20												
21												0.142
22												0.218
23												0.255
24												0.580
25												0.651
26												0.821
27												0.665
28												
29												
30												1.65
31												
TOTAL												4982
DAYS												8
MEAN												(0.624)
MAX.												1.65
MIN.												0.142

NB Water level in meters arbitrary zero.
Arbitrary zero is ________ meters above M. S. L.

WATER LEVEL AND DISCHARGE

STATION G. S. IV Year 1952

River system: Bagmati
Name of stream: Gadabari
Drainage area (km²): 214

	July		Aug.		Sept.		Oct.		Nov.		Dec.	
	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)
1		2.24				2.15		0.999				0.190
2		2.04				1.87		0.892				0.198
3		1.76		1.04		1.56		0.849				0.198
4		1.81		0.935		2.69						0.176
5				2.12		1.76		0.779				
6		0.394		0.934				0.747				
7		0.436		0.793		1.32		0.674				
8		0.929		0.688		1.09		0.601				
9		0.549				1.10		0.623				
10		0.680		1.12		1.04		0.651				
11		0.577		1.30		1.17				0.284		
12				1.53		1.02		0.615		0.284		
13		0.501		1.37				0.615		0.284		
14		0.481		1.25		1.82				0.284		
15		0.275		0.986		1.61		0.533				
16		0.363				1.34		0.507		0.252		
17		0.374		1.58		1.27		0.487		0.241		
18		0.348		1.65		1.04				0.235		
19				1.10		2.43				0.227		
20		0.368		1.15						0.224		
21		0.819		4.07		1.69		0.368		0.195		
22		0.595		1.48		1.45		0.363				
23		2.46				2.45		0.366		0.184		
24		1.85		1.45		3.12		0.341		0.258		
25		1.21		4.53		1.98				0.187		
26				2.93		1.75		0.340		0.193		
27				3.88				0.319		0.187		
28				4.79				0.280				
29				5.95				0.272				
30								0.277		0.190		
31				2.91				0.363				
TOTAL		21.059		51.536		38.72		12.861		3.709		0.762
DAYS		22		25		23		24		16		4
MEAN		(0.934)		(2.07)		(1.68)		(0.536)		(0.232)		(0.191)
MAX.		2.46		5.95		3.19		0.999		0.284		0.198
MIN.		0.275		0.688		1.02		0.272		0.184		0.176

NB Water level in meters arbitrary zero.
Arbitrary zero is__________meters above M. S. L.

WATER LEVEL AND DISCHARGE

STATION *G.S. V* Year *1952*

River system: *Bagmati*   Name of stream: *Narayan Khola*   Drainage area (km²): *20.7*

	June		July		Aug.		Sept.		Oct.		Nov.	
	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)
1				1.53				0.969		0.631		
2				0.178				0.989		0.572		
3				0.142		0.456		4.69		0.536		
4				0.246		0.385		3.10		0.476		
5				0.0963		0.425		1.21		0.510		
6				0.0595		0.431				0.479		
7				0.0566		1.87		3.38		0.484		
8				0.0651		1.61		5.26		0.433		
9				0.0595		0.994		1.81		0.467		
10				0.0425		0.932		0.963		0.464		
11				0.108		0.954		0.799		0.476		
12				0.481		0.768		2.39		0.461		0.374
13				0.331		0.881		4.37		0.453		0.334
14				0.133		1.08		1.62		0.450		0.357
15				4.77		2.30		2.37		0.439		0.348
16								1.82		0.419		0.363
17				0.232		1.40		1.47		0.391		0.368
18						0.969		1.08				0.368
19				0.212		0.940		1.29				0.346
20				0.425		3.34		1.18				0.340
21				1.04		1.99		1.44		0.419		0.337
22		0.0195		0.677		1.03		1.36		0.450		
23		0.00566		1.68				1.41		0.407		0.354
24		0.0510		0.999		4.41		1.23				0.311
25		0.352		0.966		3.40		1.06				0.324
26		0.165		6.70		1.17				0.410		0.351
27		0.0431		1.14		1.91				0.379		0.311
28		0.0889		0.402		1.84				0.354		0.317
29		0.0495		0.697		2.25				0.388		0.311
30		0.314		0.436		3.28				0.396		0.325
31				0.544		1.11				0.433		
TOTAL		1.08866		24.3485		42.125		47.26		11.777		6.139
DAYS		9		29		27		24		26		18
MEAN		(0.121)		(0.839)		(1.56)		(1.97)		(0.453)		(0.341)
MAX.		0.352		6.70		4.41		5.26		0.631		0.374
MIN.		0.00566		0.0425		0.385		0.799		0.354		0.311

NB Water level in meters arbitrary zero.
Arbitrary zero is__________meters above M. S. L.

WATER LEVEL AND DISCHARGE

STATION G.S. V Year 1952-1953

River system: Bagmati Name of stream: Narayan Khola Drainage area (km²): 20.7

	Dec.		Jan.									
	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)
1		0.300		0.204								
2		0.287		0.221								
3		0.306		0.210								
4		0 290		0.198								
5		0.293		0.190								
6		0.283		0.210								
7		0.263		0.207								
8		0.269		0.189								
9		0.263		0.193								
10		0.266										
11		0.249										
12		0.244										
13												
14												
15												
16		0.244										
17		0.246										
18		0.246										
19		0.238										
20		0.221										
21		0 218										
22		0.272										
23		0.210										
24		0.215										
25		0 221										
26		0 229										
27		0 198										
28		0.221										
29		0.210										
30		0.187										
31.		0.210										
TOTAL		6899		1.820								
DAYS		28		9								
MEAN		(0.246)		(0.202)								
MAX.		0.306		0.221								
MIN.		0.187		0.187								

NB. Water level in meters arbitrary zero.
Arbitrary zero is__________meters above M.S L.

WATER LEVEL AND DISCHARGE

STATION G S. VI   Year 1952

River system: Bagmati   Name of stream: Sali Nadi   Drainage area (km²): 13.0

	June		July		Aug.		Sept.		Oct.		Nov.	
	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)
1				1.54				1.91		0.759		
2				0.425				2.22		0.759		
3				0.346		0.983		3.33		0.813		
4				0.337		0.785		3.08		0.711		
5				0.294		1.04		2.13		0.580		
6				0.174		1.14				0.728		
7				0.583		2.19		2.00		0.744		
8				1.45		1.77		1.77		0.657		
9				0.317		1.85		3.29		0.634		
10				0.181		1.62		2.69		0.932		
11				0.184		1.46		2.22		0.589		
12				0.567		1.32		2.81		0.623		0.388
13				0.736		1.46		1.53		0.555		0.410
14				0.425		2.58		1.84		0.577		0.422
15				0.552		2.56		2.49		0.549		0.419
16								2.35		0.543		0.394
17				0.258		1.02		1.51		0.388		0.360
18						1.66		1.57				0.374
19				0.442		1.63		2.08				0.407
20				0.439		1.50		1.92				0.410
21				0.756		1.39		2.18		0.530		0.459
22		0.116		1.90		1.34		1.99		0.574		
23		0.0113		2.27				1.57		0.533		0.354
24		0.374		1.28		10.6		1.82				0.382
25		0.849		343		4.36		1.83				0.340
26		0.518		3.88		2.50				0.431		0.360
27		0.161		0.886		3.24				0.524		0.328
28		0.0991		0.719		2.91				0.569		0.325
29		0.144		1.34		3.19				0.513		0.331
30		0.615		0.878		3.19				0.558		0.319
31				0.954		1.74				0.510		
TOTAL		2.8874		27.645		61.028		52.13		15.883		6.782
DAYS		9		29		27		24		26		18
MEAN		(0.322)		(0.954)		(2.26)		(2.17)		(0.611)		(0.377)
MAX.		0.849		388		10.6		3.33		0.932		0.459
MIN.		0.0113		0.176		0.785		1.51		0.388		0.319

NB Water level in meters arbitrary zero.
Arbitrary zero is______ meters above M. S L.

WATER LEVEL AND DISCHARGE

STATION G. S. VI Year 1952-1953

River system: Bagmati

Name of stream: Sali Nadi

Drainage area (km²): 13.0

	Dec.		Jan.									
	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)
1		0.334		0.198								
2		0.337		0.190.								
3		0.311		0.176								
4		0.322		0.164								
5		0.314		0.161								
6		0.294		0.161.								
7		0.303		0.147.								
8		0.314		0.147								
9		0.311		0.147								
10		0.311										
11		0.252										
12		0.258										
13												
14												
15												
16		0.238										
17		0.235										
18		0.232										
19		0.238.										
20		0.224										
21		0.227										
22		0.227										
23		0.232										
24		0.204										
25		0.246										
26		0.243										
27		0227										
28		0.201										
29		0.170										
30		0.193										
31		0.204										
TOTAL		7.202		1.491								
DAYS		28		9								
MEAN		(0.258)		(0.166)								
MAX.		0.337		0.198								
MIN.		0.170		0.147								

NB Water level in meters arbitrary zero.
Arbitrary zero is__________meters above M. S L.

WATER LEVEL AND DISCHARGE

STATION G.S.VII (Sundarijal) Year 1952

River system : Bagmati

Name of stream : Bagmati

Drainage area (km²) : 33.7

	June		July		Aug.		Sept.		Oct.		Nov.	
	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)
1						6.43		9.29		4.02		
2				2.24		8.16		10.6		3.74		
3								10.6				
4				2.01		6.43		12.3				
5								8.29		3.25		
6						7.08				3.31		
7				0.340		8.72				2.91		
8				0.368		10.3		5.95		3.43		
9				2.77				6.49		3.99		
10				2.07		11.3		5.55		2.83		
11				2.10		7.96		8.32				0.991
12						8.66		7.59		2.66		1.76
13				8.71		8.89				2.49		1.02
14				2.44		8.04		7.08		2.75		2.01
15				1.81		963		703		2.49		
16				1.76				1.37		2.61		1.08
17				2.72				779		2.72		1.08
18				2.41		8.84		6.86				1.10
19						8.13						0.934
20				2.69		7.59						1.81
21				2.94		11.2				1.81		1.10
22		0.311		3.82		10.1				1.97		
23		0.311		6.34						3.17		1.25
24		1.33		9.74		9.51				1.78		1.27
25		1.84		10.3		15.5						
26		1.36				10.8				1.93		1.33
27		0.849				14.4				1.53		1.36
28				10.1		10.4				1.53		1.19
29		1.30		8.69		11.1				1.53		
30		1.78		13.1						1.67		
31				940		10.2				1.73		
TOTAL		9.081		109.868		229.57		127.44		61.85		19.285
DAYS		8		23		24		15		24		15
MEAN		(1.13)		(4.77)		(9.55)		(8.52)		(2.57)		(1.28)
MAX.		1.84		13.1		15.5		13.7		4.02		1.36
MIN.		0.311		0.340		643		555		1.53		0.934

NB Water level in meters arbitrary zero.
Arbitrary zero is_________meters above M. S L.

WATER LEVEL AND DISCHARGE

STATION G.S VIII (Sunderijal) Year 1952-1953

River system : Bagmati

Name of stream : Bagmati

Drainage area (km²) : 33.7

	Dec.		Jan.									
	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)
1		1.25		0.793								
2		0.736		0.708								
3		1.30		0.595								
4		0.991		0.595								
5		0.934		0.566								
6				0.680								
7		0.963		0.595								
8		0.849		0.595								
9		1.16		0.680								
10		0.963										
11		0.963		0.595								
12		0.963		0.595								
13				0.651								
14		0.849										
15		0.934		0.595								
16		0.765		0.538								
17		0.906										
18		0.765		0.623								
19		0.708		0.538								
20												
21				0.566								
22		0.708		0.510								
23		0.680		0.538								
24		0.849										
25		0.623		0.538								
26		0.793		0.538								
27				0.425								
28		0.595		0.481								
29		0.708										
30		0.680										
31		0.623										
TOTAL		22.258		13.538								
DAYS		26		23								
MEAN		(0.856)		(0.588)								
MAX.		1.30		0.793								
MIN.		0.595		0.425								

NB — Water level in meters arbitrary zero.
Arbitrary zero is__________meters above M. S L.

WATER LEVEL AND DISCHARGE

STATION *G.S. VIII* Year *1952*

River system: *Bagmati* Name of stream: *Vishnumati* Drainage area (km²): *41.4*

	July		Aug.		Sept.		Oct.		Nov.		Dec.	
	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)
1				1.23		1.57		0.999				0.334
2						1.29		0.974				0.312
3				3.05		5.10		0.857				0.277
4				1.95		3.14						0.280
5				2.58		1.74		0.771				0.289
6				2.02				0.788				
7				3.49				0765				
8				3.73		0.991		0875				0.207
9						1.15		0.788				0.207
10				3.54		1.15		0.827				0.261
11				6.79		6.31				0.649		0.291
12				4.16		1.97		0838		0476		0.289
13				3.25				1.01		0.334		
14				2.18		2.17		0932		0.397		0.297
15				3.13		2.30		0.810				0.201
16						1.76		0700		0.431		0.221
17				2.58		1.84		0.779				0.210
18				3.17		1.41						0.116
19				2.22		6.54						0156
20		3.92		2.35								
21				2.18		1.93						0.159
22		0.793		3.45		1.96		0.637				0.170
23		1.83				2.76		0.601				0.142
24		1.55		2.77		2.25		0.612				0.130
25		2.63		3.64		1.74						0.161
26		1.47		2.21		1.32		0.657				0.110
27				4.80				0651				
28		1.03		3.17				0.601				0.156
29		1.76		3.64				0.572				0150
30		2.42						0.516		0.230		0.0821
31		2.30		1.83				0.549				0.122
TOTAL		19.703		79.11		52.391		18.209		2.517		5.3301
DAYS		10		26		22		24		6		26
MEAN		(1.97)		(3.04)		(2.38)		(0.759)		(0.418)		(0.205)
MAX.		3.92		6.79		6.54		1.01		0.649		0.334
MIN.		0793		1.23		0.516		0.516		0.230		0.0821

NB Water level in meters arbitrary zero.
Arbitrary zero is______ meters above M.S.L.

WATER LEVEL AND DISCHARGE

STATION G. S VIII Year 1953

River system: Bagmati   Name of stream: Vishnumati   Drainage area (km^2): 41.4

	Jan.											
	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)	W. L. (M)	DIS. (M^3/S)
1		0.142										
2		0.102										
3		0.0765										
4												
5		0.0793										
6		0.0651										
7		0.0906										
8		0.0934										
9		0.108										
10												
11												
12												
13		0.0632										
14		0.0566										
15		0.0821										
16		0.161										
17												
18		0.0991										
19		0.0736										
20		0.0793										
21		0.130										
22		0.0963										
23		0.0991										
24												
25		0.122										
26		0.110										
27		0.136										
28		0.108										
29												
30												
31												
TOTAL		2.1732										
DAYS		22										
MEAN		(0.0986)										
MAX.		0.161										
MIN.		0.0566										

NB Water level in meters arbitrary zero.
Arbitrary zero is ________ meters above M. S. L.

WATER LEVEL AND DISCHARGE

STATION G.S. IX   Year 1952

River system: Bagmati   Name of stream: Sangla Khola   Drainage area (km²): 24.6

	July		Aug.		Sept.		Oct.		Nov.		Dec.	
	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)	W. L. (M)	DIS. (M³/S)
1				1.24		1.43		1.27				0.224
2						1.48		1.19				0.246
3				4.20		2.06		1.14				0.261
4				1.73		2.23						0.221
5				1.16		1.52		0.912				0.207
6				2.17				0.904				
7				5.18				0.771				
8				5.96		0.906		0.706				0.178
9						2.39		0.753				0.173
10				2.24		1.19		0.898				0.235
11				7.18		2.46				0.407		0.212
12				6.51		2.16		0.759		0.422		0.232
13				3.60				0.609		0.391		
14				1.76		5.46		0.857		0.288		0.215
15				4.10		2.38		0.788				0.167
16						1.88		0.640		0.346		0.156
17				3.67		2.24		0665				0.173
18				3.78		1.27						0.178
19				2.64		5.37						0.195
20				2.25								
21				3.42		2.25						0.161
22		0.847		7.44		2.83		0.459				0.147
23		0.986				3.33		0.516				0.150
24		1.49		3.13		3.25		0.476				0.170
25		2.74		5.76		1.96						0.198
26		1.31		2.11		1.77		0.436				0.156
27				5.22				0.521				
28		0.697		3.38				0.518				00934
29		1.62		3.98				0.555				0.116
30		1.99						0489		0.235		0.136
31		2.04		2.05				0.394				0.144
TOTAL		13.72		95.86		51.816		17.226		2089		4.7444
DAYS		9		26		22		24		6		26
MEAN		(1.53)		(3.68)		(2.36)		(0.717)		(0.348)		(0.183)
MAX.		2.74		7.44		5.46		1.27		0.422		0.261
MIN.		0.697		1.24		0906		0.394		0.235		0.0934

NB Water level in meters arbitrary zero.
Arbitrary zero is _____ meters above M. S L.

WATER LEVEL AND DISCHARGE

STATION G.S. IX Year 1953

River system: Bagmati Name of stream: Sangla Khola Drainage area (km²): 24.6

	Jan.											
	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)	W.L. (M)	DIS. (M³/S)
1		0.167										
2		0.127										
3												
4												
5		0.159										
6		0.122										
7		0.108										
8		0.122										
9		0.125										
10												
11												
12												
13		0.0963										
14		0.0963										
15		0.0878										
16		0.244										
17												
18		0.136										
19		0.102										
20		0.113										
21		0.110										
22		0.110										
23		0.193										
24												
25		0.147										
26		0.110										
27		0.0934										
28		0.110										
29												
30												
31												
TOTAL		2.6788										
DAYS		21										
MEAN		(0.127)										
MAX.		0.193										
MIN.		0.0878										

NB - Water level in meters arbitrary zero.
Arbitrary zero is________meters above M.S.L.

DAILY RAINFALL RECORD

STATION: Kathmandu Year 1952

Annual total (mm):

D \ M	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1							28.2	0.5	0.3			
2						0.8	0.3	4.3				
3						6.4	2.8	26.9	51.3		6.6	
4							17.8		20.1			
5						0.5	1.5	10.9	0.3			
6							1.8					
7							1.3	9.4	1.0			
8							11.4	4.8	1.0			
9							0.5	20.5				
10							4.3	15.0		15.5		
11							4.6	1.8	26.9			
12							0.4	4.3	0.3			
13						7.5	6.6	5.8	[illegible]			
14						20.1		2.3	9.6			
15							17.0	13.2	1.8			
16							8.6	13.2	8.6			
17							0.1	2.5	0.1			
18						15.8	11.9	5.8	11.9			
19						0.3	3.1	2.8	3.1			
20						2.3	47.5		16.3			
21						0.8	11.7	1.0	0.8			
22						2.8	5.6	0.6	7.4			
23							15.7	18.5				
24						15.8	11.9	25.7				
25						38.9	15.5	37.1				
26						17.5	12.4	12.1				
27						1.8	0.1	51.6				
28							0.8	0.5				
29						20.1	30.5	5.3				
30						24.1	7.8					
31							9.6					
TOTAL						170.2	315.5	305.0	168.6	15.5	6.6	

DAILY RAINFALL RECORD

STATION : *Kathmandu* Year *1953*

Annual total (mm):

D \ M	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	1.8											
2	2.5											
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												
16	10.2											
17	3.1											
18												
19												
20												
21												
22												
23	4.3											
24	0.8											
25												
26												
27												
28												
29												
30												
31												
TOTAL	22.6											

Monthly Rainfall Record

Station; Kathmandu

Project; Kulikhani Year ; 1942 ~ 1961

Year / Month	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	Year / Month
Jan.		17	26	143	0	0	0	1	21	15	Jan.
Feb.		48	27	10	60	0	13	38	18	21	Feb.
Mar.		29	68	14	11	35	0	8	48	27	Mar
Apr.		116	30	114	171	29	89	121	23	20	Apr.
May		23	40	65	88	65	209	148	120	67	May
June	154	148	134	180	215	191	179	173	380	251	June
July	218	200	489	338	381	567	322	281	506	331	July
Aug.	290	321	179	556	221	210	232	448	434	418	Aug.
Sept.	91	78	130	112	182	189	0	146	48	92	Sept.
Oct.	6	15	63	53	57	0	0	98	8	20	Oct.
Nov	0	0	0	0	0	0	0	0	0	5	Nov.
Dec.	0	0	0	0	0	0	64	6	7	0	Dec.
Total	759	995	1.286	1585	1.386	1.286	1108	1.468	1.613	1267	Total

Year / Month	1952	1953	1954	1955	1956	1967	1958	1959	1960	1961	Year / Month
Jan.	4			12	29	71	16	36	0	10	Jan.
Feb.	9			5	21	0	0	2	9	75	Feb.
Mar.	56		2	26	63	34	20	24	45	24	Mar.
Apr.	80		11	43	23	14	27	31	17	21	Apr.
May	116		192	42	225	24	93	141	117	34	May
June	170		317	98	436	156	143	238	195	293	June
July	287		605	385	335	345	268	228	321	350	July
Aug.	327		812	318	311	329	322	290	237	502	Aug
Sept.	220		248	165	138	44	157	163	152		Sept.
Oct.	16		14	33	107	13	66	92	31		Oct.
Nov.	7		0	0	26	0	0	0	0		Nov.
Dec.	0		3	1	10	12	0	0	0		Dec.
Total	1.275		2004	1.128	1.724	1.042	1.112	1.245	1.124	1.309	Total

DISCHARGE MEASUREMENT

Station : *Kulikhani*

Drainage Area *120* km² River System *Bagmati* River : *Kulikhani*

No.	Date			Water Level m.		Width m.	Flow Area m²	Mean Velocity m/sec	Discharge m³/sec	Temp. °C		Remarks
	Year	Month	Day	Reading	Change					Water	Air	
1	1962	Nov	28			10.00	5.145	0.232	1.382		11.7	used wading Rod
2	"	Dec.	1			7.50	3.042	0.617	1.879		12.8	"
3	"	"	2			10.00	4.913	0.307	1.446		11.7	"
4	1963	Feb.	26	0.96		9.50	4.403	0.253	1.111		8.9	"
5	"	Mar.	4	0.97		10.00	4.590	0.242	1.111		15.0	"
6	"	"	7	1.01		10.50	5.055	0.244	1.231		13.3	"
7	"	"	10	1.22		12.50	7536	0.414	3.114		13.3	"
8	"	"	11	1.04		10.00	5.110	0.260	1.329		14.4	"
9	"	"	13	0.99		10.00	5.027	0.233	1.169			"
10	"	"	15	0.98		10.50	5.088	0.220	1.158		17.8	"
11	"	"	17	0.97		10.50	5.050	0.202	1 108		15.6	"
12	"	"	19	0.96		10.50	5.035	0.211	1.066		15.6	"
13	"	"	24	0.96		10.50	4.970	0.209	1.032		15.6	"
14	"	"	26	0.90		10.50	5.175	0.230	1.196		16.1	"
15	"	"	29	0.95		10.50	4678	0.206	0.958		17.8	"
16	"	"	31	0.96		10.50	4.998	0.198	0 971		15.0	"
17	"	Apr.	3	0.94		10.50	4732	0.180	0.850		15.0	"
18	"	"	6	0.92		10.50	4.289	0.191	0.818		22.2	"
19	"	"	8	0.92		10.50	4.490	0.185	0.834		18.9	"
20	"	"	10	0.92		10.50	4548	0.186	0.845		15.6	"
21	"	"	28	0.97		9.50	4.438	0.263	1.167		15.6	"
22	"	May	3	0.96		10.00	4.598	0.213	0.976		13.3	"

Elevation of zero point of water gauge ; ______m. ______

DISCHARGE MEASUREMENT

Station ;

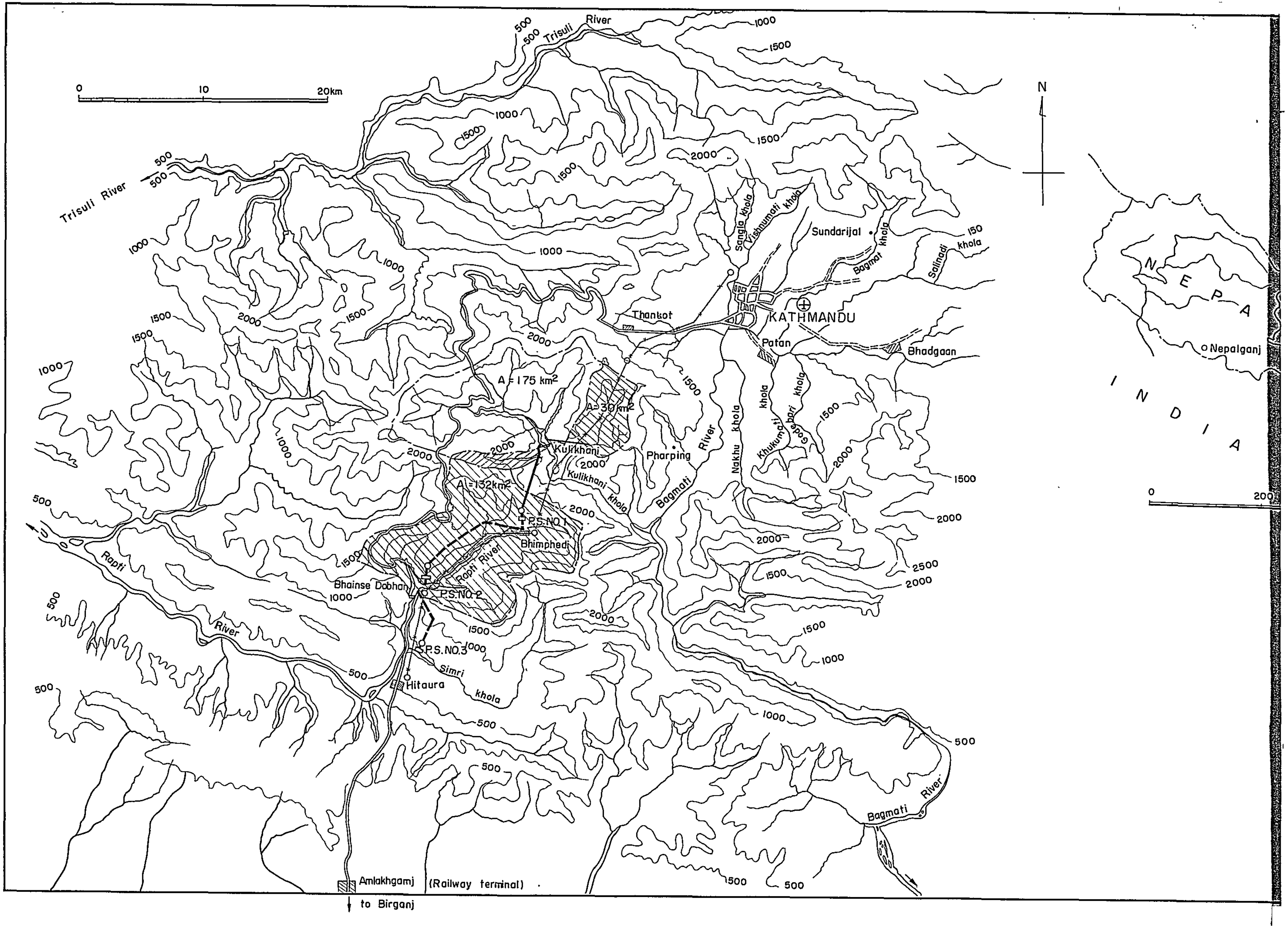
Drainage Area ______ km² River System *Rāpti* River ; *Rāpti*

No.	Date			Water Level m		Width m.	Flow Area m.²	Mean Velocity m/sec	Discharge m³/sec	Temp. °C		Remarks
	Year	Month	Day	Reading	Change					Water	Air	
	1963	Apr.	13			5.50	1.16	0.373	0.433		20.6	confluence of Mandu Khola
	1963	Apr	13			7.00	1.827	0.353	0.647		20.6	confluence of Rani Khola
	1963	Apr	13			7.50	1.753	0.464	0.814		21.1	confluence of Pandrayan Khola
	1963	Apr	13			9.00	1.696	0.495	0.839		20.6	Bhaise Dobān
	1963	Apr	16			9.00	3.925	0.288	1.132		22.2	Bayal Bauss

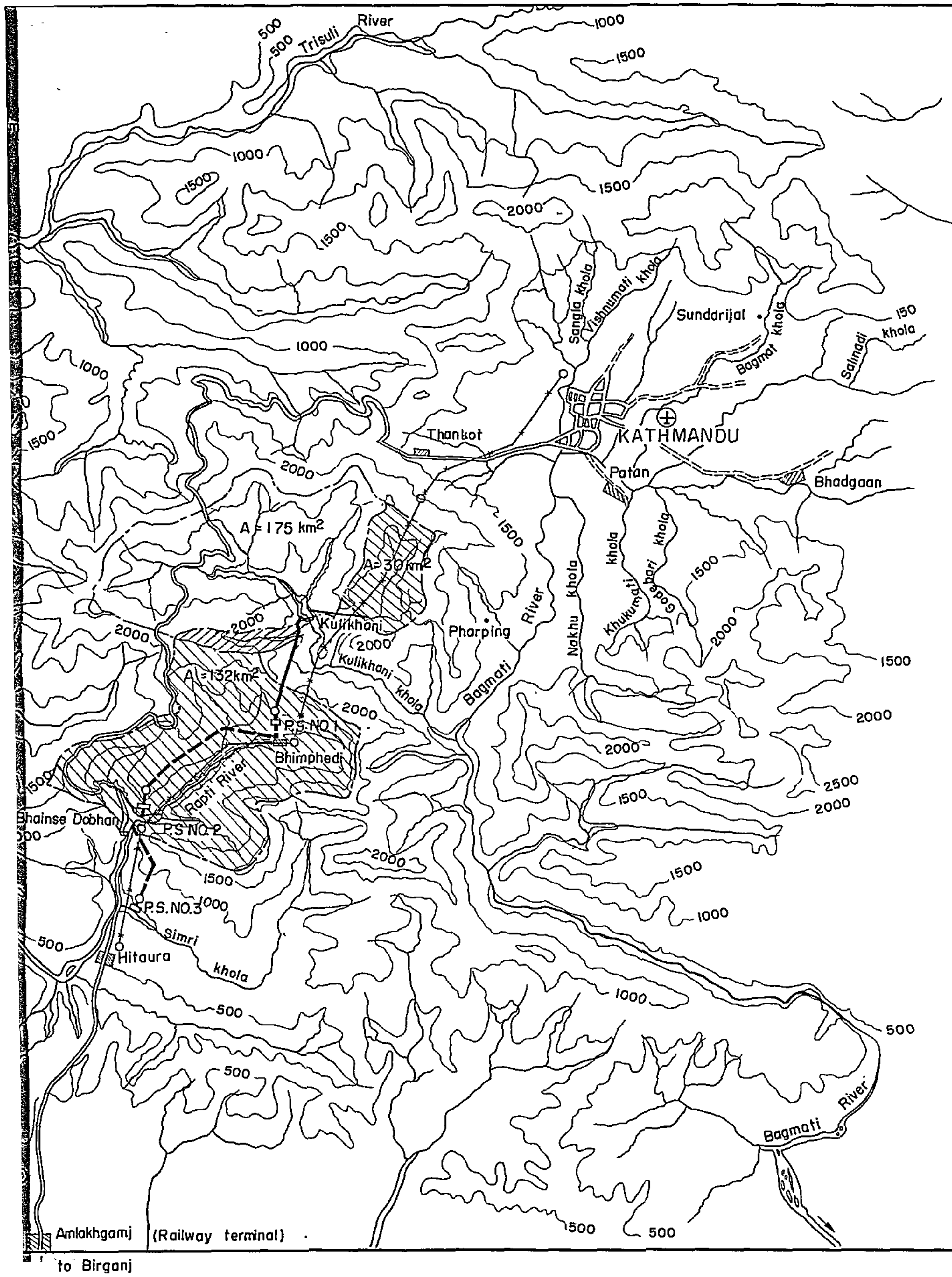
Elevation of zero point of water gauge ; ______ m.

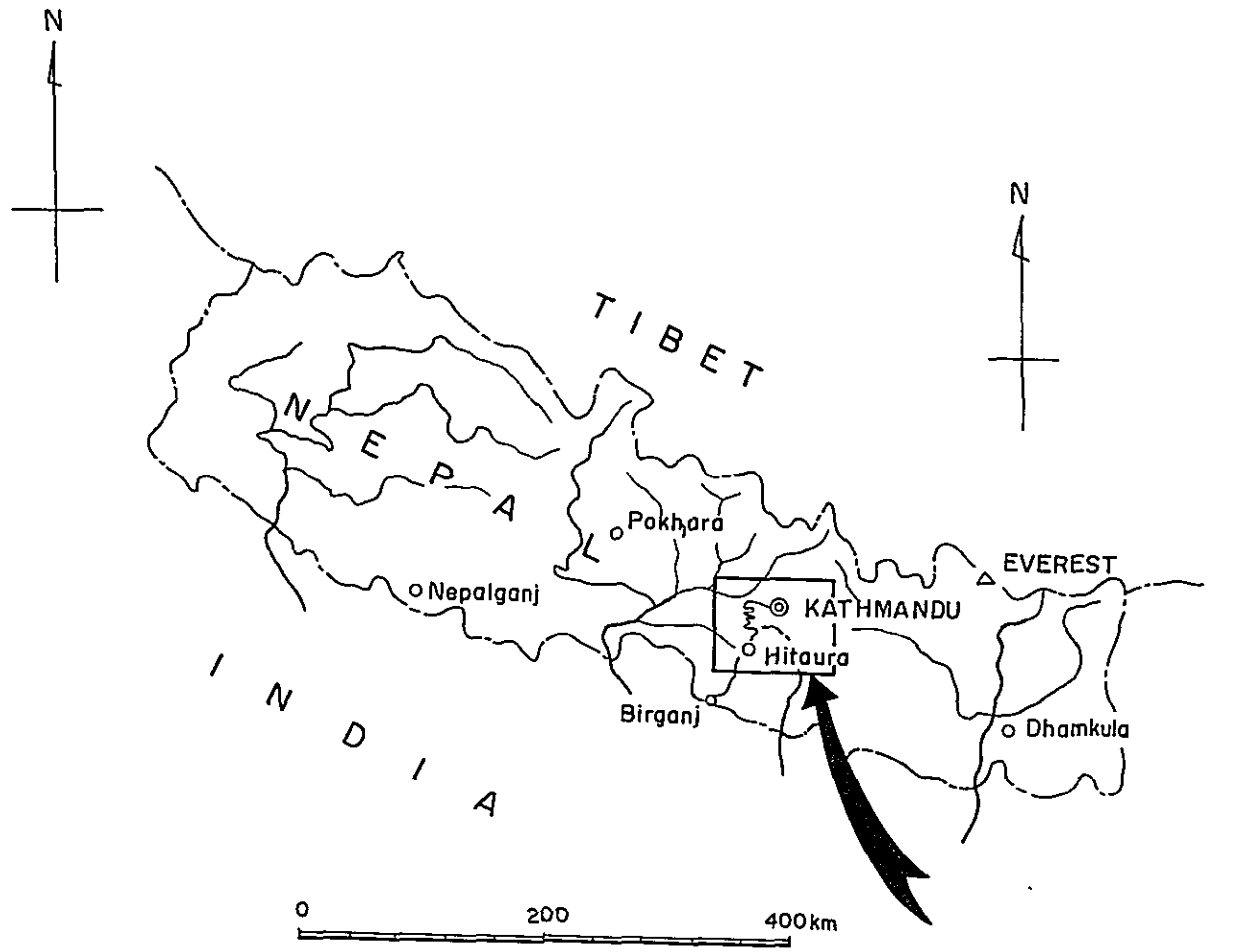
DRAWINGS

Serial No.	Title
1	Location map (1)
2	Location map (2)
3	General layout
4	General plan and typical section of rockfill dam
5	Profile of spillway and diversion tunnel
6	General plan and profile of intake and auxiliary intake
7	Plan and profile of surge tank and power station
8	General plan and profile of transmission line
9	Sabo scheme on Kulikhani and Rapti river basin
10	Plan and profile of Sabo work for Khani khola
11	Structural details of Sabo work for Khani khola



0
10
20km
N
Trisuli River
Trisuli River
500
1000
1500
2000
2500
Sangla khola
Vishnumati khola
Sundarijal
Bagmati khola
Salinadi khola
150
Thankot
KATHMANDU
Patan
Bhadgaon
A=175 km²
A=30 km²
A=132km²
Kulikhani
Kulikhani khola
Pharping
Bagmati River
Nakhu khola
Khukumati khola
Godavari khola
P.S.NO.1
Bhimphedi
Rapti River
Bhainse Dobhan
P.S.NO.2
P.S.NO.3
Simri khola
Hitaura
Rapti River
Bagmati River
Amlakhgamj (Railway terminal)
to Birganj
NEPAL
INDIA
Nepalganj
0
200



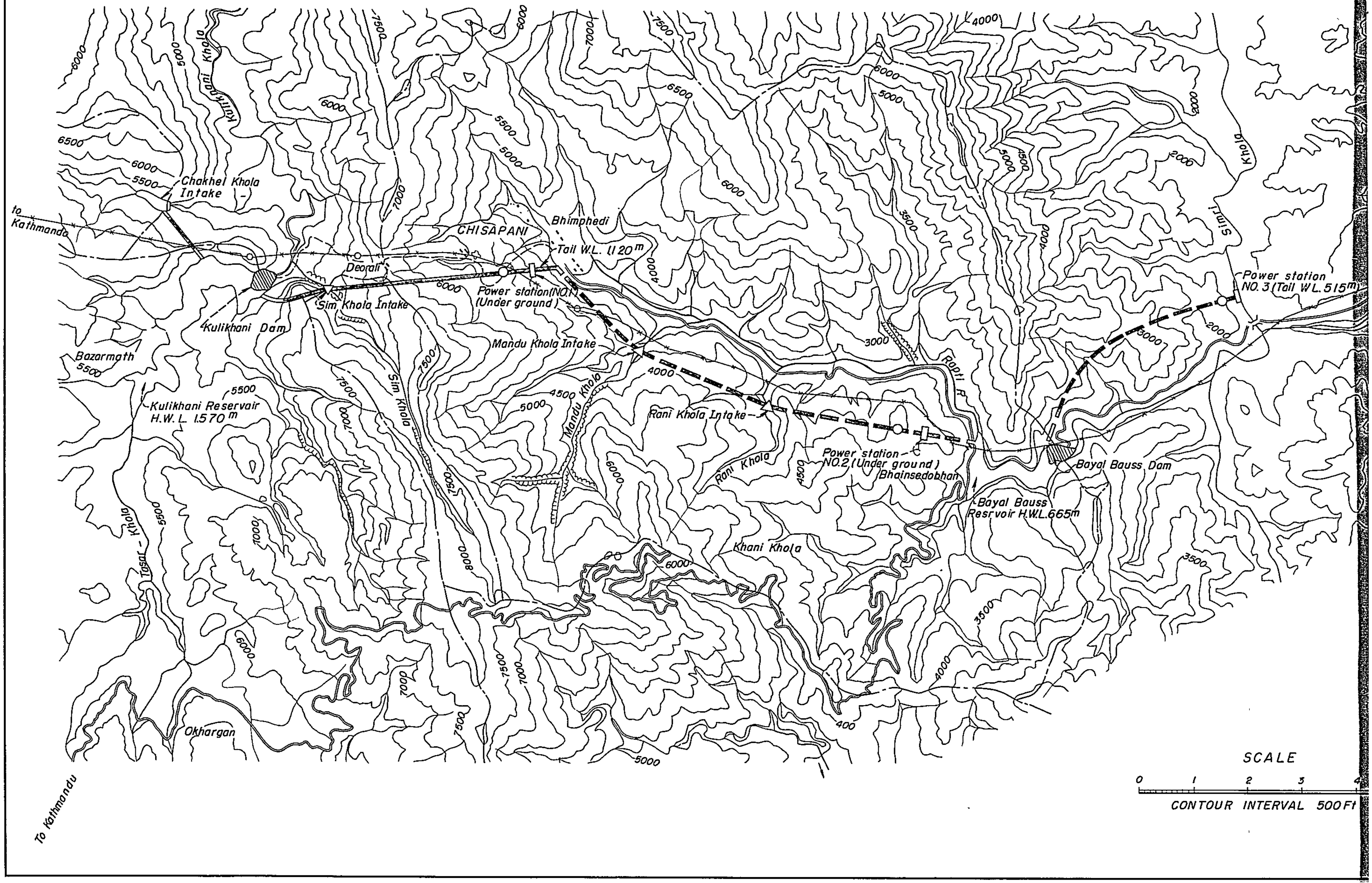


KULIKHANI PROJECT

LOCATION MAP (1)

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

NOV. 1963 NO. 1

to Kathmandu
Kulikhani Khola
Chakhel Khola Intake
CHISAPANI
Bhimphedi
Tail W.L. 1.120m
Deorali
Power station (NO.1) (Under ground)
Sim Khola Intake
Kulikhani Dam
Bazarmath
Kulikhani Reservair H.W.L. 1.570m
Mandu Khola Intake
Mandu Khola
Sim Khola
Rani Khola Intake
Rani Khola
Power station NO.2 (Under ground)
Bhainsedobhan
Rapti R.
Simri Khola
Power station NO.3 (Tail W.L. 515m)
Bayal Bauss Dam
Bayal Bauss Resrvoir H.W.L. 665m
Khani Khola
Tasar - Khola
Okhargan
To Kathmandu
6000
5000
6500
6000
5500
7500
6000
5500
5000
7000
7000
7500
6500
6000
4000
6000
5000
3500
4000
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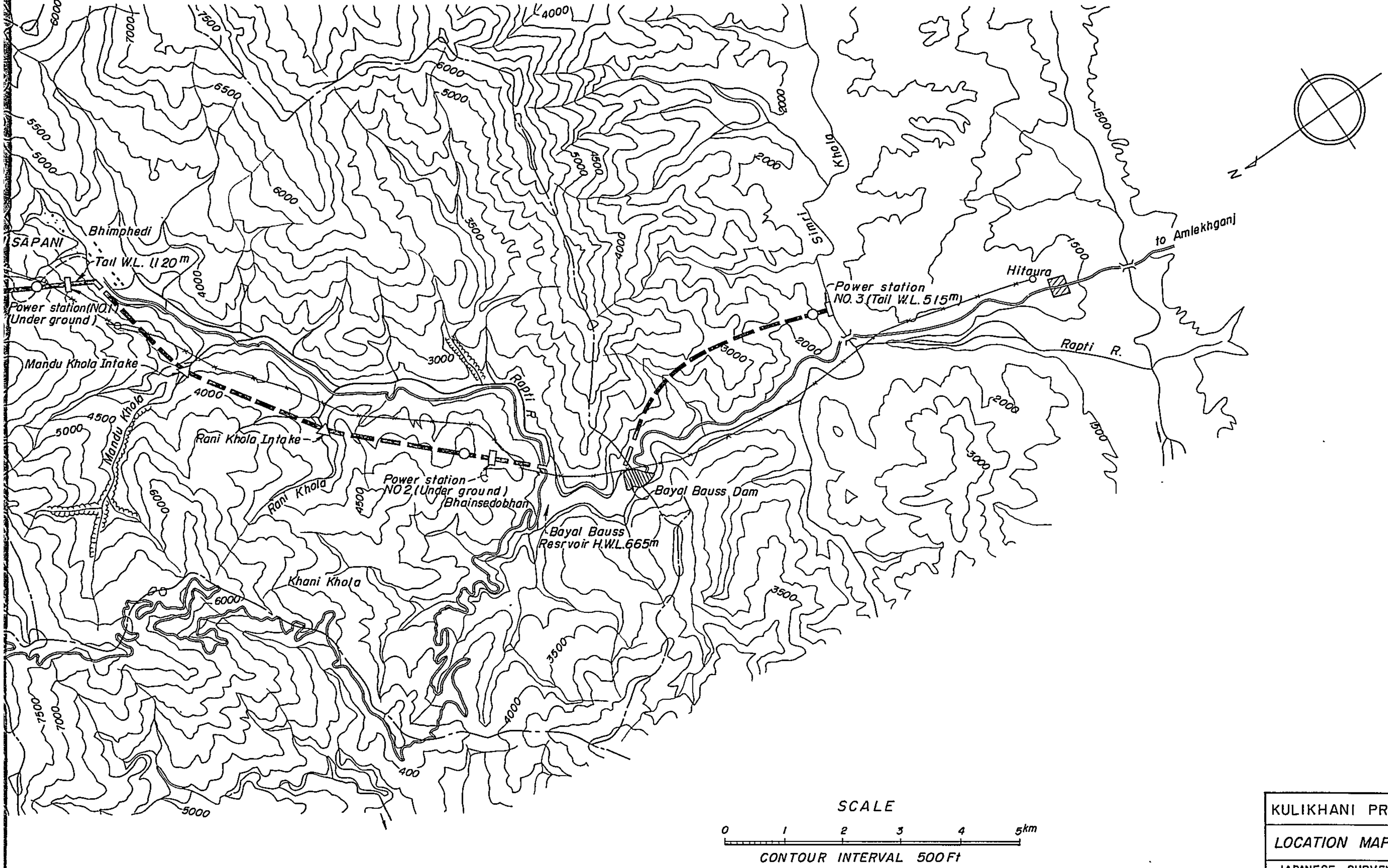
6000
4500
7000
7500
8000
5500
7000
6000
3500
3500
4000
400
7000
7500
7000
7500
5000
SCALE
0 1 2 3 4
CONTOUR INTERVAL 500 Ft

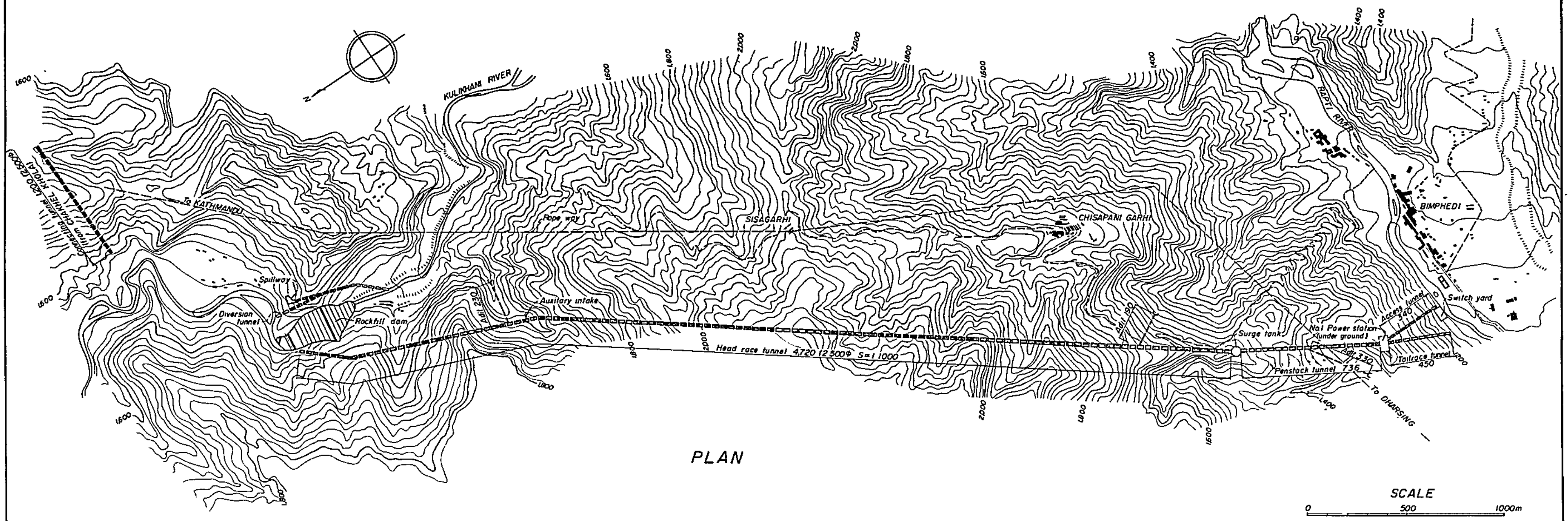


KULIKHANI PROJECT

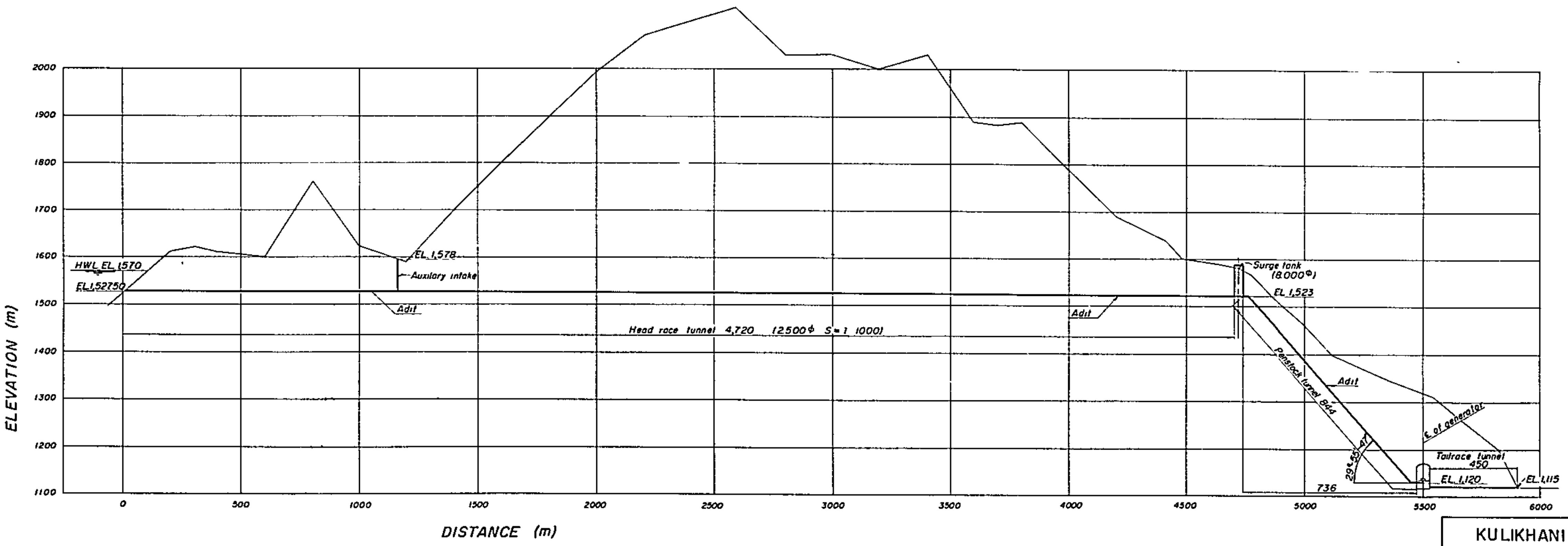
LOCATION MAP (2)

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

NOV. 1963	NO. 2



PLAN



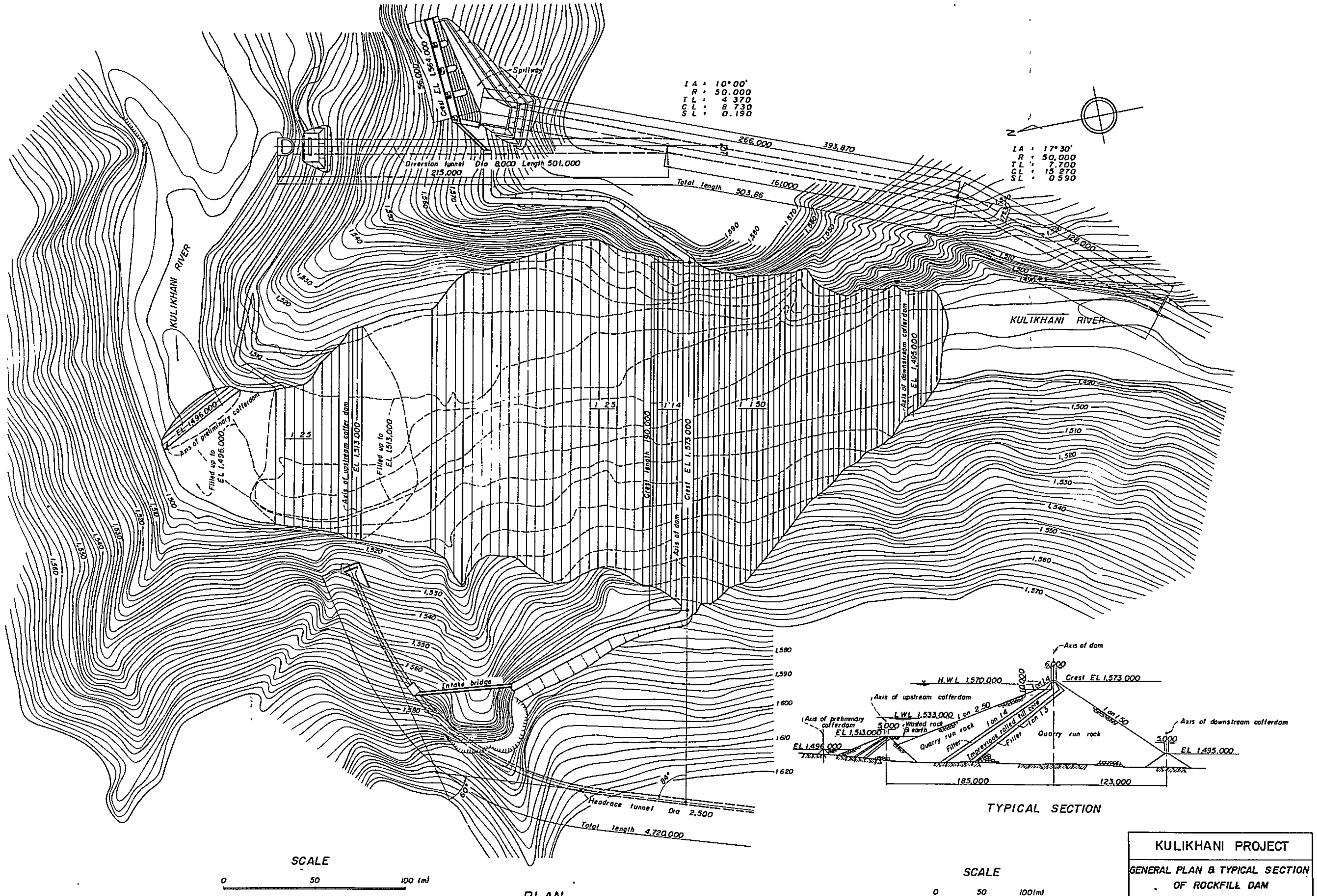
PROFILE

KULIKHANI PROJECT

GENERAL LAYOUT

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

NOV. 1963 | NO. 3

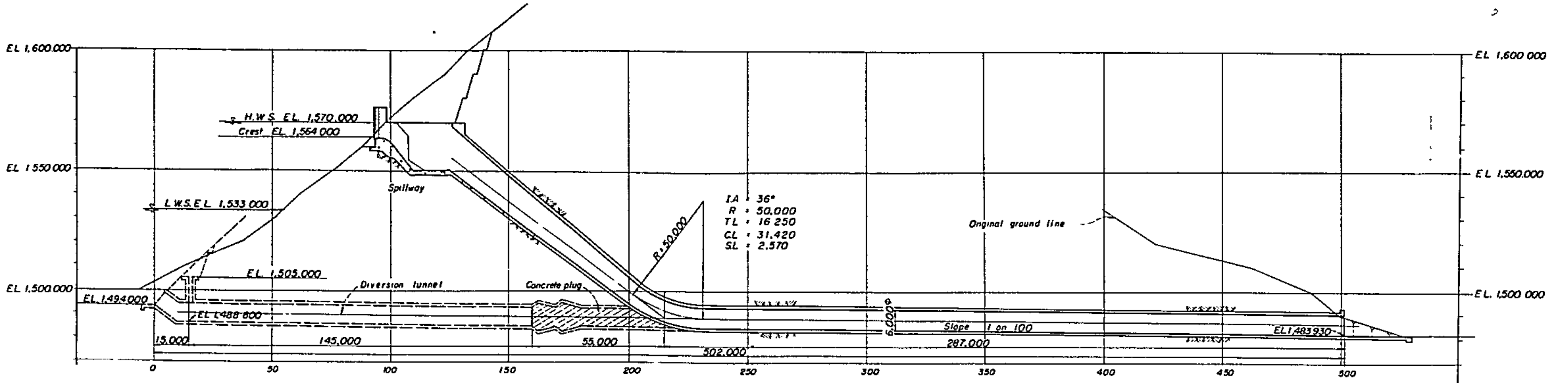


KULIKHANI PROJECT

GENERAL PLAN & TYPICAL SECTION
OF ROCKFILL DAM

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT.

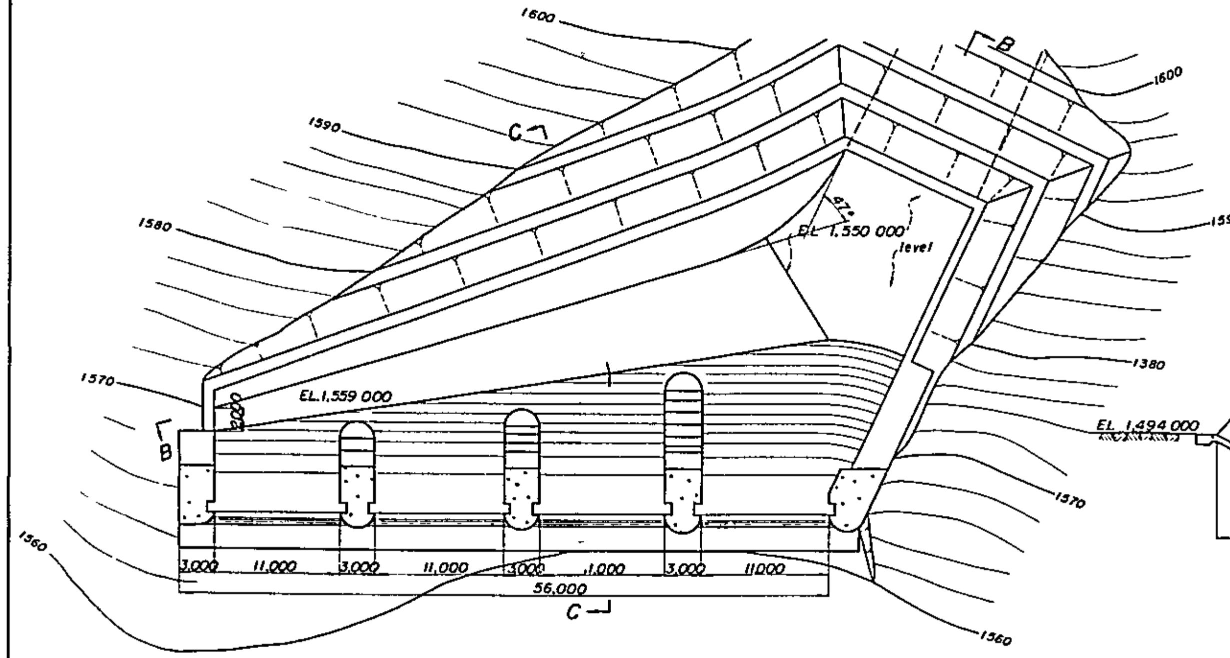
NOV 1963	NO 4



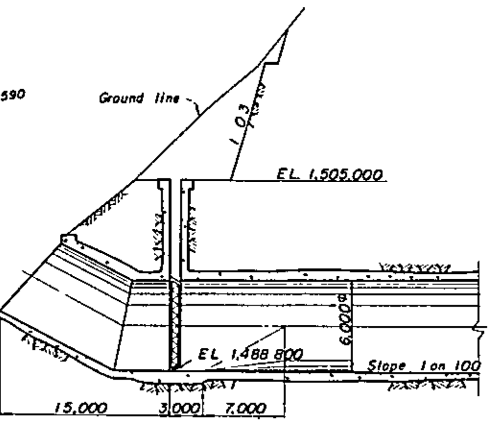
PROFILE ALONG ℄ OF SPILLWAY

SCALE

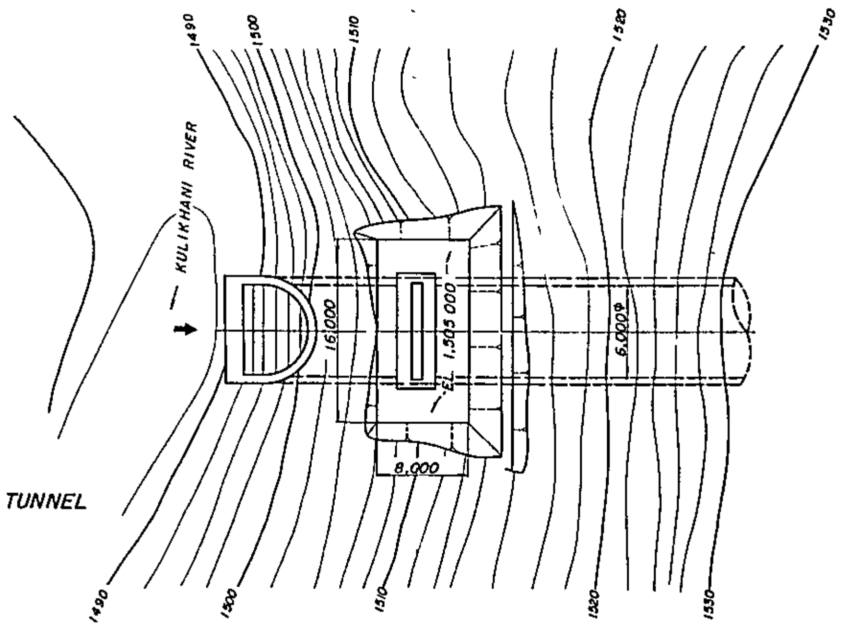
0 50 100 m



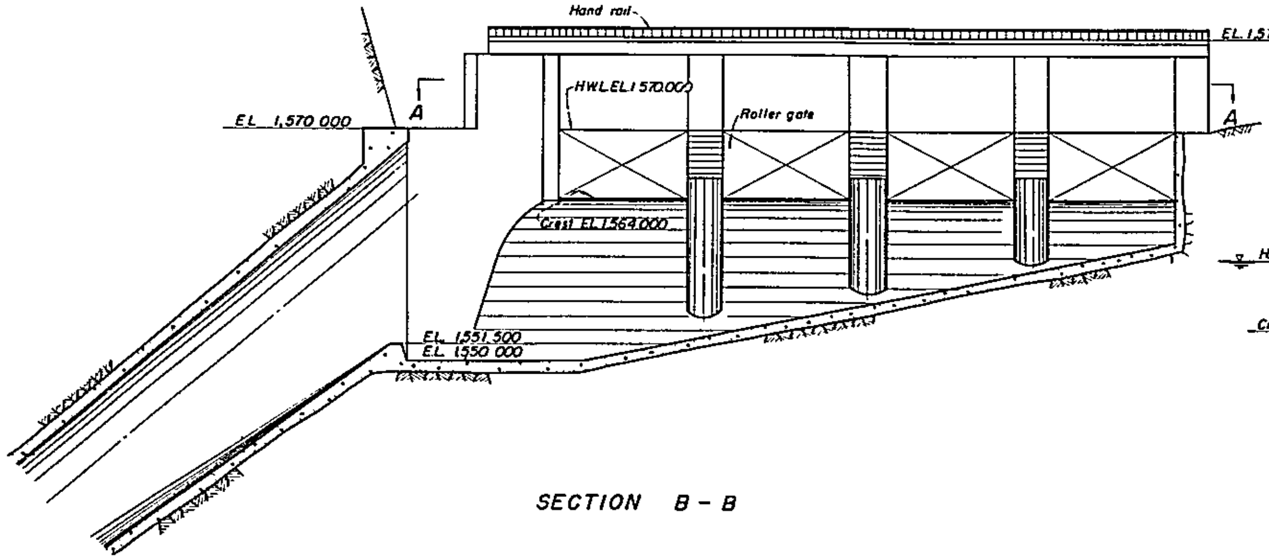
SECTION A - A



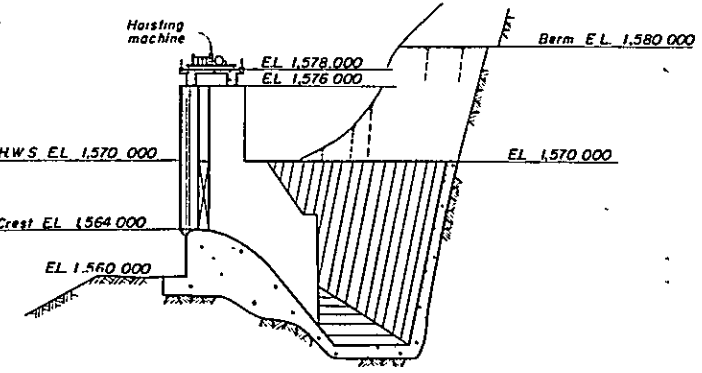
PROFILE OF INLET OF DIVERSION TUNNEL



PLAN OF INLET OF DIVERSION TUNNEL



SECTION B - B



SECTION C - C

SCALE

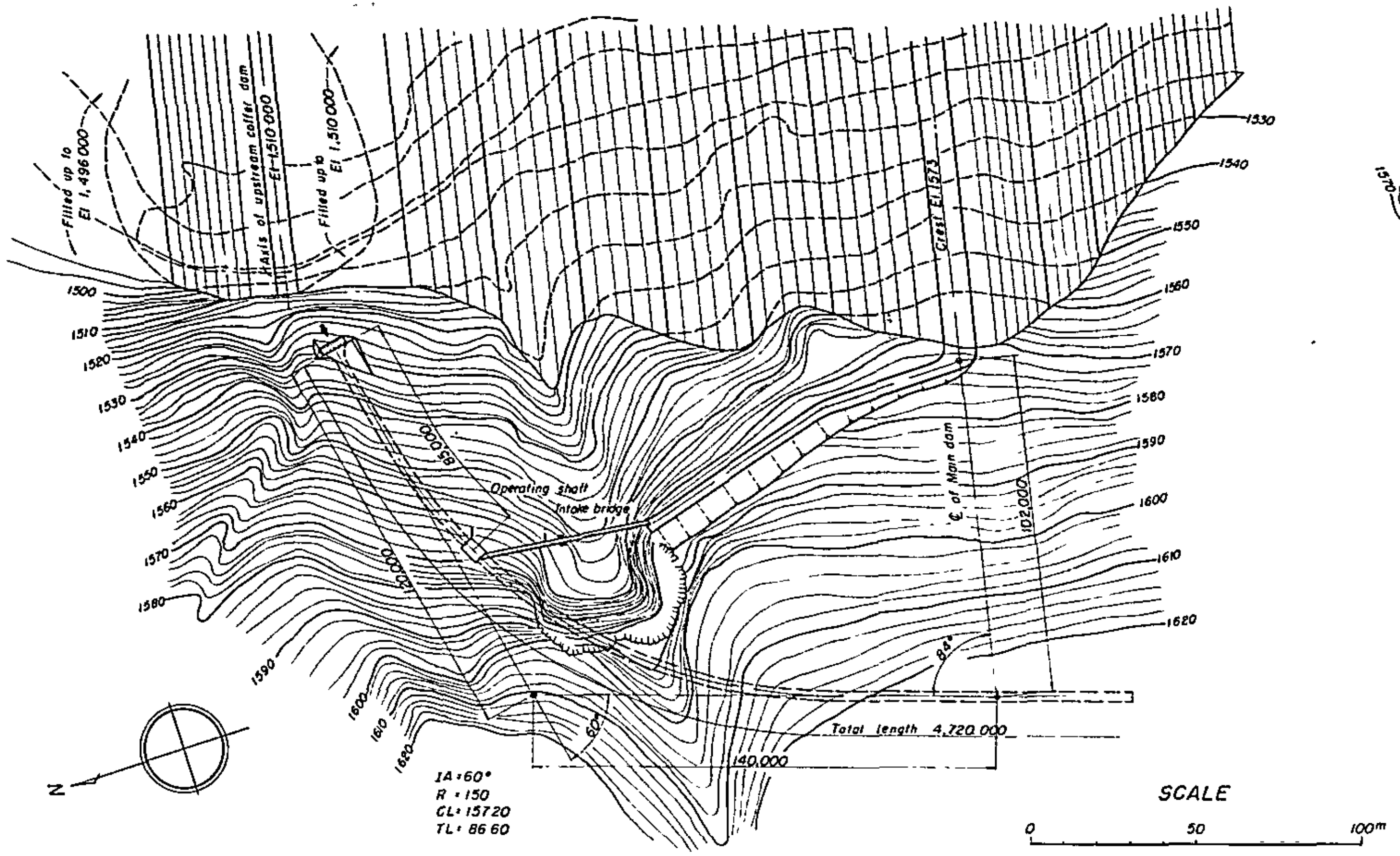
0 5 10 20(m)

KULIKHANI PROJECT

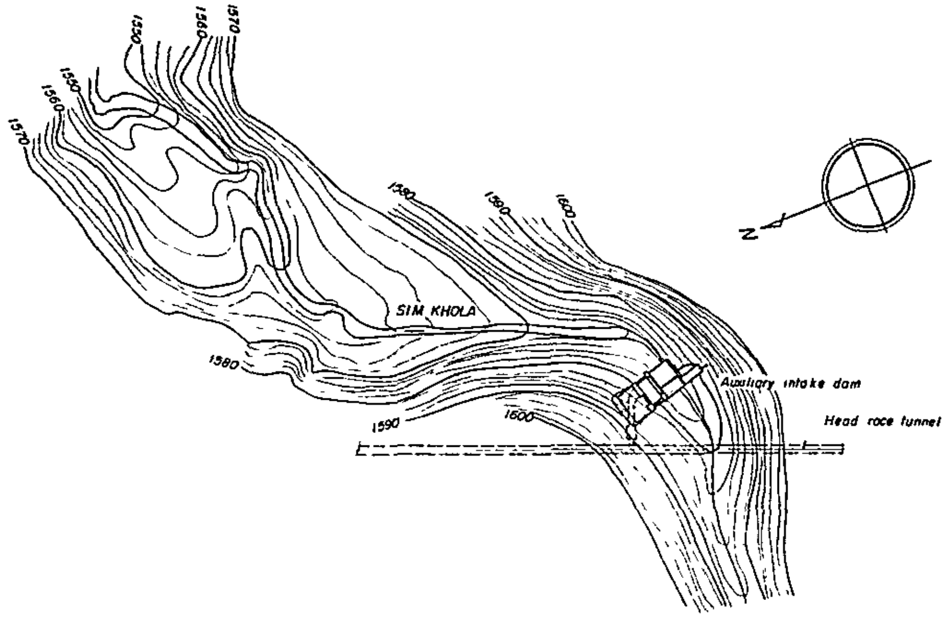
PROFILE OF DIVERSION TUNNEL
AND SPILLWAY

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

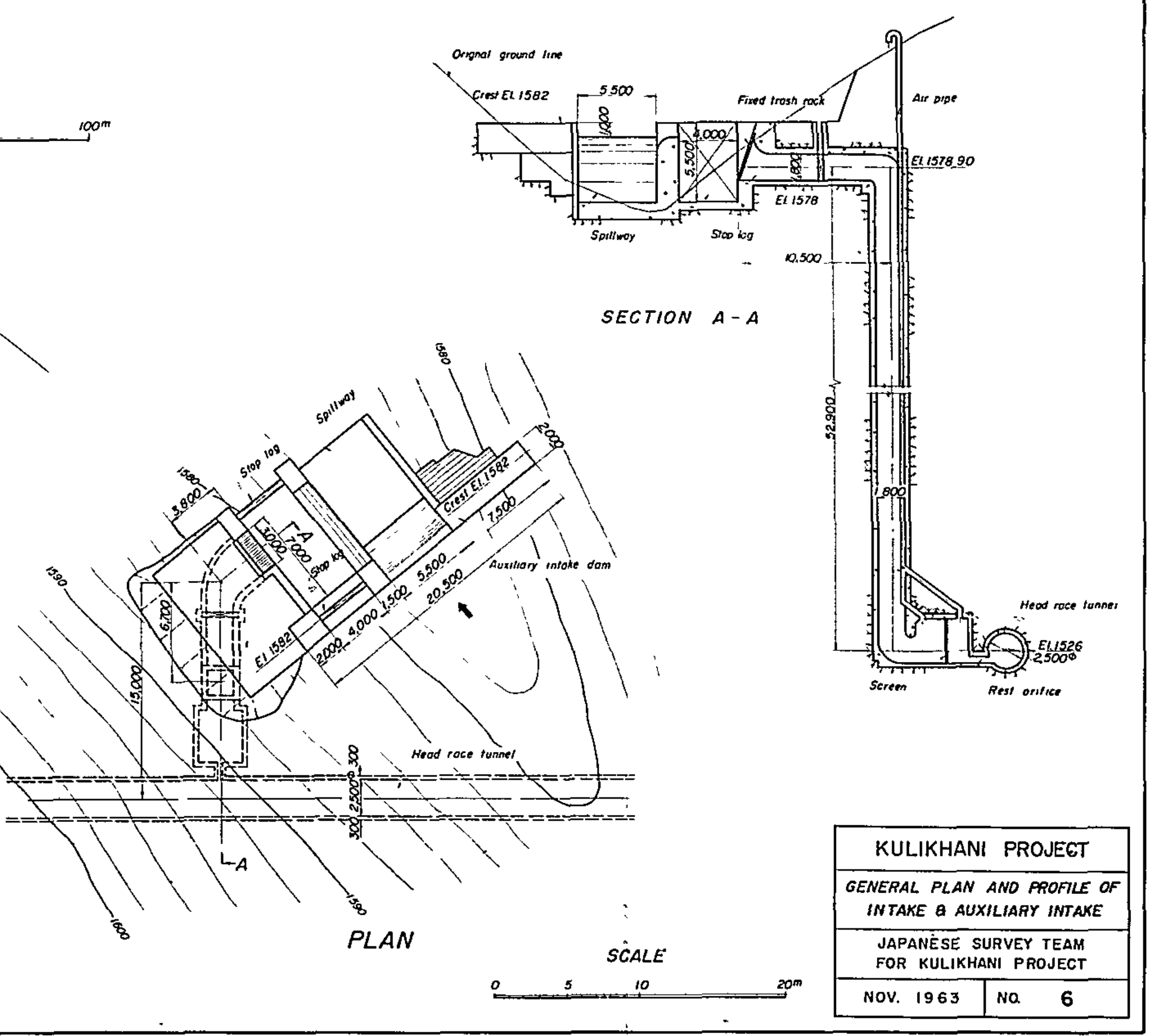
NOV. 1963 | NO. 5



GENERAL PLAN OF INTAKE

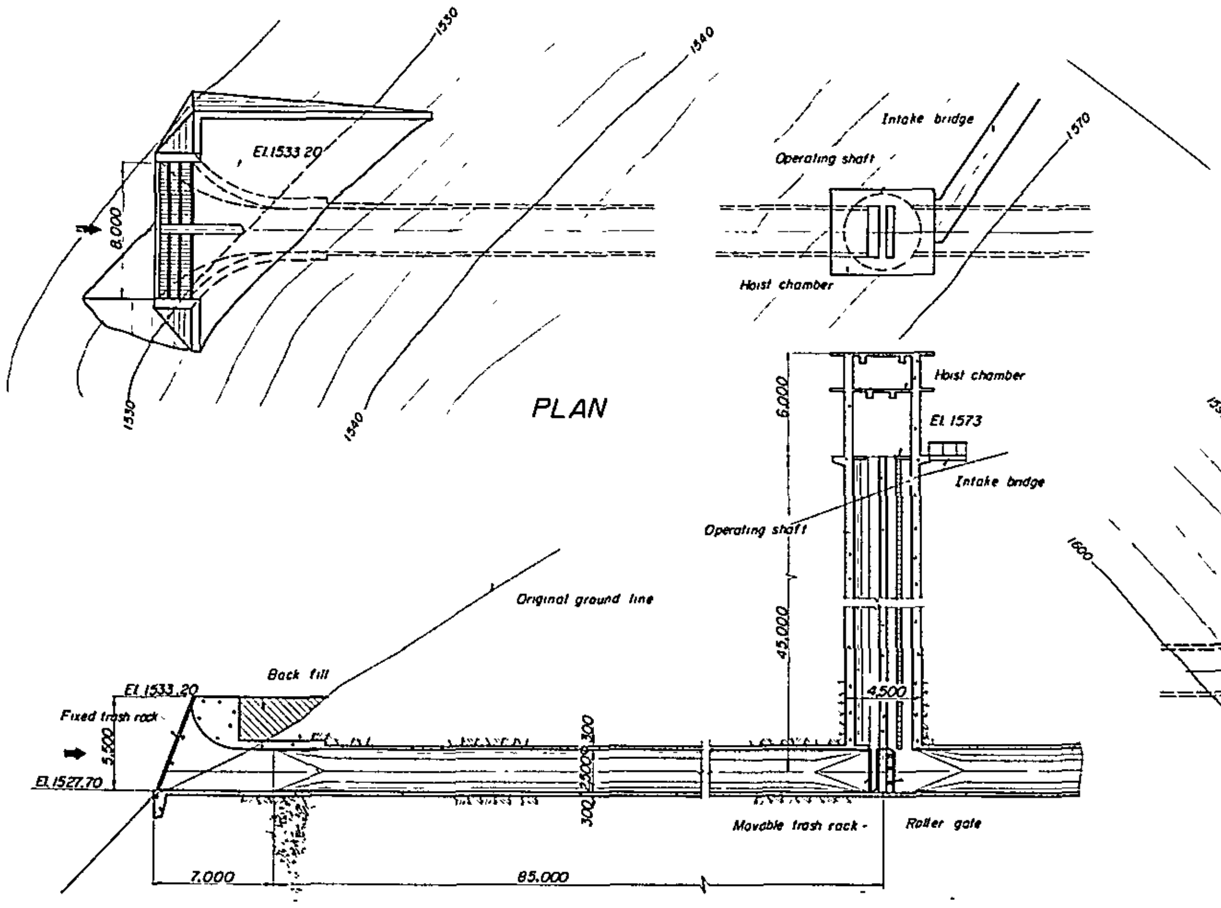


GENERAL PLAN OF AUXILIARY INTAKE



SECTION A - A

PLAN



PLAN

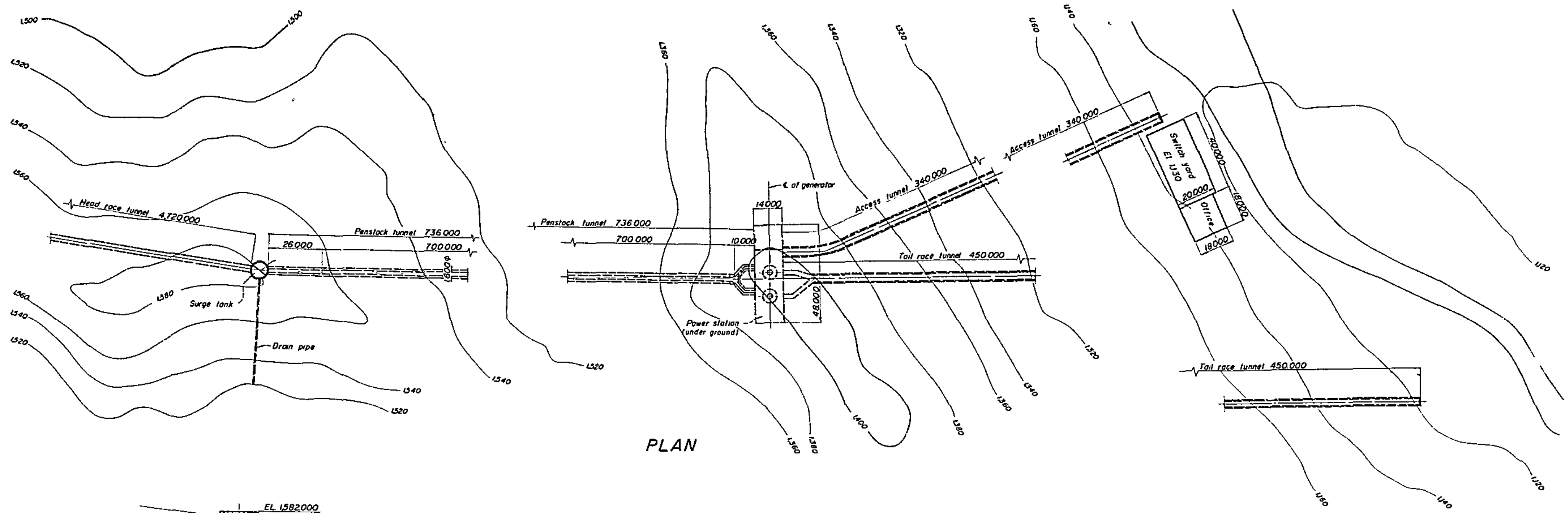
PROFILE

KULIKHANI PROJECT

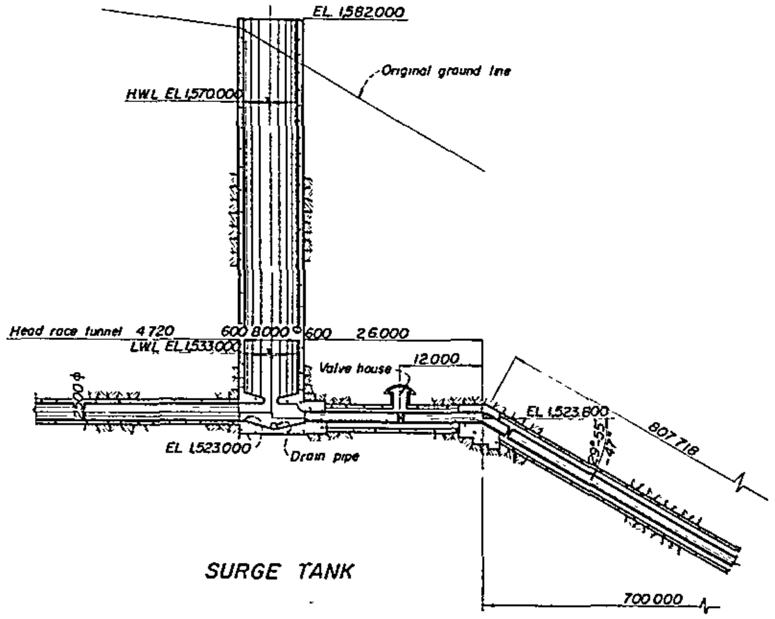
GENERAL PLAN AND PROFILE OF
INTAKE & AUXILIARY INTAKE

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

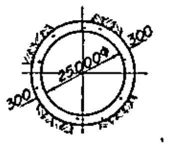
NOV. 1963	NO. 6



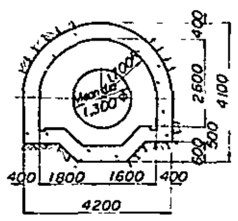
PLAN



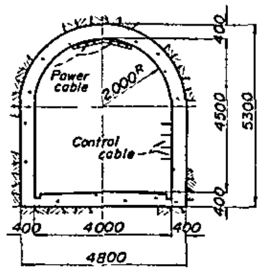
SURGE TANK



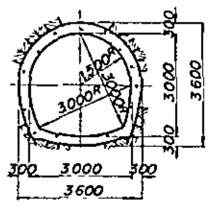
TYPICAL SECTION
OF HEADRACE TUNNEL



TYPICAL SECTION
OF PENSTOCK TUNNEL

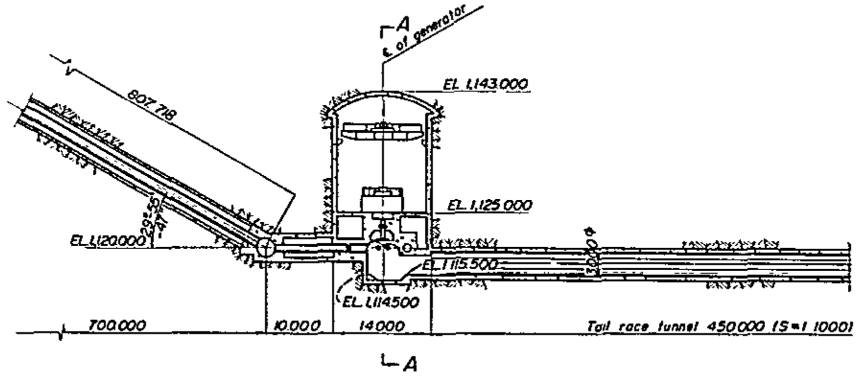


TYPICAL SECTION
OF ACCESS TUNNEL

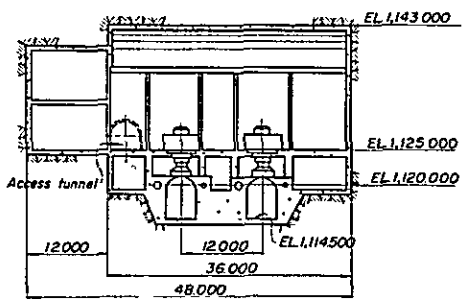


TYPICAL SECTION
OF TAIL RACE TUNNEL

SCALE
0 5 10m



POWER STATION



SECTION A－A

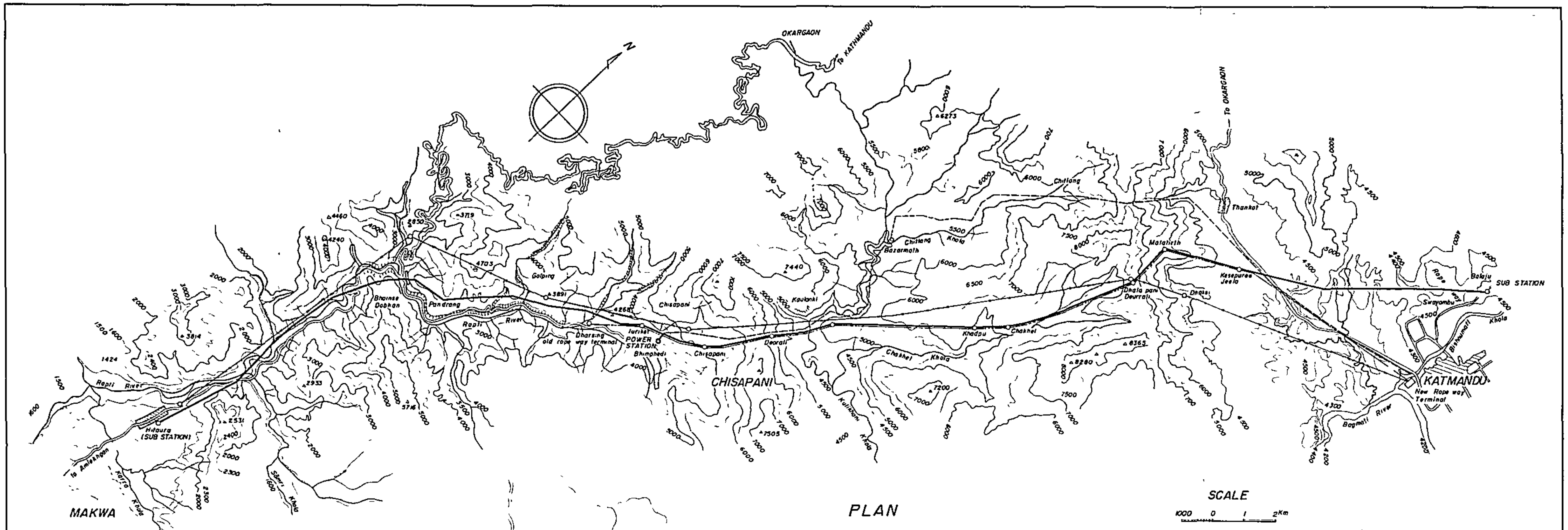
SCALE
0 10 20 30 40 50m

KULIKHANI PROJECT

PLAN AND PROFILE OF
SURGE TANK & POWER STATION

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

NOV. 1963	NO 7



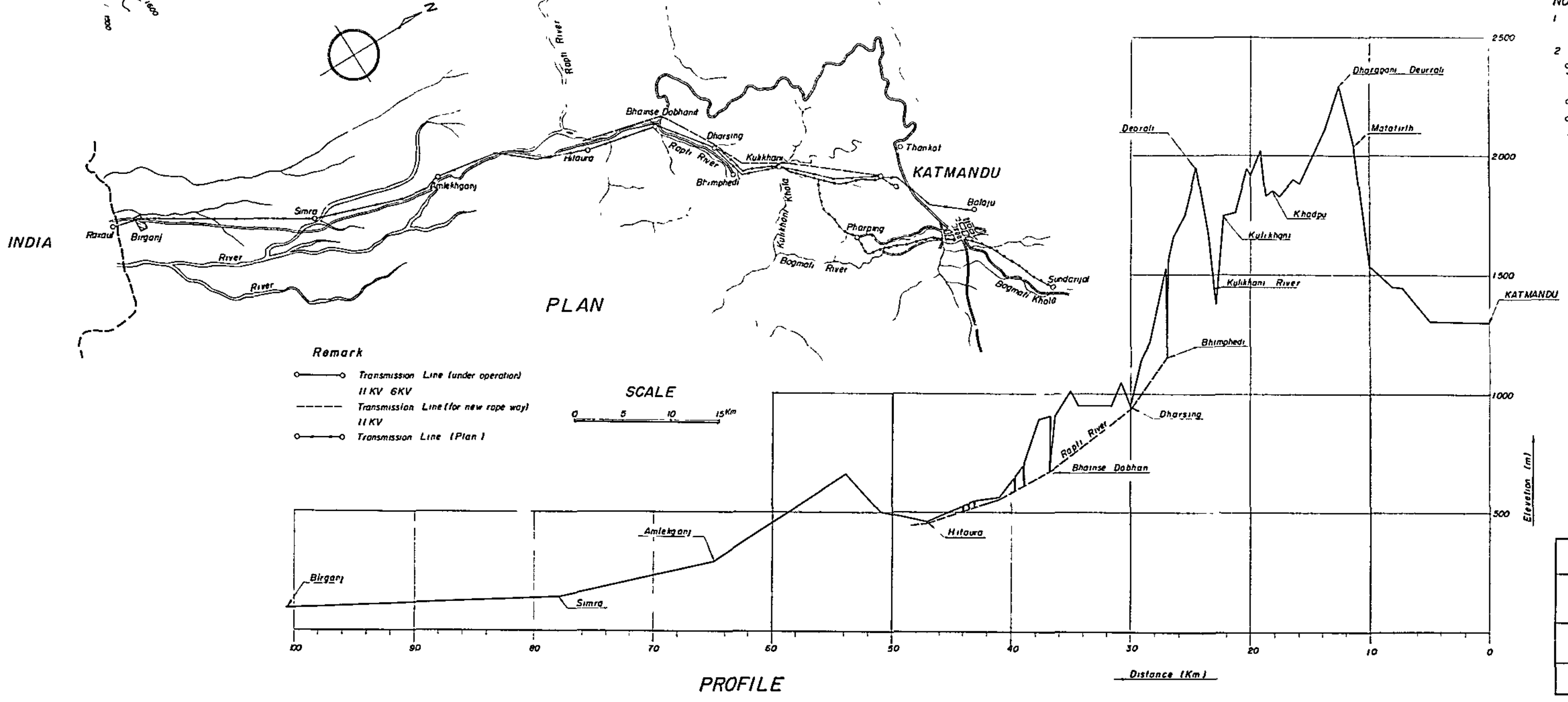
PLAN

NOTE

1 Contour interval 500 feet

2 Remark

- Transmission Line of Kulikhani Project
- Old Rope way
- New Rope way
- Telephone Line



PLAN

Remark

- Transmission Line (under operation) 11 KV 6KV
- Transmission Line (for new rope way) 11 KV
- Transmission Line (Plan)

SCALE

0 5 10 15Km

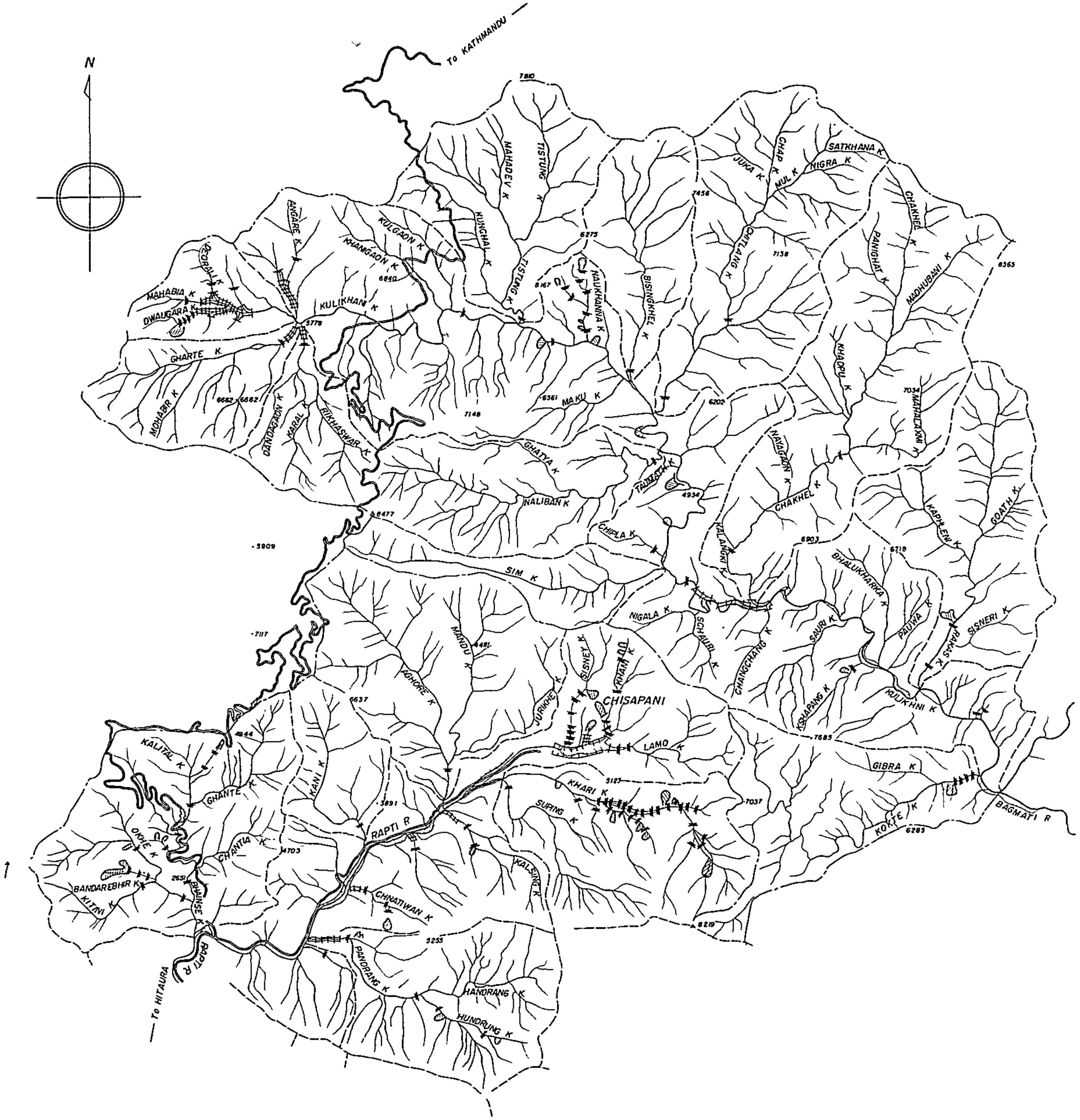
PROFILE

KULIKHANI PROJECT

GENERAL PLAN AND PROFILE
OF TRANSMISSION LINE

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

NOV 1963 NO. 8



LEGEND

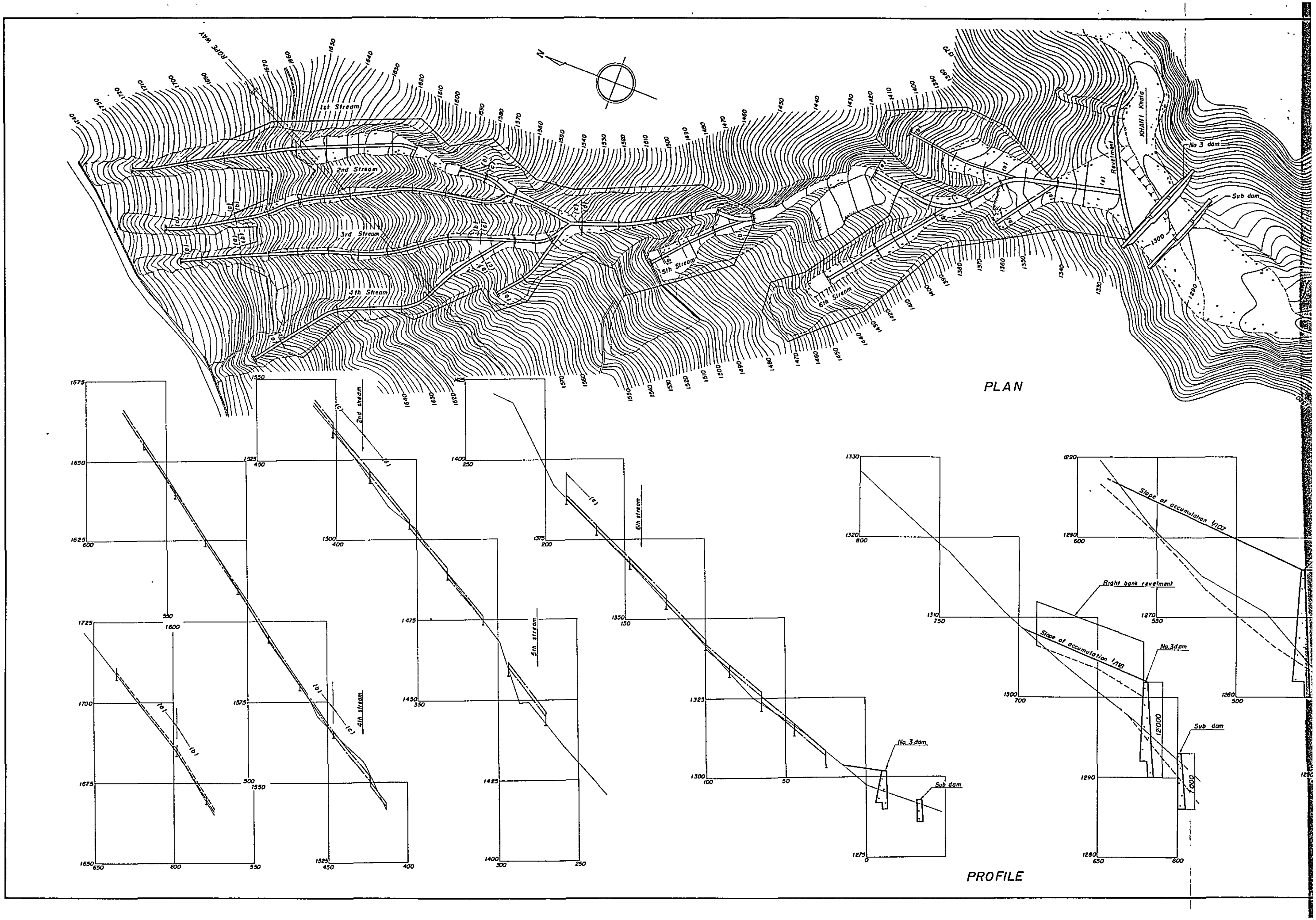
- ▯ Hillside works
- ┼ Sabo dam
- ┤ Ground sill
- ⑊ Revetment
- ⋕ Channel works
- ⊂ Groin

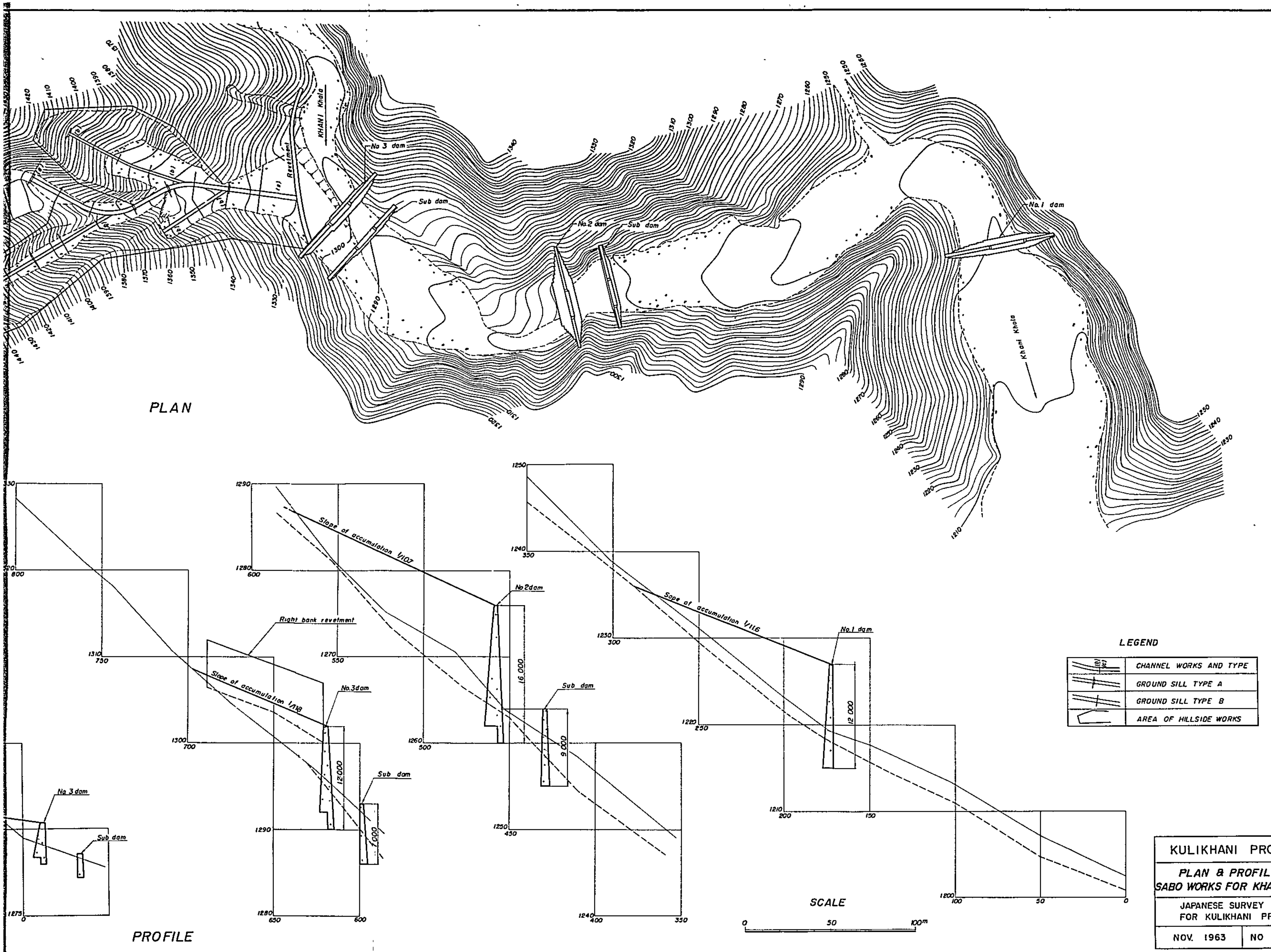
KULIKHANI PROJECT

SABO SCHEME ON KULIKHANI AND RAPTI RIVER BASIN

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

NOV. 1963	NO 9


ROPE WAY
N
1st Stream
2nd Stream
3rd Stream
4th Stream
5th Stream
6th Stream
KHANI Khola
Revetment
No.3 dam
Sub dam
1300
PLAN
2nd stream
4th stream
5th stream
6th stream
(a)
(b)
(c)
No.3 dam
Sub dam
Right bank revetment
Slope of accumulation 1/118
No.3dam
12000
7000
Sub dam
Slope of accumulation 1/107
PROFILE

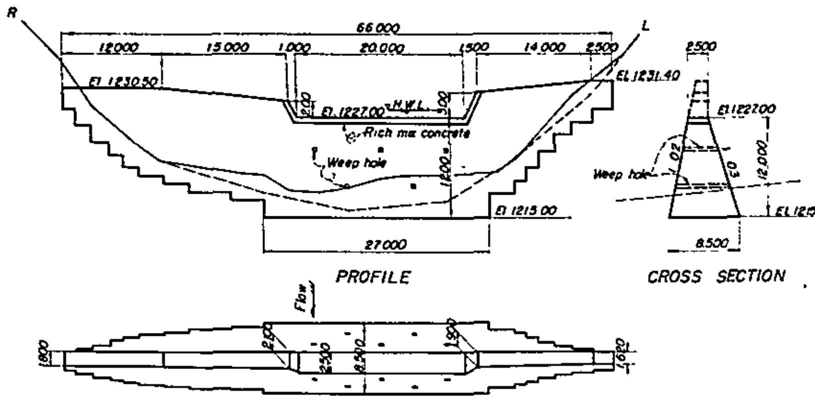


KULIKHANI PROJECT

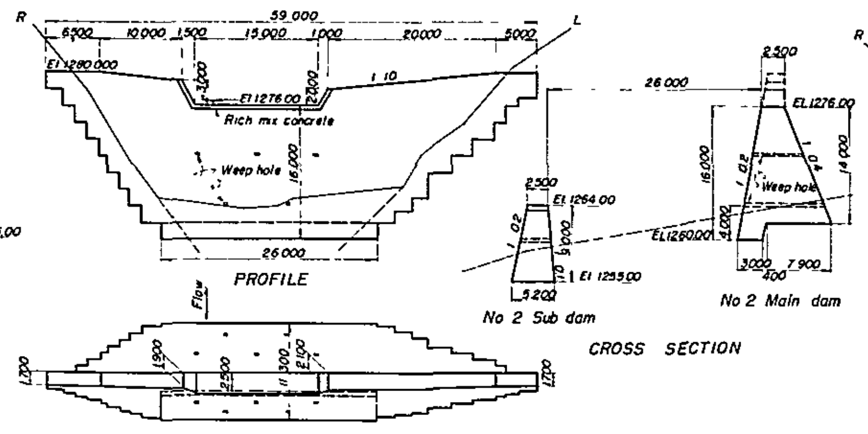
PLAN & PROFILE OF SABO WORKS FOR KHANI KHOLA

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

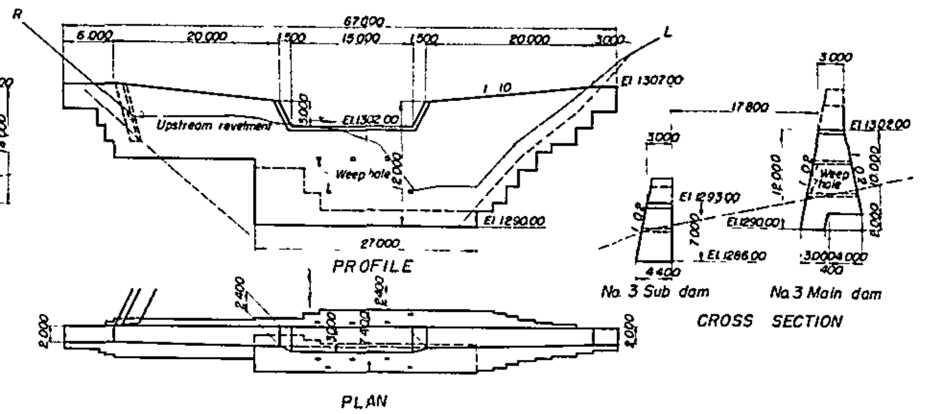
NOV. 1963 | NO 10



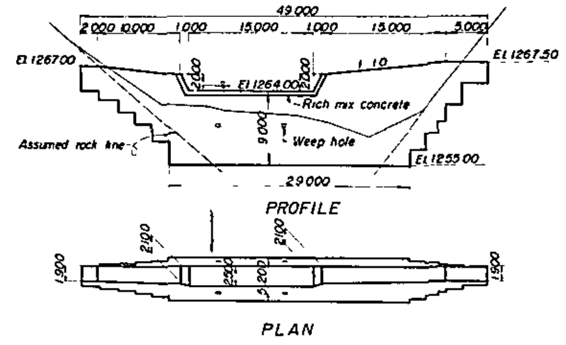
NO 1 DAM



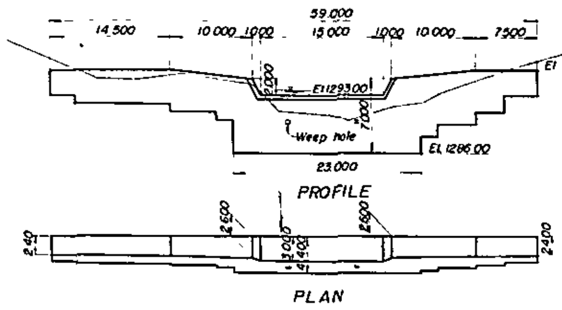
NO 2 DAM



NO 3 DAM

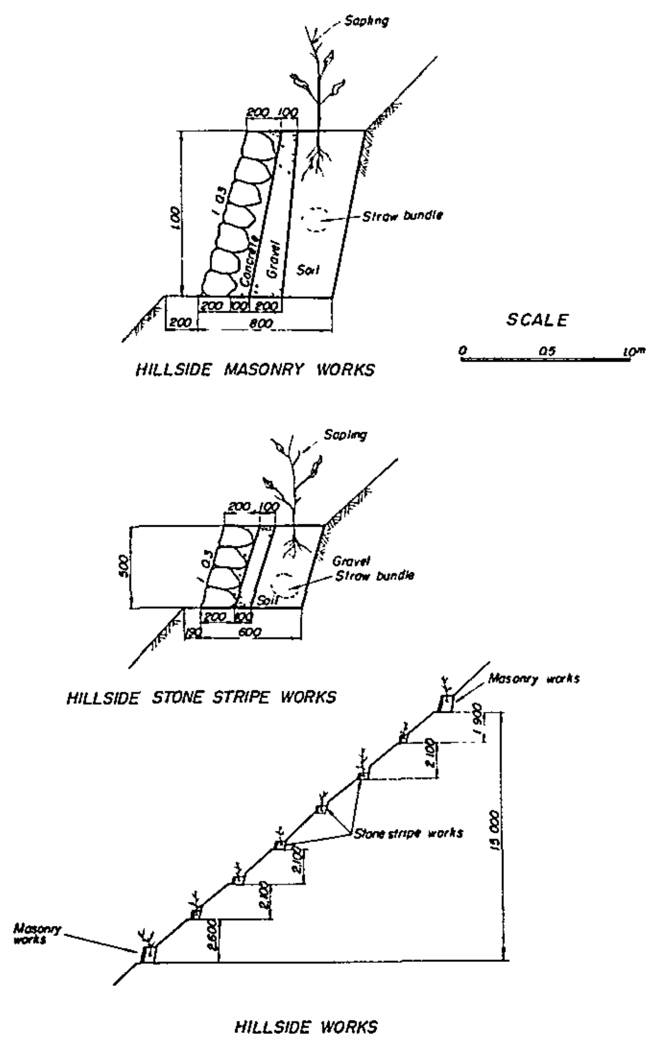


NO 2 SUB DAM



NO 3 SUB DAM

SCALE
0 5 10 20m

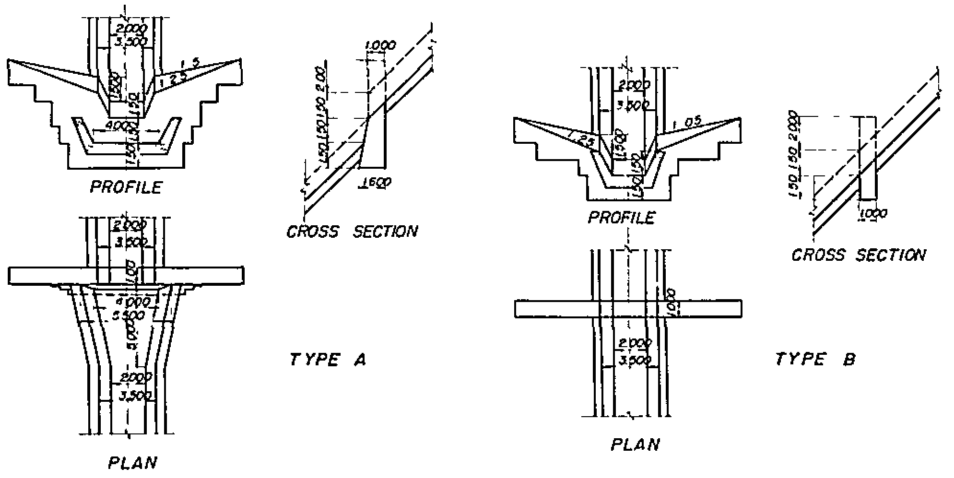


HILLSIDE MASONRY WORKS

HILLSIDE STONE STRIPE WORKS

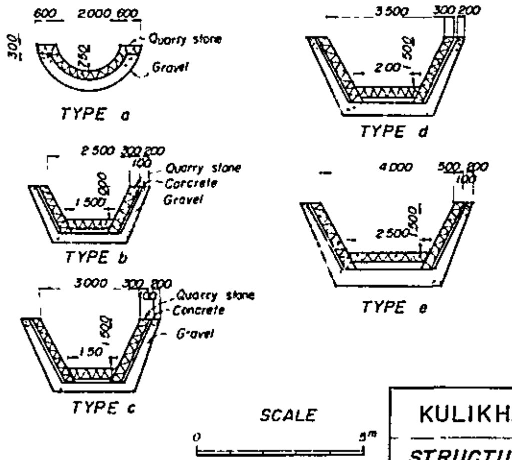
HILLSIDE WORKS

STANDARD SECTION OF HILLSIDE WORKS



STANDARD SECTION OF GROUND SILL

SCALE
0 5 10m



STANDARD SECTION OF CHANNEL WORKS

KULIKHANI PROJECT

STRUCTURAL DETAILS OF SABO WORKS FOR KHANI KHOLA

JAPANESE SURVEY TEAM
FOR KULIKHANI PROJECT

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