

Chapter – 2

Physical Features

2.1 Geographical Disposition

The Par-Tapi-Narmada link canal, its proposed six reservoirs, two barrages, two tunnels, six power houses, feeder canals and command area are located in the basins of west flowing rivers from Par to Tapi, Tapi and Narmada. The basins of west flowing rivers from Par to Tapi lie between north latitudes 20° 13' to 21° 14' and east longitudes 72° 43' to 73° 58'. The Tapi basin lies between north latitudes 20° 05' to 22° 03' and east longitudes 72° 38' to 78° 17' while the Narmada basin lies between north latitudes 21° 20' to 23° 45' and east longitudes 72° 32' to 81° 45'. The link traverses between Par and Narmada from south to north. Index map showing rivers, basin boundaries, State boundaries, dams etc is appended at Plate 1.1 in Volume-VII.

2.2 Topography of the Basins, Reservoirs and Command Area

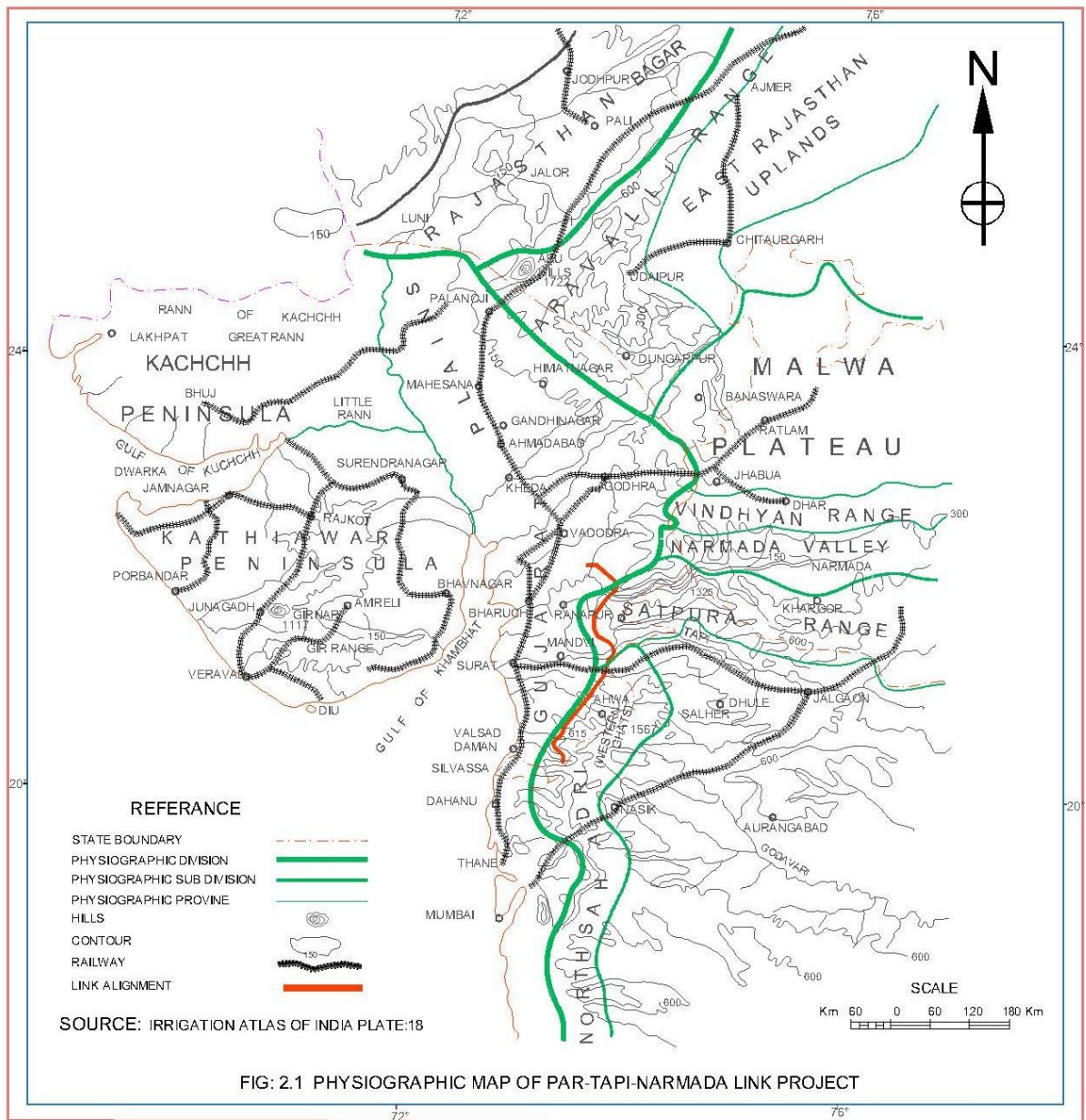
The link canal passes through Par, Auranga, Ambica, Purna, Mindhola, Tapi and Narmada basins. Physiographic map of the adjoining area of the Par-Tapi-Narmada link project is at Fig - 2.1. Each of the basins is described below separately:

2.2.1 Par Basin

The Par river is one of the important west flowing rivers in the region, north of Mumbai and south of the Tapi river. The river rises in the Sahyadri hill ranges at an elevation of about 1100 m above mean sea level in Nasik district of Maharashtra State and traverses a distance of 131 km before draining into the Arabian Sea. The Par river travels mostly through hills covered with forest and patches of cultivated lands on banks of river.

The basin lies in the States of Maharashtra and Gujarat and has a effective catchment area of 1648 km². The percentages of the area of the basin in the States of Maharashtra and Gujarat are 46.91% and 53.09 %

respectively. The basin is part of the Western Ghats portion in Maharashtra and Gujarat and is covered by Deccan traps.



2.2.2 Auranga Basin

The Auranga is one of the important west flowing rivers in the region north of Mumbai city and south of Tapi river. The river is known as Auranga after the confluence of its two tributaries the Man and the Tan. Both tributaries originate in the Sahyadri hill ranges in the Nasik district of Maharashtra State. The river traverses a distance of about 30 km from confluence of the tributaries before draining into the Arabian Sea. The

effective drainage area of the Auranga basin is 748 km², out of which 150 km² is in Maharashtra State and 598 km² is in Gujarat State. The area is hilly and covered with forest in the upstream reaches, while the area down-wards from about 15 km upstream of confluence of the Tan and the Man rivers can be described as plain with cultivated lands.

The Tan river rises at an elevation of about 645 m and the elevation where it meets the Man river is about 50 m. The length of the river upto its confluence with Man river is 52 km. The catchment area of the Tan river upto its confluence with Man river is 289 km², out of which 68 km² lies in Nasik district of Maharashtra State and the balance 221 km² lies in the Valsad and Navsari district of Gujarat State.

2.2.2 Ambica Basin

The Ambica which is a west flowing river, rises in the Sahyadri hill ranges in the Nasik district of Maharashtra State at an elevation of about 1050 m above MSL and after traversing a total distance of 164 km joins the Arabian Sea in the State of Gujarat. The effective drainage area of the Ambica basin 2685 km² out of which 102 km² lies in Maharashtra and 2583 km² is in Gujarat. The important tributaries of the Ambica river are Khapri, Kaveri and Kharera rivers.

The Khapri river rises at an altitude of 1030 m in Sahyadri hill range in Ahwa taluka of Dang district in the State of Gujarat and joins the river Ambica near village Milan at an elevation of 100 m. The length of river Khapri is about 80 km. The Khapri catchment upto its confluence with Ambica river is spread over an area of 537 km² which is about 19% of the total catchment of the Ambica basin.

2.2.4. Purna Basin

The river Purna, a west flowing river, rises in the Sahyadri hill ranges of the Western Ghats at an elevation of about 1300 m in the Ahwa taluka of Dang district in the State of Gujarat and after traversing a distance of 180 km, it outfalls into the Arabian sea. The level of the river bed drops steeply from 1300 m at source to about 115 m at the dam site as the river in

this reach passes through hilly area covered with dense forest and patches of cultivated land. The effective drainage area of the basin is 2193 km², out of which 58 km² lies in Maharashtra State and 2135 km² lies in the State of Gujarat.

The important tributaries of the Purna river are Girra, Jankhari and Damaskhadi rivers.

2.2.5 Tapi Basin

The Tapi basin is bounded on the north by the Satpura range, on east by the Mahadeo hills, on the south by the Ajanta range and the Satmala hills and on the west by the Arabian Sea. The basin has an elongated shape with a maximum length of 587 km east to west and maximum width of 201 km from north to south. The basin has two well-defined physical regions, viz. the hilly region and the plains. The hilly region covers the Satpuras, the Satmalas, the Ajanta and the Gawilgarh hills with good forests. The Khandesh and the Gujarat plains are broad and fertile areas suitable for cultivation. The Tapi basin consists mainly of black cotton soils. The coastal plains in Gujarat are composed of alluvial clays with a layer of black soil on the surface.

2.2.6 Narmada Basin

The Narmada basin is bounded on the north by the Vindhyas, on the east by the Maikalu range, on the south by the Satpura and on the west by the Arabian Sea. The basin has five well defined physiographic regions. They are:(1) The upper hilly areas covering the districts of Shahdol, Mandla, Durg, Balaghat and Seoni;(2) The upper plains covering the districts of Jabalpur, Narsimhapur, Sagar, Damoh, Chhindwara, Hoshangabad, Betul, Raisen and Sehore: (3) The middle plains covering the districts of East Nimar, part of west Nimar, Dewas, Indore and Dhar; (4) The lower hilly areas covering part of the west Nimar, Jhabua, Dhulia, Narmada and parts of Vadodara; and (5) The lower plains covering mainly the districts of Narmada, Bharuch and parts of Vadodara. The hill regions are well forested. The upper, middle and lower plains are broad and fertile areas, well suited for cultivation. The Narmada basin mainly consists of black

soils. The coastal plains in Gujarat are composed of alluvial clays with a layer of black soils on the surface.

2.2.7 Topography of the Reservoirs

Six storage reservoirs are proposed for storing and diverting the water through Par-Tapi-Narmada link. These are Jheri dam across Par river; Paikhed dam across Nar river (a tributary of Par river); Chasmandva dam across Tan river (a tributary of Auranga river); Chikkar dam across Ambica river; Dabdar dam across Khapri river (a tributary of Ambica river); and Kelwan dam across Purna river. The Jheri reservoir is entirely lies in Maharashtra whereas, Dabdar and Kelwan reservoirs lies entirely in Gujarat. Other reservoirs namely Paikhed, Chasmandva and Chikkar reservoirs lie in both Gujarat and Maharashtra. The topographical details of six reservoirs are detailed below:

The Jheri dam is proposed across Par River near village 'Jheri' in Peint taluka of Nasik district of Maharashtra State. Paikhed dam is proposed across Nar River (a tributary of Par) near village 'Paikhed' in Dharampur taluka of Valsad district of Gujarat State. It is proposed to divert surplus waters from Jheri reservoir to Paikhed reservoir through 12.70 km long inter-connecting tunnel. The combined waters will be released through the Dam toe Power House of Paikhed dam into Nar river and tapped at Paikhed barrage, proposed at about 4.60 km downstream near village 'Nani Coswadi' of Dharampur taluka, and let into the Link Canal which off-takes from Paikhed barrage.

The Chasmandva dam is proposed across Tan River (a tributary of Auranga) near village 'Chasmandva' in Dharampur taluka. The surplus waters of Tan River released through the Dam toe Power House of Chasmandva dam will be tapped at Chasmandva barrage, proposed at about 8.50 km downstream near village 'Chandha Chikadi' of Dharampur taluka, and will be diverted into the Link Canal by a Feeder Pipeline of about 2.859 km long.

The Chikkar dam is proposed across Ambica River near village 'Chikkar' in Ahwa taluka of the Dangs district in Gujarat State. The surplus

water of Ambica River will be diverted through a 14.342 km long inter-connecting Pipeline into Dabdar reservoir after power generation at Chikkar dam toe Power House. The Dabdar dam is proposed across Khapri River (a tributary of Ambica) near village 'Dabdar' in Ahwa taluka of the Dangs district. The combined surplus flows of Ambica and Khapri Rivers will be diverted into the Link Canal through a 12.258 km long Feeder Pipeline after power generation at Dabdar dam toe Power House.

The Kelwan dam is proposed across Purna River near villages 'Kelwan' and 'Kakarda' in Ahwa taluka of The Dangs district. The surplus waters of Purna River will be fed to the Link Canal through a 7.616 km long Feeder Pipeline after power generation at Kelwan dam toe Power House. Another Power House is proposed at RD 5.80 km of the Kelwan feeder Pipeline where considerable drop in ground level is observed.

2.2.8 Topography of the Command Area

(i) Topography

Topography of the command area is undulating and of moderate slope. The command area in Valsad district comprises of Deccan trap Basalt. Basaltic out crops are seen in Vansda taluka of Navsari district in which the Command area lies. The command area in the Dangs district comprises of Deccan trap Basalt. The Command Area in Tapi district is comprises of Deccan trap Basalt of Cretaceous-Eocene age, which is overlain by quaternary alluvium. Limestone and clay formation of Eocene ages and quaternary alluvium formation are seen in Command Area lying in Surat district. In the eastern side of Bharuch district, where the Command Area lies, Basaltic rocks are seen.

(ii) Land Slopes

Slopes of the lands in the command are generally moderate neither steep nor flat.

(iii) Soils

The taluka wise reports of the soil survey carried out by Gujarat Government in respect of the districts falling in the en-route command area have been collected from the Agriculture Department, Government of Gujarat. Reports on land irrigability and soil classification of Banni area of Kutchh region and SSNNL phase I (Upto Mahi river), Soil classification report and soil maps for the talukas lying in reservoir submergence areas and link alignment have also been collected. Using this information the soil map of the enroute command area has been prepared and appended at Plate -4.45 in Volume -VII.

The soils in the command area can be broadly classified into 3 main categories viz. i) Deep Black, Medium Black to Loamy Sand (Goradu) soils, ii) Deep Black with Alluvial, Laterite and Medium Black Soils and iii) Deep Black Clayey Soils.

2.3 Geology of the Basins, Reservoirs and Command Area

2.3.1 Geology of the Basins

The major part of the 'Par-Tapi' portion of the link canal and its enroute command areas are covered by Deccan trap basalts with isolated deposits of laterite. The geological formations in Par and Auranga basins where Paikhed and Chasmandva dam sites lie, belong to the Precambrian, melipozoice, tertiary and quaternary ages. Deccan traps which occupy major portion of upper reaches are of two prominent types, one being dark grey to bluish black which are hard, compact and massive and the other being light brown to pink which are soft.

Like in Par and Auranga basins, Deccan traps with dykes occupy most of the areas of Ambica basin in which Chikkar ad Dabdar dam sites are proposed. The geological formations found in Ambica basin include those of the Quaternary and Tertiary ages. The middle ranges have developed on the Deccan traps and the intermediate amphitheatres have developed out of the alluvial debris washed out from the hills. The lower reaches of the basin contain mainly alluvial plains upto coastal margins.

Deccan traps also occupy most parts of Purna basin in which Kelwan dam site is proposed. In the east, there are high ridges and deep valleys and towards the west, they merge into the lower reach composed of recent and sub-recent alluvium and sand. The stratigraphical sequences of the rocks found in the basin are Neogene, Paleogene and early Paleogene. A geological map Par-Tapi-Narmada link is at Fig - 2.2.

2.3.2 Geology of Reservoirs

i) Jheri

The Jheri reservoir area is thickly forested and restricted to the valley with steep hills on both sides. Amygdular basalts which are jointed and sheared are encountered in the area. No major fault or shear zone was noted in the area.

ii) Paikhed

In the Paikhed reservoir area the Basalts of the Deccan trap forms foundation rock. The rocks have horizontal to sub horizontal dips. The water percolation test results of these bore holes indicate that the strata in general have low permeability but higher values of equivalent permeability up to 15 lugeons since the rocks in the area have a horizontal to sub horizontal disposition.

iii) Chasmandva

In the Chasmandva reservoir area the basaltic flows of Deccan Trap form foundation rock. The rock has horizontal to sub horizontal disposition with low permeability.

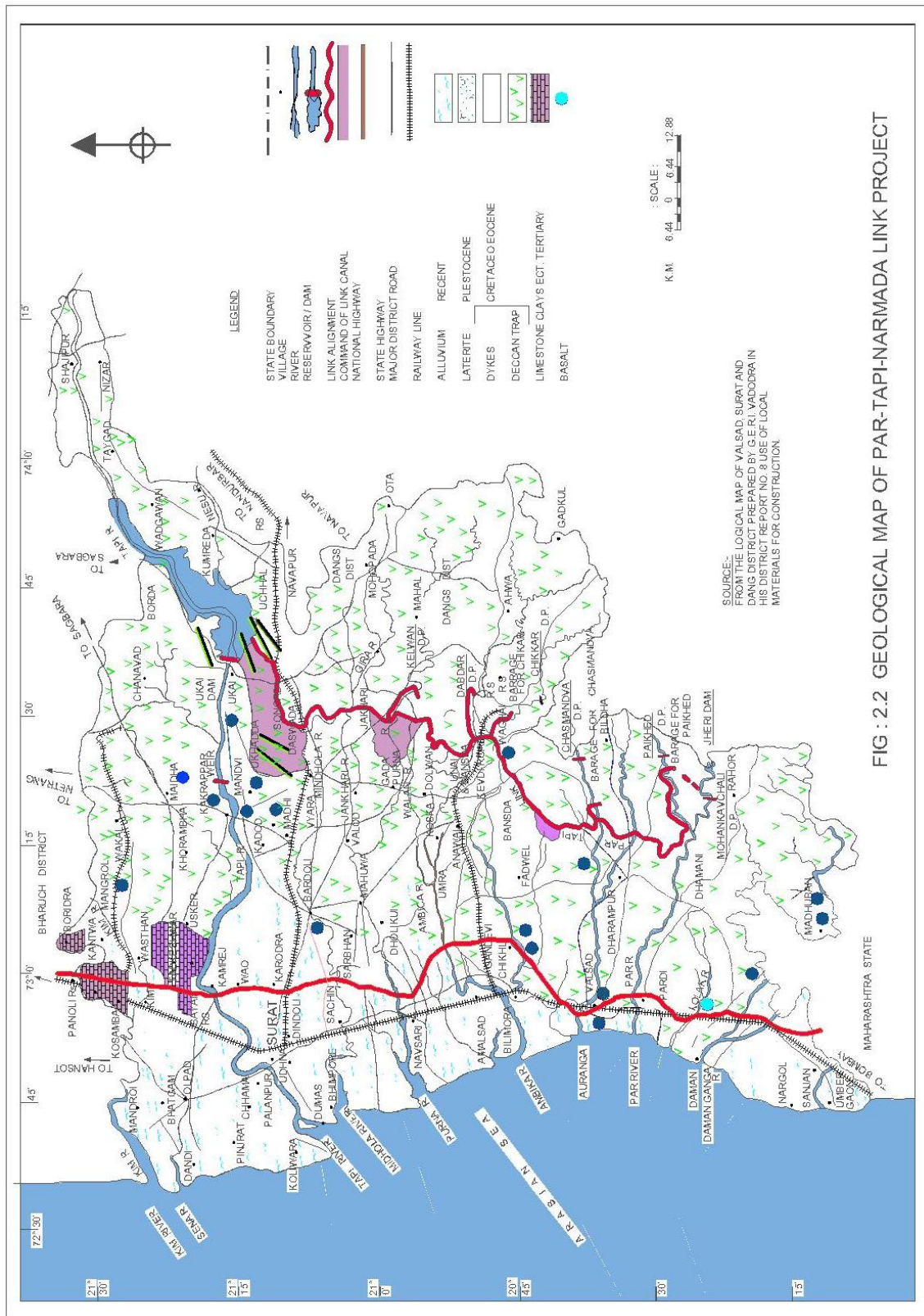


FIG : 2.2 GEOLOGICAL MAP OF PAR-TAPI-NARMADA LINK PROJECT

iv) Chikkar

The Chikkar reservoir area consists sub horizontal sequence of lava flows of Deccan traps. The contacts zone between the successive lava flows are moderately to highly weathered and marked by presence of flow breccias, with predominance of Amygdule.

v) Dabdar

The Dabdar reservoir area consists of Deccan traps. The bed rock constituting the foundation are a sequence of lava flows, which comprises Amygdaloidal, dense, perphyritic basalt and flow breccias with horizontal to sub horizontal dips.

vi) Kelwan

The Kelwan reservoir area consists of Deccan traps and it's differentiates. The exposed out crops are mainly consisting of horizontal to sub horizontal sequence of lava flows, which includes Amygdaloidal, dense, perphyritic basalt and flow breccias.

2.3.3 Geology of Command Area

The proposed Command Area of the link canal lies in Valsad, Navsari, Dangs, Tapi, Surat and Bharuch, Chhota Udepur and Panchmahal districts of Gujarat State.

Geologically the Valsad district comprises of Deccan trap with dykes of quaternary and tertiary ages. The middle ranges have developed on Deccan trap and the intermediate amphitheatres have developed out of the alluvial debris washed from the hills. The lower reaches are mainly alluvial plains.

Geologically the Navsari district comprises of Alluvium (Clay and Sand) and Trap. Basaltic out crops are seen in Vansda taluka in which the Command area lies. Ground water availability in alluvial formations is satisfactory. In Trap area, the availability of ground water is less. The ground water quality in the Command area is good.

Geologically the Dangs district is composed of Deccan trap Basalt. Basalt acts as poor aquifer. The water quality is very good.

Geologically the Tapi district is comprises of Deccan trap Basalt of Cretaceous-Eocene age, which is overlain by quaternary alluvium. The ground water availability is poor in hard rock area but its quality is good.

Limestone and clay formation of Eocene ages and quaternary alluvium formation are seen in Surat district. The ground water availability and quality is good in the proposed Command Area.

Geologically, Bharuch district is mainly divided in two types of rocks. Alluvial formations are seen in western side. In the eastern side, where the Command area lies, Basaltic rocks are seen. Ground water availability and quality is good in the proposed Command Area. Overall, the level of groundwater development in the proposed Command area of the link project can be categorized as “Safe”.

Geologically, in Chhota Udepur district, Rocks of highly intricate and varied gneissic complex; they are mostly of igneous origin, but on account of interfoliar injection, they have a general northerly foliation strike, and are continuous with gneissic complex of Central Mewar.

Geologically, in Panchmahals district Rocks of Aravali System (including Champaners) are Metamorphic and have been affected by tectonic forces forming folds. Basal conglomerates, an impure calcareous facies generally dolomitic in composition, quartzite, phyllites, slates and schists are the rocks under this system. Phyllites are common rocks and occupy large areas with quartzite as intercalations: phyllites grade into schists.

2.4 River System and Catchment Area

Each river system and its catchment area intercepted by the Par-Tapi-Narmada link is described below:

2.4.1 Par Basin

Par is a west flowing river with its catchment area lying in Maharashtra and Gujarat. It rises at an elevation of 1100 m in the Sahyadri hill ranges near village Gogul of Surgana taluka in Nasik district of Maharashtra. After traversing a distance of about 131 km, it drains into Arabian sea. The important tributaries of the Par river are Aroti, Nar, Bhimtas, Vajri and Keng.

The Par basin lies between North latitudes 20° 16' and 20° 35' and East longitudes 72° 54' and 73° 44' with effective drainage area of 1648 km².

The basin can be divided into two prominent physiographic zones. The eastern part comes under rugged mountain chains of the Sahyadri hills and descends on the western side to the edge of the uplands of Valsad district. This region is placed at a steep slope of elevation 1050 m to 100 m. The Western part, barring the coastal plains, is essentially in the sub-Sahyadrian zone of hills and valley generally lies at an elevation below 100 m.

Deccan traps with dykes of quaternary and tertiary ages occupy most of the area of the basin. The middle ranges have developed on the Deccan traps and the intermediate amphitheatres have developed out of the alluvial debris washed from the hills. The lower reaches of the basin upto the coastal margins are mainly alluvial plains.

2.4.2 Auranga Basin

Auranga is a west flowing river with its catchment in Gujarat and Maharashtra. The river is known as Auranga after the confluence of its 2 tributaries viz., Man and Tan. The rivers Man and Tan originate in the

Sahyadri hill ranges near village Dongar and Kuranjul respectively in Surgana taluka in Nasik district of Maharashtra. The length of Man and Tan rivers upto their confluence is 78 km and 49 km respectively. The Auranga river traverses a distance of about 30 km after the confluence of Man and Tan rivers before draining into the Arabian sea.

Auranga basin lies between north latitudes $20^{\circ} 30'$ and $20^{\circ} 42'$ and east longitudes $72^{\circ} 53'$ and $73^{\circ} 37'$ with effective drainage area of 748 km². A portion of Valsad and Navsari districts of Gujarat and Nasik district of Maharashtra falls in this basin.

The basin forms part of the Western Ghats in Gujarat. Physiographically, the basin can be divided into 5 groups namely,

1. Hill tops and hill slopes,
2. Hill terraces and uplands,
3. Upper and lower foot slopes (medium land),
4. Valley plains and local depressions (low lands) and
5. River and stream beds.

Geological formations in the region belong to the Precambrian, mesozoic, tertiary and quaternary ages. Deccan traps occupy major portion of the upper reaches. They are of two prominent types viz. dark grey to bluish black which are hard, compact and massive and the light brown to pink which are soft.

2.4.3 Ambica Basin

Ambica is a west flowing river with its catchment area in Gujarat and Maharashtra. It rises in the Sahyadri hill ranges near village Kotambi of Surgana taluka in Nasik district of Maharashtra. After traversing a distance of about 164 km, it drains into the Arabian Sea. Important tributaries of Ambica river are Khapri, Olan, Kaveri and Kharera.

Ambica basin lies between latitudes $20^{\circ} 31' N$ and $20^{\circ} 57' N$ and longitudes $72^{\circ} 48' E$ and $73^{\circ} 52' E$ with effective drainage area of about

2685 km². Valsad, Dangs and Surat districts of Gujarat and a small portion of Nasik district of Maharashtra fall in this basin.

Basin can be divided into 2 prominent physiographic zones. The eastern part comes under rugged mountain chains of the Sahyadri hills and descends on the western side to the edge of the uplands of Surat district. This region is placed at a general elevation of 1050 to 100 m. Western part, barring the coastal plains, is essentially in the sub-Sahyadrian zone of hills and valleys generally below 100 m elevation.

Deccan traps with dykes of quaternary and tertiary ages occupy most of the area of the basin. The middle ranges have developed on the Deccan traps and the intermediate amphitheatres have developed out of the alluvial debris washed from the hills. Lower reaches of the basin upto the coastal margins are mainly alluvial plains.

2.4.4 Purna Basin

Purna is a west flowing river with its catchment in Gujarat and Maharashtra. The river rises in the Salher hills in the Western Ghats near village Chinchu at an elevation of about 1300 m in Maharashtra State. Total length of the river from its source to outfall in the Arabian Sea is about 180 km. Important tributaries of the river are Dhodar Nallah, Barda nallah, Nagihpar nallah, Girra river, Zankhari river and Dumas khadi.

Purna basin lies between East longitude of 72^o 44' and 73^o 58' and North latitudes of 20^o 44' and 21^o 06' and effective drains an area of 2193 km².

Basin can be divided in 2 prominent physiographic Zones. The eastern part comes under rugged mountain chains of the Sahyadri hills and descends on the western side to the edge of the uplands of Surat district. The region is placed at a general elevation of 1300 to 100 m. Western part, barring the coastal plains, is essentially in the sub-sahyadrian zone of hills and valleys and generally below 100 m elevation.

Deccan traps occupy major portion of the upper reaches. In the east, there are high ridges and deep valleys and towards the west, they merge into the lower reach composed of recent and sub recent alluvium and blown sand. Stratigraphical sequences of the rocks found in the basin are neogene, paleogene and early paleogene. Availability of ground water is restricted to weathered residues and fractured zones.

2.4.5 Tapi Basin

The river Tapi which is the second largest west flowing inland river of the peninsula rises near Betul district of Madhya Pradesh at an elevation of 752 m. In the head reach for a distance of about 241 km, the river traverses through an open and partially cultivated plain before plunging into a rocky gorge in the Satpura hills. The Tapi basin extends over an area of 65,145 km² and lies between north latitudes 20° 5' to 22° 3' and east longitudes 72° 38' to 78° 17' situated in the Deccan plateau. The basin covers a drainage area of 9804 km² in Madhya Pradesh, 51,504 km² in Maharashtra and 3837 km² in Gujarat. The important tributaries joining from the left are the Purna, the Vaghur, the Girna, the Bori, the Panjhra and from the right the Aner. The drainage area of the Tapi basin upto Ukai dam is 62,225 km² of which 9,804 km² in Madhya Pradesh, 51,504 km² in Maharashtra and 917 km² in Gujarat. The Tapi basin consists of mainly black soil. The coastal plains in Gujarat have alluvial soil with black soil on the surface.

2.5 Basin Characteristics

2.5.1 Rainfall

Par Basin

Basin receives about 97% of the annual rainfall during the South-West monsoon from June to September. The maximum, minimum and annual average rainfall in the basin is 2669 mm, 1920 mm and 2180 mm respectively

Auranga Basin

Basin receives most of the rainfall from South-West monsoon during June to September. 97% of the rainfall occurs during monsoon season. Rainfall during non-monsoon season is meager. Maximum, minimum and average annual rainfall recorded in the basin are 2406 mm, 1644 mm and 2055 mm respectively.

Ambica Basin

Basin receives most of the rainfall from south-west monsoon during June to September. About 98% of the rainfall occurs during the monsoon season. Rainfall during non-monsoon months is meager. Maximum, minimum and average annual rainfall recorded in the basin is 2520 mm, 1460 mm and 1830 mm respectively.

Purna Basin

Basin receives about 97% of the annual rainfall during south-west monsoon from June to September. Maximum, minimum and annual average rainfall of in the basin is 1972 mm, 782 mm, and 1472 mm respectively.

Tapi Basin

The basin comes under the direct influence of the south-west monsoon and receives heavy and assured rainfall between June and August. The rainfall gradually decreases from Karnataka in the south to Gujarat in the north. The south-west monsoon rainfall is usually very heavy. 90% of the rainfall occurs from June to November.

2.5.2 Temperature, Relative Humidity, Wind Speed and Cloud Cover

Two meteorological observatories viz., Surat and Vadodara maintained by IMD located adjacent to the project area have been used to characterize the climatic condition of the project area. The normal temperature, relative humidity, wind speed and cloud cover observed at Surat IMD observatory (based on the data for the period from 1998 to 2007)

and Vadodara IMD observatories (based on the data for the period from 1998 to 2007) are as follows.

Temperature:

Monthly mean maximum and minimum temperatures recorded at Surat and Vadodara stations are 36.8 °C and 14.7 °C and 39.9 °C and 13.2 °C respectively.

Humidity:

Monthly mean maximum and minimum relative humidity recorded at Surat and Vadodara stations are 90% and 53% and 94% and 44% respectively.

Wind Speed:

Monthly mean maximum and minimum wind speed recorded at Surat and Vadodara stations are 6.4 km/h and 1.7 km/h and 13.3 km/h and 2.2 km/h respectively.

Cloud Cover:

Monthly mean maximum and minimum wind speed recorded at Surat and Vadodara stations are 6.2 oktas and 0.7 oktas and 6.4 oktas and 0.8 oktas respectively.