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NEPAL ELECTRICITY AUTHORITY

FINAL REPORT
OF
FEASIBILITY STUDY
ON
ARUN-3 HYDROELECTRIC POWER DEVELOPMENT PROJECT

VOLUME II
ACCESS ROAD

JUNE 1987

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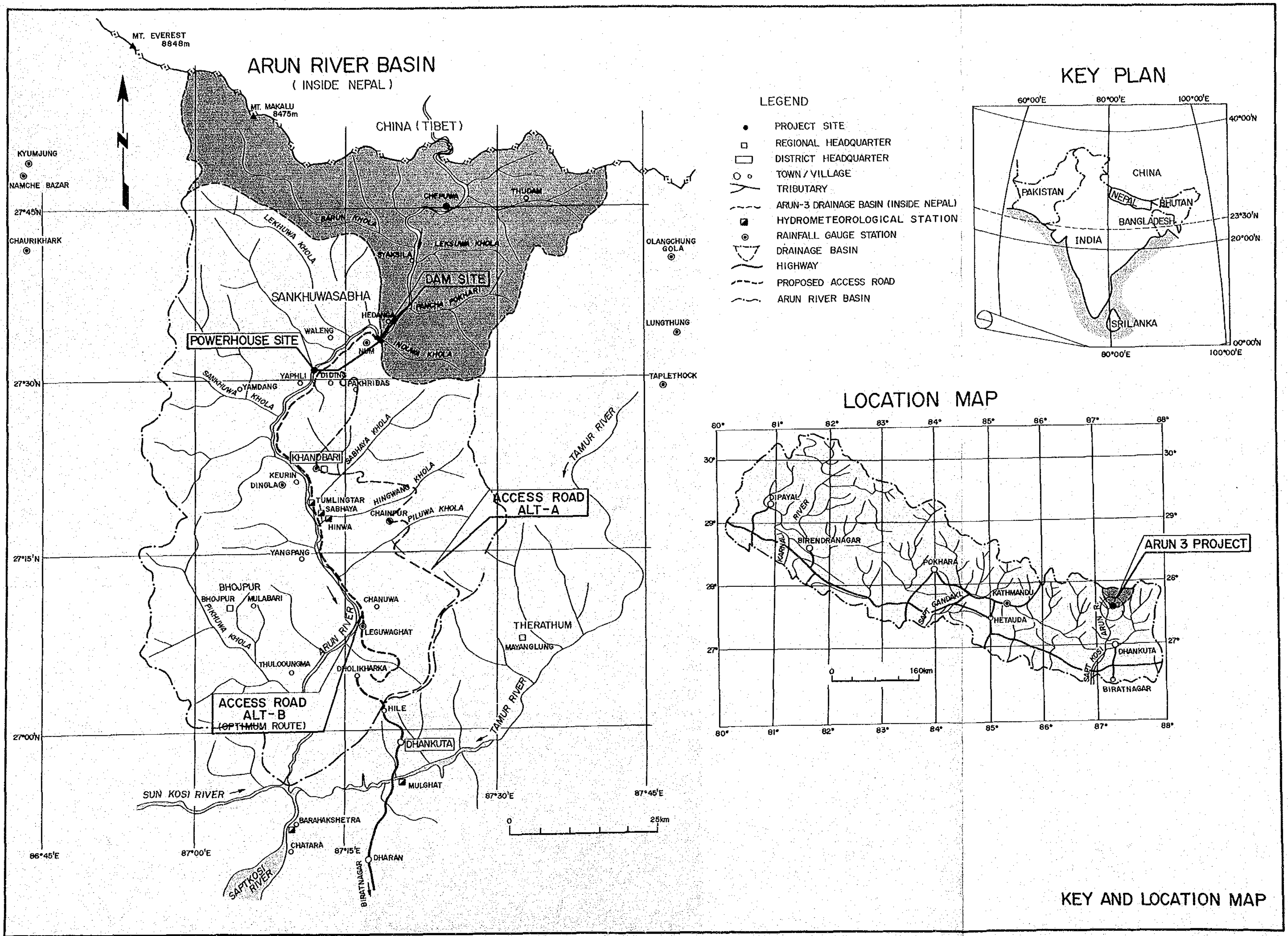
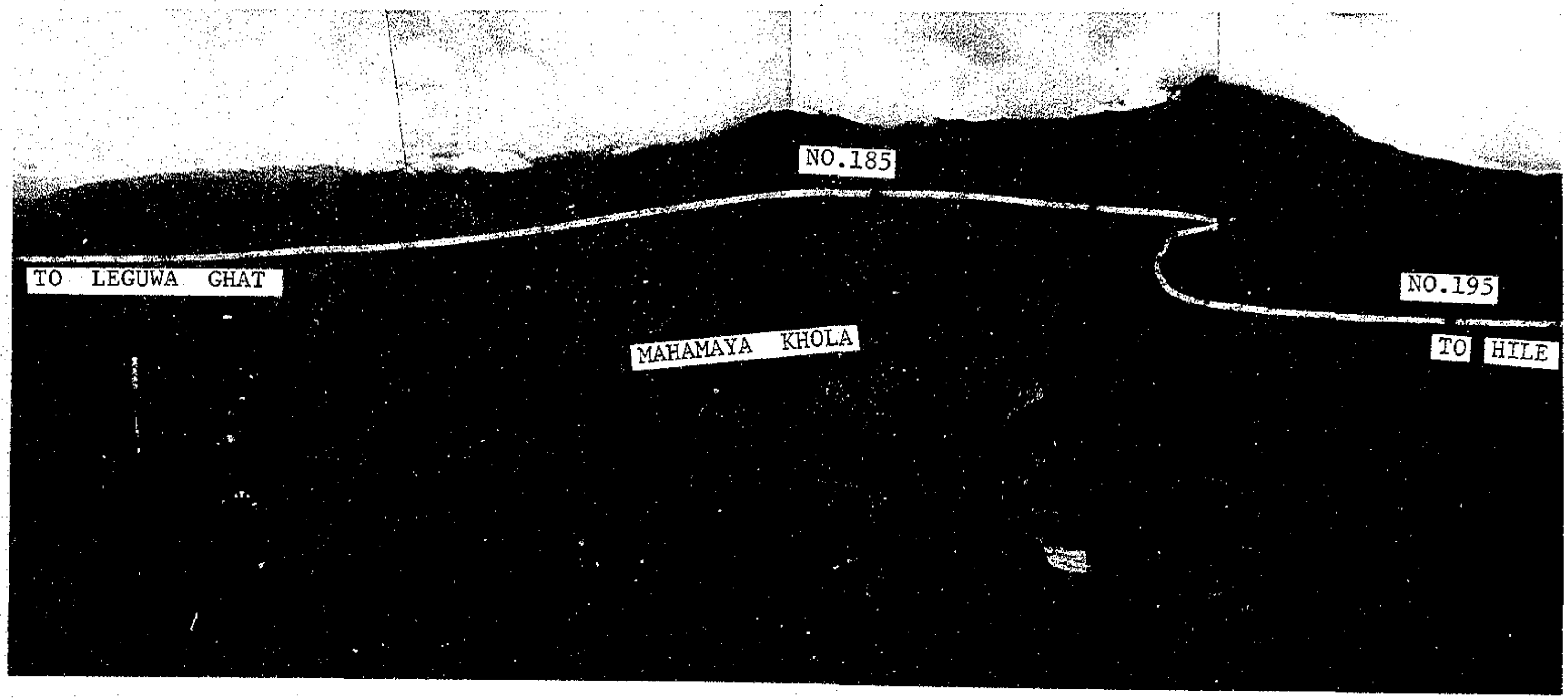


KEY AND LOCATION MAP



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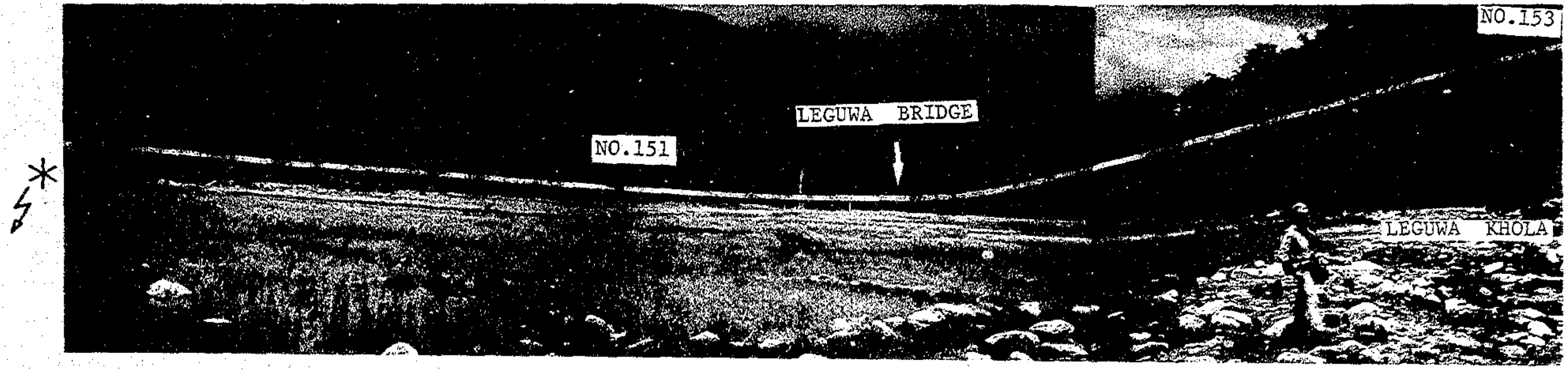

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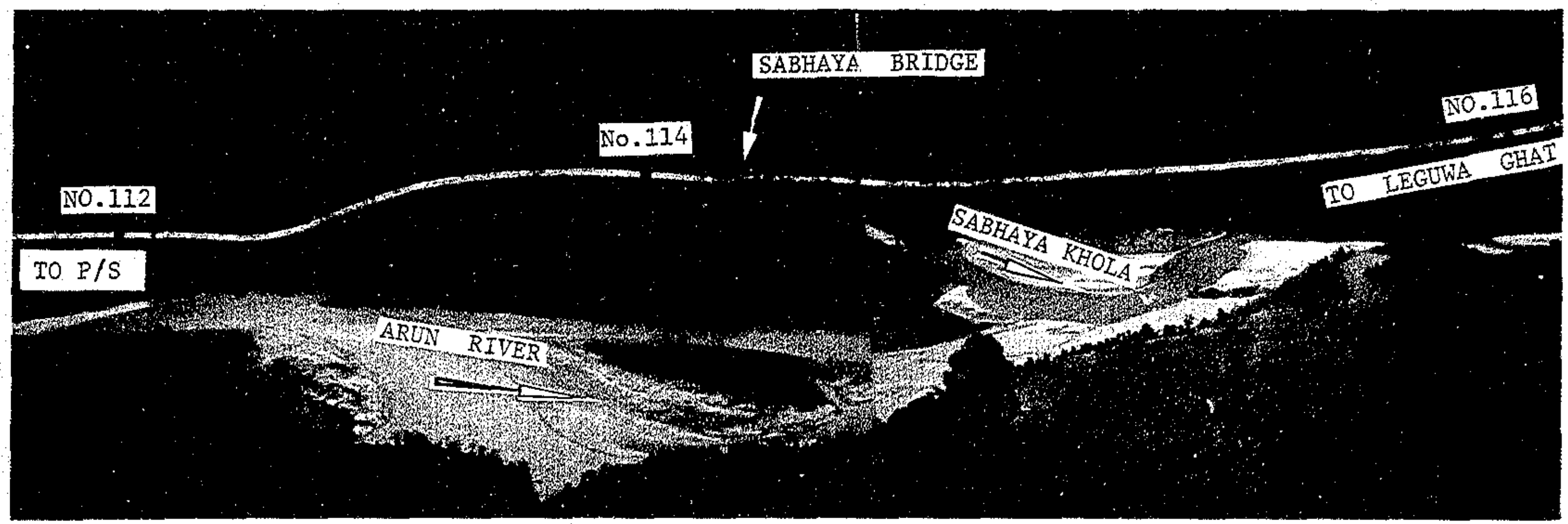

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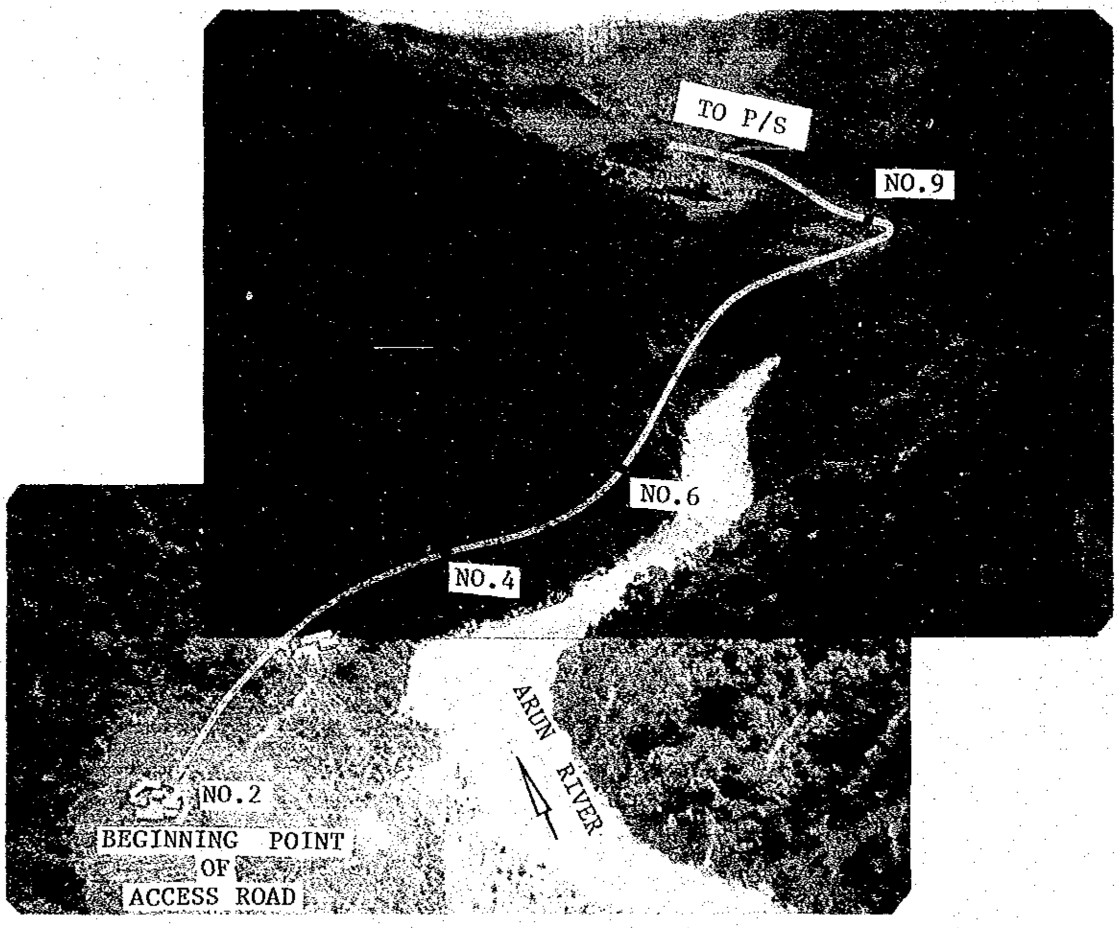

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1. GENERAL

This volume constitutes an integral part of the Final Report of the Feasibility Study of Arun 3 Hydroelectric Power Development Project (Arun 3 Project). The study was conducted by Japan International Cooperation Agency (JICA) with a study period from March 1986 through June 1987.

The present study is focussed on the selection of the optimum access road alignment and constructability based on limited field survey, aerial topographical survey and available maps on various scales.

On the basis of Agreement signed by JICA and NEA dated 12 December 1985, the Study Team carried out: (a) overall site survey, (b) corridor selection, (C) 1:10,000 scale topo-map preparation, (d) river crossing site study and preliminary design of appurtenant bridge structures, (e) preliminary design of typical road cross-sections and slope protection works, and (f) preliminary estimate of construction cost and time period. Furthermore, in the course of the survey period, NEA also conducted a study the results of which were compiled into a field report and handed over to the team. Said field report includes (a) general site survey, (b) corridor selection, (c) 1:5000 scale topo-map, (d) O&D survey, (e) preliminary design of road cross-section, (f) preliminary design of bridge structures and slope protection works, and (g) preliminary estimate of project cost and construction period. This Final Report incorporates the findings of both the Study Team and NEA surveys.

A major drawback to the development of the Arun 3 project is the lack of adequate transportation facilities. The closest road to the Arun-3 project site terminates at Hile. Although in the previous studies the Arun 3 hydro power project has proved to be economically feasible with the cost of the access road construction included in the construction cost of the project, a technical feasibility is required to be performed to identify the best alignment and the cost of the construction with the accuracy corresponding to the accuracy of other structures. The present study is to fulfil such requirement.

The proposed road is an absolute and necessary precursor to the development of the Arun 3 project. Without the road it is not feasible to undertake the massive construction of the dam, powerhouse and support facilities. Without power development, the road has a rather low development priority within the Nepal road network. The majority of any alignment lies within Sankhuwasabha District, the headquarters of which is Khandbari.

The subject road is envisioned to comprise a portion of the planned north-south trunk road through the region. Development of the Dhankuta to Khandbari section, which constitutes a major portion of the proposed access road route, is contained in HMG's Seventh Five Year Plan dated June 1985.

The plan statement, relative to the inclusion of the Hile-Khandbari section, is "... Steps toward construction of this road will be taken in coordination with Arun 3 hydroelectricity project, to be launched at the Num Khola confluence, as the former is expected to bolster the latter".

2. STUDY AREA

2.1 General

The roadway study area lies in the northern 20 km of Dhankuta District and southern 50 km of Sankhuwasabha District. It is bounded on the east by the ridges separating the Arun drainage from that of the Tamur, and on the west by the Arun River, a swath approximately 30 km wide. The elevation ranges from a low along the Arun river in the south of about 300 m, to a high of 3,000 m.

The total area of Sankhuwasabha District is 3,480 km^2 with a population density of 37.2 person/km^2 (1981). Approximately 45% of the total area is forest land while the area under cultivation is about 9,000 ha.

In addition to Hile, principal population centers of the area are: Chainpur with 4666, Pakhribas with 2893, and Khandbari with 2554 inhabitants. Chainpur is the former district headquarters, now replaced by Khandbari. Hile-Piluwa-Tumlingtar-Khandbari is the only main trail for the passage of porters. There are no accommodating facilities for travellers and trekkers beyond Khandbari.

2.2 Topography

The Arun river runs very nearly north to south. Numerous drainages run east and west resulting in a series of ridges and valleys. These are crossed by trails which following neither the river nor the ridges dividing the drainage. Slope of the hillsides is generally about 34°, although there are many outcroppings of rock, particularly in the northern portion along the Arun river. Also found along the Arun river are lengths of relatively flat river terraces approximately 5 m above the water surface. These terraces are invariably farmed. Hillsides, although steep (20 to 30°), are terraced for farming at places of which water is available from the many rivulets.

2.3 Hydrology

The Arun River falls rather rapidly at an average rate of approximately 7 m/km. A velocity of 2 to 3 m/sec emphasises the awfully power of the Arun river. The average velocity poses, to some degree, the design problems of placing a road adjacent to the river, for some reaches are quiet with stable sand banks and deposited sand bars, where the velocity is probably less than 1 m/sec, certainly so during low and normal flow. During flood flow, however, the higher velocities will occur, resulting in high erosive forces.

Within the study area are several significant Kholas. The largest of these is the Sabhaya with a drainage area of 345 km^2. Other major, although smaller drainage basins include: Piluwa, Mangmaya, Leguwa, Kenwa, Suki, Kaguwa and the Hinwan Khola. The Hinwan Khola is a branch of the Piluwa Khola. Both the Hinwan and Mangmaya are significant when considering a hilltop alignment and they join together before crossing the river alignment alternative, thence flowing into the Arun River.

Hydrologic considerations are concern in alignment selection. A low alignment, such as a river-side route, will require more and longer bridge crossings of drainages into the Arun river than a high ridgetop alternative.

The three principal drainages and their characteristics for a 50-year design peak discharge are:

Table 2-1 The Three Principle Drainages

Stream	Drainage Area km^2	50-Year Design Discharge m^3/sec	Estimated Bridge Length Required m
Sabhaya Khola	345	1225	120
Piluwa Khola	141	612	90
Leguwa Khola	35	208	70

The Kenwa, Suki and Mangmaya Kholas are expected to have drainage areas no greater than the Leguwa and require bridges of similar length of less than 60 m.

2.4 Geology

The Study area lies on the east bank of the Arun River, which starts its course within the Tibetan plateau and runs southward traversing the main Himalayan Range (the Higher Himal), forming a deep valley and subsequently crossing the study area onto the Ganga basin-Terai region.

The geology of the study area is composed of Midland metasediments and overlying Himalayan gneiss bounded by the Main Central Thrust. Lithofacies of the Himalayan gneiss and the Midland metasediments in the study area are as follows:

Himalayan gneiss:	granitic gneiss, augen gneiss, banded gneiss, micaceous schistose gneiss, garnetiferous schistose gneiss, quartzite, crystalline limestone
Midland metasediments:	phyllite, banded limestone, quartzite

Generally, the Himalayan gneiss is massive and compact except for the intercalated beds of schistose gneiss. Thinly laminated phyllite is the main member of the Midland metasediments. Phyllite in the area is foliated and appears to be rippable in most of the outcrops.

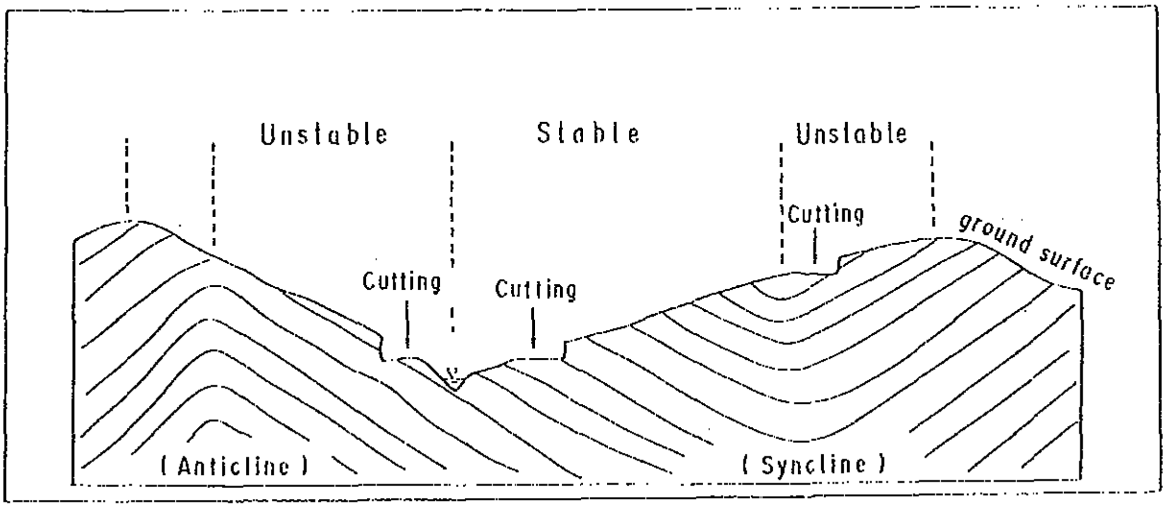
The geostructural setting of the area can be summarized as younger metasediments overlaid by up-thrusted older gneiss. Old compact gneiss forms steep topography along ridges, while less compact metasediments form the rolling terrain along the Arun River. The area covered by the metasediments is limited to the gently sloped area along the Arun River. This area, called the Tumlingtar Window by previous researchers, is surrounded by steep ridges of compact Himalayan gneiss. The thrust fault bounding the two geological units is the Main Central Thrust and is considered to have been formed during the Miocene age. Later stage deformation formed the major folding structure in the area.

Minor folding structures of the second order are common in the Midland metasediments of the east bank of the Arun River. Here, the bedding plane (stratification) of strata varies frequently forming East-West trending fold structures of the second order.

The Hile ridge is located in the east wing of the North-South trending major syncline, with a west-dipping geostructure. Therefore, the west-facing slope of the Hile ridge is geologically unstable and tends to be damaged by slope failure. On the other hand, the geology of the east bank of the Arun River is composed of east-dipping strata. Since the dip of strata is opposite to the topographic slope, the area is rather stable geotechnically as schematically described in Fig. 2-1.

Judging from the geostructures mentioned above, the road alignment along the left bank of the Arun River is geostructurally much more stable than the alignment along the ridge.

Fig. 2–1 Conceptual Illustration Showing the Relation between Topography and Geostructure for Road Construction



(1) Mass Movement (Landslide)

The mass movement of weathered rock is quite common in the Study area as a process of erosion. The types of mass movement observed in the area are slope failure and landslide.

Slope failure in this area is similar to landslip and/or debris avalanche. This is characterized by abrupt and rapid falling of the bedrock and/or weathered rock debris from the steep side slopes into the valley. The movement of failure is rapid and lasts only a short period of time.

Slope failure is mainly triggered by heavy rain, but earthquakes as well as human activity, may also cause failure. The steep slope, where slope failures occur, is formed by the interaction of geostructural upheaval and erosion. Slope failure is consequently a process of erosion. In places where erosion is very active, slope failure may occur repeatedly in the same topographic unit at the same elevation. The upper slope of the failure and the area nearby will be the probable place of the next slope failure.

Another mass movement in the area is creeping landslide. Geologically, landslide occurs widely, but concentration of landslide is obvious in the phyllite-predominant zone in the Midland metasediments, as well as micaceous-schistose-gneiss zone in the Himalayan gneiss.

Topographically, landslides occur in rather gently sloped areas. The sliding mass is composed of soil and clay containing weathered blocks of the bedrock. In the upper part of the sliding block, large boulders in soil are common, while the lower end of the sliding block (the slide front) is generally pebbley, clayey soil. The thickness of the sliding block seldom exceeds 20 m.

Landslide movement is generally slow and active for a long period of time. The main trigger of the landslides is considered to be continuous rain, but in cases where the slide front reaches the river, river erosion causes continuous sliding by eating away the toe. Most of the active landslides are observed along the main river, suggesting that river erosion is the trigger of continuous sliding of active landslides.

The bedrock where landslides occur ordinarily includes either clay minerals, or minerals easily altered to clay minerals. Faults or sheared zone may permeate the groundwater to form clay minerals.

The places where landslides occur are geologically controlled and limited and are seldom reactivated. Most of the old landslide zones observed in the Study area are now stable and being cultivated.

The characteristics of two kinds of mass movement can be summarized as follows:

Table 2-2 Characteristics of Slope Failure vs. Landslide

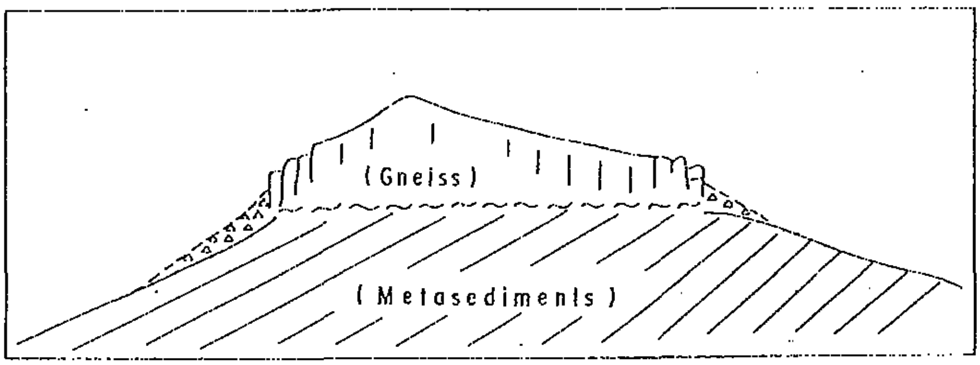
	Distribution	Movement	Period	Main Trigger	Immunity
Slope failure	Near ridge	Fast	Short	Heavy rain	None, may occur again
Landslide	River side	Slow	Long	Wash-out of sliding front	Yes

Judging from the above characteristics of mass movement within the study area, slope failure is hard to predict, and once it occurs a road routed through such an area may be destroyed completely. On the other hand, landslides may be stabilized using drain-boring, pile-driving, weighting of toe, etc. Stability against mass movement, therefore, again favours the Alternative-B route.

(2) Erosion

In general, Himalayan gneiss is resistant to erosion, while Midland metasediments are less so. Since the gneiss and the metasediments are bounded by nearly flat thrust plane, the gneiss tends to form topographical caprock surrounded by steep slope as shown in Fig. 2-2.

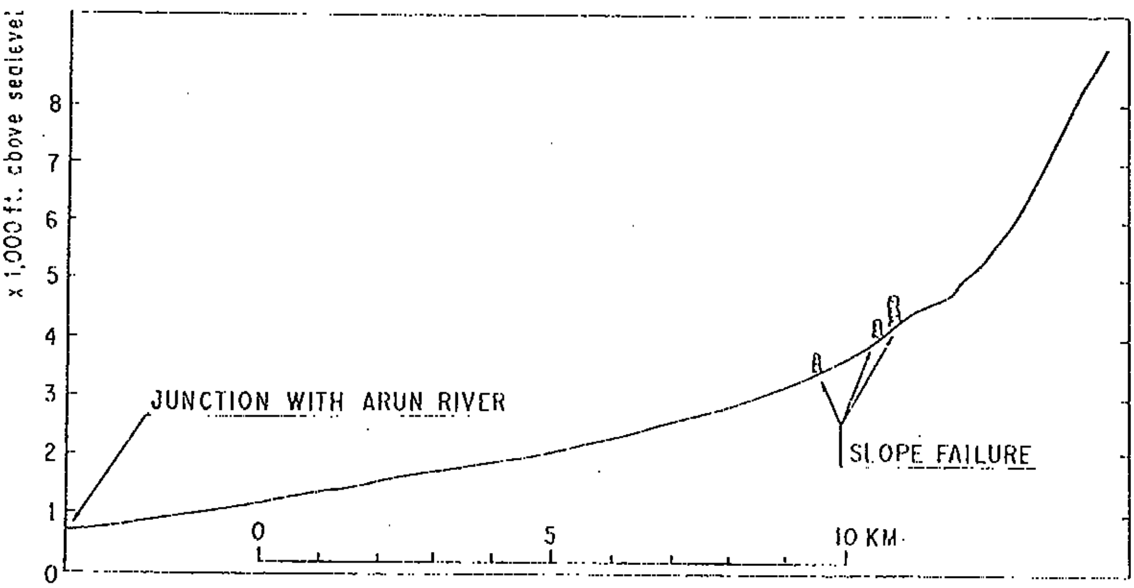
Fig. 2-2 Conceptual Illustration Showing Topographic Caprock



The longitudinal profile of Mangmaya Khola is shown in Fig. 2-3 in which the geomorphic process is clearly observed affecting or attacking the steep slope. The gneiss overlying midland metasediments is strongly affected by erosion. As a result, gneiss in the vicinity of ridges is unstable.

An erosion front is very apparent in the area. The erosion front is the boundary between younger steep topography at the down slope and gentle topography at the upper slope. Slope failure, as well as landslides, have occurred in the past at the erosion front, extending to the upper slope. Consequently, the upper slope of the erosion front is not a proper site for road construction. In locating, however, the Alternative B alignment from Pakhribas to the Arun River, it is possible to avoid this unstable region stated, within a guideline of ±6% descending gradient from Pakhribas. There is, however, an unstable area below Bospani which will tend to keep the alignment somewhat high.

Fig. 2–3 Longitudinal Profile of Mangmaya Khola



2.5 Mapping

The existing 1/50,000 topographical maps were first utilized for the road alignment study on the major alternative routes, namely (1) the river-side route and (2) the hilltop (or ridge) route. A topographical map for the total area of 180 km^2 covering both the riverside and hilltop routes was made on a scale of 1/10,000 with a 10 m contour interval from the existing 1/20,000 scale aerophotographs. The said map is based on the aerial triangulation method without a field ground survey. The magnitude of error inherent to the method is tolerable for the purpose of the alignment study. Finally, 1:5000 scale topo-mapping became available to the Study Team for further refinement of the studies including the optimum road route, and on the basis thereof bridge structure study was carried out and construction quantities were estimated.

Ground survey was conducted at the confluence of the Arun River and the Sabhaya Khola where a bridge more than 100 m in length is required to cross the Sabhaya Khola. A mapping on a scale of 1:500 was prepared using the ground survey results.

2.6 O&D Survey

The objective of the O&D survey is to identify present conditions pertaining to the movement of goods and travellers back and forth between the Terai plain in the south and the northern part of eastern Nepal via Hile. A description of the survey is as follows.

(1) Survey Method

The roadside interview method was adopted. The two types of questionnaires utilized are indicated in Appendix B. The first type was applied to porters to determine items transported, weight of loads, origin and destination of travel, etc. The second questionnaire was used in interview with all travellers to collect socio-economic data.

(2) Survey Period

The subject O&D survey was conducted over the 7 days period from 27 June to 3 July 1985. The survey time was 16 hours continuously for every survey day. Survey was conducted during the middle of the rainy season and it was determined, on the basis of results from other survey as well, that traffic load (both goods and persons) was approximately the minimum that could be expected throughout the year. This factor required careful consideration when projecting yearly average and peak traffic volumes.

(3) Survey Site

Survey was conducted at the 5 locations of Hile, Piluwa, Tumlingtar, Khandbari, and Manebhanjyang (see Fig. 2-4).

(4) Data Collection

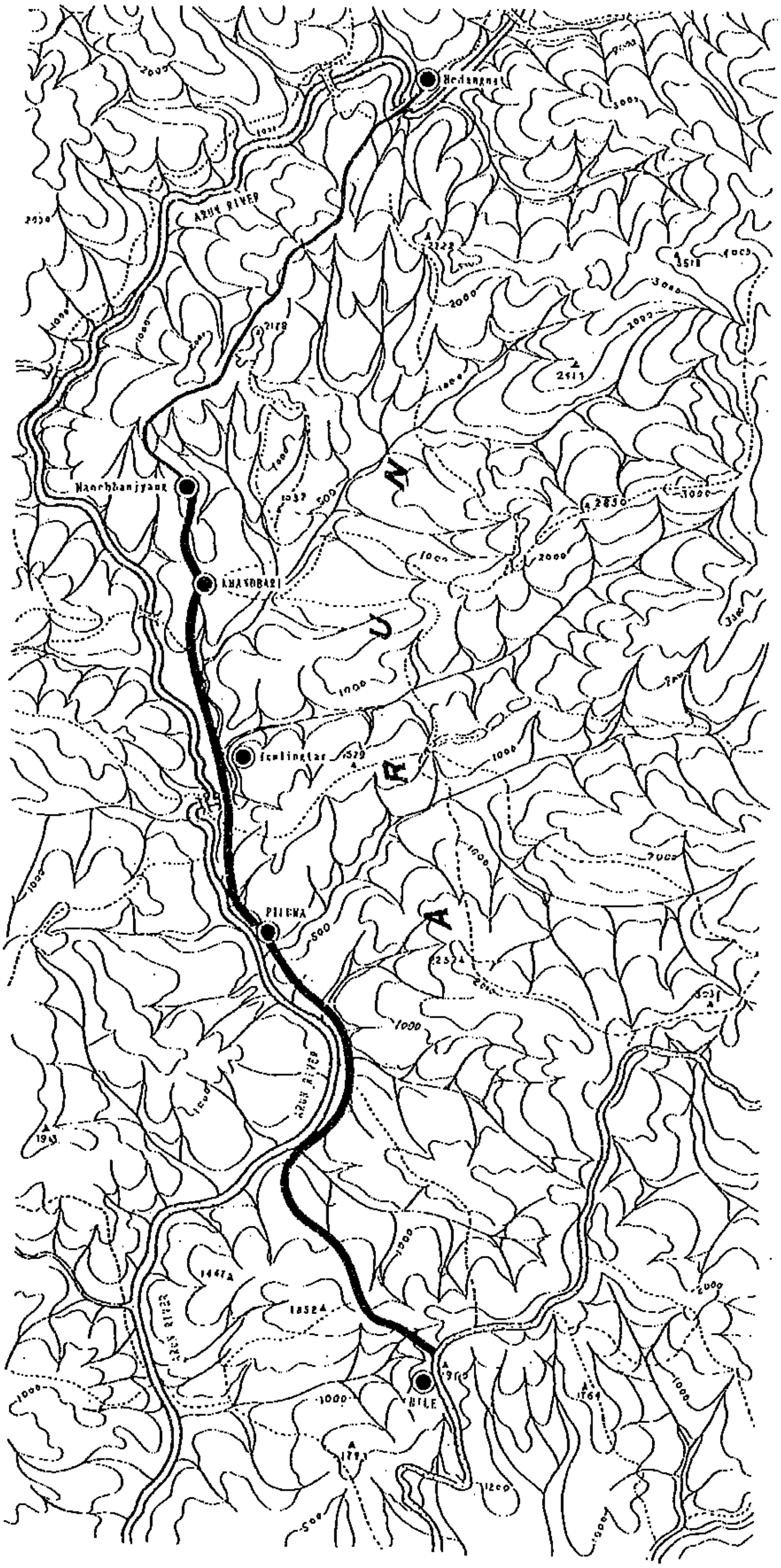
Data on movement of goods was obtained by primarily roadside questionnaire backed up by discussions with officials of Food Corporation, Agricultural Input Corporation, District Technical Office, District Forestry Office, etc. as criteria for seasonal adjustment of figures. Items transported were classified into 9 categories: rice, oil, clothing, fertilizer, sugar, salt, construction materials, food and others. Figures were collected and totalled by means of IBM-PC computer.

Collection of socio-economic data was by means of roadside interview questionnaire as discussed above. Approximately 500 porters were interviewed.

(5) Survey Results

Survey was conducted at the five points shown in Fig. 2-4. These points are Hile, Piluwa, Tumlingtar, Khandbari and Manebhanjyang. Results of survey are indicated in Appendix B. As mentioned in section (4) above, figures have been adjusted on the basis of seasonal factors. Said adjustment is based on information contained in the NEA report "Dhankuta-Khandbari Road", January 1986. The subject report confirmed that the major portion of goods moving between Tumlingtar/Khandbari and the Arun 3 dam site region travel the route along the Arun river.

Fig. 2–4 Locations of O-D Survey Stations



3. ALIGNMENT SELECTION

3.1 Criteria for Alignment Selection

The proposed road will mainly function as an access road for the transportation of construction machinery and materials for the project. Construction period is a critical factor. The road will eventually be upgraded to serve as a trunk road in the district. A portion of the road will be incorporated into the future Kosi Highway which runs through the district from north to south making a direct route from the Terai to the Chinese border.

Criteria for the selection of optimum alignment are summarized as follows:

- ° The road should be the most direct and, cost-effectively, the shortest.
- ° The route should require minimum construction time.
- ° The district headquarter, Khandbari, should be either directly on the route or be effectively connected to it by a feeder road.
- ° Where possible the road should be routed to avoid creating adverse ecological, environmental and socio-economical conditions.
- ° Corridor selection should be made with due consideration to the road's potential contribution to future development in the population centers of Khandbari, Chainpur and Tumlingtar on the east bank of the Arun as well as Dingla and Bhojpur on the west bank.

On the basis of the above general criteria, specific selection criteria are set out below:

(1) Design and Construction Method which Minimize Implementation Period

The subject access road constitutes a critical pass for Arun 3 dam and power station construction. Consequently, road design and construction method must be selected so as to minimize the implementation period. The road must be completed to a level in

1989 whereby the minimal necessary machinery and personnel may be transported to the hydropower scheme site. However, such a level does not signify the final completion of the envisaged road but rather only a sufficient degree of access at this stage to carry out construction of the said Arun 3 hydropower project.

(2) Minimal Initial Investment

Study of available construction methods must be undertaken to determine that which minimizes initial investment while still ensuring road capacity to transport necessary machinery and material for hydropower scheme construction. One possibility is a phased construction approach. Construction method must satisfy conditions of i) establishment of proper road width, ii) short construction period and iii) ease of operation and maintenance.

(3) Facilitated Operation and Maintenance

Road design must facilitate operation and maintenance such that the access road may be continuously kept in a condition permitting effective, safe and uninterrupted construction of dam, power station and other hydropower scheme components. Furthermore, consideration must be given the fact that the access road will eventually constitute in the future one segment of the envisioned north-south trunk road for the region. In this light, focus must be placed on stabilized operation and maintenance over the long term and prevention of extended road closure due to natural calamities.

(4) Procurement of Adequate Construction Labor Force

Procurement of an ample labor force at the local level for hydropower scheme construction must be readily possible.

(5) Contribution to Future Economic Development

Road alignment and design must be such that it may comprise an integral part of the nation's highway system, specifically the envisaged Kosi highway, capable of contributing to the future economic development of the surrounding area. Particular consideration should accordingly be given in road corridor selection to the potential for promoting industry and commerce in the population centers of Khandbari, Tumlingtar and Chainpur on the east bank of the Arun and Dingla and Bhojpur on the west bank.

(6) Special Design Requirements

Design must reflect special requirements imposed by the topography and geology of the route. These include such design parameters as road width, gradient, curvature radius, etc. It must be borne in mind that the subject road is through extremely mountainous terrain in the vicinity of which no other motorable roads exist, and that said route will entail various difficulties in construction. Also, due attention should be accorded potential damage from flood and GLOF from the Arun river.

(7) Practicality of Construction

Design must anticipate potential problems and difficulties which may arise during actual construction. Accordingly, road corridor selection must be made with proper attention to such design parameters as landslide and slope collapse dangers, and difficulty of construction material and equipment transport characteristic of mountainous areas, as well as optimum location of river crossing points.

(8) Environmental Impact

Design must minimize potential adverse environmental impacts of the envisaged road.

(9) Geology

Design must reflect special conditions imposed by geology of the route.

3.2 Field Reconnaissance

The Study Team conducted a limited field survey in the project areas covering the dam site and powerhouse. Field observations were made mainly along the existing foot paths which pass through steep terrain. Site reconnaissance along the river-side route between the dam site and the powerhouse site was not possible due to obstruction by a cliff.

Aerial reconnaissance by helicopter was the main means of observing the overall topographical features of the possible route areas between the south end of the Arun 3 project site, the powerhouse and Hile. Observations along the main trail connecting Hile and Num through Piluwa, Tumulingtar, and Khandbari provided additional topographical information. The Study Team also inspected the existing road along the ridge from Hile to Phidim 25 km northeast of Hile.

A summary of field reconnaissance including the results of the Field Report is presented in Appendix A.

3.3 Alignment Alternatives

While locating a road in mountainous areas, two distinct possibilities come up: follow the ridges or follow the streams, usually in that order, since location nearly always works from the highest toward the lower points. Moreover, ridge routes generally encounter fewer and smaller drainage structures and the terrain is less steep. The initial corridor consideration is the ridge which coincidentially follows a main trail from Hile through Chitre to Chainpur, Khandbari, and Fururu, where it leaves the main trail dropping to the powerhouse. From the powerhouse, the corridor follows the Arun, ending at the damsite. This corridor is designated as Alternative A on Figure 3-1.

Considered a major advantage of Alternative A is approximately 25 km of the Dhankuta (Hile) - Phidim road northeast from Hile, half of which is completed and the other half of which is now under construction.

A second principal corridor, Alternative B, runs northwesterly from Hile, generally following the main trail along the river through Leguwa Ghat and Tumlingtar. From Tumlingtar, the corridor continues to follow the Arun to the powerhouse. A spur road is envisioned to give access to Khandbari; however, it is not a part of the Arun 3 construction road and its design is to be an inferior standard, i.e., as a feeder road. Between the powerhouse and the dam only one corridor alternative is considered.

As is natural, subalternatives appear; that are intended to capitalize on the strengths of the principal alternatives and to eliminate the weaknesses. Such is the case in this study, as shown on Figure 3-1, with segments marked A_1, A_2, and A_3, all of which interconnect the alternatives A and B at their mid-routed points. Segment A_1 connects Chitre on Route A with Leguwa Ghat on Route B. Segment A_2 starts to descend heading towards the powerhouse after Khandbari on Route A. Chainpur - Tumlingtar sector is labeled as Segment A_3.

Alternative A is intended to take advantage of the 25 km section of the Dhankuta-Phidim road, substantially shortening the total new construction required. This alternative results from a map study, indicating that a climb of nearly 1,000 m could be eliminated by following a minor trail to the northwest from Pangma which runs more or less along a contour before dropping to the powerhouse.

Although the Alternative B alignment follows the river, it deviates either elevationally or laterally as much as 300 m for much of the length. In the steep turbulent reach between the powerhouse and and dam, the proposed alignment (alternatives A and B are common in this section) sits high on the hillside following the approximate elevation of the crest of the dam and tunnel adits. Below the powerhouse to Chyama Khola, and from about 2 km above Piluwa Khola to Leguwa Ghat, the proposed alignments are most critical in their position, relative to the Arun River. In these reaches, the high river water profile, river velocity and effect on the banks should be checked.

3.4 Alignment Selection

According to the study of the alternative alignment shown in Figure 3-1, the choice for the selection of the best route includes major and minor alternatives; however, the minor alternatives were not considered as an objective for evaluation as their conditions of evaluation were the same as those of the major alternatives.

Two routes of the major alternative as summarized in Table 3-1 below, i.e., the riverside route (Alternative B) (see DWG. ACR-2 through ACR-29) and the hilltop route (Alternative A) (see DWG. Appendix D) were selected and detailed comparative studies thereof are shown in Table 3-2 for each component of the criteria described in section 3.1.

Table 3-1 Two Alternative Routes

Major Alignment Alternatives	Designation	Transit Points	Route Length
Hilltop route	A	Hile-Chitre-Chainpur-Khandbari-P/H-D/S	154 km
Riverside route	B	Hile-Tumlingar-P/H-D/S	115 km

P/H : Power house site
D/S : Dam site

Hilltop Route (Alternative A)

The hilltop route originates at Hile, transits Chitre and Chainpur to reach Khandbari.

The major part of the hilltop route is located between hillsides and hilltops. Any construction over this route will require a successive large-scale cutting and backfilling operation. In addition, longer extension of the road will be necessary to keep the maximum gradient within 8% in the northern regions as the route passes through steep valleys and over high ridges. It is very likely that paddy fields, plantations, and villages in the area surrounding the construction site will be adversely influenced by the cutting soil treatment and the draining of rainwater accompanying the cutting and banking operation of the hilltop route. The trail that follows the ridge beyond Khandbari would be the alignment for a motorable route deviating as necessary to maintain a reasonable gradient. Along this ridge trail are occasional banyan and pine trees, as well as huts and tea houses, thus posing possible adverse effects on the existing environment. A public drinking water pipeline follows the trail. Further compounding the difficulties of this route, there are topographically very narrow places where the width is less than the planned 7-meter roadway requiring certain increase of the road length to find a suitable route.

The principal merit of the hilltop route is service to a greater population as it would pass through or very near to Chainpur and Khandbari. The riverside route, on the other hand, requires feeder roads to serve both of these centers. The riverside route, however, has the advantage of allowing shorter feeder roads for access to the major population centers on the west bank of the Arun river.

Riverside Route (Alternative B)

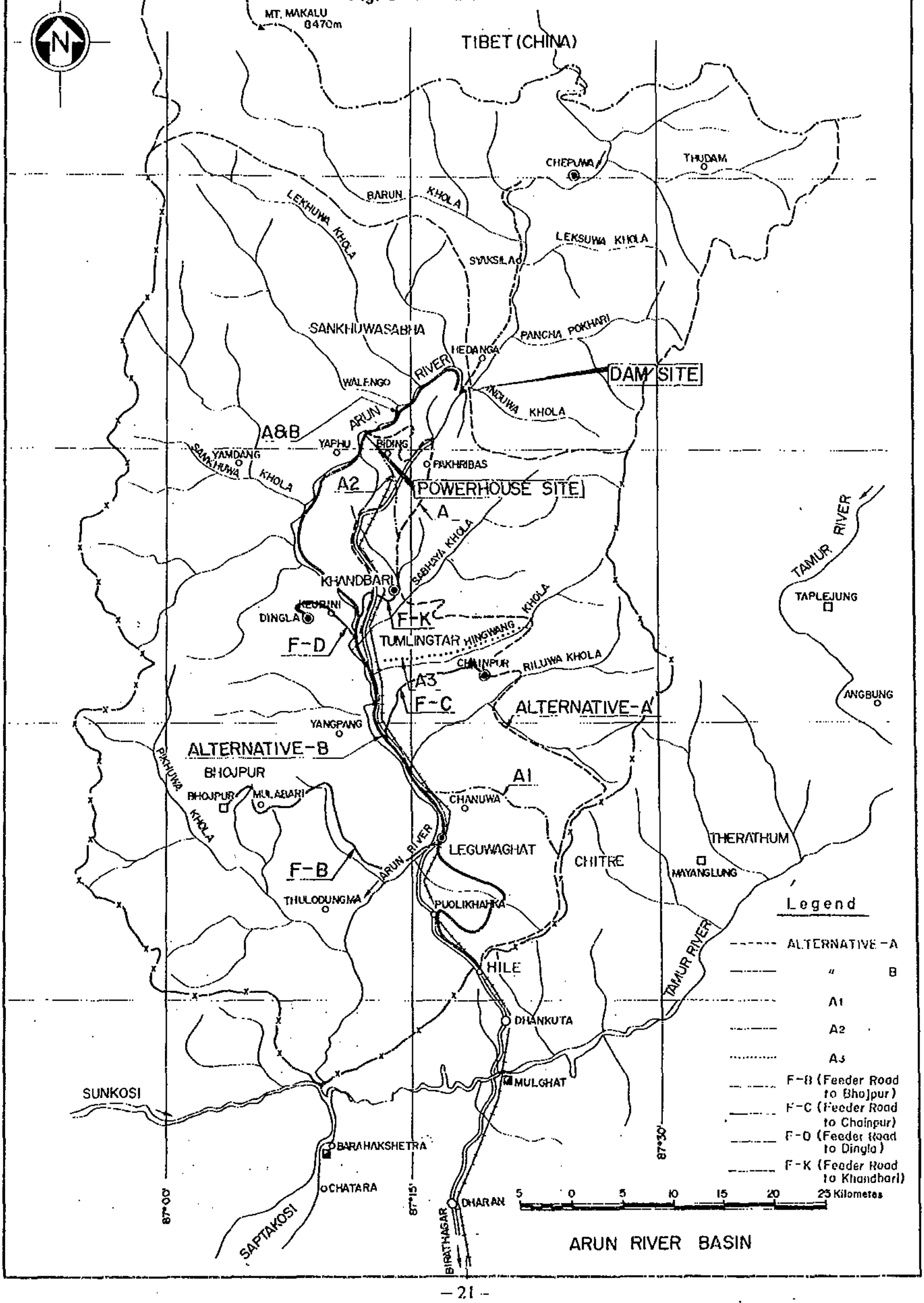
As with the hilltop route, the riverside route originates at Hile. The Hile - Pakhriwas and Leguwa Ghat - Tumlingtar segments of the route would follow existing hill trekking paths. Along these segments, problems to be encountered would be basically the same as for the hilltop route. However, as topography is generally more gentle, gradient does not require the consideration that it does with the hilltop route. As a result, compensation for dwellings, farmland, foliage, etc. affected by road construction may be minimized.

A disadvantage of the riverside route is the need for major bridges, including long spans across the Sabhaya, Piluwa and Leguwa Kholas. Also, as the route would bypass heavily populated Chainpur and Khandbari, feeder roads would be necessary to service these areas. The primary advantage of the route is the fact that large segments of the alignment would be along terrace of the Arun river, thereby facilitating design and construction.

From the viewpoint of future development of the region, the riverside route is the best location in the terms of contribution to commercial and industrial development in the major population centers on both the west and east banks of the Arun river along the access road route.

In the case of both the riverside and hilltop alignments, the route between the power station and dam sites is the same, i.e. along the left bank of the Arun at an elevation ranging from 500 to 1,000 m.

Fig. 3 -1 Alternative Routes



Optimum Route (Recommended Alternative)

On the basis of field survey and study, alternative B (ALT-B) shown in Fig. 3-1 is determined as the optimum route. Principal reasons are given below.

a. Road length minimized even including feeder roads resulting in shortest travelling time between population centers
b. Construction facilitated with consequent low construction cost and short construction period inclusive of feeder roads
c. Cost effective operation and maintenance
d. Least vulunerable to geological hazards with sufficient safety against flood damage
e. Availability of high quality construction materials
f. Least cost for compensation and land aquisition
g. Least environmental impact
h. Air access through Tumlingtar airport
i. Easy access to major population centres on the west bank of the Arun river through relevant feeder roads
j. Access road construction for future power projects on the Arun river minimized
k. Most advantageous from the view point of the national development context due to the high potential of providing a cost effective road network for regional development consisting of access road and feeder roads

Alignment alternatives are compared in Table 3-2 on the following page. The table presents a detailed comparison of the two alternative routes on the basis of the criteria set out in a-k above.

According to the master plan for Kosi river development, there are six power development projects on the Arun river. The present Arun 3 hydropower project corresponds to the Arun 2 and 3 projects set out in the master plan. The original Arun 1 project constitutes a simple pondage type power development scheme. High water level of the pondage is 402.3 meters, hence some portion of the recommended route of the access route will be inundated if the Arun 1 project is realized in the future. The subject Feasibility Study concluded that even if such eventuality occurs, the attractiveness of the recommended route persists based on the following reasons:

a. The possibility of implementation of the Arun 1 project is expected to be in the far future.

b. Rerouting the presently recommended route to avoid inundation would be costly and construction duration would be excessively prolonged.

It is therefore recommended that a partial rerouting of the access road for the Arun 3 project be considered at such time in the future as said need may arise.

3.5 Feeder Roads

As indicated in the previous section, although Alternative B is routed outside the major population centers of Khandbari and Chainpur on the east bank of the Arun, it offers better access to west bank population centers than Alternative A. However, construction of feeder roads would provide appropriate access to all population centers along the recommended route. In this section, feeder roads are studied in a preliminary manner based on 1:50,000 scale topo-mapping.

Criteria for feeder road design are:

(1) Capable of bearing truck traffic

(2) Serviceability to greatest population at least construction cost

Candidate feeder roads are:

(1) Route to Khandbari, designated as F-K

(2) Route to Chainpur, designated as F-C

(3) Route to Bohjpur, designated as F-B

(4) Route to Dingla, designated as F-D

The preliminary study results indicate that the above four selected feeder road routes are most appropriate with the view that the linkage with the recommended access road route along the river-side will constitute an effective road network for contributing to the regional socio-economic development.

As discussed above, Alternative B results in shorter feeder roads to Dingla, Bohjpur, etc. on the west bank of the Arun in comparison to Alternative A, as well as allowing for generally good corridors for all feeder roads. The four feeder roads are described in Table 3-3 and Fig. 3-1.

In order to establish the relationship between the recommended access road corridor and east bank feeder road routes, a rough calculation of construction cost for east bank feeder roads (F-K, F-C) has been made and is indicated in Table 3-3. Possible alignments for these feeders are shown in Fig. 3-2.

Fig. 3–2 Feeder Roads to Khandbari and Chainpur

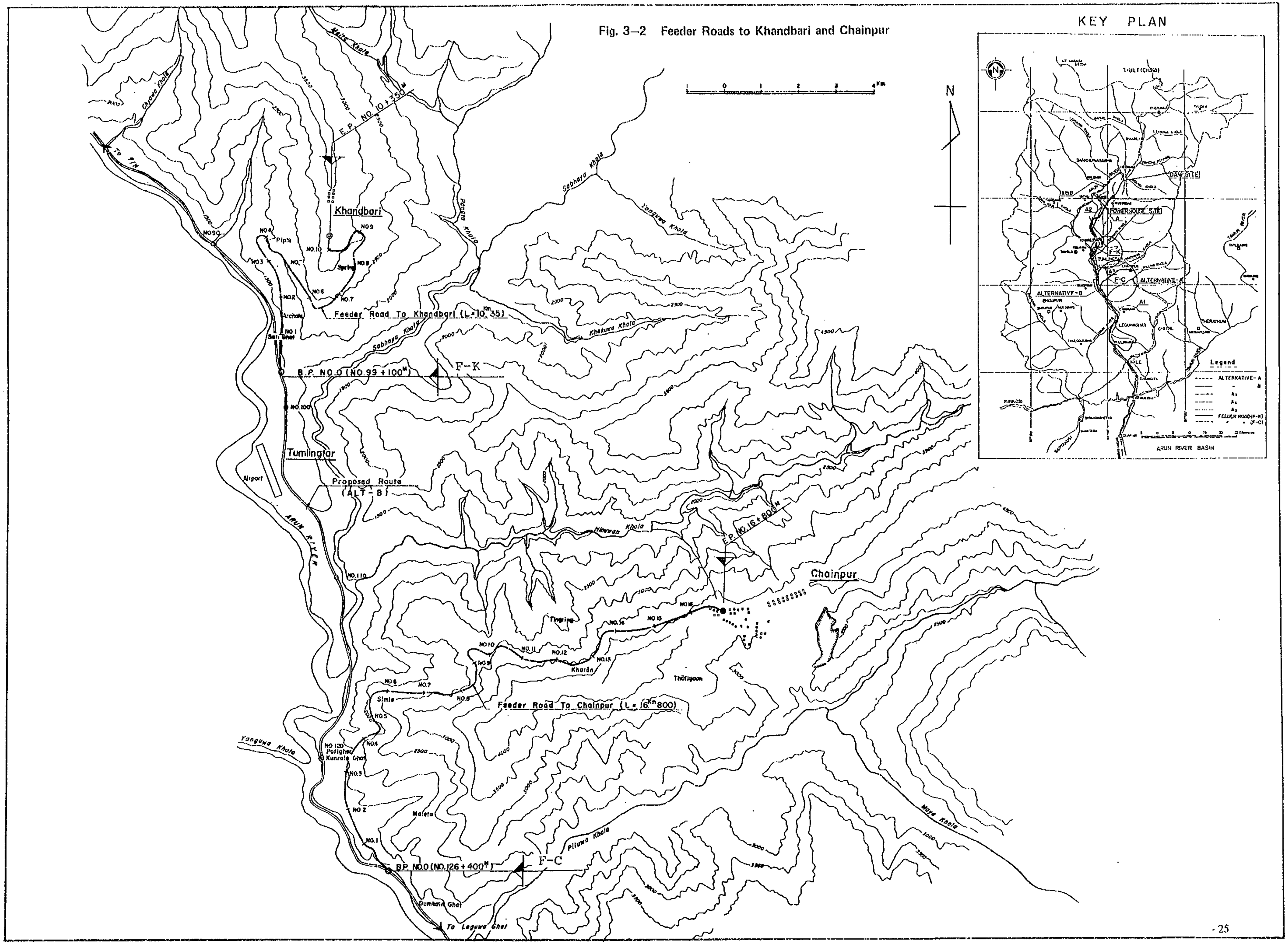


Table 3–2 Comparison of Alternative Routes

(1)

CRITERIA	ALTERNATIVE – A (Hilltop Route)		ALTERNATIVE – B (River Side Route)	
	ADVANTAGES	DISADVANTAGES	ADVANTAGES	DISADVANTAGES
1. Period to Design and Construct	No major bridges to delay schedule of design and construction period. Can utilize completed road from Hile to Chitre.	Greater length requiring longer time period for non-structural construction. Total road length 154 km.	Shortest overall length of 115 km.	Several major bridges requiring added design and construction periods.
2. Initial Investment	Can utilize existing Hile Chitre road for reducing cost. No major bridges making cost saving.	Heavy initial investment cost of \$43.0 million including for road-bed, bridge and structures.	Minimum initial investment cost of \$34.0 million including for road-bed, bridge and structures. Additional \$4.0 million for feeder road, construction for Khandbari and Chainpur.	
3. Maintainability	Less areas of potential slide above roadway. Fewer large drainage structures requiring continuous maintenance.	Greatest length to be maintained. Greatest cost of maintenance for Hile to Chitre section susceptible to slides because of adverse geologic dip. Numerous erosion fronts along ridge.	Shortest route. Least annual maintenance cost. Location on broad plain along the Arun river permitting protection from slides from above. Construction gravels readily available at several locations.	Potential risk of heavy damage due to an extreme rare event of flooding on the Arun river. Slide potential near Bospani.
4. Access to Labor Supply	29 km of length through town and villages with good labor supply.			Long walking distance to Chainpur and Khandbari making labors' commuting difficult and/or labor camps larger.

Note: Figures of this table are estimated from 1:5,000 map for Alternative B and 1:10,000 map for Alternative A.

Table 3–2 Comparison of Alternative Route (continued)

(2)

CRITERIA	ALTERNATIVE - A (Hilltop Route)		ALTERNATIVE - B (River Side Route)	
	ADVANTAGES	DISADVANTAGES	ADVANTAGES	DISADVANTAGES
5. Future Economic Development Potential	Excellent access to the established population centers for their economic growth benefit.	Neglects priority air access by bypassing the Tumlingtar airfield.	Shortest route to any populated area from Hile. Least total transportation cost with fastest market access. Enhancing development potential of tourist. Greatest access to agricultural lands providing enhanced farm market economics.	
6. Design Parameters:				
a. Curvature		Most and sharpest curves. Hile to Chitre radii less than 25 m.	Least number of sharp curves. Favourable topo conditions for better alignment.	
b. Rise and Fall		Reaches nearly 2,500 meter elevation two or more times. Very high amount of rise and fall.	Least amount of rise and fall. Very little waste due to elevation differences.	
c. Gradient		Large amount of grade greater than 6%. Hile to Chitre max gradient 12%.	90% of the road with a gradient less than 5%. Avg. max gradient less than 8%.	Frequent requirements for 6% grade between Hile and Leguwa Ghat.
d. Esttimated Travel Time Hile to Dam		4.13 hrs.	2.19 hrs.	
7. Constructability	Least amount of heavy rock construction. Least length of structures. Longest single structure estimated 60 m.	Large amount of waste excavation containing rocks and fill material causing environmental problems to area below construction.	Good availability of quality construction aggregates at several locations.	Delays at major stream crossings or requirement of temporary construction bridges.

Table 3–2 Comparison of Alternative Route (continued)

(3)

CRITERIA	ALTERNATIVE - A (Hilltop Route)		ALTERNATIVE - B (River Side Route)	
	ADVANTAGES	DISADVANTAGES	ADVANTAGES	DISADVANTAGES
8. Environmental Impact	Establishes trail travel pattern.	Many huts along ridge trail to be displaced. Peepul and banyan trees along ridge to be destroyed. Water line and public taps to be disrupted. 29 km length in populated area to be affected by construction operation. Larger total land area to be disrupted and changed. Maximum total person-trip-kilometers of travel.	Can avoid significant disruption of housing; can mitigate tree removal; can avoid choice land in most cases where gradient does not control location. Follows the heaviest and desired line travel pattern found in O & D survey. Minimum total person-trip-kilometers of travel.	Requires greater feeder road and trail support systems. Material waste into Arun river causing added deposition downstream.
9. Geology a. Geology	Himalayan Gneiss at many places.	May need blasting.	Mostly composed of thinly foliated Midland Metasediments which appear to be ripperable.	
b. Geostructure		Passes through unstable zone.	Passes stable zone.	
c. Erosion (Cycle of Erosion)		Now strongly active (matured stage).	Now inactive.	
d. Mass Movement		Many slope failures anticipated.	Few active landslide. Can be technically stabilized.	

Table 3-2 Comparison of Alternative Route (continued)

(4)

CRITERIA	ALTERNATIVE - A (Hilltop Route)		ALTERNATIVE - B (River Side Route)	
	ADVANTAGES	DISADVANTAGES	ADVANTAGES	DISADVANTAGES
10. Future power project development on the Arun river	No possibility of relocation.	Less potential to function as an access road.	Large potential to function as an access road.	Partial relocation may be required when a pondage type power project is planned.
11. Effect of flood and GLOF on the Arun river	No possibility of damage topographically.		No possibility of damage technically.	

Table 3-3 Description of Feeder Roads

Feeder Road	F-K	F-C	F-B	F-D
Starting Point Station	No.99 +100	No.126 +400	-	-
Ending Point	Khandbari	Chainpur	Bohjpur	Dingla
Estimated Length (km)	10.3	16.8	45	15.8
Estimated Cost (Million US$)	1.5	2.3	-	-
Preliminary Route	Fig. 3-2	Fig. 3-2	Fig. 3-2	Fig. 3-2
Description on the Route	Gradient 3% to 12%	Gradient 4% to 12%	-	-

Note: Figure in table was estimted on 1:50,000 Map.

4. DESIGN

4.1 Design Criteria

Road design is to be based on "Nepal Road Standards (2027)" published by the Ministry of Works and Transportation of His Majesty's Government. Design criteria are classified into geometric structural standards and structural standards.

Several factors establish the specific governing design standards including traffic type and volume, topography and service classification. Sections 4 through 12 of the above document (NRS 2027) delineate specific criteria for such detailed design features as speed, gradient, horizontal curvature, lane and shoulder widths, right-of-way requirements, structural standards, etc.

As indicated in Notes of Table 4-1, service classification refers to a distinction among trunk, feeder, district, and city roads or streets. The service classification is the determining factor for design speed, design traffic volume, etc. The Hile - Khandbari segment of the proposed road will comprise one of the designated north - south highways of the national road network and constitute the northern extension of the Kosi highway. The segment is included among trunk roads planned under the seventh five year plan of the Government.

The initial objective of the envisaged road is to enable construction of the Arun 3 hydropower scheme. Accordingly, design criteria are governed by the necessity of the road to be utilized for transport of equipment and material for dam and power station construction.

Proposed geometric structural standards for the access road are indicated in Table 4-1. Structural standard conform to NRS criteria set out in Table 4-2.

With future identification as a trunk road, design speed is established at 50 kph and maximum gradient is 8%. On the basis of 50 kph design speed, maximum radius of curvature of 70 m is recommended. The absolute minimum radius necessary for hauling a 30 m long piece of construction or power station equipment is approximately 25 m. The existing Dharan to Dhankuta section typically features gradients of 8%

and minimum curvature radii of 25 m. Identical geometric structural standards are adopted for the subject access road as indicated in Table 4-1 and these values are considered sufficient for transport of equipment and materials for Arun 3 hydropower scheme construction.

Although the subject road is assumed to be eventually classified in the future as a class I or class II trunk road, paragraph 4 of the Working Policy of the Seventh Five Year Plan states:

> "In order to make available road facilities to remote areas as quickly as possible, even roads under highways will be first constructed in the form of seasonal (eight months) fair weather roads, and gradually be promoted to permenant fair weather by constructing bridges and culverts repairs, and then, on the basis of traffic density on the road, be promoted to gravelled and black-topped form."

This mandate may be interpreted as a guideline that the roadway prism and structure width be considered in terms of a stagewise road implementation, with construction under the initial phase to establish a class II road, to be later improved to a class I road during phase two.

In light of the above described national road policy, phased construction is planned for the envisaged access road. The target road functions and levels of road completion for each construction phase are indicated in Table 4-3 "Descriptions of Phased Construction of Access Road". As discussed in more detail in subsequent section 5.1.3, the major portion of road construction will be completed during the Phase-1 (November 1987 - November 1989). By the end of phase one construction, road completion will be sufficient to allow transport of necessary equipment and material for Arun 3 hydropower scheme implementation. In the Phase-2 (two years) end of May 1991, bridge structures and other more difficult construction aspects will be completed. The miscellaneous and other works will be continued for phase-2. Target date for final road completion is November 1991.

Table 4–1 Proposed and Existing Geometric Design Criteria

Class	Road	Terrain	Design Speed (Km/hr)	Width (m) Carriage-way	Width (m) Shoulder	Gradient Max. (%)	Max. Super-elevation (%)	Mini. Horiz. Curve Radius (m)	Mini. Vert. Curve Length (m)	Sight Distance (m)
ACCESS ROAD ARUN 3 HYDROPOWER PROJECT (PROPOSED 1/)		F	50	5.0	1.0	5	5	100	50	75
		R	40	5.0	1.0	6	6	70	35	40
		M	30	5.0	1.0	8	8	50	25	30
IAA	TRUNK 2/	F	120	2x2x3.5M	4.0-6.0	3	5	$R = \frac{0.0079V^2}{(e+f)}$	$L = \frac{AS^2}{200}$	200
IA		R	80	|		4	6			110
I		M	50	2x3.5M	"	5	8			65
II	FEEDER 2/	F	100			5	5			145
		R	60	3.5M	4.0 - 5.0	6	6	"	"	85
		M	40			7	7			45
III	DISTRICT 2/	F	60			5	5			85
		R	40	3.5M	3.0 - 5.0	6	6	"	"	45
		M	30			7	7			30

Notes: 1/ Newly proposed for Access Road of Arun 3 Hydropower Project.

2/ As per Nepal Road Standards (2027).

Trunk Road - (Rajmarg or National Highway)

These serve directly the greater portion of the longer distance travel, provide consistently higher level of service in terms of travel speeds, and bear the inter community mobility (regional interest). These road shall be the main arterial routes passing through the length & breadth of the country as a whole.

Feeder Road

These roads are important to travel of a localised nature than that which trunk roads are intended to serve. These serve the communities wide interest and connect important towns districts and zonal headquarters to the Trunk roads.

District Road

This class of road consisting of all roads not defined as trunk or feeder & city roads, serves primarily by providing access to abutting land carrying little to thorough movement.
These roads serves as collector to the feeder roads. These roads should give access to one or more villages to the nearest market or to higher types of roads. Moderate travel speeds are typical on such roads.

Abbreviations

F : Flat
R : Rolling
M : Mountainous

R : Radius of curve
L : Length of vertical curve
V : Design speed
f : Co-efficient of friction
A : Algebraic difference in approach grade percent
S : Sight distance

Table 4–2 Structure Design Criteria

Structure	Standards of Loading
Major Bridge	HS20-44 or IRC-Class A or any other equivalent loading
Medium to Minor Bridge & Culvert	HS15-44 or IRC Class A or any other equivalent loading
Temporary Structure	HS15-44 or IRC-Class B or any other equivalent loading

Table 4–3 Descriptions of Phased Construction of Access Road

Phase	Designation	Function	Traffic	Design Criteria
Phase - 1 Nov., 1987 to Nov., 1989 2 years	Pilot Road	Carriage way for transporting road construction equipment & materials	. Bulldozer . Power shovel . Earthwork equipment	Road width ≑ 3.5M
	Temporary Access Road	Capable of transporting various kinds of construction machinery, materials & personnel for access road and main hydropower construction	. Cargo truck . Trailer truck . Construction machinery (Road & hydropower construction equipment and materials)	See Table 4-1 & 4-2
	Temporary Bridge	As same as above	. Road construction equipment and material . Hydropower construction equipment and material	See Table 4-2
Phase - 2 Dec., 1989 to Dec., 1991 2 years	Bridge	Completion of permanent bridge	All kinds of traffic	See Table 4-2
	Access Road for Arun 3 Hydropower	Completion of permanent bridge and road	All kinds of traffic	See Table 4-1 & 4-2

4.2 Typical Roadway Section

Typical sections are indicated in Figs. 4-1, 4-2 and 4-3.

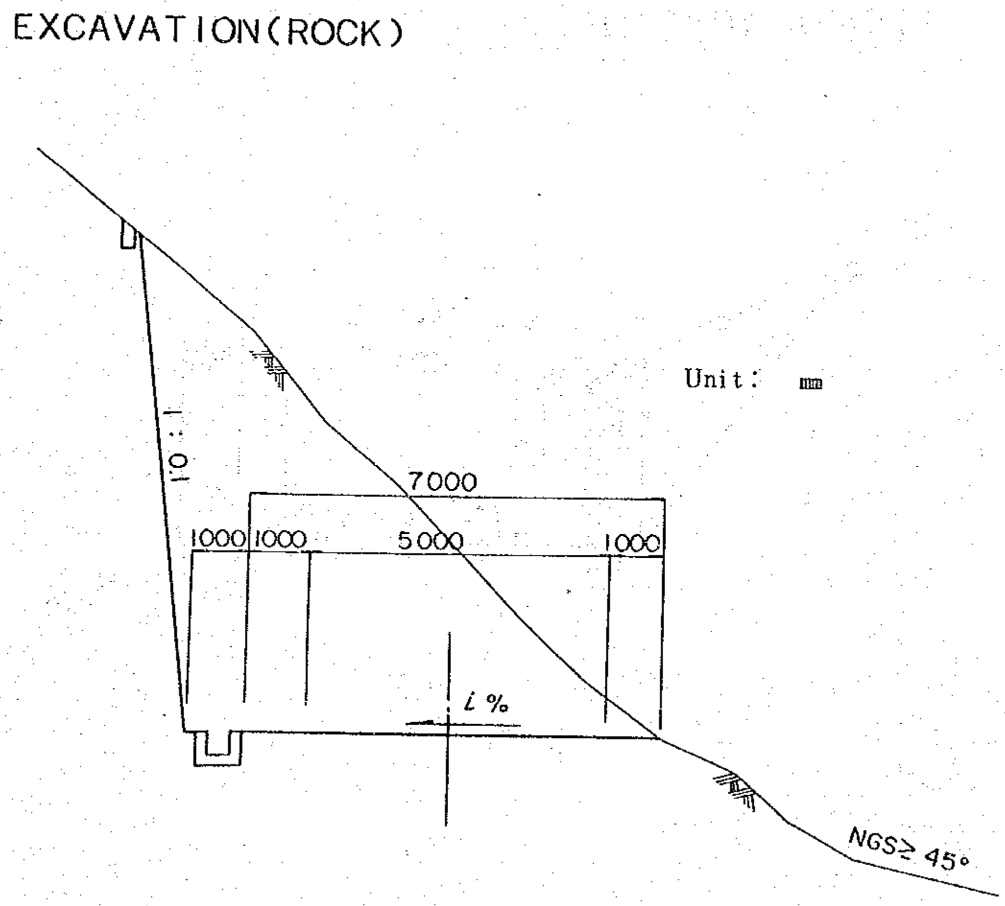
On the basis of 1:50,000 scale topographical mapping provided by NEA, a surface profile was drawn for the proposed road slope gradient. Gradient of 45° or more was assumed as rock, and gradient less than 45° was designated as unclassified (UNCL). The soil characteristics of this latter classification are unclear; however, ground is assumed to be comprised of both rock and unidentified soils.

Considering the function of the road for transport of equipment and materials for dam and power station construction, design traffic is 10 t class trucks. Road section is planned as small as possible to minimize construction period and cost. However, in order to ensure safety of traffic in the steep terrain over which a portion of the road is routed, it is recommended that a carriage way of 5.0 m with two 1.0 m shoulders and a 1.0 m drainage clearance on the hill side be adopted.

Road sections at structures, i.e., bridges and culverts, are as follows. Bridge road width is 3.5 m, with lateral clearance on both sides of 1.0 m. At portions where drainage culverts are placed, road section remains the same as for other non-bridge segments.

Temporary bridges are planned to speed up construction. Two possible types of temporary bridge are shown in Fig. 4-5.

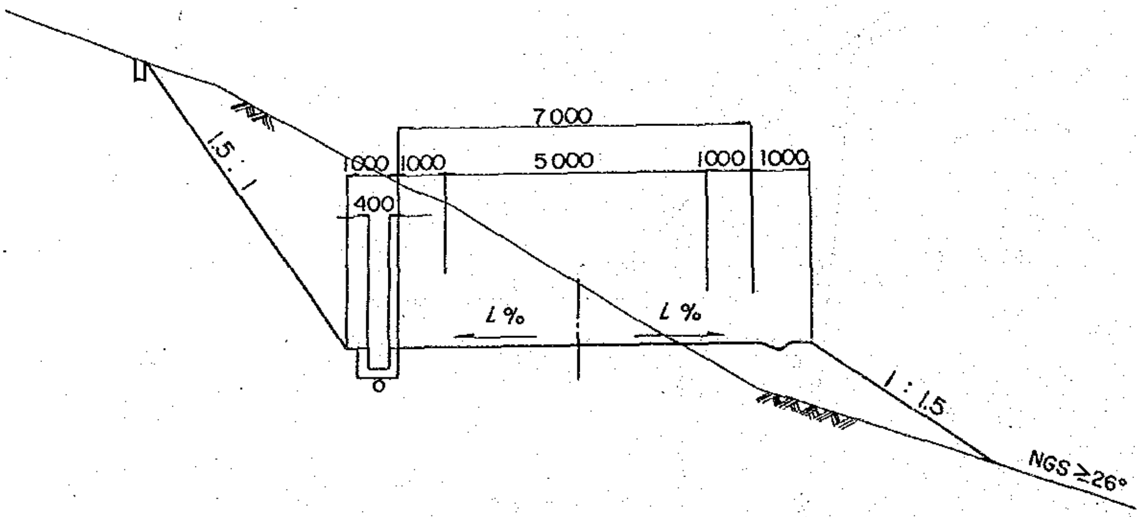
Fig. 4–1 Typical Cross Section (Rock Excavation)

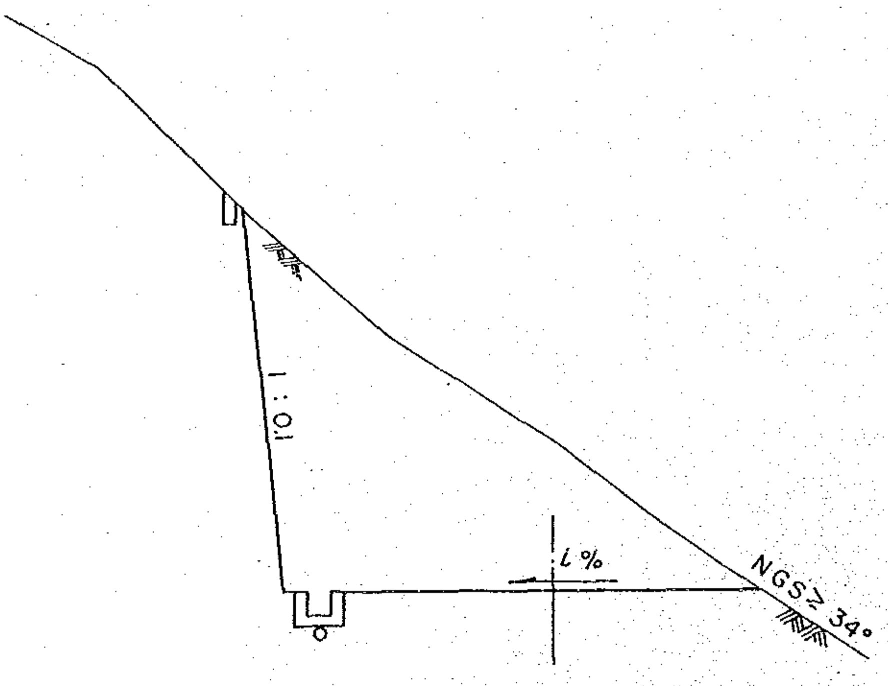


Note: NGS : Natural Ground Slope
NGS were estimated from 1:50,000 MAP given by NEA

Fig. 4–2 Typical Cross Sections (UNCL)

EXCAVATION(UNCL)

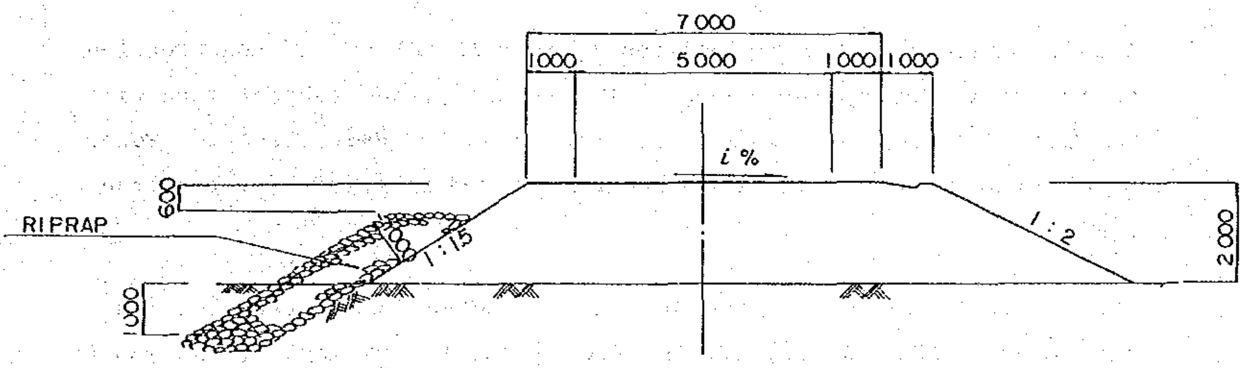




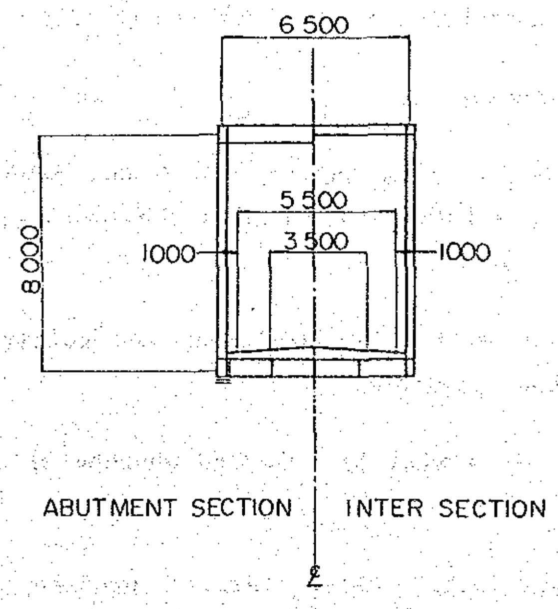
Note: UNCL: Unclassified Excavation

Fig. 4–3 Typical Cross Sections (Embankment & Bridge)

EMBANKMENT



BRIDGE



4.3 Road

The concept of road design on the optimum route is described in this paragraph. Within the national road network scheme, the envisaged road is intended to comprise one segment of the Kosi highway and as such will serve to connect the Sankhuwasabha district with Hile and points south. At present, the Department of Roads is constructing a road from Hile through Shinduwa to Chitre.

ALT-B, selected as the optimum route, is critical to the construction of the Arun 3 hydropower scheme. Consequently, the subject road will be designed for an access to the Arun 3 Hydroelectric Power Development Project site area of equipment and materials for construction.

Optimum route (ALT-B) begins at Hile, traverses hilly terrain, transits Leguwa Ghat and follows the Arun river to Tumlingtar, the power house site and finally to the dam site planned at Num. The special features of this route are that it experiences a large elevation change along the hilly portion from 2,000 m in the vicinity of Hile to around 250 m at Leguwa Ghat, as well as the fact that a large segment of the road is routed on low elevation river terrace and steep rock cliffs along the Arun. The road plan set out below reflects these complex topographical conditions and the fact that the road is intended for the construction of an access to the Arun 3 site.

(1) Horizontal Alignment

(i) Road length along gentle slopes and Arun river terrace will be maximized to minimize the overall road length as much as possible.

(ii) Alignment will avoid dwellings and cultivated fields to the extent possible.

(iii) Bridge sites will be selected whereby bridge span length is minimized.

(iv) Alignment will follow terrain profile to the extent possible to minimize cutting and embanking.

(v) In this road project, the envisaged road is principally viewed as an access road to the Arun 3 site, and consideration is not given to the selection of a road corridor through the population centers of Chainpur and Khandbari located in hilly areas at some distance from the Arun river.

(2) Vertical Alignment

(i) Road route may be broadly classified into hilly segment and river terrace segments. For the hilly segment, maximum gradient is to be 8%. The segment along river terrace is to be at a location unaffected by flooding, and roadbed embankment height is to be 2.0 m.

(ii) Clearance between bottom level of a bridge girder and an estimated design flood level is to be minimul 1.0 m.

4.4 Bridges

On the basis of 1:5000 scale topo-mapping, eight bridge sites are considered necessary for ALT-B. These sites are indicated in the Table 4-4.

Table 4-4 Proposed Bridge Sites

No.	Station1/	River	Catchment Area (km^2)2/	Bridge Length (m)2/
1	152 + 20	Leguwa khola	35	70
2	143 + 300	Kenwa khola	25	40
3	132 + 310	Piluwa khola	141	90
4	114 + 200	Sabhaya khola	3753/	1203/
5	84 + 110	Chyawa khola	12	40
6	47 + 50	Kaguwa khola	22	40
7	35 + 330	Rata khola	8.6	30
8	34 + 390	Suki khola	6.5	30

Notes: 1/ See DWG. ACR-4 through ACR-29

2/ Computed from 1:5,000 scale topo-map

3/ Computed from 1:500 scale topo-map

In the course of formulating the bridge plan for the subject project, temporary and permanent bridge structures were considered in terms of implementation period and envisaged road function requirements, with particular attention given to the design and construction of the longest span bridge at Sabhaya khola.

4.4.1 Bridge Planning

Main points for consideration in the formulation of a bridge plan are the following:

(1) Bridge design maiximizes the ease of construction and cost effectiveness.

(2) Design maximizes the application of local construction technology, materials and labor.

(3) Operation and maintenance are facilitated.

In addition to the above general criteria, bridge type is determined taking into consideration required substructure, span, etc. as dictated by topographical and geological conditions prevailing at the candidate site. Detailed field investigation of bridge sites including foundation investigation was not included in the subject assignment except for a bridge with a span more than 100 m. A 1:500 scale topo-mapping at the Sabhaya Khola bridge site in particular was prepared during the course of the study. A preliminary selection of all other bridge sites and spans was made on the basis of 1:5000 scale topo-mapping and is indicated in Table 4-4. Three bridges are anticipated as having spans in excess of 60 m, i.e. bridges at Leguwa, Piluwa and Sabhaya Kholas.

Design bridge loads are indicated in Table 4-2. As shown on Fig. 4-3, bridge section is 3.5 m width with 1.0 m wide shoulder on both sides.

(1) Bridge Type

Bridge type for the subject project is broadly classified into those bridges with span in excess of 60 m and those with span less than 60 m.

Typical span length and corresponding bridge types are indicated in Table 4-5. On the basis of these typical types and considering specific requirements of the subject project, candidate bridge types for a bridge in excess of 60 m span length are comparatively examined in Table 4-6. For this bridge, a steel bridge (simple truss) is determined as optimum given the site conditions and constraints affecting construction.

For spans of less than 60 m, a concrete type bridge is conceivable as well as the steel type. However, taking into consideration factors of material availability, skilled labor requirements and difficult terrain conditions, a simple steel truss bridge is considered appropriate. Box girder or continuous girder type steel bridges are not recommended due to transport and erection difficulties stemming from girder weight and length.

Table 4-5 Typical Bridge Type vs. Span Length

	Type	Span Length (L) (50m, 100m, 150m)	Girder Height 1/
Steel Bridge	Simple Composite Girder		L/18
	Simple Beam		L/17
	Continuous Girder		L/18
	Simple Box Girder		L/22
	Continuous Box Girder		L/23
	Simple Truss		L/ 9
	Continuous Truss		L/10
	Inverted Langer Girder		L/ 6.5
	Inverted Lohse Girder		L/ 6.5
	Arch		2/ L/ 6.5
Prestressed Concrete Bridge	Pretentioned Girder		L/15
	Hollow Slab-Bridge		L/22
	Simple T-Type Girder		L/17.5
	Simple Composite Girder		L/15
	Jointed Composite Girder		L/15
	Continuous Composite Girder		L/16
	Simple Box Girder		L/20
	Continuous Box Girder (Cantilever Method)		L/15
	Continuous Box Girder (Timbering Method)		L/18
R.C Br.	Reinforced Concrete Hollow Slab-Bridge		L/20

Note: 1/ L = Span Length

2/ Sag-Ratio

Table 4–6 Comparison Study for Sabhaya Khola Bridge

Bridge Length = 60^M x 2 span = 120^M
Width = 5.5^M

Bridge Types	Construction period (Superstructure and substructure)	Quantity of steel and cost of superstructure	Erection method	Comments
Concrete bridge (prestress concrete)	<u>Superstructure</u> <u>days</u> preliminary works 30 girder manufacture 210 finishing work 15 <u>Substructure</u> pier 210 abutments 180	<u>Weight</u>: 760t <u>Cost</u>: US$1,320/$m^2$	* Slide and extend method, and stazing method (over water) * Slide and extend method (over land)	* Quality control of prestress concrete is difficult. * Procurement and delivery of construction materials and equipment is costly and time consuming. * Skilled labor is necessary. * A wide construction yard is necessary for girder manufacture for superstructure.
Steel bridge (Girder)	<u>Superstructure</u> <u>days</u> manufacture 120 placement 127 <u>Substructure</u> pier 210 abutments 180	<u>Weight</u>: 260t <u>Cost</u>: US$1,250/$m^2$	* Cantilever method (over water) * Staging method (over land) * Travel crane 15t	* Bridge components are heavy. * Large equipment such as crane, etc. is necessary for bridge erection. * Skilled labor such as welders, etc. is necessary.
Steel bridge (Truss)	<u>Superstructure</u> <u>days</u> manufacture 90 placement 101 <u>Substructure</u> pier 150 abutments 150	<u>Weight</u>: 280t <u>Cost</u>: US$875/$m^2$	* Cantilever method (over water) * Staging method (over land) * Travel crane 5t	* Transport and erection of bridge components may be performed by manual labor. * As steel panels are used for slabbing, construction period is short. * Construction can be largely carried out utilizing manual labor.

4.4.2 Sabhaya Khola Bridge

(1) Bridge Site

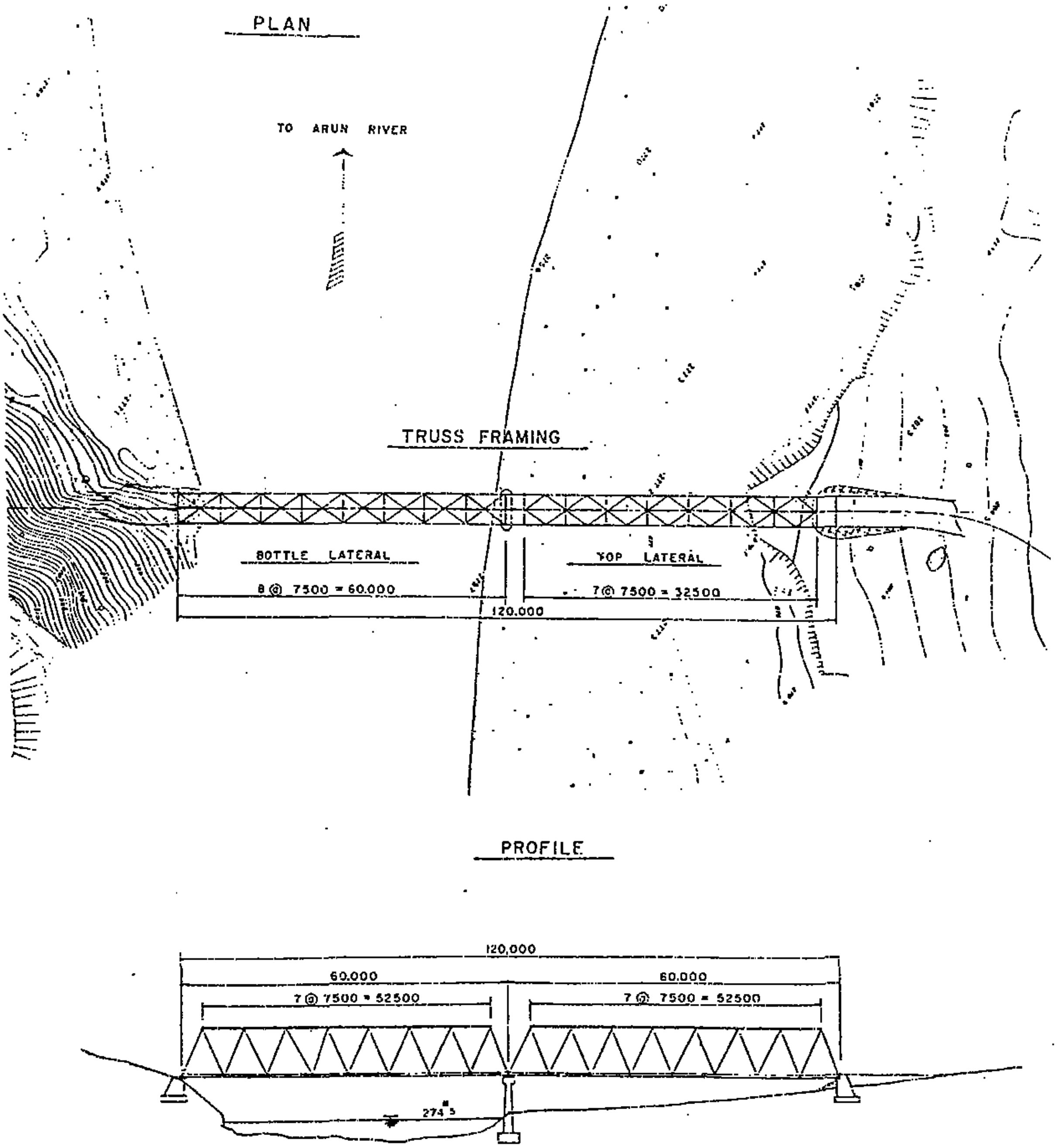
Sabhaya bridge is located on the Sabhaya Khola at a point 500 m upstream from its confluence with the Arun river. The bridge site is on the proposed road route in the vicinity of station 114+400. The site was selected to minimize bridge length and was determined on the basis of 1:500 scale topo-mapping prepared from the results of field survey.

Bridge length is 120 m with two spans. Piers are sited on the major riverbed. Flood traces at the site are evident to an elevation of 281.0 m. Consequently, the elevation of bottom of girder is to be 282.0 m to allow 1.0 m tolerance between girder bottom and flood water level. Optimum bridge location and the said bridge clearance must be finalized during the detail design stage.

(2) Superstructure

Span configuration and steel bridge (simple type) as indicated in Fig. 4-4 are considered appropriate for Sabhaya bridge. Special advantages of the bridge type over others are short time necessary for design and erection, and capability of transport and erection utilizing light equipment or manpower as bridge structural components may be manufactured in small sections.

Fig. 4-4 General View of Sabhaya Bridge



4.4.3 Temporary Bridges

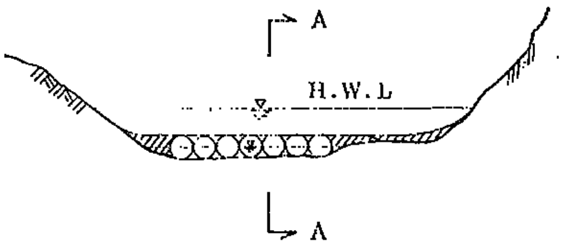
The envisaged road requires completion of construction within a limited period of time. Consequently, the selected construction method must expedite progress to the extent possible. In this light, temporary bridges are necessary to allow transport of road construction materials and equipment across rivers during the implementaion stage. Design and erection of temporary bridges will be as simple as possible. The design and construction of permanent bridges will be carried out parallel with road construction.

As indicated in Fig. 4-5, two types of temporary bridge are preliminarily proposed. One type consists of corrugated pipe, while the other utilizes H-beam. Both types are submerged during high water. Although other types of temporary bridge may be considered, basic emphasis must remain on short construction period and low cost.

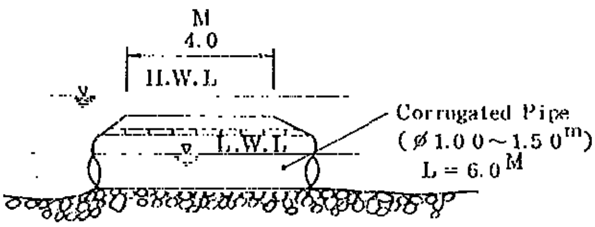
Fig. 4--5 Temporary Bridge Sections

TYPE-- 1

(Corrugated Pipe)

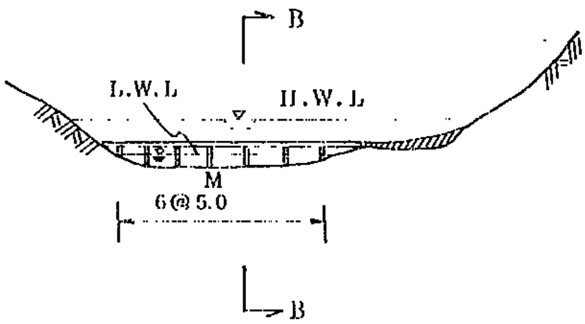


SECTION A-A

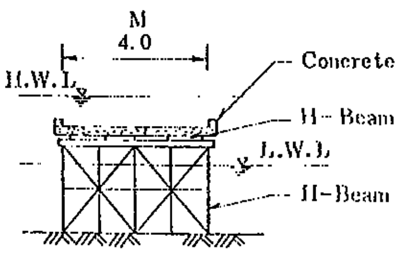


TYPE-- 2

(H--Beam bridge)



SECTION B--B



4.5 Drainage and Slope Protection

Drainage facilities are extremely important to ensure road and traffic safety. Design of said facilities must focus on simple construction, cost effectiveness and facilitated maintenance.

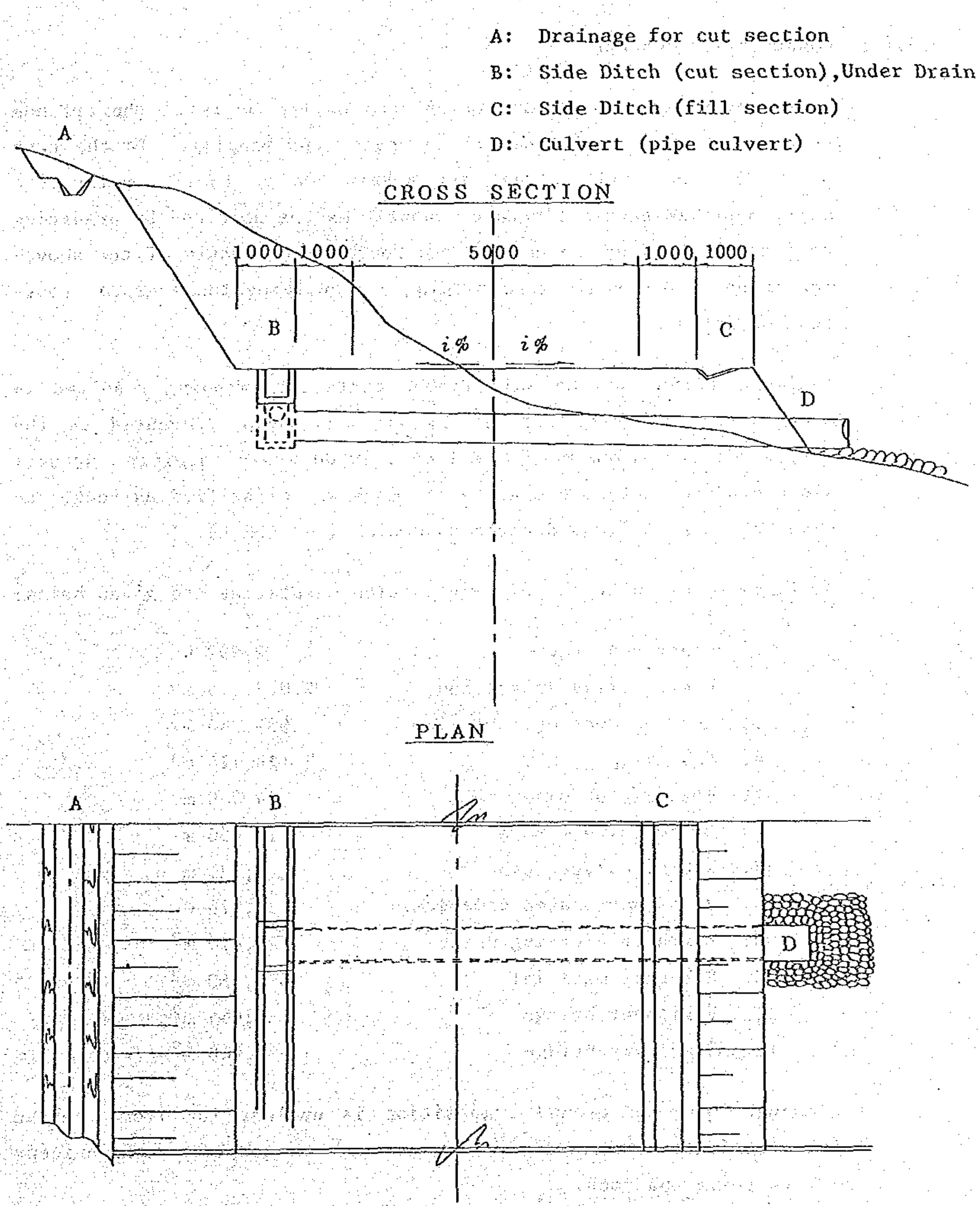
Three types of drainage facility are indicated in the previous section 4.2. The first type comprises an interceptor ditch on the slope shoulder to prevent surface runoff from the upper slope to reach the cut slope and road surface. The second type is an interceptor drain on the road shoulder to catch runoff from the cut slope and road surface. The shoulder drain is underlain by a perforated underdrain to collect subsurface seepage and prevent softening of the roadbed. The third type of facility is culvert pipe underlying the roadbed widthwise to allow exit of water collected in the road shoulder drain and underdrain.

The interceptor ditch above the cut slope should be appropriately treated at its lower portion to prevent seepage, but otherwise can constitute a simple earthen excavation. The road shoulder drain is an open channel either of concrete or masonry. Corrugated pipe is considered most appropriate for sub-roadbed culvert outfalls due to simplicity of construction and short implementation period. Drainage type and location are shown in Fig. 4-6.

Slope protection methods are either of the structure type, or the non-structure type (utilizing plants). In the case of the former, gabions and masonry are typically used in Nepal. The use of plants for slope protection in the country is not common and further study will be required for practical application.

As a general rule for the subject project, cutting and embanking should be kept to an absolute minimum, and where slope protection is necessary, methods commonly applied in Nepal such as gabion and masonry reinforcement should be utilized.

Fig. 4–6 Drainage Type and Locations



5. CONSTRUCTION SCHEDULE AND COST

5.1 Construction Schedule

5.1.1 Construction Quantity

Construction quantities are calculated on the basis of the optimum road route determined from 1:5000 scale topo-mapping. In the case of earthworks which account for nearly 40% of total construction cost, a preliminary estimate of quantities was obtained by preparing road cross-sections along the road route on the basis of the above-mentioned 1:5000 scale topo-mapping and applying the average cross-section method.

Estimates based on the said 1:5000 scale topo-mapping resulted in construction quantity figures larger than those presented in the Interim Report which were based on 1:10000 scale mapping. Natural slope gradient determined at 45° or more was classified as rock, and that less than 45° was denoted as unclassifed (UNCL).

Preliminary calculations of construction quantities are given below:

1.	Clear and grub	2,992 ha
2.	Unclassified excavation	2,017,175 m^3
3.	Rock excavation	989,250 m^3
4.	Embanking	2,126,725 m^3
5.	Interceptor ditch	64,540 m
6.	60 cm culvert pipe	15,650 m
7.	180 cm culvert pipe	6,625 m
8.	20 cm perforated underdrain	22,275 m
9.	Earth reinforcing works	20,675 m^2
10.	Sub-base material	685,380 m^2
11.	Permanent bridge	3,055 m^2
12.	Temporary bridge	1,040 m^2

Although specific ground composition is unclear for item 2 above (unclassified excavation), it is assumed to comprise both unidentified soils and rock.

5.1.2 Construction Planning

(1) General

The construction plan must be formulated so as to ensure safe completion of the works within the designated time period. This requires careful attention to all factors affecting construction, particularly topography, geology, working conditions, etc. Especially in regards to those construction work items which have a critical effect on the construction schedule, the optimum work method must be carefully selected. The envisaged road is to serve initially as access to the Arun 3 site and as such any delay in the road construction schedule will have a major impact on implementation of the said hydropower scheme.

Consequently, the access road construction plan and schedule must be formulated with utmost consideration of the unique features affecting the project. These features may be set out as follows:

(i) The road must be completed within 2 years from commencement of construction to a level whereby access of necessary equipment and materials for Arun 3 hydropower scheme construction is possible.

(ii) Road is routed through hill terrain and as such features topographical and geological conditions which complicate construction.

(iii) Road length is great (115 km).

(iv) Current motorable access to the road project site reaches only as far as Hile.

(v) Eight river crossings are planned.

In view of the features set out above, careful attention must be given during construction schedule formulation to primary works of earth moving and bridge construction, as well as procurement of principal construction materials and equipment.

As indicated in Fig. 5-1, the road route has been divided into 4 construction Sections. Sections were determined with consideration to such factors as topographical features, section length, difficulty of construction, existence of airfield at Tumlingtar, population centers, river crossing points, etc. Principal rivers constitute boundaries between the sections.

Due to lack of existing access roads to the road site area, construction approach will be by Single Front from Hile. Supplemental logistics for all sections will be provided through Tumlingtar airfield.

The four construction sections are as follows:

a. Hile - Leguwa Ghat .... Section 1
b. Leguwa Ghat - Tumlingtar .... Section 2
c. Tumlingtar - Powerhouse site (P/S) ... Section 3
d. (P/S) - Dam site (D/S) .... Section 4

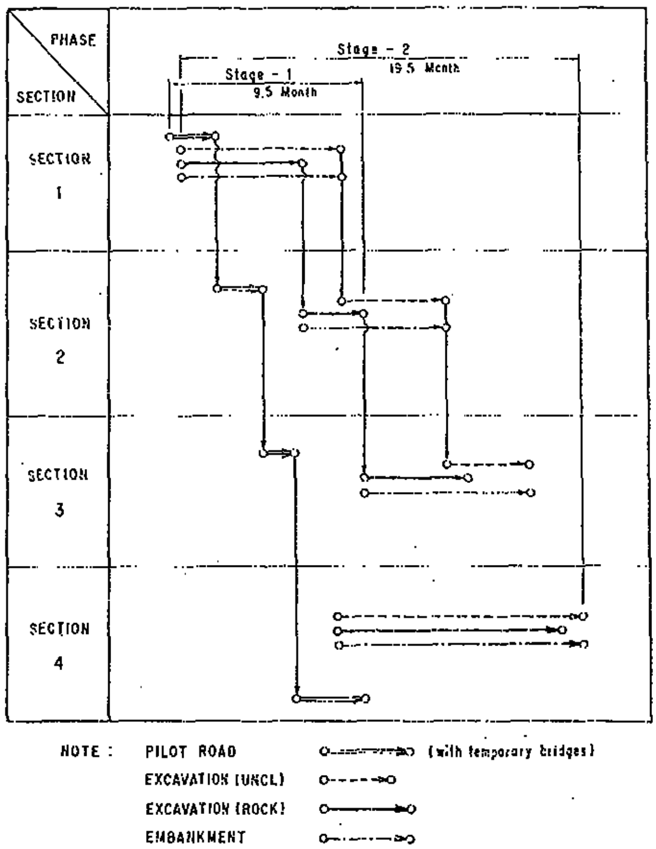
(2) Earth Moving Works

Earth moving works constitute a critical path for the road construction schedule. Said works are affected by factors of rugged topography and large amounts of earth to be moved. Earth moving works are estimated as comprising approximately 40% of total construction cost.

Specifically, earth moving works consist of 3 million m^3 of excavation and 2 million m^3 of embanking. Construction method will accordingly have to be carefully formulated to allow for completion of such large-scale works in the limited time available. In order to minimize the construction period, it is recommended that a Pilot Road be initially constructed.

Given the requirements of the construction schedule for the Arun 3 hydropower scheme, the Pilot Road (total length of 115 km) is to be completed during the 2 year first phase of road construction. Construction of the pilot road will enable subsequent simultaneous implementation of final road construction at the various points along the route as required, thereby minimizing time required for road completion. Of particular importance is the need to commence the large scale rock excavation for the 21 km segment located between the powerhouse and dam sites (Section 4). This work is a potential constraining factor on the overall construction schedule, and as such it is critical to implement as timely as possible the 94 km of pilot road covering Sections 1, 2 and 3 from Hile necessary to reach the said area. Difficulties affecting the pilot road construction vary greatly along the route depending on factors of topography, geology, etc. It may be necessary at some points for the pilot road to temporarily deviate from the final road alignment in the areas where construction is particularly difficult in order to allow for rapid completion of the said pilot road.

A brief construction flow chart for earth moving works is presented below.



As shown in the above chart, the initial construction stage will consist of pilot road construction beginning in sequence with Section 1 and through Section 4 over a period of 9.5 months. In the wake of pilot road progress, equipment will be deployed for earth moving works in Sections 1 - 3 to be carried out in sequence beginning with Section 1. Equipment will be deployed separately, however, for Section 4 immediately upon arrival of the pilot road at that section.

Other construction works (drainage facilities, etc.) will be implemented simultaneously for each of the Sections. (Please refer to Fig. 5-3.)

Table 5-1 indicates envisioned equipment necessary for earth moving works as well as standard production anticipated per day per work party.

Pilot and main road construction work is simply illustrated in Figs. 5-2 and 5-3.

Principal criteria for formulation of the earth moving plan are set out below.

(i) Earth moving works should begin first with light equipment and manual labor to secure sufficient work space for later introduction of heavy machinery.

(ii) Excavated materials will be used as much as possible for embanking, with excess material to be discarded at designated disposal areas.

(iii) Work days per month are 10 in the rainy season and 20 in the dry season, and work hours per day are 8.

(iv) Smooth supply of fuel, oil, consumables and spare parts should be secured to ensure efficient mobilization of equipment.

(3) Bridges

As discussed in the previous section 4.4, the subject road requires three long bridges and five bridges of intermediate length. In order to expedite construction of the pilot road, temporary bridges at river crossing points are envisaged as indicated in previous section 4.4.3. As these temporary bridges are set at the riverbed level, they will be submerged during the rainy season. Permanent bridges will be designed and constructed parallel to earth moving works and thus not constitute a critical path in the overall construction schedule.

(4) Procurement of Construction Equipment, Materials and Aggregate

Principal construction equipment and materials consist of earth moving machinery, bridge components, cement and reinforcing bar for substructure works, and culvert pipe for drainage facilities. Of the aforementioned, cement and reinforcing bar are manufactured in Nepal; however, in light of supply capacity and quality, serious consideration including procurement from off-shore must be given before final decision.

Earth moving equipment, bridge components, fuel, and oil may be entirely procured off-shore. Procurement time period and procedures must therefore be given careful attention.

Aggregate is required for a range of purposes including bridge substructure construction, slope reinforcement works, and as gravel and paving material. Conceivable procurement would be either use of river gravel, or production through crushing of rock. Road alignment segment through hilly terrain is in areas of much rock availability; however, the major portion of said rock is weak due to heavy weathering, etc. Large quantities of good quality aggregate material is nevertheless found in the riverbeds of tributaries of the Arun river. Gravel occuring in the bed of the main Arun river, however is of poor quality, being highly micaceous and fine grained, and consequently not suited as aggregate material.

Approximately 690,000 m^3 of good quality material will be necessary as gravel surfacing aggregate in the course of road construction. Procurement of this aggregate and sub-base works accordingly constitute a critical path of road construction as i) 115 km of road must be completed to a level by the end of 1989 whereby equipment and material may be transported for Arun 3 hydropower scheme construction, and ii) large quantities of aggregate material are required. For these reasons, crushing facilities must be constructed and production of aggregate should begin as promptly as possible following the commencement of road construction. In the event that a portable crushing plant with a capacity of 60t/h is utilized at a rate of 25 days per month and 10 hours per day, monthly production of crushed aggregate is 15,000 t per month. Seventeen months of operation would accordingly be necessary to produce the required 690,000 m^3 of aggregate. As crushed stone aggregate is indispensable in maintenance of a gravel surfaced road, ample production capacity and stock must be available at all times.

Fig. 5–1 Construction Sections

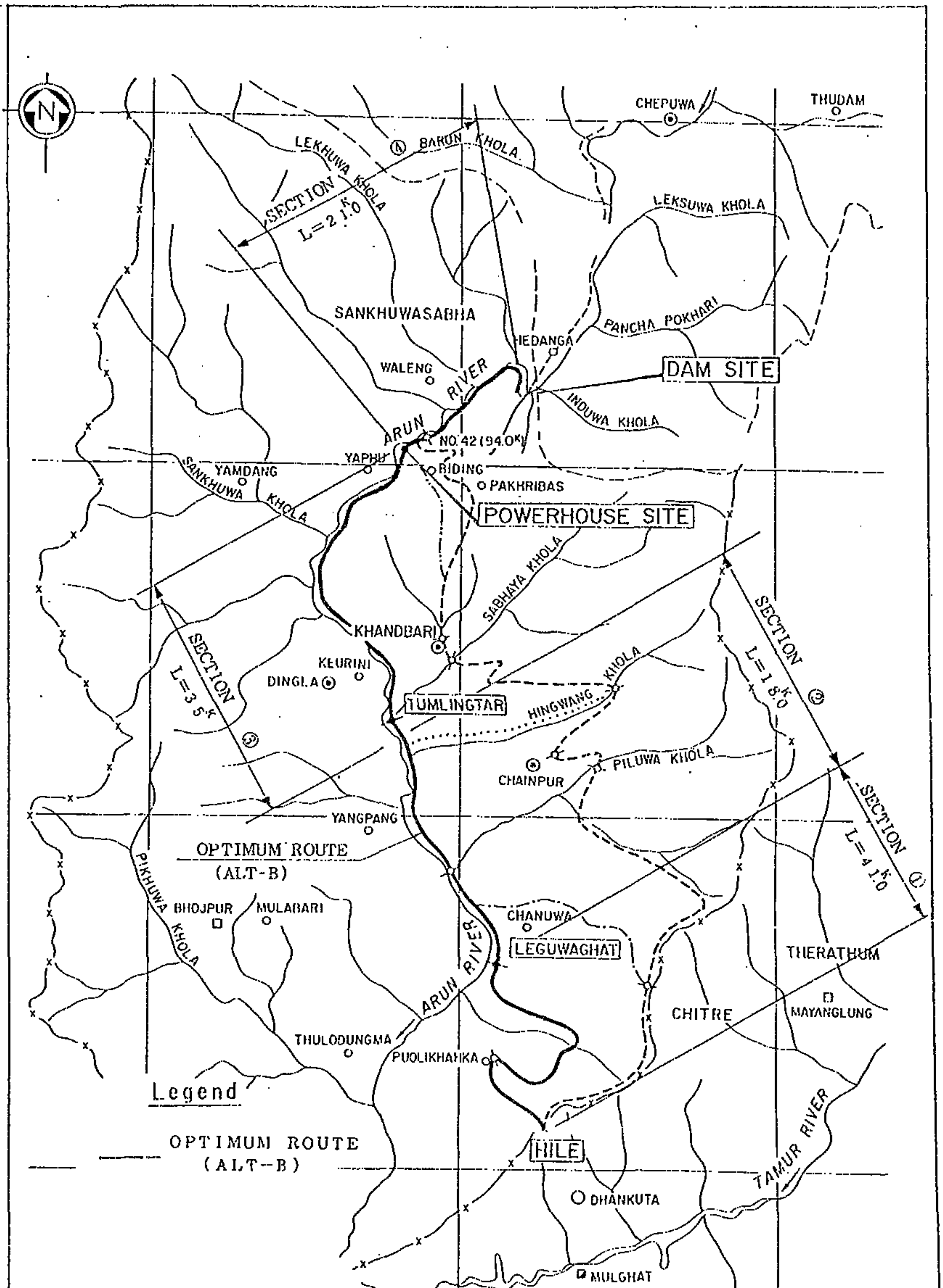
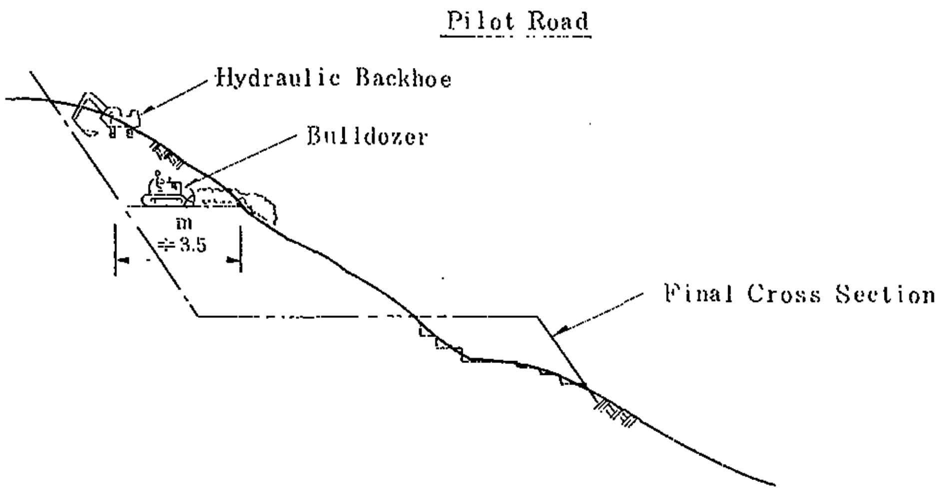


Table 5-1 Earthwork Equipment

Job Item	Equipment per 1-party	Production Q(m^3/day/party)
100 Clear & Grub	2 Saws	1,200
110 Unclassified Excavation	Bulldozer, Hydraulic backhoe, Damp truck, Loader	930
120 Rock Excavation	Drill, Loader, Crawler drill, Dump truck, Bulldozer, Backhoe	11 - 140
130 Embankment	Bulldozer, Roller	200 - 800
105 Pilot Road	Bulldozer, Hydraulic backhoe	430

Fig. 5-2 Illustration of Earthwork (1)



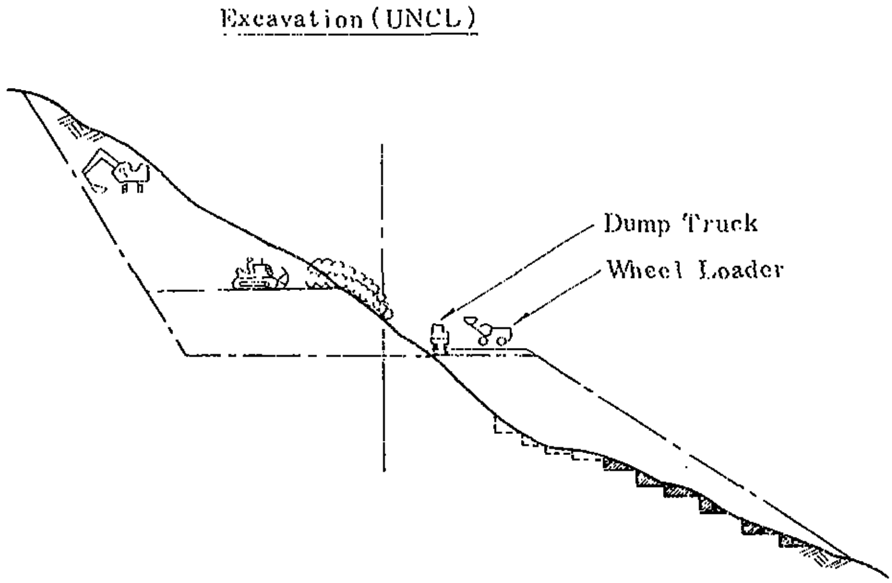
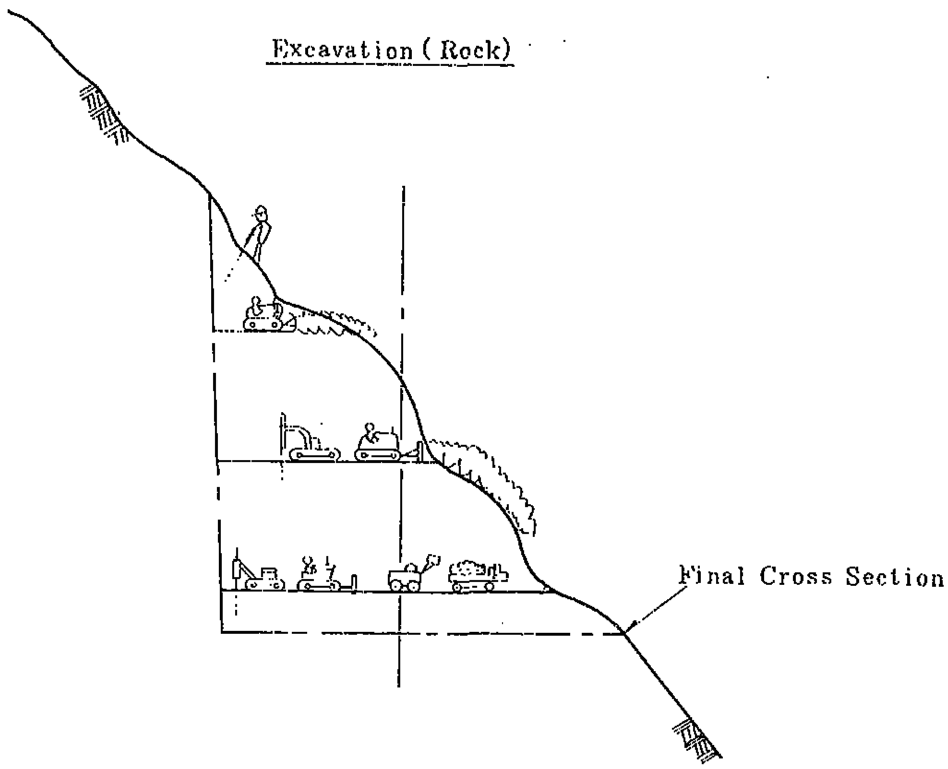


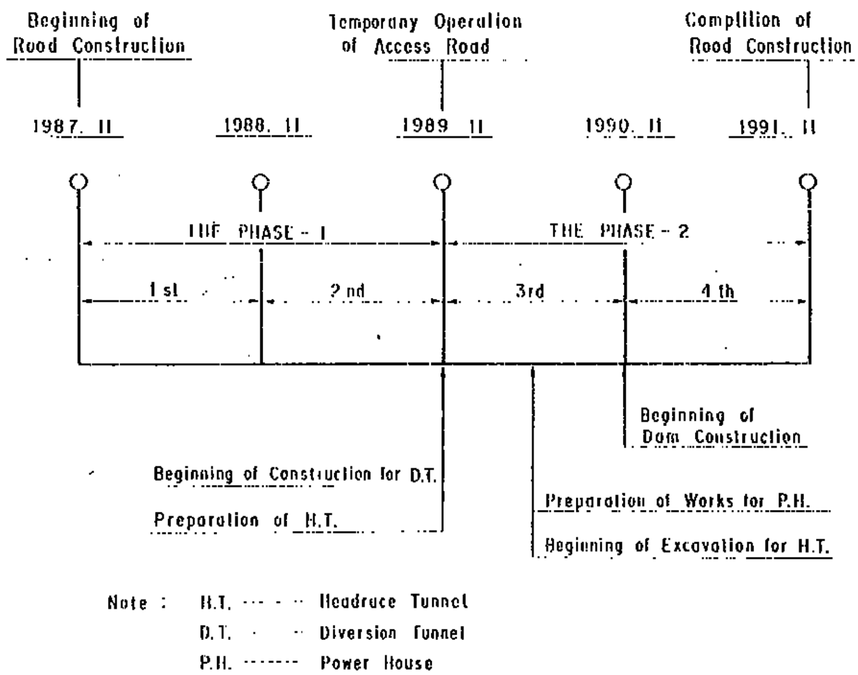
Fig. 5–3 Illustration of Earthwork (2)



5.1.3 Construction Schedule

(1) General

Implementation of the access road is planned as one component of the overall Arun 3 hydropower project. The relationship between access road construction and the Arun 3 hydroscheme construction schedule is depicted in the chart below.



According to the above schedule, access road construction will commence in November 1987, and said road is to be ready two years later in November 1989 for transport of equipment and materials for Arun 3 hydropower scheme construction. The major portion of construction of hydropower facilities is scheduled to begin subsequent to November 1989.

In order to complete access road construction in line with the planned schedule, it is clear that work method must be well suited to construction quantities, and available equipment and manpower. Construction schedule is governed by selection of work method, and said schedule is drawn up to reflect the construction plan set out in the previous section.

(2) Schedule

The construction plan outlined hereunder assumes the following two conditions: i) the road route is divided into 4 construction sections and ii) the entirety of construction works will be tendered as one package, with award to a single tenderer. The reasons for the latter condition are to avoid over-complication of the structure executing construction, as well as the fact that swift completion of the pilot road through all sections is essential and execution by a single contractor entity will expedite timely carrying out of the works.

The following qualifications will be required of the contractor:

(i) Is capable of mobilizing sufficient equipment and skilled personnel (including operators) to execute the works effectively.

(ii) Is well experienced in mechanized construction techniques.

(iii) Is well experienced in construction supervision.

In order to allow for effective utilization of construction machinery, the pilot road is to be completed for Sections 1 - 4 within 9.5 months of start of construction. As the pilot road progresses, excavation (UNCL, rock) is to be carried out in single front fashion for Sections 1 - 3 in succession beginning with Section 1. Excavation in Section 4 will commence immediately upon arrival of the pilot road in that section.

Embanking works are to be carried out simultaneously with excavation utilizing excavated materials to the extent possible. Remaining construction works are to be carried out separately for each section.

Critical points in the access road construction schedule are earth moving works and sub-base works. Consequently earth-moving works are to be carried out immediately in the wake of pilot road progress. Sub-base works will require prompt securement of stable production and supply of aggregate materials, with sub-base work itself being carried out upon completion of earth moving.

If construction is executed in accordance with the schedule indicated in Table 5-2, road completion will be to a level by the end of the first phase construction in November 1989 whereby necessary construction materials and equipment for Arun 3 hydropower scheme implementation may be transported to the site. In the second phase, permanent bridge structures and other remaining works will be completed, with design road section achieved by November 1991. Remaining works denotes upgrading where necessary of i) construction works carried out rapidly during the first phase in order to ensure access to the Arun 3 site by November 1989 or ii) works impaired in rainy seasons occuring during the construction period.

The above are depicted in the bar chart in Fig. 5-4

Fig. 5-4 Access Road Construction Schedule

CONSTRUCTION SECTION	WORK ITEMS	QUANTITY
	PREPARATION WORKS	
SECTION 1	HILE TO LEGUWA GHAT, L=41KM	
SECTION 1	100 CLEAR & GRUB	1067 HA
SECTION 1	105 PILOT ROAD	41 KM
SECTION 1	110 UNCLASSIFIED EXCAVATION	790,425 M³
SECTION 1	120 ROCK EXCAVATION	13,600 M³
SECTION 1	130 EMBANKMENT	1065,525 M³
SECTION 1	200 INTERCEPTOR DITCH	23,000 M
SECTION 1	210 60cm CULVERT PIPE	5,580 M
SECTION 1	230 180cm CULVERT PIPE	2,362 M
SECTION 1	260 20cm PERFORATED UNDERDRAIN	7,941 M
SECTION 1	300 REINFORCED EARTH WALL	7,372 M²
SECTION 1	400 SUB-BASE MATERLAL 20cm	244,353 M²
SECTION 1	600 BRIDGE-LEGUWA KHOLA	455 M²
SECTION 1	610 TEMPORARY BRIDGE	1 PL
SECTION 1	700 MISCELLANEOUS WORKS	
SECTION 2	LEGUWA GHAT TO TUMLINGTAR, L=18KM	
SECTION 2	100 CLEAR & GRUB	468 HA
SECTION 2	105 PILOT ROAD	18 KM
SECTION 2	110 UNCLASSIFIED EXCAVATION	510,175 M³
SECTION 2	120 ROCK EXCAVATION	191,250 M³
SECTION 2	130 EMBANKMENT	240,275 M³
SECTION 2	200 INTERCEPTOR DITCH	10,100 M
SECTION 2	210 60cm CULVERT PIPE	2,150 M
SECTION 2	230 180cm CULVERT PIPE	1,037 M
SECTION 2	260 20cm PERFORATED UNDERDRAIN	3,487 M
SECTION 2	300 REINFORCED EARTH WALL	3,236 M²
SECTION 2	400 SUB-BASE MATARIAL 20cm	107,277 M²
SECTION 2	600 BRDGE-PILUWA,KENWA KHOLA	910 M²
SECTION 2	600 BRIDGE-SABHAYA KHOLA	780 M²
SECTION 2	610 TEMPORARY BRIDGE	3 PL
SECTION 2	700 MISCELLANEOUS WORKS	
SECTION 3	TUMLINGTAR TO POWER HOUSE, L=35KM	
SECTION 3	100 CLEAR & GRUB	911 HA
SECTION 3	105 PILOT ROAD	35 KM
SECTION 3	110 UNCLASSIFIED EXCAVATION	368,075 M³
SECTION 3	120 ROCK EXCAVATION	285,375 M³
SECTION 3	130 EMBANKMENT	333,250 M³
SECTION 3	200 INTERCEPTOR DITCH	19,600 M
SECTION 3	210 60cm CULVERT PIPE	4,763 M
SECTION 3	230 180cm CULVERT PIPE	2,016 M
SECTION 3	260 20cm PERFORATED UNDERDRAIN	6,780 M
SECTION 3	300 REINFORCED EARTH WALL	6,292 M²
SECTION 3	400 SUB-BASE 20cm	205,594 M²
SECTION 3	600 BRIDGE-CHYAWA & KAGUWA K.	520 M²
SECTION 3	610 TEMPORARY BRIDGE	2 PL
SECTION 3	700 MISCELLANEOUS WORKS	
SECTION 4	POWER HOUSE TO DAM SITE, L=21KM	
SECTION 4	100 CLEAR & GRUB	546 HA
SECTION 4	105 PILOT ROAD	21 KM
SECTION 4	110 UNCLASSIFIED EXCAVATION	348,500 M³
SECTION 4	120 ROCK EXCAVATION	380,905 M³
SECTION 4	130 EMBANKMENT	487,675 M³
SECTION 4	200 INTERCEPTOR DITCH	11,840 M
SECTION 4	210 60cm CULVERT PIPE	2,857 M
SECTION 4	230 180cm CULVERT PIPE	1,210 M
SECTION 4	260 20cm PERFORATED UNDERDRAIN	4,067 M
SECTION 4	300 REINFORCED EARTH WALL	3,775 M²
SECTION 4	400 SUB-BASE 20cm	125,156 M²
SECTION 4	600 BRIDGE-SUKI,RATA	390 M²
SECTION 4	610 TEMPORARY BRIDGE	2 PL
SECTION 4	700 MISCELLANEOUS WORKS	
	HYDROPOWER SCHEME CONSTRUCTION	

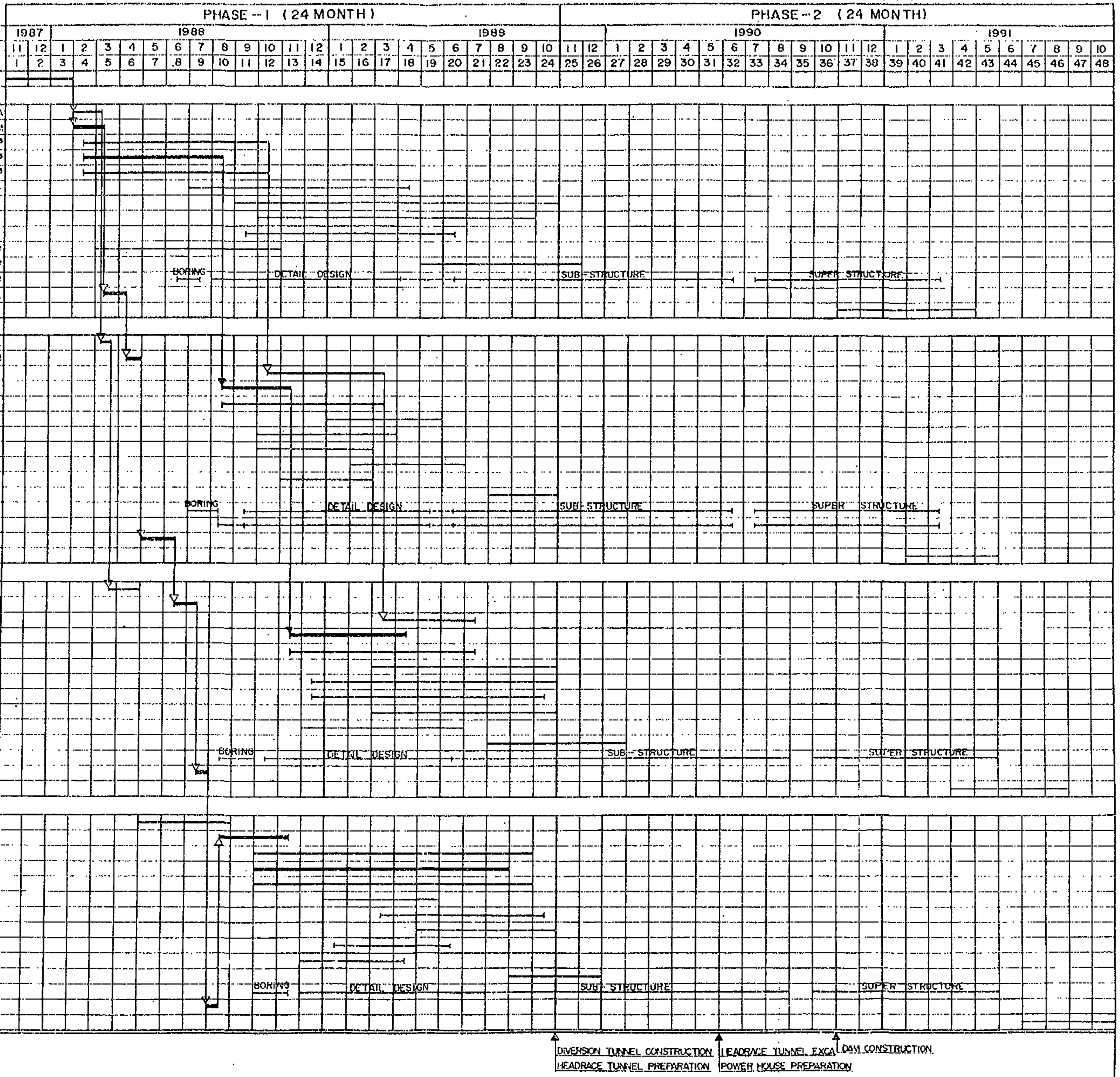


Table 5–2 Major Construction Schedule (continued)

• Main Equipment

Work Items		Equipment	Output	Number	Construction Seciton 1	2	3	4
Pilot Road		• Bulldozer (10T, 21T) Power Shovel (1.5 m^3)	55 m^3/H	Bulldozer 8 unit	1988.2 M 2.3	2.3	1.5 M; month	1988.8 3.5 '88.11
Excavation	UNCL	• Bulldozer (21T) • Power Shovel Loader (1.5 m^3) Dump Truck (10T)	116 m^3/H	Bulldozer 6 units (For Seciton 1, 2, 3) Bulldozer 2 units (For Section 4)	1988.2 '88.10 8.0 M	'89.3 5.0	'89.7 4.0	88.10 '89.10 12.0
Excavation	ROCK	• Braker • Drill • Crawler Drill • Bulldozer (21T) Power Shovel Dump Truck (10T) Loader (1.5 m^3)	Braker 11 m^3/day Drill 36 m^3/day Crawler Drill 80 m^3/day	10 sets Braker 25 sets Drill 15 sets Crawler Drill	'88.2 '88.8 6.0	'88.11 3.0	'89.4 5.0	
Excavation	ROCK	• Drill • Crawler Drill Power Shovel Dump Truck (10T) • Bulldozer (21T) Loader (1.5 m^3)	Drill 40 - 75 m^3/day Crawler Drill 140 m^3/day	10 sets Drill 6 sets Crawler Drill				1988.10 '89.10 11.0

Table 5–2 Major Construction Schedule

● Main Equipment

Work Items	Equipment	Output	Number	Construction Seciton 1	2	3	4
FILL	● Bulldozer (21T) ● Roller (10T)	Pallalell work with excavation		1988.2 – '88.10 8.0 M	'88.8 – '89.3 7.0	89.11 – '89.7 8.0	88.10 – '89.10 12.0
SUB-BASE	● Roller ● Grader Bulldozer ● Dump Truck Wheel Loader	360 m^3/day	10 units Dump Truck 1 unit Grader 1 unit Roller	1989.5 – '89.12 7.0 M	'89.8 – '89.11 3.0	'89.8 – '90.2 6.0	'89.9 – '90. 0I 4.0

5.2 Cost

5.2.1 Unit Cost

The following unit prices are based on the results of field survey by the Study team and information from the report submitted by ACE Consulting Engineers, Kathmandu, Nepal to the Department of Roads of the Ministry of Works and Transportation regarding the Dhankuta-Arun 3 Road Project. Estimated unit prices are as follows:

1.	Clear and grub	US$200.00/ha
2.	Unclassified excavation	1.90/m^3
3.	Rock excavation	7.16/m^3
4.	Interceptor ditch	24.00/m
5.	60 cm culvert pipe	118.00/m
6.	180 cm culvert pipe	367.00/m
7.	20 cm perforated underdrain	40.00/m
8.	Earth reinforcement works	225.00/m
9.	Sub-base material (20 cm thickness)	4.20/m^2
10.	Permanent bridges	1,100.00/m^2
11.	Temporary bridges	260.00/m^2

Unit cost for excavation includes disposal. Bridge unit cost includes both superstructure and substructure.

Construction of temporary bridges (item 11) is to precede permanent bridges in order to expedite overall road construction.

5.2.2 Total Cost

Access road construction cost has been computed on the basis of construction quantities set out in section 5.1.1 and unit costs given in section 5.2.1. A breakdown of costs is presented in Table 5-3. In the said table, "Miscellaneous and other works" are estimated at 10% of construction cost. Costs cover construction from phase one through to the completion of phase two construction as discussed in the previous section 5.1.3, "Construction Schedule".

Total construction cost is calculated 20% greater than the total cost figure in the Interim Report. The reason for this is that construction quantity estimates increased over those adopted at the Interim Report stage when recalculated on the basis of 1:5000 scale topomapping.

Table 5–3 Construction Costs

(No.2 - No.230+230m)

Item No.	Work Description	Unit	Quantity 1/	Unit Price	Amount US$
100	Clear & Grub	ha	2,992	200.00	598,400
105	Pilot Road 2/	km	151	—	—
110	Unclassified Excavation	m^3	2,017,175	1.90	3,832,632
120	Rock Excavation	m^3	989,250	7.16	7,083,030
130	Embankment	m^3	2,126,725	0.75	1,595,043
200	Interceptor Ditch	m	64,540	24.00	1,548,960
210	60 cm Culvert Pipe	m	15,650	118.00	1,846,700
230	180 cm Culvert Pipe	m	6,625	367.00	2,431,375
260	20 cm Perforated Underdrain	m	22,275	40.00	891,000
300	Reinforced Earth Wall	m^2	20,675	225.00	4,651,875
400	Sub-Base Material 20 cm	m^2	685,380	4.20	2,878,596
600	Bridge Structure	m^2	3,055	1,100.00	3,360,500
610	Temporary Bridge	m^2	1,040	260.00	270,400
	Sub Total				30,988,511
700	Miscellaneous & Others Works		10%		3,098,851
	Estimated Total				34,087,362

Notes: 1/ Quantity of this table was revised on the basis of 1:5000 maps produced in Oct. 1986.

2/ Cost for pilot road is included in item Noes. 110 & 120.

Compensation costs for relocation of families, as well as farmland, trees and vegetation of productive value, etc. destroyed through land aquisition for the road route have been included within contingency costs for the Arun 3 hydropower scheme.

6. CONCLUSIONS AND RECOMMENDATIONS

Access road construction constitutes a critical path within the Arun 3 hydropower project construction schedule. Completion of the said road is a controlling factor in commencement of Arun 3 implementation. Construction confronts factors of road length and difficulties in construction posed by the hilly terrain through which the road is routed.

In the course of the subject Study, optimum road corridor selection, construction cost estimation and construction plan formulation were carried out. These works were based on available existing data, results of site survey as well as necessary mapping and drawings prepared in the course of the Study.

Under the Study, firstly a comparitive study of potential road corridors was performed. In particular, two leading candidate alignments, namely the hilltop route (ALT-A) and the Arun riverside route (ALT-B), were compared in detail. Comparison was carried out utilizing existing 1:50,000 scale topomapping and 1:10,000 scale mapping prepared during the study, and principal criteria for comparison included ease of construction, construction cost and time period, road length, etc. On the basis of this study, the riverside route (ALT-B) was determined as the optimum route. The optimum route and major population centers such as Khandbari, Chainpur, Bhojpur and Dingla can be effectively linked by adequate feeder roads. Such network development will contribute to the economical development of the communities.

The selected riverside route is divided into 4 sections. Section 1 begins at Hile, the closest motorable point to the Arun 3 site from the east - west highway traversing the Terai plain, and proceeds 41 km northwest through rugged hill terrain to Leguwa Ghat along the Arun river. The second section extends from Leguwa Ghat north along the Arun river for 18 km to Tumlingtar which features the sole STOL airfield in the project region. Road route through the second section requires bridge structures at 8 crossing points of tributaries of the Arun river. Section 3 continues from Tumlingtar again northward along the Arun river to the powerhouse site. Section length is 35 km. Road route in section 2 and 3 both follow the Arun 3 river on relatively low terrace which is relatively stable both topographically and geologically. Road route through this section features gentle turns of long curvature.

The final section, section 4, extends for 21 km along the Arun river from the powerhouse site to the dam site through an area of steep rock cliffs. Consequently, the quantity of rock excavation required is considerably more than that for the other sections.

The Arun left bank, along which the proposed road is routed, features less agricultural activity. River terrace consists of both cultivated and non-cultivated areas, and the access road will pass to the extent possible through unfarmed land. In section 1 where relatively numerous points of greater population density are found, care in determination of final road alignment was taken to avoid residences and minimize resettlement. Residences affected by road construction are 20. Despite total road length of 115 km, only approximately 90 ha of deforestation will be necessary.

The construction plan for the access road was formulated from the standpoint of integration with the overall Arun 3 hydropower scheme construction plan. The reason for this is that completion of the access road is a principal controlling factor in commencement of Arun 3 construction. Accordingly within two years of start of access road construction, said road is to be completed to a level whereby major equipment and material for Arun 3 implementation may be transported to the hydropower scheme site.

In the latter part of the Study period, the Team received from NEA newly prepared 1:5,000 scale topo-mapping and a field report including field reconnaissance findings, O&D survey, etc. These beneficial materials were effectively incorporated along with the Team's own findings into the evaluation of appropriateness of the selected corridor, and preparation of construction plan and cost estimate.

Principal points of the construction plan are as follows:

(1) The road route was divided into 4 sections in consideration of conditions of topography, geology, problems affecting construction, etc.

(2) A pilot road will be initially completed to permit effective construction works in each of the 4 sections.

(3) Construction method to be applied will emphasize the use of construction machinery.

(4) The completed access road will include 8 bridge structures. However, at the pilot road stage, temporary bridges at riverbed level will be constructed. This will prevent permanent bridge construction from creating a bottleneck for execution of the other access road construction works.

(5) Pilot road construction will be single front, beginning at Hile and continuing on through to completion. Other construction works will be carried out in the wake of pilot road progress. Deployment of equipment and personnel, supervision, etc. will require a high degree of technical proficiency and supervisory experience on the part of the contractor.

(6) It is recommended that the entirety of construction works is tendered as one package, with award to a single tenderer. The reasons is to avoid over-complication of the structure executing construction, as well as the fact that swift completion of the pilot road through all sections is essential and execution by a single contractor entirety will expedite timely carrying out of the works.

(7) Construction quantities were calculated on the basis of 1:5000 scale topomapping, site reconnaissance by foot, and aerial observation by helicopter. Accordingly, some revision of figures may be necessary at the actual implementation stage of construction.

Study findings indicate that the riverside route constitutes the optimum corridor. Construction is possible such that road completion is to a level where access of equipment and materials to the Arun 3 site is possible at the end of two years from start of works, with final road section achieved at the end of four years.

Construction cost is preliminarily estimated at US$4 million to completion of the pilot road and US$34 million to final road completion.

The following recommendations are made as critical to timely implementation of the access road, and as such the Arun 3 hydropower project as well.

(1) Detailed design for the access road should be performed as soon as possible to include minimally the following works:

(i) Preparation of at least 1:2000 scale topomapping for detailed computation of construction quantities. If such mapping is not possible due to time limitations, a tendering format must be considered which permits smooth modification or revision of design as per conditions encountered by the contractor in-situ.

(ii) Foundation survey at bridge sites, particularly for the bridge at Sabhaya Khola.

(iii) Identification of suitable quarry sites.

(iv) Detailed design of sub-base, bridge structures, drainage facilities and other structures.

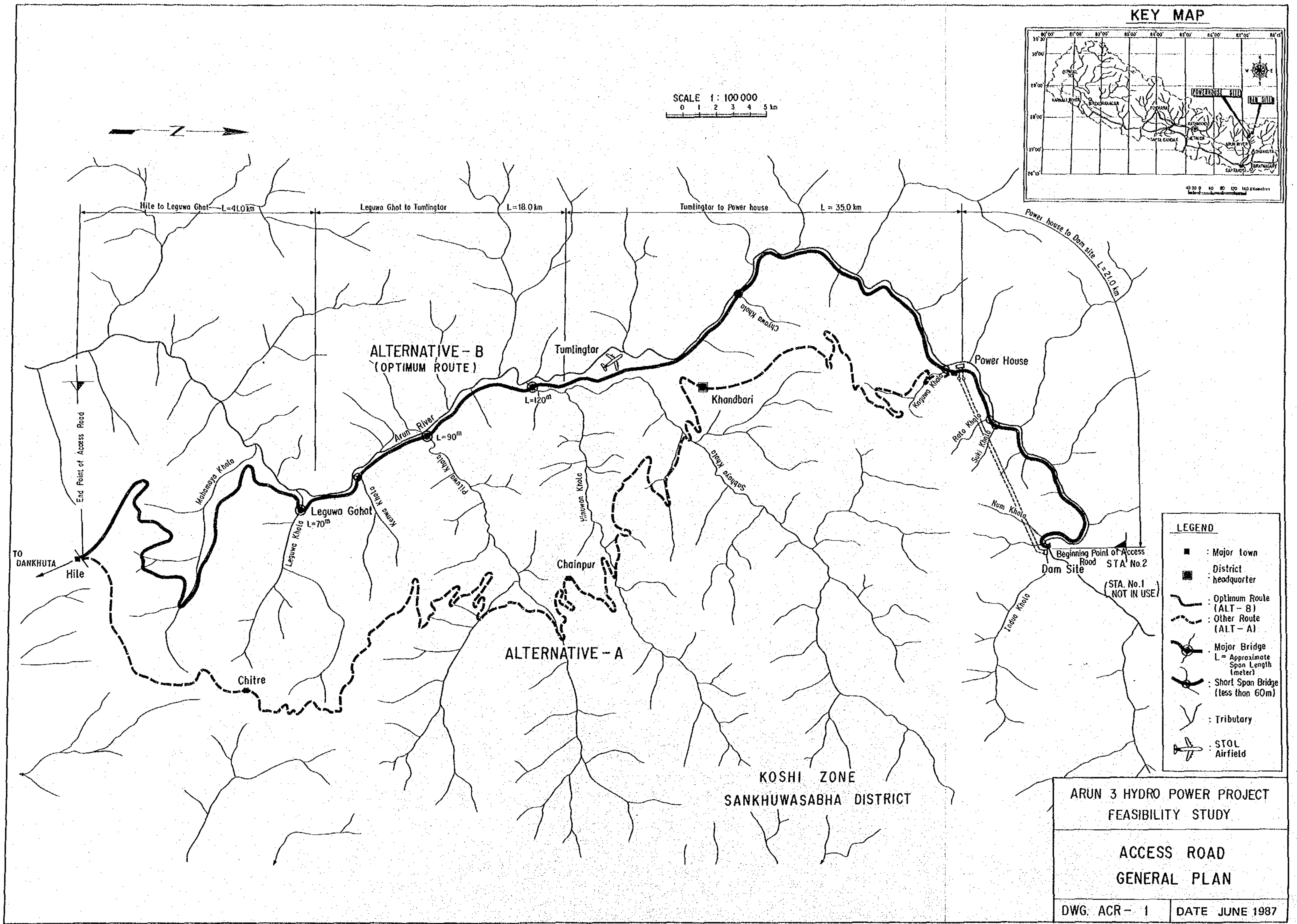
(v) Preparation of tender documents, design specifications, design drawings and study of appropriate tendering method.

(2) Land aquisition should be carried out so as construction progress is not impeded.

(3) An environmental impact study should be undertaken with focus on the long term effects of road construction on the environment. Disturbance during the construction period to the natural ecosystem should be minimized, and construction planning should be critically reviewed from this standpoint.

(4) Design and construction of the access road should be carefully conducted to minimize landslide and soil erosion along the route. Sufficient funds for maintenance should be allocated.

(5) Detailed design of the selected feeder roads closely relating with the community development should also be made according to the development priority.

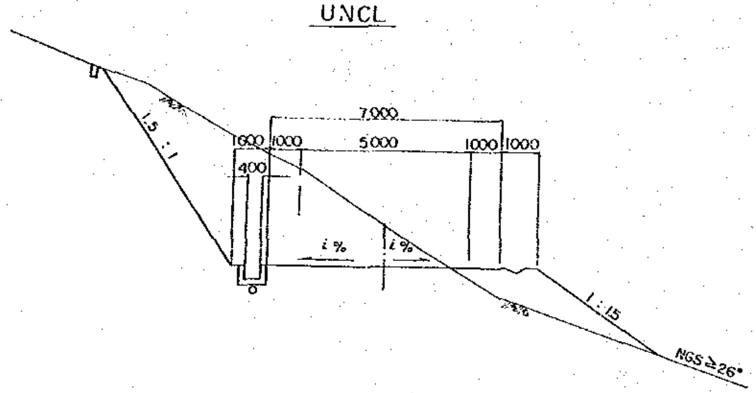


KEY MAP
POWERHOUSE SITE
DAM SITE
SCALE 1 : 100 000
0 1 2 3 4 5 km
N
Hile to Leguwa Ghat L=41.0 km
Leguwa Ghat to Tumlingtar L=18.0 km
Tumlingtar to Power house L=35.0 km
Power house to Dam site L=21.0 km
ALTERNATIVE - B
(OPTIMUM ROUTE)
Tumlingtar
Khandbari
Chyawa Khola
Power House
Kasuwa Khola
Rato Khola
Suki Khola
Num Khola
Beginning Point of Access Road
STA No.2
Dam Site
(STA. No.1 NOT IN USE)
Induwa Khola
End Point of Access Road
TO DANKHUTA
Hile
Mahamaya Khola
Leguwa Gahat
L=70m
Leguwa Khola
Kemma Khola
Arun River
L=90m
Piluwa Khola
L=120m
Hinuwan Khola
Sabhaya Khola
Chainpur
Chitre
ALTERNATIVE - A
KOSHI ZONE
SANKHUWASABHA DISTRICT
LEGEND
: Major town
: District headquarter
: Optimum Route (ALT - B)
: Other Route (ALT - A)
: Major Bridge L = Approximate Span Length (meter)
: Short Span Bridge (less than 60m)
: Tributary
: STOL Airfield
ARUN 3 HYDRO POWER PROJECT
FEASIBILITY STUDY
ACCESS ROAD
GENERAL PLAN
DWG. ACR- 1
DATE JUNE 1987

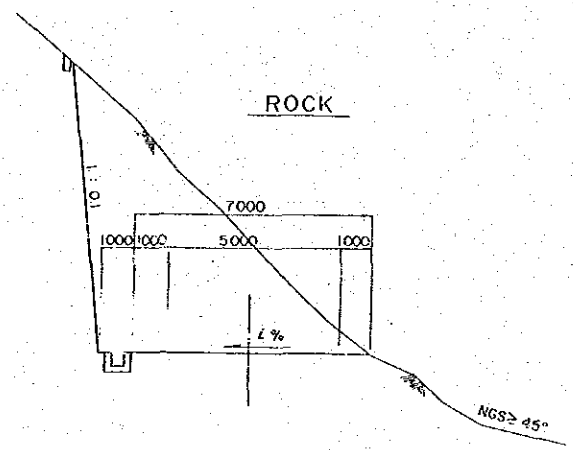
TYPICAL CROSS SECTION

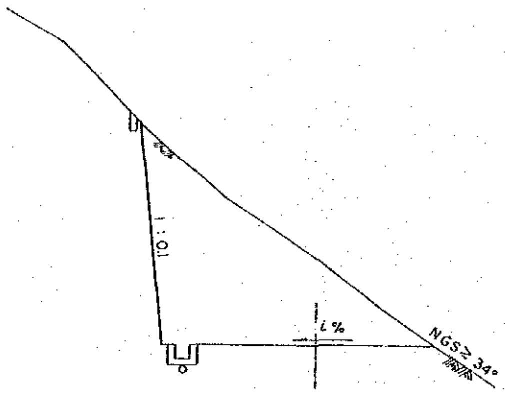
EXCAVATION

UNCL



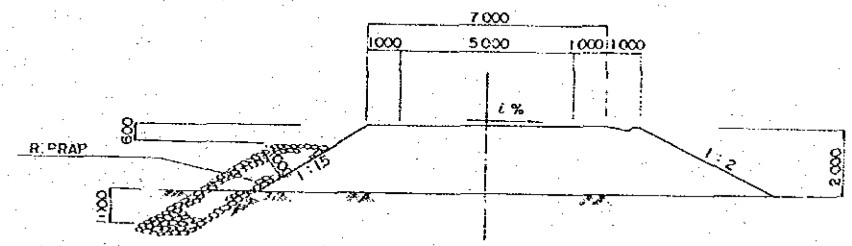
ROCK



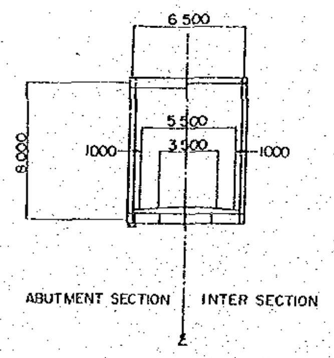


EMBANKMENT Scale 1 : 500

NOTE
N.G.S : NATURAL GROUND SLOPE
UNCL : UNCLASSIFIED
NGS were estimated from 1 : 50,000 map given by NEA

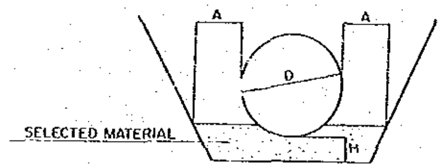


BRIDGES S=1:200



CORRUGATED PIPE

No Scale



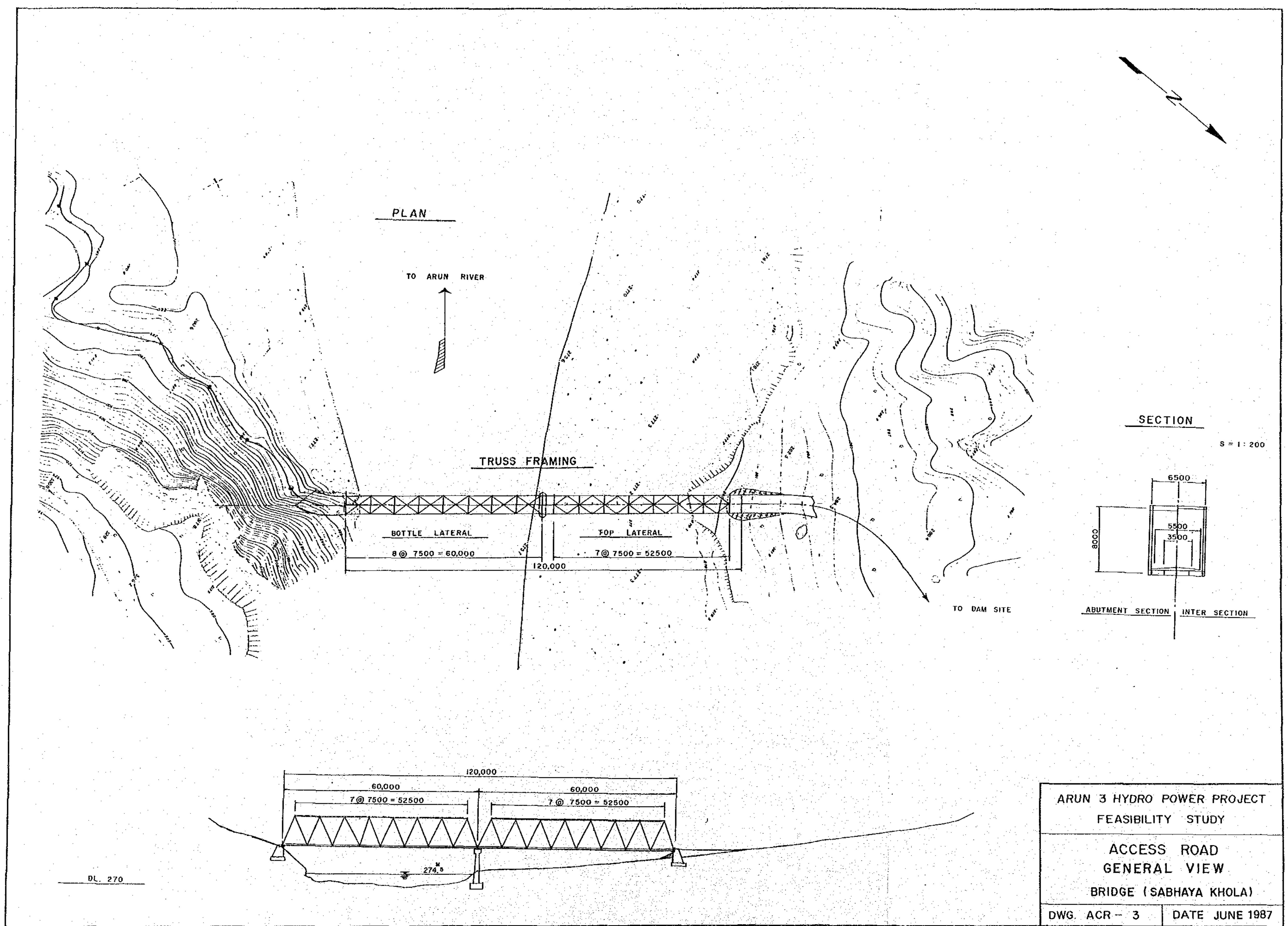
unit : cm

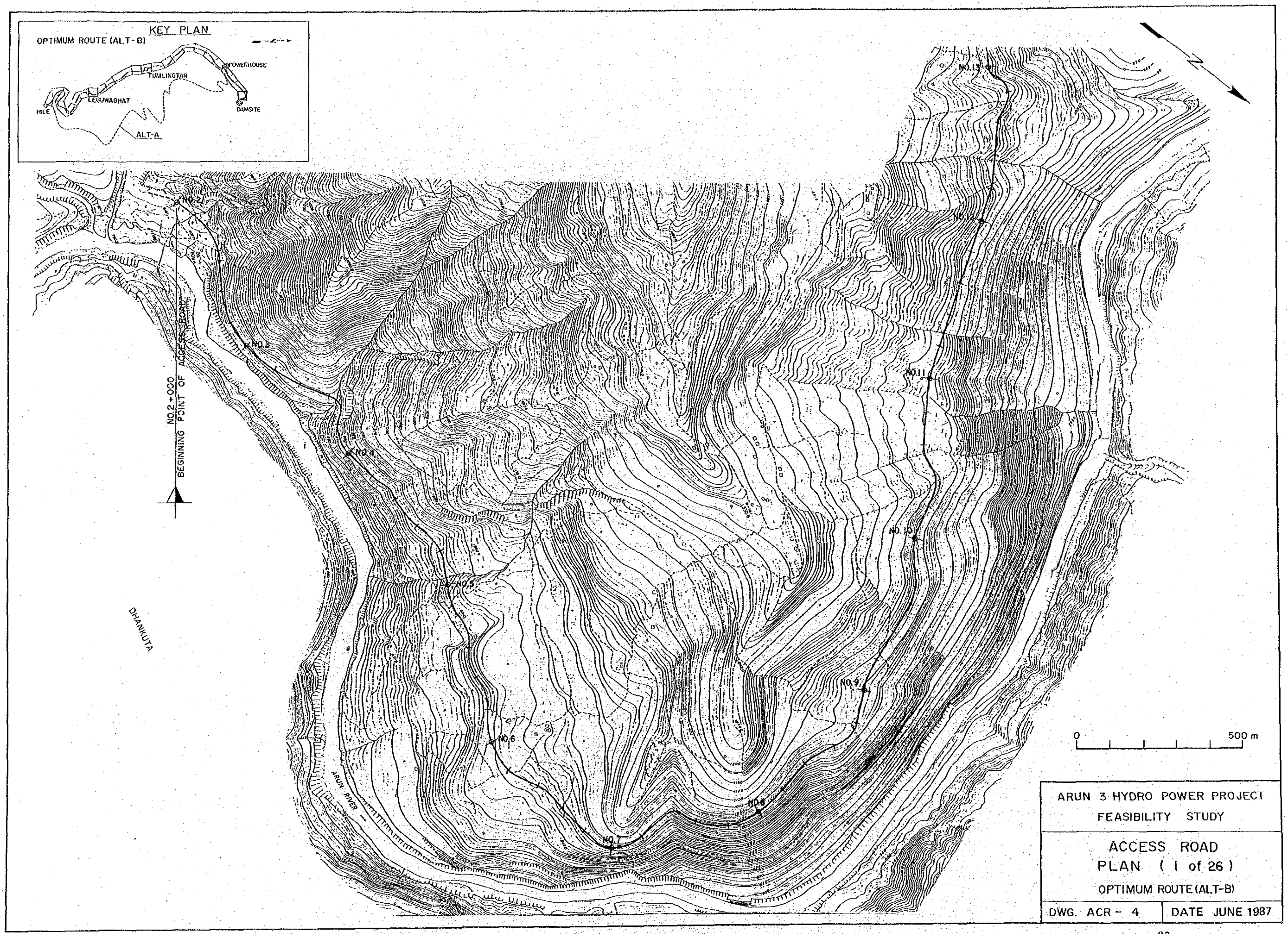
D (ø)	H	A
60	10	50
180	30	50

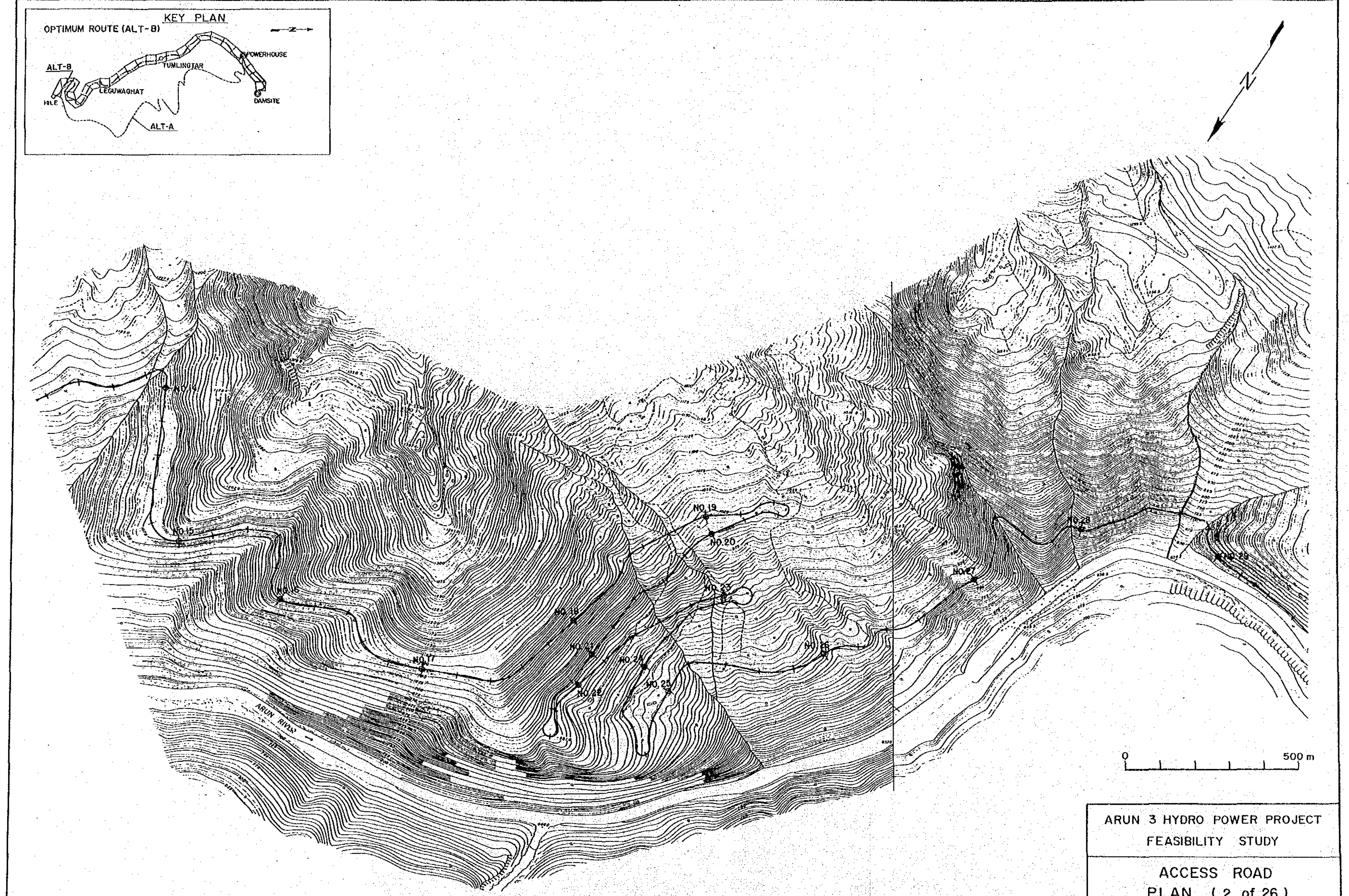
ARUN 3 HYDRO POWER PROJECT
FEASIBILITY STUDY

ACCESS ROAD
PLAN (1 of 28)
OPTIMUM ROUTE (ALT-B)

DWG. ACR – 2 | DATE JUNE 1987


PLAN
TO ARUN RIVER
TRUSS FRAMING
BOTTLE LATERAL
TOP LATERAL
8 @ 7500 = 60,000
7@ 7500 = 52500
120,000
TO DAM SITE
SECTION
S = 1 : 200
6500
5500
3500
8000
ABUTMENT SECTION
INTER SECTION
120,000
60,000
60,000
7@ 7500 = 52500
7 @ 7500 = 52500
274.5
DL. 270
ARUN 3 HYDRO POWER PROJECT
FEASIBILITY STUDY
ACCESS ROAD
GENERAL VIEW
BRIDGE (SABHAYA KHOLA)
DWG. ACR – 3
DATE JUNE 1987


KEY PLAN
OPTIMUM ROUTE (ALT-B)
POWERHOUSE
TUMLINGTAR
LEGUWAGHAT
HILE
DAMSITE
ALT-A
N
NO.2
NO.3
NO.4
NO.5
NO.6
NO.7
NO.8
NO.9
NO.10
NO.11
NO.12
NO.13
NO.2+000
BEGINNING POINT OF ACCESS ROAD
DHANKUTA
ARUN RIVER
0
500 m
ARUN 3 HYDRO POWER PROJECT
FEASIBILITY STUDY
ACCESS ROAD
PLAN (1 of 26)
OPTIMUM ROUTE (ALT-B)
DWG. ACR - 4
DATE JUNE 1987



ARUN 3 HYDRO POWER PROJECT
FEASIBILITY STUDY

ACCESS ROAD
PLAN (2 of 26)
OPTIMUM ROUTE (ALT-B)

DWG. ACR – 5	DATE March, 1987