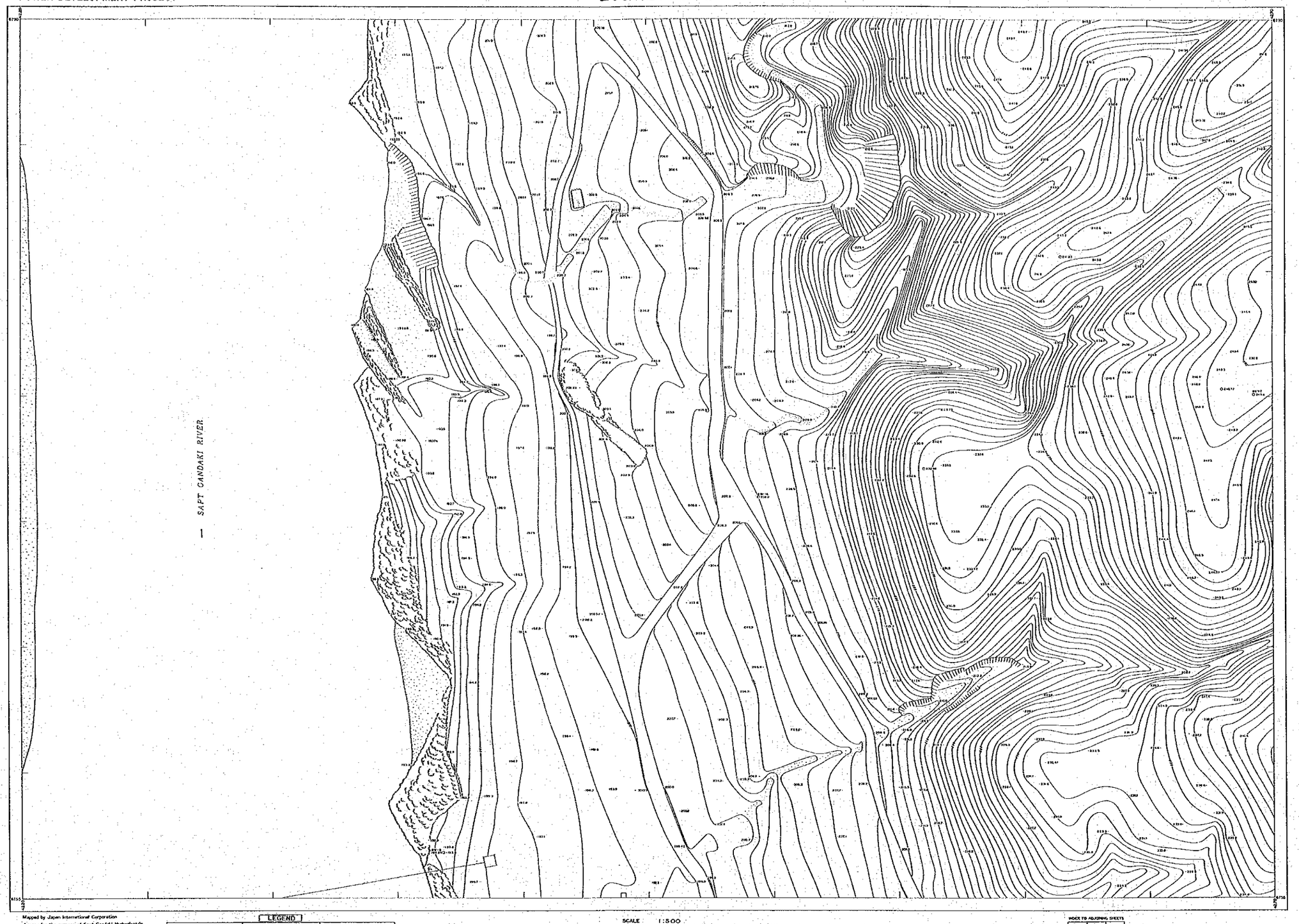
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 8



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study

LEGEND

Control station (BM)	River Stream	Slope	
Spot Elevation	Flow Arrow	Broad Leaf	
Formed Roads	Cutting	Grass	
Trail	Embankment	Fields	
Buildings	Depression		
Bridge	Cliff		
Ferry	Bare Hill		
	Sand		

SCALE 1:5.00

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False easting : 0 meter
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9996
Zone number : 44th Grid Zone
Spheroid : Everest

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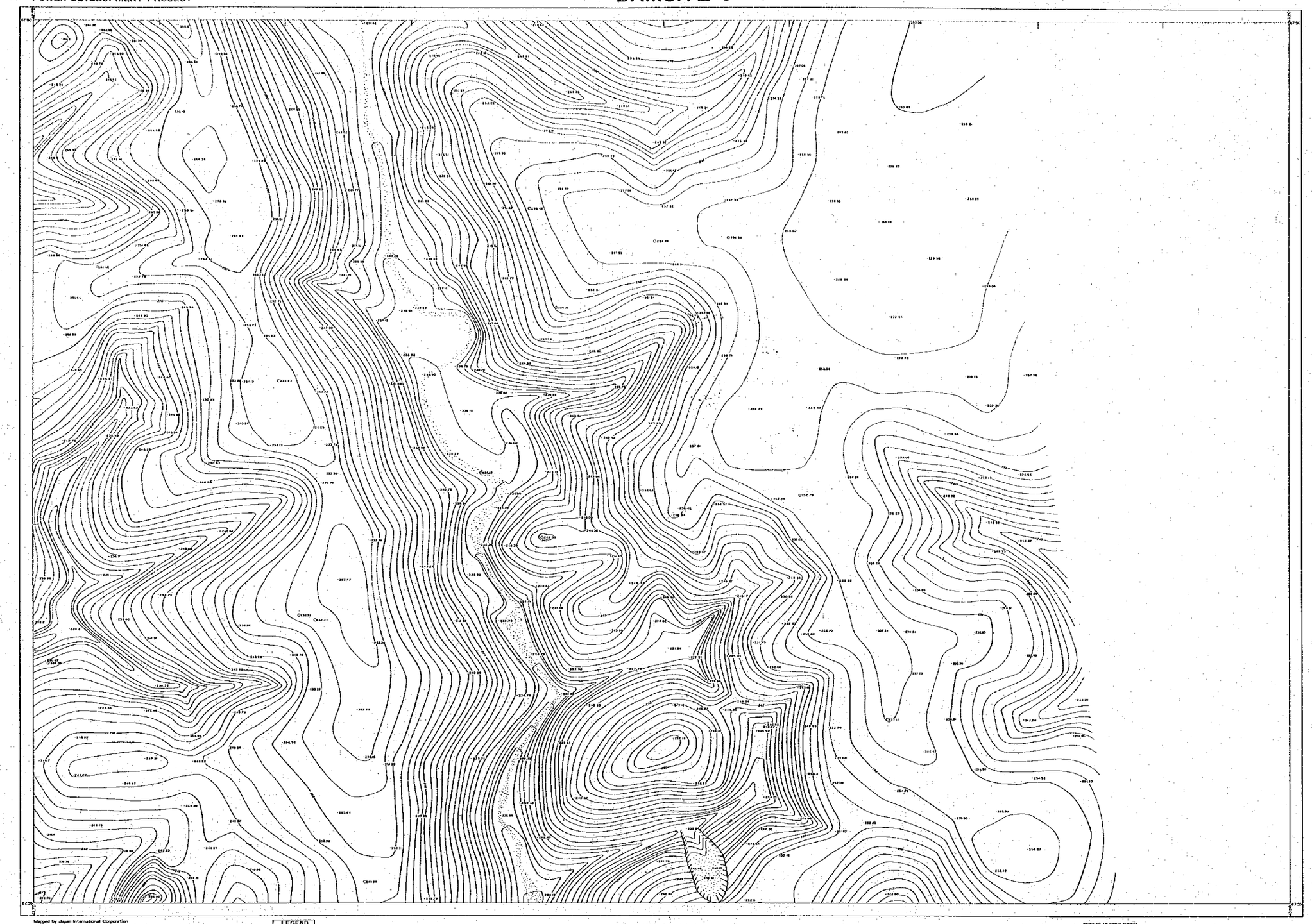
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 9



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

Control station (BM's)	⊡	River Stream		Sheet	
Spot Elevations	315	Flow Arrow		Broad Leaf	
Formed Roads		Cutting		Grass	
Trail		Embankment		Fields	
Buildings		Depression			
Bridge		Cliff			
Ferry		Bare rock			
		Sand			

SCALE 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRAHSVERSE MERCATOL PROJECTION

Longitude of origin : Centre of meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meters
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9999
Zone number : 44.5 Std Zone
Spheroid : Everest

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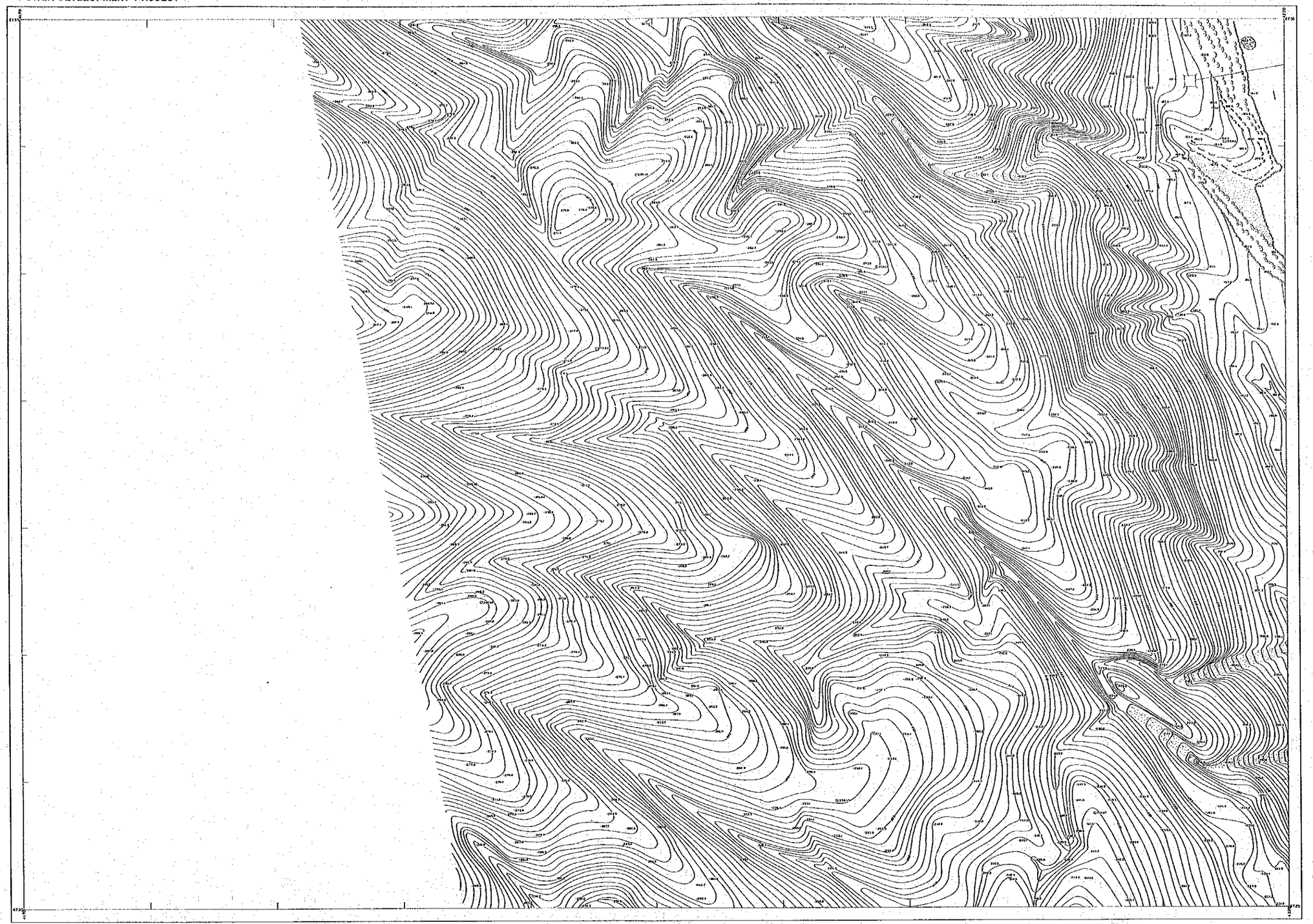
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 10



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

SCALE 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

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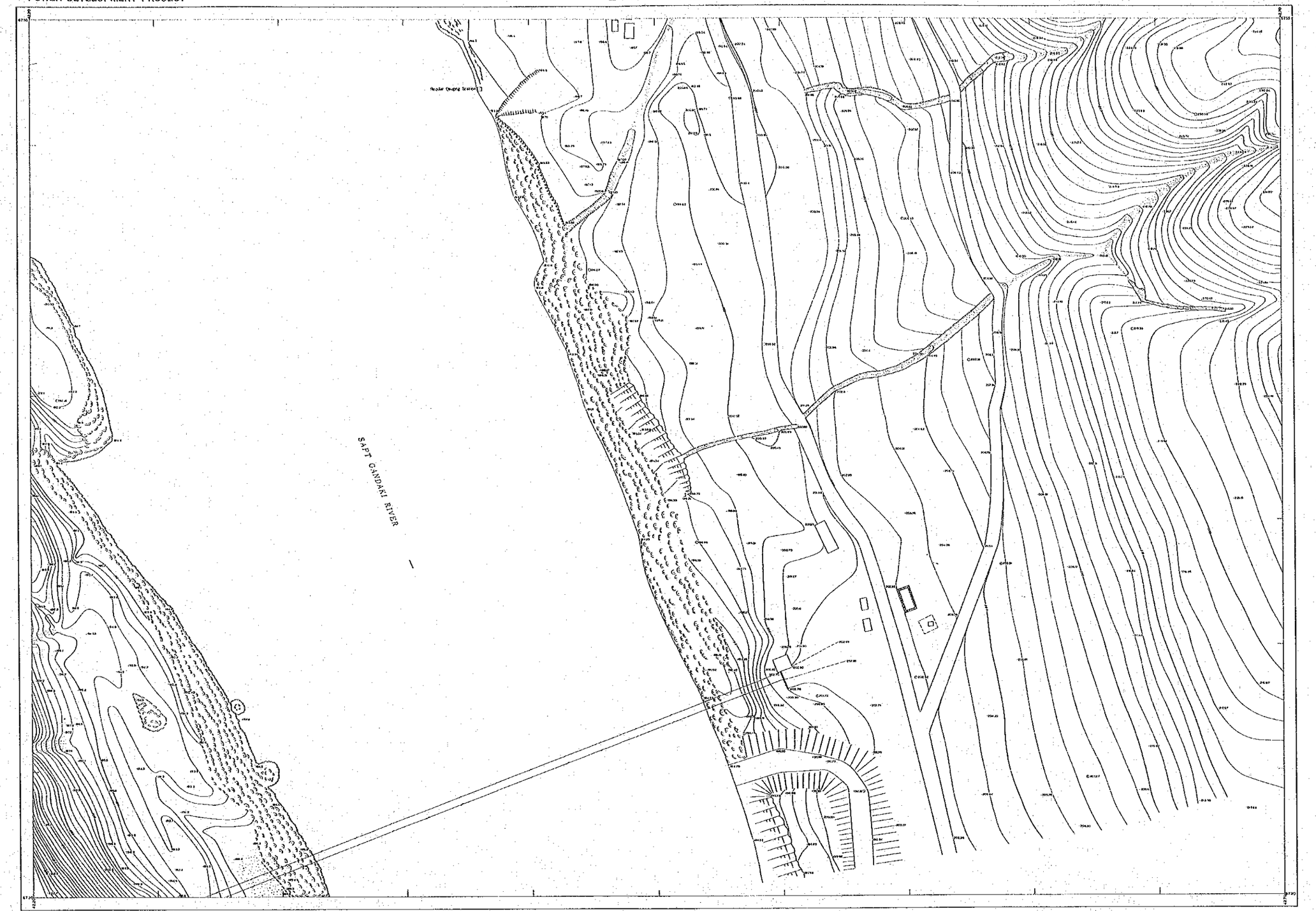
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE II



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

SCALE 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meter
Scale factor on the central meridian : 0.9999
Zone number : 44 S Grid Zone
Spheroid : Everest

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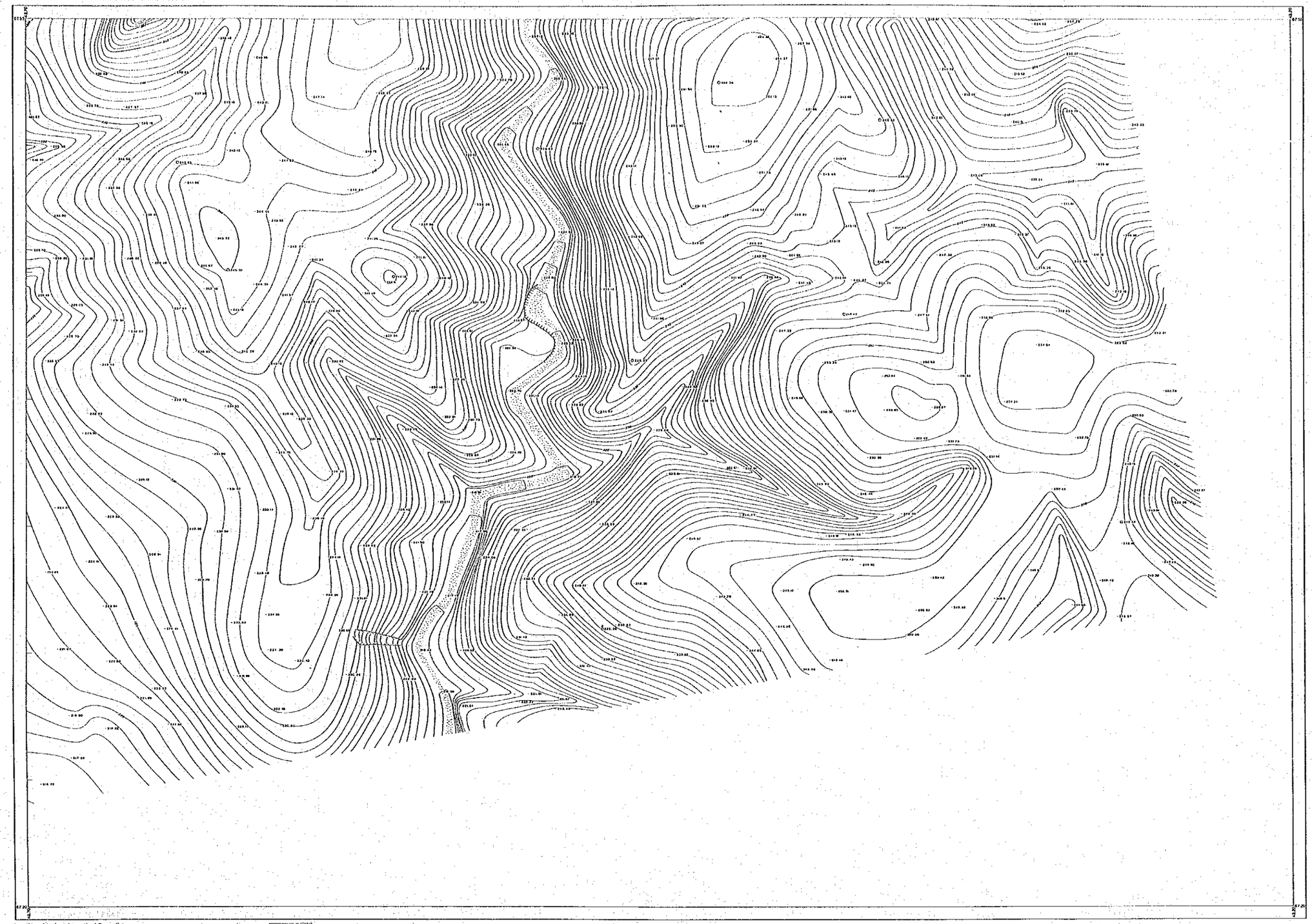
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 12



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

Control station (BM's)	⊡	River Stream		Slopes	
Spot Elevations	319	Flow Arrow		Broad Leaf	
Filtered Roads		Cutting		Grass	
Trail		Embankment		Fields	
Buildings		Depression			
Bridges		Cliff			
Ferry		Bare rock			
		Sand			

SCALE 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

Longitude of origin : Central meridian 84°E+/-
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9999
Zone number : 44.5 WGS Zone
Spheroid : Everest

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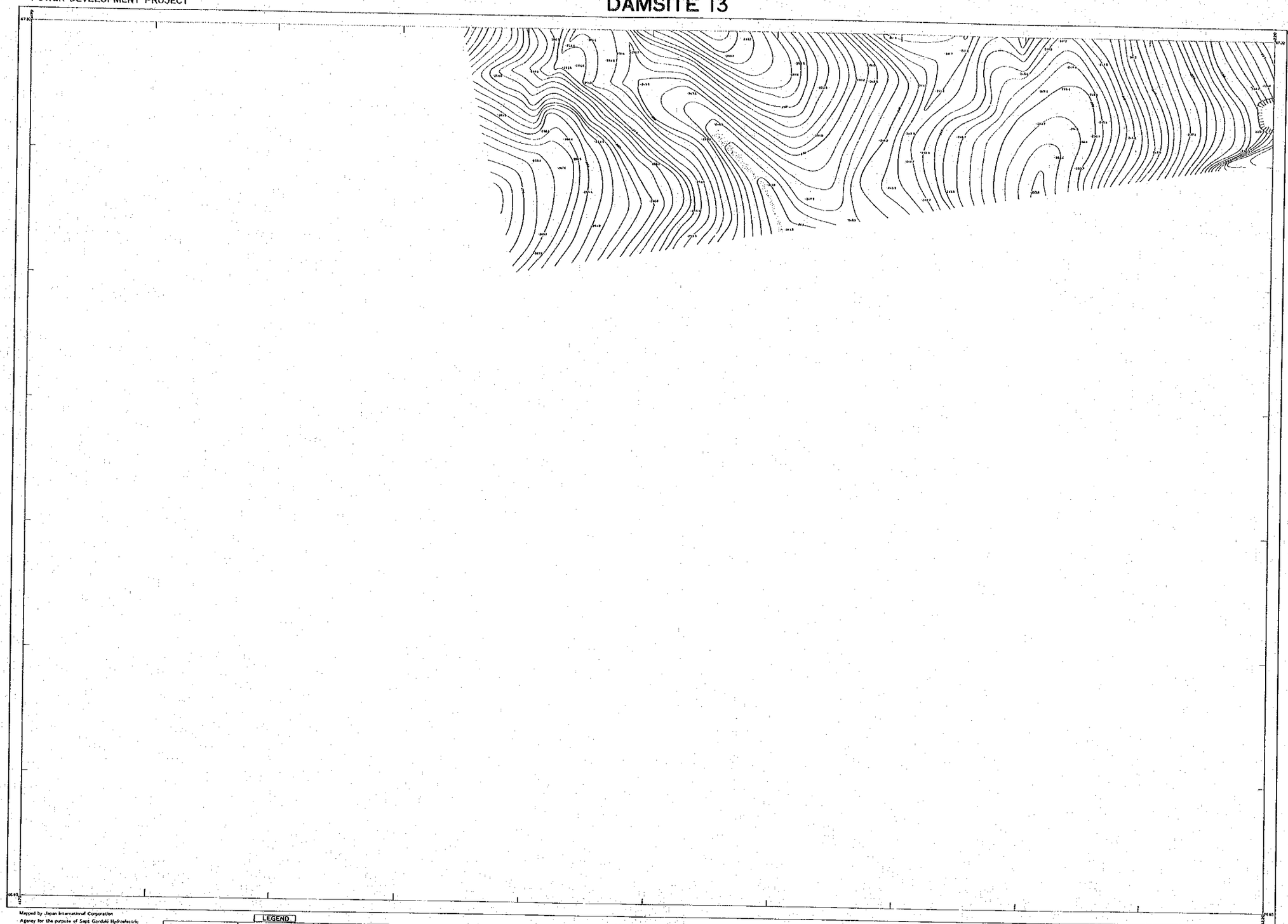
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 13



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study

LEGEND

Control station (Intl.)	⊡	River Stream		Slopes	
Base Directions	+E.S.	Flow Arrow		Broad Leaf	
Formed Roads		Existing		Grass	
Trail		Embankment		Fields	
Bridges		Depression			
Ferry		Cliff			
		Bare rock			
		Sand			

SCALE 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meters
Scale factor at the central meridian 0.9995
Zone number : 44 N Grid Zone
Spheroid : Everest

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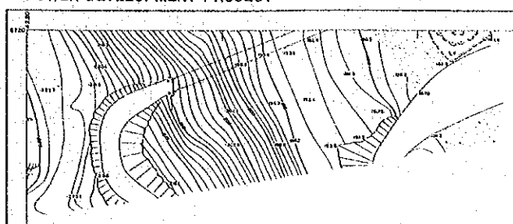
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE 14



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

Control station (BMs)	⊡	River Stream		Slopes	
Spot Elevations	519	Flow Arrow		Broad Leaf	
Formed Roads		Cutting		Grass	
Trail		Embankment		Fields	
Buildings		Depression			
Bridges		Cliff			
Ferry		Bare rock			
		Sand			

SCALE : 1:500

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0 degree(s)
False Northing : 0 (zero)
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9999
Zone number : 44.5 Arbi Zone
Spheroid : Everest

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II

TOPOGRAPHIC MAP OF PROJECT AREA

OF 1 TO 2,000 IN SCALE (2 SHEETS)

SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE (1/2,000) I

Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

Control station (GMs)	□	River Stream		Slopes	
Spot Elevations	+ 2.3	Flow Arrow		Broad Leaf	A A
Formed Roads		Cutting		Grass	A A
Trail		Embankment		Fields	V V
Buildings		Depression			
Bridges	>30t(c.lass)	Cliff			
Ferry		Bare rock			
		Sand			

SCALE 1:2,000

CONTOUR INTERVAL 2 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

Longitude of origin : Central meridian 84°east
Latitude of origin : 0° (Equator)
False northing : 10 000km
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9999
Zone number : 44 S Grid Zone
Spheroid : Everest

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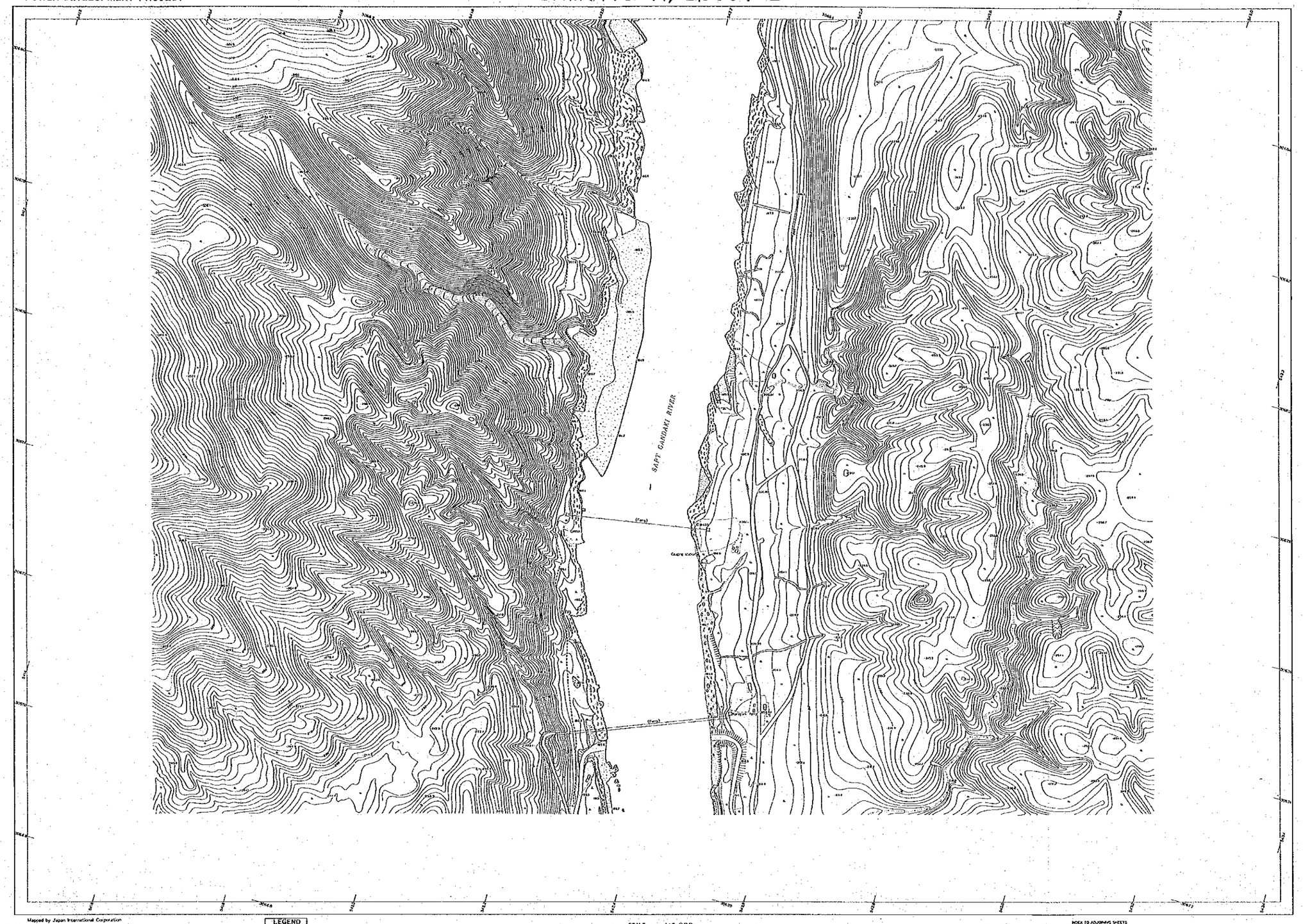
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

DAMSITE (1/2,000) 2



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study

LEGEND

Control station (BMs)	CI	River Stream		Slopes	
Rock Elevations	+218	Flow Arrow		Broad Leaf	
Formed Roads		Cutting		Grass	
Trail		Embankment		Paddy	
Buildings		Depression			
Bridge		Cliff			
Ferry		Rare rock			
		Sand			

SCALE 1:2,000

CONTOUR INTERVAL 5 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9999
Zone number : 44 N Grid Zone
Spheroid : Everest

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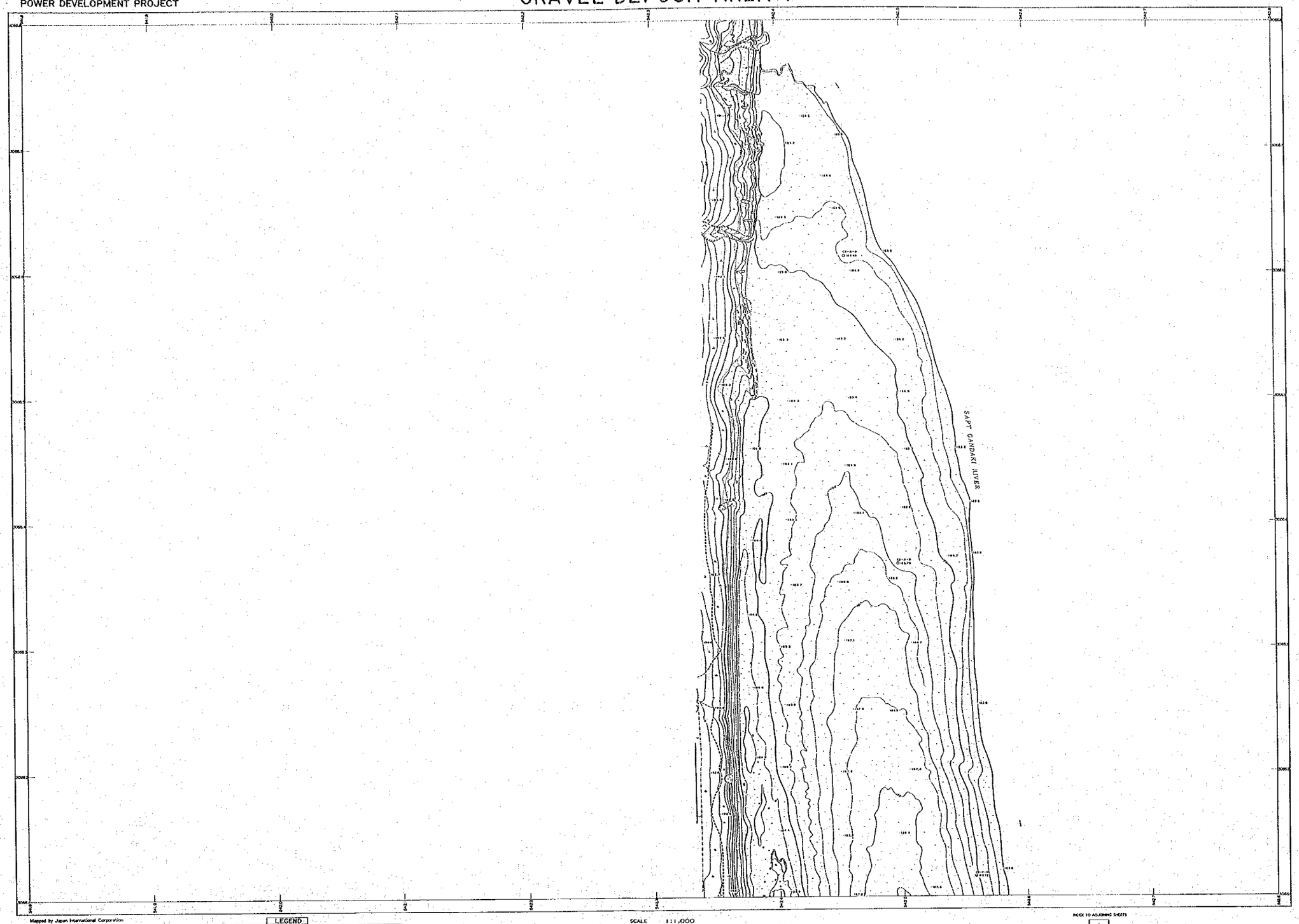
III

TOPOGRAPHIC MAP OF SAND AND GRAVEL DEPOSIT AREA OF 1 TO 1,000 (3 SHEETS)

SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

GRAVEL DEPOSIT AREA I



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study

LEGEND

SCALE 1 : 1,000

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

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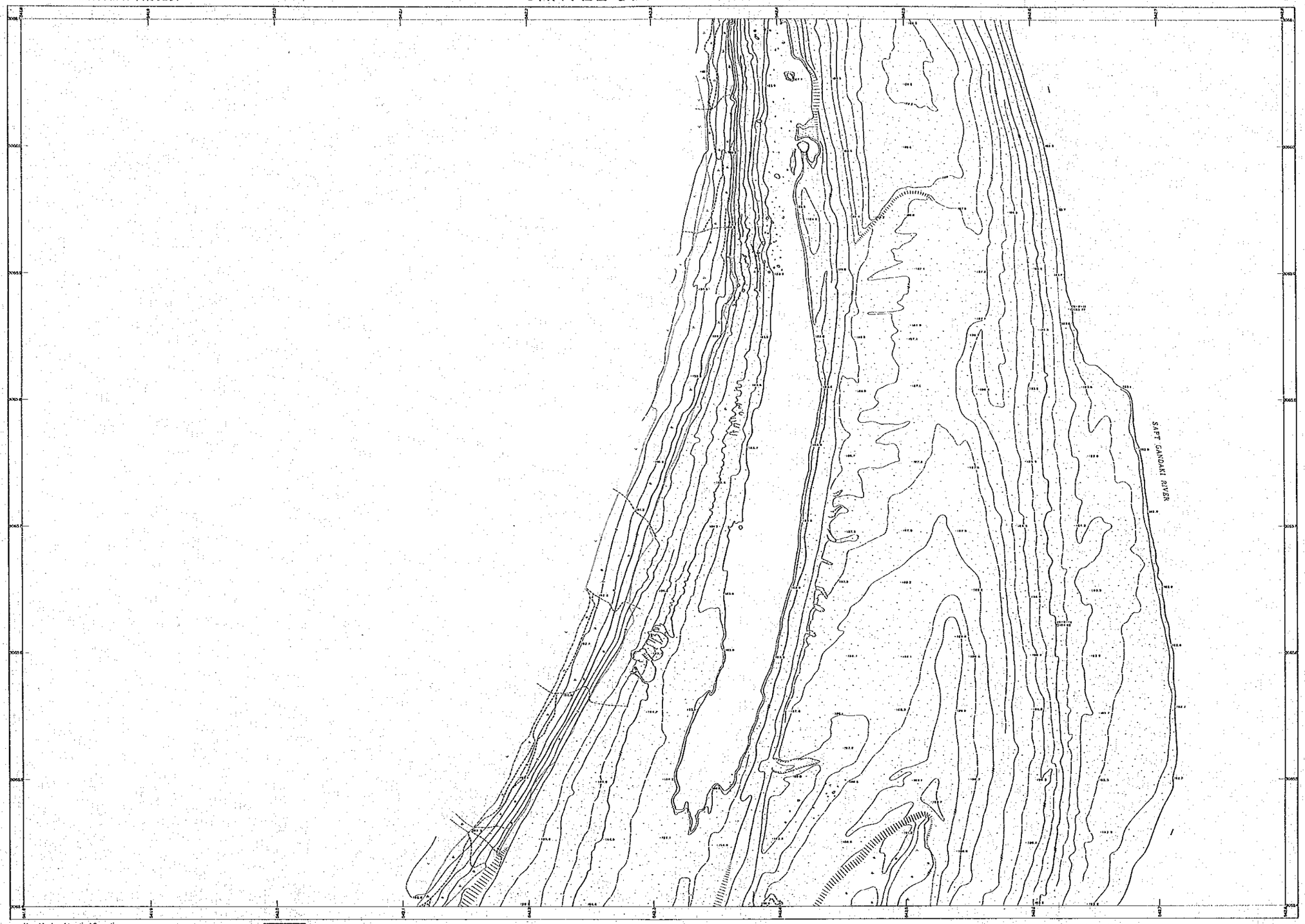
3

SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

GRAVEL DEPOSIT AREA 2



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

SCALE 1:1,000

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

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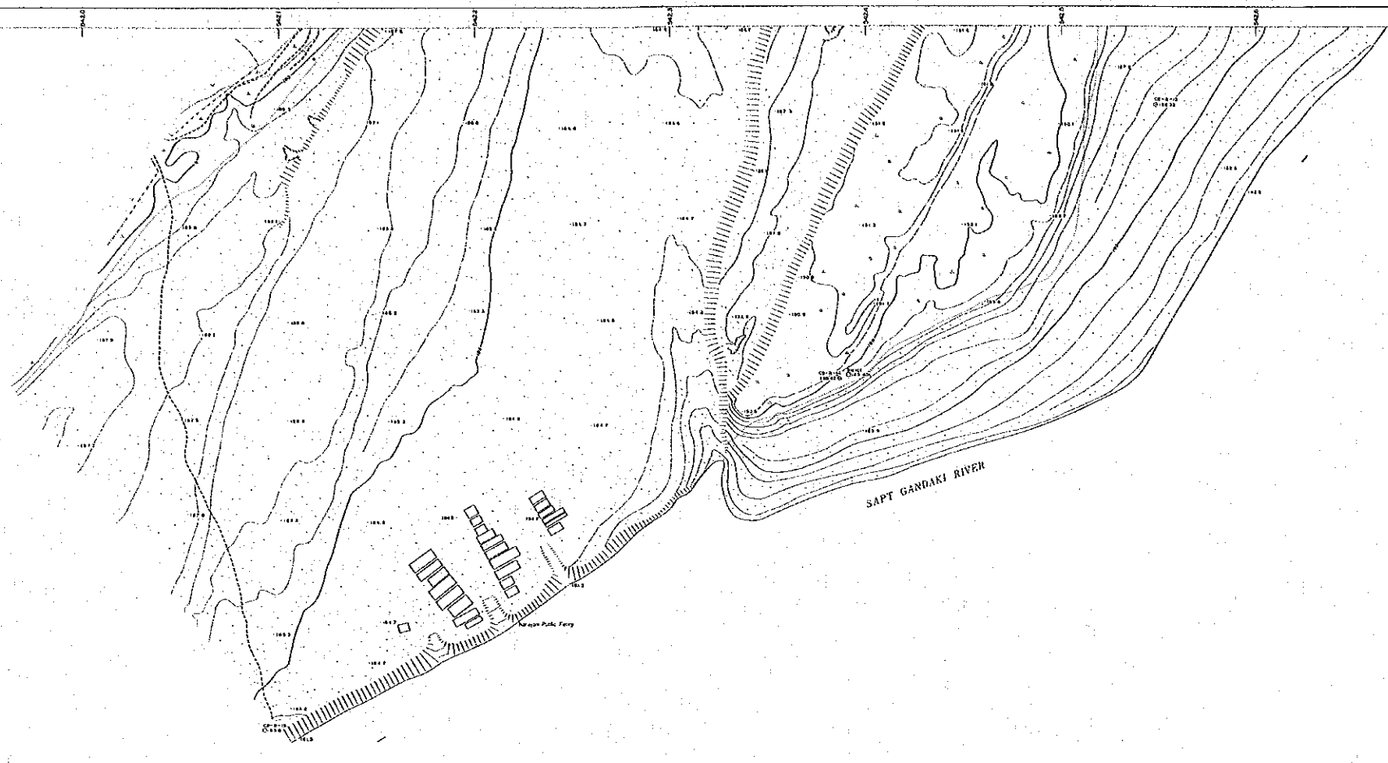
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

GRAVEL DEPOSIT AREA 3



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study

LEGEND

Control station (BM&)	□	River Stream		Slopes	
Spot Elevations	+ 816	Flow Arrow		Broad Leaf	
Formed Roads		Cutting		Grass	
Trail		Embankment		Paddy	
Buildings		Depression			
Bridges		Cliff			
Ferry		Bare rock			
		Sand			

SCALE 1:1,000

CONTOUR INTERVAL 1 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meters
Scale factor on the central meridian : 0.9996
Zone number : 44 S Grid Zone
Spheroid : Everest

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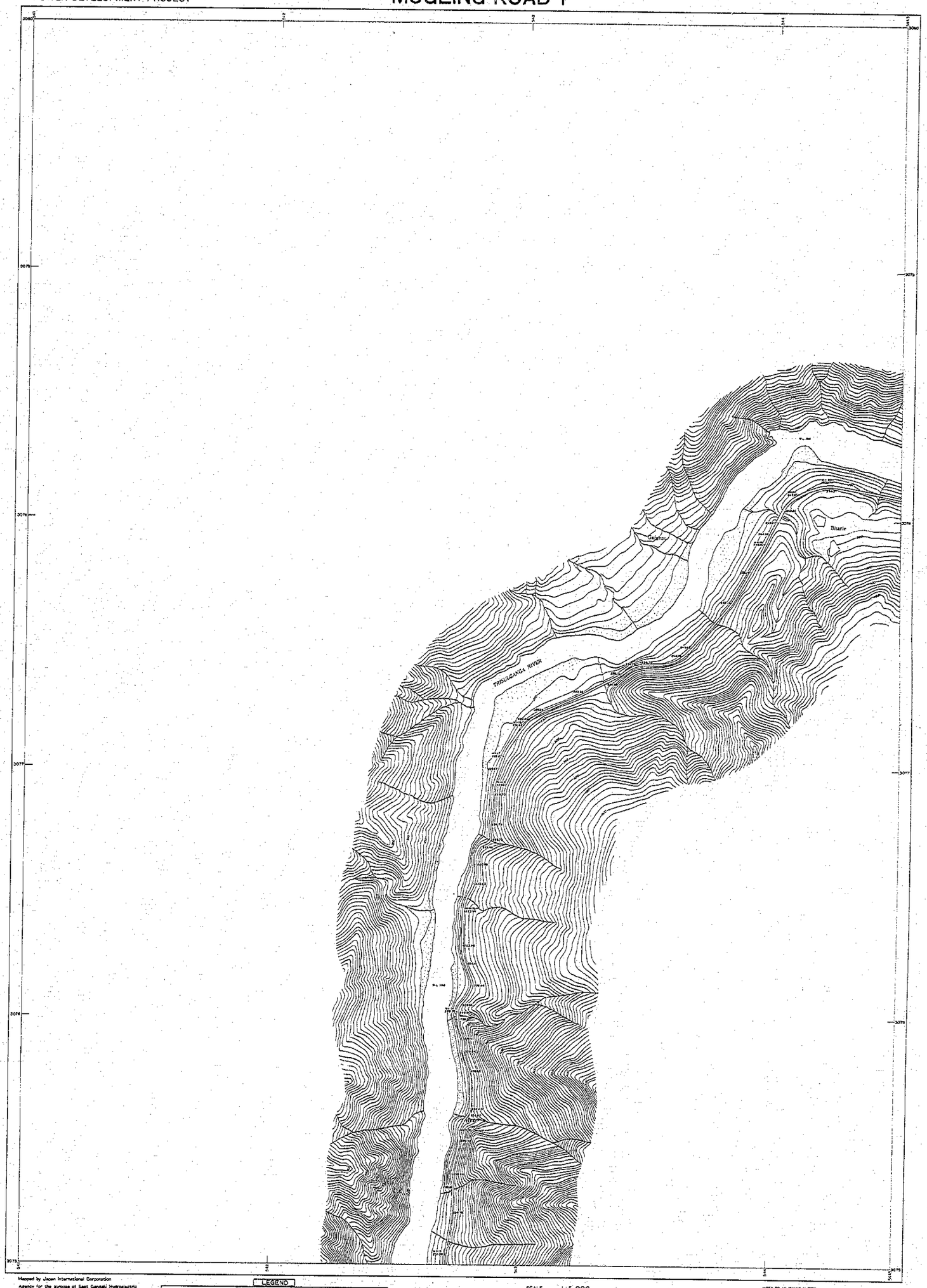
IV

PLAN OF MUGLING ROAD

(4 SHEETS)

SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

MUGLING ROAD I



Mapped by Jacon International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

SCALE 1:5,000

CONTOUR INTERVAL 10 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9699
Zone number : 44 S Grid Zone
Spheroid : Everest

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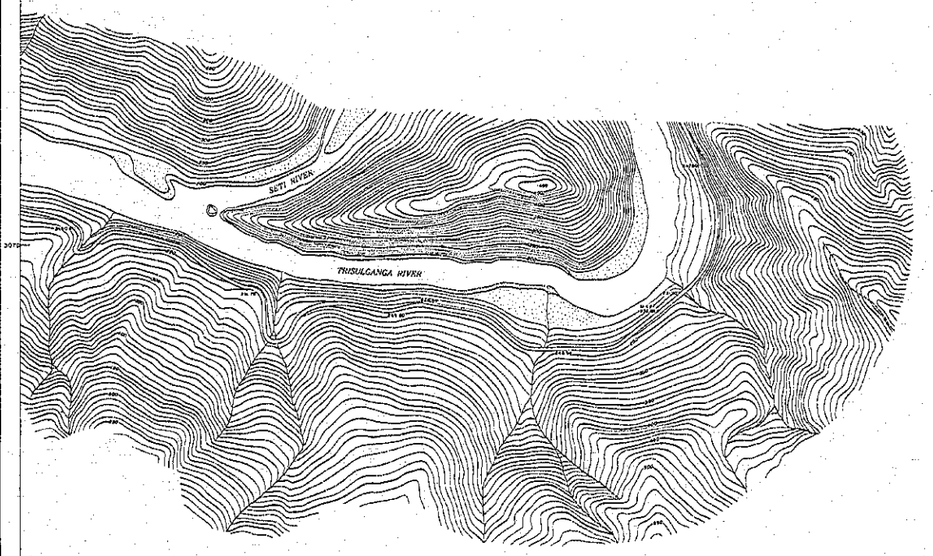
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

MUGLING ROAD 2



Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study

LEGEND

Control station (BMK)	⊙	River Stream		Slopes	
Spot Elevations	1.23	River Areas		Broad Leaf	
Formed Roads		Cutting		Grass	
Trail		Embankment		Fields	
Buildings		Over hanging			
Bridges		Cliff			
Ferry		Bare rock			
		Sand			

SCALE 1:5,000

CONTOUR INTERVAL 10 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meters
Scale factor on the central meridian : 0.9999
Zone number : 44 N Grid Zone
Spheroid : Everest

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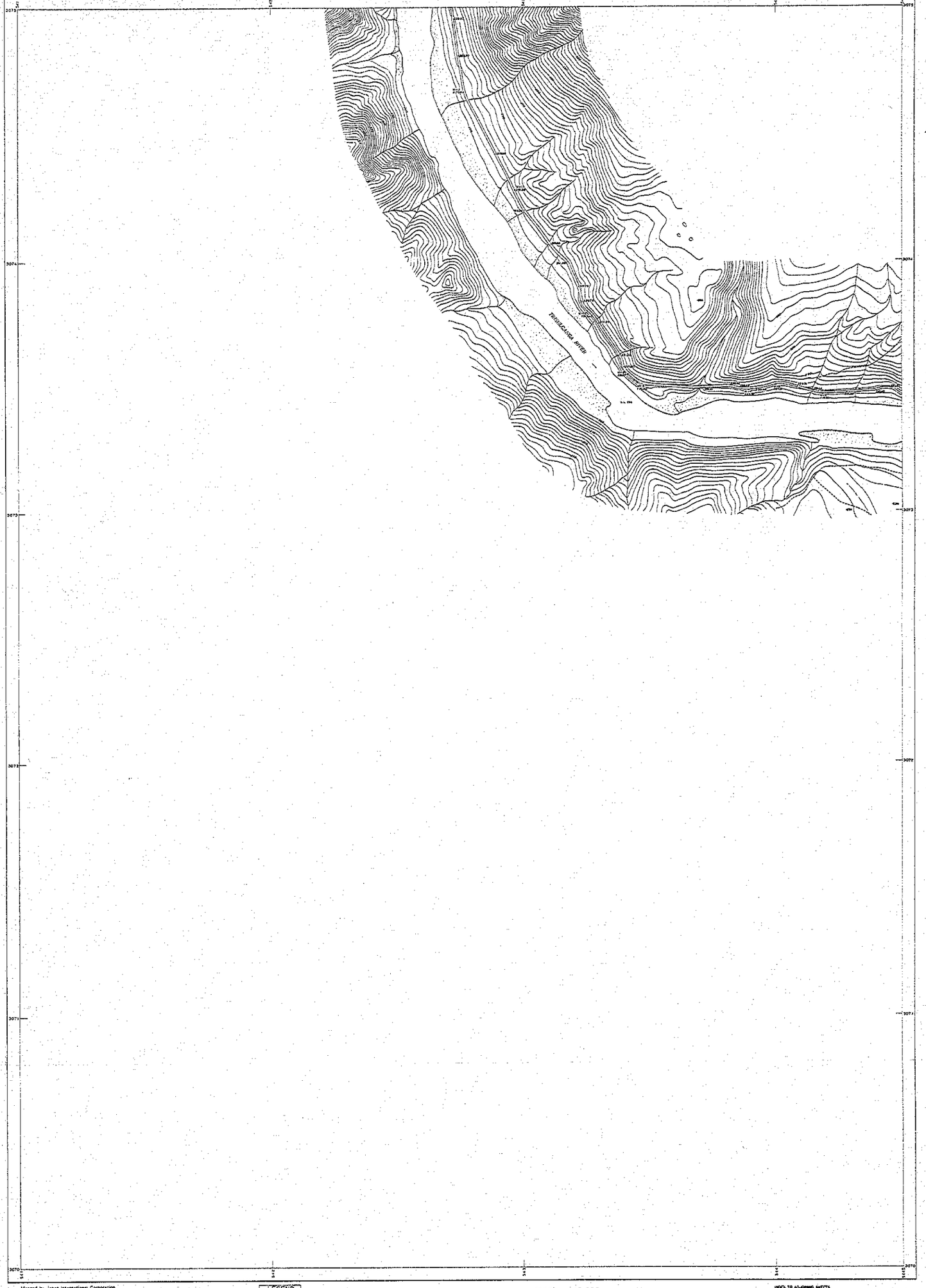
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

MUGLING ROAD 3



Mapped by Japan International Corporation Agency for the purpose of Sapt Gandaki Hydroelectric Power Development Project Feasibility Study.

LEGEND

Control station (Bkt)	□	River Stream		Slopes	
Spot Elevations	318	Flow Arrow		Broad Leaf	
Formed Roads		Cutting		Grass	
Trail		Embankment		Paddy	
Buildings		Depression			
Bridges	40MCM wood	Cliff			
Ferry		Rock ridge			
		Sand			

SCALE : 1:5,000

0 100 200 300 400m

CONTOUR INTERVAL 10 METRES

UNIVERSAL TRANSVERSE MERCATOR PROJECTION

Longitude of origin : Central meridian 84°East
Latitude of origin : 0° (Equator)
False northing : 0 meter
False Easting : 500,000 meters
Scale factor at the central meridian : 0.9996
Zone number : 44 S Grid Zone
Spheroid : Everest

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SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT

MUGLING ROAD 4

Mapped by Japan International Corporation
Agency for the purpose of Sapt Gandaki Hydroelectric
Power Development Project Feasibility Study.

LEGEND

SCALE 1:5,000

CONTOUR INTERVAL 10 METRES

UNIVERSAL TRANSVERSE MERCATOL PROJECTION

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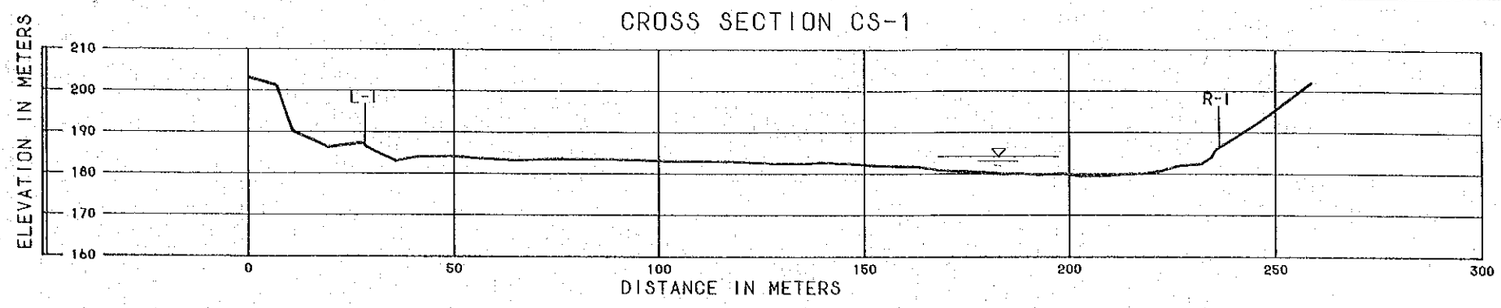
V

RIVER CROSS SECTIONS

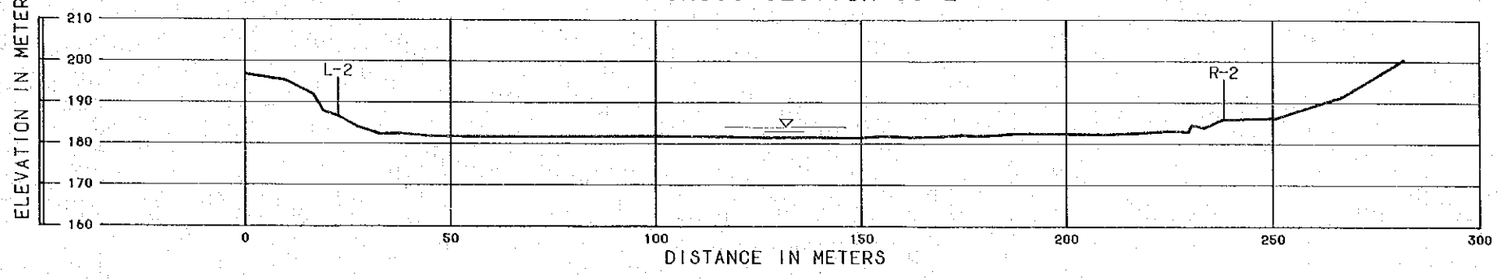
(8 SHEETS)

CROSS SECTION CS-1



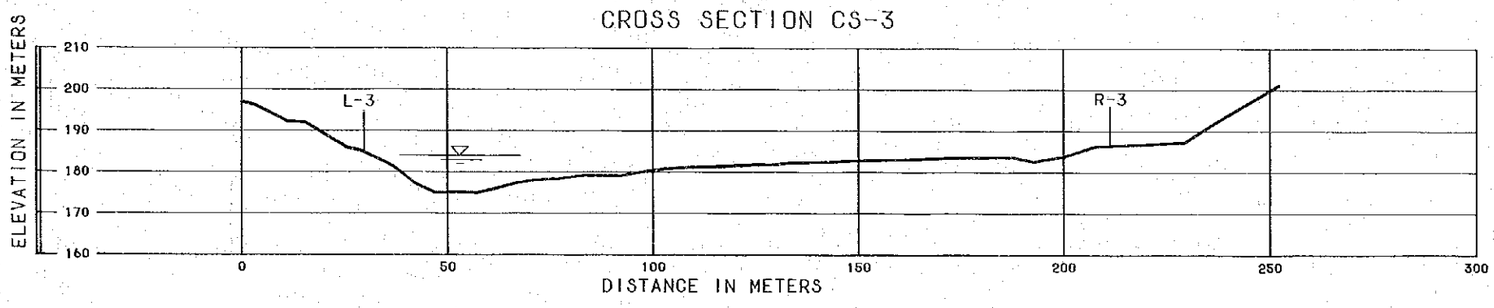
Station	N	E	EL
R - 1	3068552.05	541936.55	186.16
L - 1	3068598.54	542138.27	186.61
Observed water level			184.03

CROSS SECTION CS-2



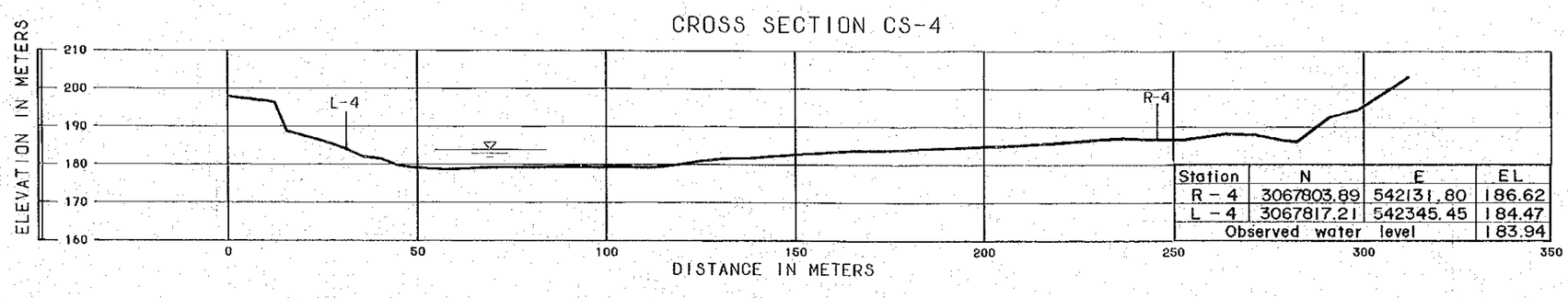
Station	N	E	EL
R - 2	3068324.40	542041.91	185.90
L - 2	3068379.92	542248.90	186.50
Observed water level			184.00

CROSS SECTION CS-3



Station	N	E	EL
R - 3	3068063.85	542116.20	186.61
L - 3	3068088.54	542295.72	185.06
Observed water level			184.06

CROSS SECTION CS-4

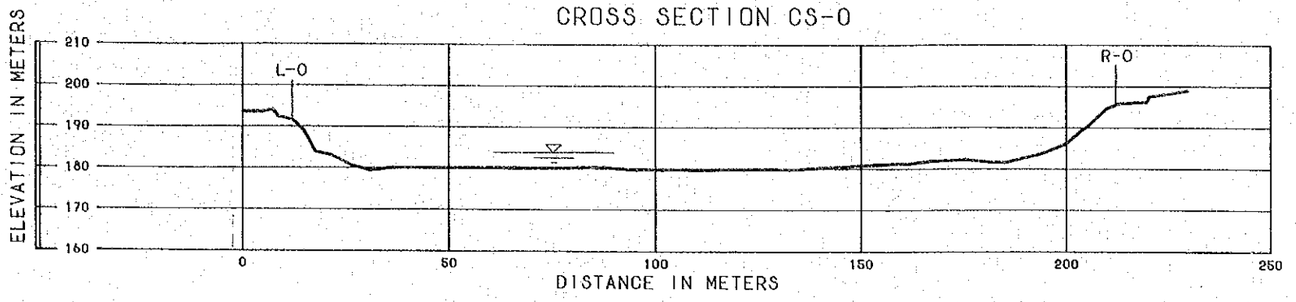


Station	N	E	EL
R - 4	3067803.89	542131.80	186.62
L - 4	3067817.21	542345.45	184.47
Observed water level			183.94

RIVER CROSS SECTIONS (1)

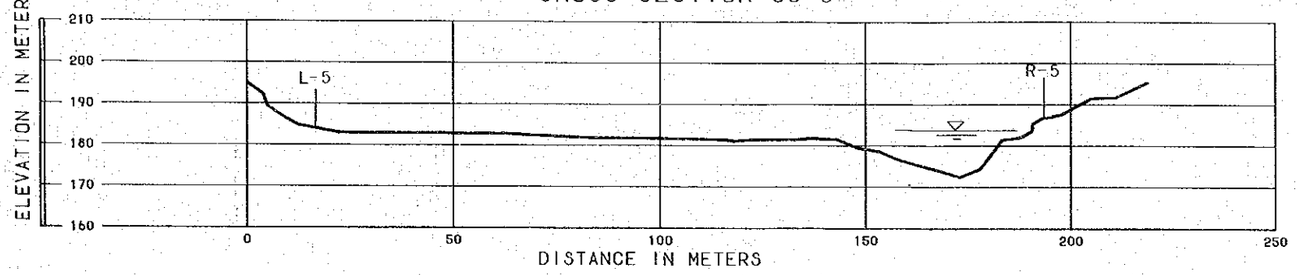
HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

CROSS SECTION CS-0



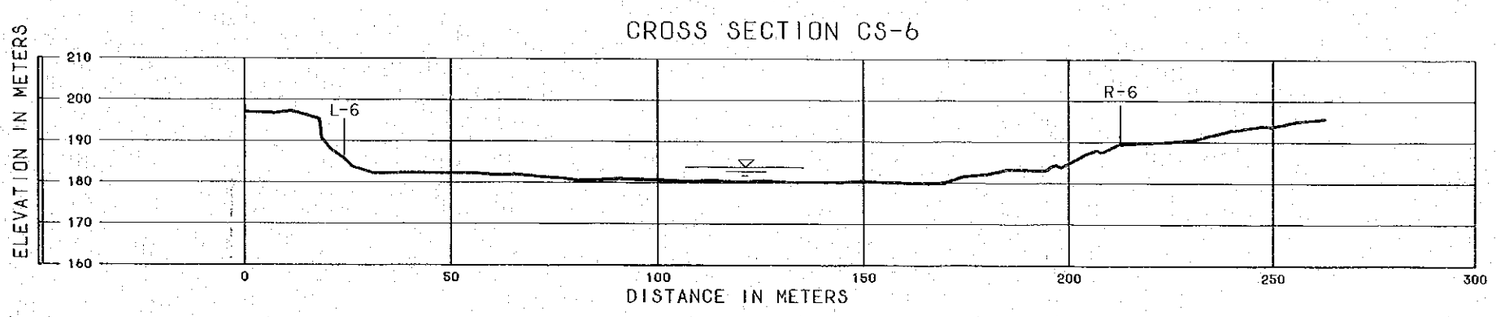
Station	N	E	EL
R - 0	3067526.39	542166.85	195.88
L - 0	3067562.90	542364.15	191.54
Observed water level			183.92

CROSS SECTION CS-5



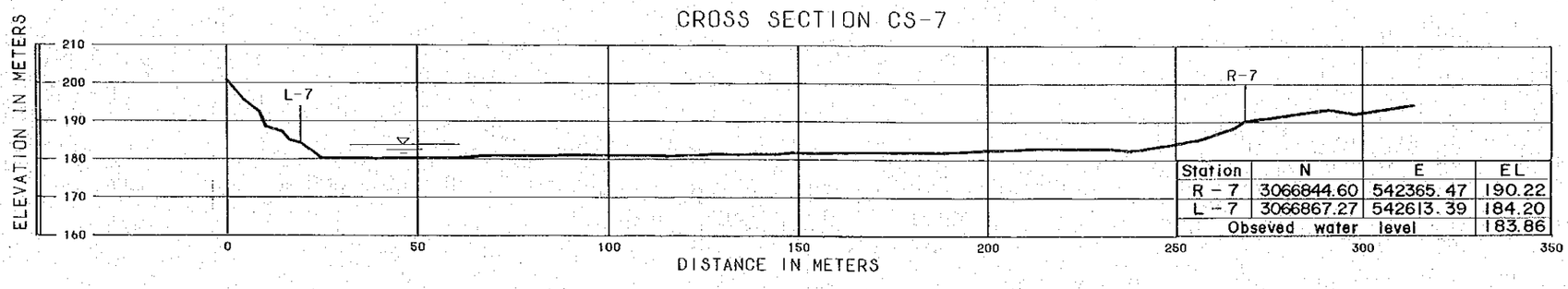
Station	N	E	EL
R - 5	3067284.90	542273.69	186.80
L - 5	3067343.51	542440.20	183.91
Observed water level			183.90

CROSS SECTION CS-6



Station	N	E	EL
R - 6	3067058.27	542349.03	189.45
L - 6	3067098.11	542533.17	185.59
Obseved water level			183.88

CROSS SECTION CS-7

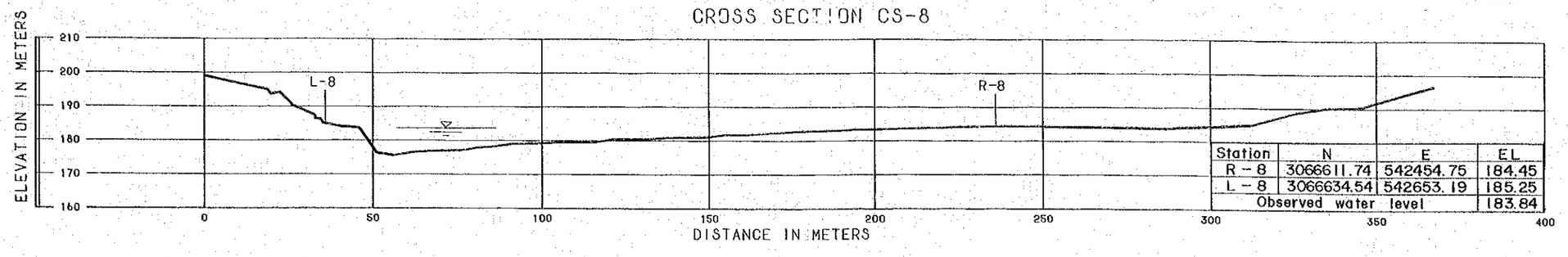


Station	N	E	EL
R - 7	3066844.60	542365.47	190.22
L - 7	3066867.27	542613.39	184.20
Obseved water level			183.86

RIVER CROSS SECTIONS (2)

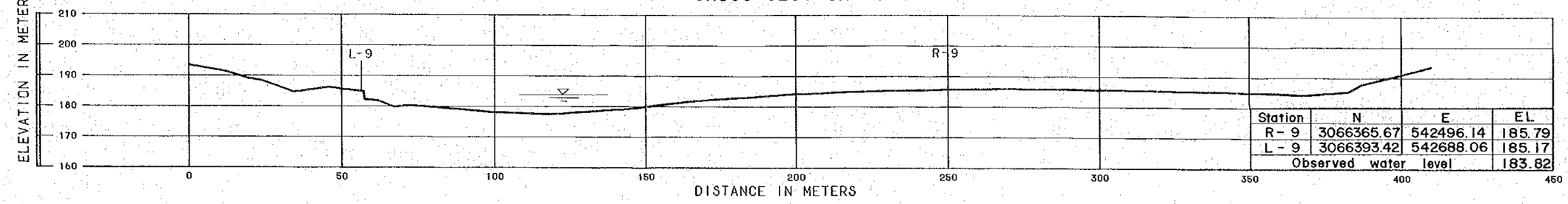
HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
POWER DEVELOPMENT PROJECT
FEASIBILITY REPORT
JAPAN INTERNATIONAL COOPERATION AGENCY

CROSS SECTION CS-8



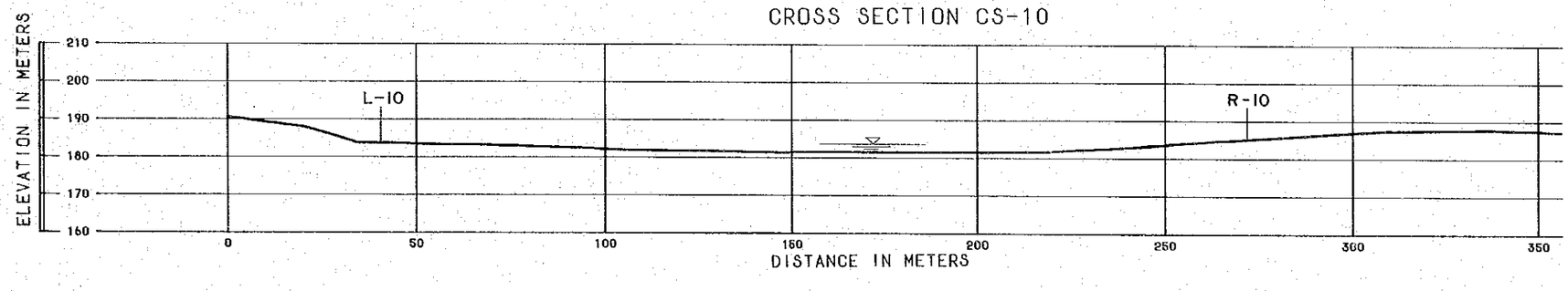
Station	N	E	EL
R-8	3066611.74	542454.75	184.45
L-8	3066634.54	542653.19	185.25
Observed water level			183.84

CROSS SECTION CS-9

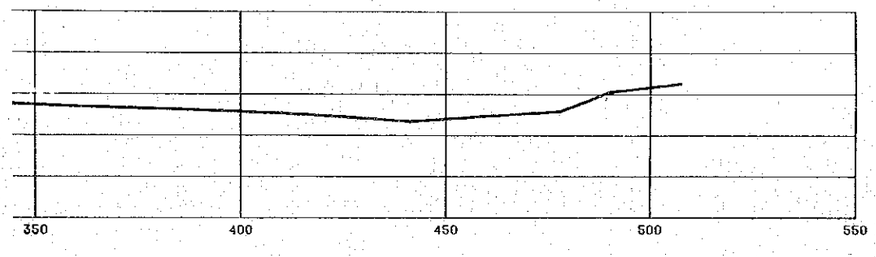


Station	N	E	EL
R-9	3066365.67	542496.14	185.79
L-9	3066393.42	542688.06	185.17
Observed water level			183.82

CROSS SECTION CS-10



Station	N	E	EL
R-10	3066113.47	542576.15	185.06
L-10	3066159.94	542832.33	185.74
Observed water level			183.82



RIVER CROSS SECTIONS (3)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
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FEASIBILITY REPORT
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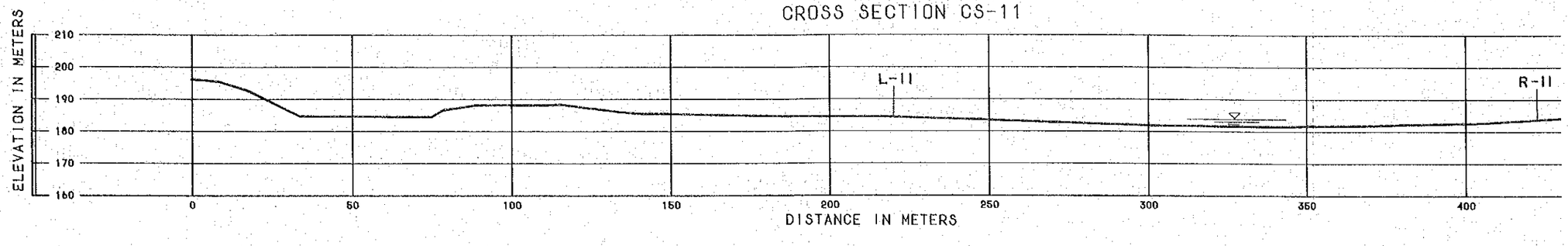
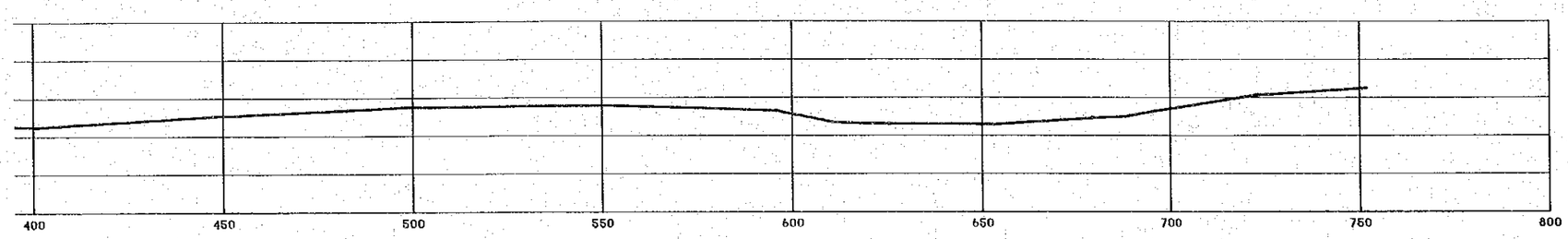
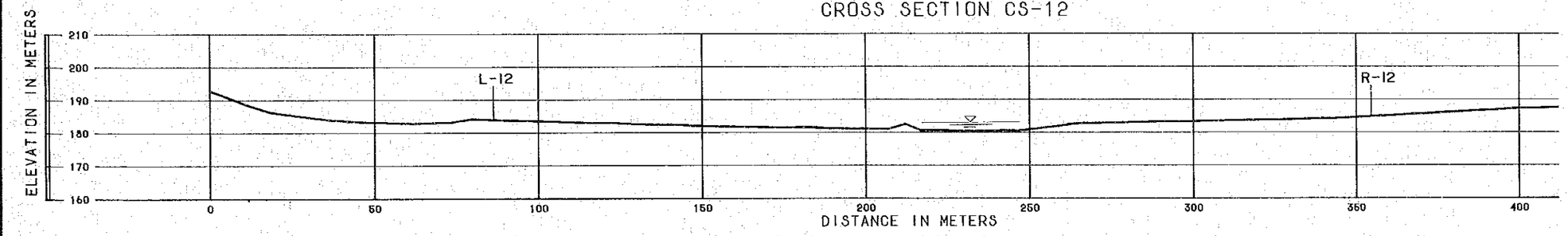
CROSS SECTION CS-11

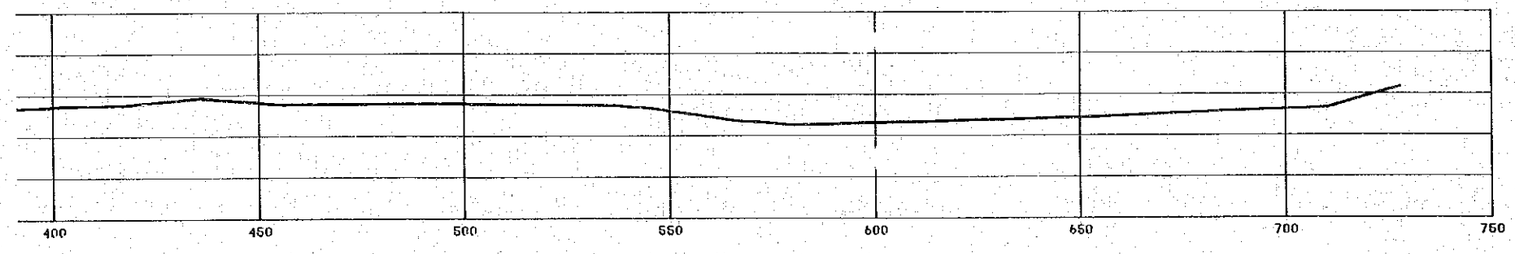




Station	N	E	EL
R-11	3065871.42	542632.97	183.77
L-11	3065888.24	542834.82	184.51
Observed water level			183.77

CROSS SECTION CS-12





Station	N	E	EL
R-12	3065621.12	542620.30	184.92
L-12	3065624.80	542888.04	183.92
Observed water level			183.04

RIVER CROSS SECTIONS (4)

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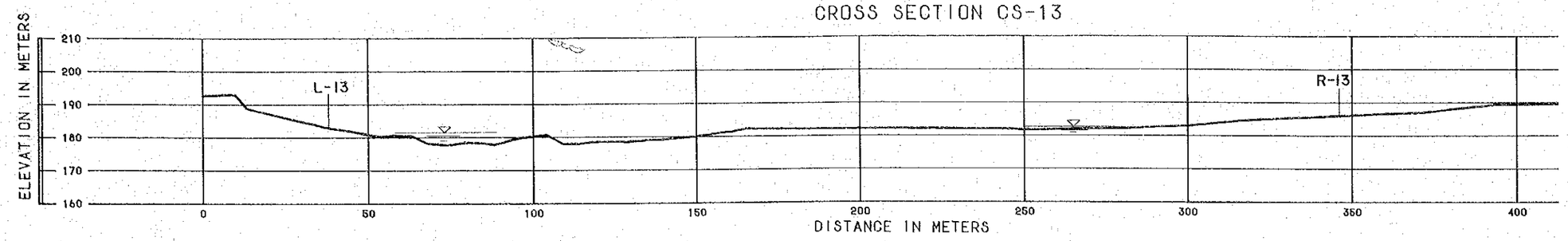
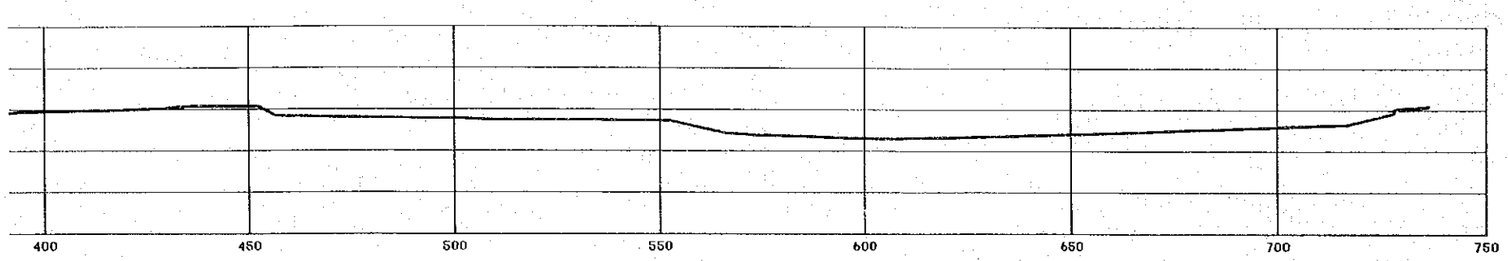
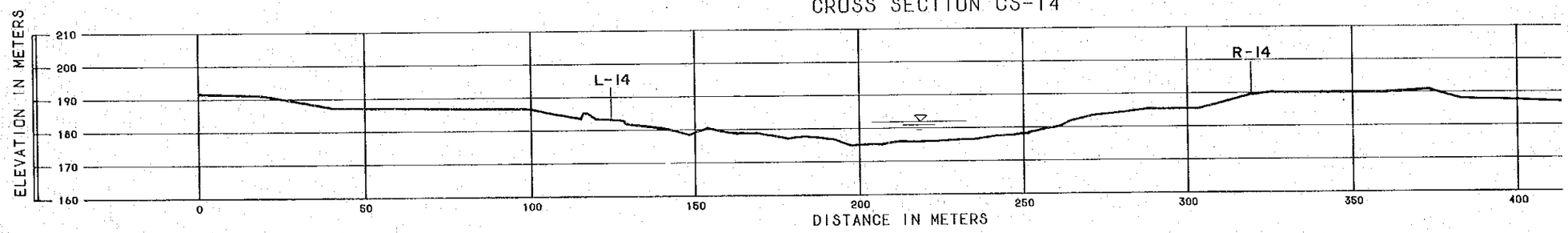
CROSS SECTION CS-13



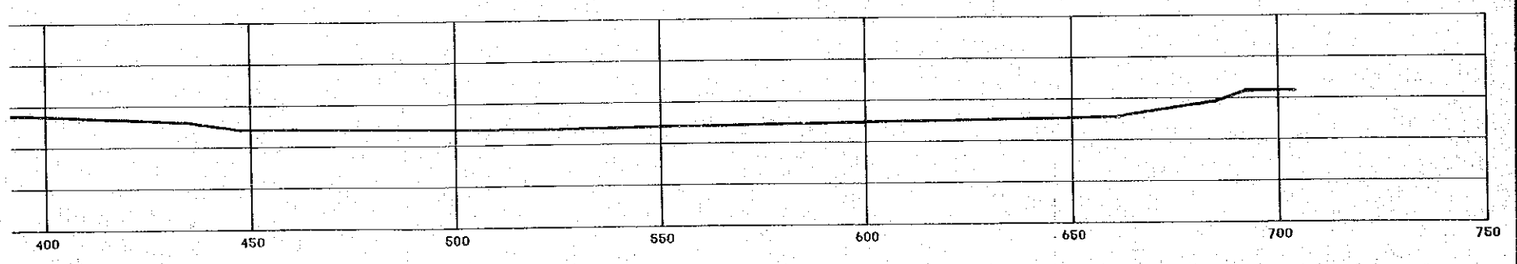
Station	N	E	EL
R-13	3065360.73	542547.88	186.22
L-13	3065149.07	542770.96	182.88
Observed water level		R	182.50
		L	181.98



CROSS SECTION CS-14



Station	N	E	EL
R-14	3065221.42	542386.65	189.42
L-14	3065041.60	542460.87	183.30
Observed water level			181.92



RIVER CROSS SECTIONS (5)

HIS MAJESTY'S GOVERNMENT OF NEPAL
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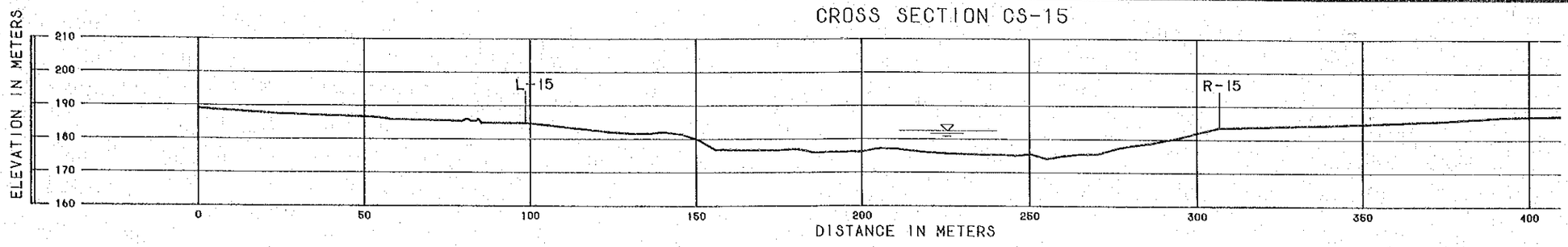
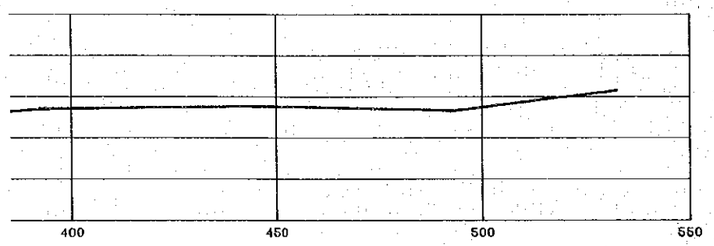
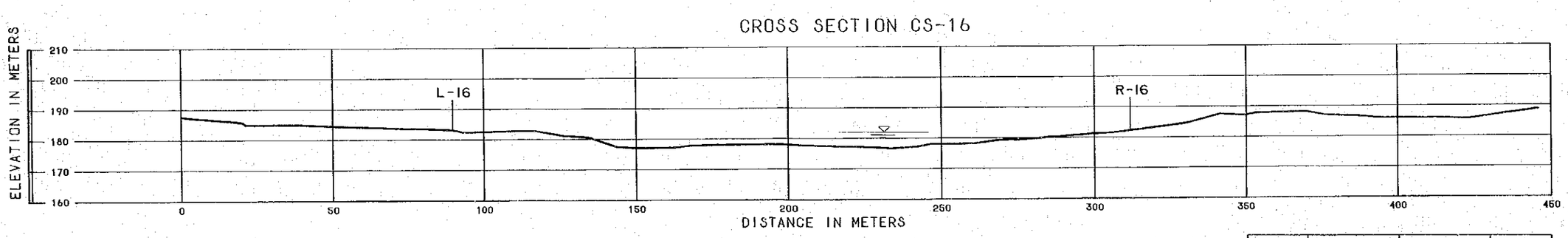
CROSS SECTION CS-15





Station	N	E	EL
R-15	3065043.10	542092.59	183.63
L-15	3064873.10	542212.12	184.82
Observed water level			182.05

CROSS SECTION CS-16



Station	N	E	EL
R-16	3064954.08	541901.62	182.31
L-16	3064769.86	542024.91	183.20
Observed water level			181.91

RIVER CROSS SECTIONS (6)

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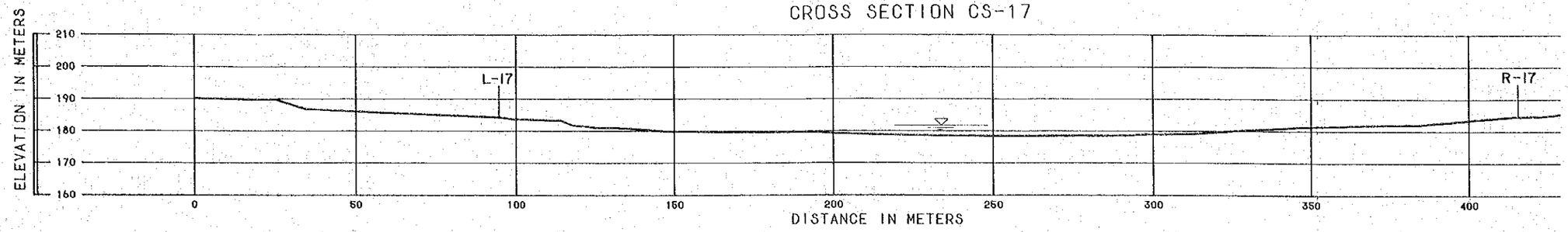
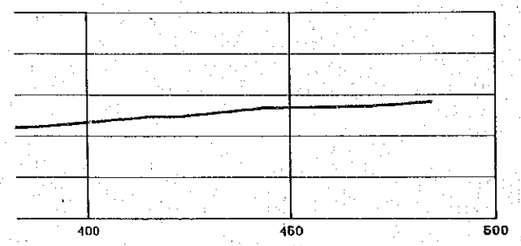
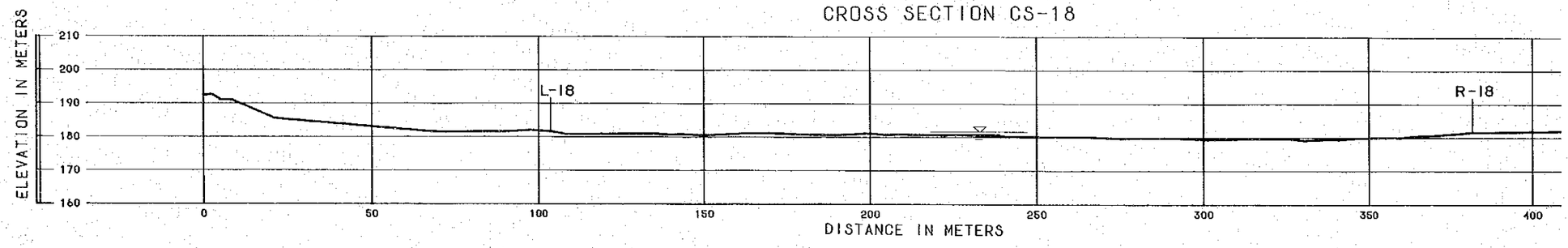
CROSS SECTION CS-17



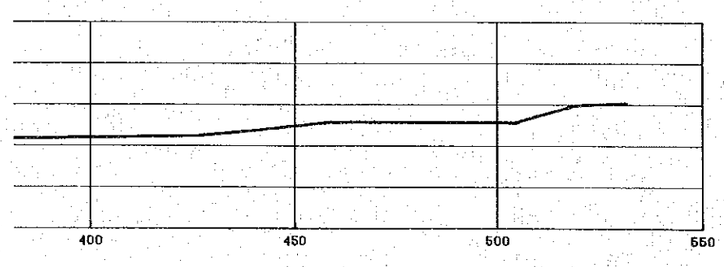
Station	N	E	EL
R-17	3064907.40	541713.45	184.74
L-17	3064627.22	541868.05	184.38
Observed water level			181.83



CROSS SECTION CS-18



Station	N	E	EL
R-18	3064724.90	541416.00	181.75
L-18	3064498.52	541576.61	181.87
Observed water level			181.66



RIVER CROSS SECTIONS (7)

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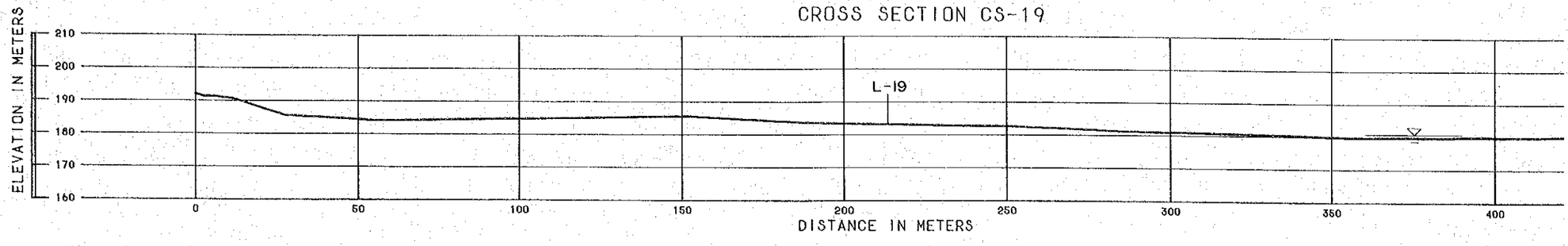
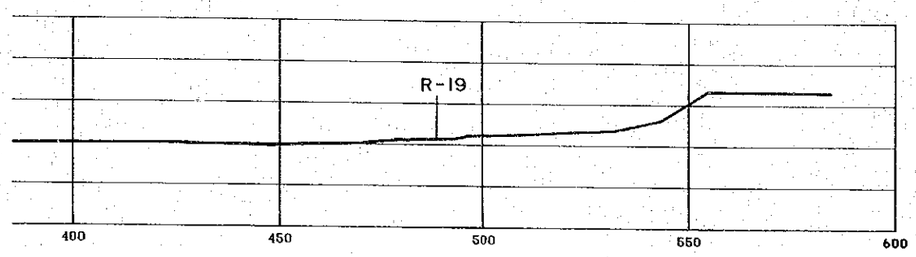
CROSS SECTION CS-19



Station	N	E	EL
R-19	3064665.32	541158.06	181.39
L-19	3064429.62	541299.32	183.13
Observed water level			181.31



RIVER CROSS SECTIONS (8)

HIS MAJESTY'S GOVERNMENT OF NEPAL
SAPT GANDAKI HYDROELECTRIC
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ANNEX (B)

CONSTRUCTION MATERIALS

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LIST OF TABLES

LIST OF FIGURES

LIST OF ATTACHMENTS

TITLE

I. INTRODUCTION

In Stage I, the field survey for construction material consisting of site reconnaissance and data collection was carried out for the period from February to March 1981 to assess the construction material sources conceived in the SMEC's Prefeasibility Report and to prepare a detailed investigation plan in Stage II. On the basis of survey results in Stage I, it was judged that the construction material sources proposed by SMEC were generally acceptable. On the other hand, the preliminary study which was made in the course of preparing the Interim Report I based on the survey results in the Stage I indicated that the rockfill type and concrete gravity type dams are competitive in comparison with their construction costs and that it is needed to make further investigation and study for determination of the most advantageous dam type of the project. Accordingly, the field investigation for construction materials in Stage II was carried out regarding concrete aggregates, core, filter and rockfill materials, taking into consideration the respective material requirements in the said two dam types.

The field work for construction material investigation was carried out for the period from December to March 1982. On the basis of the survey results, this report intends to assess the quality, suitability and available quantity of these construction materials in detail. The results of topographic and geological surveys such as map preparation of 1 to 1,000 in scale in the sand and gravel deposit location and core boring and seismic exploration at the damsite are incorporated in assessing the available quantity of construction material.

The soil test was conducted at the laboratory of the Institute of Engineering in Kathmandu in accordance with the specification prepared by the JICA Team. The field investigation was carried out in collaboration with the counterpart personnel provided by HMG.

II. LOCATION OF SAMPLING AND LABORATORY TEST

2.1 Location of Sampling

The core material source was selected on the left bank of the damsite. Seven (7) test pits were dug at the site for sampling of core materials together with observation of its low layer. The samples were taken from different depths of these test pits and tested at the laboratory.

As for concrete aggregates, fourteen (14) test pits for coarse aggregate were excavated at the river deposits located within 4 km up and downstream from the damsite, while five (5) test pits for fine aggregate were explored at the river deposits in the Khageri Khola. The laboratory test results for the concrete aggregates were used in assessing the quality of filter materials.

The location of the above test pits are shown in Fig.-B.1, and the sectional sketches of those are attached in the end of this Annex (B).

The rockfill material source was selected at the rock quarry located on the left bank of the Trisulganga River, 7 to 10 km north of the damsite, as shown in Fig.-B.1. Four (4) samples were collected from the rock quarry and tested in the laboratory. On the other hand, it was confirmed through the reconnaissance survey that there is no problem in its available quantity.

2.2 Laboratory Test

The items of laboratory tests for construction materials performed in Stage II are summarized below.

(i) For concrete coarse aggregate

- Sieve analysis for 12 samples
- Specific gravity and absorption for 12 samples
- Unit weight of aggregate for 6 samples
- Friable particles in aggregate for 12 samples
- Soundness for 6 samples

- Abrasion for 6 samples

(ii) For concrete fine aggregate

- Sieve analysis for 5 samples
- Specific gravity and absorption for 5 samples
- Unit weight of aggregate for 5 samples
- Friable particles in aggregate for 5 samples
- Soundness for 2 samples

(iii) Core materials

- Specific gravity for 9 samples
- Water content for 9 samples
- Grain size analysis for 9 samples
- Liquid limit for 9 samples
- Plastic limit for 9 samples
- Compaction test for 4 samples
- Triaxial test;

  2 samples under the condition of unconsolidated - undrained

  2 samples under the condition of consolidated - undrained with observation of pore pressure
- Permeability for 2 samples

(iv) Rockfill materials

- Specific gravity and absorption for 4 samples
- Abrasion for 4 samples
- Soundness for 4 samples

The laboratory test items required for the gravel fill and filter material are covered by the above (i) and (ii). Samples collected from each material site were tested in accordance with the Japanese Industrial Standard (JIS).

III. CONCRETE COARSE AGGREGATES

3.1 General Description

The necessary concrete volume of the project is approximately estimated at 1,300,000 m^3 and 810,000 m^3 for the concrete gravity dam scheme and the fill type dam scheme respectively. Thus, the coarse aggregates required for the above concrete will amount to about 2,400,000 tons and 1,500,000 tons respectively.

Large quantity of river gravels for the above coarse aggregates is available in the river channels of the Kali Gandaki, the Trisulganga and the Sapt Gandaki rivers within 4 km upstream and downstream of the damsite. The gravel deposit nearest to the damsite is located at Devi Ghat in the confluence of the Trisulganga river and the Kali Gandaki river (Referred to as "gravel deposit (A)"). Another large gravel deposits are located in the right (gravel deposit "B") and the left (gravel deposit "C") banks at about 4 km downstream of the damsite. Other gravel deposits are in the Kali Gandaki river and in the right bank of the Trisulganga river within 2 km upstream of the confluence.

Investigation of the quality and the available quantity of the coarse aggregates from the above gravel deposits was made by excavating test pits and carrying out various laboratory tests for the samples collected from the test pits. For gravel deposit "B" which is the largest of the gravel deposits and from which coarse aggregates will be mostly extracted, the seismic exploration and the plane table survey were also made to estimate the exact available quantity. The description of the investigation works executed, the investigation results and findings in its quantity and quality are provided hereinunder.

3.2 Investigation Work

Aiming to confirm the available quantity by investigating the depth of the gravel deposits and to test the quality, test pits were excavated in the gravel deposit "A", "B" and "C". The investigation of other gravel deposits in the Kali Gandaki river and in the right bank of the Trisulganga river in the upstream of the confluence was limited to the

detailed reconnaissance for them, because of the necessity to build some temporary bridges across the river for its extraction, resulting in costly coarse aggregates. It was judged that the required quantity of the coarse aggregate could be secured from the gravel deposit "A", "B" and "C".

The test pit arrangement in each gravel deposit was made as follows at the position shown in Fig.-B.1, considering that the arrangement would make it possible to measure the depth of the deposit, to test the quality and to cover the whole deposit area.

Gravel Deposit	Test Pit No.
"A"	3 Nos. (CTP-8, CTP-9, CTP-10)
"B"	9 Nos. (CTP-1, CTP-2, CTP-3, CTP-4, CTP-5, CTP-6, CTP-7, CTP-11, CTP-12)
"C"	2 Nos. (CTP-13. CTP-14)

Observation and sketch of the test pits to confirm the gravel deposit thickness were made for all the excavated test pits. Sampling for laboratory tests was also made from all the excavated test pits.

The following laboratory tests for the concrete coarse aggregates were carried out for the purpose of confirmation of its quality and available quantity in each grain size.

- Sieving analysis
- Specific gravity and absorption
- Washing test
- Abrasion test
- Soundness test
- Weight of unit volume

Considering that abrasion test, soundness test and weight of unit volume test comparatively take long time in addition to the limited investigation period and the poor electric power supply condition in

Nepal for the laboratory test, these tests were limited to several typical samples. Further, the grain size in test pits CTP-13 and CTP-14 was found to be too fine to use as concrete coarse aggregates and it was judged that the materials in this area would not be available for the coarse aggregates. Thus, the laboratory tests for the samples from these two test pits were not carried out.

The laboratory test items carried out for each sample of the coarse aggregates are shown in Table-B.1.

The seismic exploration and plane table survey were also carried out in the gravel deposit "B" which is of the largest scale and will be the main borrow area of the coarse aggregates, and intended to supplement the investigation of the available quantity of these materials.

The seismic exploration lines in the area were arranged as shown in Fig.-B.1 in consideration of relationship with the test pits investigation.

3.3 Available Quantity

The concrete requires coarse aggregates in a suitable grain size gradation. Thus, the available quantity of the coarse aggregates should be investigated for each grain size.

The sieving analysis was carried out to investigate the available quantity of each grain size of the coarse aggregates for samples from all the test pits.

The sieving analysis results for the coarse aggregates are given in Table-B.2 and graphically shown in Fig.-B.2.

Based on the sieving analysis results, the proportion of grain size of each gravel deposit, which is worked out as average in each gravel deposit, is as follows.

Grain Size Distribution in Each Gravel Deposit

Grain Size (mm)	Gravel Deposit "A" (%)	Gravel Depossit "B" (%)	Gravel Deposit "C" (%)
80 over	11.7	10.1	11.0
40 - 80	26.3	28.3	24.8
20 - 40	18.8	21.6	19.7
10 - 20	13.0	10.6	12.0
5 - 10	4.9	6.3	5.5

Total volume of each gravel deposit was investigated as follows through the available quantity investigations as mentioned.

Total Volume of Each Gravel Deposit for Coarse Aggregates

Gravel Deposit	Total Volume of Deposit	
	in m^3	in ton
A	300,000	555,000
B	1,800,000	3,330,000
C	400,000	740,000
Total	2,500,000	4,625,000

From the above, the available quantity of each grain size is obtained as follows.

Available Quantity of Coarse Aggregates in Each Grain Size

Grain Size (mm)	Gravel Deposit "A" (10^3 ton)	"B" (10^3 ton)	"C" (10^3 ton)	Total (10^3 ton)
80 over	65	336	81	483
40 - 80	146	942	184	1,272
20 - 40	104	719	146	969
10 - 20	72	353	89	514
5 - 10	27	210	41	278

On the other hand, the required volume of the concrete in the project is approximately estimated at 1,300,000 m^3 and 810,000 m^3 for the concrete gravity dam scheme and the fill type dam scheme, respectively. The coarse aggregates required for the above concrete will be about 2,400,000 tons and 1,500,000 tons in total, respectively. Further, the standard dam concrete requires the following grain size distribution of the coarse aggregates.

Grain Size Distribution Required for the Coarse Aggregates of the Standard Dam Concrete

(Unit: %)

Maximum Size (mm)	Grain Size (mm) 150 - 80	120 - 80	80 - 40	40 - 20	20 - 10	10 - 5
150	35 - 20		32 - 20	30 - 20	20 - 12	15 - 8
120		25 - 10	35 - 20	35 - 20	25 - 15	15 - 10

Accordingly, the project will require the following quantity of each grain size of the coarse aggregates;

Required Quantity of Coarse Aggregates in Each Grain Size

(Unit: 10^3)

Grain Size (mm)	Case of Max. Size. 150 mm		Case of Max. Size. 120 mm	
	Concrete Gravity Dam Scheme	Fill Type Dam Scheme	Concrete Gravity Dam Scheme	Fill Type Dam Scheme
150 - 80	840 - 480	560 - 320		
120 - 80			600 - 240	400 - 160
80 - 40	768 - 480	515 - 320	840 - 480	560 - 320
40 - 20	720 - 480	480 - 320	840 - 480	560 - 320
20 - 10	480 - 288	320 - 190	600 - 360	400 - 240
10 - 5	360 - 192	240 - 130	360 - 240	240 - 160

Compared with the required quantity as indicated above, the available quantity from gravel deposit "A", "B" and "C" will be sufficient in all the grain sizes.

3.4 Quality

To confirm the following qualities which is required for the coarse aggregates of the standard concrete, the said laboratory tests were conducted.

- Suitable grain size distribution,
- Suitable specific gravity, absorption and unit weight,
- Suitable content of friable particles,
- Durability, and
- Stability

In order to confirm the above qualities, the following laboratory tests were carried out for the samples obtained from the test pits.

- Sieving analysis,
- Specific gravity and absorption test,
- Weight of unit volume test,
- Washing test
- Abrasion test, and
- Soundness test

The test results are summarized in Table-B.2 and Table-B.3.

There is no problem in the grain size distribution and the available quantity of each grain size as stated in the previous paragraph.

The specific gravity, absorption and weight of unit volume are related to voids in the grain of the aggregates. Those will be the indices indicating the physical and mechanical properties of the coarse aggregates, and the standard specifies that each of the above values should be as follows;

Specific gravity	more than 2.5
Absorption	less than 3%
Weight of unit volume	1,550 - 2,000 kg/m^3

The test result indicates the specific gravity of 2.69 to 2.76, the absorption of 0.30 to 0.77% and the weight of unit volume of 1,850 to 1,920 kg/m^3, which are within the above standard range.

The friable particles of clay or silt, etc. contained in the coarse aggregates will affect the concrete strength. Thus, it is specified 0.088 mm should be less than 1.0%. As seen in Table-B.3, the washing test result indicates 0.06 to 0.55% of the friable particles are contained, which also satisfies the standard.

Sufficient physical and chemical durability of coarse aggregates will be essential for the production of the concrete with the standard strength. The abrasion test for confirming the physical durability resulted in the reduction of weight (loss due to abrasion) in the range of 11 to 27.4%, which is considered as sufficient durability in consideration of the standard which specifies that the weight reduction by the abrasion test should be less than 40%. The soundness test (sodium sulfate method) for testing the chemical durability indicated the weight loss of 0.43 to 2.40%. The chemical durability of the coarse aggregates is also considered sufficient, referring to the standard that the loss of weight due to soundness test should be less than 12%.

As mentioned, it was confirmed that there is not any quality problem in the concrete coarse aggregates extracted form the gravel deposits in the upstream or downstream of the damsite.

IV. CONCRETE FINE AGGREGATES

4.1 General Description

Taking into consideration the concrete volume of the project, the required quantity of the fine aggregates will approximately be 1,000,000 tons and 650,000 tons in the case of concrete gravity dam scheme and fill type dam scheme, respectively.

The sand bars for the extraction of the above concrete fine aggregates are found in the river channels of the Kali Gandaki, the Trisulganga and the Sapt Gandaki rivers. The sand bars are also found in the comparatively minor rivers of the Khageri, the Jaishri and the Beldeha Khola, etc. or in the Rapti River.

In view of the hauling distance, the river sand in the Kali Gandaki, the Trisulganga or the Sapt Gandaki will be desirable. However, the river sand in the large rivers such as the Kali Gandaki, the Trisulganga or the Sapt Gandaki river are too fine, siliceous, and mixed with fine fragments of slates and other sedimentary rocks. Thus, it was judged that the river sand in these large rivers would not be suitable for the concrete fine aggregates apparently.

The sand deposits in the Jaishri and the Beldeha Khola were too meager for the required quantity. It appeared that the river sand in the Rapti River which runs from east to west through the Inner Terai Plain would be well dependable in quality and sufficient in its quantity. Its extraction, however, will requrie too much hauling distance of more than 20 km, resulting in too expensive concrete fine aggregates.

The sand deposits in the Khageri Khola did not appear to be a very good source of fine aggregates. However, it was judged they could be used as fine aggregates in view of the acceptable hauling distance of about 7 to 8 km, relatively preferable grain size distribution and the scale of the deposit which extends over an area of 5 km with a width of about 200 m. Thus, the investigation of fine aggregates was concentrated on the confirmation of their quality and available quantity from the Khageri Khola. The investigation result is given hereinafter.

4.2 Investigation Work

There is a large sand deposit at about 1 km upstream from the crossing of the Khageri Khola and the East-West Highway. This sand deposit extends over 5 km to the upstream along the river channel.

It was found through the overall reconnaissance that there is no difference in the property of the sand in the range of about 5 km length of the sand deposit. Thus, it was decided that the investigation of the available quantity and quality would be carried out for the typical sand deposit which is located at 1 km to 2 km upstream from the said crossing of the river and the East-West Highway and would become the main borrow area of the fine aggregates.

Five test pits for investigating the available quantity by observing the thickness of the sand deposit and for collecting the samples for the quality investigation, were excavated as shown in Fig.-B.1. In its arrangement, attention was paid to cover the whole area of the deposit.

The sketch of the excavated test pits are provided in the end of this ANNEX. As seen in the sketch, the excavation of the test pits were all stopped at the depth of about 1.5 m, though the thickness of the sand deposit was deeper than that. The existence of spring water at this depth was the reason why the excavation was stopped. The fine aggregates require a special control of the moisture content and, for such continuously submerged wet sand, the control of the moisture content will become difficult. Thus, the sand deposit deeper than 1.5 m was considered not desirable as fine aggregates for the project.

The following laboratory tests for investigating the essential qualities for the use as the concrete fine aggregates were carried out for the samples collected from the above test pits.

- Sieving analysis
- Specific gravity and absorption
- Washing test
- Abrasion test
- Soundness test
- Weight of unit volume

4.3 Available Quantity

As stated, the sand deposit in the Khageri Khola spreads over an area of 5 km in length and 200 m in width. The deposit thickness is estimated at more than 3.0 m. However, the sand found below a depth of 1.5 m is under submerged condition and there are some difficulty in its use as stated previously. Thus, assuming that the sand deposit deeper than 1.5 m will not be used as fine aggregates, the total volume of the sand deposit in the Khageri Khola is calculated at about 1,500,000 m^3 or 2,500,000 tons.

As seen in Table-B.4 in which the sieving analysis results are given, the sand includes over-size pebbles (over 5 mm) of about 35% in average, which will be excluded by screening. Therefore, the available quantity will be the remaining 65%, i.e. 1,500,000 tons.

On the other hand, the required fine aggregates are approximately estimated at 1,000,000 tons in the concrete gravity dam scheme and 700,000 tons in the fill type dam scheme. Thus, the available quantity of the fine aggregates will be adequate, provided that its quality is acceptable.

4.4 Quality

Table-B.4 shows the grain size distribution and the fineness modulus, excluding the over-size grain. The fineness modulus is the index indicating whether the grain size distribution is acceptable or not, and the standard recommends that the fineness modulus of the concrete fine aggregates should be in the range from 2.3 to 3.1.

As seen in Table-B.4, most of the fineness modulus worked out are within the above range of 2.3 to 3.1, though only the sample from Test Pit No. FTP-3 is slightly lower than the allowable limit showing the fineness modulus of 2.1. Therefore, the grain size distribution is considered acceptable for the concrete fine aggregates of the project.

Other quality test results for fine aggregates are given in Table-B.5. The specific gravity and absorption are all within the standard. However, taking into consideration the standard value of the weight

reduction in the washing test of the fine aggregates, i.e. within 3%, the washing tests for the samples from Test Pit No. FTP-1 and NO. FTP-5 resulted in unsatisfactory values, indicating 10% in Test Pit No. FTP-1 and 6% in Pit No. FTP-5. The above means relatively high content of the fine materials consisting of silt or clay. Thus, washing for reducing such fine materials down to the allowable degree is considered necessary in the use of the sand in the Khageri Khola. The soundness test, i.e. the chemical durability test, also indicated slightly high value in samples from Test Pit No. FTP-3 beyond the limit of 10% recommended in the standard by 2%. However, it is not always prohibited to apply it to the fine aggregates and such a slight deviation from the standard is considered acceptable.

In general, the sand in the Khageri Khola is not of very good quality for the concrete fine aggregates as shown in the quality test results. Its quality, however, is within the acceptable range. In veiw of its acceptable quality and favourable hauling distance compared with other deposits, the sand deposit in the Khageri Khola is recommendable as the source of the concrete fine aggregates.

V. CORE MATERIALS

5.1 Investigation Work

In the case that the dam will be designed as a fill type dam, impervious core materials of about 400,000 m^3, which will work as the water stop against the leakage through dam body, will become necessary.

For the above requirement, the clayey earth materials on the tablelands in both banks of the damsite are available. Approach to the tableland in the right bank, however, is relatively difficult due to its steep topography, the difficulty of providing the access road and the necessity of construction of a bridge crossing the river. The tableland in the left bank is considered favourable as the borrow area of the core materials in consideration of its easy provision of the access road and the convenience of the core embankment work at the construction stage.

Thus, the investigation work in the Stage-II was carried out aiming to confirm the available quantity and quality of the clayey earth materials covering the tableland of the left bank.

For the confirmation of the available quantity and sampling for the laboratory tests, seven test pits were excavated in the position shown in Fig.-B.1.

The core material is required to have suitable workability, impermeability and strength. Thus, for the confirmation of the above necessary properties for the core materials, the following laboratory tests were carried out;

- Specific gravity test,
- Water content test,
- Grain size analysis,
- Liquid and plastic limit test,
- Compaction test,
- Triaxial compression test, and
- Permeability test.

The compaction test, triaxial compression test and permeability test take a long time to carry out for all the samples. Since it was considered that the tests for the typical samples would give sufficient data for judgement, the above three laboratory tests were limited to the typical samples only.

The laboratory tests were mainly performed in the laboratory of the Institute of Engineering in Kathmandu. As for the triaxial compression test, the facilities owned by the above Institute of Engineering were not sufficient to carry out the triaxial compression test under the condition of the consolidated-undrained with observation of pore pressure, and therefore, the triaxial compression tests were carried out using the facilities owned in the Kulekhani Project.

5.2 Availalbe Quantity

The cover of the clayey earth materials on the tableland of the left bank was investigated to be 3.0 to 4.0 m in thickness as seen in the sketch of the excavated test pits. It was also found that the clayey earth materials extensively spread on the tableland and that its available quantity is estimated to be more than 1,000,000 m^3 which is much enough for around 400,000 m^3 of the required volume.

5.3 Quality

The results of the laboratory tests carried out for investigating the quality of the clayey earth materials are all given in Table-B.6, Table-B.7, and Fig.-B.4 to Fig.-B.8.

Findings from the laboratory test results are as follows;

The grain size analysis result revealed that the clayey materials on the tableland contain too much fine grain size to use it as the core material without any treatment. The use as it is, will cause problems such as occurrence of crack due to consolidation, high pore pressure in the core, poor workability of the core embankment and poor mechanical strength. Therefore, it is necessary to consider to secure the proper workability, strength, density and impermeability by mixing some

coarse size sand and gravel from the riverbed, or quarry rock.

Regarding the strength, the density and the workability, those will be improved by mixing of the coarse grain size. The laboratory test results indicated a considerably favourable values of the mechanical strength and density without any mixture of the coarse grain size, and therefore, satisfactory strength, density and workability are expected to be obtained by mixing the coarse materials.

The impermeability will be reduced by the mixture of the coarse materials. However, the permeability test result indicated a high impermeability of 10^{-7} cm/sec order near the optimum moisture content. Thus, the impermeability of the order of 10^{-6} cm/sec, which is required for the core material of the dam, is presumed to be still ensured even if some coarse materials to obtain the suitable grain size distribution, strength and workability, etc. are mixed.

Thus, it was investigated in the Stage-II that the clayey earth materials covering the tableland in the left bank of the damsite could be used by a proper mixing of the coarse materials. Further detailed investigations such as the ratio of the coarse material mixture and the necessary compaction energy, etc. will still be required for the core material, and which should be examined at the detailed design stage.

VI. ROCKFILL AND FILTER MATERIALS

In the case of realization of the fill type dam scheme, rockfill materials of the order of 1,500,000 to 2,000,000 m^3 will be required. The quarry rocks at 7 to 10 km north of the damsite or the gravel deposits spread in the Kali Gandaki, the Trisulganga and the Sapt Gandaki rivers are considered as the possible sources for the above.

With regard to the riverbed gravel, it was found through the investigation for the concrete coarse aggregates that it contains much fine materials and it is considered necessary to obtain a proper grain size distribution of the rockfill material of the dam by excluding the fine materials by screening. There is no problem in its available quantity, although the borrow area will have to be extended up far upstream of the Trisulganga or the Kali Gandaki including the upstream and downstream of the Sapt Gandaki and its extraction will require several temporary bridges and access roads. It is also confirmed through the investigation for the concrete coarse aggregate that the quality of the riverbed gravel is quite satisfactory as rockfill material of the dam.

Table-B.8 indicates the quality test results for the quarry rock at 7 to 10 km north of the damsite. A sufficient strength and durability of the quarry rock itself was indicated in the test results. However, the detailed field reconnaissance revealed that the quarry rock is considerably cracky. It is anticipated that the dam rockfill materials to be extracted from the quarry site will result in a small grain size gradation. However, observing the degree of the cracks, it is judged that the grain size distribution, the mechanical strength and the permeability required for the dam rockfill materials can be secured by an appropriate arrangement of blasting. Its available quantity is quite enough since it is found extensively in the area.

The filter material of the dam will have to be produced by mixing river sand with gravel or quarry rock, since the material with the grain size distribution satisfying the conditions required for the filter is not available nearby.

The investigations carried out for concrete coarse aggregates, fine aggregates and rockfill materials indicated that there is no problem in their availability and quality. Thus, there is no problem to produce the filter materials by mixing together the necessary materials.

TABLES

Table-B.1: LABORATORY TEST ITEMS FOR COARSE AGGREGATES

Test Pit No.	Test Item					
	Sieving Analysis	Specific Gravity & Absorption	Washing Test	Abrasion Test	Soundness Test	Weight Unit of Volume
CTP-1	C	C	C	C	C	C
" -2	C	C	C	C	C	C
" -3	C	C	C	E	E	E
" -4	C	C	C	E	E	E
" -5	C	C	C	C	C	C
" -6	C	C	C	C	E	C
" -7	C	C	C	E	E	E
" -8	C	C	C	E	E	E
" -9	C	C	C	C	C	C
" -10	C	C	C	C	C	C
" -11	C	C	C	E	E	E
" -12	C	C	C	E	E	E

Remarks: C; Carried out
E; Eliminated

Table-B.2: SIEVING ANALYSIS RESULT FOR COARSE AGGREGATE

Sieve (mm)	Passing (Remaining) Rate of Each Sieve in % (Excluding size larger than 150 mm dia.) Test Pit No.												Remark
	CTP-1	CTP-2	CTP-3	CTP-4	CTP-5	CTP-6	CTP-7	CTP-8	CTP-9	CTP-10	CTP-11	CTP-12	
80	92.5(7.5)	91.5(8.5)	89(11)	95(5)	86(14)	95(6)	80(20)	100(0)	75(25)	90(10)	83(17)	95(5)	
40	58(42)	58(42)	65(35)	60(40)	55(45)	75(25)	60(40)	81(19)	36(64)	69(31)	52(48)	76.5(23.5)	
20	36(65)	42(58)	41.5(58.5)	38(62)	33(67)	47.5(52.5)	43(57)	54(46)	25.5(74.5)	50(50)	37(63)	52(48)	
10	24(76)	33(67)	31(69)	28(72)	23(77)	31.5(68.5)	35(65)	36(64)	20.5(79.5)	34(66)	30(70)	35(65)	
5	19(81)	27(73)	23(77)	21(79)	18(82)	23(77)	30.5(69.5)	30(70)	18(82)	28(72)	25(75)	29(71)	

Sieve (mm)	Remaining Rate of Each Sieve in % (Excluding size larger than 150 mm and smaller than 5 mm) Test Pit No.												Remark
	CTP-1	CTP-2	CTP-3	CTP-4	CTP-5	CTP-6	CTP-7	CTP-8	CTP-9	CTP-10	CTP-11	CTP-12	
80	9.26	11.64	14.29	6.33	17.07	6.49	28.78	0	30.49	13.89	22.67	7.04	
40	51.85	57.53	45.45	50.63	54.88	32.47	57.55	27.14	78.05	43.06	64.00	33.10	
20	80.25	79.45	75.97	78.48	81.71	68.18	82.01	94.29	90.85	69.44	84.00	67.61	
10	93.83	91.78	89.61	91.14	93.90	88.96	93.53	65.71	96.50	91.67	93.33	91.55	
5	100	100	100	100	100	100	100	100	100	100	100	100	

Table-B.3: QUALITY TEST RESULT FOR COARSE AGGREGATE

Test Pit No.	Specific Gravity and Absorption		Washing Test	Abrasion Test	Soundness Test	Weight of Unit Volume
	Specific Gravity	Absorption (%)	Rate Passing 0.088 mm Sieve (%)	Weight Reduction (%)	Weight Reduction (%)	(t/m^3)
CTP - 1	2.72	0.77	0.39	27.4	0.43	1.920
- 2	2.70	0.77	0.55	24.4	1.90	1.892
- 3	2.69	0.69	0.46	-	-	-
- 4	2.70	0.70	0.30	-	-	-
- 5	2.69	0.71	0.06	16.43	2.40	1.890
- 6	2.76	0.33	0.06	16.43	-	1.850
- 7	2.75	0.51	0.06	-	-	-
- 8	2.71	0.30	0.30	-	-	-
- 9	2.73	0.60	0.20	11.10	0.88	1,861
- 10	2.70	0.74	0.46	18.77	1.24	1.846
- 11	2.71	0.73	0.35	16.53	2.35	1.870
- 12	2.69	0.65	0.43	-	-	-
- 13	-	-	-	-	-	-
- 14	-	-	-	-	-	-

Note: Grain size in Test Pit No.13 and No.14 was too fine, and judged not applicable for coarse aggregate. Thus, no laboratory test was carried out for the above.