JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

GOVERNMENT OF MAHARASHTRA,INDIA
DEPARTMENT OF IRRIGATION

MASTER PLAN STUDY
ON
PUMPED STORAGE HYDROELECTRIC POWER DEVELOPMENT
IN
MAHARASHTRA STATE, INDIA

FINAL REPORT
SUMMARY

MARCH , 1998

ELECTRIC POWER DEVELOPMENT CO.,LTD.
PACIFIC CONSULTANTS INTERNATIONAL

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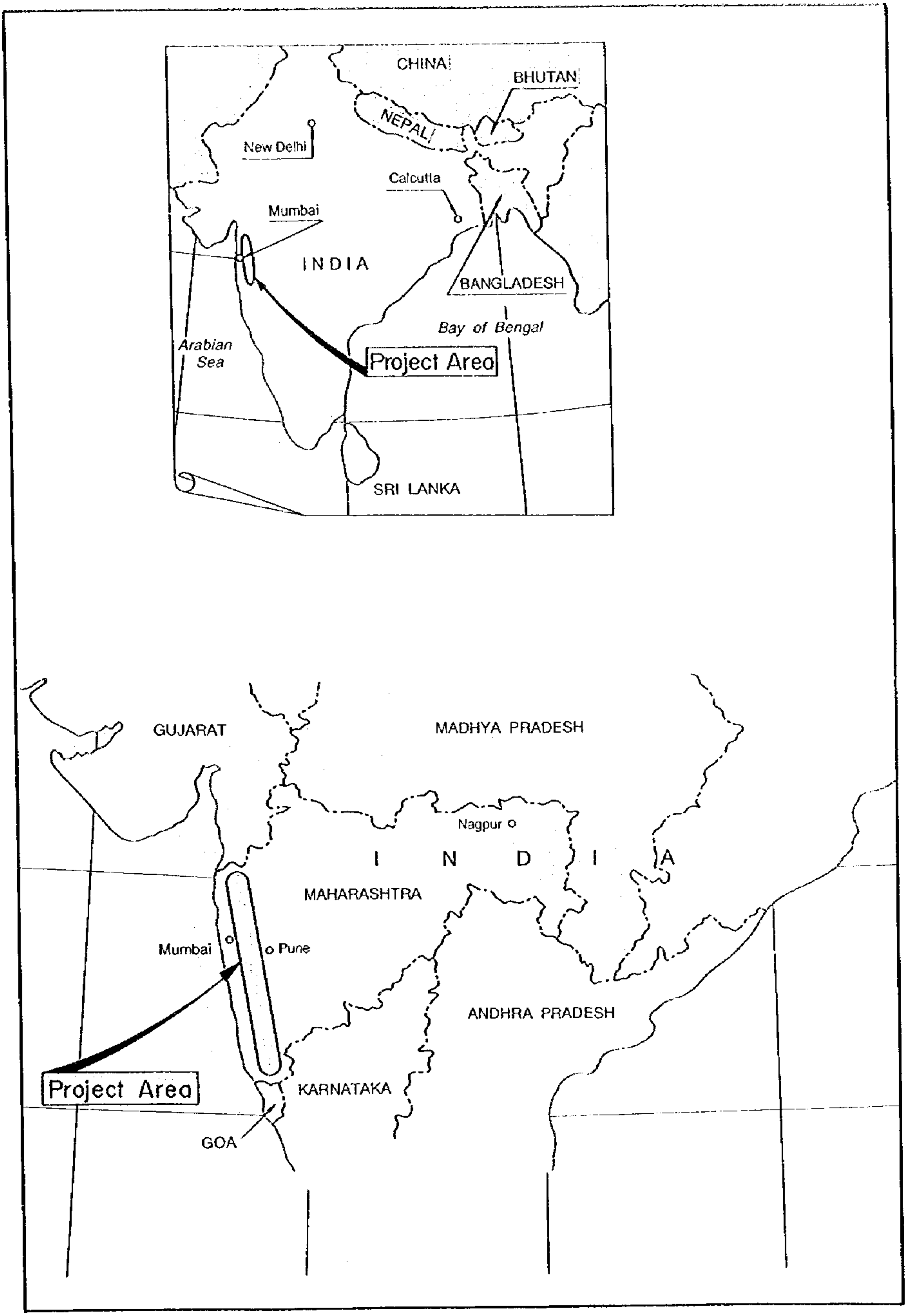
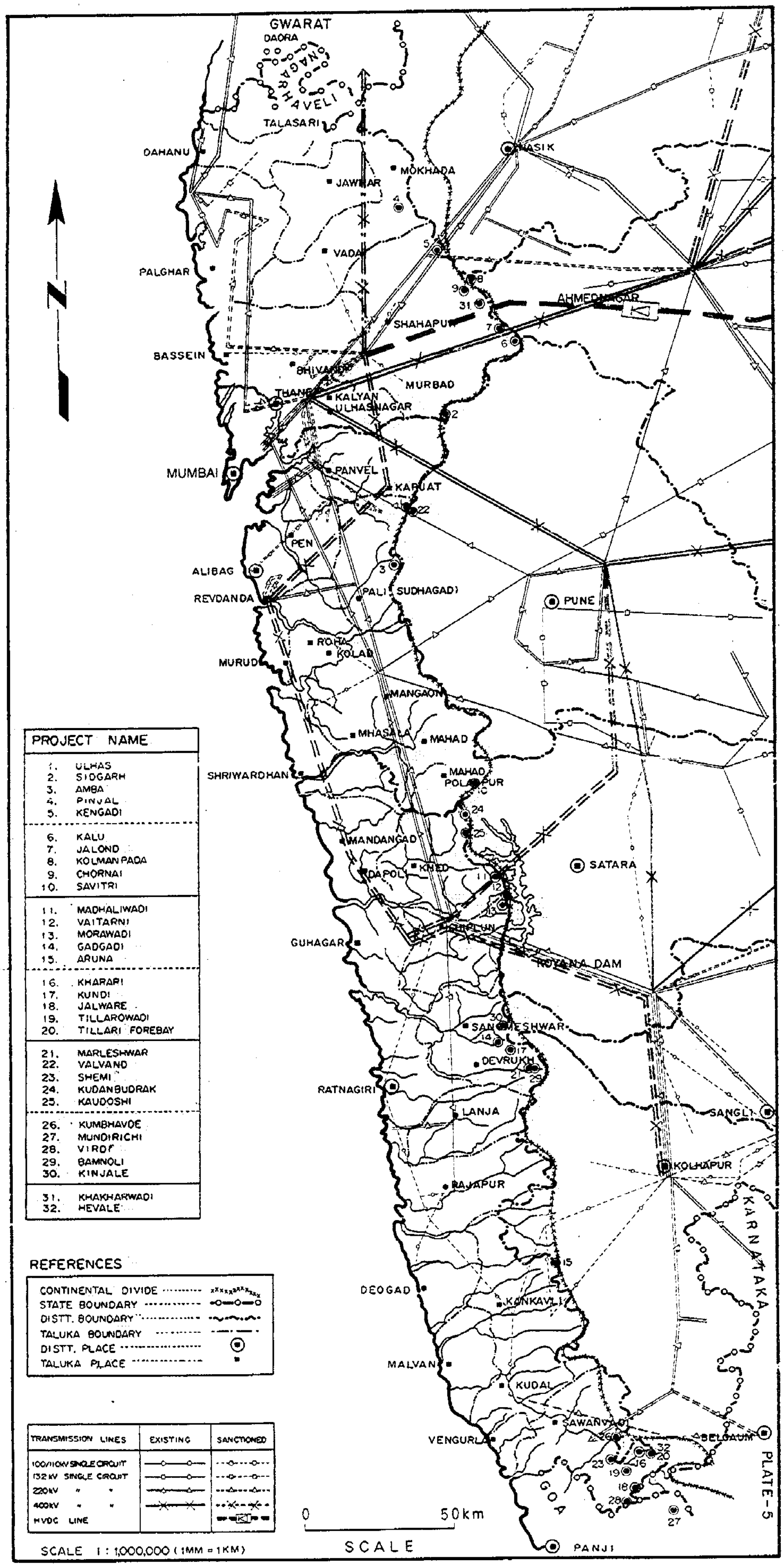
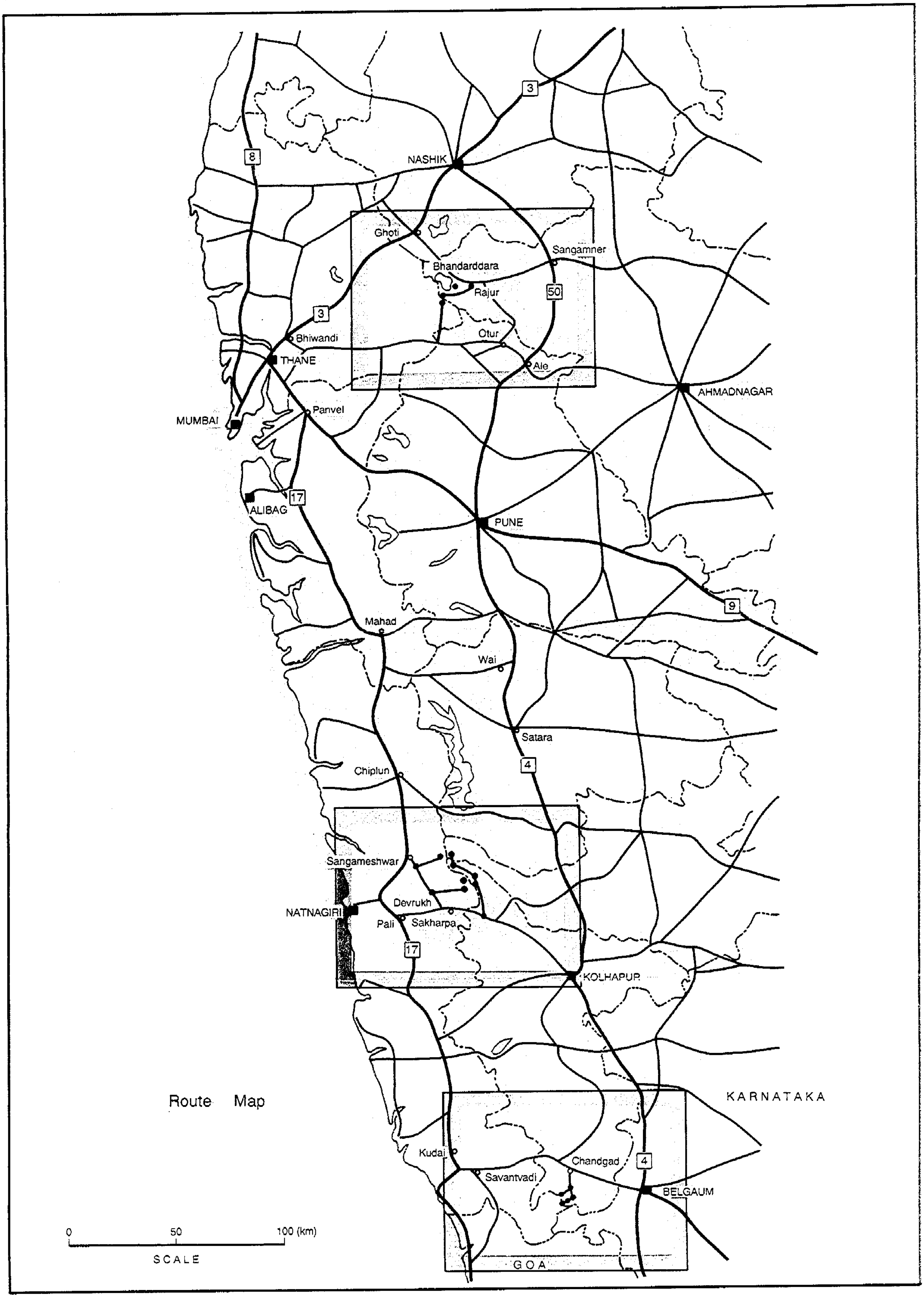
LOCATION MAP




GWARAT
DAORA
NAGAR HAVELI
TALASARI
DAHANU
MOKHADA
JAWHAR
NASIK
VADA
PALGHAR
AHMEDNAGAR
SHAHAPUR
BASSEIN
BHIVANDI
MURBAD
THANE
KALYAN
ULHASNAGAR
MUMBAI
PANVEL
KARJAT
PEN
ALIBAG
REVDANDA
PALI
SUDHAGADI
PUNE
ROHA
KOLAD
MURUD
MANGAON
MHASALA
MAHAD
SHRIWARDHAN
MAHAD
POLADPUR
MANDANGAD
KHED
DAPOLI
SATARA
GUHAGAR
CHIPLUN
KOYANA DAM
SANGMESHWAR
DEVRUKH
RATNAGIRI
LANJA
SANGLI
KOLHAPUR
RAJAPUR
KARNATAKA
DEOGAD
KANKAVLI
MALVAN
KUDAL
SAWANTVADI
VENGURLA
BELGAUM
GOA
PANJI
PLATE-5
PROJECT NAME
1. ULHAS
2. SIDGARH
3. AMBA
4. PINJAL
5. KENGADI
6. KALU
7. JALOND
8. KOLMANPADA
9. CHORNAI
10. SAVITRI
11. MADHALIWADI
12. VAITARNI
13. MORAWADI
14. GADGADI
15. ARUNA
16. KHARARI
17. KUNDI
18. JALWARE
19. TILLAROWADI
20. TILLARI FOREBAY
21. MARLESHWAR
22. VALVAND
23. SHEMI
24. KUDANBUDRAK
25. KAUDOSHI
26. KUMBHAVDE
27. MUNDIRICHI
28. VIRDI
29. BAMNOLI
30. KINJALE
31. KHAKHARWADI
32. HEVALE
REFERENCES
CONTINENTAL DIVIDE
STATE BOUNDARY
DISTT. BOUNDARY
TALUKA BOUNDARY
DISTT. PLACE
TALUKA PLACE
TRANSMISSION LINES
EXISTING
SANCTIONED
100/110KV SINGLE CIRCUIT
132KV SINGLE CIRCUIT
220KV
400KV
HVDC LINE
0
50km
SCALE
SCALE 1 : 1,000,000 (1MM = 1KM)



NASHIK
3
8
Ghoti
Sangamner
Bhandarddara
Rajur
50
3
Bhiwandi
Otur
THANE
Ale
AHMADNAGAR
MUMBAI
Panvel
17
ALIBAG
PUNE
9
Mahad
Wai
Satara
4
Chiplun
Sangameshwar
Devrukh
NATNAGIRI
Pali
Sakharpa
17
KOLHAPUR
KARNATAKA
Kudal
Chandgad
4
Savantvadi
BELGAUM
GOA
0
50
100 (km)
SCALE

Route Map

Jalond: Upper reservoir (Panoramic view from the left hill near Kumshet)

Mareshwar: Upper reservoir
(Panoramic view from the left bank of main dam)

Mareshwar: Lower reservoir
(View from the dam axis to reservoir area)

Tillari Forebay: Upper reservoir, Hevale: Lower reservoir and Upper reservoir
(Panoramic view from the left bank of upper reach)

Hevale: Upper reservoir
(Panoramic view from the top of the mountain to the east)

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CHAPTER 1 INTRODUCTION

1.1 Process and Background

Maharashtra State is situated in western India. With Mumbai, India's largest commercial city, the population of Maharashtra State is 78,700,000. Over the past five years, the power demand in Maharashtra State has increased at a high 8.5% annual growth. As of March, 1993, the maximum power demand was 6,828MW.

At the end of 1994, the installed capacity of the State was 9,324MW, approx. 81% of which was provided by thermal power, this mainly by coal-fired power plants. While the main role of the thermal power generation systems is to supply the base power, they are presently forced to control their output to meet the demand every minute. Consequently, the systems are significantly deteriorated.

Maharashtra State lacks appropriate sites for reservoir type hydro power plants which would be able to effectively respond to the peak demand. Contrarily, with steep mountains to the south and north, the topography of its western region provides many sites which would be appropriate for a pumped storage power project.

The power source of the State is currently concentrated into thermal/gas turbine power generation (81%). According to future development plans, the proportion of thermal/gas turbine power generation will be promoted even further.

Regarding the demand forecast, the difference between the peak load and off-peak load is expected to increase.

Therefore, installation of pumped storage power plant, with its excellent start-shutdown and load follow-up performance, enables the promotion of a highly efficient, regular and continuous load operation of thermal power generation facilities and prevents vary-load operation which is adverse for thermal power generation facilities. It is expected to ensure system safety and improve the system reliability, thereby improving the supply reliability and enabling the highly efficient operation of all related power source facilities.

The Indian Government requested the Japanese Government to conduct a Master Plan Study for a pumped storage hydroelectric power development in the Konkan Region, Maharashtra State, as part of a Project to achieve highly efficient power facility operation in that State.

The Japanese Government agreed to provide technical assistance for this Project and a JICA Preliminary Study Team was dispatched to India from January to February, 1994, with Mr. H. Adachi (Power Development Specialist, JICA) as its leader.

This Preliminary Study Team conducted a site reconnaissance, data collection for the study and also held discussion with Government of Maharashtra Irrigation Department (GOMID). The Scope of Work (S/W) and related Minutes of Meeting (M/M) for the Master Plan Study on Pumped Storage Hydroelectric Power Development in Maharashtra State, India were finalized, and formally agreed upon by the signing by the both parties of the said documents on11th February, 1994.

In order to carry out the study contemplated in the above S/W and M/M, JICA selected a consulting firm and awarded the works to the joint venture of the Electric Power Development Co., Ltd. (EPDC) and Pacific Consultants International (PCI), upon completion of a prescribed documentary examination.

The Study Team, formed in accord with the above Agreement and with Mr. T. Ushijima (EPDC) as its leader, began this Study in September, 1994.

The study team carried out such activities as data collection, review of the previous studied master plan study, hydrological survey, a geological investigation work, and environmental impact accessment.

The field work was carried out in cooperation with the team's counterparts from the GOMID. During the study, the study team transferred technical know-how to their counterparts through the field investigation and JICA invited two counterparts to Japan for technical training. All the work for this Study was completed by March, 1998.

1.2 Objectives, Scope and Contents of Study

1.2.1 Objective of the Study

The Study was carried out to produce a Master Plan for pumped storage hydroelectric power development and to conduct a Pre-feasibility Study of the candidate sites accordingly, thereby establishing a pumped storage hydroelectric power development program for the Feasibility Study in the future for Maharashtra State.

A further objective was to transfer technology related to pumped storage power generation to GOMID engineers.

1.2.2 Area and Scope of Study

(1) Area of Study

The Study was applied to the Konkan Region, a coastal area of Maharashtra State.

(2) Scope of Study

The scope of the Study was a development study for a pumped storage hydroelectric power development.

The scope of Study was initially planned to be carried out in the following three stages;

1) Master Plan Study
2) Detailed Site Investigation
3) Pre-feasibility Study

However, the geological site investigation was partially canceled because parts of the study area were situated in forestry protection areas. Also, permission to take out the 1:10,000 topographic maps produced by the aerial photographic surveys which were carried out by Survey of India from the country was not granted by Government of India. Consequently, only 1) Master Plan study and 2) Detailed site study were carried out, this excluding some geological site investigation work.

1.3 Member of JICA Study Team

Mr. Terumi Ushijima	Team Leader (till March 1996)
Mr. Shigeru Kondo	Pumped Storage Hydro Power Planning Engineer Team Leader (from December 1997)
Mr. Toshio Takahashi	Pumped Storage Hydro Power Planning Engineer
Mr. Toshiyuki Sato	Civil Design Engineer
Mr. Taku Maeda	Hydrologist
Mr. Akio Shikano	Engineering Geologist
Mr. Nobukazu Sugiyama	Geological Investigation Engineer

Mr. S. P. Bagli	Geological Investigation Engineer (Drilling)
Mr. S. S. Vaishampayan	Geological Investigation Engineer (Seismic Props.)
Mr. Toshiro Wada	Electrical Engineer
Mr. Ryuhei Oyama	Electromechanical Design Engineer
Mr. Hideaki Morishita	Transmission Line Engineer
Mr. Sumio Tsuru	Environmental Engineer
Mr. Teruhiko Tsumura	Environmental Engineer (till March 1996)
Mr. Sanpei Nakanishi	Environmental Engineer (from December 1997)
Mr. S. D. Chawathe	Environmental Engineer
Mr. Takao Ozaki	Project Economist
Mr. Hidenori Yaguchi	Coordinator

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CHAPTER 2 GENERAL FEATURES OF THE STATE OF MAHARASHTRA AND PROPOSED SITES

2.1 General Futures of the State of Maharashtra

2.1.1 Geography

The state of Maharashtra is in the west central India with a western coast line along the Arabian Sea and bounded by the states of Gujarat on the northwest, Madhya Pradesh on the north and east, Andhra Pradesh on the southeast, and Karnataka on the southwest. Most of the area comprise the Deccan Plateau.

The third largest state of India, both in area and population, Maharashtra was formed in 1960 when the Marathi and Gujarati linguistic areas of the former Bombay State were separated. Bombay city became the capital of the new state.

Geographically, Maharashtra State is divided into five districts, Konkan, Desh, Khandesh, Marathwada and Vidarbha.

Konkan district is a coastal area. It is a narrow strip some 50 km to 60 km wide and 500 km long stretching from north to south between the Western Ghats mountains to the east and the Arabian Sea to the west.

Desh district is Maharashtra's central and most representative area. It comprises the Deccan Plateau. The principal rivers are the Godavari, Bhima and Krishna, which rise in the Western Ghats and flow southeastward to the Bay of Bengal.

Originating in Trimbakeshwar in Nashik District, the Godavari is the longest river and passes through the cities of Nashik, Kapargaon, Paithan, Gangakhed, and Nanded. The Godavari Valley is the historic cradle of Marathi culture. Here the modern Marathi language emerged.

The Bhima River originates in Bhimashanker and, joined by its tributaries the Kukadi, Pawana, Indirayani, Mula-Mutha, Neera, and Karha, it joins the Krishna River at Raichur in Karnataka State.

The Krishna River originates in maharabaleshwar. Joined by its tributaries Venna, Koyna, and Panchganga, it runs through the cities of Wai, Sangli, Miraj, and Narsobawadi.

Khandesh district comprises the Tapi River Valley where alluvial bottomlands produce cotton, oilseeds, and tobacco. The area has been the object of rivalry as a frequently contested transitional zone between northern and southern India.

Marathwada district comprises Marathi-speaking districts that were part of the former princely State of Hyderabad. Dependence on agriculture as source of livelihood in this district than in any other.

Vidarbha district is easternmost area in the State of Maharashtra. It focuses on Nagpur, the third largest city in Maharashtra.

2.1.2 Climate

Maharashtra State is situated between lat.16°N. and lat.22°N. It lies in the monsoon zone with four clear seasons of summer, rainy season, autumn, and winter.

Winter temperature can soar above 40°C. However, being affected by the sea, the highest temperature along the coast ranges between 20°C to 25°C, although the humidity is high here. From mid-June to mid-October, Maharashtra State experiences heavy rainfall from the southeasterly monsoons. In Konkan, especially, the annual rainfall can reach some 2,500 mm to 3,500 mm.

2.1.3 Population

A 1991 census indicated the population of 78.7 million in Maharashtra State, and 843.9 million in India. The population of Maharashtra State was showing a 25% increase in ten years over the 62.8 million of 1981.

More than half of people in Maharashtra State are engaged in agriculture. Maharashtra State has also played a leading role in the India's march toward industrial development. The main factors supporting this industrial development are the State's geographic location, rich land, long coastline and good ports, its road and railway networks, funding, and abundant human resources and raw materials. Especially, the textile industry has the longest history in India. Maharashtra is also superior in both the fields of machinery production and chemical production. The official language of Maharashtra State is Marathi.

2.1.4 Macro Economy and Power Sector

(1) Growth and Macro Management of Economy

India, with the total population of 929 million (mid-1995) and US$ 337.5 per capita national income, is among the lowest income developing economies in the world. Since its independence after the World War II, India kept politically democratized system with the centrally controlled economy in the major industry sectors. In the meantime, the private sector has been on the track for steady progress and larger share of production. In the 1980s, India kept in shape in economic performance with an average annual growth rate rising more than 5 percent from about 3.5 percent in the 1960s and 70s. This was largely due to an accelerated growth in the industrial sector, gradual deregulation of industry, increasing public expenditure, the steady devaluation of the rupee, and the trade regime liberalization. In 1990, the GDP growth rate dropped sharply to 0.8 % in 1991 largely due to a severe foreign exchange shortage associated with the Gulf War and political uncertainty[1].

In the face of severe balance of payment crisis, a new government launched the policy reform program to restore India's macro economy balance focusing on the investment regime, trade policies, the financial sector, taxation and public enterprises in July 1991. With the government firm decision to maintain the thrust of that bold stabilization and structural policy package, the following FY1992 and 1993 proved to be the years of recovery for India with 4 percent in these two consecutive years.

Over the past five years, reform of the investment, exchange-rate and trade regimes, of the financial sector, and of the tax system have ended four decades of planning and have initiated a quiet economic revolution. Helped by an unprecedented sequence of good monsoons, a relaxation in fiscal policies and a robust supply-response to the reforms, growth gained momentum with real GDP at 6.6 % and 6.2 % (estimate) in the respective of fiscal years of 1995 and 1996. The government's Common Minimum Program of June 1996 identifies the key challenges ahead, vis-à-vis, reducing the country's chronically high fiscal deficits, further liberalizing the economy, agriculture in particular, meeting the infrastructure requirements, and ensuring social justice. Numerically, the government has fixed a 7 percent GDP growth target for the next Five-Year Plan (FY1997-2002).

[1] India's foreign exchange reserves in mid-June 1991 was less than US$ 1.0 billion, only sufficient to finance two weeks of imports.

(2) The Energy Sector、Policy and Issues

(a) Overview

The per capita electric power energy consumption level in India is only about 270 kWh per annum placing the country among the lowest in the world[2]. Despite significant progress in system expansion, power shortages remain one of the binding constraints to overall economic growth in India. In FY1995, a supply shortfall was a little bit alleviated while being downsized to 9 percent of peak capacity requirements. A supply shortfall is projected to increase to 22 percent by the year 2000.

(b) Policy and Issues

Part of the official strategy to increase energy self-reliance and reduce the energy supply-demand gap, the policy goals are set to (i) enhancing the least cost energy development planning in harmonious environment of growth and welfare, (ii) increase energy availability by developing oil and non-oil energy sources, (ii) mobilize local energy resources to the maximum extent possible (renewable and non-renewable). Further, policy goal is aiming at promoting direct investment from external and the domestic private resources to the power sector through the schemes of BOT and/or BOO.

The weak financial position of state electricity boards (SEBs) is counted as another issue in the power sector with a high debt service burden for the Board, exacerbated by the increased cost of borrowing. In this connection, an alleviation of the government burden of subsidy is also called for.

Unlike other states in India, the pace of tariff reform in Maharashtra has been impressive in recent years, with the tariff level increasing at an average annual rate of 7.4 percent in real terms in the 1985-91 period. Rate of return on net fixed assets after depreciation and debt services in 1992 was 3.5 percent which indicated high above the average of all SEBs in India.

[2] This compares with per capita electricity consumption levels of 433 kWh in the Philippines, 688 kWh in the People's republic of China, 1,070 kWh in Thailand, and 1,384 kWh in Malaysia. (Ref: Asian Development Bank, *Renewable Energy Development Project*, AR, 1996, p.2)

2.2 Natural and Social Environment around Proposed Sites

2.2.1 Natural Environment

The proposed three sites are located in the mountain side of the Konkan region. The region lies in a high precipitation zone. The region has three distinctive seasons, namely, Summer (march to May), Monsoon (June to mid-October), and Winter (mid-October to February), and the annual rainfall exceeding 2,000 mm. The main precipitation is brought by Southwest monsoon and about 90% of annual rainfall is received in the rainy season. The average temperature in summer, monsoon and winter seasons in 1990 were 30°C, 27.5°C and 24°C, respectively. The maximum temperature of the year was 47°C, and the minimum temperature was 4°C.

Geologically, Maharashtra forms a part of the peninsula called the Peninsular Shield of India, which is considered to be a very old stable part of the earth's crust. Physiographically, the major part of Maharashtra comprises an ancient plateau exposed for long ages to denudation and approaching peneplain. The mountain systems are of the relict type, the important ones being the Western Ghats or Sahyadri, ranging from north to south, parallel to the coast for almost the entire length of the State with a general elevation of 550 m above the mean sea level. Eastwards, there are plains of Maruthcoda, Khandesh and Vidgrbha. Melghtt range which is a branch of Satpyra hills is on the northern side of the State. It is generally accepted that the western coast has been formed as a result of faulting. The Western Ghats, as a result, comprise the Deccan trap lava flows which are several hundred meters thick near the coast and gradually thin out eastwards. The geographical distribution of minerals in the state have a relation with the type of geological formation in any region. Geologically, the region is formed mainly by layers of basaltic lava. The upper reservoir sites are situated at the elevation of around 700-900 meters from the mean sea level, and the lower reservoir sites around 200-300 meters.

The Western Ghats, where proposed projects sites are located, is one of the evergreen forest regions of the country. The Hevale site comes entirely under semi-green reserved forest, whereas the Jalond and Marleshwar sites comprise both forest and non-forest land including some agricultural land. Forest in Maharashtra is known to be rich in biological diversity. India is rich in biological diversity, with 75,000 species of animals and over 45,000 species of plants. As for the latter, there are 15,000 species of flowering plants, 5,000 of algae, 1,600 of lichens, 20,000 of fungi. Many of these plants have medicinal properties. Although the region still maintains diverse animal and plant communities, the forest degradation is comparably high.

2.2.2 Social Environment

No villages will be directly affected by the project at any of the three sites, although a few villages are located in the immediate vicinity of the Jalond and Marleshwar sites. Villagers lead a self-sufficient life, cultivating non-irrigated and less fertile land and gracing cattle in stony waste land. They grow rice, bajari, nagli and other crops. Some villagers work in Mumbai during the off-season. Villages have no public facilities, except primary schools with one or two classrooms. Electricity is available, but not all the households are under contract to receive power service. Water source is usually wells and occasionally river water. During the dry season, some villages are provided with tanker water.

Agriculture has been a major occupation for the inhabitants of the rural regions of Maharashtra State. However, except sugarcane, the agricultural production per hectare in Maharashtra is less than the national average. The agriculture, mostly, has to depend on monsoon rain. The central regions of Maharashtra have less rainfall in the monsoon season. The irrigated land out of the total land sown in the State is only 13%. The corresponding figures for other States are higher, mostly, 30-90%. The amount of fertilisers used in the State is 66 kg/ha, which is grossly less compared to the corresponding figures for other States, which often exceed 130 kg/ha. About 70% of the people in Maharashtra depend on agriculture, while only 12% of the total cultivated area is irrigated. The principle food crops are wheat, rice, jowar, bajari and pulses, and the important cash crops are cotton, sugarcane, groundnut and tobacco. Villagers near the project sites earn their living by cultivating small, less fertile land and by keeping cattle. Some of the villages are inhabited by tribal population.

Generally, permanent migration does not take place for the general areas of the Jalond, Marleshwar and Hevale sites. On the other hand, seasonal migration from other states or regions does take place; but it is limited mostly to workers who are brought by contractors for various construction activities for roads, dams, buildings, etc. In Hevale, it has been reported that workers are brought for bamboo cutting. Basically, these workers return to their native places after the completion of work.

The State Government has plans to ensure safe water supply to rural population of the State. The progress in this context, however, is still poor, and villagers still have to depend upon the water supply from shallow wells. These wells often dry up in dry seasons; and the villagers have to transport water from long distances. The incidence of water-borne diseases such as typhoid, cholera, dysentery, and other diseases caused by water-borne parasites such as guinea worm becomes high, although those diseases occur sporadically, and do not reach epidemic proportions.

2.3 Routes to Project Sites

2.3.1 General Conditions of Access Roads

Automobiles were used to travel to the sites. Locally obtained jeep-type vehicles were then used to travel between the lodgings to villages neighboring the dam sites. In most cases, the site reconnaissance carried out from these villages to the dam sites were done on foot.

National highways were used to travel between the sites. These national highways are single-lane in both directions and are mainly straight, leading across open fields with wide shoulders which provides good visibility. Road maintenance is relatively good and all the national highways are paved. However, the pavement often suffers damage in the rainy season with overall repair work conducted in all sections after the rains end of rainy season.

Traffic is heavy. This is mainly due to large vehicles such as trucks for material transportation, local buses operated in Maharashtras State, and long-distance buses running between the states. With these large vehicles, there is also a mixture of automobiles, jeep-type vehicles, motorcycles, scooters, auto-tricycles, bicycles, and ox drawn carts.

The traffic on the local roads which connect the national highways is somewhat similar to that of the national highways except there are fewer large vehicles and the roads are narrower.

The final access roads that connect the towns located along these local roads and villages in the vicinity of the dam sites are very different, being narrow, rarely paved and with very uneven, rough surfaces. The roads in the vicinity of the villages near the dam sites are only as wide as the average automobile, and there are sections which are impassable for vehicles other than jeep-types.

Site reconnaissance around the dam sites were conducted on foot. The dam sites and reservoir areas are farmlands and grass lands. These are covered by shrubs with networks of footpaths. Here, local people as well as cattle and sheep grazing in the pastures passed on a few occasions during the survey.

We experienced no problems in movement because this reconnaissance was in the dry season. However, movement during the rainy season is seen as extremely difficult. This is also seen as true of travel on the national highways at that time.

2.3.2 Joland

(1) Upper Reservoir

The village in the neighborhood of the upper reservoir is Kumshet in the Ahmednagar District. The starting point for Kumshet is Rajur which is located on a local road that connects Ghoti on National Highway #3 and Sananmner on National Highway #50. The following shows the approach to the site;

	From	To	Type to Road	Distance (km)
(a)	Mumbai	Ghoti	National highway	115
(b)	Bhiwandi	Rajur	Tar Road	30
(c)	Turn-off	Kumshet	Jeepable Read	25
(d)	Kumshet	Dam site	On foot	2

The roads between Rajur and Kumshet can be traversed by jeep-type vehicles. These roads present a mixture of paved and unpaved sections. The road turns to west at a point 11 km from Kumshet and thereafter becomes very narrow and unevenly surfaced.

Except for the dam site itself, the reservoir areas in the present plan is farmland and movement by Jeep was also possible.

There is a regular, once-a-day round trip bus service to Kumshet.

(2) Lower Reservoir

The village in the neighborhood of the lower reservoir is Merdi in the Thana District. The starting point for Merdi is a point 42 km toward Bhiwandi from Otur located on a local road that connects Bhiwandi on National Highway #3 and Ale on National Highway #50.
Merdi is 6 km to the north from this turn-off.
The following shows the approach to the site;

	From	To	Type to Road	Distance (km)
(a)	Mumbai	Bhiwandi	National Highway	25
(b)	Bhiwandi	Turning	Highway	85
(c)	Turn-off	Merdi	Tar Road	6
(d)	Merdi	Navalwadi	Jeepable Road	2
(e)	Navalwadi	Damsite	On foot	2

The study team moved from the rest house at Bandaradara Dam where we stayed at Merdi via Rajur and Otur.

The road between the Turning and Merdi is asphalt pavement and provides good visibility and easy driving. A bus service is available to Merdi. The survey team changed from automobiles to jeep-type vehicles at Merdi to move further into the village of Navalwadi. From there we walked to the dam site. Jeep-type vehicles were used between Merdi and Navalwadi and, as there were no roads, we drove across farmlands and the like.

2.3.3 Marleshwar

(1) Upper Reservoir

The village in the neighborhood of the upper reservoir is Gothna in Ratnagiri District. The starting point for Gothna is a point 26 km towards Kolhapur from Sakharpa located on a local road that connects Pali on National Highway #17 and Kolhapur on National Highway #4. The team advanced another 24 km from here, then turned to north for Gothna. The Kadvi Dam is under construction at a point 8 km from this turn point. The following is the approach to the site;

	From	To	Type to Road	Distance (km)
(a)	Mumbai	Pali	National Highway	290
(b)	Pali	Turn-off	Highway	42
(c)	Turn	Entrance to Gothna	Jeepable Road	24
(d)	Entrance to Gothna	Gothna	Jeepable Road	6
(e)	Gothna	Dam Site	On foot	2

The study team stayed at a private guest house in Amba, 18 km from Sakharpa in the direction of Kolhapur. The road from the Turning to entrance to Gothna is single-lane only. The traffic on this road is relatively heavy due to trucks hauling earth and sand, probably for use in the construction of the Kadvi Dam. This road is paved up to the Kadvi Dam. Other sections of the road are unpaved and after the dam, becomes a steep gradient with many hairpin curves.

There is a road between the entrance to Gothna and Gothna which although extremely uneven, can be traversed by jeep-type vehicles. This road runs through the projected reservoir site between Gothna and the dam site. Most of the area in these sections are flat farmland and pasture.

(2) Lower Reservoir

The village in the neighborhood of the lower reservoir is Bamnoli in Ratnagiri District. The turning for Bamnoli is 2 km toward Sakharpa from Devrukh which is on a local road that connects Sakharpa and Sangameshwar on National Highway #17. Bamnoli is located 13 km north-east from this turning. On the way, there is a divergence to Marlshwar Temple which is located by a waterfall in the lower reaches of the upper Dam. The following shows the approach to the site;

From	To	Type to Road	Distance (km)
(1) Mumbai	Sangameshwar	National Highway	355
(2) Sangameshwar	Turn-off	Tar Road	18
(3) Turn-off	Bamnoli	Tar Road	15
(4) Bamnoli	Dam Site	On foot	2

The study team lodged at the rest house in Devrukh. The tar road that runs through Devrukh is a by-path running from Sangameshwa to Sakharpa and although paved, is narrower than the other local roads.

It is almost the same as the road to Bamnoli, but a section from a point 1 km short of Bamnoli onward is unpaved. We walked from Bamnoli to the dam site along the cultivated farmland lining the riverside.

2.3.4 Hevale

(1) Upper Reservoir

To reach the Upper Reservoir of Hevale turn right at Motanwadi, which is 11 km short of Tilarinagar which is on the tar road that connects Changad and Tilarinagar, then a further 5 km to get near the Ishvarling Temple, then walk another 2 km to the south through bush land. The following shows the approach to the site;

	From	To	Type to Road	Distance (km)
(1)	Mumbai	Kudai	National Highway	470
(2)	Kudai	Changed	Tar Road	68
(3)	Changed	Motanwadi	Tar Road	13
(4)	Motanwadi	Ishvarling Temple	Tar Road	7
(5)	Ishvarling Temple	Dam Site	On Foot	2

(2) Lower Reservoir

The lower reservoir is located in the neighborhood of the Tillari Hydro Power Station that utilizes the same road. The direct access road is 25 km south of Chandged which lies between Kundai on National Highway #17 and Belgaum of the Karnataka State on National Highway #4. The following shows the approach to the site;

	From	To	Type to Road	Distance (km)
(a)	Mumbai	Kudai	National Highway	470
(b)	Kudai	Changed	Tar Road	68
(c)	Changed	Tilarinagar	Tar Road	24
(d)	Tilarinagar	Dam Site	Tar Road	5

While the approach from Tilarinagar to the site is relatively easy, permission from MSEB is required to go to the lower reservoir site, since it is necessary to pass through the power station site which is under the control of MSEB. There are also many hairpin bends in the steeply inclined road to the lower reservoir.

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CHAPTER 3 CURRENT STATUS OF ELECTRIC UTILITY INDUSTRY AND POWER SUPPLY/DEMAND PLAN

3.1 Current Status of Electricity Supply

The growth in India s power demand during the ten years from 1982 - 1992 was very strong. The annual average growth rate was high at 8.3%, with an elasticity to GDP being as high as 1.57. However, the electric energy consumption per capita is very low, being 294 kWh in 1992. These data appear to indicate that per capita energy consumption is forced to stay low as the national population is as very large at 870 million, while the elasticity to the GDP is high in line with rapidly expanding rural electrification.

India s electric utility industry is administered by the central government and the state governments of each state. There are also small utility companies operated by a small number of private enterprises and IPP ventures from abroad.

The central government has the Ministry of Power (MOP). The Central Electricity Authority (CEA) comes under the MOP's jurisdiction and administers all technical matters and licensing procedures. Currently, in each state, the State Electricity Board (SEB) administers the demand forecast, power development planning and power system operation, as well as executes the business of an electric utility company.

In Maharashtra State, the Maharashtra State Electricity Board MSEB administers all the state s power system operations, including power demand forecast, supply planning, power system planning and power system operation planning (control of frequency and voltage and power trade with other states). It also handles the construction and operation of thermal power plants and the operation of hydroelectric plants. The MSEB constitutes the Western Region Power Council jointly with the Gjarat SEB and Madhya Pradesh SEB, and owns the inter-state interconnection transmission lines between these states and also those between Andhra Pradesh, Karmatak and Goa States.

The planning and construction of hydroelectric power plants in Maharashtra State is administered by GOMID (the irrigation bureau of Maharashtra State) which is the counterpart of this study. When a new hydroelectric power plant is completed, it is operated for testing for a certain period and then transferred to the MSEB.

3.2 Current Status of Power Supply Facilities

Maharashtra State consumes some 15% of India is total electricity consumption, thereby making it the largest power consuming state. In 1993, the net energy consumption was 36,808 GWh. This consisted of 17.6% household consumption, 43.0% industrial, 24.2% agricultural, 15.2% commercial, and others. The majority of electricity was consumed in Bombay, Pune, Nagpur and their surrounding areas where the population and industrialization is high. In Maharashtra State, the annual energy consumption growth rate from 1983 to 1993 was 7.5%.

The Study mission surveyed the current status of existing power facilities in Phase-1 survey in India. The Mission observed the central load dispatching office of the Western Region and obtained data on the maximum daily load curve and minimum daily load curve for 1993 through discussions with the office staff.

In the Phase-2 Survey in India, the Study Mission surveyed the current status of existing thermal power plants. These thermal plants are to serve the pumping resources of pumped-storage power plants with their night output.

As of the end of 1994, the total installed capacity of existing power generation facilities in Maharashtra State was 9,324 MW and consisted of 1,589 MW by hydroelectric power (17%) and 7,545 MW by thermal power (81%). In addition, the MSEB has a 1,548 MW share of the thermal power plants owned by the NTPC and the nuclear power plants owned by the NPC. These thermal power plants are located at the mine mouths of eastern coal mines and are operated for base load supply. The base load thermal power in the whole state represents 81% of the total installed capacity.

Under these conditions it is very difficult to operate the power systems in terms of voltage and frequency control. These was an example wherein the system frequency fluctuated from 51.30 Hz at light load to 48.4 Hz at heavy load. This indicates that the power system badly lacks peak supply sources such as large hydroelectric plants or pumped-storage plants.

3.3 Power Supply/Demand Plan

The power demand projection up to 2010 in Maharashtra State is presented in the 14th Power Demand Projection Report released by the MSEB and CEA. According to this Report, it is anticipated that the demand growth rte from 1995 to 2001 will be 7% on annual average, 6% from 2002 to 2006, and 5% from 2007 to 2010.

According to the power development plan of Maharashtra State, the total system capacity will grow from the 10,722 MW of 1994 to 18,69 MW by 2002. The portion of this 7,922 MW increment supplied by hydroelectric power is only 1991 MW.

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CHAPTER 4 PUMPING RESOURCES IN MAHARASHTRA STATE

The pumping resources in Maharashtra State were calculated based on this demand projection, power development plan and the daily load curves of maximum load day and minimum load day, which information was supplied by the central load dispatching office of the Western Region. The figures given in the table below were obtained by this calculation, indicating that at least 700 MW of pumping resources will be available after 1995, and 1,200 being estimated to be a credible value for 2010.

Table 4.1 Pump Resources and Generating Energy in Maharashtra (1993 - 2010)

Year	Pump Resources	Pumping Hours	Gross Pumping Energy	Generating Energy
1995	700 MW	5.5 h	3,850 MWh	2,503 MWh
2000	1,900 MW	6.0 h	10,900 MWh	785 MWh
2005	900 MW	5.5 h	4,750 MWh	3,088 MWh
2010	1,200 MW	5.3 h	6,400 MWh	4,160 MWh

The power flows of the power system including these pumped-storage plants have been calculated for years 2000, 2005 and 2010 for the maximum and minimum loads. The required amount of reactive power compensating devices and transformer tap positions that enable adequate power flow distributions in each case have also been calculated.

The power system stability has been calculated for the three pumped-storage sites to be selected, and it was verified that all these sites present no stability problem.

CONTENTS

CHAPTER 5 SELECTION OF PRIORITY PROJECTS

5.1 Primary Inventory Study

5.1.1 Procedure for Formulation of Scheme

The Study Team confirmed the locations of upper and lower dams of 23 schemes which had been identified by GOMID on the topographical sheets with the counter part from GOMID during the first site survey.

The Study Team received the Pre-investigation Study (PIS) Report of 23 schemes prepared by GOMID.

Also the Study Team identified fresh pumped storage power schemes other than 23 schemes identified by GOMID using topographical maps. The Study Team gave his attention on the hill top reservoir type pumped storage scheme which had not been included in 23 schemes, for identification of scheme.

The preliminary economic evaluation is shown **Table 5.1-1**.

5.1.2 Conclusion of Primary Inventory

32 schemes were planned and examined at the primary inventory stage.

However, upper reservoirs of Savitri, Kundi are located in Krishna river basin and lower reservoirs are located in Western flow river basin and will create a water right issues against other states. The other hand, Maharashtra state has a right to utilize the water resource in the upper stream basin from Paithan dam on Godavari river even with diversion water scheme.

And a private power utility company is proposing Maharashtra State Government to implement Valvande project utilizing Private Sector participation policy.

According to the result of the primary invenry study, GOMID and the Study Team had a conclusion that Jalond, Kinjale Marleshwar, Tillari Forebay and Hevale were taken up for the site reconnaissance in the next step.

5.2 Secondary Inventory Study

After conducting the site reconnaissance at Joland, Morleshwal, Kinjale, Tillari Forebay and Hevale sites, the preliminary inventory was revised based on the results of site reconnaissance for the secondary inventory study.

Based on the secondary inventory study, Marleshwar, Jalond and Hevale projects should be taken up and the detailed site investigations should be conducted for the above said projects in the next stage.

Table 5.1-1 Outline of Project (1/2)

	Items	Unit	1 Ulhas	2 Sidgarh	3 Amba	4 Pinjal	5 Kengadi	6 Kalu	7 Jalond	8 Kolman -pada	9 Chornai	10 Savitri	11 Madhali -wadi	12 Vaitarni	13 Morawadi	14 Gadgadi	15 Aruna	16 Kharari
	Installed Capacity	MW	600	350	500	30	160	300	1,000	250	480	1,000	500	360		200	440	420
	Unit Capacity	MW	150	175	250	30	160	150	250	125	240	250	250	180		100	220	210
	Number of Units	unit	4	2	2	1	1	2	4	2	2	4	2	2		2	2	2
Upper	Catchment Area	km^2	6.68	1.00	6.21	2.85	2.45	3.10	20.68	3.38	2.83	5.51	2.68	1.28		0.78	4.78	3.22
	Surface Area	km^2	1.27	0.20	0.47	0.07	0.99	0.54	1.78	0.35	0.85	0.40	0.33	0.25		0.35	0.27	0.52
	Crest Elevation	EL. m	680	906	698	367	590	863	865	828	782	908	683	680		820	882	809
	F.R.L	EL. m	676	902	694	363	586	859	861	824	778	904	679	676		816	878	805
	M.D.D.L	EL. m	670	886	674	349	576	848	850	810	765	874	649	664		786	850	792
	Drowdown	m	6	16	20	14	10	11	11	14	13	30	30	12		30	28	13
	Sedimation Level	EL. m	661	877	665	340	570	839	841	801	756	865	640	655		766	841	783
	Gross Reservoir Capacity	$10^6 m^3$	12.29	2.75	6.65	3.15	5.20	6.09	21.30	4.56	8.50	9.97	6.42	2.52		1.98	5.17	6.11
	Generating Reservoir Capacity	$10^6 m^3$	4.80	2.20	4.28	1.34	2.50	2.50	7.50	2.36	4.55	6.50	4.80	3.36		1.34	3.28	2.94
	Dam Height	m	45	36	58	37	35	48	45	43	32	49	50	35		50	52	37
	Dam Crest Length	m	960	550	320	450	550	550	500	650	600	500	550	450		500	450	450
Lower	Catchment Area	km^2	4.56	0.92	7.99	32.11	5.48	2.71	3.43	3.31	2.48	7.41	6.79	9.61		13.92	2.82	9.12
	Surface Area	km^2	0.26	0.14	0.23	1.04	0.27	0.15	0.55	0.17	0.46	0.47	0.60	0.38		0.49	0.23	0.25
	Crest Elevation	EL. m	142	263	162	237	299	326	297	385	324	278	173	218		182	300	200
	F.R.L	EL. m	138	259	158	233	295	322	293	381	320	274	169	215		178	296	196
	M.D.D.L	EL. m	108	229	128	228	282	292	263	351	302	249	150	195		171	267	174
	Drowdown	m	30	30	30	7	13	30	30	30	18	25	19	20		7	29	22
	Sedimation Level	EL. m	99	220	119	219	273	283	254	342	293	240	141	186		162	258	165
	Gross Reservoir Capacity	$10^6 m^3$	6.35	2.94	6.14	12.75	3.38	3.32	10.74	3.44	6.03	9.52	8.60	5.94		5.85	4.58	4.82
	Generating Reservoir Capacity	$10^6 m^3$	4.80	2.20	4.28	1.34	2.50	2.50	7.50	2.36	4.55	6.50	4.80	3.36		1.34	3.28	2.94
	Dam Height	m	62	38	52	37	39	61	62	40	39	62	45	58		32	50	60
	Dam Crest Length	m	1,000	450	460	400	200	500	550	450	600	600	375	550		400	400	560
	Headrace Tunnel Length	m	1,600	450	1,950	1,250	800	0	1,000	500	0	1,850	400	900		3,100	2,250	1,000
	Penstock Tunnel Length	m	970	1,100	950	250	700	1,100	1,100	950	1,050	1,200	1,000	1,000		1,200	1,300	850
	Tailrace Tunnel Length	m	1,400	1,050	950	1,250	1,600	1,800	1,200	900	1,200	1,800	3,200	1,900		2,000	350	2,400
	Standard Intake Water Level	m	675	897	688	359	583	856	858	820	774	895	670	673		807	869	801
	Standard Tail Water Level	m	127	248	147	230	290	311	282	370	313	265	162	207		175	285	188
	Gross Head	m	548	649	541	129	293	545	576	450	461	630	508	466		632	584	613
	Max. Power Discharge	m^3	143	66	127	40	74	74	224	71	135	193	143	100		40	97	87
	Transmission Line Length	km	56	57	1	20	1	3	1	15	60	75	55	35		45	36	105
	Economy		B	B	B	C	C	C	A	C	A	A	B	C		C	B	B

Selected Project for the Secondary Inventory Study

Table 5.1-1 Outline of Project (1/2)

	Items	Unit	1 Ulhas	2 Sidgarh	3 Amba	4 Pinjal	5 Kengadi	6 Kalu	7 Jalond	8 Kolman -pada	9 Chornai	10 Savitri	11 Madhali -wadi	12 Vaitarni	13 Morawadi	14 Gadgadi	15 Aruna	16 Kharari
Installed Capacity		MW	600	350	500	30	160	300	1,000	250	480	1,000	500	360		200	440	420
Unit Capacity		MW	150	175	250	30	160	150	250	125	240	250	250	180		100	220	210
Number of Units		unit	4	2	2	1	1	2	4	2	2	4	2	2		2	2	2
Upper	Catchment Area	km^2	6.68	1.00	6.21	2.85	2.45	3.10	20.68	3.38	2.83	5.51	2.68	1.28		0.78	4.78	3.22
	Surface Area	km^2	1.27	0.20	0.47	0.07	0.99	0.54	1.78	0.35	0.85	0.40	0.33	0.25		0.35	0.27	0.52
	Crest Elevation	EL.m	680	906	698	367	590	863	865	828	782	908	683	680		820	882	809
	F.R.L	EL.m	676	902	694	363	586	859	861	824	778	904	679	676		816	878	805
	M.D.D.L	EL.m	670	886	674	349	576	848	850	810	765	874	649	664		786	850	792
	Drowdown	m	6	16	20	14	10	11	11	14	13	30	30	12		30	28	13
	Sedimation Level	EL.m	661	877	665	340	570	839	841	801	756	865	640	655		766	841	783
	Gross Reservoir Capacity	10^6m^3	12.29	2.75	6.65	3.15	5.20	6.09	21.30	4.56	8.50	9.97	6.42	2.52		1.98	5.17	6.11
	Generating Reservoir Capacity	10^6m^3	4.80	2.20	4.28	1.34	2.50	2.50	7.50	2.36	4.55	6.50	4.80	3.36		1.34	3.28	2.94
	Dam Height	m	45	36	58	37	35	48	45	43	32	49	50	35		50	52	37
	Dam Crest Length	m	960	550	320	450	550	550	500	650	600	500	550	450		500	450	450
Lower	Catchment Area	km^2	4.56	0.92	7.99	32.11	5.48	2.71	3.43	3.31	2.48	7.41	6.79	9.61		13.92	2.82	9.12
	Surface Area	km^2	0.26	0.14	0.23	1.04	0.27	0.15	0.55	0.17	0.46	0.47	0.60	0.38		0.49	0.23	0.25
	Crest Elevation	EL.m	142	263	162	237	299	326	297	385	324	278	173	218		182	300	200
	F.R.L	EL.m	138	259	158	233	295	322	293	381	320	274	169	215		178	296	196
	M.D.D.L	EL.m	108	229	128	228	282	292	263	351	302	249	150	195		171	267	174
	Drowdown	m	30	30	30	7	13	30	30	30	18	25	19	20		7	29	22
	Sedimation Level	EL.m	99	220	119	219	273	283	254	342	293	240	141	186		162	258	165
	Gross Reservoir Capacity	10^6m^3	6.35	2.94	6.14	12.75	3.38	3.32	10.74	3.44	6.03	9.52	8.60	5.94		5.85	4.58	4.82
	Generating Reservoir Capacity	10^6m^3	4.80	2.20	4.28	1.34	2.50	2.50	7.50	2.36	4.55	6.50	4.80	3.36		1.34	3.28	2.94
	Dam Height	m	62	38	52	37	39	61	62	40	39	62	45	58		32	50	60
	Dam Crest Length	m	1,000	450	460	400	200	500	550	450	600	600	375	550		400	400	560
Headrace Tunnel Length		m	1,600	450	1,950	1,250	800	0	1,000	500	0	1,850	400	900		3,100	2,250	1,000
Penstock Tunnel Length		m	970	1,100	950	250	700	1,100	1,100	950	1,050	1,200	1,000	1,000		1,200	1,300	850
Tailrace Tunnel Length		m	1,400	1,050	950	1,250	1,600	1,800	1,200	900	1,200	1,800	3,200	1,900		2,000	350	2,400
Standard Intake Water Level		m	675	897	688	359	583	856	858	820	774	895	670	673		807	869	801
Standard Tail Water Level		m	127	248	147	230	290	311	282	370	313	265	162	207		175	285	188
Gross Head		m	548	649	541	129	293	545	576	450	461	630	508	466		632	584	613
Max. Power Discharge		m^3	143	66	127	40	74	74	224	71	135	193	143	100		40	97	87
Transmission Line Length		km	56	57	1	20	1	3	1	15	60	75	55	35		45	36	105
Economy			B	B	B	C	C	C	A	C	A	A	B	C		C	B	B

[ ] Selected Project for the Secondary Inventory Study

Table 5.1-1 Outline of Project (2/2)

	Items	Unit	17 Kundi	18 Jalware	19 Tillari -wadi	20 Tillari -Forebay	21 Marlesh -war	22 Valvand	23 Shemi	24 Kudan -budrak	25 Kaudoshi	26 Kumb- havde	27 Mundi -richi	28 Virdi	29 Bamnoli	30 Kinjale	31 Khakhar -wadi	32 Hevale
Installed Capacity		MW	1,200	440		720	1,200	1,200	60	450	400	630	750	660	1,320	420	660	960
Unit Capacity		MW	200	220		180	200	200	60	225	200	210	250	220	220	210	220	240
Number of Units		unit	6	2		4	6	6	1	2	2	3	3	3	6	2	3	4
Upper	Catchment Area	km^2	1.67	2.47		3.22	8.15	2.68	47.00	4.20	4.88	4.32	——	——	——	——	——	——
Upper	Surface Area	km^2	0.63	0.34		0.52	1.57	0.78	0.59	0.33	0.30	0.98	0.21	0.17	0.56	0.23	0.24	0.32
Upper	Crest Elevation	EL. m	880	767		740	861	660	382	679	621	820	825	823	887	843	766	747
Upper	F.R.L	EL. m	876	763		736	857	656	378	675	617	816	823	821	885	841	764	745
Upper	M.D.D.L	EL. m	846	748		711	846	626	371	645	590	797	793	791	855	811	734	715
Upper	Drowdown	m	30	15		25	11	30	7	30	27	19	30	30	30	30	30	30
Upper	Sedimation Level	EL. m	837	738		702	837	599	362	636	581	788	——	——	——	——	——	——
Upper	Gross Reservoir Capacity	10^6m^3	11.80	5.12		8.14	19.87	14.04	9.55	7.54	5.70	9.94	6.43	5.12	11.23	3.76	7.29	9.81
Upper	Generating Reservoir Capacity	10^6m^3	8.92	3.57		6.83	8.68	9.36	1.6	5.53	3.95	7.60	5.00	4.00	8.70	2.93	5.67	7.64
Upper	Dam Height	m	50	42		※60	76	70	27	54	61	50	26	23	27	23	26	27
Upper	Dam Crest Length	m	400	400		※500	500	600	300	340	140	300	1,908	1,910	2,460	1,600	2,020	2,310
Lower	Catchment Area	km^2	9.90	9.41		22.46	23.20	6.40	10.57	12.60	14.76	15.53	9.83	7.46	18.31	4.81	5.95	22.46
Lower	Surface Area	km^2	0.69	0.28		0.45	0.75	0.84	0.22	0.34	0.47	0.86	0.85	0.54	0.55	0.28	0.35	0.50
Lower	Crest Elevation	EL. m	280	220		189	201	117	200	327	183	458	167	106	229	205	265	200
Lower	F.R.L	EL. m	276	216		185	197	113	196	323	179	454	163	102	225	201	261	196
Lower	M.D.D.L	EL. m	251	192		166	176	92	185	293	149	435	143	84	195	171	231	166
Lower	Drowdown	m	25	24		19	21	21	11	30	30	19	20	18	30	30	30	30
Lower	Sedimation Level	EL. m	242	182		157	167	82	176	284	140	426	134	75	186	162	202	157
Lower	Gross Reservoir Capacity	10^6m^3	13.08	5.93		7.71	13.54	15.51	3.23	8.37	7.84	11.82	14.85	8.90	13.19	4.42	10.19	11.72
Lower	Generating Reservoir Capacity	10^6m^3	8.92	3.57		5.83	8.68	9.36	1.60	5.53	3.95	7.60	5.00	4.00	8.70	2.93	5.67	7.63
Lower	Dam Height	m	50	50		44	56	47	45	62	63	48	47	46	59	55	80	72
Lower	Dam Crest Length	m	500	600		650	500	1,250	300	400	440	600	400	320	380	320	420	600
Headrace Tunnel Length		m	450	2,800		0	1,900	400	1,600	1,000	2,000	1,500	0	0	0	0	0	0
Penstock Tunnel Length		m	1,200	1,100		1,100	1,150	1,050	500	620	700	520	1,270	1,100	1,160	1,250	1,010	1,070
Tailrace Tunnel Length		m	1,300	1,400		1,350	1,150	700	1,100	850	1,600	1,200	2,000	2,600	1,600	2,200	1,550	1,450
Standard Intake Water Level		m	867	759		728	854	647	376	666	609	810	814	812	876	832	755	736
Standard Tail Water Level		m	267	207		178	189	105	191	312	168	447	155	95	214	190	250	185
Gross Head		m	600	552		550	665	546	185	354	448	363	659	717	62	642	505	551
Max. Power Discharge		m^3	265	106		173	258	278	47	164	118	294	149	119	259	87	168	227
Transmission Line Length		km	55	100		95	160	60	110	70	55	100	120	125	61	45	55	100
Economy			A	A		A	A	A	C	B	B	B	A	A	A	B	C	B

[shaded] Selected Project for the Secondary Inventory Study

Table 5.1-1 Outline of Project (2/2)

	Items	Unit	17 Kundi	18 Jalware	19 Tillari -wadi	20 Tillari -Forebay	21 Marlosh -war	22 Valvand	23 Shemi	24 Kudan -budrak	25 Kaudoshi	26 Kumb- havde	27 Mundi -richi	28 Virdi	29 Bamnoli	30 Kinjale	31 Khakhar -wadi	32 Hevale
Installed Capacity		MW	1,200	440		720	1,200	1,200	60	450	400	630	750	660	1,320	420	660	960
Unit Capacity		MW	200	220		180	200	200	60	225	200	210	250	220	220	210	220	240
Number of Units		unit	6	2		4	6	6	1	2	2	3	3	3	6	2	3	4
Upper	Catchment Area	km^2	1.67	2.47		3.22	8.15	2.68	47.00	4.20	4.88	4.32	----	----	----	----	----	----
	Surface Area	km^2	0.63	0.34		0.52	1.57	0.78	0.59	0.33	0.30	0.98	0.21	0.17	0.56	0.23	0.24	0.32
	Crest Elevation	EL. m	880	767		740	861	660	382	679	621	820	825	823	887	843	766	747
	F.R.L	EL. m	876	763		736	857	656	378	675	617	816	823	821	885	841	764	745
	M.D.D.L	EL. m	846	748		711	846	626	371	645	590	797	793	791	855	811	734	715
	Drowdown	m	30	15		25	11	30	7	30	27	19	30	30	30	30	30	30
	Sedimation Level	EL. m	837	738		702	837	599	362	636	581	788	----	----	----	----	----	----
	Gross Reservoir Capacity	10^6m^3	11.80	5.12		8.14	19.87	14.04	9.55	7.54	5.70	9.94	6.43	5.12	11.23	3.76	7.29	9.81
	Generating Reservoir Capacity	10^6m^3	8.92	3.57		5.83	8.68	9.36	1.6	5.53	3.95	7.60	5.00	4.00	8.70	2.93	5.67	7.64
	Dam Height	m	50	42		※50	76	70	27	54	61	50	26	23	27	23	26	27
	Dam Crest Length	m	400	400		※500	500	600	300	340	140	300	1,908	1,910	2,460	1,500	2,020	2,310
Lower	Catchment Area	km^2	9.90	9.41		22.46	23.20	6.40	10.57	12.60	14.76	15.53	9.83	7.46	18.31	4.81	5.95	22.46
	Surface Area	km^2	0.69	0.28		0.45	0.75	0.84	0.22	0.34	0.47	0.86	0.85	0.54	0.55	0.28	0.35	0.50
	Crest Elevation	EL. m	280	220		189	201	117	200	327	183	458	167	106	229	205	265	200
	F.R.L	EL. m	276	216		185	197	113	196	323	179	454	163	102	225	201	261	196
	M.D.D.L	EL. m	251	192		166	176	92	185	293	149	435	143	84	195	171	231	166
	Drowdown	m	25	24		19	21	21	11	30	30	19	20	18	30	30	30	30
	Sedimation Level	EL. m	242	182		157	167	82	176	284	140	426	134	75	186	162	202	157
	Gross Reservoir Capacity	10^6m^3	13.08	5.93		7.71	13.54	15.51	3.23	8.37	7.84	11.82	14.85	8.90	13.19	4.42	10.19	11.72
	Generating Reservoir Capacity	10^6m^3	8.92	3.57		5.83	8.68	9.36	1.60	5.53	3.95	7.60	5.00	4.00	8.70	2.93	5.67	7.63
	Dam Height	m	50	50		44	56	47	45	62	63	48	47	46	59	55	80	72
	Dam Crest Length	m	500	600		650	500	1,250	300	400	440	600	400	320	380	320	420	600
Headrace Tunnel Length		m	450	2,800		0	1,900	400	1,600	1,000	2,000	1,500	0	0	0	0	0	0
Penstock Tunnel Length		m	1,200	1,100		1,100	1,150	1,050	500	620	700	520	1,270	1,100	1,160	1,250	1,010	1,070
Tailrace Tunnel Length		m	1,300	1,400		1,350	1,150	700	1,100	850	1,600	1,200	2,000	2,600	1,600	2,200	1,550	1,450
Standard Intake Water Level		m	867	759		728	854	647	376	666	609	810	814	812	876	832	755	736
Standard Tail Water Level		m	267	207		178	189	105	191	312	168	447	155	95	214	190	250	185
Gross Head		m	600	552		550	665	546	185	354	448	363	659	717	62	642	505	551
Max. Power Discharge		m^3	265	106		173	258	278	47	164	118	294	149	119	259	87	168	227
Transmission Line Length		km	55	100		95	60	60	110	70	55	100	120	125	61	45	55	100
Economy			A	A		A	A	A	C	B	B	B	A	A	A	B	C	B

[ ] Selected Project for the Secondary Inventory Study

Table 5.2-1 The Secondary Inventory

Item		7		20		21		30		32	
		Joland		Tillari Forebay		Marleshwar		Kinjale		Hevale	
Installed Capacity	MW	1,000		125		1,200		420		800	
Unit Capacity	MW	250		125		200		210		200	
Number of Unit	Unit	4		1		6		2		4	
		Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Catchment Area	Km^2	20.68	3.43	2.22	1,992	8.15	23.20	-	4.81	-	19.92
Surface Area	Km^2	1.78	0.55	0.22	0.22	1.57	0.75	0.23	0.28	0.32	0.50
Crest Elevation	m	865	297	729.044	192	861	201	843	205	747	214
F.R.L.	m	861	293	726.314	188	857	197	841	201	745	210
M.D.D.L.	m	850	263	720.59	180	846	176	811	171	715	180
Drawdown		11	30	5.72	8	11	21	30	30	30	30
Sedimentation Level	m	841	254	715.67	170	837	167	-	162	-	170
Gross Reservoir Capacity	10^6m^3	21.30	10.74	2.12	4.02	19.87	13.54	3.76	4.42	9.81	9.810
Generating Reservoir Capacity	10^6m^3	7.50	7.50	1.024	1.024	8.68	8.68	2.93	2.93	6.49	6.49
Type of Dam		Masonry	Masonry	Masonry	Masonry	Masonry	Masonry	C.F.R.F.	Masonry	C.F.R.F	Masonry
Dam Height	m	45	62	23.24	60	76	56	23	55	27	80
Dam Crest Length	m	300	550	350.00	600	350	550	1,500	320	2,310	700

Item		Length	Number of Tunnels	Diameter (m)	Length	Number of Tunnels	Diameter (m)	Length	Number of Tunnels	Diameter (m)	Length	Number of Tunnels	Diameter (m)	Length	Number of Tunnels	Diameter (m)
Headrace Tunnel	m	1,000	2	5.3	-	-	-	1,750	2	5.7	-	-	-	-	-	-
Penstock Tunnel	m	1,100	4	3.8~2.6	1,150	1	2.8~2.0	1,000	6	3.3~2.3	1,250	4	3.3~2.8	1,070	4	3.5~2.5
Tailrace Tunnel	m	1,200	2	5.3	1,150	1	3.1	1,400	2	5.7	2,200			1,450	2	5.0
Standard Intake Water Level	m	858			723			854			832			736		
Standard Tail Water Level	m	282			184			189			190			197		
Gross head	m	576			539			665			642			537		
Max Power Discharge	m^3	224			30			258			87			193		
Economy	-	A			C			A			B			B		

C.F.R.F.: Concrete Facing Rock Fill Dam

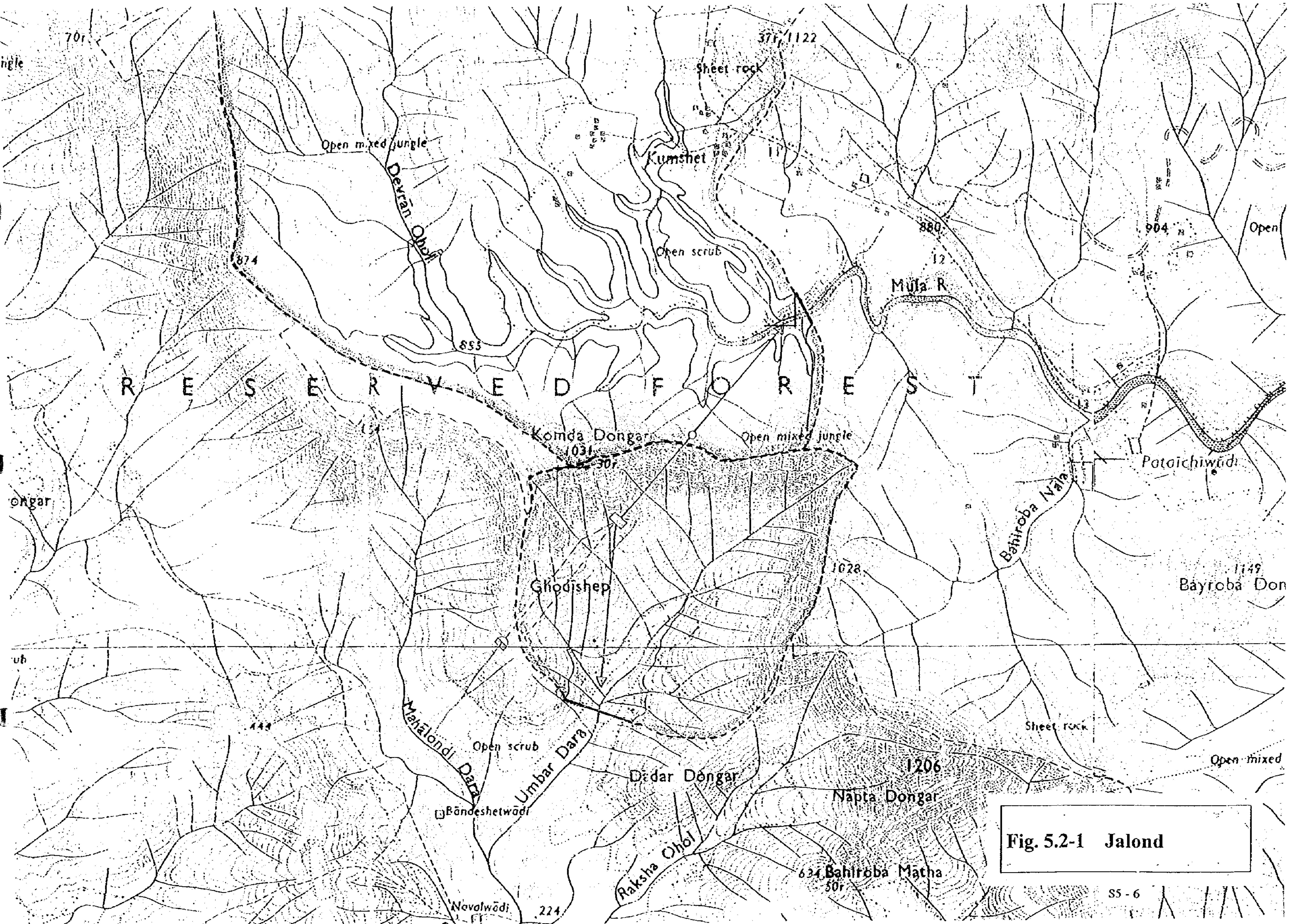

Fig. 5.2-1 Jalond

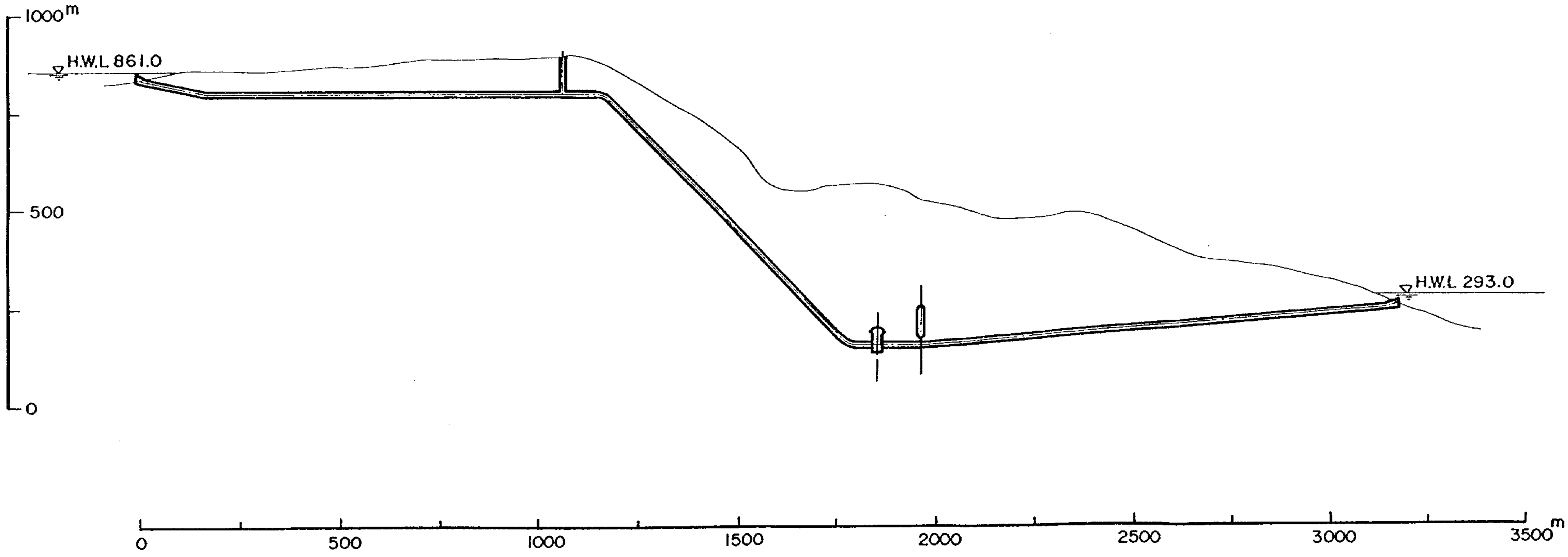

Fig. 5.2-2 Jalond

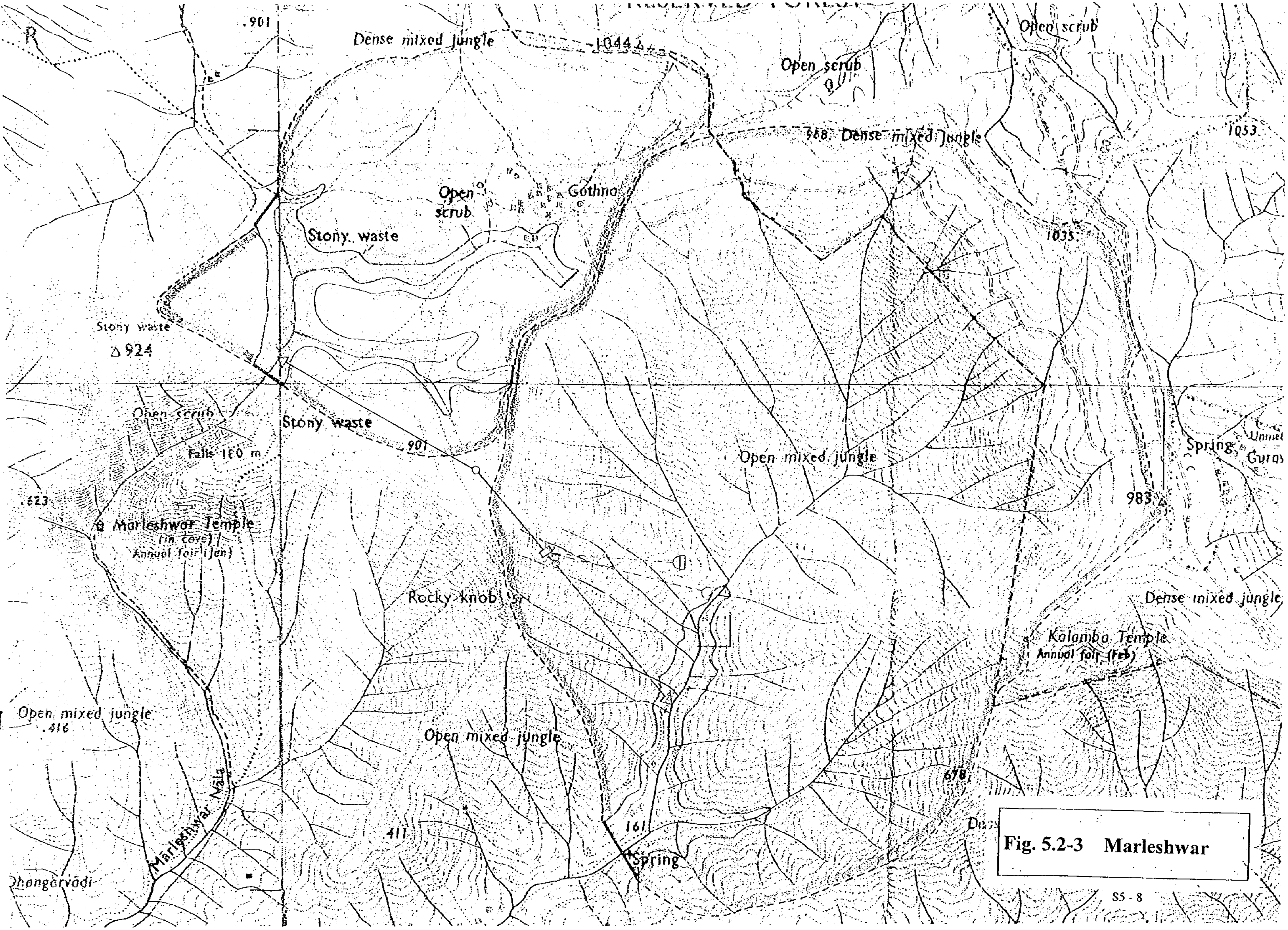

Fig. 5.2-3 Marleshwar

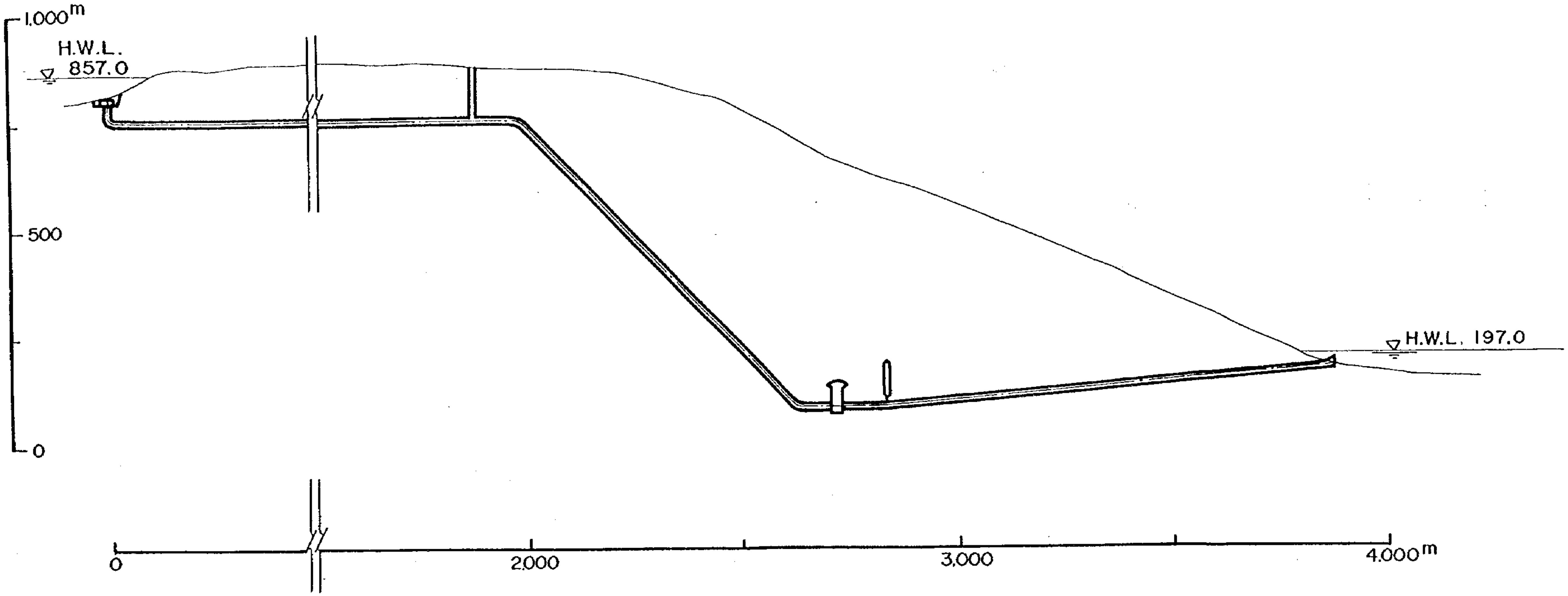

Fig. 5.2-4 Marleshwar

Fig. 5.2-5 Kinjale

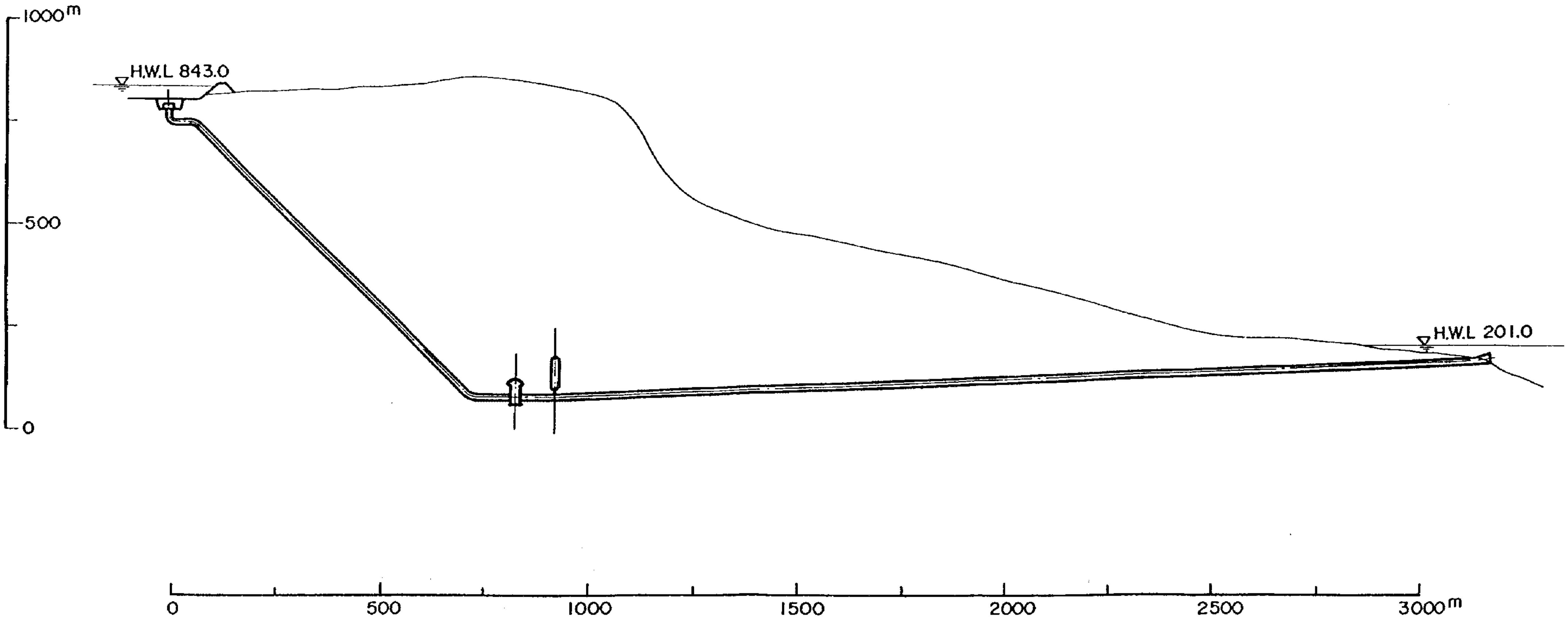

Fig. 5.2-6 Kinjale

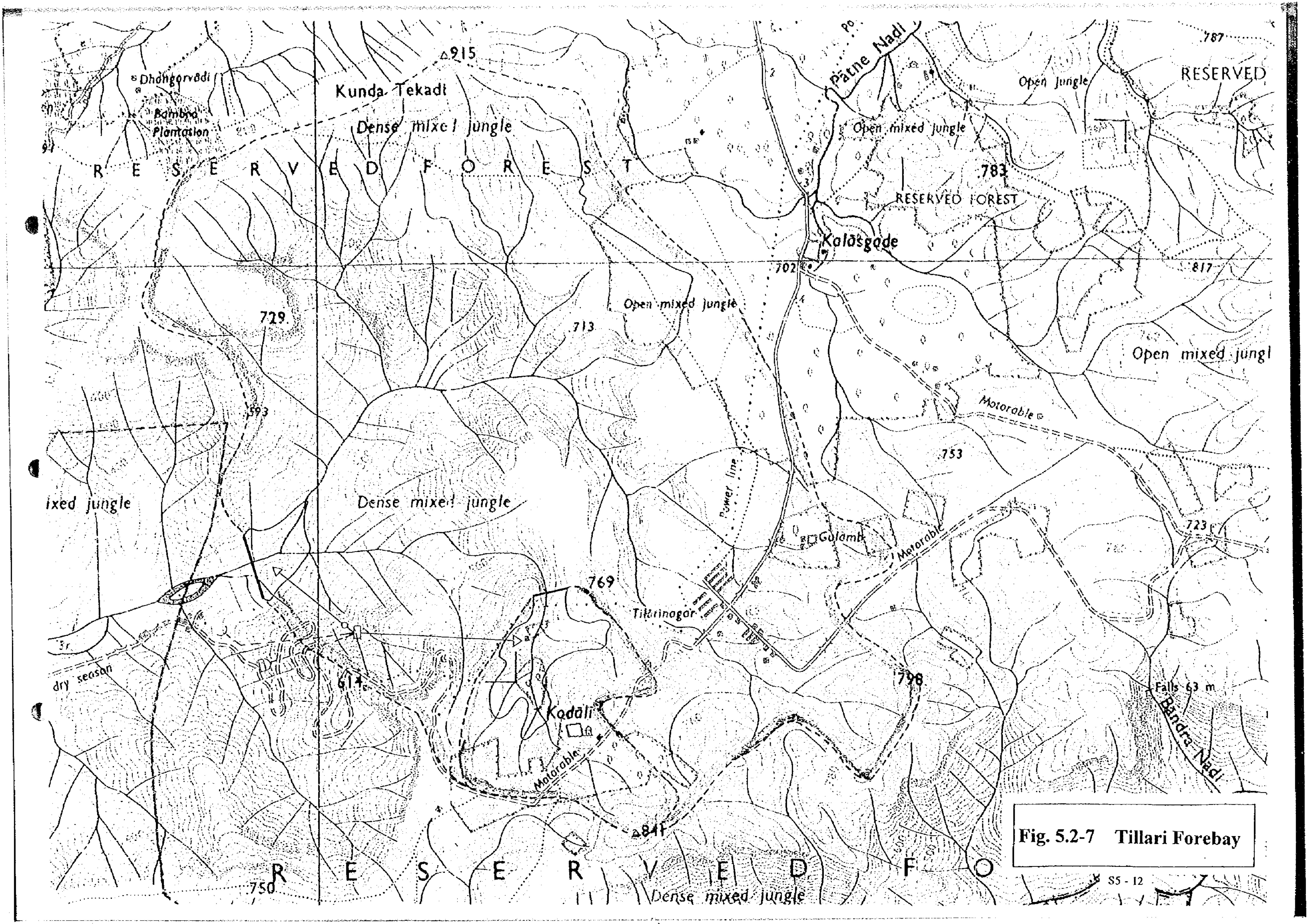

Fig. 5.2-7 Tillari Forebay

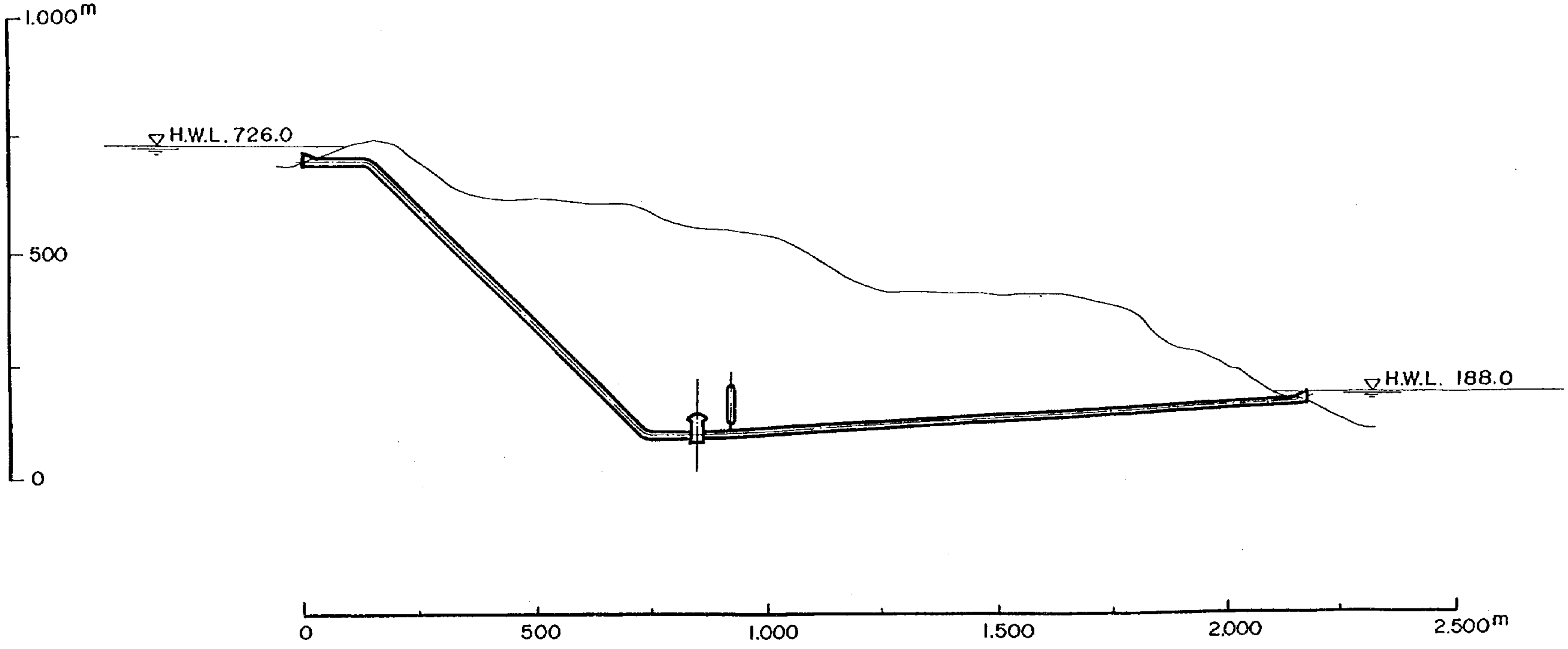

Fig. 5.2-8 Tillari Forebay

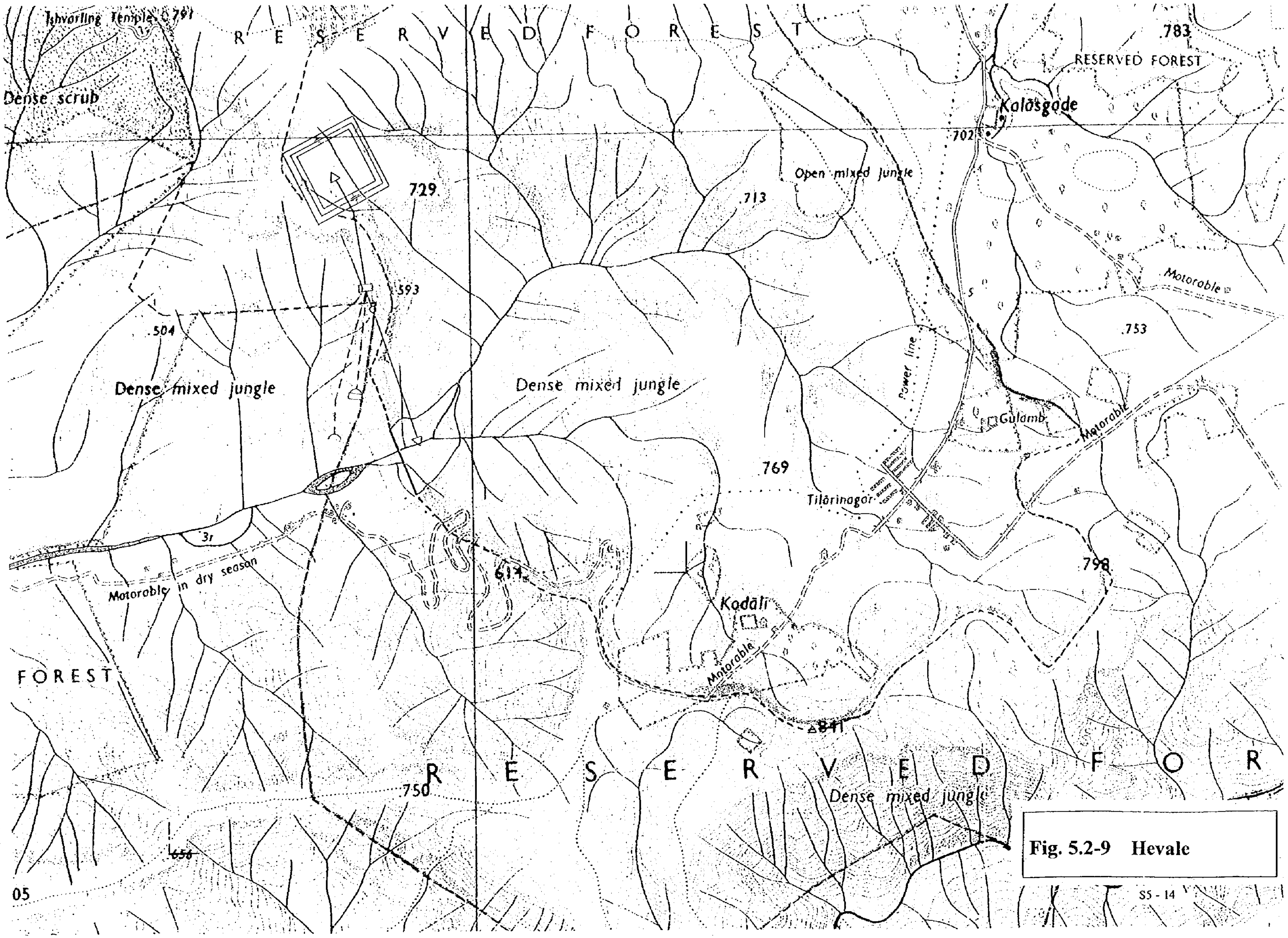

Fig. 5.2-9 Hevale

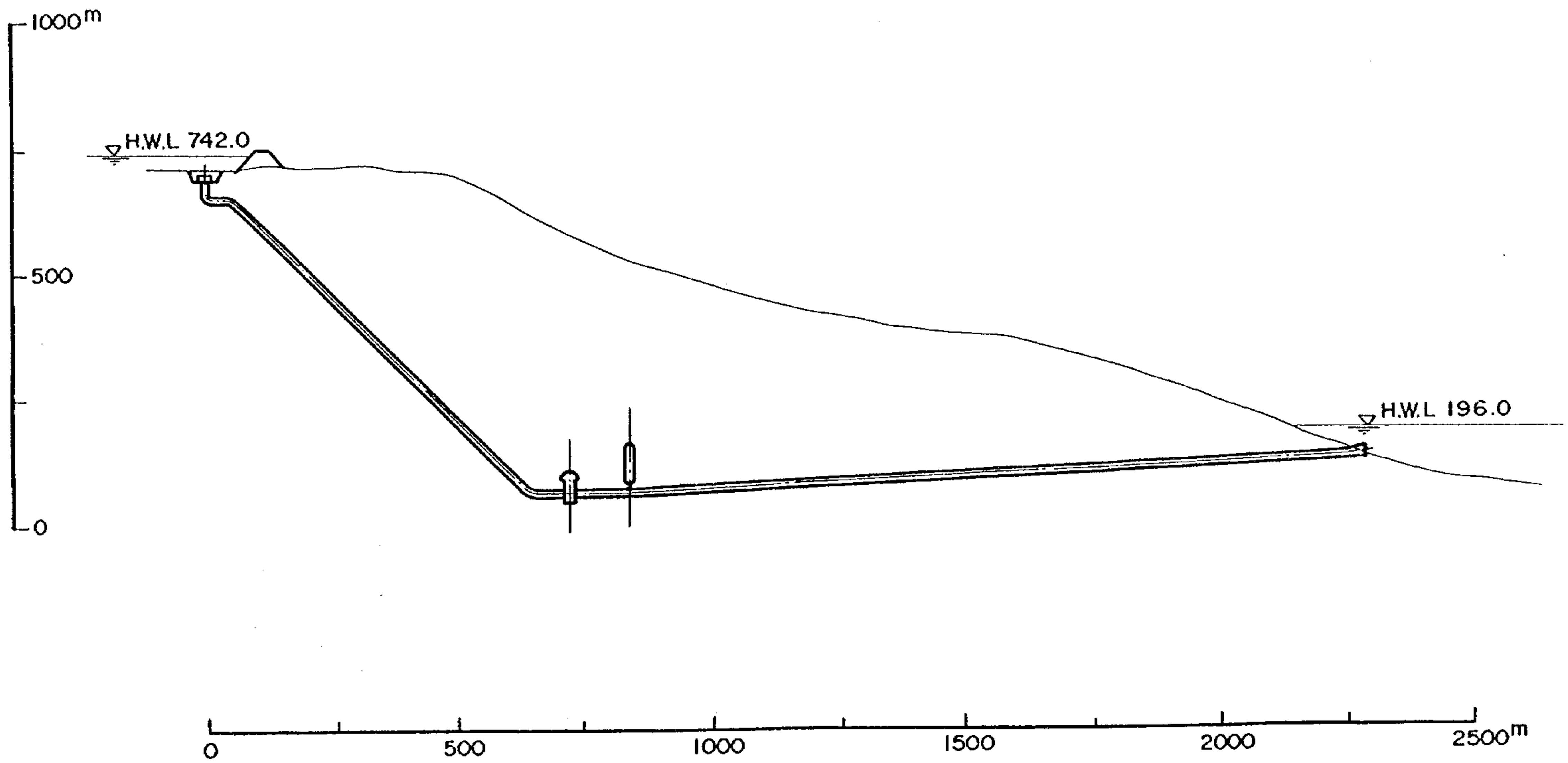

Fig. 5.2-10 Hevale