ADANI POWER (JHARKHAND) LTD

SOURCE SUSTAINABILITY STUDY FOR DRAWL OF WATER FROM RIVER GANGA

FOR PROPOSED GODDA THERMAL POWER PLANT IN JHARKHAND

Final Report

July 2018

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ADANI POWER (JHARKHAND) LTD

ACHALRAJ, OPP MAYOR BUNGALOW, LAW GARDEN AHMEDABAD-380006, GUJARAT

SOURCE SUSTAINABILITY STUDY FOR DRAWL OF WATER FROM RIVER GANGA

FOR PROPOSED GODDA THERMAL POWER PLANT (2 x 800 MW) IN JHARKHAND

Executed by

Academy of Water Technology and Environ Management

In Technical Collaboration with

INDIAN INSTITUTE OF SOCIAL WELFARE & BUSINESS MANAGEMENT

(A CONSTITUENT INSTITUTE OF THE UNIVERSITY OF CALCUTTA)

CSIR-Central Glass & Ceramic Research Institute

(A Unit of Council of Scientific and Industrial Research)

FOREWORD

ADANI Group is one of the leading business houses of the country with combined market capitalisation of around US$ 20 billion, a sales turnover of US$ 12 billion, employing over 10,000 people and having diverse interests in global trading, development and operation of Ports, IDC Terminal, establishment of SEZ, Oil Refining, Logistics, Gas Distribution, Power Generation, Power Transmission and Power Trading etc.

Adani Power (Jharkhand) Limited (APJL), a wholly owned subsidiary of Adani Power Limited (APL), is proposing to set up 2 x 800 MW coal-based super critical Thermal Power Plant at Godda & Poriyahaat Tehsils under Godda District of Jharkhand for export of power to Bangladesh Country. APJL is planning to construct the water intake and pipeline infrastructure on river Ganga to meet water requirement of 36 MCM of proposed power plant. In view of this it is necessary to ascertain the availability of the water with 100% reliability as it is necessary for the power plant functioning. Also, the impact of the proposed water drawl from Ganga River even in lean season along with impacts on downstream competing users arising out of the withdrawal of water is to be assessed as per requirement of MoEF&CC.

Accordingly, APJL has commissioned AWTEM in technical collaboration with IISWBM and CSIR-CGCRI to undertake source sustainability study for drawl of water from river Ganga for proposed Godda Thermal Power Plant (2x800 mw) in Jharkhand.

The study presents results of the comprehensive analysis of different components associated with the hydrology, hydrogeology, geo-morphology, LULC of the area and about water source sustainability. The report provides an in-depth analysis on different components associated with water balance study with some recommendations on precautionary conservation measures to counterbalance any unforeseen negative impact on the natural ecosystem of the area.

This study would have not been possible without the constant support and guidance of Shri Santosh Singh, Sr VP & Head-Environment and Shri R. N. Shukla, AGM, Corporate Environment Group, and other executives & officers of APL, we are indebted to acknowledge their guidance and support.

We are also thankful to Shri Manish Singh, GM (Land Acquisation & CSR), Shri Harseh Kumar and other executives of AP(J)L for their valuable guidance and support provided from time to time in completion of field survey.

The study has been carried out under the technical collaboration with IISWBM and CSIR-CGCRI , we put on record my deep appreciation to the faculty members & research scholars of IISWBM and scientists and other staff members of CSIR-CGCRI associated with this project for bringing out such a comprehensive report.

We are indebted to acknowledge the guidance and proactive support extended by the faculty members and research scholars of Department of Geography of Presidency University, University of Calcutta & Department of Environmental Science, University of Kalyani and Director of Good Earth Enviro Care in execution of the present study.

Kolkata
July 30, 2018

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LIST OF ABBREVIATION

ABBREVIATION		DESCRIPTION
ADCP	:	Acoustic Doppler Current Meter
APJL	:	Adani Power Jharkhand Limited
APL	:	Adani Power Limited
AWTEM	:	Academy of Water Technology & Environment Management
BCM	:	Billon Cubic Meter
CSIR- CGCRI	:	Council of Scientific & Industrial Research-Central Glass & Ceramic Reseach Institute
CWC	:	Central Water commission
DEM	:	Digital Elevation Model
EC	:	Environmental Clearance
FDC	:	Flow Duration Curve
G&D	:	Gauge & Discharge
GJMVP	:	Ganga Jal Marg Vikash Project
GTPP	:	Godda thermal Power Plant
IISWBM	:	Indian Institute of Social Welfare & Business Management
IMD	:	Indian Meterogical Department
IWAI	:	Inland Water Authourity of India
LULC	:	Land Use and Land Cover
MoEF&CC	:	Ministry of Environment , Forest &Cliamate Change
MoWR	:	Ministry of Water Resource
NRCD	:	National River Consevation Directorate
SOI	:	Survey of India
SRTM	:	Shuttle Rader Topographic Mission
WAPCOS	:	WAPCOS Ltd. Government of India Undertaking
WRD	:	Water Resource Department
WRIS	:	Water Resources Information System

EXECUTIVE SUMMARY

The Adani Group, is one of the leading business houses of the country with combined market capitalization in excess of US$ 20 billion, a sales turnover of US$ 12 billion, employing over 10,000 people and having diverse interests in global trading, development and operation of Ports, IDC Terminal, establishment of SEZ, Oil Refining, Logistics, Gas Distribution, Power Generation, Power Transmission and Power Trading etc.

Adani Power (Jharkhand) Limited (APJL), is a subsidiary company of Adani Power Limited (APL), which has been formed to develop 2x800 MW Thermal Power Plant for Exporting Power to Bangladesh Country at near Motia, Gangta, Gaighat & other adjacent villages of District Godda, Jharkhand.

APJL is planning to construct the water intake and pipeline infrastructure on river Ganga to meet its water requirement of 36 MCM annually. In view of this it is necessary to ascertain the availability of the water with 100% reliability as it is vital for functioning of power plant. Also, the impact of the proposed water drawl from Ganga River even in lean season along with impacts on downstream competing users arising out of the withdrawal of water is to be assessed as per the Ministry of Environment, Forest and Climate Change (MoEF&CC) Environment Clearance conditions.

Accordingly, APJL has commissioned AWTEM in technical collaboration with IISWBM and CSIR-CGCRI to undertake source sustainability study for drawl of water from river Ganga for proposed GTPP. The prime objectives of the present study were as follows:

- To study water availability in River Ganga for all seasons as well as during scanty rain and heavy rain;
- To study the river behaviour for leanest period and flooding period;
- To study impact on hydrology and downstream flow and ecology due to water withdrawal for proposed TPP;
- To identify downstream competing users and impact on them due to proposed withdrawal of water;
- To formulate plan for maintaining minimum ecological/enviornmental flow in the river Ganga;
- To delineate Water Management Plan.

The scope of the study includes the undertaking of a reconnaissance hydrological survey. On the basis of the reconnaissance hydrological survey a framework were evolved for undertaking time bound detailed field survey for characterizing the flow in river Ganga besides collecting other primary as well as secondary data required for assessing the hydrology and behaviour of river Ganga. Preparation of inventory of downstream competing users along with medium/minor lift irrigation scheme constructed at downstream and the quantum of water being withdrawn by these users.

The proposed location of intake water system for the GTPP is: 25°14' 36.52"N, 87°41' 18.02"E which consists of Pumping (drawl) water from River (Intake location) and conveying it in pipeline upto plant reservoir through de-silting basin and intermediate reservoir. The locations have been selected based on position of main flow close to the right bank as well as morphological stability of the river bank line analyzed using historical imageries. Pipe line corridor length from water intake system point at River Ganga at Sahibganj to Power Project site is approx. 92.5 km. It crosses through various villages/Blocks of Sahibganj and Godda districts.

The present study has been exploratory in nature based on primary as well as secondary data of proposed intake location at right bank of river Ganga near Sahibganj which is located approx. 92 km from the proposed Godda TPP site.

Seasonal river flow rate is calculated before and after the intake well point using the minimum last 10 years' time series secondary data on monthly water level from recorded gauge height. Primary data of velocity and depth of channel also collected during pre – monsoon period i.e May 2018 near intake well for discharge computation and to ground check the authenticity and variation with the available secondary data. Subsequently, the sediment load also taken into consideration during river flow study. Based on the available monthly water flow in the river month - wise water demand are matched. The study also analyses the impact of intake water from intake well on local subsurface water and downstream in the different season.

To study the river behaviour around 10 km upstream and 10 Km downstream from the intake well for the leanest period and flooding period, two sets of high-resolution satellite images of pre-monsoon and post-monsoon period are procured, the digital elevation model of the area created for geomorphology of the terrain and detailed analysis. This is to understand the lateral and vertical accretion, channel migration of the river in the area. The morphological changes are matched with the river flow data for understanding the river behaviour along the Intake well point.

To study the impact on hydrology and downstream flow due to water withdrawal for proposed TPP monthly water availability is calculated and its impact on downstream water availability and impact on the behaviour of the river is assessed using digital model.

The reconnaissance survey was undertaken by a team of AWTEM Consortium along with APJL Team from 20th to 22nd April 2018. The team had a kick-off meeting at the Water Intake System Site Office at Sahibganj to finalise the modalities for commencing the field study as well as collection of secondary data. During the reconnaissance survey, AWTEM team member along with APJL Team visited the intake well site as well as upstream and downstream. During the field visit team members had interactions with local people to understand their water requirement along with usage and dependence on river Ganga for domestic as well as agricultural activities. The irrigation water requirement being met from river Ganga in both upstream and downstream of proposed intake well were also explored through interaction with the local community. The existing weirs/barrage/dams in the river reach were also explored. The detailed public consultation was undertaken involving the PAPs of proposed water intake system.

River Ganga originates in the Himalayas at the confluence of Rivers Alaknanda and Bhagirathi at Devprayag. Overall, River Ganga is longer than 2600 km depending on which streams are considered as her originating and terminating streams. The lower most part of the Lower Ganga segment tends to be braided, especially in the delta. The entire river valley (including the active floodplain) is a sensitive geomorphic-ecological river space. Lower Ganga sub-basin is in alluvial plains with low undulation. The lower reaches of the sub-basin are slightly above the sea-level, however, the upper portion rises up to 200 meters. The major LULC class in the sub-basin consists of cropped area (Double/Triple, Rabi only, Kharif only) which accounts for 49.46% of the total area. The soil texture of the sub-basin may be classified as clayey, loamy, and sandy and some rock outcrops. Annual rainfall of the basin varies from 244 mm to 3,782 mm and mean rainfall of 30 years is found to be 1,270 mm. Out of 30 years, for 15 years annual rainfall is higher than the mean rainfall and for remaining 15 years it is lower than the mean rainfall. The annual water resources of Lower Ganga sub-basin during these two extreme rainfall conditions are 266.45 BCM and 128.57 BCM respectively. The command area considered during the year 2014-15 has been worked out to be 9,71,31,000 hectare. The Ganga river network is intercepted by numerous dams and barrages. Dams and barrages affect river morphology, stability and ecological balance, fertility of the river and its floodplains, nature of flood events, human health, and basin performance.

The area within 10 km from the Water Intake Well includes two contrasting landscapes: the floodplains of the Ganga in the north and east, and the basaltic Rajmahal hills in the south. It is situated about 14 km upstream of the southward bend of the Ganga as it leaves its middle course through the Great Plains of the northern India into the lower course through the Bengal delta. The floodplains of the Ganga is restricted to 30 m. Area between 30 and 45 m forms the recessional plain while the region above 100 m forms the hills proper. The transitional piedmont zone is seen between and 45 m and 100 m. The river itself forms the dominating feature in the central portion of the area with its lean season level of water at 20–25 m above mean sea level. Its floodplains, including mid-channel sandbars and palaeocourses are confined mostly within 30 m. The area overlaps with the recessional plains formed by slope retreat of the Rajmahal ranges and outliers (30–45 m).Elevation of the hills proper start from 100 m and

continues up to 300 m. The transitional piedmont zone occupy the zone between and 45 m and 100 m. With an average annual discharge of ~16,650 cumecs, Ganga is one of the mightiest as well as most dynamic rivers of the world. The flow of the river increases almost eight-times during the monsoon months compared to the lean period, represented in the images in this report. Its highest gauge height has been recorded at 30.91 m at Sahebganj that would inundate the entire northern and eastern sections of the study area. The apparently safe location of the Water Intake Point is attested by its situation at the edge of the mender / braidbelt.

Owing to the seasonality of its discharge and composition of bank materials – largely sands – the Ganga constantly shifts its course within its meander belt. The changes in braids of the river during the last 46 years. It shows the apparently safe location of the Water Intake Well as it is situation just at the edge of the meander belt of the Ganga, with the right riverbank never shifting south of this point. It seems that the higher elevation of the recessional plain immediately to the east of the site with basalt in its basement, resisted southward migration of the river at this locality

To bring out the land use land cover characteristics of the area within 10 km from the Water Intake Well, Sentinel-2A MSAI data of 10-Apr-2018 were classified using maximum likelihood algorithm, after extensive ground truth verification. The analysis indicates that the farmlands cover more than half of the region and nearly all of the recessional plains south of the Ganga and the floodplains to its north. The low-lying and flood-prone river bars are mostly composed of sands (5.3%) and are also utilised for agriculture. The built-up areas (0.8%) are seen along the road and railway in from of five settlements, of which Satichauki and Sakrigali is closest (~2 km) to the Water Intake Point. The uplands areas are mostly covered by forests / orchards (18.5%) with sporadic patches of agriculture where valley-fills and villages are present. Evidence of deforestation and degradation of the vegetal cover is seen in some areas of the hill-tops (4.9%). Basalt quarrying (0.9%) has emerged as a major economic activity of the region in recent decades, and mostly occupies the piedmont location for easy accessibility and transportation.

AWTEM has obtained the data of the Rain Gauge stations situated in the project vicinity of lower Ganga basin to assess the water availability including monthly inflow data in the river Ganga. The long term rainfall data for Jharkhand from 1871 to 2016 have been collected from National Data Centre, IMD, Pune to analyze the dependable rainfall and average duration curve for rainfall. Jharkhand has an average yearly rainfall of 855.9 to 1872.8 mm with an average of 1335.6 mm and is generally uniform with little variation i.e. Standard Deviation of ±206.58. The rainfall data for four rain gauge stations namely Bhagalpur, Katihar, Sahebganj and Malda have also been collected through Customized Rainfall Information System (CRIS), Indian Meteorological Department, Government of India to assess the inflow of water and water availability in the proposed intake site at River Ganga. The analysis of long term trend from 2013 to 2017 of rainfall at upstream as well as downstream stretch of proposed intake site at river Ganga reveals that the annual rainfall at Sahibgunj varies from 1145 to 1645 mm, however, in the upstream stretch of proposed intake site the annual rainfall varies from 1009.8

to 1467.8 mm. The weighted average monsoon rainfall at 75% and 90% dependability for the Jharkhand Ganga sub-basin has been worked out and found to be 1172 mm and 1091 mm.

Monthly hydrograph of daily flow in River Ganga in the project area has been developed on the basis of 10 years daily discharge date collected from CWC for G&D Station at Azmabad for years 2005-06 to 2015-16. The analysis reveals that the average flow from July to December varies from 2405 to 32964 cum/s. Accordingly monthly FDC has been also developed on the basis of ten daily discharge data collected.

Water discharge was measured at intake site along with upstream and downstream of intake site for lean season i.e. from 18th to 20th May, 2018. Stream velocity measurements were conducted with a Current Meter (Valeport Model 106 Current Meter). The measurement of depth in terms of bathymetry survey has been done by using Eco- sounder (Velport Medas surveyor Sl. No. 45663) with single transducer along the cross sections. The estimated discharge at intake site work out to be 2027.58 cumecs by Direct CS zone wise average velocity i.e 0.5641 m/s and average depth of 6.011 m. Whereas the estimated discharge at intake site work out to be 1993.10 cumecs by direct co-ordinate method and overall average velocity i.e 0.5659 m/s.

The physio-chemical and bacteriological quality of water need to be assessed not only to estimate various treatment required for it ultimate use in TPP but it is also important to have details on presence of salts and nature of water (acidic or alkaline) which may have effect on intake well structure and equipments. The prime parameter includes pH, electrical conductivity, dissolve solids, suspended solids. Total hardness, sulphates, carbonates, bi-carbonates, chlorides, iron, calcium, magnesium, etc. Accordingly, water quality of River Ganga at intake site along with upstream as well as the downstream was assessed as per BIS 10500 guidelines.

Water is proposed to be withdrawn primarily during monsoon period and during this period silt laden water of monsoon flow may cause damage to under water components of intake well system resulting in costly repair and maintenance of equipment. The problem is more severe in River Ganga which carries lots of sediment containing quartz during monsoon. The maximum silt load was recorded during August i.e. 6,11,700 tons/day.

The river Ganga and its tributaries are home to a wide variety of aquatic biota (microscopic flora and fauna to higher invertebrates, vertebrates and plants). The field survey was undertaken in pre-monsoon period (May, 2018). During field survey for plankton study, five locations were selected which includes the proposed water intake site along with 3 d/s and 1 u/s of intake site. With the help of mechanised vessel, water sample of mid river streams was collected (at a depth of 0.5 – 1.0 meter) and filtered through plankton net (mesh 40 nm). At each sampling location 100 liter river water was filtered and samples were collected and preserved. The samples were brought to laboratory for microscopic study to ascertain the taxa. Periphytons were collected at random at river banks. Zoobenthios and other macro flora/fauna were examined along the study stretch and also at fish landing zones. The aquatic macrophytes and riparian vegetation composition were also recorded during field survey.

Species Diversity, which measures the bio-diversity and heterogeneity of aquatic ecosystem, was calculated based on the Shanon Weiner's function. The analysis reveals that the phytoplankton diversity ranges from 3.27-3.59 whereas the equitability index ranges from 0.80 to 0.88. The analysis further reveals that the zooplankton diversity ranges from 2.75 to 2.92 whereas the equitability index ranges from 0.87 to 0.92.

There are many factors which may affect the ecological integrity of river Ganga of which anthropogenic activities along the river Ganga is of the prime concern. These causatives are of major concern today with respect to threat of aquatic biodiversity of river Ganga. The some of the major causes includes habitat fragmentation, shrinkage , alteration, Invasion by Alien Species, encroachment, disturbances and malnutrition, etc.

As the water availability at proposed intake site is very high, the water abstraction of only 36 MCM annually from river Ganga at Satichouki mouza near Sahebganj for proposed GTPP is not likely to have any significant ecological impact. However, it may have some ecological impact in the form of habitat shrinkage and alteration. To combat/compensate the habitat shrinkage sand bars which were formed on the river bed need to be dredged in a periodic interval. As a long term management options for reduction of river water abstraction, water runoff facilities of proposed intermittent reservoir (at Simik talau, near Karmatola Station) should be excavated with appropriate drainage linkage from the neighbouring area. Appropriate Dry ash disposal system can also be explored along with regular water audit in power plant.

To assess the socio economic profile the villages falling within 2 km distance along with both the bank of the river Ganga in downstream up to Farakka Barrage have been identified using 2011 census atlas. The demographic profile of these villages as well as the land use pattern and irrigation facilities have been extracted using the latest census data other documents of Department of Water Resource and Irrigation, Government of Jharkhand and have been analysed to assess the existing water usage pattern and livelihood dependency on river Ganga at down stream upto the nearest next barrage from proposed intake location i.e Farakka Barrage. For public consultation to identify and asses the dependency of the local people on river Ganga and likely impact caused due to drawl of water for Godda TPP the questionnaire has been developed and were used for the purpose.

The villages at the downstream reach of river Ganga lies in Sahibganj, Taljhari, Rajmahal, Borio, Udhwa and Barharwa block of Sahibganj district in Jharkhand and Ratua I, Kaliachak II, Kaliachak III and Manikchak block of Maldah district in West Bengal. In total 225 villages lies in this zone. Of these only 158 villages are inhabited. In the district of Sahibganj only 102 villages are inhabited out of the total 140 villages. Whereas, in the district of Maldah, only 56 villages are inhabited out of the total 85 villages lying within 2 km distance from the Ganga river bank on either side.

As per Census of India, 2011 data, total populations in the villages at the downstream reach lies in Sahibganj district, Jharkhand and Maldah district, West Bengal. The total population (approximate) residing at the downstream reach of propose intake well are 4,64,733 covering a total of 92211 households on both the right and left side bank of the river. On the right-hand side river bank, a total of 35696 households are there ranging in the Sahibgang district, whereas, 56515 households are there in the district of Sahibgang and Maldah in the downstream left-hand bank of the river. Out of Total population in the downstream study area, about 184353 is the total working population. The right bank has a total population of 77626 and the left bank has a population of 106727.

In the downstream side of the intake location of river Ganga, in the district of Sahibganj, Jharkhand, the total geographical area of the villages within 2 km. distance from either side of the river bank is 19258.75 hectares. Of this area, 18357.12 hectares lies in the right-hand side bank, covering villages in the blocks of Sahibganj; Taljhari; Rajmahal; Borio; Udhwa; and Barharwa and the remaining in the left-hand side bank, in the block of Sahibganj. Of the 19258.75 hectares in Sahibganj district, about 272 hectares is forest coverage and 10232.66 hectares is the net sown area.

As a part of the study, probable downstream users impacts associated with the proposed withdrawal of water from River Ganga have been identified. Mainly the water is used for irrigation, drinking and other domestic purposes by downstream users. Due to proposed withdrawal of water from Ganga River, water availability during the monsoon and winter season will not be affected for downstream users as per the water availability study as sufficient water is available in the river. But it may affect up to certain extent during the summer/lean season. However, water drawl is not proposed during lean season.

Impact due to proposed water drawl for Godda TPP on water availability, water quality, ecology as well as socio-economy of local people at downstream of the intake point has been assessed on the basis of data collected from CWC for nearest GD&Q site Azmabad for the year 2006-2016. The impact on water availability at downstream due to proposed withdrawl of water for Godda TPP presents that the water availability at intake site stretch of river Ganga from June to December varies from 1700 to 17492 cum/sec at 90% dependability. However, the average discharge required to pumped is only 3.0 m^3/s (including sediment flushing which will come back in the river) for proposed thermal power plant. The analysis of change in the water flow at downstream of intake point after the proposed withdrawl of water for Godda TPP from river Ganga varies from 0.01 to 0.21% at 75% dependability, whereas 0.01 to 0.25% at 90% dependability of flow. As the overall change in the water flow at downstream of the intake point is likely to be 0.020% at 75% dependability and 0.03% at 90% dependability. Therefore APJL can withdraw the 36 MCM water from the proposed intake site without affecting the downstream users.

There are seven numbers of small and medium weirs constructed in lower Ganga basin. The storage capacity of dams/barrages/weirs are mostly filled in June & mid of July month. The store water is used for agricultural and ground water recharge in these regions.

Thus substantial quantity of water shall overflow the anicuts during monsoon and flows towards the downstream of propose intake structure and finally disposal in the River Ganga.

The water management & conservation plan for the proposed GTPP has been prepared with a view to help in conserving water during lean season/drought situations and ultimately reduce the demand of fresh water consumption from the River Ganga as they are allowed to withdraw water on during monsoon season. However, the plan may not be limited to lean season, but shall be followed all the year round. In order to reduce fresh water demand for the proposed power plant, some of the water conservation steps will be followed as recapturing & recycling this water for has a significant potential for water savings.

- APJL should construct a bigger reservoir for storing water, so that sufficient water can be stored that will be utilized during summer season, when enough water is not available.

- APJL will do Rain harvesting, which may play an important role in conservation of water.

- Closed circuit cooling system should be adopted for the thermal power plant to optimize fresh water requirement.

- In the Conventional Thermal Power Plants apart from cooling towers, water is also consumed in ash handling process. Bottom Ash from the boilers will be converted to slurry using the partially treated wastewater in water impounded bottom ash hopper and transported to co processing units for disposal. Work up on proposed methods – Dry Ash Handling, HCSD for unutilized ash, FGD make up from blow down and treated water for AHP & CHP

- Moreover, in order to reduce the water demand in fly ash handling and disposal, a dry phase pneumatic conveying system is also adopted.

- The major waste-water generated from the plant like DM Plant discharge will be treated in a Waste Water Treatment Plant and recycled for its reuse in the Plant. No discharge of liquid waste is foreseen from the proposed power plant. The coal pile area runoff water during monsoon season will be led to a well-designed Coal Setting pond. Coal particles will settle down in the Pond and clear water will be allowed to overflow to the Central Monitoring Basin for treatment in the Effluent Treatment Plant (ETP) of the Power Project.

- Automation of control systems shall be done as far as possible to reduce water losses.

- The rain water is collected separately in the Storm Water Drain running all around the project. Rain Water Harvesting Pit would be connected to the Storm Water Drain. Excess rain water will flow to common collection pit from where water can be pumped for use in the ash handling system.

- Regular maintenance of pumps and valves shall be carried out.

- Water audits shall be carried out regularly and records of water consumption and wastewater generation shall be maintained.

The study has been carried out in order to identify the likely impacts on water availability and downstream users due to withdrawal of water from the River Ganga. All the impacts associated with the withdrawal of water from the River Ganga which were likely to have an effect on the availability of water and downstream competing users have been identified and studied in detail. The foremost positive impact of the project is increase in agricultural production as the water from the river would be pumped into intermittent reservoir which will help in increasing the water table of that area.

Considering the scenario of likely impacts, there are some impacts on the ecological environment of the River Ganga which shall be mitigated naturally with due course of time as ecological cycle has a self-sustaining capacity. Moreover, there are insignificant impacts on the downstream users due to the additional water withdrawal due to the proposed TPP. Further, the project proponent i.e. APJL also undertakes CSR activities which shall have beneficial impacts on the socio-economic environment.

Looking to the overall project scenario, it has been noticed that the project in totality may be considered environmentally safe.

1.0 INTRODUCTION

1.1 BACKGROUND

The Adani Group, is one of the leading business houses of the country with combined market capitalization in excess of US$ 20 billion, a sales turnover of US$ 12 billion, employing over 10,000 people and having diverse interests in global trading, development and operation of Ports, IDC Terminal, establishment of SEZ, Oil Refining, Logistics, Gas Distribution, Power Generation, Power Transmission and Power Trading etc. Adani Port at Mundra promoted by the ADANI Group is operational since 1998.

Adani Power Ltd (APL) has been formed for development of a number of Power Projects along with its associated dedicated transmission systems. Adani Power Ltd commissioned India's first super critical 660 MW unit at Mundra on 22nd Dec 2010. Presently, the company has total installed generation capacity of 10,480 MW, out of which 4620 MW (4x330 MW + 5x660 MW) at Mundra, 3300 MW (5x660 MW) at Tiroda,1320 MW (2x660) at Kawai, 1200 MW (2x600 MW) at Udupi and 40 MW Solar Power Plant at Bitta.

Adani Power (Jharkhand) Limited (APJL), is a subsidiary company of Adani Power Limited (APL), which has been formed to develop 2x800 MW Thermal Power Plant in Jharkhand. APJL have identified Thermal Power Plant (TPP) location near village Motia in Godda district of Jharkhand (Figure 1.1). The estimated water requirement of proposed Godda TPP is about 36 MCM annually which is envisaged to be met from River Ganga.

FIGURE 1.1: LOCATION OF PROPOSED 2 X 800 MW GODDA TPP NEAR MOTIA VILLAGE, JHARKHAND

1.2 NEED OF THE STUDY

The proposed 1600 MW (2x800MW) Thermal Power Project is Coal based Thermal Power Plant is planned for Exporting Power to Bangladesh Country at near Motia, Gangta, Gaighat & other adjacent villages of District Godda, Jharkhand by Adani Power (Jharkhand) Limited(AP(J)L).

Adani Power (Jharkhand) Limited (APJL) has been planning to construct the water intake and pipeline infrastructure on river Ganga. The water consumption for Godda TPP is about 36 MCM/year and is proposed to be sourced from Ganga River. Water received from the source (Intake Well) is treated in treatment plant and then used further for power plant purpose. The fresh water to cater the plant needs such as power cycle make up, auxiliary cooling water, services, potable water, etc. is fed from water treatment plant for proposed plant.

In view of this it is necessary to ascertain the availability of the allotted water quantity with 100% reliability as it is necessary for power plant functioning during the year, without affecting the requirement of the downstream areas during whole year.

Also, the impact of the proposed water drawl from Ganga River even in lean season along with impacts on downstream competing users arising out of the withdrawal of water is to be assessed as per detailed scope of the work described in subsequent paragraphs.

For the compliance of the conditions of Ministry of Environment, Forest and Climate Change (MoEF&CC) Environment Clearance, i.e. TOR No. 27 of MoEF&CC: Source of water and its sustainability even in lean season shall be provided along with details of ecological impacts arising out of withdrawal of water and taking into account inter-state shares (if any). Information on other competing sources downstream of the proposed project and commitment regarding availability of requisite quantity of water from the Competent Authority shall be provided along with letter / document stating firm allocation of water.

The water allocation for the project was granted by WRD, Government of Jharkhand from river Chir. The studies were carried out by WAPCOS and Submitted to MoEF&CC for appraisal. MoEF&CC had granted EC to project based on the water allocation from river Chir. However, looking at long-term sustainability, WRD has changed the water allocation from river Chir to river Ganga (Annexure 1.1). Therefore, this study is carried out for the same Terms of Reference for river Ganga.

Accordingly, APJL has commissioned AWTEM in technical collaboration with IISWBM and CSIR-CGCRI to undertake source sustainability study for drawl of water from river Ganga for proposed Godda Thermal Power Plant (2x800 mw) in Jharkhand.

1.3 OBJECTIVES OF THE STUDY

The prime objectives of the proposed study are as follows:

- To study water availability in River Ganga for all seasons as well as during scanty rain and heavy rain;
- To study the river behaviour for leanest period and flooding period;
- To study the hydrology of river Ganga;
- To study impact on hydrology and downstream flow and ecology due to water withdrawal for proposed TPP;
- To identify downstream competing users and impact on them due to proposed withdrawal of water;
- To prepare inventory of existing medium/minor/lift irrigation schemes constructed at downstream.
- To formulate plan for maintaining minimum ecological/enviornmental flow in the river Ganga;
- To delineate Water Management Plan.

1.4 SCOPE OF STUDY

The scope of the study includes the undertaking of a reconnaissance hydrological survey. On the basis of the reconnaissance hydrological survey a framework would be evolved for undertaking time bound detailed field survey for characterizing the flow in river Ganga besides collecting other primary as well as secondary data required for assessing the hydrology and behaviour of river Ganga. Preparation of inventory of downstream competing users along with medium/minor lift irrigation scheme constructed at downstream and the quantum of water being withdrawn by these users. The detail scope of study shall cover following:

1. To obtain necessary data for hydrological aspects of the project.
2. To study the DPR of the Project.
3. To obtain the secondary data of the existing medium/minor/lift schemes constructed downstream if any.

4. To obtain Topo-sheets and Satellite images of the related area, if required.

5. Collection of Rainfall and Runoff data of river flow for vetting of DPR and/or EIA report.

6. To study the water availability in river for livelihood of the people for all situations, i.e. during scanty Rainfall as well as heaviest rainfall.

7. Review and analysis of the collected secondary data.

8. Preparation of water availability data and suggest measure for improvement if necessary.

9. To study river behaviour up to the next dam/barrage on the Ganga River for all the River flow conditions, i.e. leanest period and flooding period.

10. Formulation of master plan and prioritization of water allocation across different season and for all likely possible situations.

11. Hydrology prepared by department shall be studied and vetted.

12. Review of the water management plans, flow regulation plan, plans for maintaining ecological flow and lean season flow and plan for downstream user.

13. Impact on hydrology of Ganga River and downstream flow due to the proposed water allocation for Thermal Power Plant.

14. Study of downstream ecology and impact assessment due to proposed withdrawal of water.

15. Identification of downstream competing users and impact on them due to proposed withdrawal of water.

16. Delineation of Management Plan, if any.

The Scope of Work would also include presentation of the study report before the Expert Appraisal Committee of MoEF&CC and subsequent preparation of replies to the clarifications asked, if any.

2.0 WATER INTAKE SYSTEM

The brief detail of proposed water intake system for GTPP is presented in subsequent sections.

2.1 LOCATION OF INTAKE WATER SYSTEM

Location of Intake water system is presented in Table 2.1.

TABLE 2.1: LOCATION OF PROPOSED INTAKE WATER SYSTEM

Project Authority	**Adani Power (Jharkhand) Ltd, AP(J)L**
Project	Water Intake System & Water Pipe Line Project for 2x800 MW Ultra Super Critical Thermal Power Plant
Selected Location	Water Intake System – Villages – Sati Chowki Khutari in Borio Block, Sahibganj District, Jharkhand, India. Water Pipe Line Route – 92.7 km in two district(s): Sahibganj & Godda of Jharkhand
Coordinates of Intake Site	25°14' 36.52"N 87°41' 18.02"E

2.2 CLIMATE AND METEOROLOGICAL DATA

Nearest meteorological station (of Indian Meteorological Department) to the proposed site is at Dumka. Meteorological data as recorded at Dumka are presented in Table 2.2.

TABLE 2.2: METEOROLOGICAL DATA AT DUMKA

Dry Bulb Temperature	Max: 34.4° C, Mean: 28.8° C, Min: 18.2 ° C
Relative Humidity	Max: 83%, Mean: 60%, Min: 39%
Rainfall Annual Average	1317 mm
Maximum 24hour rainfall	307.3 mm
Rainfall (Sahibganj) Annual Average	1576 mm

2.3 SALIENT FEATURES OF INTAKE WATER SYSTEM

The proposed Intake water system for project consists of Pumping (drawl) water from River (Intake location) and conveying it in pipeline upto plant reservoir through Desilting basin and Intermediate reservoir. Table 2.3 presents monthly water drawl schedule from River Ganga for Godda TPP.

A circular radial Intake well pump house is proposed in the Ganga River bed. A pump house is planned to have vertical pumps. The Raw Water Pumps at intake well will lift the water and deliver it to the Desilting basin through a Rising main MS pipeline.

There will be desilting basin (on land near to intake) of suitable size with associated pump house. Water will be lifted by the pump from the sump near desilting basin and transported to the Intermediate reservoir. From intermediate pump house, water shall be pumped to Raw Water Reservoir in plant through MS pipeline.

Suitable cathodic protection & coating system shall be adopted for corrosion protection of pipeline.

The construction & infrastructure work of Intake Water system will be completed within 18 months from the start of construction activity.

TABLE 2.3: MONTHLY WATER DRAWL SCHEDULE FROM RIVER GANGA FOR GODDA TPP

Month	Number of Days	Water Drawl (MCM)
June	30	7
July	31	6
August	31	4
September	30	4
October	31	4
November	30	5
December	31	6
Total		36

Average pumping capacity: 3 m^3/s (including silt flushing)
Average pumping hours: 20 per day
Average pumping days: 30 per month

2.4 SELECTION CRITERIA

Water Intake System

The selection of promising intake locations is usually based on the following considerations:

- The intake has to be placed at most feasible location where water is available in required quantum
- The intake should be near morphologically stable river bank
- The approach to the intake system should be easily accessible
- The intake should be near the thalweg (main flow)

- Considering existing or upcoming developments like pumping stations, barrage, navigation structure like terminal, bridges at upstream and downstream close to the proposed location

- Away from Protected Areas, National Parks, Wildlife Sanctuary (Ecological Considerations)

The Ganga passes through Jharkhand for about 65 km and within this reach of the river, the main channel (thalweg) comes to the right bank at two locations, near Sahibgunj and Rajmahal. Therefore, prima facie, these are the two possible locations for the intake system and have been studied for further detailed analysis for finalization of the location for the intake.

These locations were further examined using historical satellite images taken at different times to assess the bank line shifting or stability as well as observations from site visits. The study of the river morphology near the identified intake locations, Sahibgunj and Rajmahal is presented in subsequent sections.

Three promising locations in order of priority, suitable for placing the intake have been identified (Figure 2.1). The locations have been selected based on position of main flow close to the right bank as well as morphological stability of the river bank line.

These locations are further examined on satellite images taken at different times to assess the bank line shifting or stability. The locations have been identified based on existing morphology condition of river. Using historical imageries, changes in river morphology in the past will be assessed and the locations will further be shifted accordingly. It is expected there might be requirement of shifting slightly upstream or downstream of the identified locations due to ground constraints like accessibility, land use nearby, constructability ease, any upcoming or planned structure or facility as well as considering river bank behavior in the past.

As river Ganga is the only perennial river that flows in the state of Jharkhand and through Sahibganj area, to draw water from river Ganga, a water availability study was conducted. Based on the study three options emerged based on the morphological stability of the river bank line and feasibility of construction of intake system:

- Option - 3: Not found feasible considering land use pattern and habitation.

- Option - 2: Not found feasible considering the water pipe line passes through Rajmahal hills, Coal mine area and forest area.

- Option - 1: Found feasible due to following points:

- The river reach has been stable in past at this location and sufficient water depth is available throughout the year (Figure 2.2).

- The pipeline route is also found more suitable for this option as it avoids the hills, coal mine area and reduces forest area, making it comparatively less technical and regulatory constraint oriented in implementation.

FIGURE 2.1: PROPOSED LOCATIONS OF WATER INTAKE SITE AT RIVER GANGA

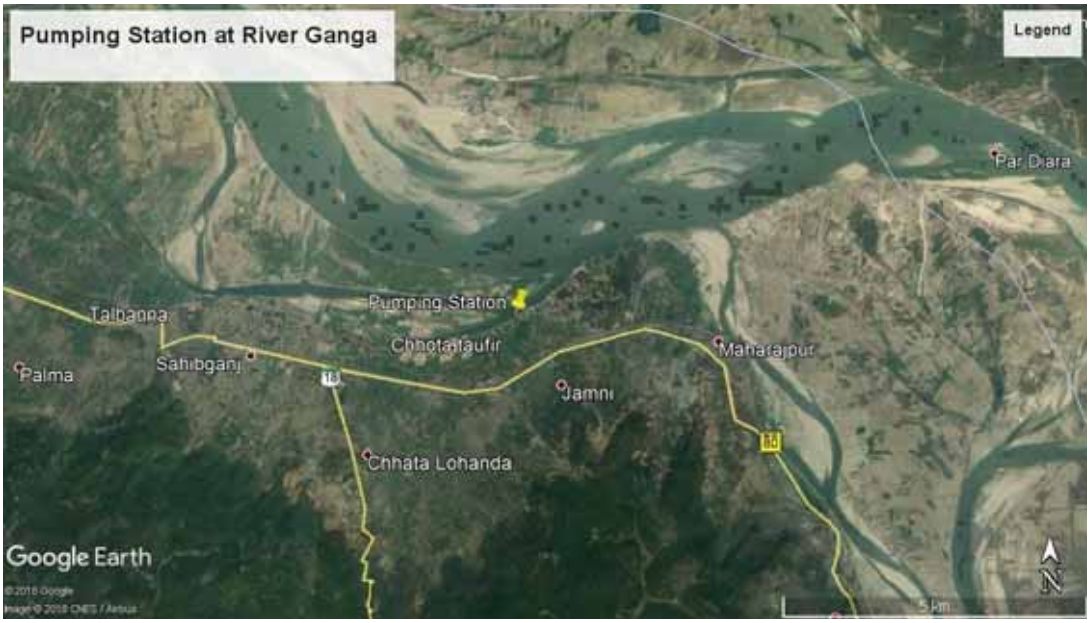


FIGURE 2.2: SELECTED LOCATION OF WATER INTAKE SITE AT RIVER GANGA

Water Pipeline Route

The basis of selection of the pipe line corridor horizontal alignment include the following considerations:

- Shortest route
- Avoid habitation
- Close to road networks (accessibility)
- Minimum curves in horizontal as well as vertical alignment
- Minimum cross drainages
- Considering existing or upcoming development along the corridor
- Away from protected areas for example area of wildlife sanctuary, national park (ecological consideration)

Three preliminary pipeline corridor alignments have been conceived considering hills, forests, habitations, other land use like mining area, drainage lines, administrative boundaries, accessibility (road networks), constructability, length of corridor, static head.

Pipe Line Route 1: Intake Location: Option 1, Sahibgunj , via Sahibganj – Damanikoh – Pratappur - Charka Ghat - Plant (Length 96 km)

Pipeline Route (1A): Intake Locations: Option 1 Sahibgunj, via Sahibganj – Boria-Murcha-Pratappur-Charka Ghat -Plant (Length 100 km). This route diverts at location Nirapara of Route 1 and goes to Boria-Pratapur and join route 1 again at Rauldih.

Pipeline Route 2: Intake Locations: Option 2 Upstream of Rajmahal town, via Raybazar-Brindawan – Borio – Pratappur-Charka Ghat (Length 100 km). This route starts at intake Option 2 and goes to join Boria on route 1A which further joins Route 1 at Rauldih.

The static head difference between any of the intake location and the power plant is about 70 m (difference between lean flow water level in the Ganga at Sahibgunj and average ground level near TPP location)

The above three alignments have been finalized on Survey of India (SOI) 1: 50000 scale topography sheets (open series maps without contour) to understand the land use, habitations, village names, drainage, and ground features etc. as well as closer view of digital elevation model (i.e., SRTM topography). The alignments are shown on satellite imageries, SOI maps as well as, SRTM topography separately and presented on 1: 50000 scale in different sheets/maps (A0 size printable) plates.

The intake location Option 1 is found to be more promising because (i) its closeness with an upcoming IWT project which also suggest the river bank and river reach have been stable in past at this location and sufficient water depth has been available throughout etc. The pipe line route 1 is found to be more suitable option as it bypasses (avoids) hills, forest area, therefore, will have comparatively less technical and regulatory constraints in implementation (Figure 2.3). The pipe line route 1A from intake Option 1 and the route 2

from intake Option 2 pass through Raj Mahal hill and forest area, therefore, these routes will have more technical and regulatory difficulties in implementation.

Three routes have been evaluated and alternate – 01 is finalized based on lesser requirement of forest diversion (Table 2.4).

TABLE 2.4: PROPOSED WATER PIPELINE ROUTE

Description	Alternate 01	Alternate 02	Alternate 03
Route Length	92.7 km	99.0 km	91.5 km
Forest Length in Route	6.9 km	15 km	25 km
Coal Block Length in Route	Nil	8.0 km	Nil
Highest elevation	101.0 m	130.0 m	230.0 m
Availability of approach	80%	60%	60%

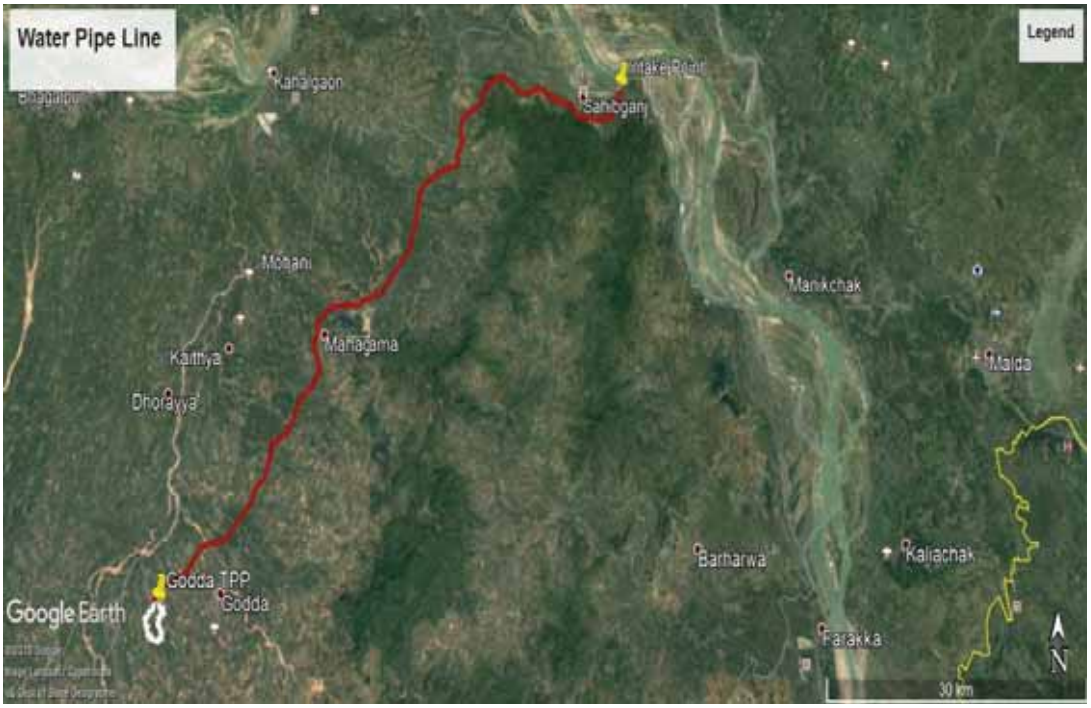


FIGURE 2.3: PROPOSED WATER PIPELINE ROUTE

2.5 LAND REQUIREMENT

Pipeline corridor width has been envisaged as 20 m considering following:

- Pipe corridor (approx. 8.3 m) considering two number of pipes (1500NB/ 1600NB size, & considering provision of future pipe line)
- Transmission tower corridor (approx. 6.5m for 33kV)
- Service road (3.750m with 0.70m shoulder on either side)

Pipe line corridor length from Water Intake System point at River Ganga at Sahibganj to Power Project site is approx. 92.5 km. It crosses through various villages/Blocks of two districts. Table 2.5 shows the complete area statement (Private, Government and Forest land).

TABLE 2.5: AREA STATEMENT OF PROPOSED WATER PIPELINE CORRIDOR

Sl. No.	District	Block	Total nos. of village	Required Private Land (In Acre)	Required Govt. Land (In Acre)	Total Forest Area Required (In Acre)	Total required land in Block (in Acre)
	(1)	(2)	(3)	(4)	(5)	(6)	(7=4+5+6)
1	Sahibganj	Borio	13	25.240	0.000	6.066	31.306
2		Taljhari	2	6.145	0.000	0.590	6.735
3		Mandro	28	101.452	0.000	10.855	112.307
4		Sahibganj	1	5.698	0.000	0.060	5.758
Total			**44**	**138.535**	**0**	**17.571**	**156.106**
5	Godda	Meherma	16	50.137	5.575	--	55.712
6		Boarijor	14	42.571	1.086	17.390	61.047
7		Mahagama	27	57.486	4.965	--	62.451
8		Pathargama	18	51.209	6.628	--	57.837
9		Godda	21	58.314	10.729	--	69.043
10		Poreyahat	1	0.000	0.000	1.860	1.860
Total			**97**	**259.717**	**28.983**	**19.250**	**307.950**
Total Area in water pipe line route				**398.252**	**28.983**	**36.821**	**464.056**
Total Running km as per land type				**80.4**	**5.2**	**6.9**	**92.5**

Strategy for Land Acquisition:

Non-Forest land shall be applied to Government of Jharkhand for ROU and Forest land shall be applied for diversion.

P1: Location of Proposed Intake Site of GTPP at River Ganga

P2: Land Proposed to be Acquired for Setting up of Water Intake System of GTPP

P3: IWT Multi-Modal Terminal Being Set Up Near Proposed Intake Water System of GTPP

P4: Status of Lean Season Flow Near Proposed Intake Site of GTPP at River Ganga

P5: Status of Lean Season Flow at U/S of Proposed Water Intake Site of GTPP

P6: Status of Lean Season Flow at D/S of Proposed Water Intake Site of GTPP

3.0 METHODOLOGY

3.1 WORK METHODOLOGY

The present study has been exploratory in nature based on primary as well as secondary data. The work methodology for this study as per the parameters of the scope of work was planned such that it would lead to the specific objective of the study, which are described as follows:

- Comprehensive Reconnaissance survey of site
- Meeting with Adani Power Jharkhand Limited {AP(J)L} officials.
- Preliminary study of River Ganga Basin and understanding the water requirements at site
- Collection of rainfall and runoff data, maps, reports, etc if available.
- Study of the collected data
- Analysis, validation of the collected secondary data.
- Hydrological study of the River Ganga.
- Water availability in the River Ganga for all the situations such as lean season etc.
- Existing flood management plans and suggests measures if required for flood mitigation.
- River behavior for all the river flow condition.
- Impact assessment on the downstream flow due to the proposed withdrawal for all the river flow condition.

3.2 DATA COLLECTION

Proposed intake location at right bank of river Ganga near Sahibganj which is located approx. 92 km from the proposed Godda TPP site.

Rainfall Data

Long term rainfall data for the entire Ganga basin, particularly for project area would be collected from Indian Meteorological Department (IMD)

Stream Flow Data

For the proposed study the stream flow and sediment load data at Sahibganj (if available) as well as stream flow and sediment load information at Azamabad and Farakka Barrage would also be collected monitored by Central Water Commission (CWC).

Stream Flow Water Quality

Water sample would be collected from the downstream as well as upstream of proposed intake well at river Ganga and physio-chemical as well as bacteriological and biological quality of water would be analyzed.

Hydrographic Survey

Hydrographic survey for about 3-5 days during Monsoon season and 3-5 days during lean season (Summer season) would be undertaken.

Bathymetry Survey

Current observations (ADCP) and Gauge levels at the proposed Intake location along the width of the river would also be undertaken, if required. Average width of the river in this reach is approx. 3km.

Topographic Survey

Topographic survey along the river bank (both left and right bank up to buffer of 2 KM) would be undertaken, if required through DGPS and Total Station.

Toposheet

The relevant toposheets of the intake well area along with its buffer zone would be collected and subsequently analysed.

Satellite Imagery

Satellite data products – Multispectral imageries would be acquired for timeseries analysis of various hydrological as well geomorphological features of river Ganga near intake well. The following steps would be opted for the study –

I. Flood Frequency analysis for the design flood in the river stretch along with change detection studies would be carried out using SCS curve Number technique along with SWMM conceptual model. Base flow determination.

II. Analysis of River Bank using Satellite Images

III. Micro level study of water pocket near possible Intake location

IV. Hydraulic River Modelling using state-of-the-art software.

V. Estimation of Discharge for Intake structure would be carried out using the proposed water drawl schedule for GTPP.

The data requirements, their sources and status of procurement of the data are presented in Table 3.1.

TABLE 3.1: DATA REQUIREMENTS, SOURCES AND COLLECTION STATUS

Data Requirement	Source	Collection Status
Remote sensing images DEM Topography-sheets, Survey of India , 1: 50000 scale Open series map	USGS site Shuttle Radar Topographic Mission (SRTM), 90 M SOI , Dehradun	Collected Collected Collected
Rainfall IMD's Daily Gridded Data (0.250 x 0.250)	IMD Pune	Collected (1917-2016)
Gauge, Discharge, silt Data	Central Water Commission	Received data for Azmabad CWG GD&Q site of CWC from APJL
Bathymetry survey near the proposed intake location along with upstream and down strem site	Primary data	Collected
Water Quality & Ecological Monitoring near the Proposed intake location along with upstream and down strem site	Primary data	Collected

Seasonal river flow rate is calculated before and after the intake well point using the minimum last 10 years' time series secondary data on monthly water level from recorded gauge height. Primary data of velocity and depth of channel also collected during pre – monsoon period near intake well for discharge computation and to ground check the authenticity and variation with the available secondary data. Subsequently, the sediment load also taken into consideration during river flow study. Based on the available monthly water flow in the river month - wise water demand are matched.

The study also analyses the impact of intake water from intake well on local subsurface water and downstream in the different season.

To study the river behaviour around 10 km upstream and 10 Km downstream from the intake well for the leanest period and flooding period, two sets of high-resolution satellite images of pre-monsoon and post-monsoon period are procured, the digital elevation model of the area created for geomorphology of the terrain and detailed analysis. This is to understand the lateral and vertical accretion, channel migration of the river in the area. The morphological changes are matched with the river flow data for understanding the river behaviour along the Intake well point.

To study the impact on hydrology and downstream flow due to water withdrawal for proposed TPP monthly water availability is calculated and its impact on downstream water availability and impact on the behaviour of the river is assessed using digital model.

3.3 RECONNAISSANCE SURVEY

The reconnaissance survey was undertaken by a team led by Dr. Ashim Bhattacharya, Dr.K.M Agrawal and Ms Moumita Sarkar from AWTEM Consortium along with APJL Team from 20th to 22nd April 2018. The team had a kick-off meeting at the Water Intake System Site Office at Sahibganj on 20th April 2018 to finalise the modalities for commencing the field study as well as collection of secondary data.

Initially, APJL Team appraised the objective of proposed study and the required coverage of the same as per MoEF&CC Environmental Clearance condition. APJL Team also shared the detailed information regarding proposed site of water intake well as well as water pipeline corridor and intermittent water reservoir. They also shared the key features of proposed water intake system. During the meeting detail plan for undertaking field study was also discussed and resolved that all the required primary data need to be collected before the onset of monsoon, preferably within 30th May 2018.

The modalities for collection of secondary data from Water Resource/Irrigation Department, Government of Jharkhand/Bihar; Ministry of Water Resource (MoWR), Government of India (GOI); National River Conservation Directorate (NRCD), GOI; Central Water Commission (CWC); Inland Water Authority of India (IWAI), Indian Meteorological Department (IMD), etc. APJL Team assured their full support and guidance required for collecting the primary data as well as secondary data from local as well as district authority(s).

Accordingly, Dr. Bhattacharya and Dr. Agrawal suggested to commence the field study from first week of May and complete the same by third week of May 2018.

During the reconnaissance survey, AWTEM team member along with Adani Power (Jharkhand) Ltd Team visited the intake well site as well as upstream and downstream of the same on 21st and 22ndApril 2018. During the field visit team members had interactions with local people to understand their water requirement along with usage and dependence on river Ganga for domestic as well as agricultural activities. The irrigation water requirement being met from river Ganga in both upstream and downstream of proposed intake well were also explored through interaction with the local community. The existing weirs/barrage/dams in the river reach were also explored. The detailed public consultation was undertaken involving the PAPs of proposed water intake system.

3.4 PRELIMINARY FIELD OBSERVATIONS

Proposed intake point is located in the downstream of Sahibganj Town. It is just beyond the convergence point of the main river Ganga and the canal that flows through the town of Sahibganj. In the vicinity of Intake well at the upstream the main ferry ghat that serves as one of the main waterways connecting Sahibganj with Manihari block in the state of Bihar across the river Ganga. River waterway is functional all-round the year. Gangetic Dolphin are oftenly observed in this stretch. The observed bird species in this stretch during the pre monsoon are mostly cranes, little black cormorant, etc . The adjoining agriculture land and pastures are flooded during monsoon. The site supports different trees and shrubs viz. Babool, Mango, Palm etc. However, in the vicinity presence of mango orchards is predominant. Two IWT floating type terminals at downstream i.e. at Sahibganj and Rajmahal are coming up and are in the construction phase, having pontoon on water front with berth size of 35 m each.

The villages falling within 2 km distance along with both the bank of the river Ganga in down stream of proposed intake site upto Farakka Barrage have been identified using 2011 census atlas to assess the socio economic status of the people residing in the river reach. The demographic profile of these villages along downstream of the river Ganga, on both the right and left side bank falling in the districts of Sahibganj in Jharkhand; and Maldah in West Bengal as well as the land use pattern and irrigation facilities have been extracted using the latest census data i.e 2011 and other documents of Department of Water Resource and Irrigation, Government of Jharkhand. For public consultation to identify and asses the dependency of the local people on river Ganga and likely impact caused due to drawl of water for Godda TPP the questionnaire has been developed and were for the purpose.

The discussions with local community around proposed water intake system reveals that the dependency on river Ganga for domestic water requirement is only for few villages which are very close to the bank of river Ganga. In most of the villages the water requirement for domestic purpose is being met from ground water sources as the ground water level in these villages is very high i.e. less than 5-10 m. However for irrigation purpose the farmers whose land is very close to river Ganga they directly withdraw the water from Ganga using stand alone water pump system. The initial survey of the project site reveals that there are

no minor, medium as well as major lift irrigation system. The major concern of the community people regarding availability of water is the deteriorating quality of the river water. It was observed that the agricultural land adjacent to the vicinity of the river Ganga is usually flooded during the monsoon, whereas, bare minimum impact is on the village. It can be stated that the drawl of water for the proposed thermal power plant could possibly provide intermittent flood relief due to the withdrawal of water as the surrounding area is highly flood prone during the monsoon season.

The initial observation on existing crop pattern of river reach area reveals that along the bank soil being very fertile the range of vegetable being cultivated by local people during the non- monsoon period i.e November to May. The adjacent agricultural area which is usually not affected by flooding is used for cultivation of paddy as well as wheat, maize and sometimes bajra.

Over the last few decades, the river Ganga network has been consideredably fragmented by dams and barrages. These obstructions slice the rivers into several segments, thereby interrupting the flow of water, nutrient, sediments and aquatic biota of the river. So far a total of over 28 dams, barrages, or other kinds of major structural obstruction were reported to exist on river Ganga and its tributaries with Indian territory (Ministry of Water Resources, 2014).

Water level in the braided channel of river Ganga (i.e. is passing through the town of Sahibganj) during summer (month of April) was found to be approx. 15 -20 m. The width of the river in this stretch is around 25 – 30 m near the ghat at Sahibganj town. This channel is perennial and does not dries up during the even summer. A water intake well of Indian Railways is located approx. 10 m. from the Sahibganj ferry ghat. This well mainly serves the railway colony located in the town and the railway station. It was observed that the water from the river is used basically for holy rituals, bathing, washing and agriculture purposes (across in the fields located on the island), and immersion of idols. The main or primary users are the village communities residing in the vicinity of the river bank.It is observed that there is bare minimum waste disposal in and around the ghat area.

The land area around the banks of the river at Sahibganj around the vicinity of the intake area is very prone to erosion and formation of new land (island/mainland) due to the natural river flow pattern.

A few meters adjacent to the left side of the ghat a small ferry is located. This serves the small fishermen, farmers & agricultural labours and the locals. Small to medium boats operate here. The island on the opposite side is used for farming, especially vegetables (bottle groud, bitter groud, cucumber, parval, kakri, turai). A second abandoned intake well is located on the left side of the ghat. The fishing community is basically residing near the ghat. Observed bird species – crane (white necked), shalik, house crow. Many fish species are found in the canal, the daily catch consists of Palva (Tangra), Putia (Puti), Aar, baam, bele, prawns, baspata, kukri, phesa, kawalori/luri, batasi etc.

P7: Study Team Members at Proposed Intake Site of GTPP at River Ganga

P8: Discussion with Local People Regarding Acquisition of Land for Proposed Water Intake Site of GTPP

P9: Discussion with Local People Regarding Likely Impact of Setting up of Water Intake System at River Ganga

P10: Local People Livelihood Dependent on River Ganga Near Intake Site

P11: Local People Livelihood Dependent on River Ganga Near Intake Site

P12: Local People Livelihood Dependent on River Ganga Near Intake Site

4.0 GANGA RIVER BASIN

4.1 GANGA RIVER NETWORK

River Ganga originates in the Himalayas at the confluence of Rivers Alaknanda and Bhagirathi at Devprayag. However, before this confluence, the Alaknanda herself had merged with four major Himalayan rivers. Overall, River Ganga is more than 2500 km long, and perhaps longer than 2600 km depending on which streams are considered as her originating and terminating streams. The river line diagram of Ganga and its major tributaries and distributaries is presented in Figure 4.1.

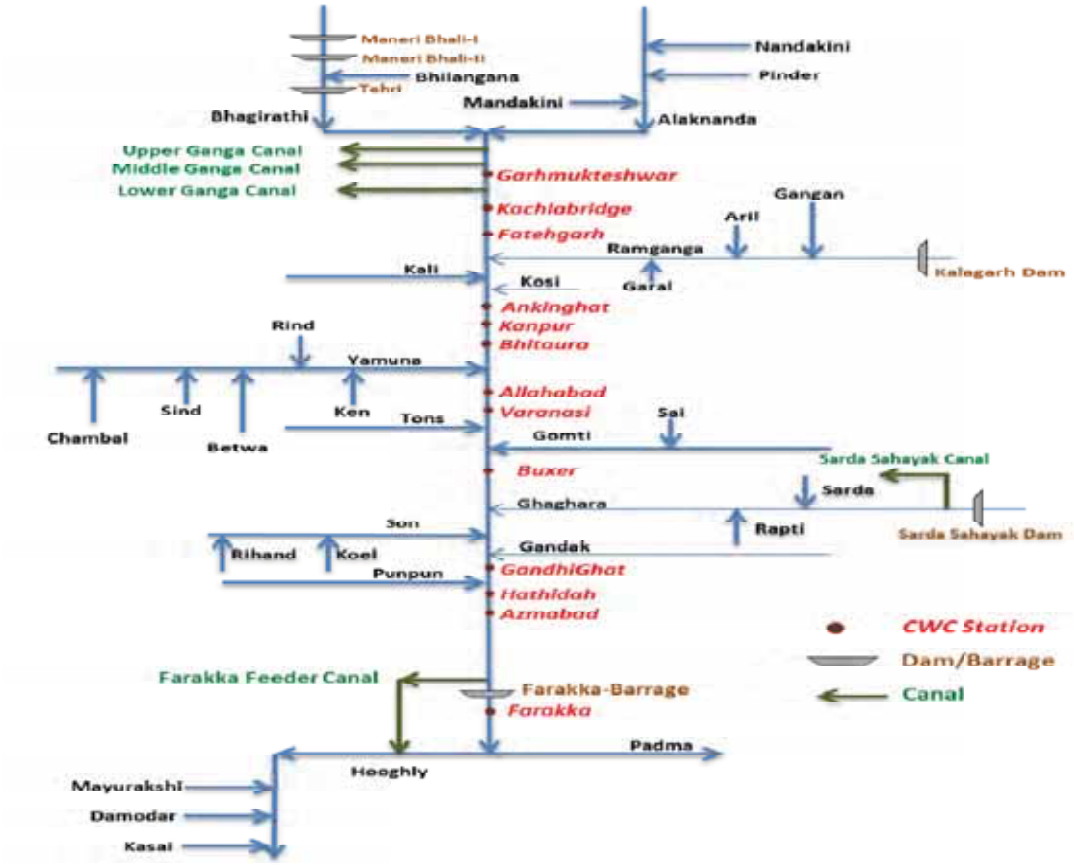


FIGURE 4.1: RIVER LINE DIAGRAM OF GANGA AND ITS MAJOR TRIBUTARIES AND DISTRIBUTARIES

River Network: National River Ganga originates in the Himalayas with several major head-streams – Alaknanda, Bhagirathi, Bhilangana, Dhauliganga, Mandakini, Nandakini and Pindar, which progressively join together on or before Devaprayag. Descending in the plains, the river flows approximately southeast and is joined by several large streams such as Ramganga, Yamuna, Kosi, Gandak, Gomti, Sone, Karamnasa and Ghaghra to become an immense river in the plains below Allahabad. The river then flows through the Rajmahal hills and divides into two streams. The eastern branch – River Padma – flows southeast through Bangladesh to join the Brahmaputra and Meghna rivers before flowing into the sea. The south-flowing branch – River Hooghly – is joined by Rivers Damodar and Mayurakshi before reaching the sea. The oied outfalls of the to ahes togethe fo the olds lagest delta

In Lower Ganga Reach, it receives water from three categories of rivers. In the first category perennial rivers, which originate in Himalayas and carry snow fed flows with significant discharge in the non-monsoon season. This includes Kosi, Gandak, Karnali (Ghaghra) and Mahakali (Sharda) river systems. In the second category are the rivers like Mechi, Kankalm, Kamla, Bagmati, West Rapti and Babai rivers which are fed by precipitation as well as ground water recharge and springs. Although these rivers are also perennial, they are commonly characterized by wide seasonal fluctuations in discharge. The third category of river systems includes a large number of small rivers in the terrain which originate from the southern Shivalik range of hills. These rivers are seasonal with little flows during the dry season but characterized by flash floods during the monsoon. Many important small, large and mega religious congregations are a part of socio-cultural dimensions of the riverine system at several places, the most important being at Ganga Sagar where the river merges into the sea. A line diagram showing the lower reach of Ganga Basin is shown in Figure 4.2. The river in the third reach is wide and considerable changes in the sediment transport and deposition is observed which eventually leads to frequent change in the river course and wide spread flooding. Figure 4.3 presents the lower Ganga sub-basin network.

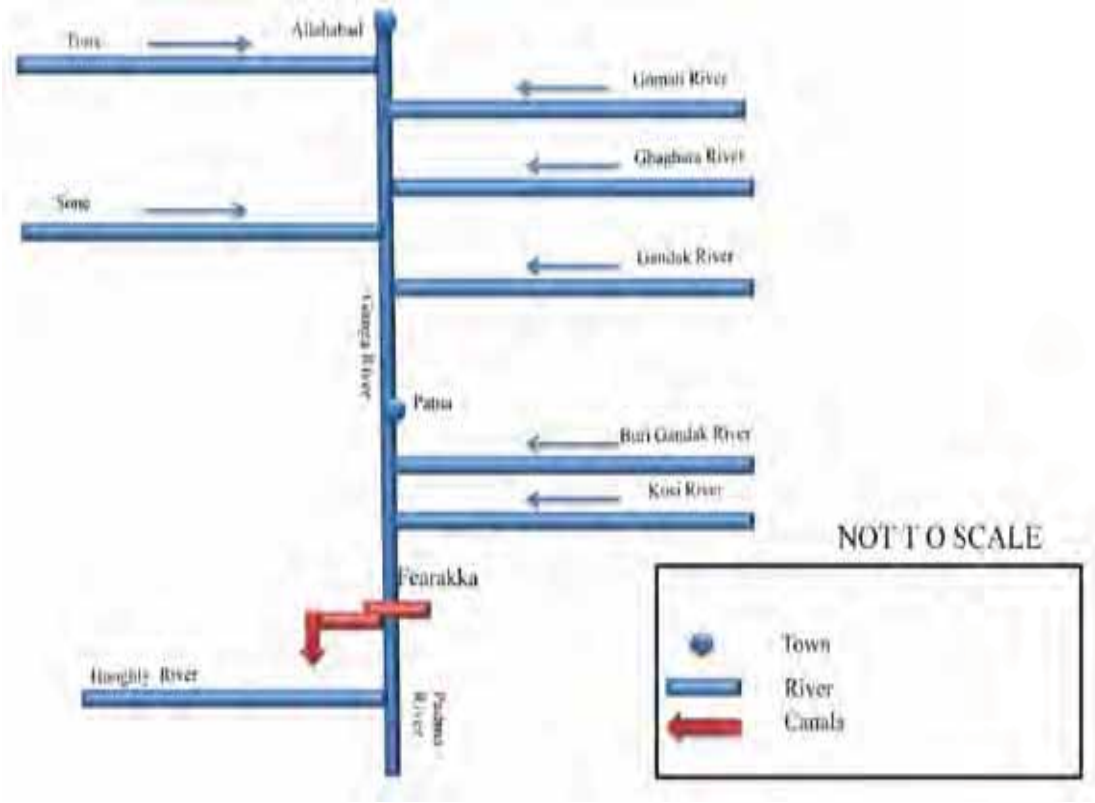


FIGURE 4.2: LOWER REACH OF GANGA BASIN

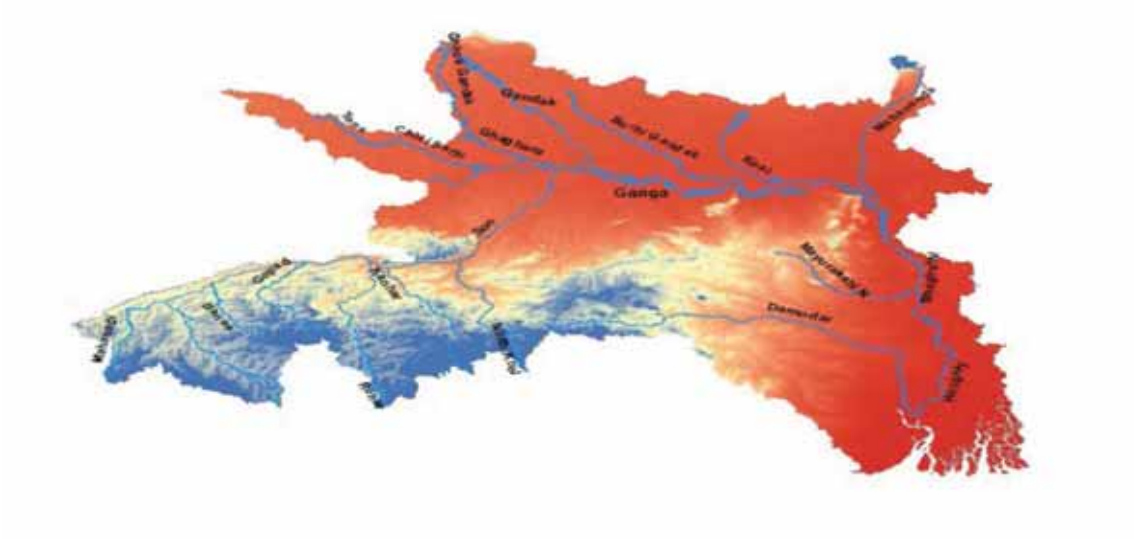


FIGURE 4.3: LOWER GANGA SUB-BASIN NETWORK

4.2 GEOMORPHOLOGY OF LOWER GANGA SUB-BASIN

The lower most part of the Lower Ganga segment tends to be braided, especially in the delta. Geomorphic map of Ganga river valley is presented in Figure 4.4. The entire river valley (including the active floodplain) is a sensitive geomorphic-ecological river space. Based on remote sensing data and other inputs, the active floodplain of the Lower Ganga stretches has been mapped as shown in Figure 4.4. The analysis reveals significant diversity of valley widths and geomorphic features in different reaches of the river, which have strong implications for the hydrological regime, water resource management, and ecological health of lower Ganga sub- basin.

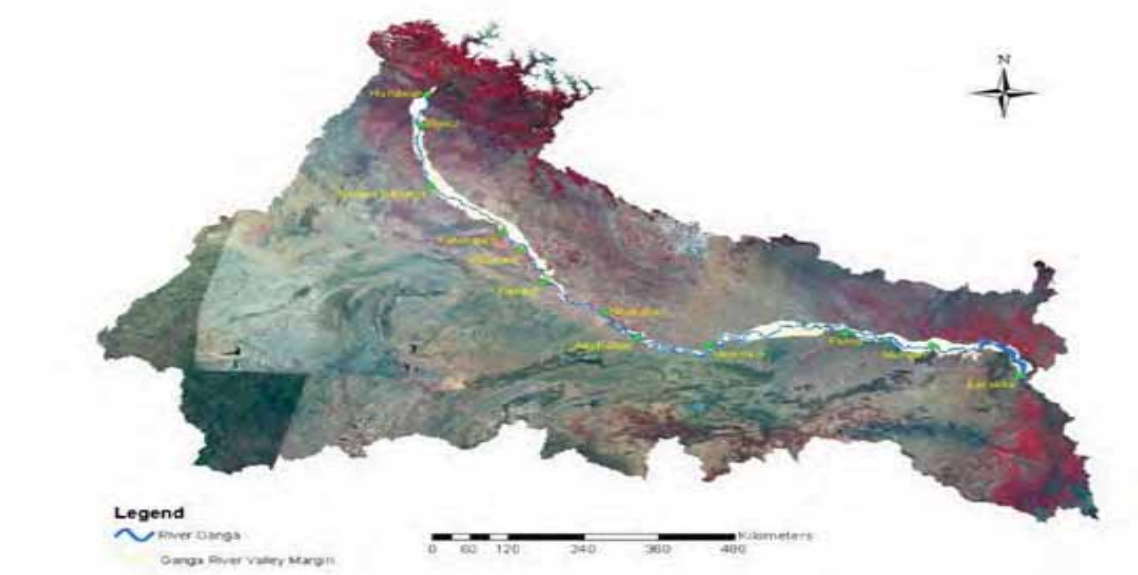


FIGURE 4.4: GEOMORPHIC MAP OF GANGA RIVER VALLEY

4.3 TOPOGRAPHY OF LOWER GANGA SUB-BASIN

Lower Ganga sub-basin is in alluvial plains with low undulation. The lower reaches of the sub-basin are slightly above the sea-level, however, the upper portion rises up to 200 meters. The elevation values ranges from a minimum of 0 m to a maximum of 2,566 m. The average elevation is about 192 m in the basin. Figure 4.5 shows Shuttle Radar Topographic Mission (SRTM) Digital Elevation Model (DEM) map of the sub-basin.

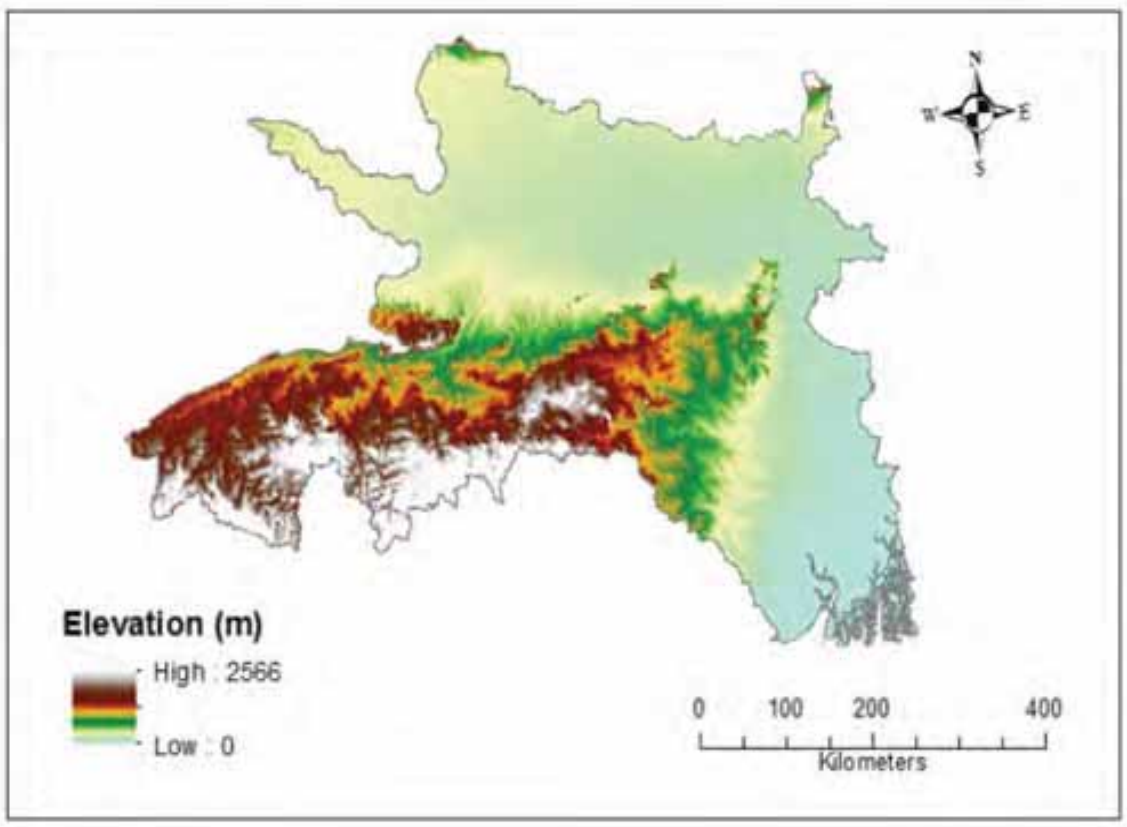


FIGURE 4.5: SRTM DEM MAP OF LOWER GANGA SUB-BASIN

4.4 LAND USE AND LAND COVER OF LOWER GANGA SUB-BASIN

The Land Use and Land Cover (LULC) map of Lower Ganga sub-basin for the year 2004-05 is shown in Figure 4.6. Figure 4.7 shows the distribution (in percentage) of LULC in the basin. The major LULC class in the sub-basin consists of cropped area (Double/Triple, Rabi only, Kharif only) which accounts for 49.46% of the total area.

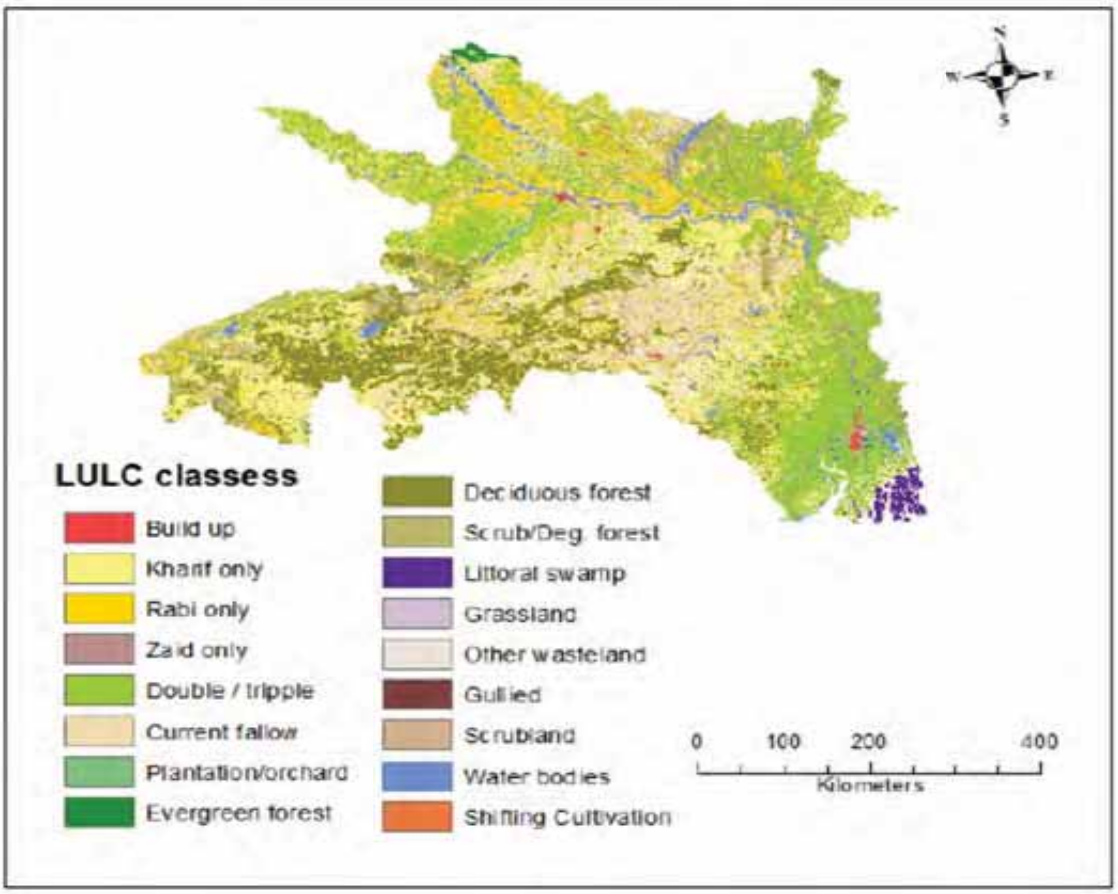


FIGURE 4.6: LULC MAP OF LOWER GANGA SUB-BASIN

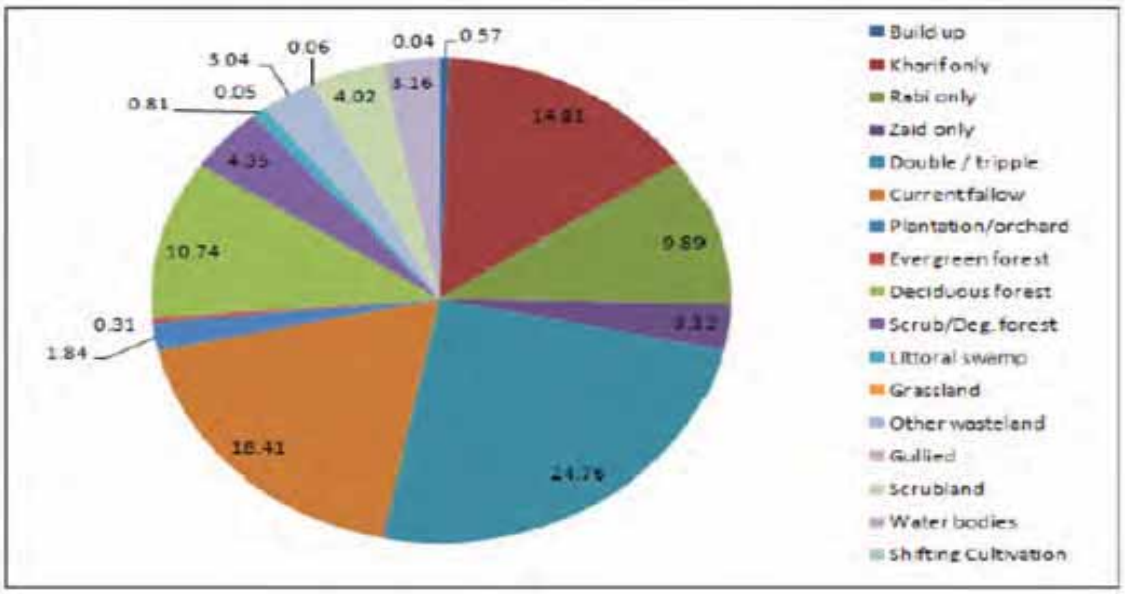


FIGURE 4.7: DISTRIBUTION OF LULC IN LOWER GANGA SUB-BASIN

4.5 SOIL TEXTURE OF LOWER GANGA SUB-BASIN

The soil texture of the sub-basin may be classified as clayey, loamy, and sandy and some rock outcrops. Figure 4.8 shows the soil texture map of the sub-basin.

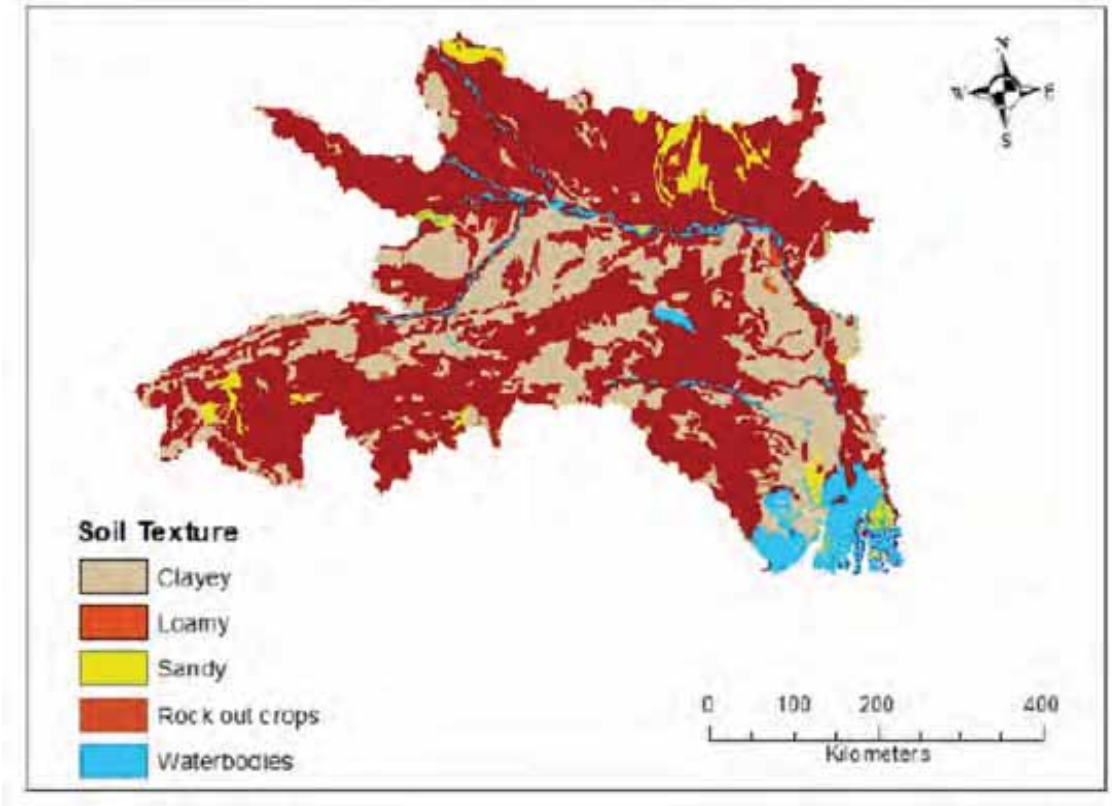


FIGURE 4.8: SOIL TEXTURE MAP OF LOWER GANGA SUB-BASIN

4.6 RAINFALL GRIDS OF LOWER GANGA SUB-BASIN

Figure 4.9 shows gridded annual rainfall map of Lower Ganga sub-basin for year 2004-05. The variation in the annual rainfall during study period of 30 years (1985-86 to 2014-15) is shown in the Figure 4.10. Annual rainfall of the basin varies from 244 mm to 3,782 mm and mean rainfall of 30 years is found to be 1,270 mm. Out of 30 years, for 15 years annual rainfall is higher than the mean rainfall and for remaining 15 years it is lower than the mean rainfall.

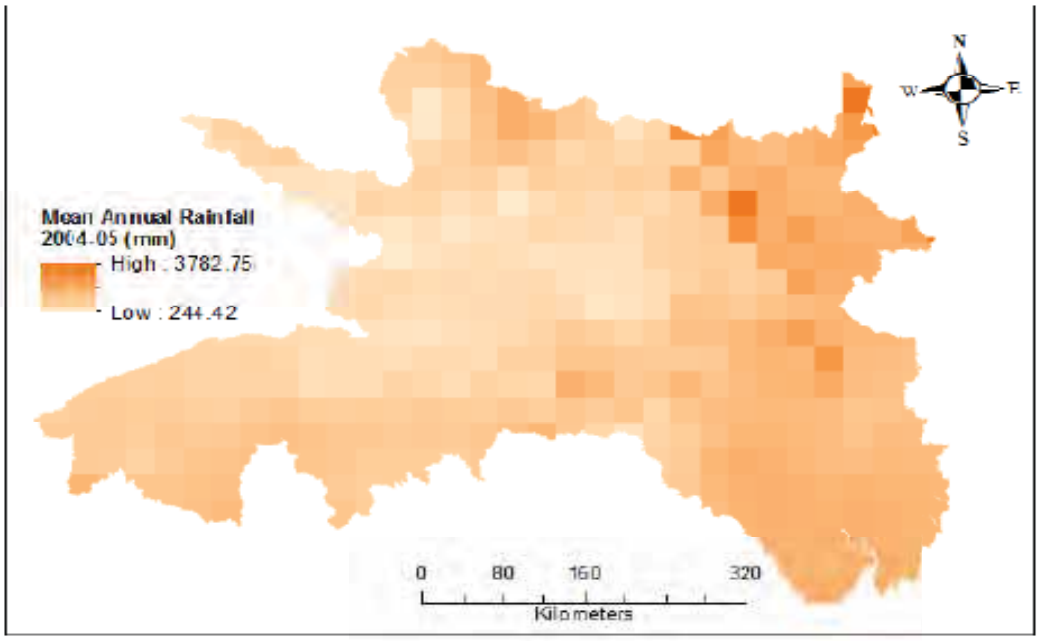


FIGURE 4.9: GRIDDED RAINFALL OF LOWER GANGA SUB-BASIN

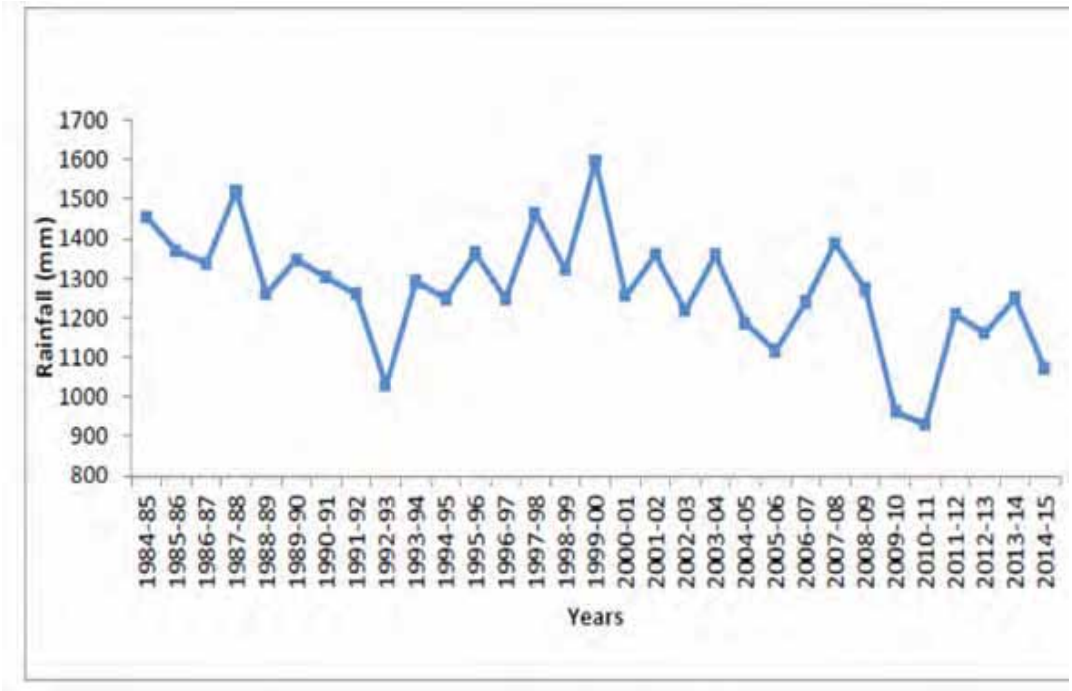


FIGURE 4.10: ANNUAL RAINFALLS IN LOWER GANGA SUB-BASIN

Source: CWC/BPMO/BP/WRA/October, 2017

4.7 TEMPERATURE GRIDS OF LOWER GANGA SUB-BASIN

Gridded mean annual temperature map of the basin for 2004-05 year is shown in Figure 4.11.

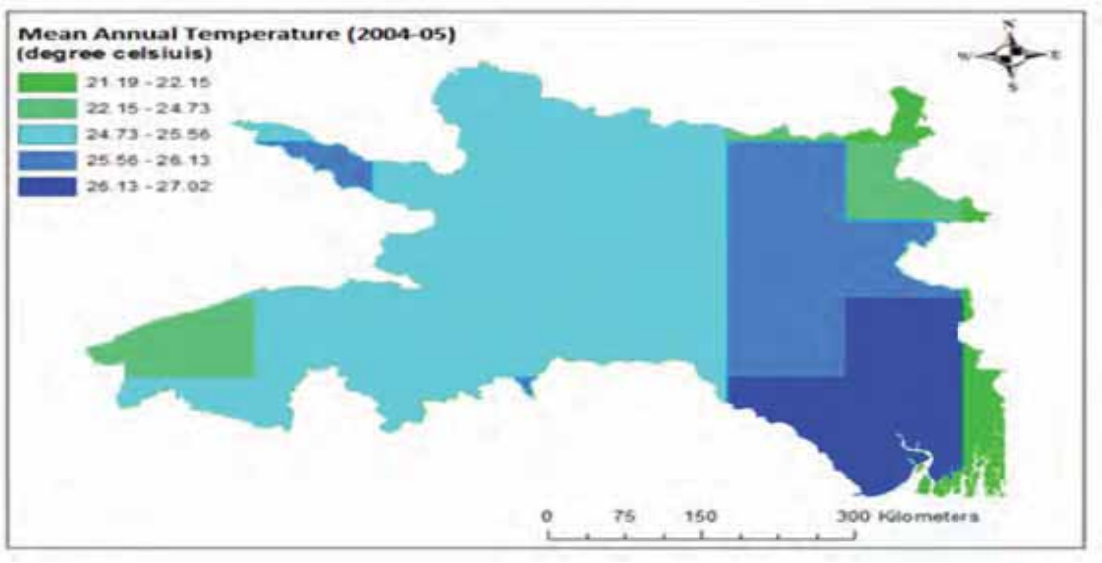


FIGURE 4.11: GRIDDED MEAN ANNUAL TEMPERATURE FOR LOWER GANGA SUB-BASIN

4.8 WATER RESOURCE OF LOWER GANGA SUB-BASIN

The maximum and minimum annual water resource availability is 266.45 BCM during 1999-2000 and 128.57 BCM during 2010 -11 respectively in the 30 years period. The average annual water resource availability of Lower Ganga sub-basin is 192.60 BCM. 75% dependable flow of Lower Ganga sub-basin is 179.25 BCM.

The water resources availability of Lower Ganga sub-basin accounts for about 52.86% of mean annual rainfall during the period 1985-86 to 2014-15. The total population as per 2011 census is 240.63 million and hence average annual water availability per capita is about 800.39 cubic metres.

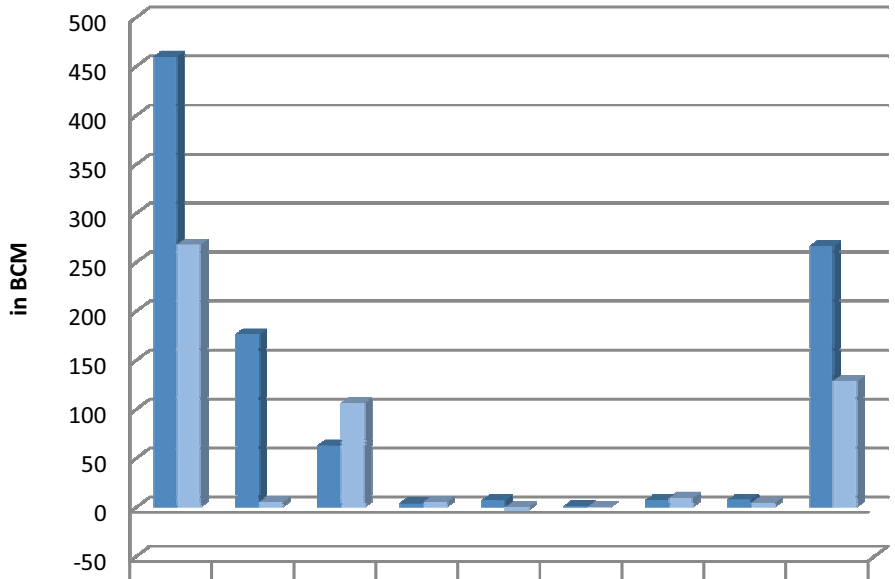
Out of the total 30 years of meteorological data base of study period, during the years 1999-2000 and 2010-11, extreme wet and dry rainfall conditions occurred in Lower Ganga sub-basin respectively. The annual water resources of Lower Ganga sub-basin during these two extreme rainfall conditions are 266.45 BCM and 128.57 BCM respectively as shown in Table 4.1. The water balance components during these years are presented in Figure 4.12.

TABLE 4.1: WATER RESOURCE AVAILABILITY IN LOWER GANGA SUB-BASIN DURING EXTREME RAINFALL CONDITIONS

Condition	Year of Occurrence	Rainfall (BCM)	Water Resources Availability (BCM)
Maximum Rainfall	1999-2000	459.76	266.45
Minimum Rainfall	2010-11	268.03	128.57

Source: CWC/BPMO/BP/WRA/October, 2017

FIGURE 4.12: WATER BALANCE COMPONENTS OF LOWER GANGA SUB-BASIN DURING MAXIMUM & MINIMUM RAINFALL



	Rainfall	Q-calib	ECII	DIL	GW Flux	Reservoir Flux	Export	Res. Evaporation	Water availability
Maximum Rainfall	459.76	176.5	62.95	3.99	6.94	0.87	7.38	7.82	266.45
Minimum Rainfall	268.03	5.19	106.37	5.44	-2.85	0.26	9.74	4.43	128.57

Source: CWC/BPMO/BP/WRA/October, 2017

4.9 IRRIGATION COMMAND AREA OF LOWER GANGA SUB-BASIN

Figure 4.13 shows location of irrigation command boundaries inside and outside the Lower Ganga sub-basin considered for the year 2014-15. The command area considered during the year 2014-15 has been worked out to be 9,71,31,000 hectare (excluding the basin outside command).

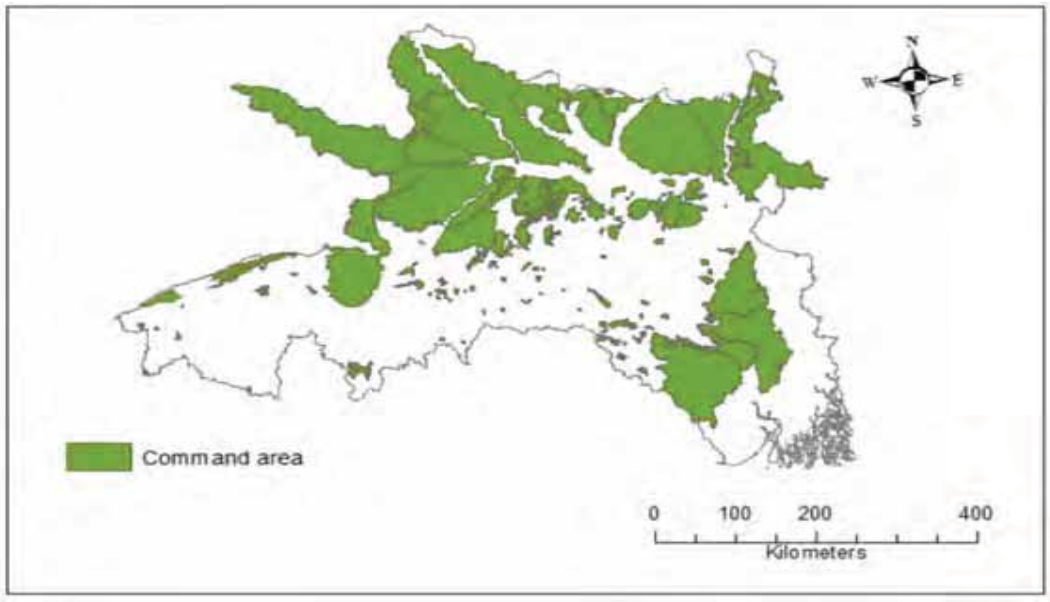


FIGURE 4.13: IRRIGATION COMMAND BOUNDARIES OF LOWER GANGA SUB-BASIN

4.10 DAMS AND BARRAGES OF LOWER GANGA SUB-BASIN

The Ganga river network is intercepted by numerous dams and barrages. The detail of dams, barrages and wires of lower sub Ganga basin is presented in Annexure 4.1. Dams and barrages affect river morphology, stability and ecological balance, fertility of the river and its floodplains, nature of flood events, human health, and basin performance.

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5.0 GEOMORPHOLOGICAL STUDY

5.1 REGIONAL TOPOGRAPHY

The regional topography of the area covering Godda TPP Plant location possible intake locations on the right bank of the Ganga near Sahibgunj and Raj Mahal towns are shown in Figure 5.1. It also shows the drainage / rivers which are starting from hillocks (Raj Mahal Hills) and flowing towards east and west.

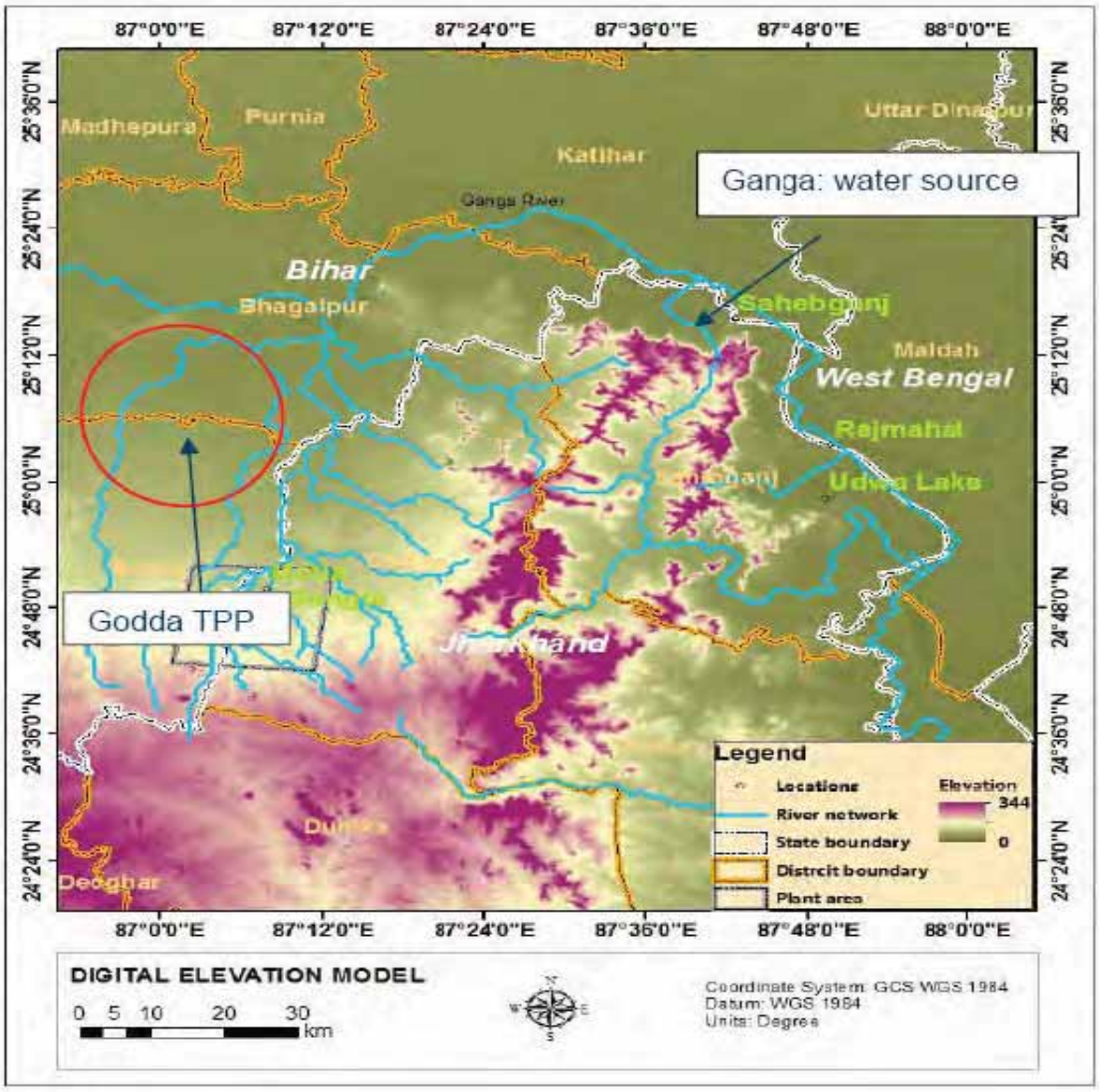


FIGURE 5.1: REGIONAL TOPOGRAPHY COVERING GTPP SITE, INTAKE SITE & PIPELINE CORRIDOR

The survey of India (SOI) topography sheet (scale- 1:50000) of the area have been identified and found to be in restricted area. The restricted areas topography sheets with contours and spot levels are made available with clearance from defence. However the open series map (OSM), which do not contain contours and spot elevations, of the restricted maps are ,made available to general public/ consultants/students etc. The consultant has procured relevant OSMs, these maps have been helpful in understanding land use, habitation, villages, forest area etc, and further improvement in the pipeline alignment. SRTM (90 m) Digital Elevations Models (DEM) / topography data have been used to understand the general topography of the area, identify hillocks, valleys, major drainages etc. and accordingly plan pipeline corridor and understanding elevation differences.

5.2 HYDROGEOLOGY AND SOIL

Understanding geological formations and soil characteristics, etc. in the area of interest is also important in order to selection of location of intake infrastructure as well as plan pipeline routing, laying of pipeline over land or below ground surface (i.e buried), and construction technology etc.

HYDROGEOLOGY OF GODDA DISTRICT

The hydrogeological formation in the Godda District is presented in Figure 5.2. There is recent alluvium along the Jharkhand/ Bihar border on the west side of the Godda district. The soil type in the district is mostly acidic, radish yellow, light textured and highly permeable with poor water holding capacity.

HYDROGEOLOGY OF SAHIBGUNJ DISTRICT

The hydrogeological map of the Sahibgunj District is presented in Figure 5.3. There is Ganga alluvium formation all along the right bank of the Ganga in the Sahibgunj District covering Sahibgunj and Raj Mahal towns. There is Raj Mahal hill trap in formation in between the TPP and the Ganga. Major soil type of the district is the Raj Mahal type soil which derived from basaltic lava. These soils are black in colour, very fertile and restricted to Raj Mahal lava areas. The other soil type of the district are red soil, eroded scarp soil, foothill soils, tal (flood plain) soil and alluvial soil.

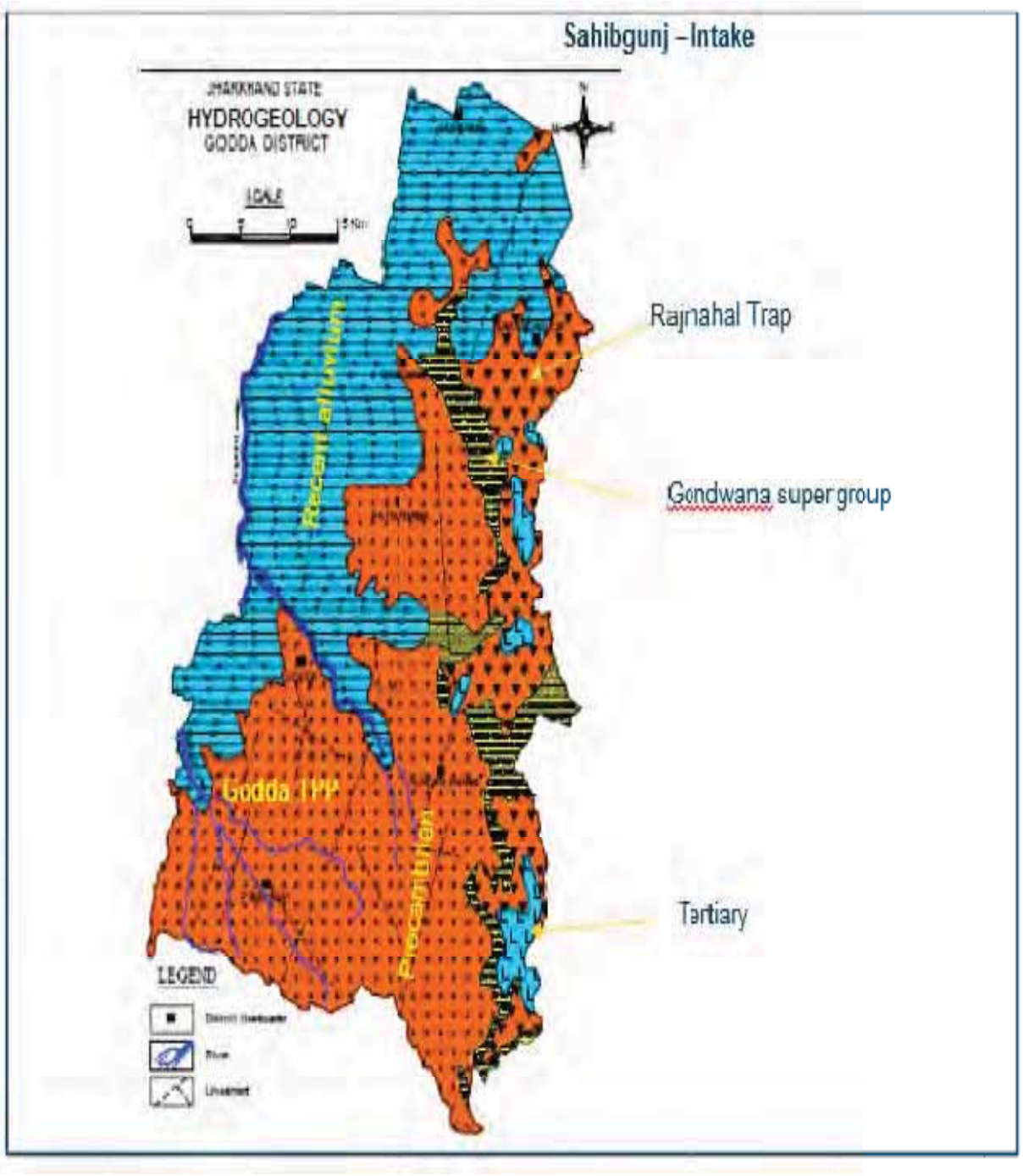


FIGURE 5.2: HYDRGEOLOGICAL MAP OF GODDA DISTRICT

Source: CGWB Godda District Brochure 2007

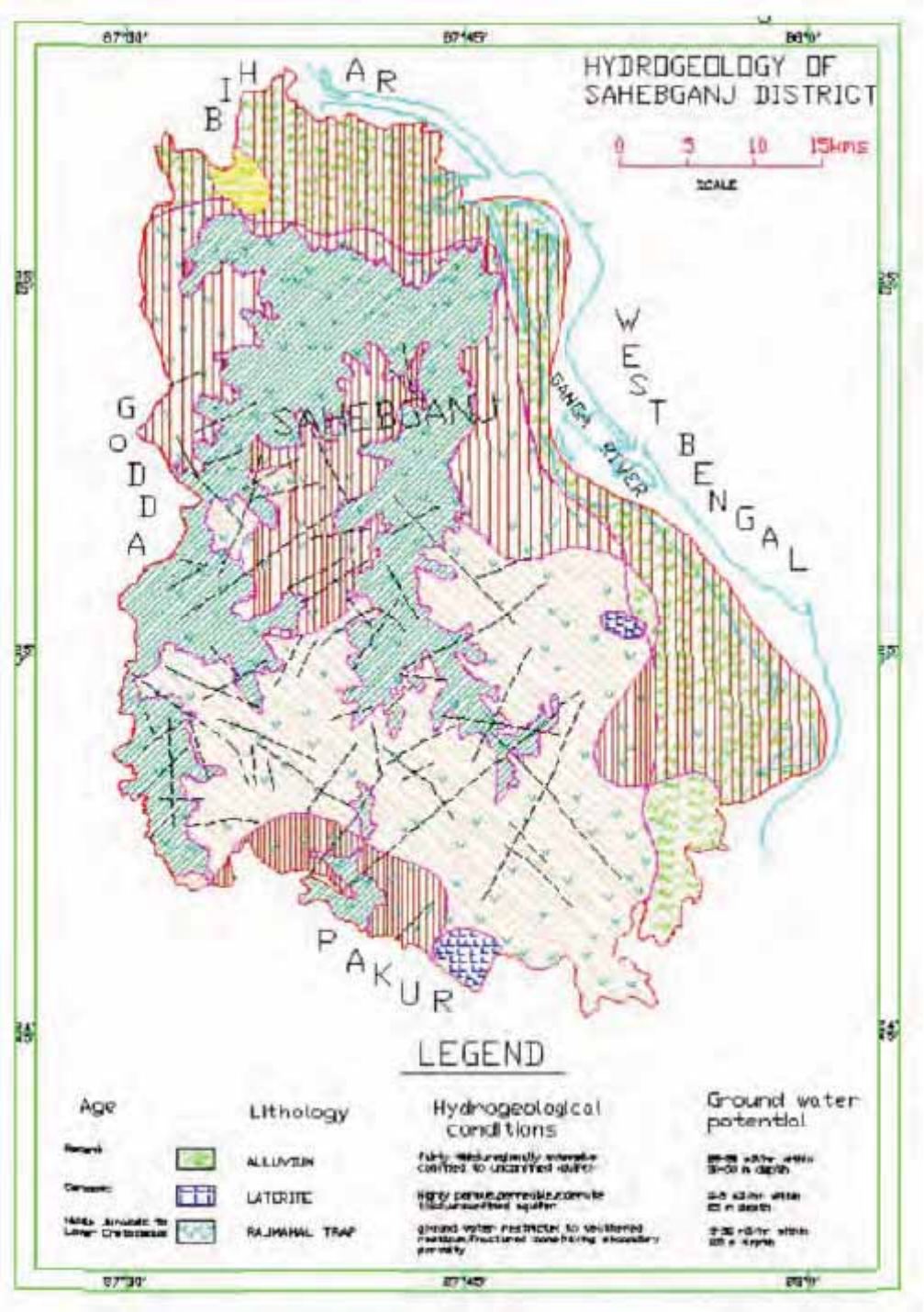


FIGURE 5.3: HYDRGEOLOGICAL MAP OF SAHIBGUNJ DISTRICT

Source: CGWB District Brochure for Sahibgunj, 2008

5.3 GEOMORPHOLOGY

The area within 10 km from the Water Intake Well includes two contrasting landscapes: the floodplains of the Ganga in the north and east, and the basaltic Rajmahal hills in the south (Figure 5.4).

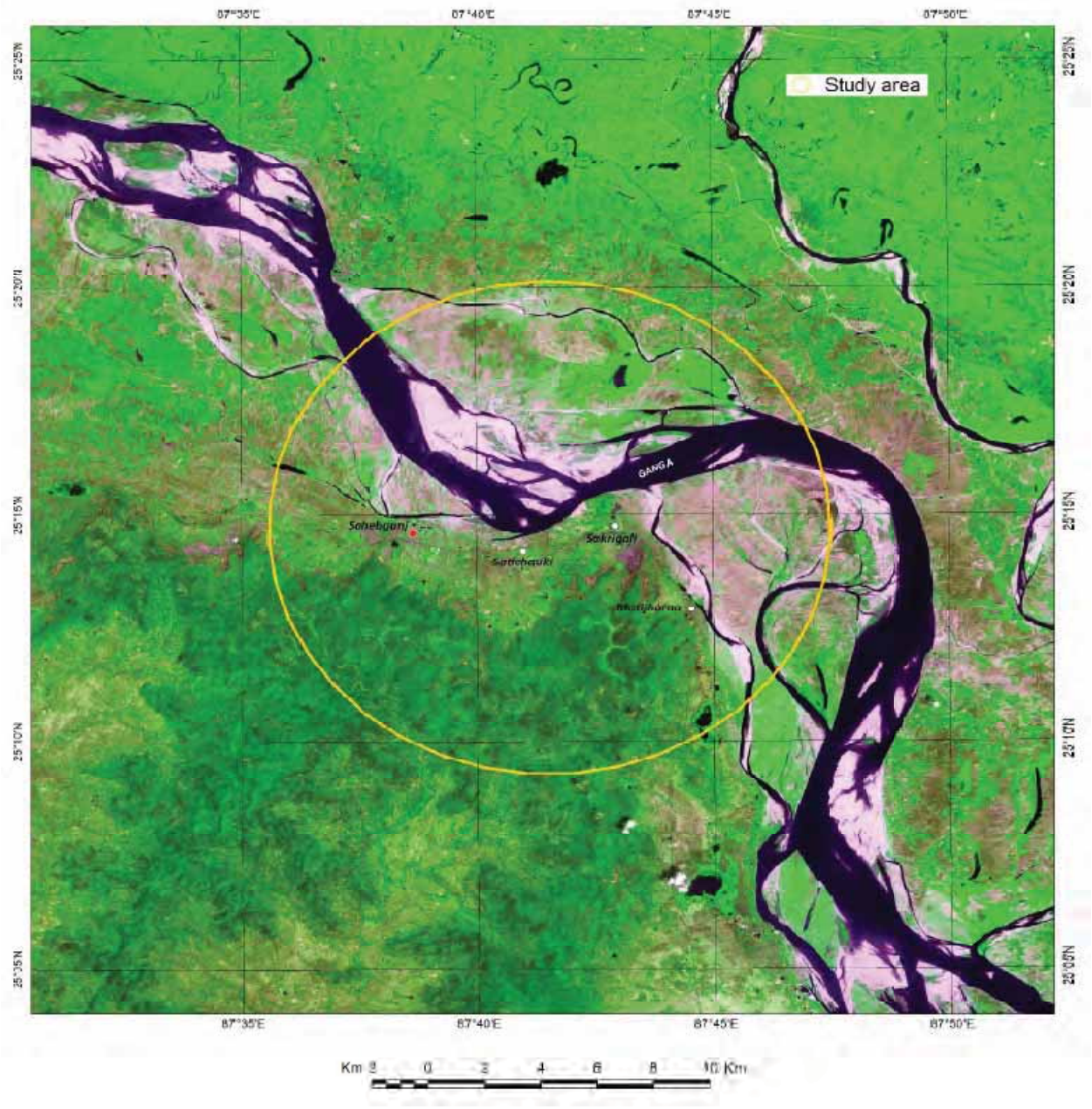


FIGURE 5.4: LOCATION OF THE STUDY AREA DEFINED BY A 10-KM BUFFER AROUND THE WATER INTAKE POINT

Source: False Colour Composite prepared from Sentinel-2A MSAI data of 10-Apr-2018.

It is situated about 14 km upstream of the southward bend of the Ganga as it leaves its middle course through the Great Plains of the northern India into the lower course through the Bengal delta.

The floodplains of the Ganga is restricted to 30 m. Area between 30 and 45 m forms the recessional plain while the region above 100 m forms the hills proper. The transitional piedmont zone is seen between and 45 m and 100 m (Figure 5.5).

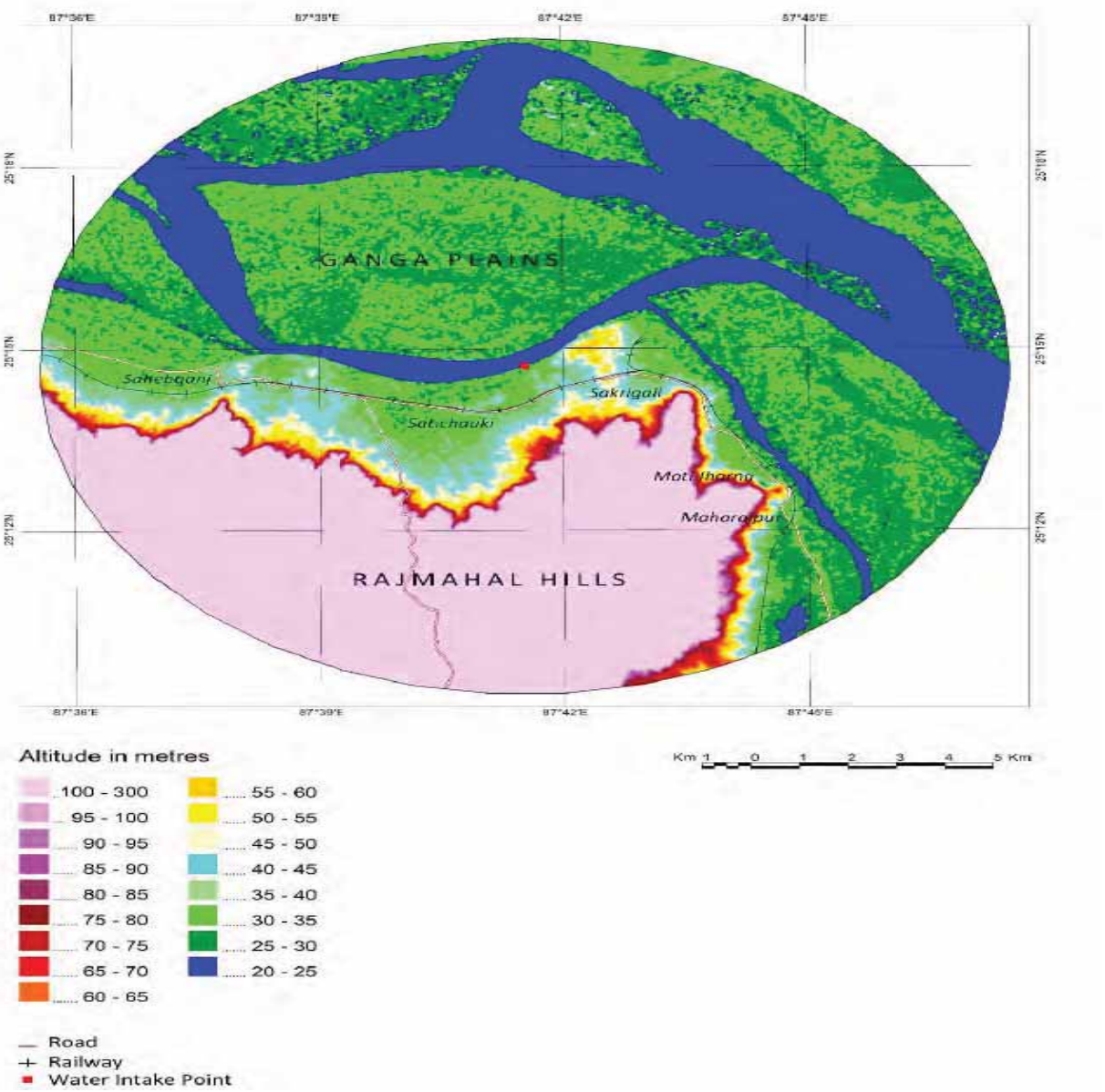


FIGURE 5.5: PHYSIOGRAPHY OF THE STUDY REGION

Source: Digital Elevation Model prepared from 1 arc-second Shuttle Radar Topography Mission data of Feb 2000; Tile# N25-E087.

The river itself forms the dominating feature in the central portion of the area with its lean season level of water at 20–25 m above mean sea level (Figure 5.5). Its floodplains, including mid-channel sandbars and palaeocourses are confined mostly within 30 m. The area overlaps with the recessional plains formed by slope retreat of the Rajmahal ranges and outliers (30–45 m).

Elevation of the hills proper start from 100 m and continues up to 300 m. The transitional piedmont zone occupy the zone between and 45 m and 100 m.

With an average annual discharge of ~16,650 cumecs, Ganga is one of the mightiest as well as most dynamic rivers of the world. The flow of the river increases almost eight-times during the monsoon months compared to the lean period, represented in the images in this report. Its highest gauge height has been recorded at 30.91 m at Sahebganj that would inundate the entire northern and eastern sections of the study area (Figure 5.5).

The apparently safe location of the Water Intake Point is attested by its situation at the edge of the mender / braidbelt, as denoted by the lower right diagram (Figure 5.5).

Owing to the seasonality of its discharge and composition of bank materials – largely sands – the Ganga constantly shifts its course within its meander belt. The changes in braids of the river during the last 46 years is represented in Figure 5.6. It shows the apparently safe location of the Water Intake Well as it is situation just at the edge of the meander belt of the Ganga, with the right riverbank never shifting south of this point. It seems that the higher elevation of the recessional plain immediately to the east of the site (Figure 5.5), with basalt in its basement, resisted southward migration of the river at this locality.

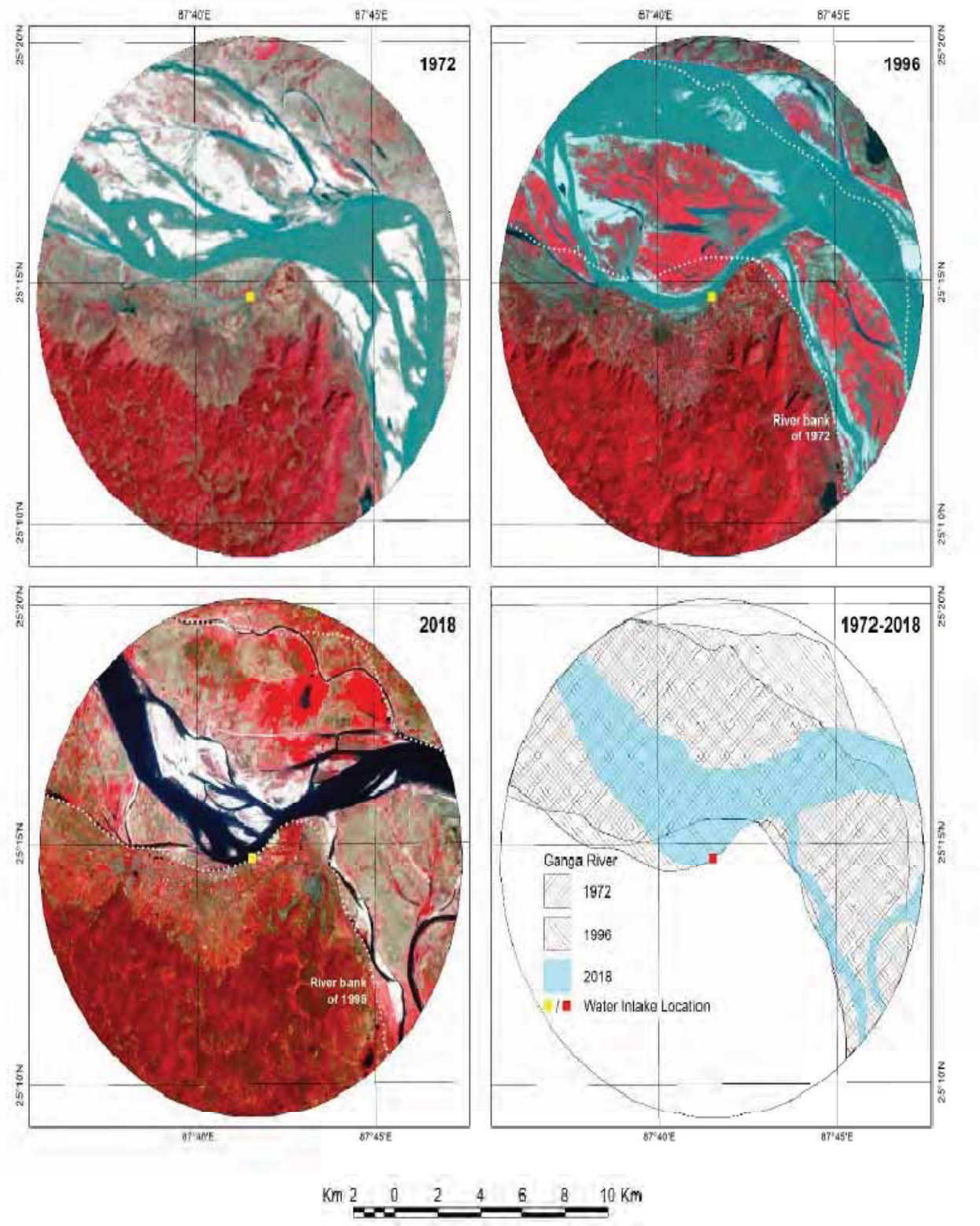


FIGURE 5.6: SHIFT IN THE COURSE OF THE GANGA BETWEEN 1972 AND 2018

5.4 LAND USE LAND COVER

To bring out the land use land cover characteristics of the area within 10 km from the Water Intake Well, Sentinel-2A MSAI data of 10-Apr-2018 (Table 5.1) were classified using maximum likelihood algorithm, after extensive ground truth verification. The results are shown in Figure 5.7 and Table 5.2. These indicate that the farmlands cover more than half of the region and nearly all of the recessional plains south of the Ganga and the floodplains to its north. The low-lying and flood-prone river bars are mostly composed of sands (5.3%) and are also utilised for agriculture. The built-up areas (0.8%) are seen along the road and railway in from of five settlements, of which Satichauki and Sakrigali is closest (~2 km) to the Water Intake Point. The uplands areas are mostly covered by forests / orchards (18.5%) with sporadic patches of agriculture where valley-fills and villages are present. Evidence of deforestation and degradation of the vegetal cover is seen in some areas of the hill-tops (4.9%). Basalt quarrying (0.9%) has emerged as a major economic activity of the region in recent decades, and mostly occupy the piedmont location for easy accessibility and transportation.

TABLE 5.1: DETAILS OF SATELLITE DATA USED IN THE STUDY

Satellite	Sensor	Resolution	Path-Row / Tile Id	Date Of Acquisition
Landsat-1	MSS	60 m	150/042	07-Nov-1972
Landsat-5	TM	30 m	139/043	05-Nov-1996
Sentinel-2A	MSAI	10 m	T45RWH & T45RWJ	10-Apr-2018

TABLE 5.2: AREA STATISTICS OF LANDUSE-LANDCOVER CLASSES OF THE AREA WITHIN 10 KM FROM THE WATER INTAKE WELL

LU-LC CLASSES	Area (ha)	Per Cent of Total Area
Farmland: Cropped	8,528.10	27.15
Farmland: Fallow / Grassland	9,814.95	31.24
Quarry	280.18	0.89
Built-up	261.66	0.83
Forest / Orchard	5,804.93	18.48
Degraded Forest	1,555.71	4.95
Sand	1,675.54	5.33
Water	3,494.93	11.12
Total	*31,416.00*	*100.00*

Source: Maximum Likelihood Classification of Sentinel–2 MSAI data of 10-Apr-2018. Tile# T45RWH & T45RWJ

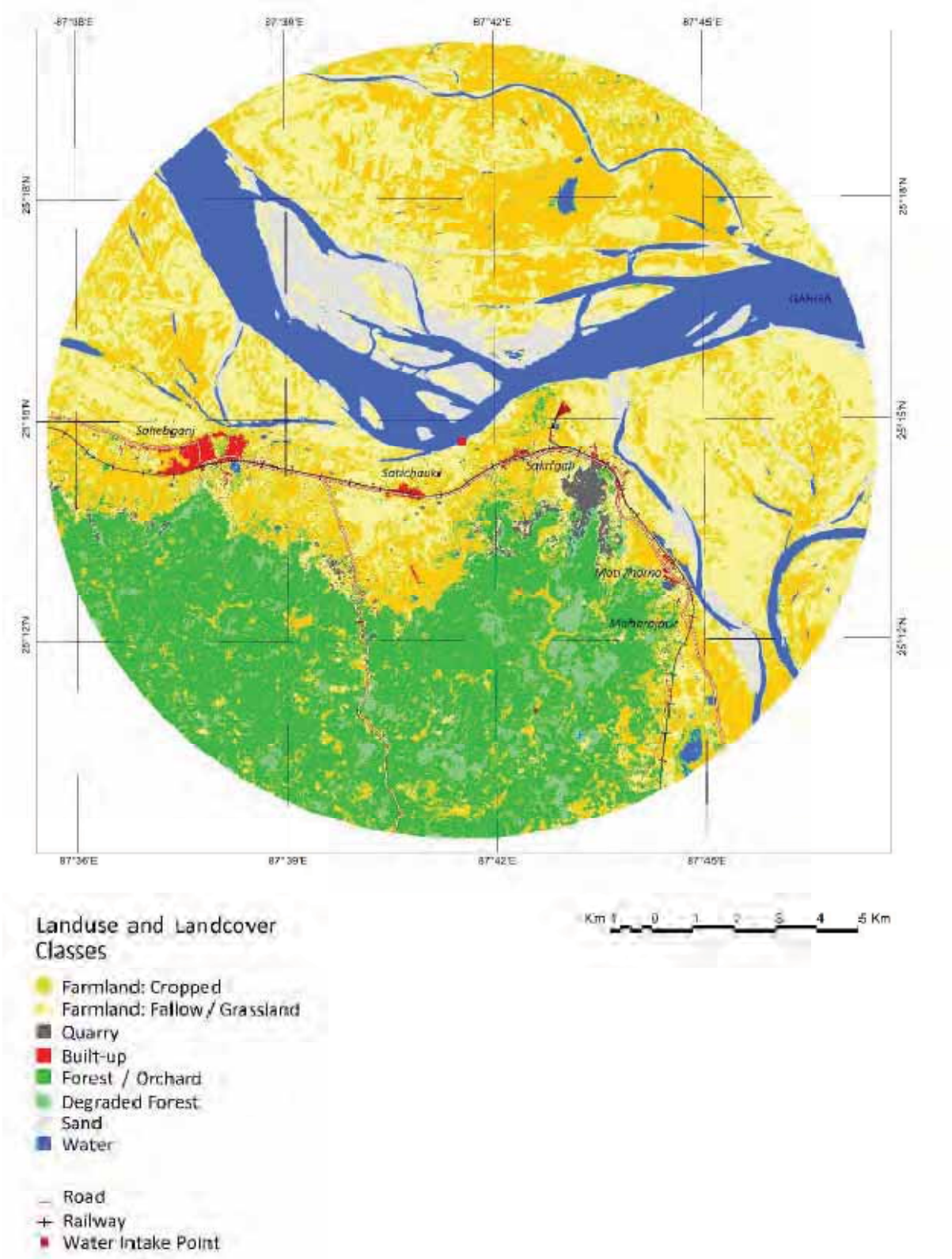


FIGURE 5.7: LAND USE LAND COVER CHARACTERISTICS OF THE STUDY AREA

Source: Maximum Likelihood Classification Of Sentinel–2 Msai Data Of 10-Apr-2018. Tile# T45rwh & T45rwj

P13: Geomorphological Study at Proposed Intake Site of GTPP at River Ganga

P14: Geomorphological Study at Proposed Intake Site of GTPP at River Ganga

P15: Characterization of Geological Formation at Water Intake Site

6.0 WATER AVAILABILITY & HYDROLOGICAL STUDY

6.1 RAINFALL PATTERN

AWTEM has obtained the data of the Rain Gauge stations situated in the project vicinity of lower Ganga basin to assess the water availability including monthly inflow data in the river Ganga. All the rain gauge stations are provided with ordinary rain gauge only.

The long term rainfall data for Jharkhand from 1871 to 2016 have been collected from National Data Centre, IMD, Pune to analyze the dependable rainfall and average duration curve for rainfall. Jharkhand has an average yearly rainfall of 855.9 to 1872.8 mm with an average of 1335.6 mm and is generally uniform with little variation i.e. Standard Deviation of ±206.58 (Figure 6.1). The long term trend of monthly variation in the rainfall for Jharkhand region is presented in Figure 6.2.

FIGURE 6.1: LONGTERM RAINFALL PATTERN FOR JHARKHAND REGION (1917-2016)

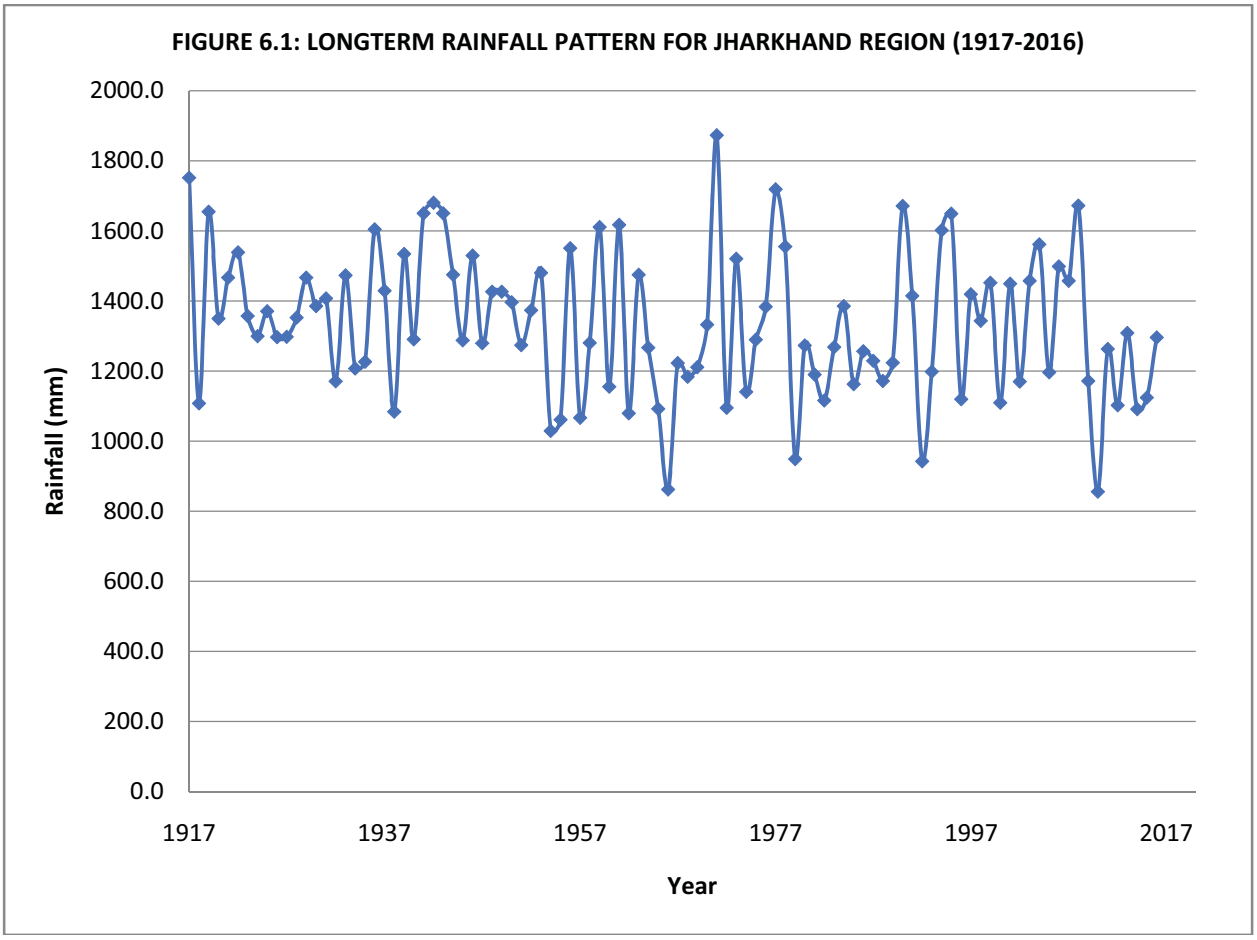
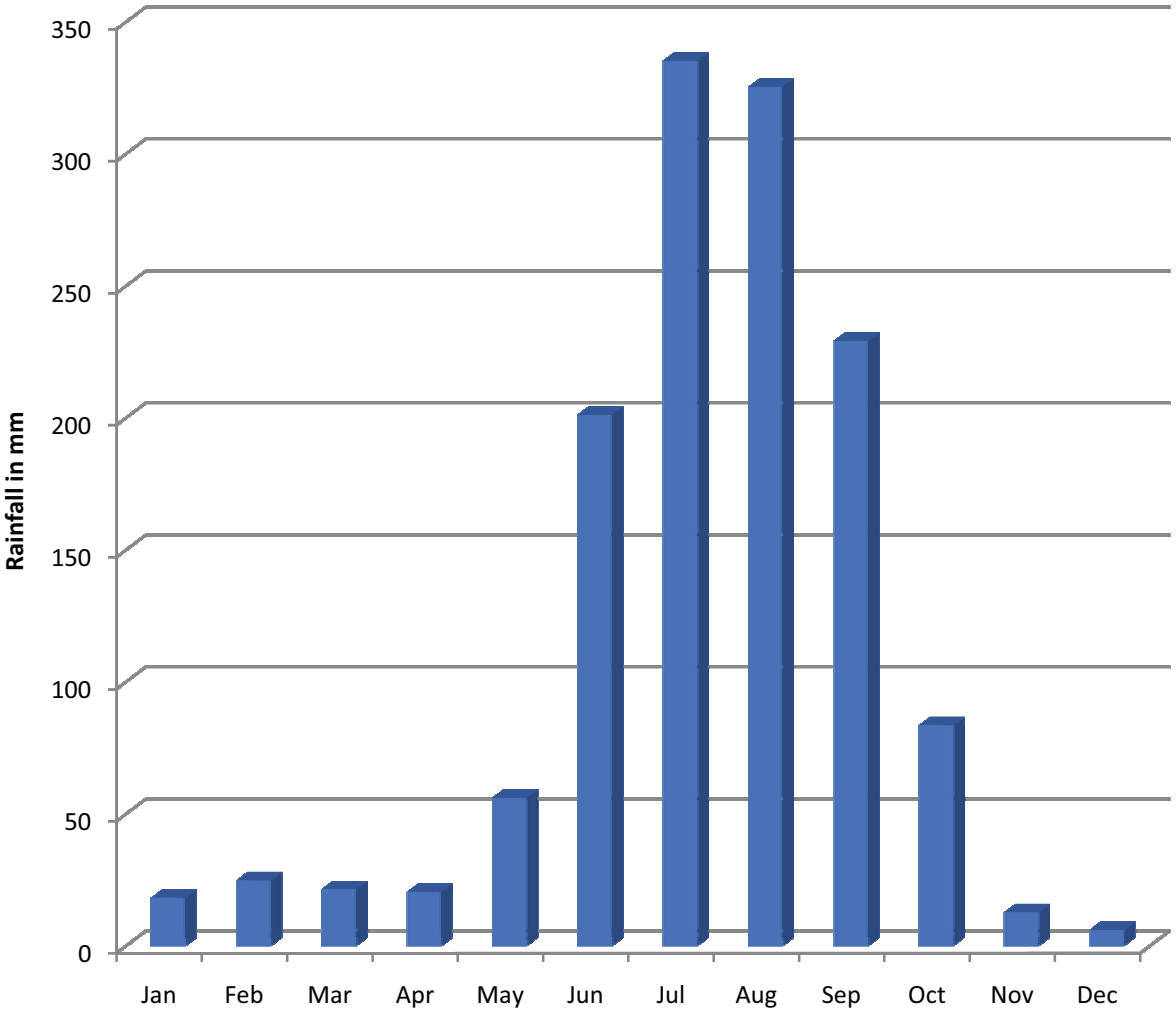
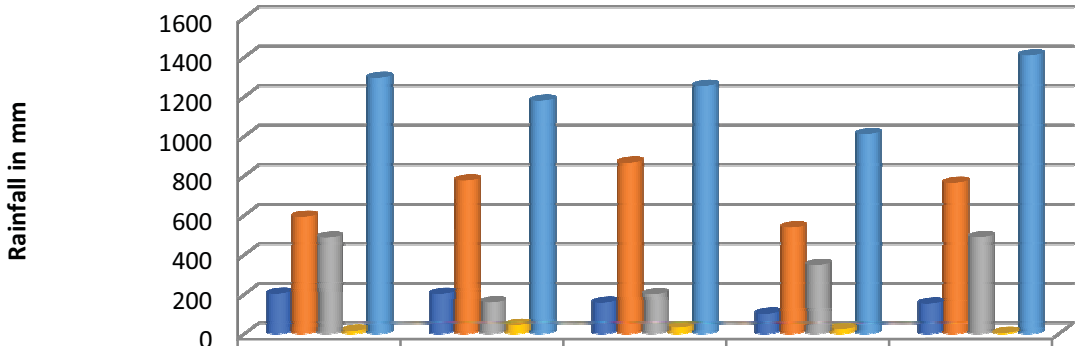


FIGURE 6.2: LONG TERM TREND OF MONTHLY VARIATION IN THE RAINFALL IN JHARKHAND REGION (1871-2016)



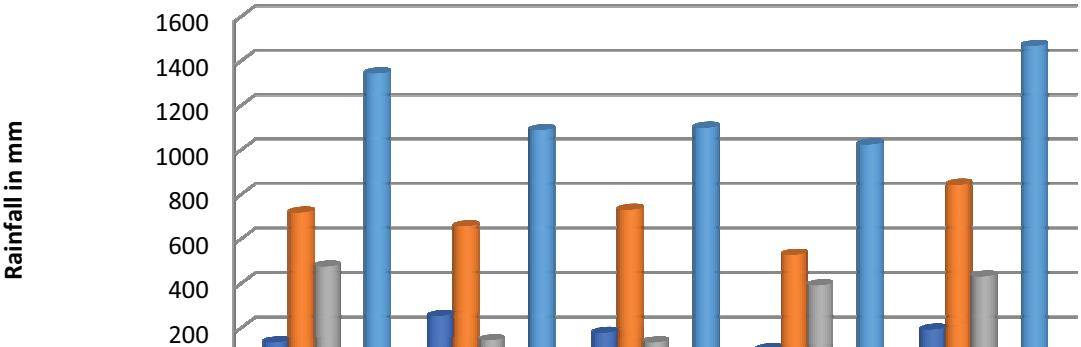
The rainfall data for four rain gauge stations namely Bhagalpur, Katihar, Sahebganj and Malda have also been collected through Customized Rainfall Information System (CRIS), Indian Meteorological Department, Government of India to assess the inflow of water and water availability in the proposed intake site at River Ganga. Figure 6.3 to 6.6 present the long term trend (2013 to 2017) of rainfall at upstream as well as downstream stretch of proposed intake site at river Ganga. The analysis reveals that the annual rainfall at Sahibgunj varies from 1145 to 1645 mm, however, in the upstream stretch of proposed intake site the annual rainfall varies from 1009.8 to 1467.8 mm.

FIGURE 6.3: LONG TERM TREND OF RAINFALL - BHAGALPUR (2013-2017)



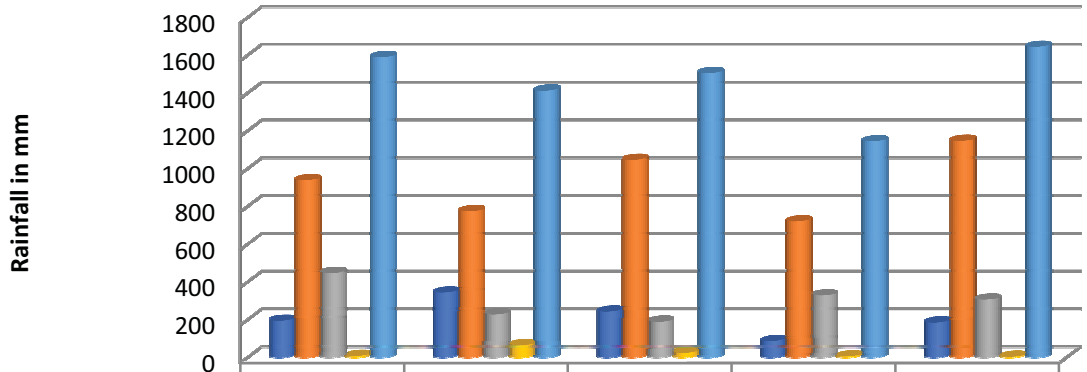
	2013	2014	2015	2016	2017
PRE MONSOON	202	201.4	157	100.8	152.3
MONSOON	591.7	774.9	865	537.3	763.6
POST MONSOON	486.5	158.6	199.4	347.2	488.4
WINTER	14.5	43.9	32.1	24.5	4
ANNUAL	1294.7	1178.8	1253.5	1009.8	1408.3

FIGURE 6.4: LONG TERM TREND OF RAINFALL - KATIHAR (2013-2017)



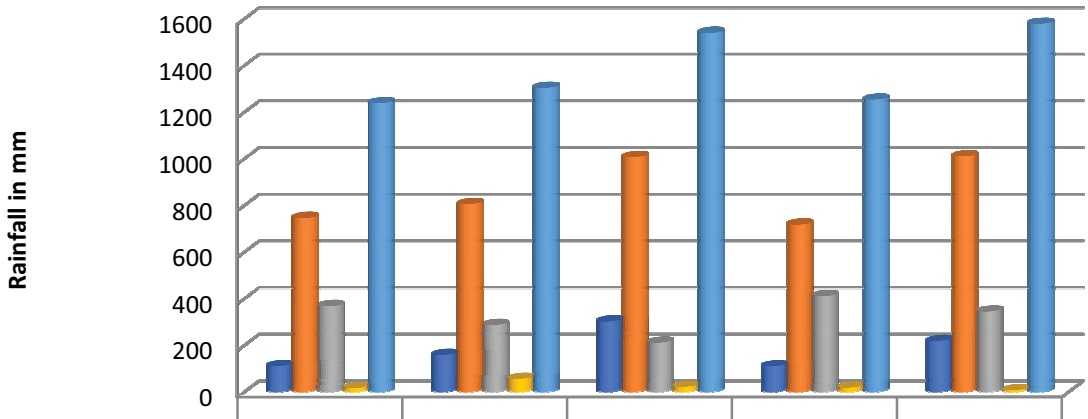
	2013	2014	2015	2016	2017
PRE MONSOON	135.7	253.6	178	104.8	192.3
MONSOON	718.8	656.6	731	528.5	843.5
POST MONSOON	476.1	144.7	135.6	391.9	431.3
WINTER	13.4	34.3	55.1	0	0.7
ANNUAL	1344	1089.2	1099.7	1025.2	1467.8

FIGURE 6.5: LONG TERM TREND OF RAINFALL - SAHIBGUNJ (2013-2017)



	2013	2014	2015	2016	2017
PRE MONSOON	195.3	344.2	244	87.6	186
MONSOON	939	775.2	1047	721.2	1147.4
POST MONSOON	448	229.2	190	329.8	307
WINTER	8.6	64.8	25.2	6.4	4.6
ANNUAL	1590.9	1413.4	1506.2	1145	1645

FIGURE 6.6: LONG TERM TREND OF RAINFALL - MALDA (2013-2017)



	2013	2014	2015	2016	2017
PRE MONSOON	110	157.7	301.3	109.1	217.8
MONSOON	745.2	804.6	1006.4	716.8	1009.6
POST MONSOON	367.4	286.4	210.8	409.9	344
WINTER	15	54.7	20.4	16.9	6.6
ANNUAL	1237.6	1303.4	1538.9	1252.7	1578

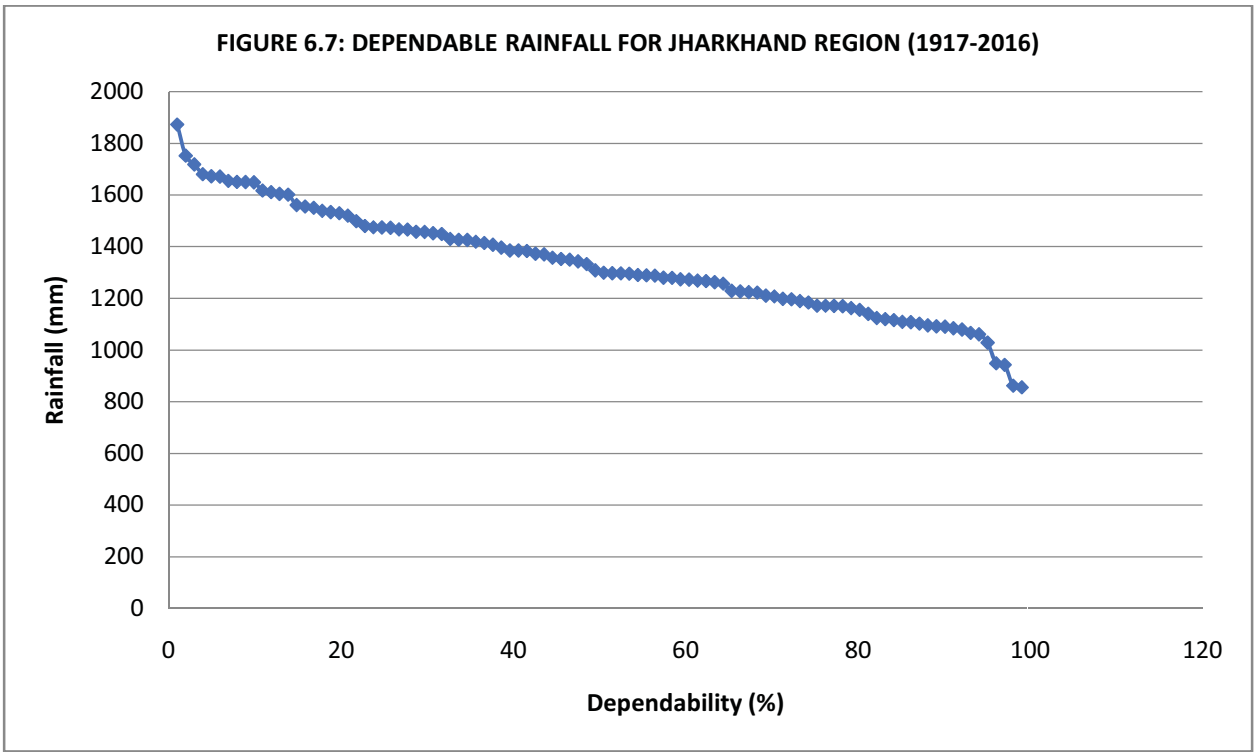
Dependable Rainfall

The weighted average monsoon rainfall at different percentage dependability for the Jharkhand Ganga sub-basin has been worked out and calculation for the same are kept at **Annexure 6.1.** The results thereof are given in Table 6.1 and Figure 6.7. As the 75% and 90% dependability are of great importance in the field of hydrology the same were estimated and found to be 1172 mm and 1091 mm.

TABLE 6.1: DEPENDABLE RAINFALL IN JHARKHAND REGION (1917-2016)

Sl. No.	% Dependability	Rainfall in mm
1	10	1649.4
2	20	1529.6
3	30	1457.4
4	40	1385.5
5	50	1308.7
6	60	1272.7
7	70	1207.7
8	80	1155.7
9	90	1091

FIGURE 6.7: DEPENDABLE RAINFALL FOR JHARKHAND REGION (1917-2016)



6.2 RIVER WATER LEVEL

The fluctuation of the water level at intake site is one of the important parameters which govern the planning and hydraulic designing of a water withdrawing system and fixing of entry ports or crest levels, pump levels and other system configurations. Since water to be withdrawn directly from the river i.e without creating ponding by putting any structure like weir/ barrage/ anicuts etc. Across the flow to rise water level and facilitate diversion of water into cannel or intake system, the measured water level and its variation in different season need to be known with its probability of exceedance. For designing an intake system, we need to fix entry port level/ crest level of the system, that level will be lower than the 90% dependable river water level. Since the possible location for intake system appear to be Sahibgunj the correlated water surface profile obtained from the observed water levels at the four stations have been used to determine the water level at the proposed intake location in between (Table 6.2). The best fit curves have been developed between water levels observed at Bhagalpur. Kahalgaon, Sahibgunj and Farakka for observations in non-monsoon and monsoon period.

TABLE 6.2: GANGA WATER LEVEL BETWEEN BHAGALPUR (SAMPLE DATA)

CWC G&D Station	Cumulative Distance from Bhagalpur (Km)	16.06.2014 (non-monsoon), m	31.8.2016 (monsoon), m	Highest Observed, m
Bhagalpur	0	25.41	34.45	34.50 (2013)
Kahalgaon	28	24.53	32.55	32.87 (2003)
Sahibgunj	101	22.52	28.88	30.91 (1998)
Farakka	164	15.78	24.10	25.14 (1998)

The measured water level at CWC G&D in the reach of interest from Bhagalpur to Farakka station for non- monsoon and monsoon period as per CWC flood bulletin, have been analyzed and presented in Figure 6.8.

Further based on the water level data of Azmabad obtained from CWC (which is at 60 Km up-stream from proposed intake location) for the period from 2006-2016 were interpolated for Sahibgunj based on the month wise slop derived. The entry ports for the proposed intake structure are considered at the level of 50% and 90% exceedants water flow at Sahibgunj interpolated based on the Azmabad water level data for the period 2006-2016 received from CWC .

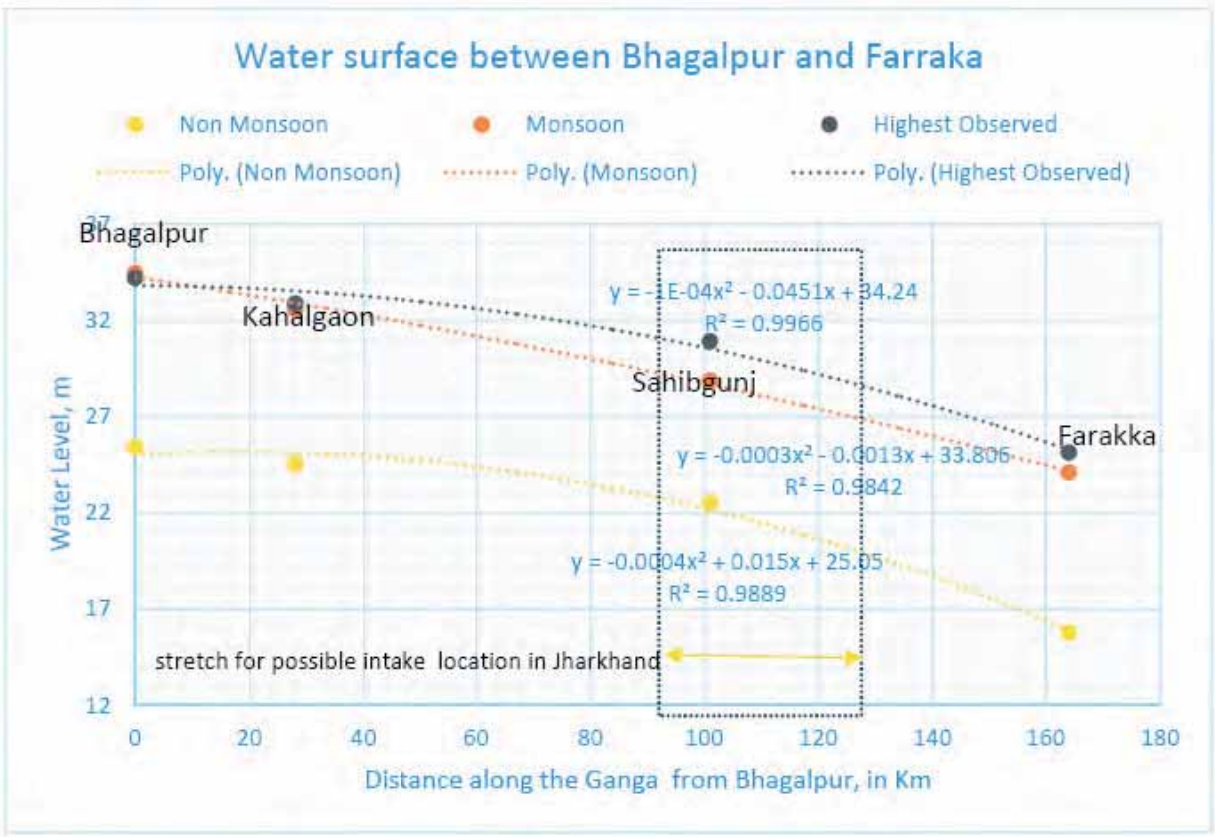


FIGURE 6.8: WATER SURFACE PROFILE BETWEEN BHAGALPUR AND FARAKKA

6.3 RIVER BATHYMETRY

The bathymetry and cross section of river Ganga near proposed intake site is presented in Figure 6.9 to 6.16.

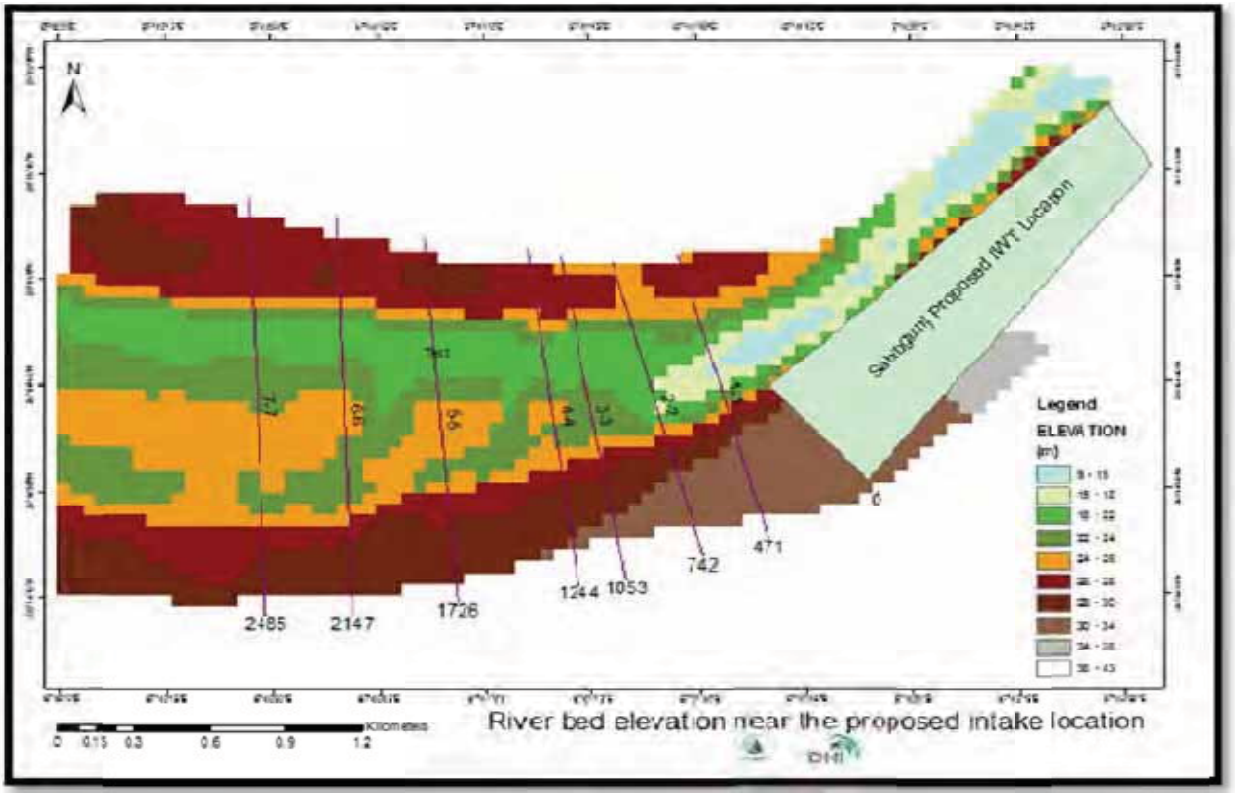


FIGURE 6.9: RIVER BATHYMETRY NEAR PROPOSED INTAKE SITE

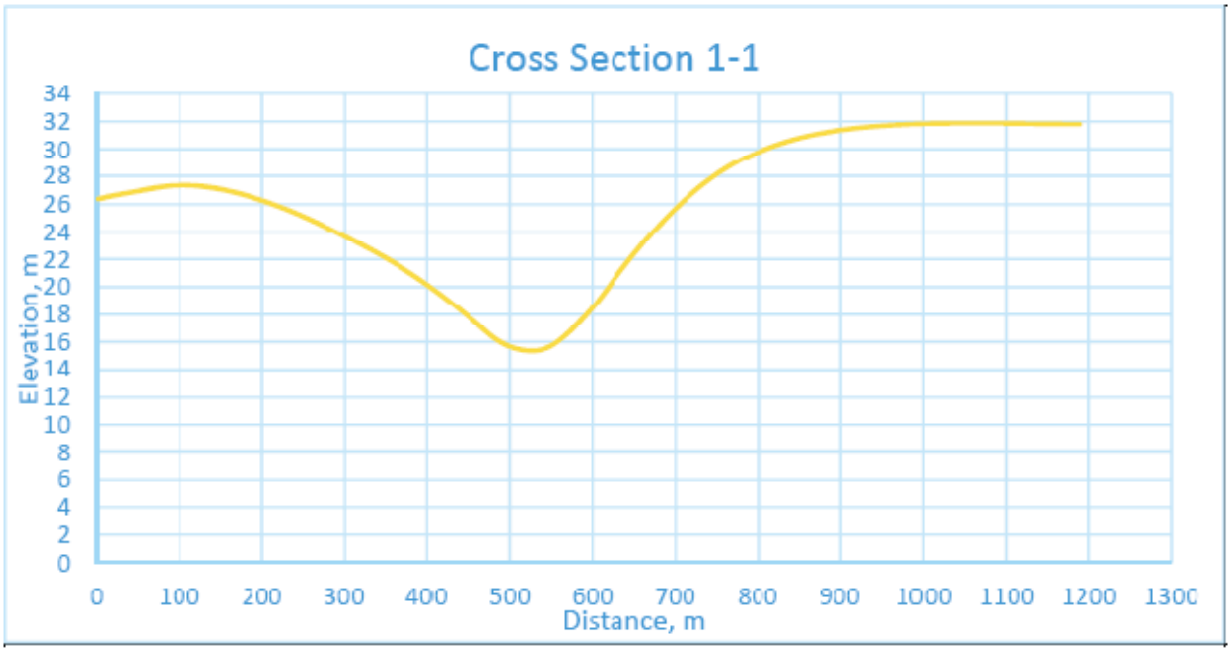


FIGURE 6.10: CROSS SECTIONAL PROFILE (1-1) AT 471 M U/S FROM IWT

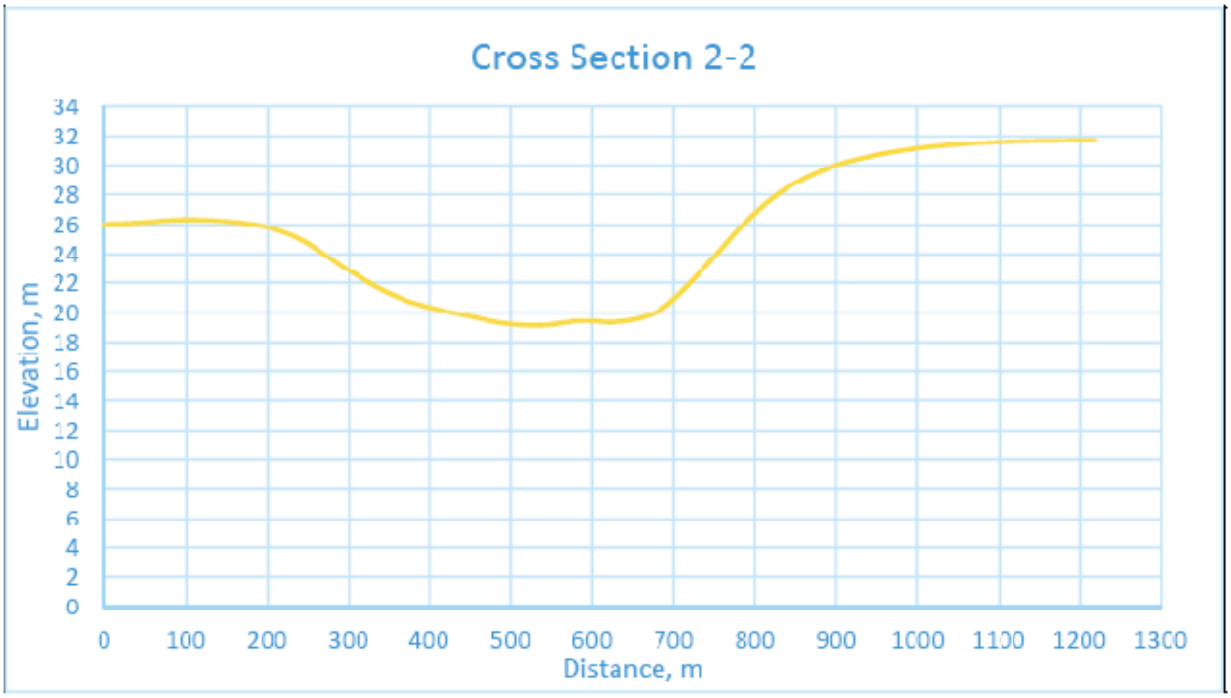


FIGURE 6.11: CROSS SECTIONAL PROFILE (2-2) AT 742 M U/S FROM IWT

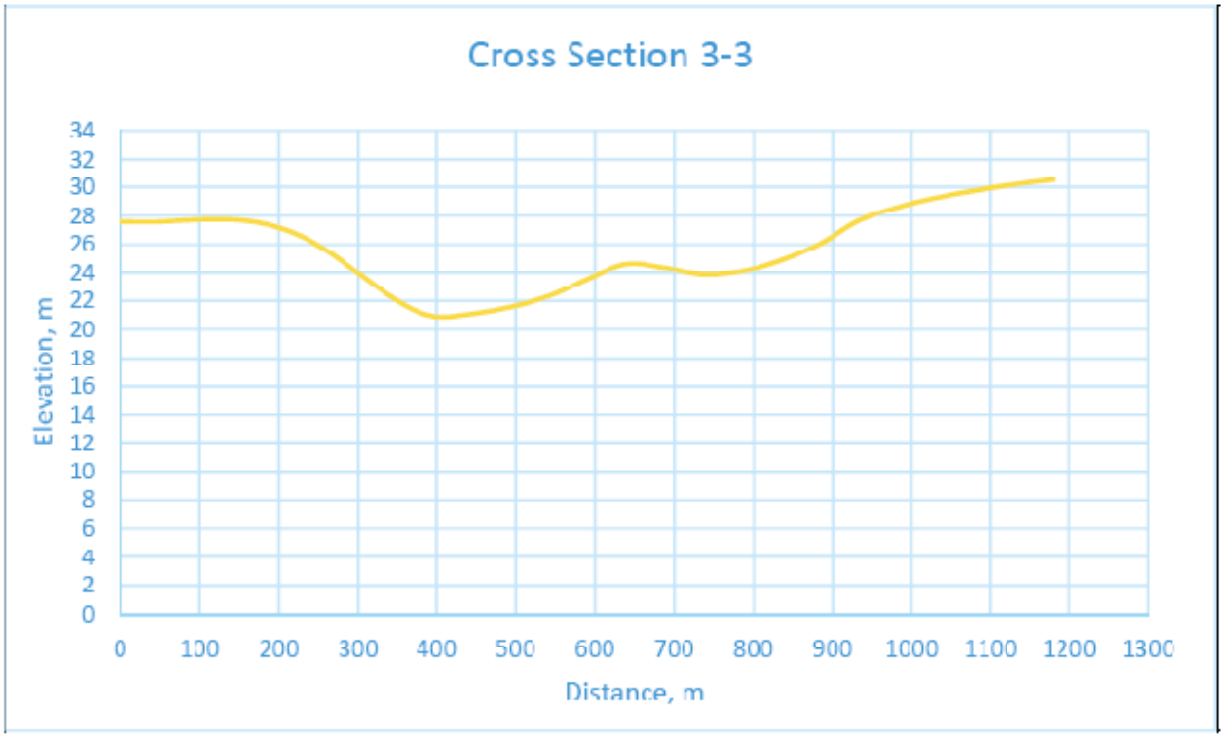


FIGURE 6.12: CROSS SECTIONAL PROFILE (3-3) AT 1053 M U/S FROM IWT

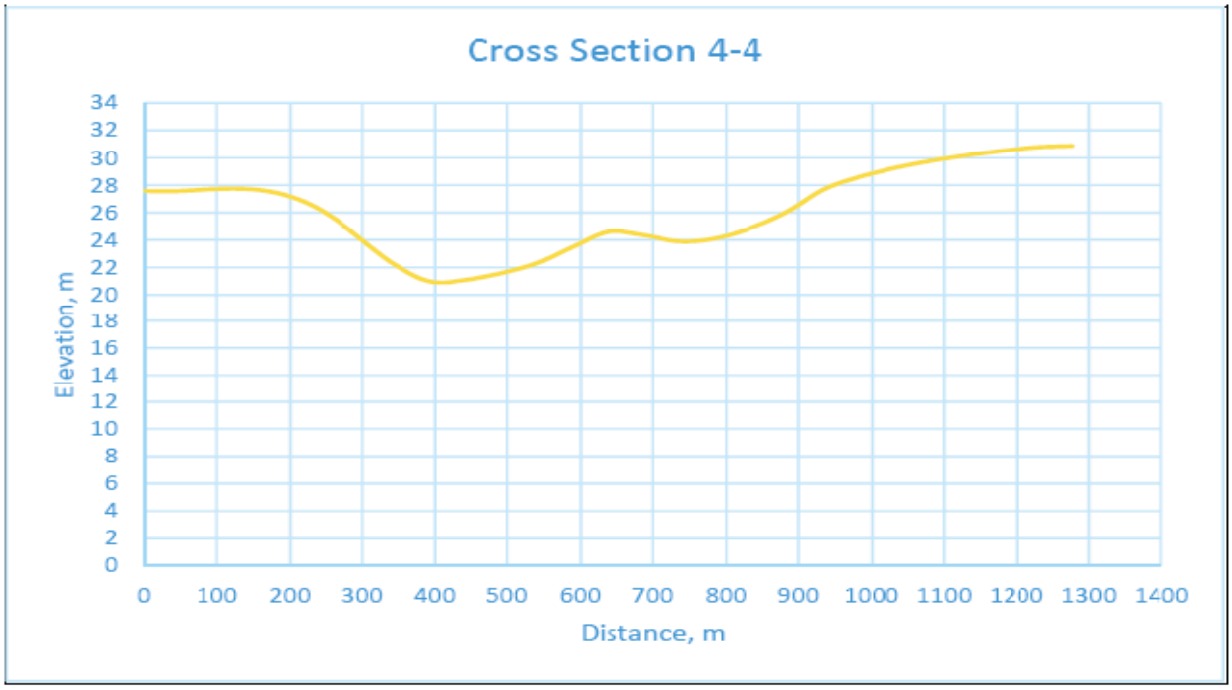


FIGURE 6.13: CROSS SECTIONAL PROFILE (4-4) AT 1244 M U/S FROM IWT

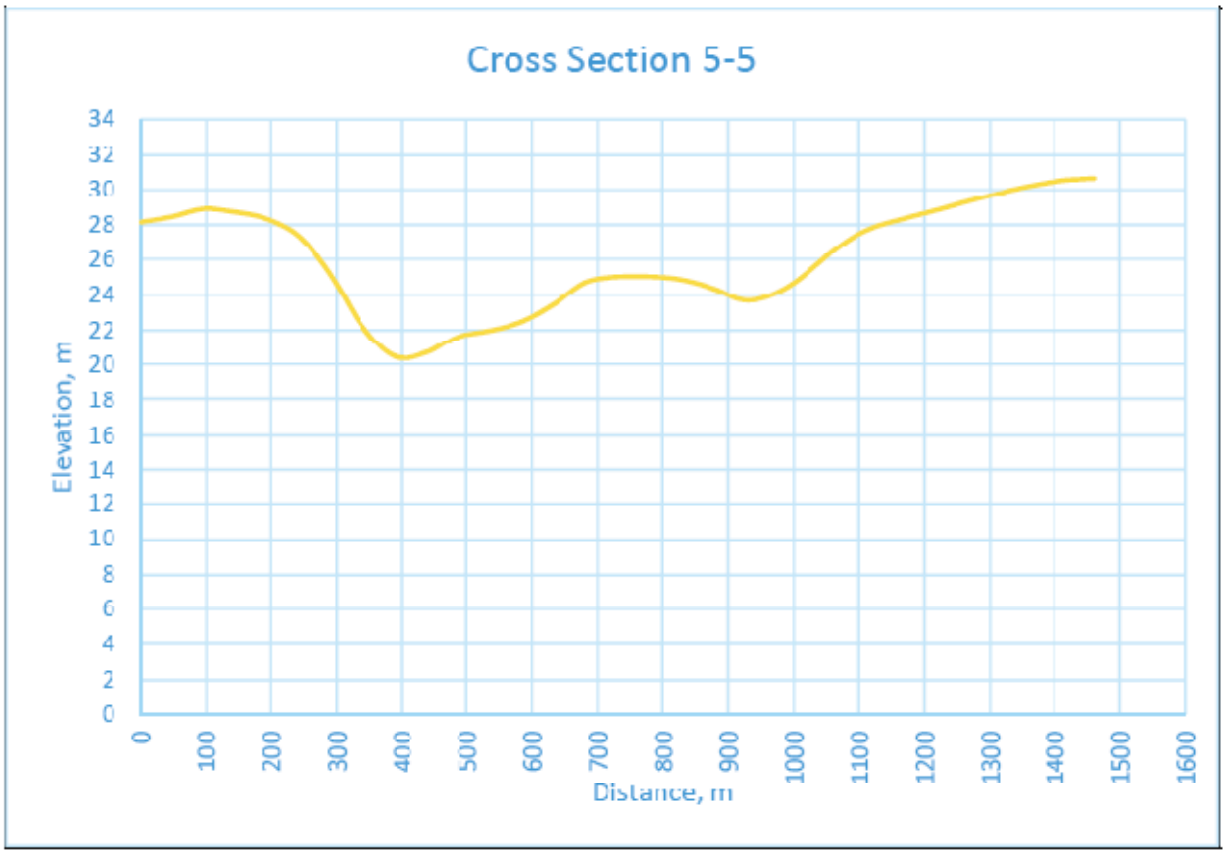


FIGURE 6.14: CROSS SECTIONAL PROFILE (5-5) AT 1726 M U/S FROM IWT

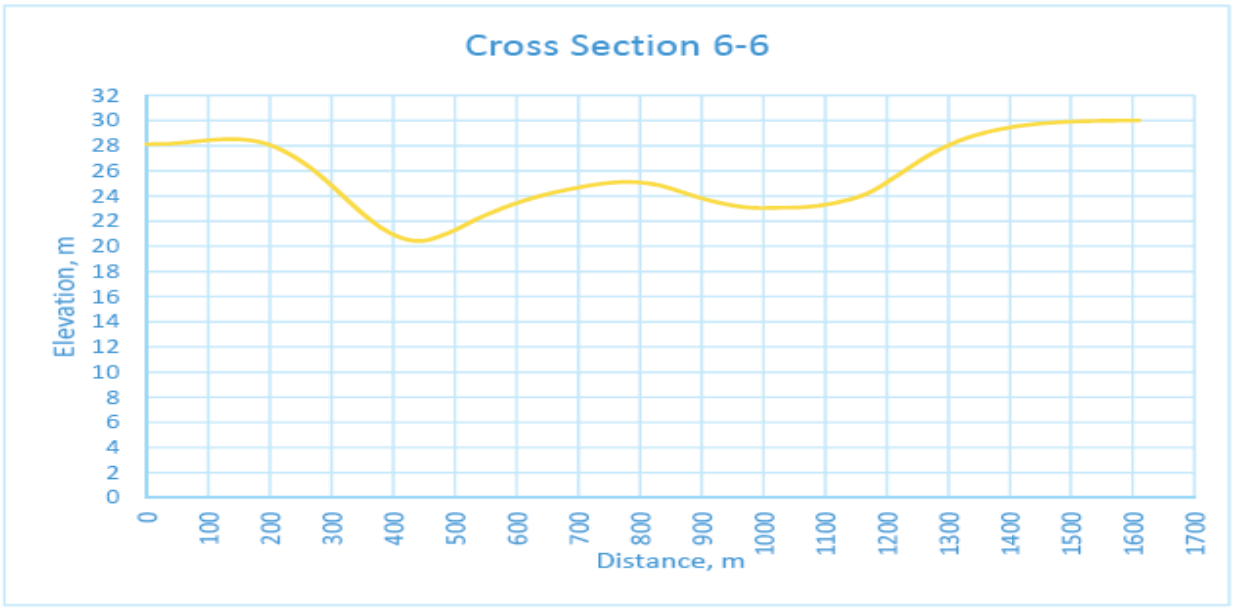


FIGURE 6.15: CROSS SECTIONAL PROFILE (6-6) AT 2147 M U/S FROM IWT

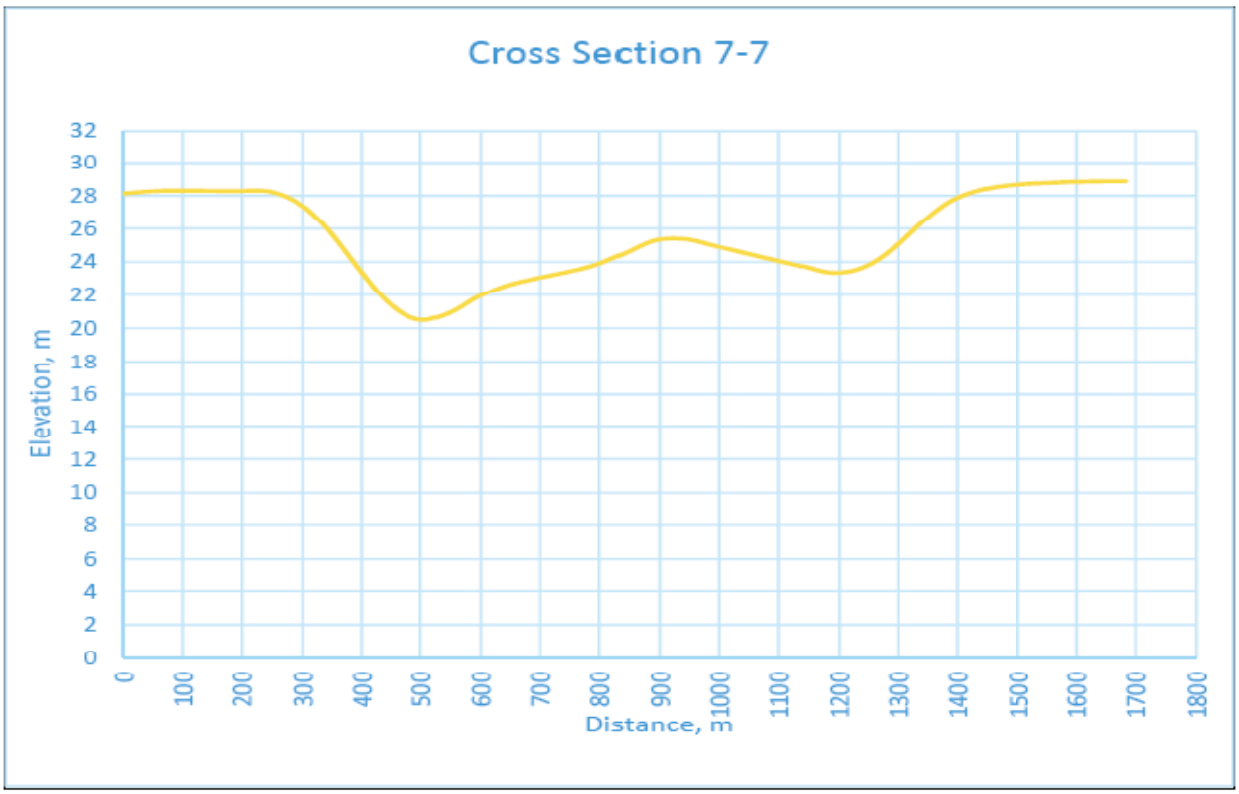
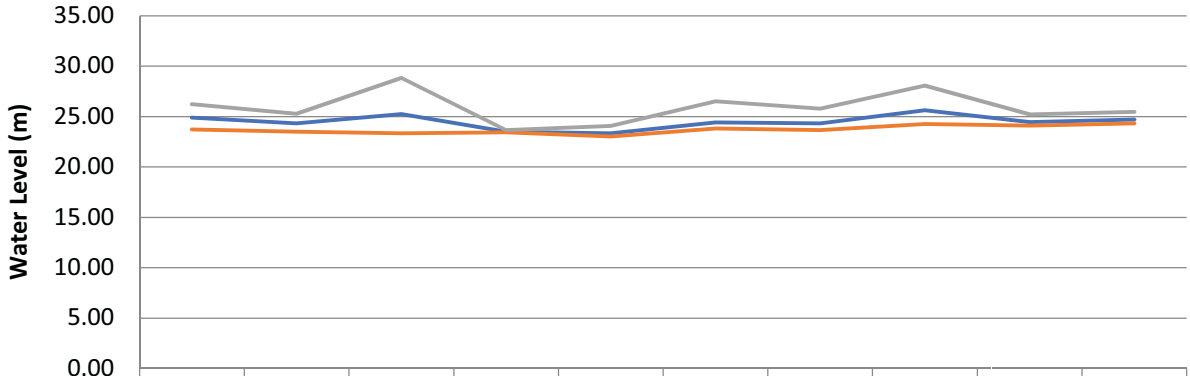


FIGURE 6.16: CROSS SECTIONAL PROFILE (7-7) AT 2485 M U/S FROM IWT

6.4 WATER DISCHARGE

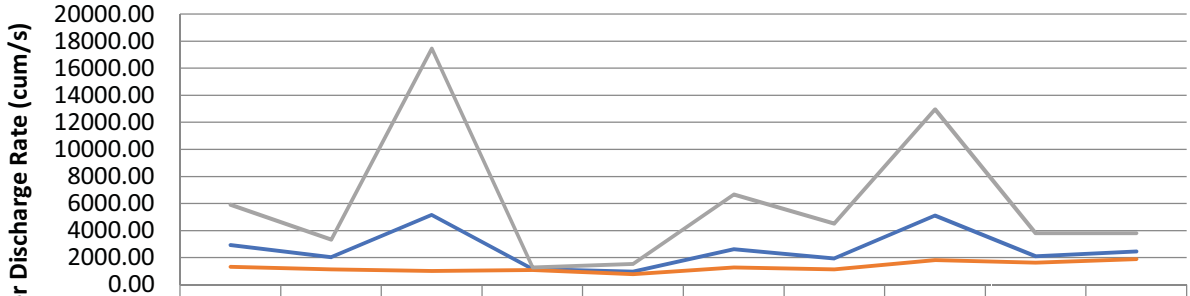
The status of water level and water discharge in River Ganga in the project area has been analyzed on the basis of 10 years daily discharge data collected from CWC for G&D Station at Azmabad for years 2005-06 to 2015-16 (Annexure 6.2). The month wise status of water level and water discharge is presented in Figure 6.17-6.40.

FIGURE 6.17: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - JUNE



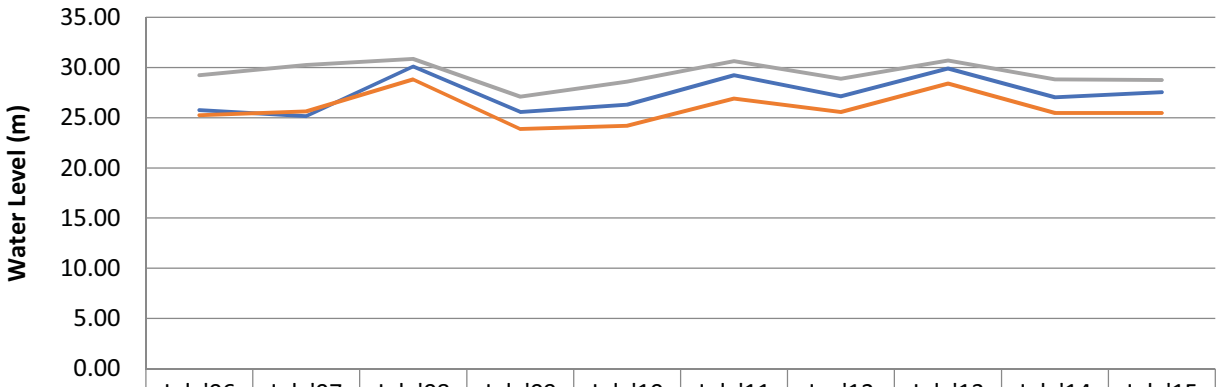
	Jun, '06	Jun, '07	Jun, '08	Jun, '09	Jun, '10	Jun, '11	Jun, '12	Jun, '13	Jun, '14	Jun, '15
Avg	24.89	24.32	25.22	23.50	23.34	24.42	24.33	25.61	24.45	24.70
Min	23.726	23.506	23.340	23.420	23.010	23.830	23.670	24.260	24.120	24.330
Max	26.226	25.270	28.83	23.650	24.060	26.500	25.780	28.060	25.200	25.470

FIGURE 6.18: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - JUNE



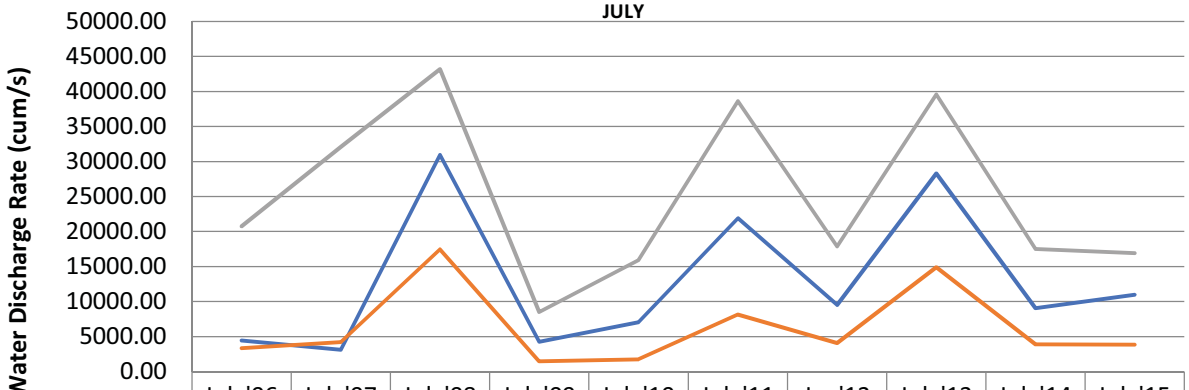
	Jun, '06	Jun, '07	Jun, '08	Jun, '09	Jun, '10	Jun, '11	Jun, '12	Jun, '13	Jun, '14	Jun, '15
Avg	2924.3	2014.4	5141.1	1146.6	962.07	2608.1	1932.8	5088.6	2105.3	2447.6
Min	1310.0	1125.0	1020.0	1080.0	775.00	1260.0	1136.0	1800.0	1630.0	1880.0
Max	5900.0	3325.0	17450	1265.0	1525.0	6650.0	4500.0	12950.	3800.0	3790.0

FIGURE 6.19: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - JULY



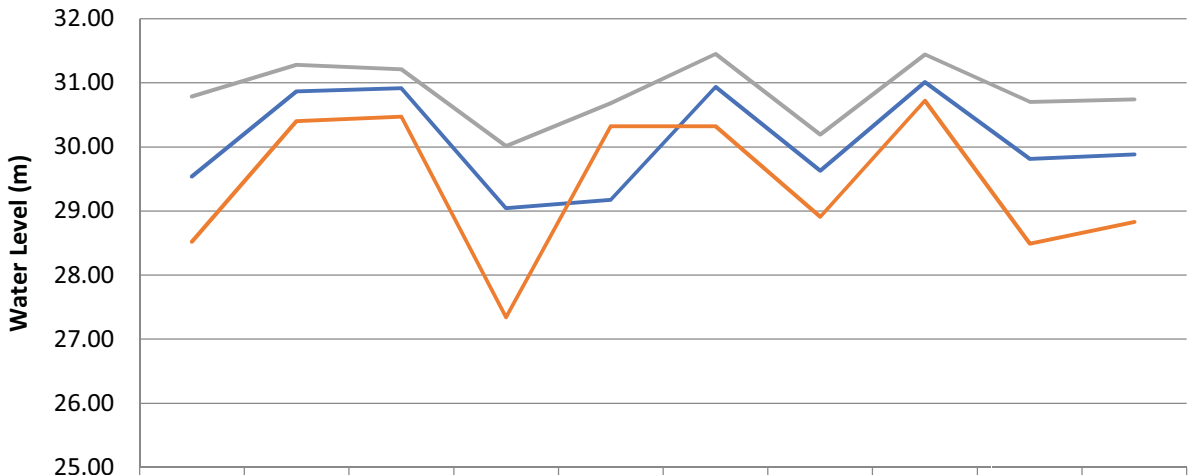
	Jul, '06	Jul, '07	Jul, '08	Jul, '09	Jul, '10	Jul, '11	Ju, '12	Jul, '13	Jul, '14	Jul, '15
avg	25.76	25.15	30.09	25.55	26.28	29.23	27.11	29.90	27.03	27.53
min	25.276	25.66	28.83	23.9	24.22	26.92	25.58	28.42	25.5	25.49
max	29.236	30.25	30.87	27.09	28.59	30.66	28.88	30.71	28.82	28.74

FIGURE 6.20: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - JULY



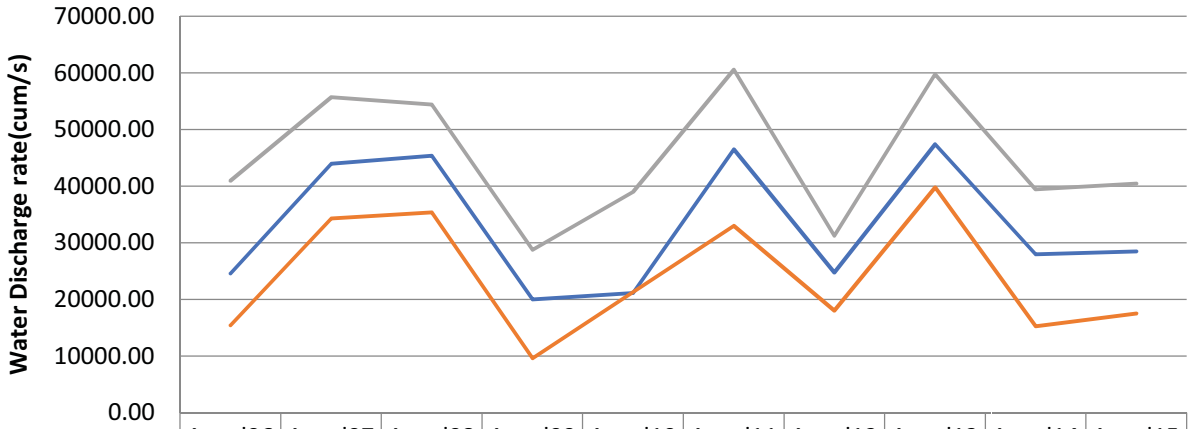
	Jul, '06	Jul, '07	Jul, '08	Jul, '09	Jul, '10	Jul, '11	Ju, '12	Jul, '13	Jul, '14	Jul, '15
avg	4425.0	3100	30934.	4238.7	7009.6	21890.	9507.2	28282.	9057.9	10960.
min	3325	4225	17450	1470	1750	8125	4050	14900	3870	3840
max	20750	32100	43200	8500	15900	38650	17850	39600	17500	16900

FIGURE 6.21: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - AUGUST



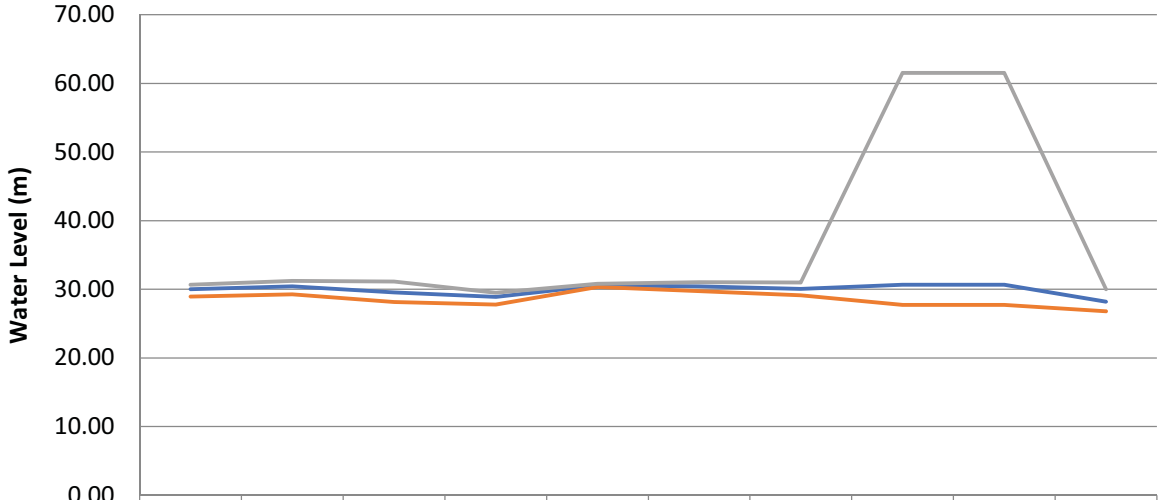
	Aug, '06	Aug, '07	Aug, '08	Aug, '09	Aug, '10	Aug, '11	Aug, '12	Aug, '13	Aug, '14	Aug, '15
Avg	29.54	30.87	30.92	29.04	29.17	30.94	29.62	31.01	29.81	29.88
Min	28.516	30.4	30.470	27.34	30.32	30.32	28.91	30.72	28.49	28.83
Max	30.786	31.28	31.210	30.01	30.68	31.45	30.19	31.44	30.7	30.74

FIGURE 6.22: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - AUGUST



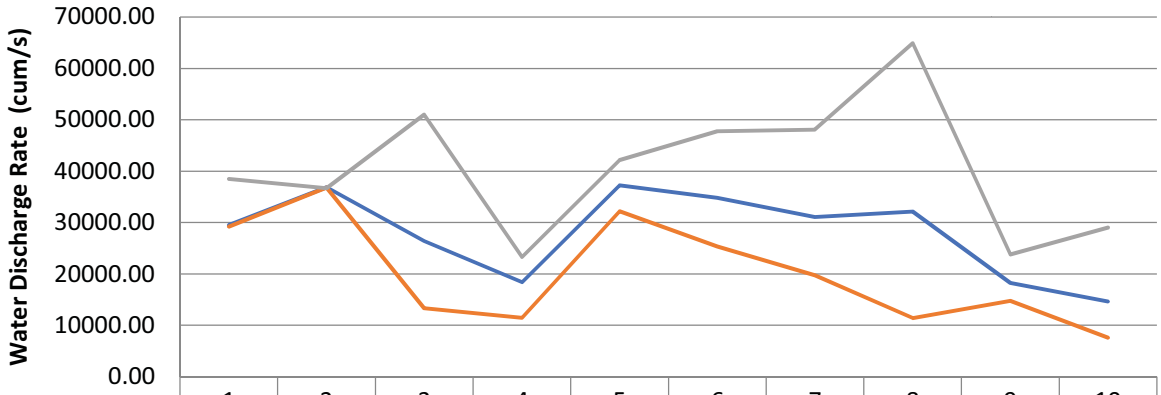
	Aug, '06	Aug, '07	Aug, '08	Aug, '09	Aug, '10	Aug, '11	Aug, '12	Aug, '13	Aug, '14	Aug, '15
Avg	24583.	43940.	45370.	20004.	21150.	46495.	24770.	47416.	27949.	28462.
Min	15450	34300	35400	9650	21330.	33050	18050	39800	15275	17550
Max	41000	55750	54450	28800	39000	60600	31300	59800	39500	40500

FIGURE 6.23: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - SEPTEMBER



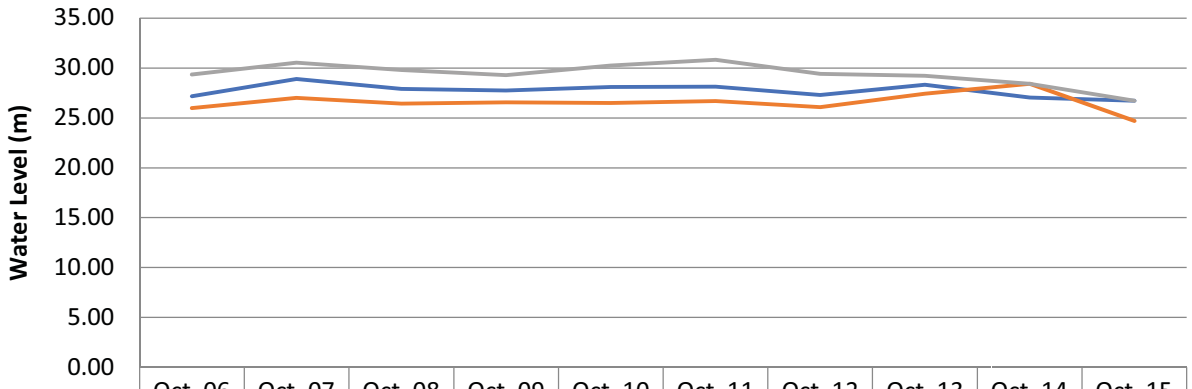
	Sept, '06	Sept, '07	Sept, '08	Sept, '09	Sept, '10	Sept, '11	Sept, '12	Sept, '13	Sept, '14	Sept, '15
Avg	30.00	30.412	29.533	28.883	30.58	30.44	30.04	30.66	30.66	28.21
Min	28.956	29.250	28.13	27.76	30.33	29.71	29.12	27.74	27.74	26.8
Max	30.656	31.250	31.13	29.51	30.83	31.03	31.01	61.52	61.52	30.02

FIGURE 6.24: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - SEPTEMBER



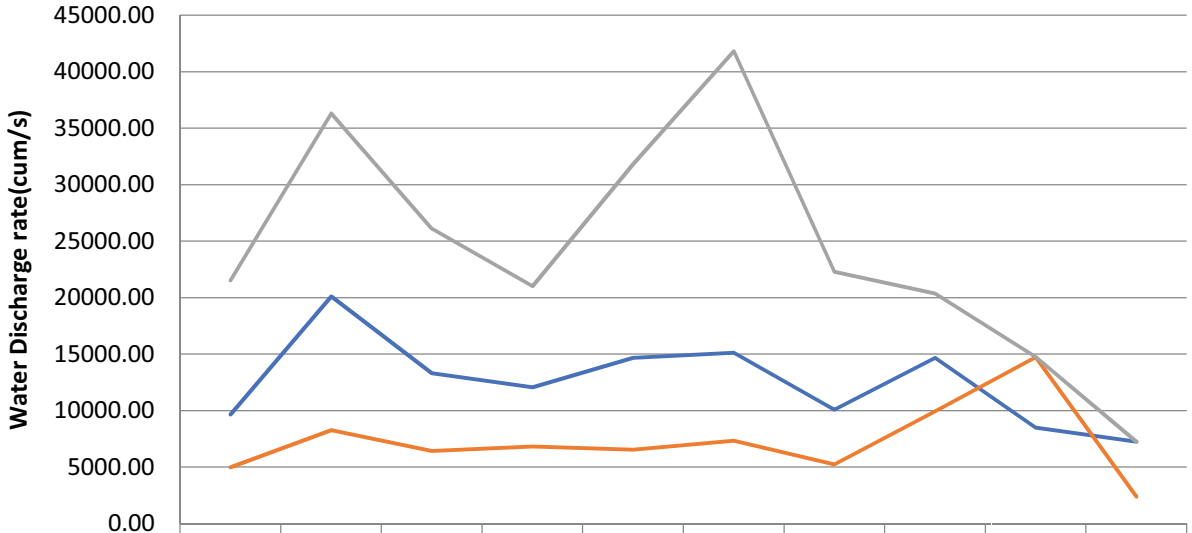
	1	2	3	4	5	6	7	8	9	10
Avg	29492.	36855.	26376.	18343.	37236.	34782.	31045.	32157.	18266.	14625.
Min	29181.	36787.	13300	11450	32200	25350	19750	11400	14750	7600
Max	38500	36698.	51000	23300	42200	47800	48100	64900	23800	29000

FIGURE 6.25: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - OCTOBER



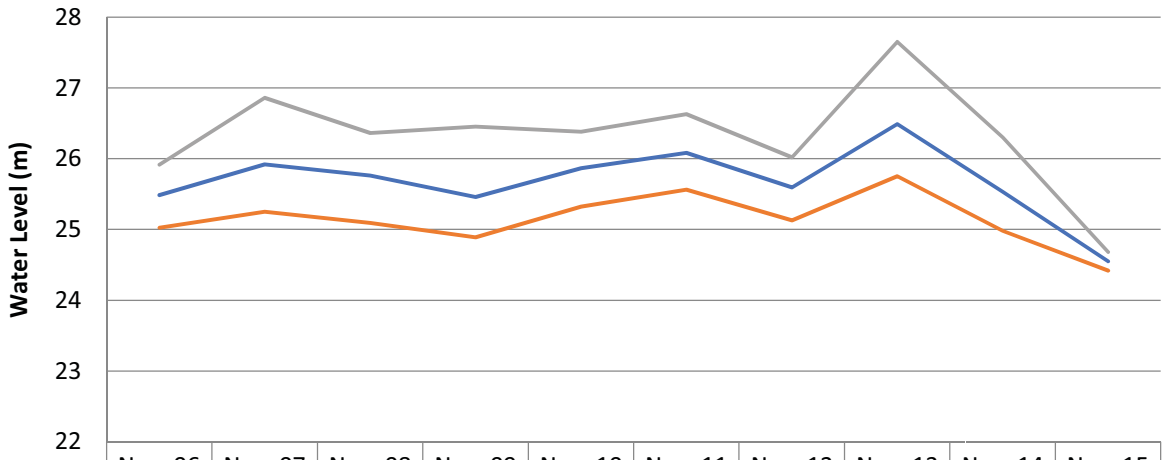
	Oct, 06	Oct, 07	Oct, 08	Oct, 09	Oct, 10	Oct, 11	Oct, 12	Oct, 13	Oct, 14	Oct, 15
Avg	27.16	28.90	27.90	27.74	28.09	28.13	27.27	28.31	27.01	26.70
Min	25.956	26.98	26.43	26.56	26.48	26.68	26.06	27.42	28.4	24.69
Max	29.326	30.53	29.79	29.26	30.23	30.81	29.4	29.2	28.4	26.7

FIGURE 6.26: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - OCTOBER



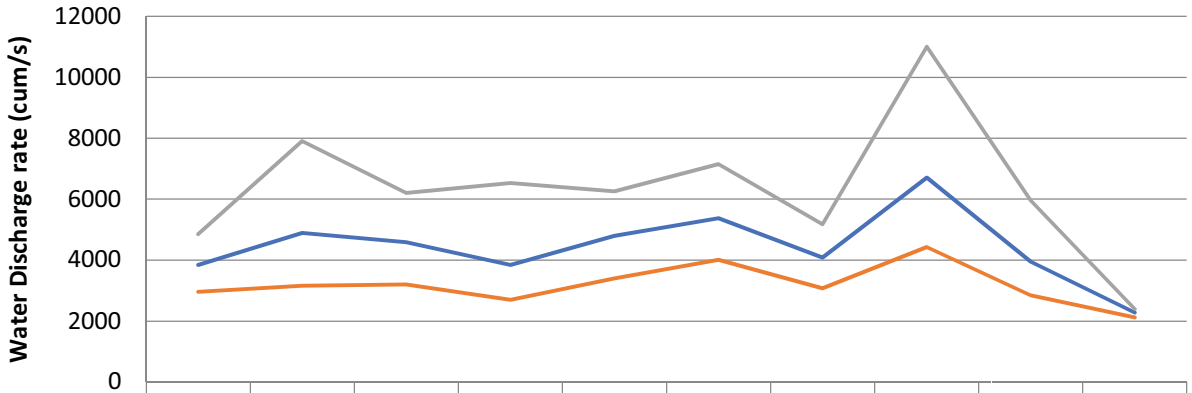
	Oct, 06	Oct, 07	Oct, 08	Oct, 09	Oct, 10	Oct, 11	Oct, 12	Oct, 13	Oct, 14	Oct, 15
Avg	9669.1	20106.	13305.	12053.	14679.	15129.	10085.	14661.	8499.5	7250.0
Min	5000	8300	6450	6850	6575	7350	5275	9950	14750	2400
Max	21525	36300	26100	21000	31800	41800	22300	20350	14750	7250

FIGURE 6.27: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - NOVEMBER



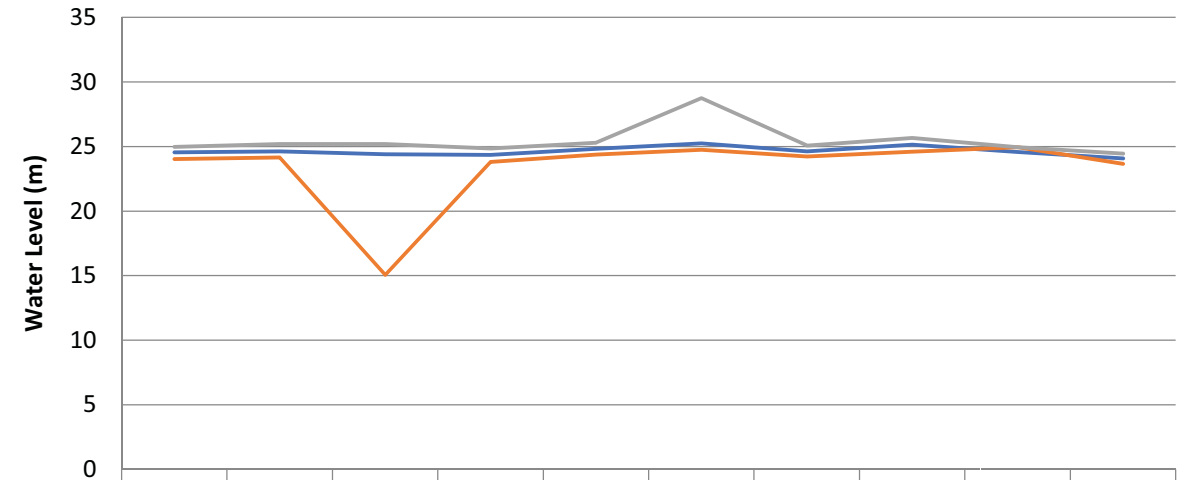
	Nov, 06	Nov, 07	Nov, 08	Nov, 09	Nov, 10	Nov, 11	Nov, 12	Nov, 13	Nov, 14	Nov, 15
Avg	25.485	25.92	25.76	25.46	25.86	26.08	25.59	26.49	25.53	24.55
Min	25.026	25.25	25.09	24.89	25.32	25.56	25.13	25.75	24.98	24.42
Max	25.916	26.86	26.36	26.45	26.38	26.63	26.02	27.65	26.3	24.68

FIGURE 6.28: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - NOVEMBER



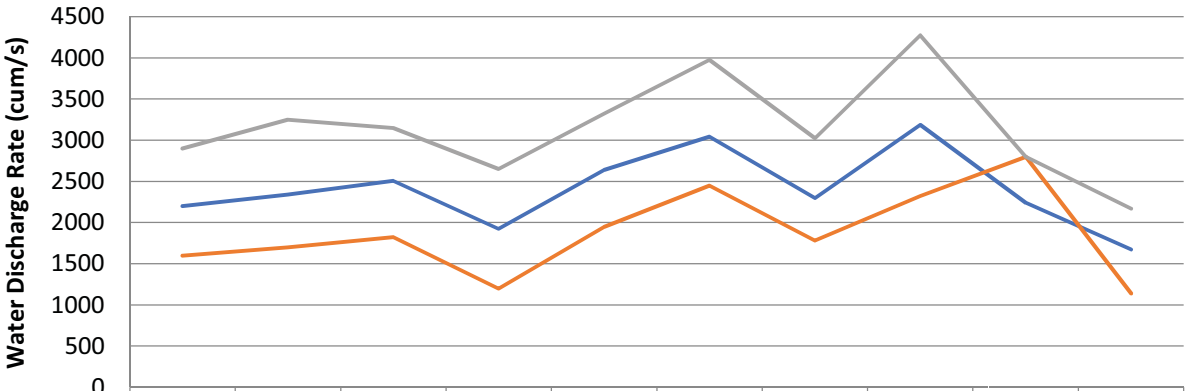
	Nov, 06	Nov, 07	Nov, 08	Nov, 09	Nov, 10	Nov, 11	Nov, 12	Nov, 13	Nov, 14	Nov, 15
Avg	3844.1	4890.8	4585.0	3843.8	4793.3	5374.1	4086.0	6705.1	3942.0	2276.3
Min	2950	3150	3200	2690	3400	4000	3075	4425	2840	2115
Max	4850	7900	6200	6525	6250	7150	5175	11000	5950	2390

FIGURE 6.29: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - DECEMBER



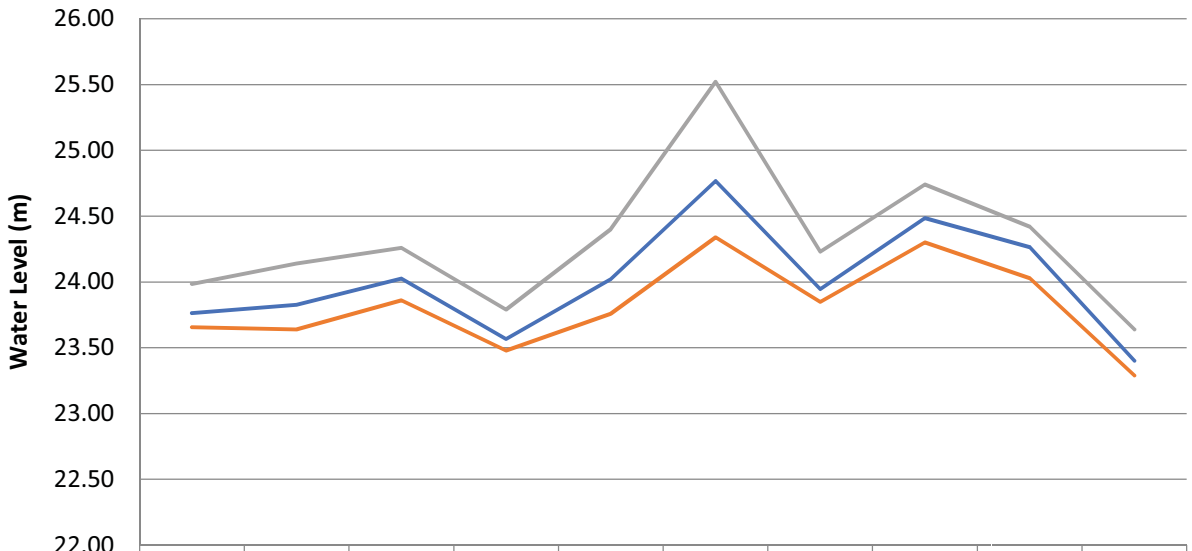
	Dec, 06	Dec, 07	Dec, 08	Dec, 09	Dec, 10	Dec, 11	Dec, 12	Dec, 13	Dec, 14	Dec, 15
Avg	24.56	24.63	24.39	24.35	24.83	25.25	24.63	25.15	24.57	24.08
Min	24.026	24.16	15.06	23.82	24.38	24.76	24.24	24.61	24.95	23.67
Max	24.986	25.21	25.19	24.85	25.29	28.74	25.09	25.68	24.95	24.46

FIGURE 6.30: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - DECEMBER



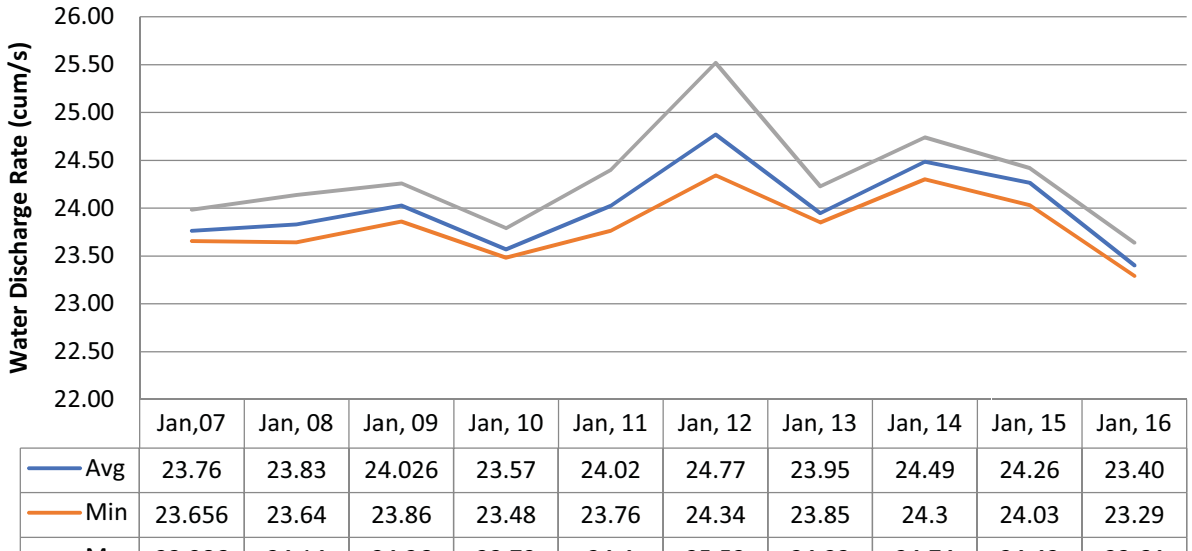
	Dec, 06	Dec, 07	Dec, 08	Dec, 09	Dec, 10	Dec, 11	Dec, 12	Dec, 13	Dec, 14	Dec, 15
Avg	2202.2	2341.7	2506.4	1923.0	2641.4	3045.6	2295.9	3189.3	2240.9	1671.1
Min	1600	1700	1825	1200	1950	2450	1780	2320	2800	1140
Max	2900	3250	3150	2650	3325	3975	3025	4275	2800	2170

FIGURE 6.31: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - JANUARY



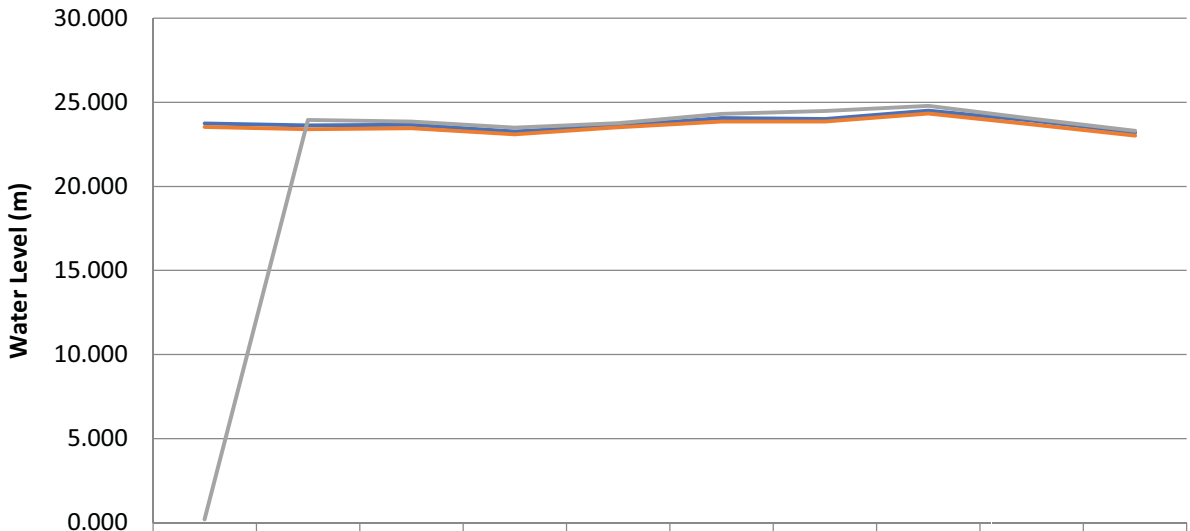
	Jan,07	Jan, 08	Jan, 09	Jan, 10	Jan, 11	Jan, 12	Jan, 13	Jan, 14	Jan, 15	Jan, 16
Avg	23.76	23.83	24.026	23.57	24.02	24.77	23.95	24.49	24.26	23.40
Min	23.656	23.64	23.86	23.48	23.76	24.34	23.85	24.3	24.03	23.29
Max	23.986	24.14	24.26	23.79	24.4	25.52	24.23	24.74	24.42	23.64

FIGURE 6.32: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - JANUARY



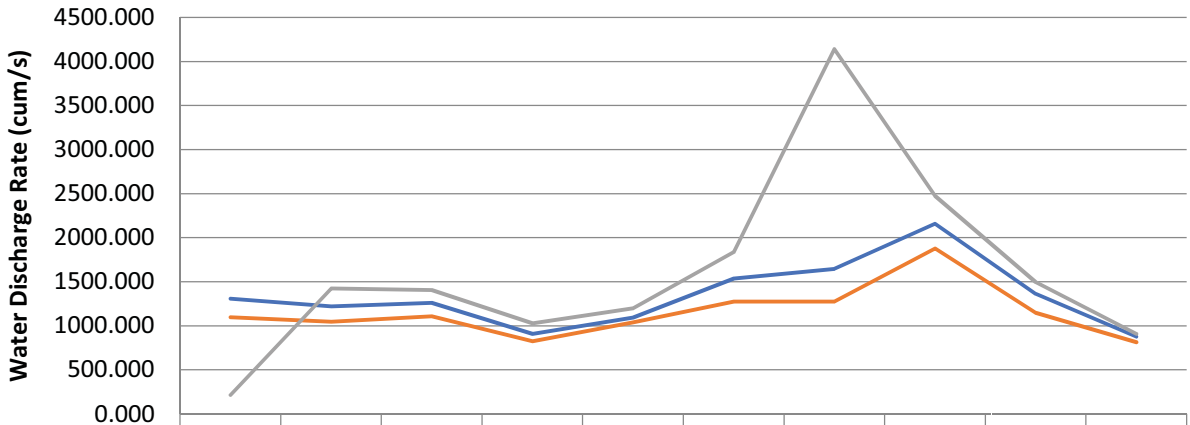
	Jan,07	Jan, 08	Jan, 09	Jan, 10	Jan, 11	Jan, 12	Jan, 13	Jan, 14	Jan, 15	Jan, 16
Avg	23.76	23.83	24.026	23.57	24.02	24.77	23.95	24.49	24.26	23.40
Min	23.656	23.64	23.86	23.48	23.76	24.34	23.85	24.3	24.03	23.29
Max	23.986	24.14	24.26	23.79	24.4	25.52	24.23	24.74	24.42	23.64

FIGURE 6.33: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - FEBRUARY



	Feb ,07	Feb, 08	Feb, 09	Feb, 10	Feb, 11	Feb,12	Feb, 13	Feb, 14	Feb, 15	Feb, 16
Avg	23.745	23.61	23.66	23.26	23.61	24.06	24.02	24.51	23.91	23.20
Min	23.536	23.4	23.45	23.1	23.52	23.85	23.86	24.33	23.69	23.02
Max	0.211	23.96	23.86	23.49	23.76	24.31	24.48	24.79	24.03	23.30

FIGURE 6.34: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - FEBRUARY

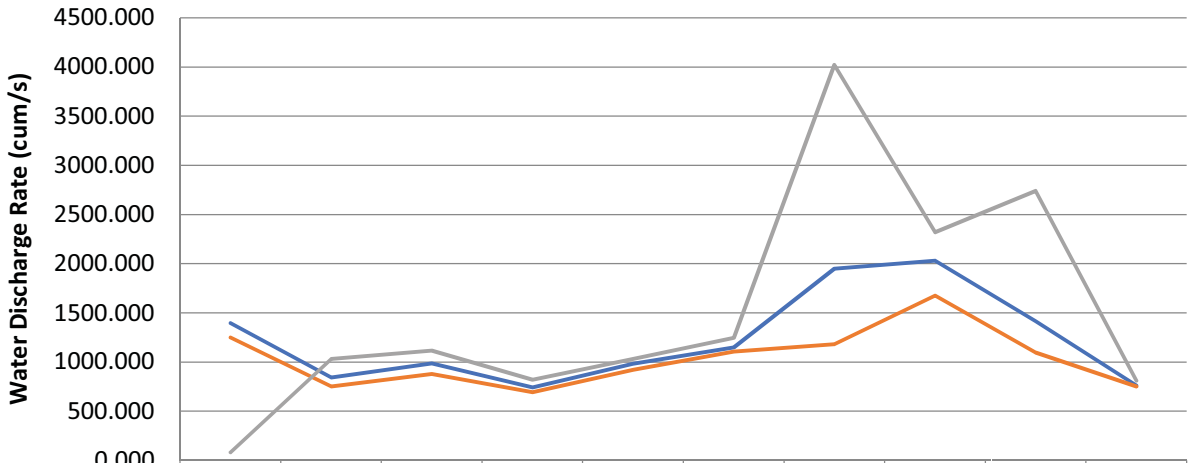


	Feb ,07	Feb, 08	Feb, 09	Feb, 10	Feb, 11	Feb,12	Feb, 13	Feb, 14	Feb, 15	Feb, 16
Avg	1306.4	1222.1	1259.2	908.21	1094.0	1537.0	1645.3	2158.5	1362.5	875.69
Min	1100	1048.6	1110.8	825	1040	1275	1275	1880	1150	815
Max	217.51	1425	1407.6	1030	1200	1840	4141	2475	1500	910.00

FIGURE 6.35: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - MARCH

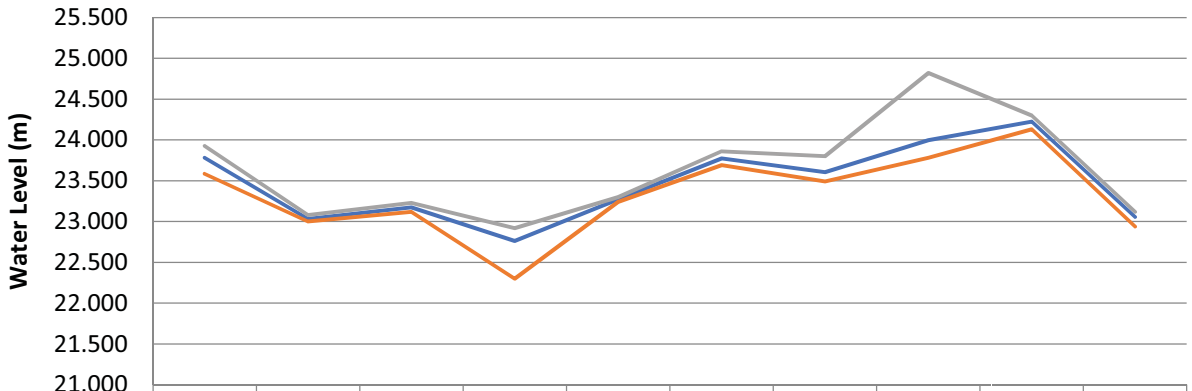
	Mar,07	Mar, 08	Mar, 09	Mar, 10	Mar, 11	Mar, 12	Mar, 13	Mar, 14	Mar, 15	Mar, 16
Avg	23.827	23.17	23.28	22.85	23.38	23.69	24.07	24.39	23.92	22.94
Min	23.736	23.07	23.18	22.70	23.26	23.63	23.72	24.08	23.6	22.92
Max	23.956	23.39	23.44	23.09	23.5	23.82	24.52	24.61	24.18	23.01

FIGURE 6.36: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - MARCH



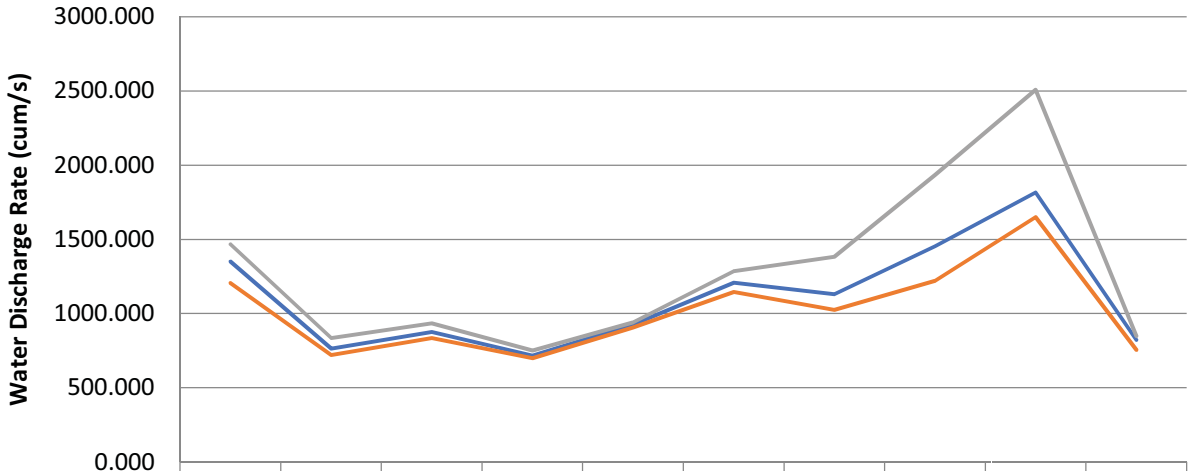
	Mar,07	Mar, 08	Mar, 09	Mar, 10	Mar, 11	Mar, 12	Mar, 13	Mar, 14	Mar, 15	Mar, 16
Avg	1394.0	840.67	984.28	740.39	980.89	1149.1	1949.5	2030.3	1416.0	759.76
Min	1248.4	750	879.45	693	920	1105	1180	1675	1095	750
Max	80.774	1030	1115	820	1030	1245	4022	2320	2739.1	810.00

FIGURE 6.37: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - APRIL



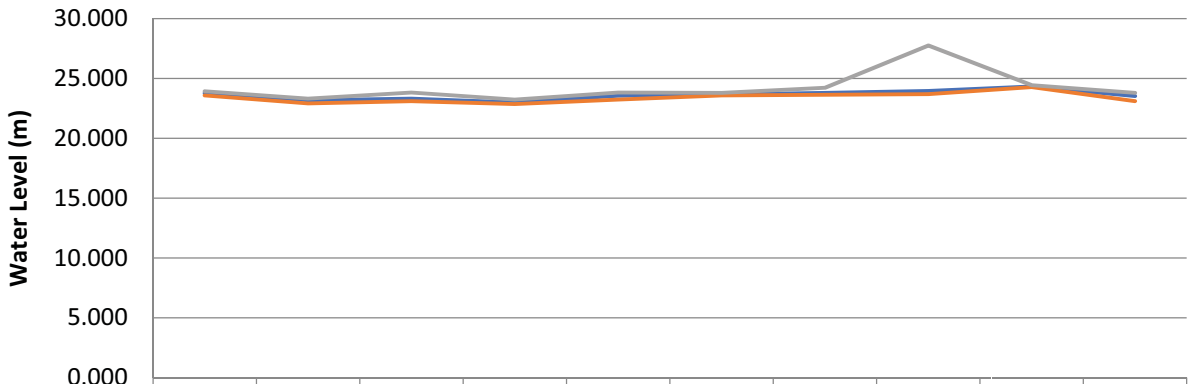
	Apr,07	Apr, 08	Apr, 09	Apr, 10	Apr, 11	Apr, 12	Apr, 13	Apr, 14	Apr, 15	Apr, 16
Avg	23.782	23.03	23.17	22.76	23.27	23.77	23.61	24.00	24.23	23.06
Min	23.586	23	23.12	22.3	23.24	23.69	23.49	23.78	24.13	22.94
Max	23.926	23.08	23.23	22.92	23.3	23.86	23.8	24.82	24.3	23.12

FIGURE 6.38: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - APRIL



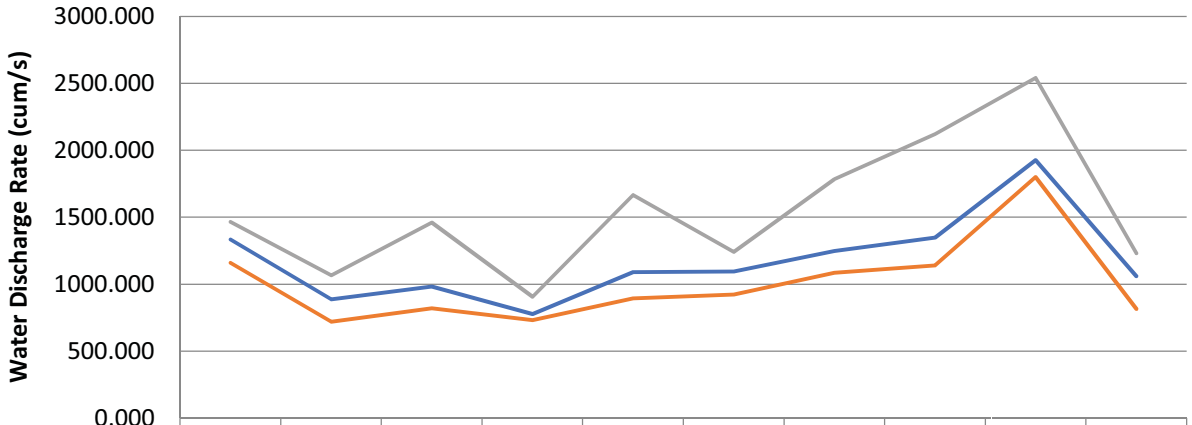
	Apr,07	Apr, 08	Apr, 09	Apr, 10	Apr, 11	Apr, 12	Apr, 13	Apr, 14	Apr, 15	Apr, 16
Avg	1349.2	763.48	875.92	715.60	923.83	1207.2	1129.3	1452.1	1815.0	820.20
Min	1205	720	835	698	905	1145	1025	1220	1650	755
Max	1465	833.65	933.26	750	940	1285	1381	1933.1	2507.3	847

FIGURE 6.39: LONG TERM TREND OF VARIATION OF WATER LEVEL OF RIVER GANGA AT AZMABAD - MAY



	May,07	May,08	May,09	May, 10	May,11	May,12	May,13	May,14	May,15	May,16
Avg	23.756	23.17	23.29	22.98	23.53	23.64	23.78	23.94	24.33	23.52
Min	23.576	22.9	23.09	22.85	23.22	23.56	23.61	23.68	24.26	23.08
Max	23.926	23.32	23.84	23.24	23.83	23.81	24.23	27.75	24.45	23.8

FIGURE 6.40: LONG TERM TREND OF VARIATION OF WATER DISCHARGE OF RIVER GANGA AT AZMABAD - MAY

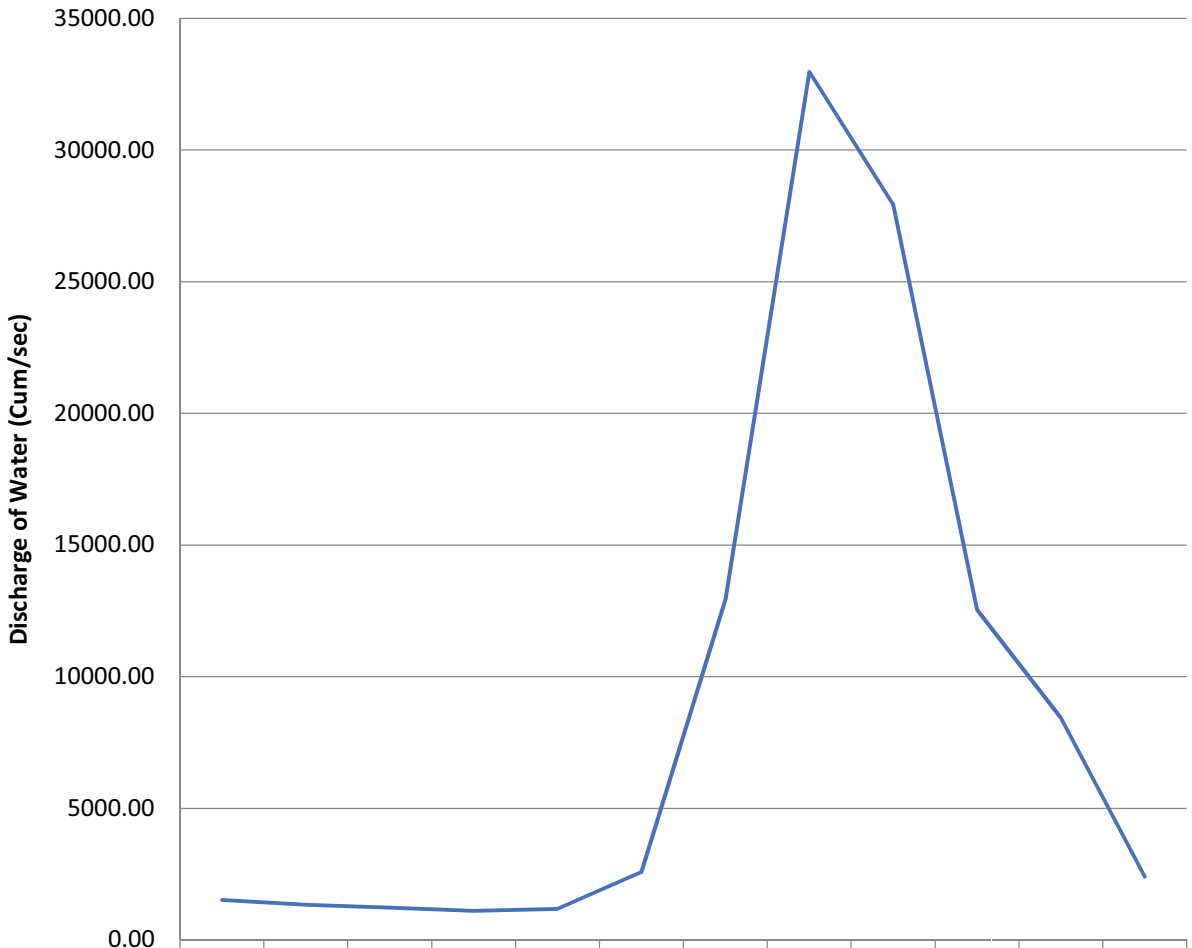


	May,07	May,08	May,09	May, 10	May,11	May,12	May,13	May,14	May,15	May,16
Avg	1333.2	887.31	982.83	776.81	1089.5	1094.8	1246.2	1346.8	1925.4	1057.5
Min	1160.1	720	820	732	895	923	1085	1140	1800	815
Max	1465	1065.7	1459.3	905	1666.7	1240	1782	2120	2541.2	1230

6.5 ASSESSMENT OF WATER AVAILABILITY

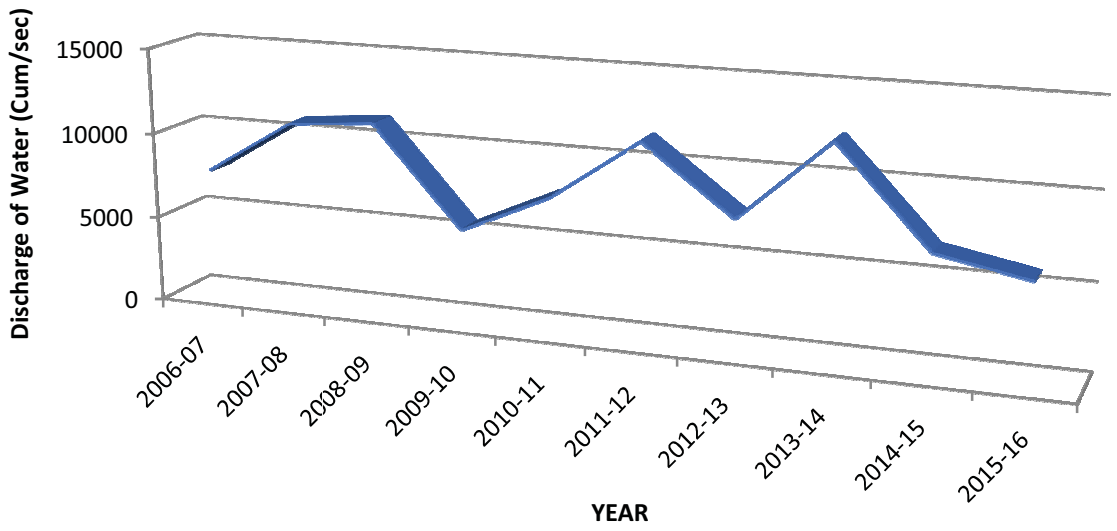
Monthly hydrograph of daily flow in River Ganga in the project area has been developed on the basis of 10 years daily discharge date collected from CWC for G&D Station at Azmabad for years 2005-06 to 2015-16. The Month wise distribution of discharge of water is presented in Figure 6.41. The analysis reveals that the average flow from July to December varies from 2405 to 32964 cum/s. The annual hydrograph of average daily discharge of water for 2006-2016 is presented in Figure 6.42.

FIGURE 6.41: MONTHLY HYDROGRAPH OF DAILY FLOW IN RIVER GANGA (2006-2016)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Series1	1521.	1336.	1224.	1105.	1174.	2574.	12940	32964	27918	12544	8434.	2405.

FIGURE 6.42: ANNUAL HYDROGRAPH OF AVERAGE DAILY FLOW (2006-2016)



Flow Duration Curve (FDC) has been drawn to know the temporal water availability at the proposed project site. It shows a discharge which has equaled or exceeded certain percentage of time out of the total time period which is generally taken one year. From FDC minimum flow for any dependability may be obtained/interpolated.

Accordingly monthly FDC has been developed on the basis of ten daily discharge data for years 2005-06 to 2015-16 collected from CWC for nearest G&D Station at Azmabad. Figure 6.43 to 6.54 present monthly FDC from January to December developed based on ten daily average discharge of 10 years (2006-2016). Figure 6.55 presents the seasonal FDC on the basis of ten daily average discharge of 10 years (2006-2016).

The probable water discharge for various desired i.e. 50%, 75% & 90% dependability has been estimated by arranging ten daily average discharge of the concerned month in descending order and using Weilbul's formula:

$$P = (M/N+1) \times 100$$

Where,

P = Probability that a given flow will be equaled or exceeded (% of time)
M = Ranked position on the listing (Dimension less)
N = Number of events for period of record (Dimension less)

FIGURE 6.43: FLOW DURATION CURVE - JANUARY (2006-2016)
[Using 10 Daily Discharge Data]

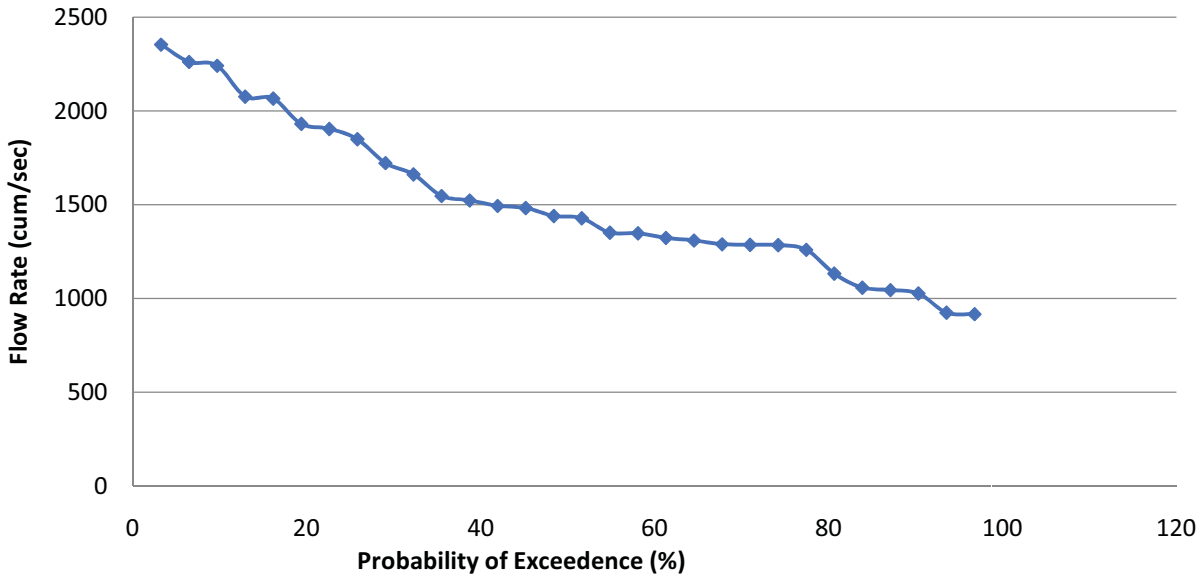
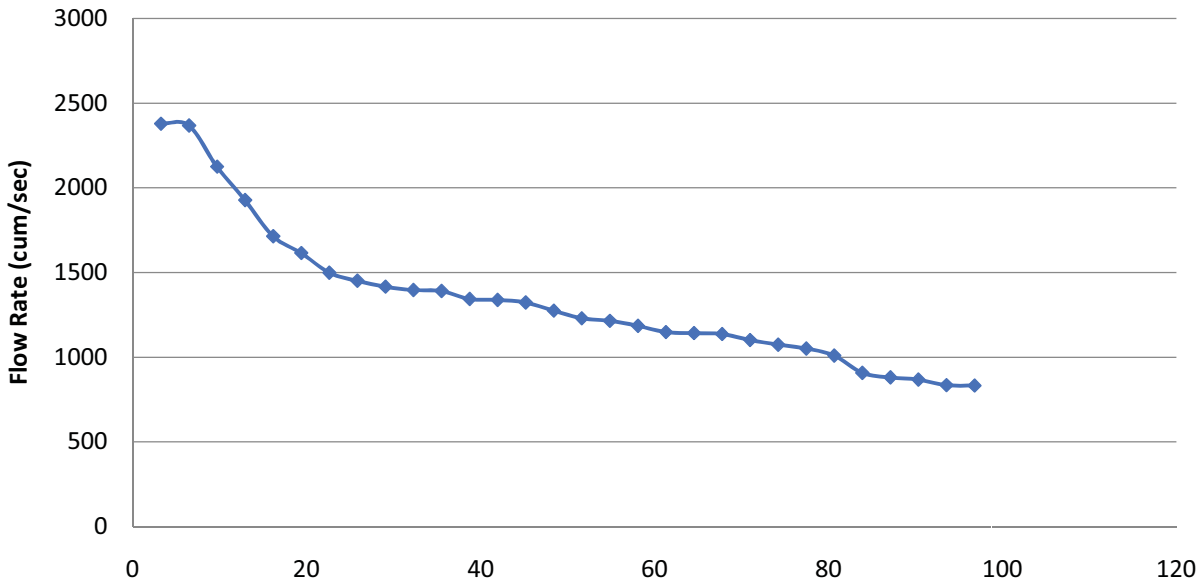


FIGURE 6.44: FLOW DURATION CURVE - FEBRUARY (2006-2016)
[Using 10 Daily Discharge Data]



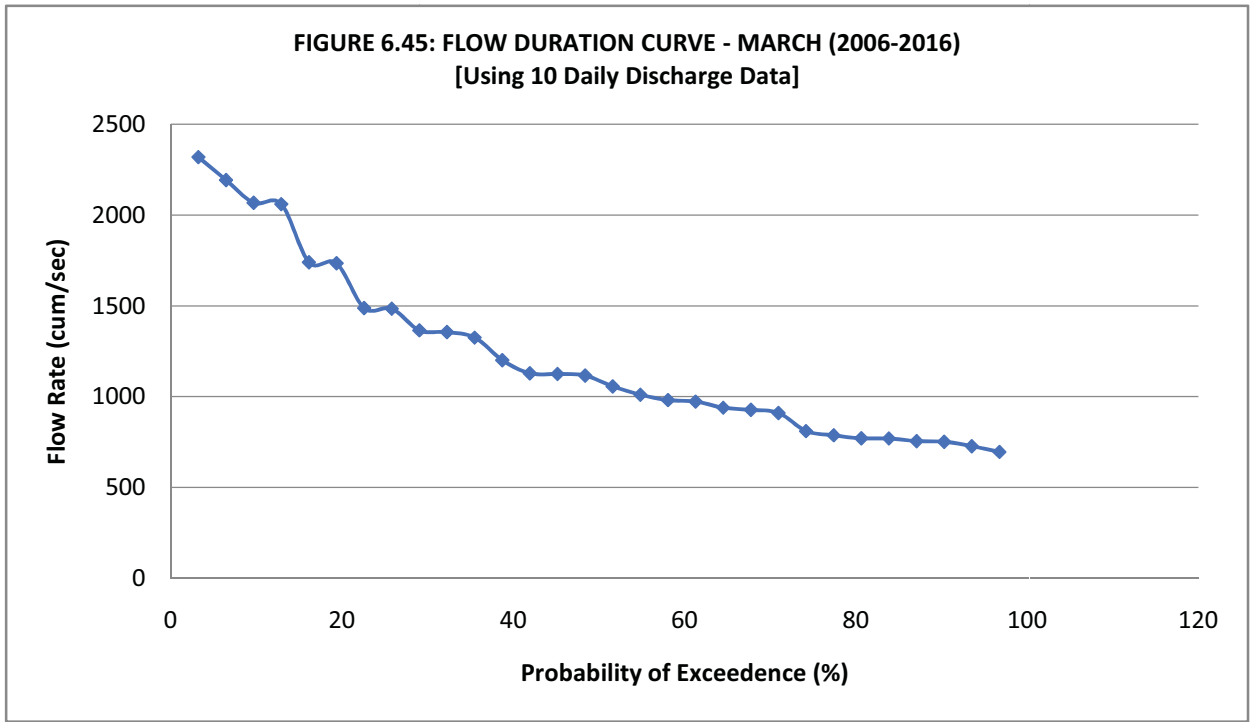


FIGURE 6.45: FLOW DURATION CURVE - MARCH (2006-2016)
[Using 10 Daily Discharge Data]
Flow Rate (cum/sec)
2500
2000
1500
1000
500
0
0
20
40
60
80
100
120
Probability of Exceedence (%)

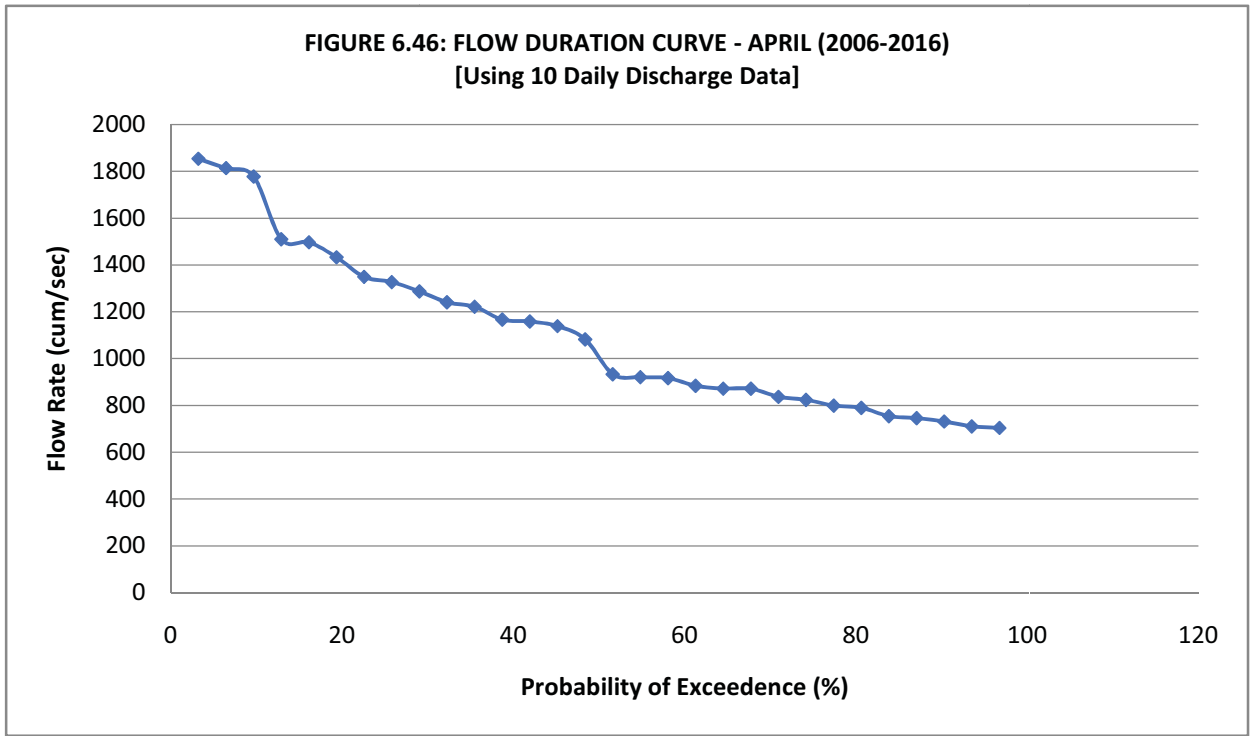


FIGURE 6.46: FLOW DURATION CURVE - APRIL (2006-2016)
[Using 10 Daily Discharge Data]
Flow Rate (cum/sec)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
20
40
60
80
100
120
Probability of Exceedence (%)

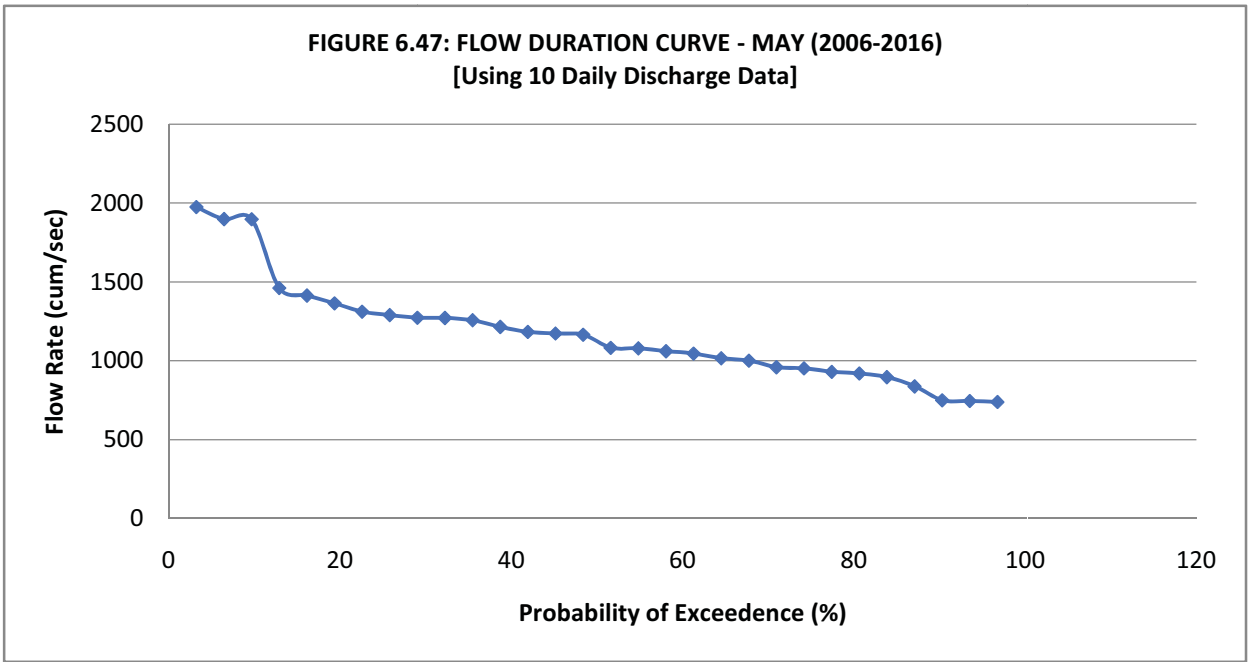


FIGURE 6.47: FLOW DURATION CURVE - MAY (2006-2016)
[Using 10 Daily Discharge Data]
Flow Rate (cum/sec)
2500
2000
1500
1000
500
0
0
20
40
60
80
100
120
Probability of Exceedence (%)

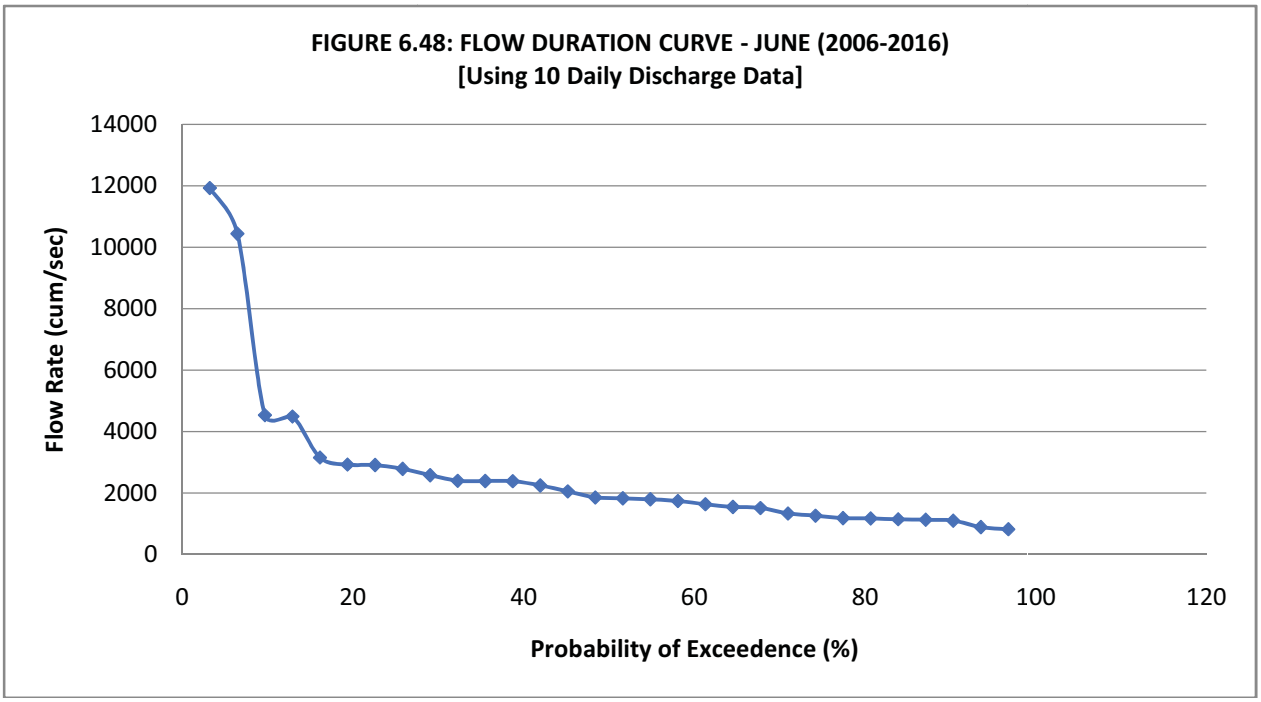


FIGURE 6.48: FLOW DURATION CURVE - JUNE (2006-2016)
[Using 10 Daily Discharge Data]
Flow Rate (cum/sec)
14000
12000
10000
8000
6000
4000
2000
0
0
20
40
60
80
100
120
Probability of Exceedence (%)

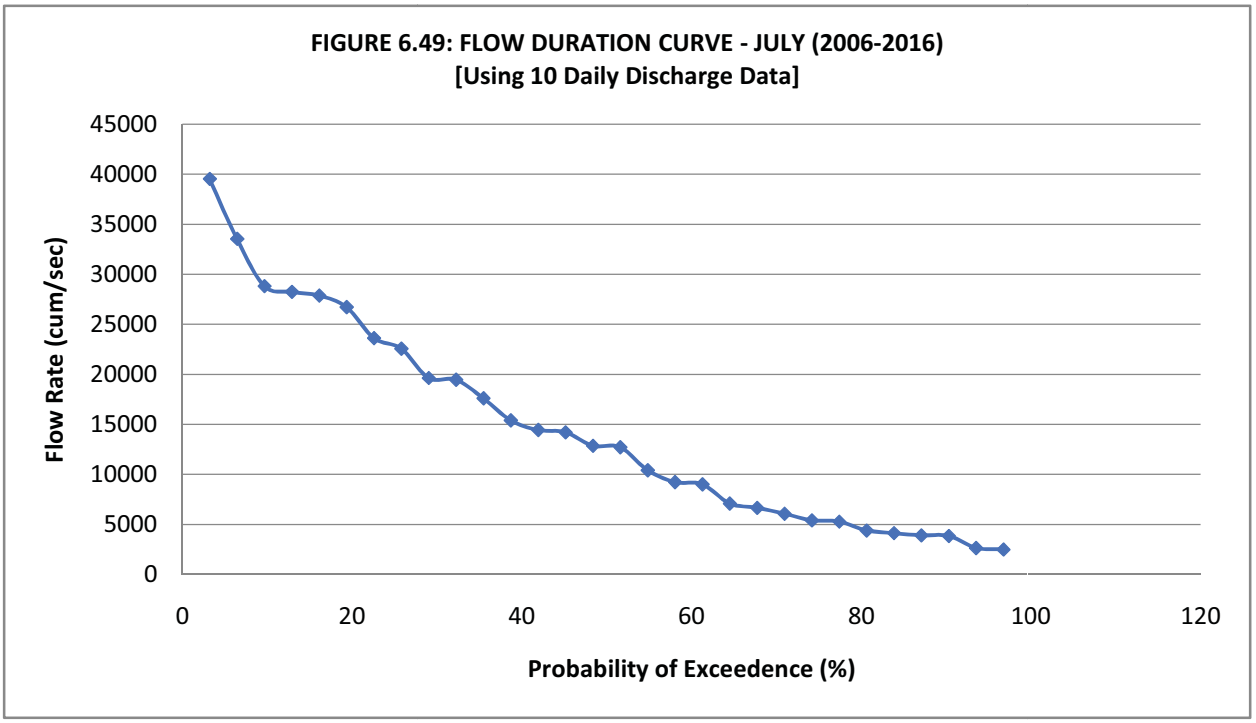


FIGURE 6.49: FLOW DURATION CURVE - JULY (2006-2016)
[Using 10 Daily Discharge Data]
Flow Rate (cum/sec)
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
0
20
40
60
80
100
120
Probability of Exceedence (%)

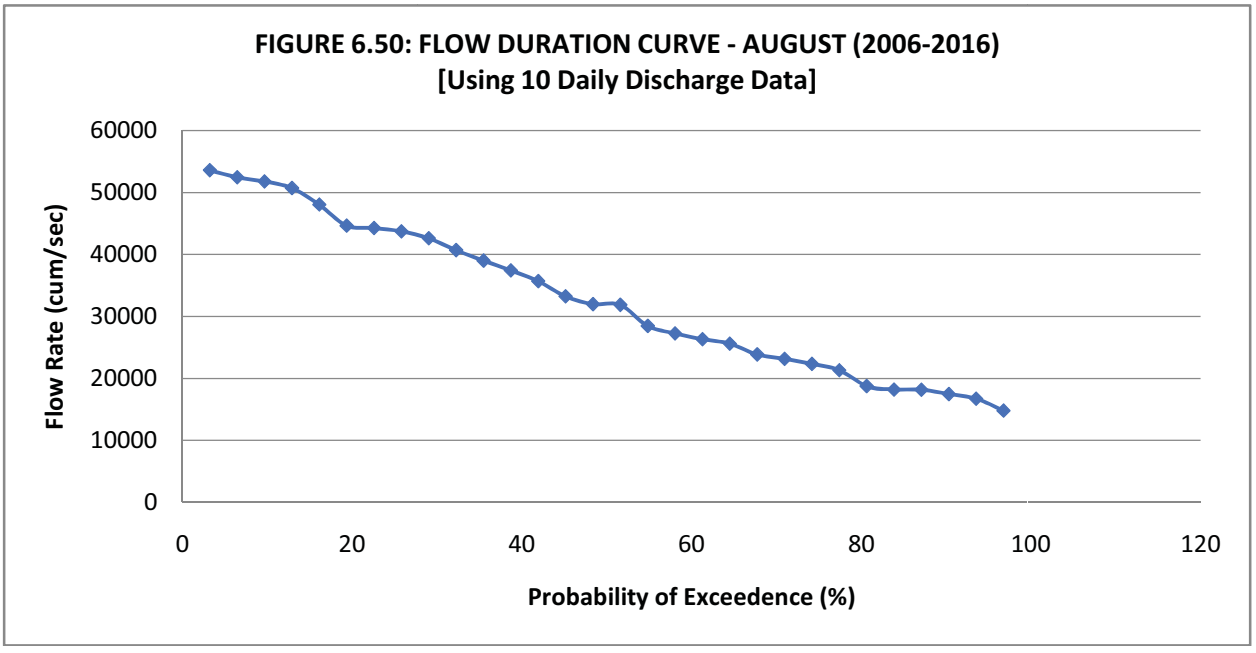


FIGURE 6.50: FLOW DURATION CURVE - AUGUST (2006-2016)
[Using 10 Daily Discharge Data]
Flow Rate (cum/sec)
60000
50000
40000
30000
20000
10000
0
0
20
40
60
80
100
120
Probability of Exceedence (%)

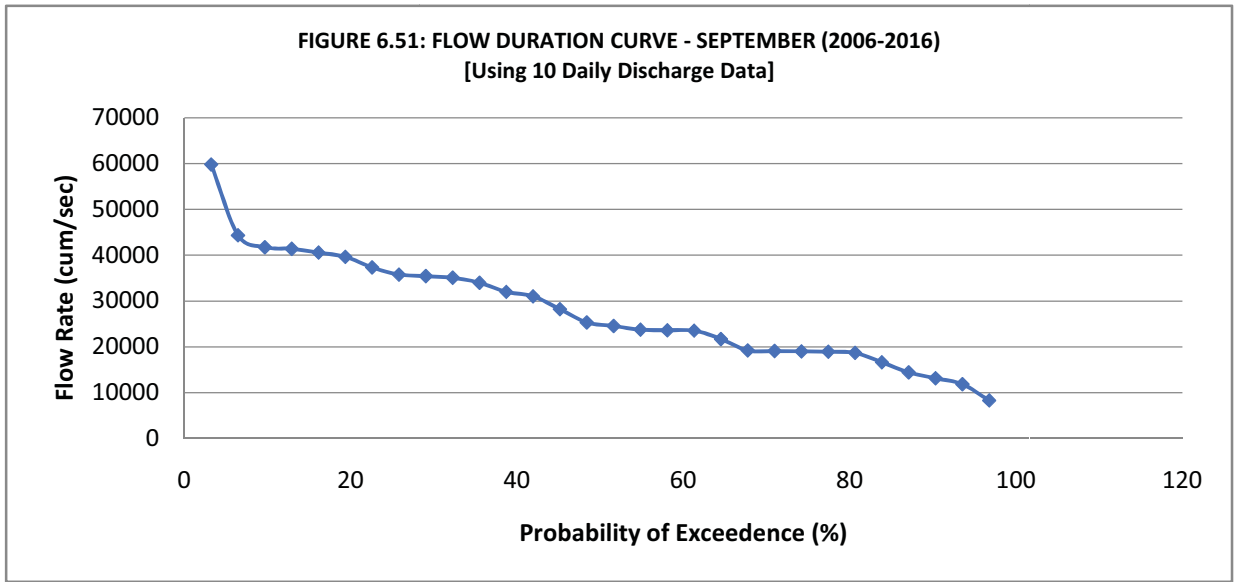


FIGURE 6.51: FLOW DURATION CURVE - SEPTEMBER (2006-2016)
[Using 10 Daily Discharge Data]
Flow Rate (cum/sec)
70000
60000
50000
40000
30000
20000
10000
0
0
20
40
60
80
100
120
Probability of Exceedence (%)

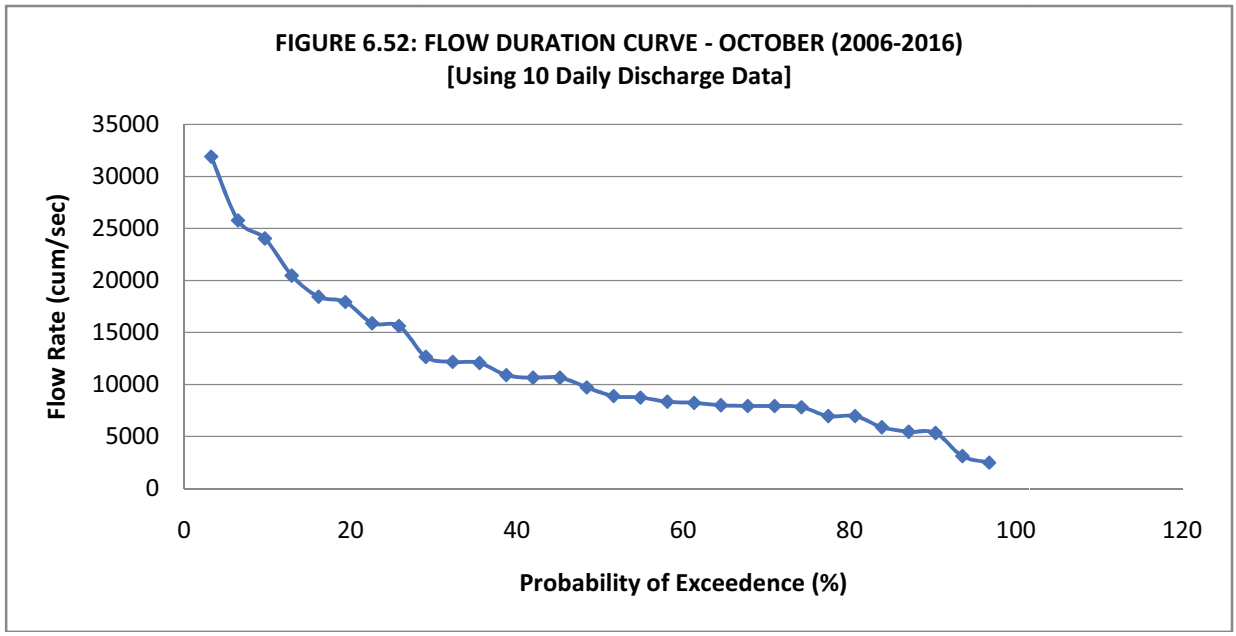


FIGURE 6.52: FLOW DURATION CURVE - OCTOBER (2006-2016)
[Using 10 Daily Discharge Data]
Flow Rate (cum/sec)
35000
30000
25000
20000
15000
10000
5000
0
0
20
40
60
80
100
120
Probability of Exceedence (%)

FIGURE 6.53: FLOW DURATION CURVE - NOVEMBER (2006-2016)
[Using 10 Daily Discharge Data]

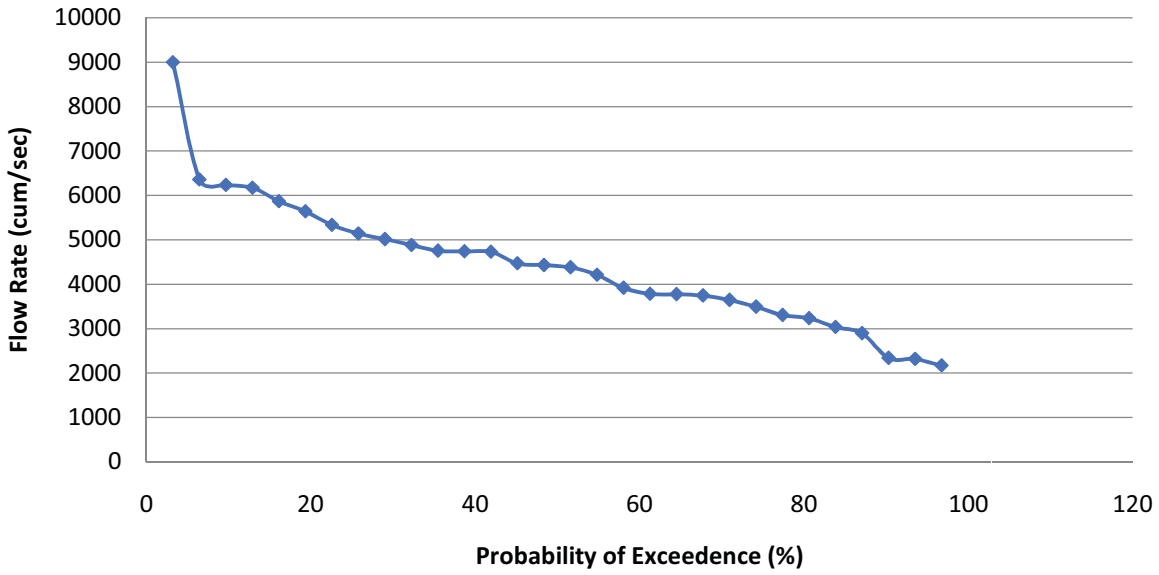


FIGURE 6.54: FLOW DURATION CURVE - DECEMBER (2006-2016)
[Using 10 Daily Discharge Data]

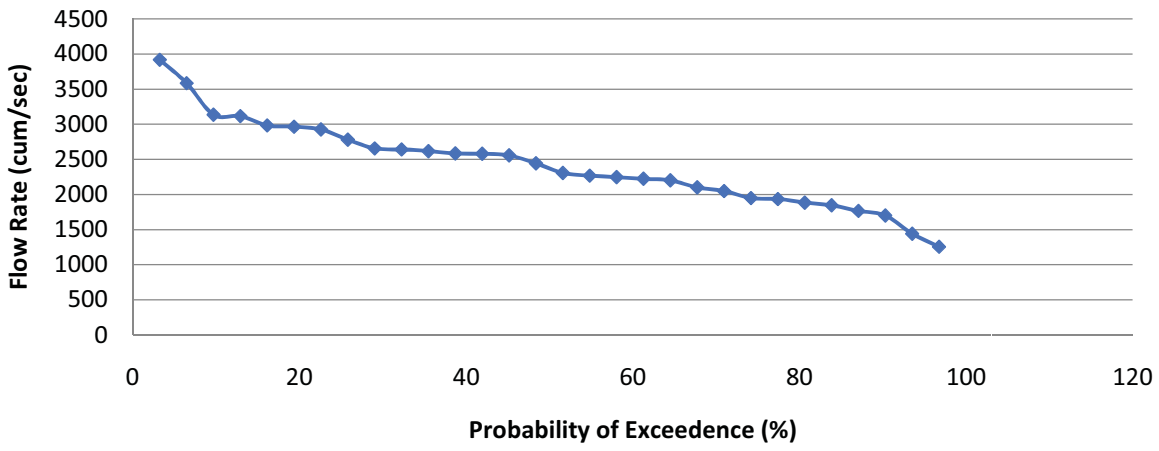
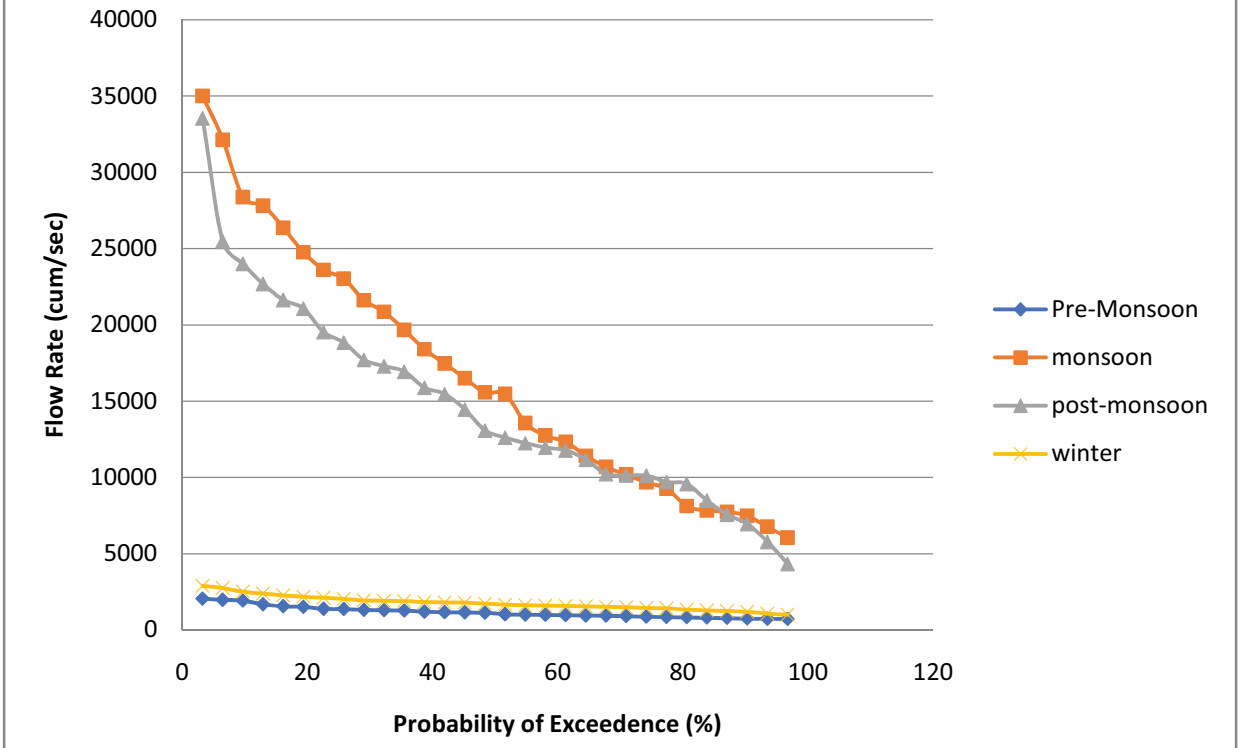


FIGURE 6.55: SEASONAL FLOW DURATION CURVE - 2006-2016
[Using 10 Daily Discharge Data]



6.6 MEASUREMENT OF WATER DISCHARGE

Water discharge was measured at intake site and upstream and down stream of intake site for lean season i.e. from 18th to 20th May, 2018. Methodology adopted for water discharge measurement at proposed location of intake site along with upstream and downstream were as follows:

Stream velocity measurements were conducted with a Current Meter (Valeport Model 106 Current Meter). This Current Meter works on a basic one second cycle, during which the impeller counts are taken and a single compass heading reading is made, from which the east and north velocity vectors are calculated and then summed over the averaging period. The Current meter was attached to the side of the Boat, just below the water surface, and the measured stream velocity was digitally displayed and recorded at regular points and intervals along the taken cross-section, with simultaneous measurement of the depth at each of these points. The cross- section was divided into a number of sections and the average velocity for each of these sections was used to compute the respective discharge for each section, which were finally summed up to compute the total discharge for that cross section.

The measurement of depth in terms of bathymetry survey has been done by using Eco- sounder (Velport Medas surveyor Sl. No. 45663) with single transducer along the cross sections. There are three respected cross-sections have been surveyed, one from intake point, second one down stream from the intake point and last one upstream from the intake point. This eco-sounder works on a basis of transmitting sound pulses into water. The data is recorded according to the time interval between emission and return of pulse and the data is used for determining the depth along with the speed of sound in water at the time. The transducer was fixed to the side of the boat, just below the water surface; so that it can work easily with the movement of the boat. The data was stored and transferred to the computer separately according to the sections. The cross-sections were divided in to no. of sections and the average depth of each section was used for computation of discharge for each sections in all respective cross sections. Finally, to compute the total discharge, value of each section has been added.

Bathmetric survey detail at cross section 1 of River Ganga i.e intake site is presented in Figure 6.56 to 6.57. The estimated discharge at intake site work out to be 2027.58 cumecs by Direct CS zone wise average velocity i.e 0.5641 m/s. Whereas the estimated discharge at intake site work out to be 1993.10 cumecs by direct co-ordinate method and overall average velocity i.e 0.5659 m/s (Table 6.3).

Surveyed line 1 From intake point Bathymetry survey done From right(south) bank to left bank(north) .	▪Actual surveyed length : 483.27meters ▪After validation following the same course , Length 483.36meter. ▪Deviation less than 0.03% ▪Total no. of measured points along the surveyed line: 972 points.

FIGURE 6.56: BATHYMETRIC SURVEY AT CROSS SECTION 1 OF RIVER GANGA - INTAKE SITE

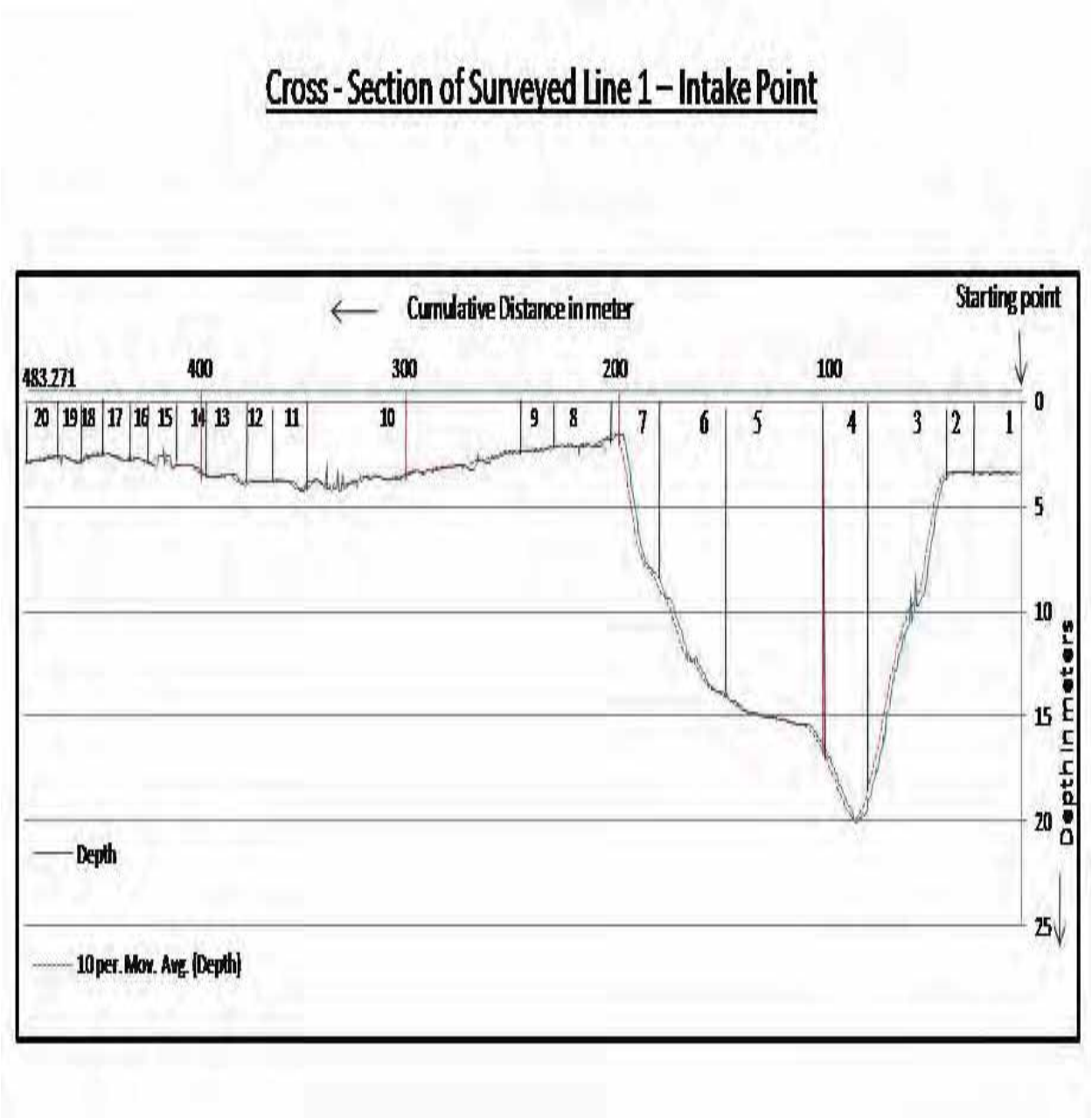


FIGURE 6.57: PROFILE OF WATER LEVEL AND DEPTH AT CROSS SECTION 1 OF RIVER GANGA - INTAKE SITE

Bathmetric survey detail at cross section 2 of River Ganga i.e down stream site is presented in Figure 6.58 to 6.62. The estimated discharge at down stream site work out to be 23075.29 cumecs by Direct CS zone wise average velocity i.e 1.6277 m/s. Whereas the estimated discharge at cross section 2 worked out to be 23106.15 cumecs by direct co-ordinate method and overall average velocity i.e 1.6264 m/s (Table 6.4). However considering the straight line which couldnot be followed due to the availability of adequate water for navigation of launch mounted with ADCP and Eco Sounder the projected discharge likely to be 14929.52 cumecs at cross section 2 of river Ganga i.e down stream of intake site.

FIGURE 6.58: BATHYMETRIC SURVEY AT CROSS SECTION 2 OF RIVER GANGA – DOWNSTREAM SITE

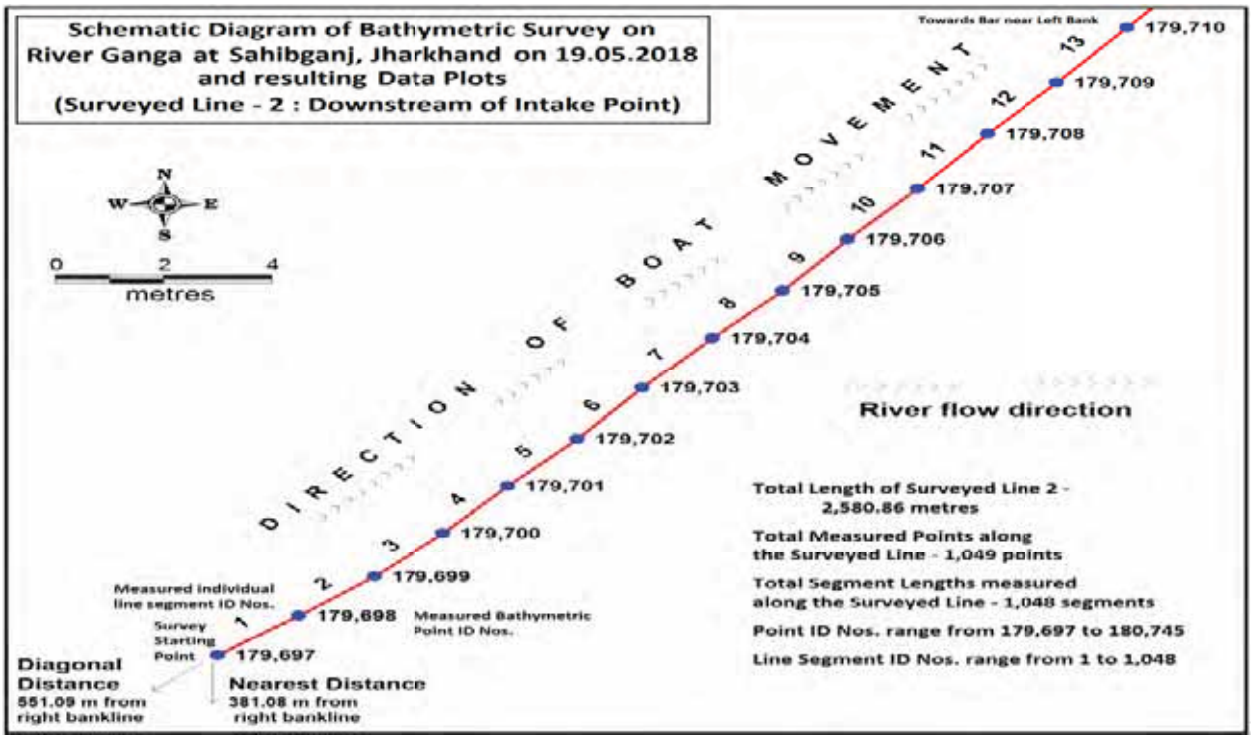


FIGURE 6.59: ZONATION FOR BATHYMETRIC SURVEY AT CROSS SECTION 2 OF RIVER GANGA – DOWNSTREAM SITE

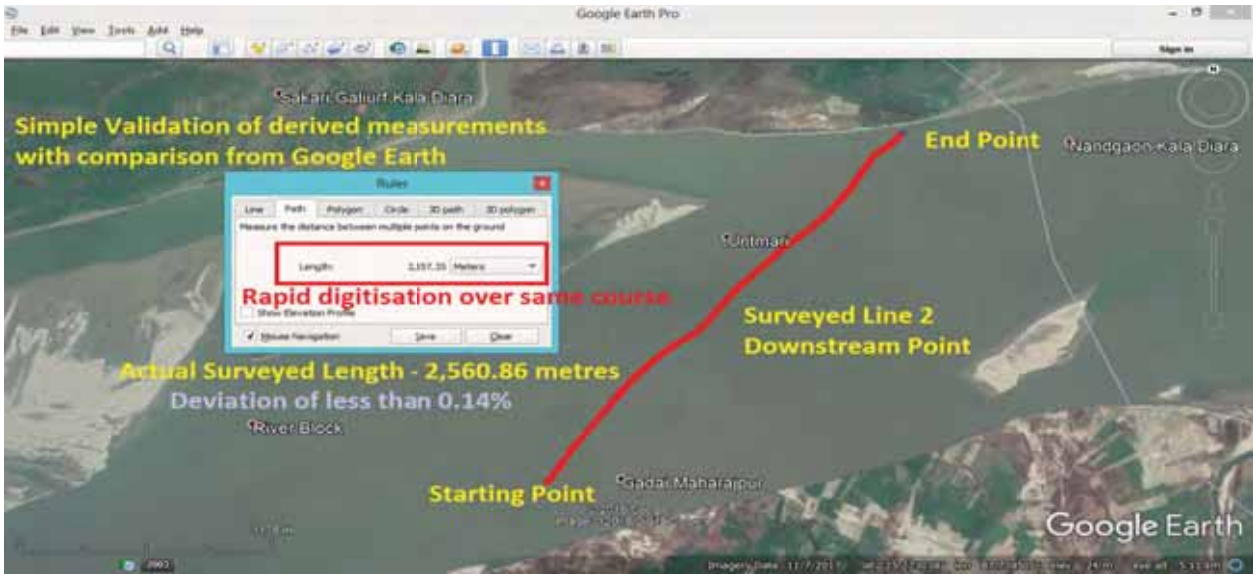


FIGURE 6.60: VALIDATION OF BATHYMETRIC SURVEY AT CROSS SECTION 2 OF RIVER GANGA – DOWNSTREAM SITE

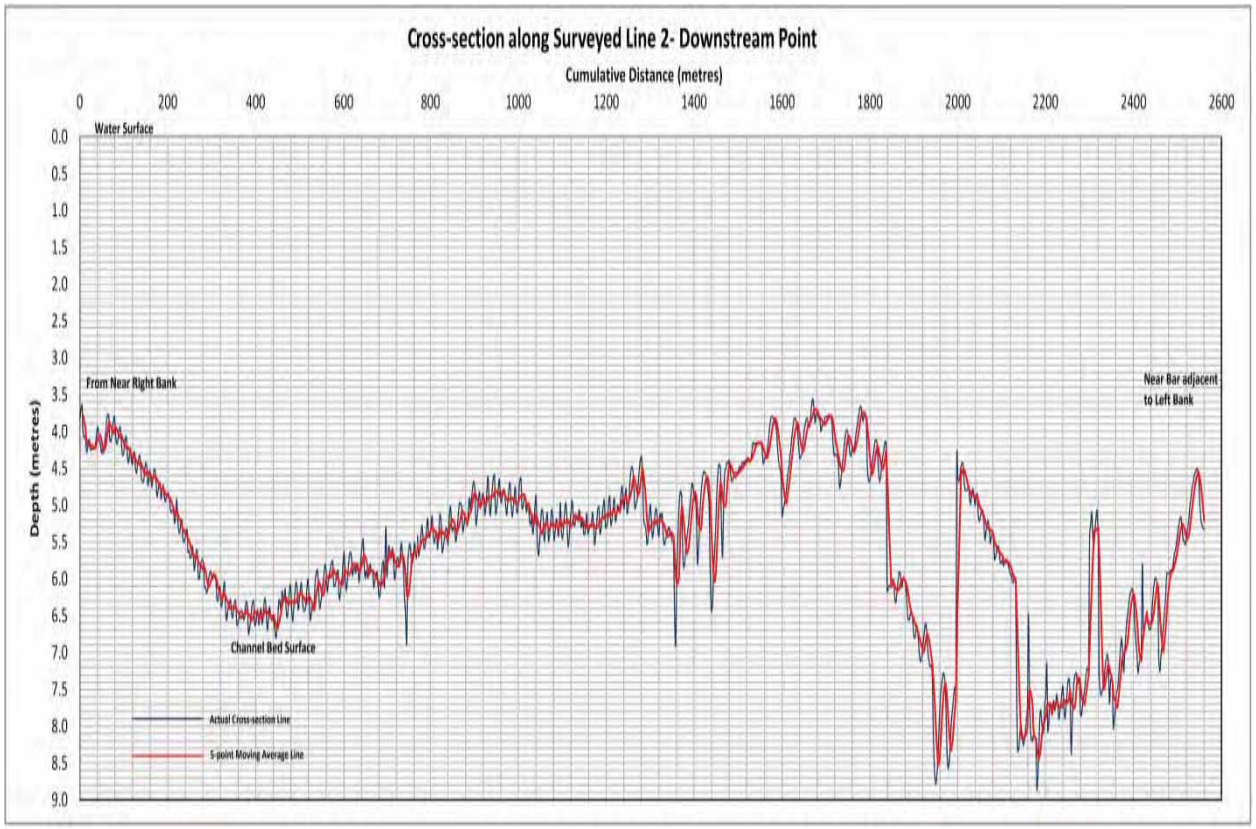


FIGURE 6.61: PROFILE OF WATER LEVEL AND DEPTH AT CROSS SECTION 2 OF RIVER GANGA – DOWNSTREAM SITE

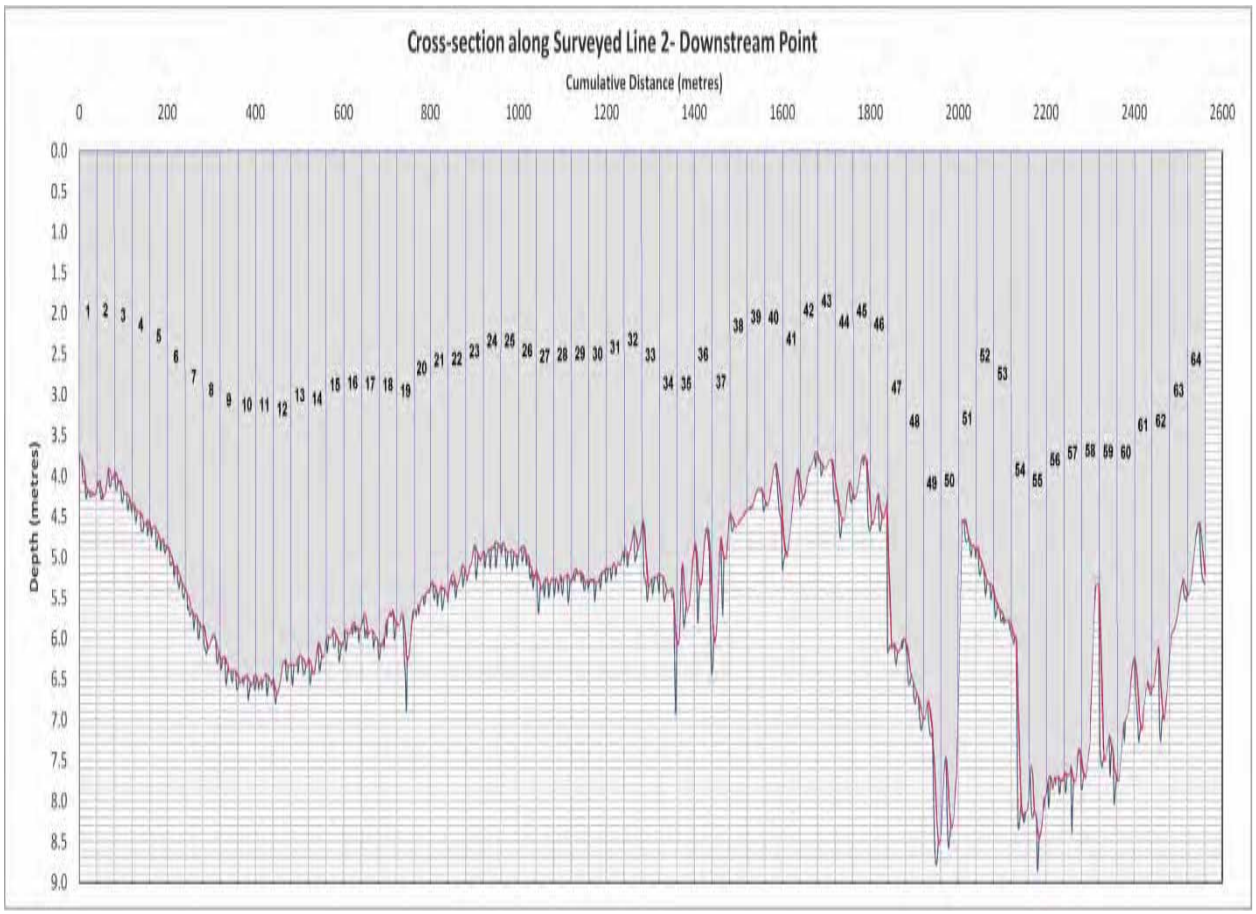


FIGURE 6.62: ZONEWISE PROFILE OF WATER LEVEL AND DEPTH AT CROSS SECTION 2 OF RIVER GANGA – DOWNSTREAM SITE

Bathmetric survey detail at cross section 3 of River Ganga i.e up stream site is presented in Figure 6.63 to 6.64. The estimated discharge at down stream site work out to be 6040.58 cumecs by Direct CS zone wise average velocity i.e 1.24665 m/s. Whereas the estimated discharge at intake site work out to be 5978.61 cumecs by direct co-ordinate method and overall average velocity i.e 1.3372 m/s (Table 6.5).

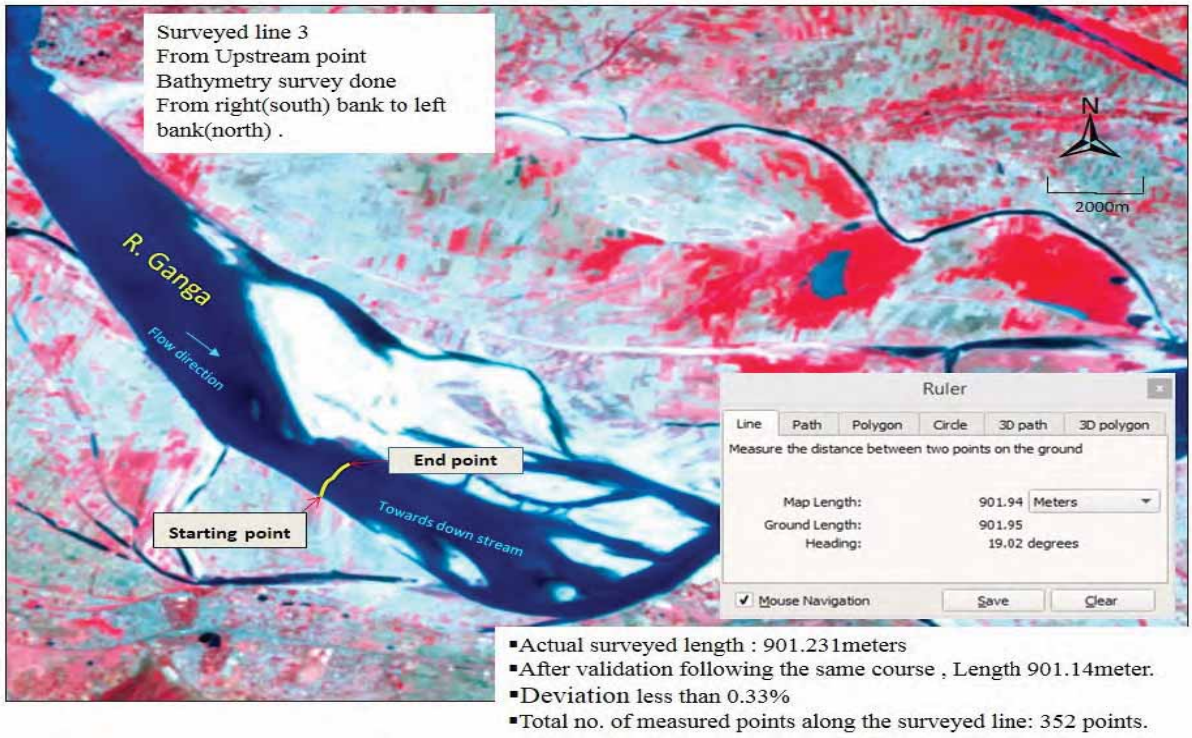


FIGURE 6.63: BATHYMETRIC SURVEY AT CROSS SECTION 3 OF RIVER GANGA – UPSTREAM SITE

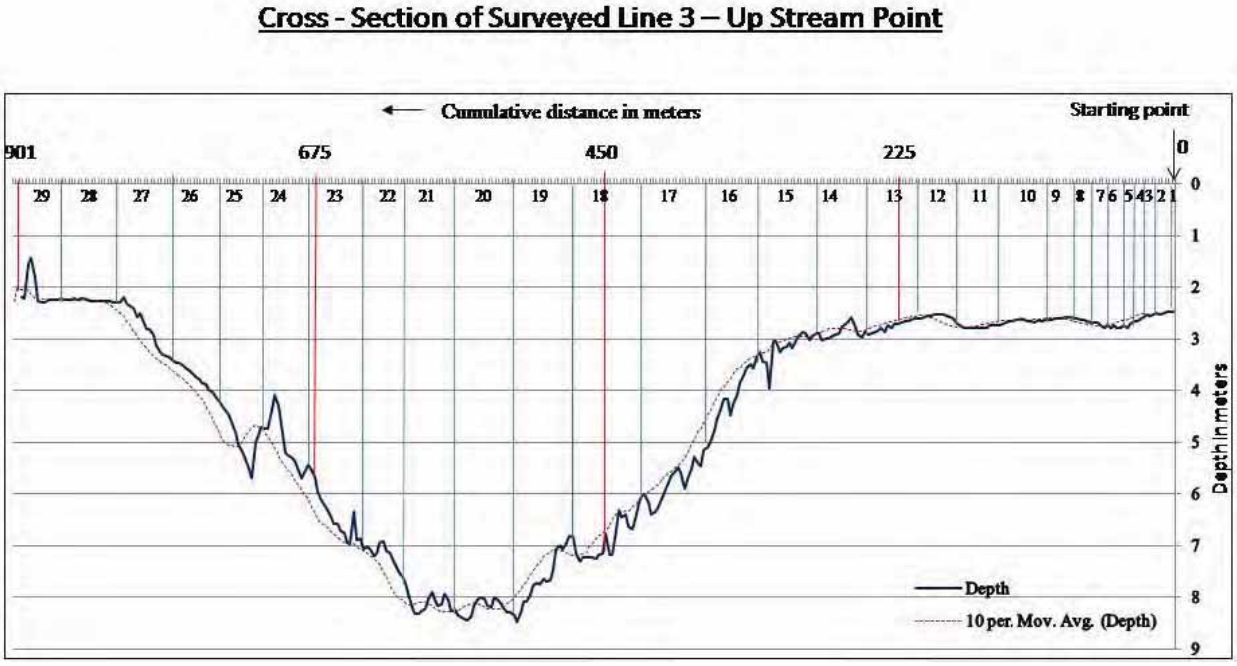


FIGURE 6.64: PROFILE OF WATER LEVEL AND DEPTH AT CROSS SECTION 3 OF RIVER GANGA – UPSTREAM SITE

TABLE 6.3: ESTIMATION OF DISCHARGE IN CUMECS FOR CROSS-SECTION 1 -INTAKE POINT

CS1_ZONE_ID	Area in m^2	Depth of Water in m	Avg Velocity of Water in m/sec	Discharge in cumecs
1	60.387794	3.463	0.5116	30.89439541
2	34.876	3.23	0.6496	22.6554496
3	618.236793	14.6259	0.6214	384.1723432
4	543.94416	17.8929	0.5175	281.4911028
5	453.647952	14.92263	0.5644	256.0389041
6	373.296924	13.4667	0.5332	199.0419199
7	290.6412585	10.11395	0.5466	158.8645119
8	105.261174	5.4738	0.4055	42.68340606
9	33.080919	2.0159	0.4143	13.70542474
10	233.1471189	2.32633	0.7215	168.2156463
11	330.1480182	3.2942	0.6585	217.40247
12	40.575249	3.9663	0.8637	35.04484256
13	87.2079225	4.01325	0.8325	72.60059548
14	81.5533419	3.75303	0.8305	67.73005045
15	36.545775	3.4575	0.8503	31.07487248
16	23.0104	2.935	0.5135	11.8158404
17	22.5792	2.88	0.4502	10.16515584
18	29.281882	2.681	0.3134	9.176941819
19	30.55206	2.723	0.4294	13.11905456
20	31.211796	2.9818	0.054	1.685436984
Estimated Discharge by Direct CS zone wise average velocity:				
	Total Area in square meter	**Avg Depth In m**	**Avg Velocity in m/s**	**Discharge in cumecs**
	3459.185738	**6.011**	**0.56408**	**2027.578365**
Estimated Discharge by Direct co-ordinate method and overall average velocity:				
	3521.9562	**6.011**	**0.5659**	**1993.075014**

About 0.15% difference between two methods used for estimation of water discharge.

TABLE 6.4: ESTIMATION OF DISCHARGE IN CUMECS FOR CROSS-SECTION 2 – DOWNSTREAM POINT

CS2_ZONE_ID	Area in m^2	Depth of Water in m	Avg Velocity of Water in m/sec	Discharge in cumecs
1	160.8444	4.08	1.2263	197.2355
2	162.1487	4.04	1.3488	218.7061
3	166.8329	4.19	1.5475	258.1739
4	178.0397	4.50	1.6416	292.2700
5	189.0687	4.76	1.7120	323.6856
6	204.7664	5.19	1.7502	358.3821
7	225.6187	5.69	1.7560	396.1864
8	237.3986	6.06	1.7668	419.4239
9	258.1527	6.38	1.7733	457.7693
10	257.5618	6.48	1.7490	450.4756
11	259.2002	6.49	1.7363	450.0363
12	258.5961	6.40	1.7498	452.4785
13	250.3458	6.27	1.7138	429.0301
14	246.4177	6.17	1.7290	426.0563
15	240.9108	5.99	1.7494	421.4494
16	235.5918	5.86	1.7433	410.6955
17	234.7150	5.89	1.7313	406.3504
18	231.7773	5.83	1.7533	406.3635
19	237.0582	5.85	1.7505	414.9705
20	217.8432	5.48	1.7714	385.8874
21	217.6121	5.38	1.7913	389.7978
22	208.8041	5.23	1.7690	369.3744
23	201.2081	4.97	1.7915	360.4643
24	191.9093	4.87	1.8003	345.4847
25	199.1603	4.93	1.7602	350.5620
26	198.5272	5.03	1.7843	354.2222
27	211.5397	5.28	1.7718	374.8130
28	212.2124	5.28	1.7428	369.8508
29	206.9372	5.21	1.7543	363.0367
30	209.7293	5.22	1.7205	360.8393
31	203.9503	5.05	1.7160	349.9787
32	191.0059	4.78	1.6962	323.9779
33	207.3378	5.18	1.7277	358.2106
34	214.5791	5.53	1.7465	374.7625
35	214.6809	5.25	1.7456	374.7470
36	196.7070	5.11	1.7375	341.7785

37	210.4511	4.98	1.7354	365.2169
38	179.1053	4.52	1.7330	310.3895
39	170.1160	4.25	1.7416	296.2741
40	166.1929	4.13	1.7512	291.0369
41	176.4121	4.39	1.7478	308.3330
42	157.0457	3.93	1.7458	274.1704
43	154.9838	3.89	1.7320	268.4320
44	172.8267	4.30	1.7240	297.9532
45	157.0689	4.04	1.7360	272.6716
46	172.5996	4.46	1.7706	305.6048
47	243.0454	6.07	1.7418	423.3365
48	261.2149	6.67	1.7458	456.0289
49	290.3742	7.54	1.7418	505.7737
50	313.6158	7.40	1.7402	545.7542
51	201.2915	4.74	1.7618	354.6354
52	204.4030	5.22	1.7586	359.4631
53	223.9204	5.73	1.7392	389.4423
54	290.4326	7.41	1.7572	510.3481
55	320.9286	8.02	1.7582	564.2460
56	306.7592	7.69	1.7516	537.3194
57	305.6403	7.59	1.7292	528.5132
58	267.4830	6.33	1.7298	462.6920
59	285.7144	7.45	1.7025	486.4287
60	279.6238	6.81	1.0750	300.5956
61	262.4190	6.72	0.6776	177.8151
62	258.7403	6.43	0.3954	102.3059
63	232.0942	5.56	0.1226	28.4547
64	192.6234	4.95	0.0754	14.5238
Estimated Discharge by Direct CS zone wise average velocity:				
	Total Area in m^2	**Avg Depth m**	**Avg Velocity in m/s**	**Discharge in cumecs**
	14195.9155	**5.55**	**1.6277**	**23075.2859**
Estimated Discharge by Direct co-ordinate method and overall average velocity:				
	14207.1301	**5.55**	**1.6264**	**23106.1496**

About 0.13% difference in results between the two methods used for estimation of water discharge

TABLE 6.5: ESTIMATION OF DISCHARGE IN CUMECS FOR CROSS SECTION 3 - UPSTREAM POINT

CS3_ZONE_ID	Area in m^2	Depth of Water in m	Avg Velocity of Water in m/sec	Discharge in cumecs
1	25.74886	2.632	0.420333	10.8231
2	40.22132	2.615	1.213667	48.81527
3	22.70742	2.63	1.534	34.83318
4	25.53786	2.7093	1.6055	41.00104
5	25.16057	2.7233	1.612167	40.56303
6	28.20358	2.5691	1.277133	36.01973
7	33.32789	2.7808	1.612167	53.73011
8	44.1489	2.823	1.6275	71.85233
9	37.09169	1.9758	1.599667	59.33435
10	119.6719	3.34195	1.596833	191.0961
11	107.9055	3.24245	1.595833	172.1992
12	181.3181	5.4885	1.6015	290.3809
13	211.4014	6.2	1.632167	345.0423
14	267.3747	6.8856	1.684167	450.3036
15	254.3199	5.1269	1.671333	425.0533
16	366.5194	7.96089	1.69	619.4177
17	385.1331	8.13375	1.671833	643.8783
18	400.8188	8.2473	1.668333	668.6993
19	409.8308	7.9619	1.401667	574.4462
20	281.136	6.05988	1.867333	524.9746
21	219.9395	6.469381	0.6565	144.3903
22	126.0722	4.2889	0.505	63.66647
23	195.6368	4.93285	0.3915	76.59182
24	144.7798	4.197124	0.689167	99.77741
25	124.324	3.47041	0.9655	120.0348
26	100.5652	2.5676	0.814	81.86006
27	123.1929	2.5215	0.8285	102.0653
28	90.41797	2.23486	0.3645	32.95735
29	47.24099	1.897	0.355	16.77055
Estimated Discharge by Direct CS zone wise average velocity:				
	Total Area in square meter	**Avg Depth m**	**Avg Velocity in m/s**	**Discharge in cumecs**
	4439.747	**4.300**	**1.246648**	**6040.578**
Estimated Discharge by Direct co-ordinate method and overall average velocity:				
	4470.798	**4.300**	**1.337257**	**5978.607**

About 0.12% difference between two methods used for estimation of water discharge

6.7 STATUS OF WATER QUALITY

The physio-chemical and bacteriological quality of water need to be assessed not only to estimate various treatment required for it ultimate use in TPP but it is also important to have detail s on presence of salts and nature of water (acidic or alkaline) which may have effect on intake well structure and equipments. The prime parameter includes pH, electrical conductivity, dissolve solids, suspended solids. Total hardness, sulphates, carbonates, bi-carbonates, chlorides, iron, calcium, magnesium, etc.

Accordingly, water quality of River Ganga at intake site along with upstream as well as the down stream was assessed. For the purpose 5 sampling location were selected as presented in Figure 6.65 and Table 6.6. The sample were collected and preserved for subsequent analyses using the standard methods. The prime parameters analyzed as per BIS 10500 Guidelines were analised to asses the quality of water at River Ganga in the intake project site. The major essential parameters includes, pH, Conductivity/TDS; TSS; Total Hardness; Ca hardness; Alkailinity; Chloride; Silica, Iron; Sulphate ; Phosphate; Nitrate; Bacterilogical Count- E-Coli; and Insecticides/ Pesticides. The status of water quality of River Ganga at intake site along with upstream as well as the down stream is presented in Table 6.7. Table 6.8 presents the status of Pesticide / Insecticides present in the water of River Ganga at intake site.

TABLE 6.6: DETAILS OF WATER SAMPLING LOCATION AT RIVER GANGA

S. No	Location id	Location	North Coordinates	East Coordinates	Date of Sampling	Remarks
1.	S-1	Intake well	25°14’36.52’’	87°41’18.02’’	6.05.2018	-
2.	S-2	Sakrigali	25°15 ’39.53’’	87°43’00.34’’	6.05.2018	Downstream
3.	S-3	Kanhaisthan	25°5 ’55.27’’	87°46’12.10’’	5.05.2018	Downstream
4.	S-4	Rajmahal	25°3’23.45’’	87°50’15.96’’	5.05.2018	Downstream
5.	S-5	Rampur	25°15 ’38.50’’	87°39’56.57’’	6.05.2018	Upstream

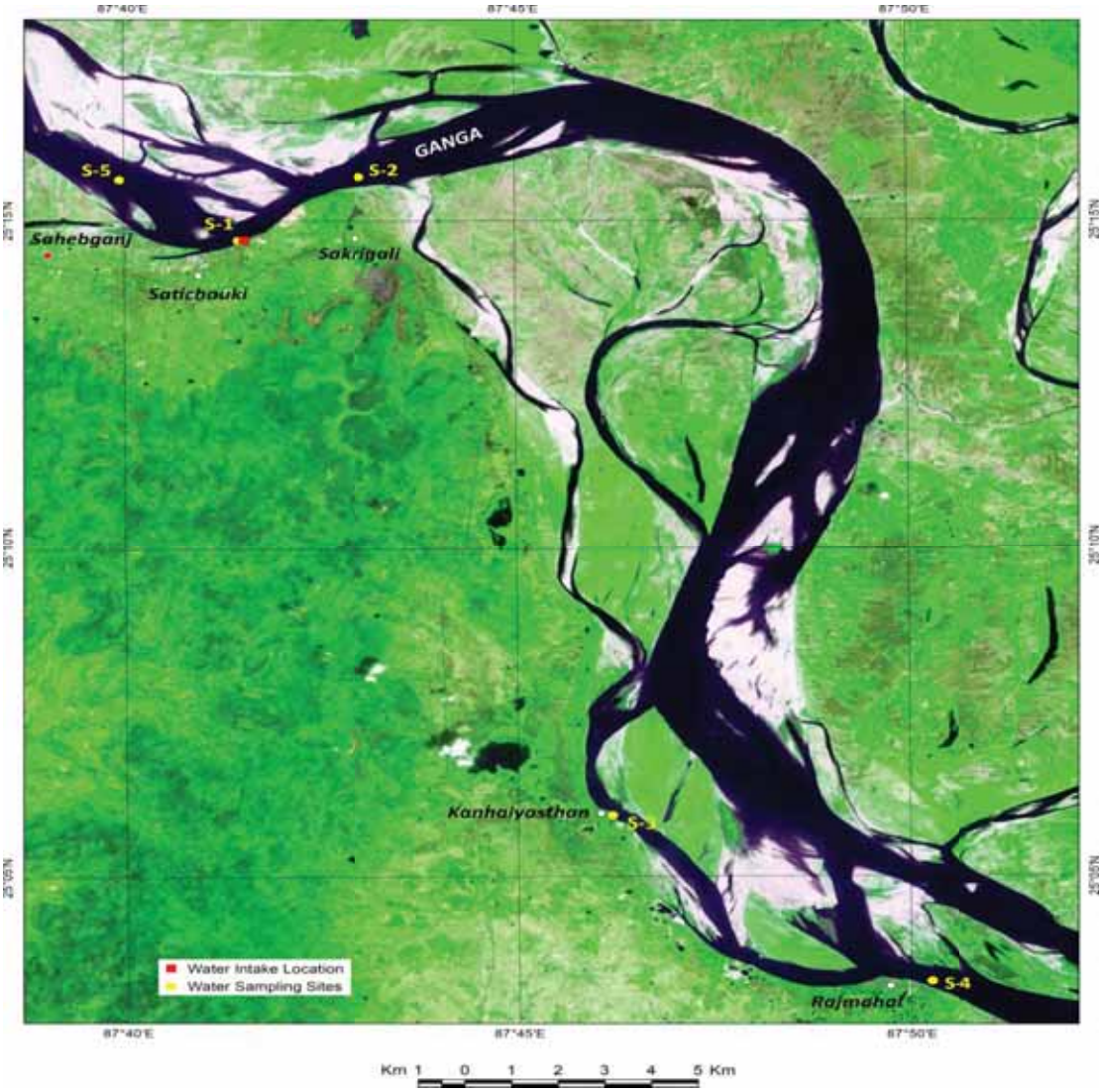


FIGURE 6.65: LOCATION OF WATER QUALITY SAMPLING STATIONS AT RIVER GANGA

TABLE 6.7: STATUS OF WATER QUALITY OF RIVER GANGA

Constituents	Acceptable Limit *	Results (mg/l)					Method
		Sample1 Intake well	Sample2 Sakarigali	Sample3 Kanhaisthan	Sample4 Rajmahal	Sample 5 Rampur	
Turbidity (NTU)	1	1.82	1.05	0.78	1.25	0.88	
Conductivity (um/s)	-	390	345	381	377	379	
Total Dissolved Solids(mg/l)	500	232	205	226	222	225	
Salinity (ppt)	-	0.17	0.15	0.16	0.16	0.16	
Aluminium (as Al), mg/l	0.03	ND	ND	ND	ND	ND	ICP-AES
Calcium (as Ca), mg/l	75	33.55	32.88	33.63	33.40	32.53	
Magnesium (as Mg),mg/l	30	19.78	18.97	19.21	19.06	18.75	
Iron (as Fe), mg/l	0.3	0.01	0.01	0.01	0.01	0.013	
Sodium (as Na) mg/l	-	19.71	19.32	19.22	19.17	19.47	
Potasium (as K),mg/l	-	2.95	2.86	2.96	2.99	3.03	
Phosphorous (as P) , mg/l	-	0.24	0.35	ND	0.36	0.06	
Total Chromium (as Cr), mg/l	0.05	ND	ND	ND	ND	ND	
Cadmium (as Cd), mg/l	0.003	ND	ND	ND	ND	ND	
Lead (as Pb), mg/l	0.01	0.06	0.05	0.05	0.05	0.05	
Zinc (as Zn) mg/l	5.0	ND	ND	ND	ND	ND	
Strontium (as Sr) mg/l	-	0.14	0.13	0.14	0.14	0.13	
Manganese (as Mn), mg/l	0.1	0.02	0.019	0.019	0.019	0.019	
Cooper (as Cu), mg/l	0.05	ND	ND	ND	ND	ND	
Nickel (as Ni), mg/l	0.02	0.02	0.01	0.01	0.01	0.01	
Selenium (as Si), mg/l	0.01	3.11	3.07	3.81	3.82	3.09	
Sulphur (as S), mg/l	-	3.11	3.07	3.81	3.82	3.09	
Arsenic (as As), ppb	10	3.5	4.0	4.2	4.1	3.5	AAS
Fluoride (as F), mg/l	1.0	0.16	0.14	0.14	0.24	0.18	IC-Metrohm
Chloride (as Cl), mg/l	250	13.84	12.09	13.57	13.97	13.73	
Bromide (as Br), mg/l	-	0.605	0.57	0.58	0.47	0.55	
Nitrate (as NO_3), mg/l	45	0.31	0.27	0.04	0.06	0.37	
Phosphate (as PO_4), mg/l	-	ND	0.10	0.04	ND	ND	
Sulphate (as SO_4), mg/l	200	30.66	24.48	29.71	29.71	31.10	
Biological Oxygen Demand (BOD), mg/l	-	<5	<5	<5	<5	<5	
Chemical Oxygen Demand (COD), mg/l	-	20	10	10	40	10	
Total Coliform Bacteria, MPN	-	240	240	40	95	13	

*** Acceptable Limit as per IS-10500: 2012; # ND: Not detected, BDL: Below detection limit**

TABLE 6.8: STATUS OF PESTICIDES / INSECTICIDES IN WATER OF RIVER GANGA

Sl. No.	Parameter	Unit	Concentration	(Drinking Water Standarad as per IS 10500:2012)
			Location: Water Inake well at River Ganga, Sahebgunj	
1.	Alachlor	µ g/L	<MRL	20
2.	Aldrin	µ g/L	0.0046	0.03
3.	Dieldrin	µ g/L	0.012	0.03
4.	Butachlor	µ g/L	<MRL	125
5.	Alpha-Endosulfan	µ g/L	0.0008*	0.4
6.	4-4,DDT	µ g/L	0.0002*	1.0
7.	Malathion	µ g/L	<MRL	190
8.	Parathion Methyl	µ g/L	<MRL	0.3
9.	Chlorpyrifos	µ g/L	0.002*	30
10.	Atrazine	µ g/L	<MRL	2
11.	Ethion	µ g/L	<MRL	3
12.	Monocrotophos	µ g/L	<MRL	1
13.	Phorate	µ g/L	<MRL	2

MRL=Minimum Reporting Limit (MRL for Alachlor = 1.0 µ g/L, Butachlor =0.25 µ g/L, Endosulphan Sulphate=0.002 µ g/L, Parathion Methyl = 0.5 µ g/L, Atrazine=0.5 µ g/L, Ethion=1.0 µ g/L, Monocrotophos =2.5 µ g/L, phorate=2.5 µ g/L).

The Parameters marked as *are reported as per direction of the customer though the value are below MRL.

6.8 SEDIMENT TRANSPORTATION

Water is proposed to be withdrawn primarily during monsoon period and during this period silt laden water of monsoon flow may cause damage to under water components of intake well system resulting in costly repair and maintence of equipment. The problem is more severe in River Ganga which carry lot of sediment containing quartz during monsoon. Table 6.9 presents status of silt load of river Ganga near intake site.

Hence, the characteristics of sediment i.e. size, shape, hardness and concentration, which are site specific has to be assessed. Sediment sampling at intake site for concentration, sieve analysis and petro-graphic analysis (for mineral composition and shape) is essential for assessing their possible removal.

TABLE 6.9: MONTHLY AVERAGE SILT LOAD (TONES/DAY) OF RIVER GANGA

Year	June	July	August	September	October	November	December	January	February	March	April	May
2006-2007	78396	604327	1481535	1888275	432650	97295	51633	29975	30112	31946	30712	30269
2007-2008	49242	524445	2373302	1959374	952594	152158	61116	33765	29379	18995	17204	20210
2008-2009	158989	1E+06	2510986	1388729	579639	112797	56395	33034	32497	22184	19904	22410
2009-2010	26073	108877	669782	657932	416429	119195	51042	25322	28190	16510	16101	17584
2010-2011	21872	197130	797655	2364425	594299	129878	62219	34221	24903	22013	22013	25161
2011-2012	-	-	-	-	-	-	-	-	-	-	-	-
2012-2013	-	-	-	-	-	-	-	-	-	-	-	-
2013-2014	-	-	-	-	-	-	-	-	-	-	-	-
2014-2015	-	-	-	-	-	-	-	-	-	-	-	-
2015-2016	57139	251890	611700	351923	67197	39391	34328	16473	17408	12677	14892	19706

Source: CWC, Patna

P16: Bathymetry Survey Team Members at Proposed Intake Site of GTPP at River Ganga

P17: Mounting of ADCP and Eco-Sounder for Bathymetry Survay at Proposed Water Intake Site of GTPP

P18: Bathymetry Survey Using ADCP and Eco-Sounder at Proposed Water Intake Site of GTPP

7.0 ECOLOGICAL IMPACT ASSESSMENT

7.1 ECOLOGICAL IMPACT ASSESSMENT

The river Ganga and its tributaries are home to a wide variety of aquatic biota (microscopic flora and fauna to higher invertebrates, vertebrates and plants). The status of flora and fauna of River Ganga and its riparian zones have been documented over past few decades (Bilgrami and Dutta Munshi, 1985; Sinha, 2014; GRBMP, 2015). The overall biological profile of River Ganga is shown in Figure 7.1.

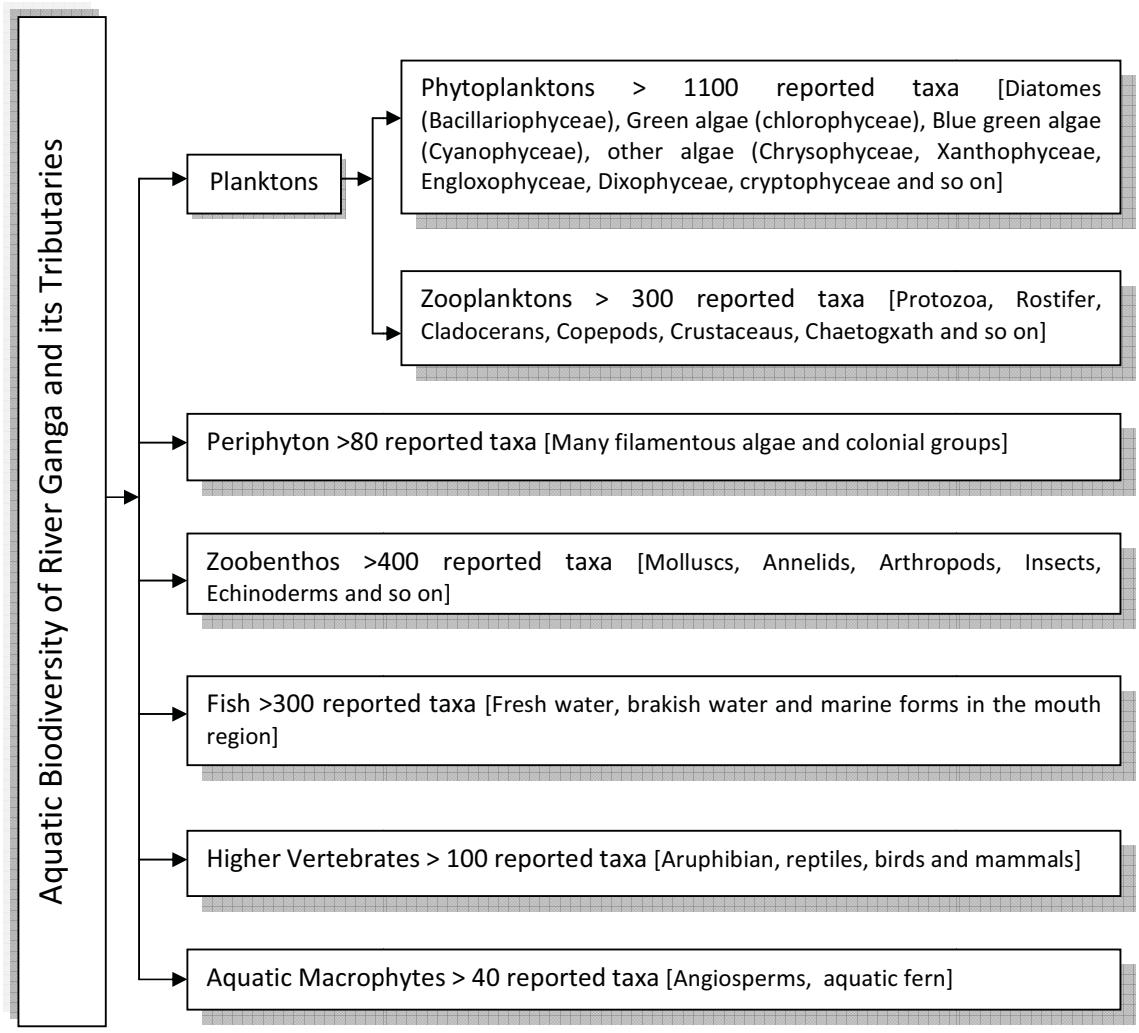


FIGURE 7.1: AQUATIC BIODIVERSITY OF RIVER GANGA AND ITS TRIBUTARIES

The Ganga river basin receives around one million cubic meter of water per square km annually. Out of this, 50% is available to surface flow, 30% is lost through evapo-transpiration and the rest is lost through groundwater seepage. Annual flow is around 468.7 x 10^9 m^3 which is equivalent to 25.2% of India's total water resources. Annual mean discharge rate of the River is 18.7 x 10^3 per second (Singh, 1996; Welcomme, 1985; Sinha, 2014).

The present study was undertaken to understand the likely ecological impact of 36 MCM water withdrawl from river Ganga at Sahebganj area of Jharkhand State for operation of proposed Godda Thermal Power plant.

The aquatic biodiversity of River Ganga is unique and categories in three major regions namely upper reach (mountain region), middle reach (Gangetic flood plain) and lower reach (flood plain to estuarine zone). The present study confined in middle reach covering 10 km upstream and 10 - 15 km downstream of proposed water intake point near Sahebgunj township of Jharkhand State.

7.2 ECOLOGICAL SAMPLING TECHNIQUES

The field survey was undertaken in premonsoon period (May, 2018). During field survey sampling locations are identified and fish landing stations are also visited along the river course of study area. For plankton study, five locations were selected include the site for proposed water intake point of Godda TPP (Figure 7.2). With the help of mechanised vessel, water sample of mid river streams was collected (at a depth of 0.5 – 1.0 meter) and filtered through plankton net (mesh 40 nm). At each sampling location 100 lit river water was filtered and samples were collected and preserved. The samples were brought to laboratory for microscopic study to ascertain the taxa. Periphytons were collected at random at river banks. Zoobenthios and other macro flora/fauna were examined along the study stretch and also at fish landing zones. The aquatic macrophytes and riparian vegetation composition were also recorded during field survey.

7.3 STATUS OF AQUATIC FLORA & FAUNA

The biotic distribution in river Ganga as revealed in the present study are summarised below:

(a) **Phytoplanktonic (algal) flora:** Though in the past over 100 species of phytoplanktons were recorded in the year long survey in around 500 km river stretch, in the present study it was revealed that a good amount of fresh water phytoplanktonic biota bloom in premonsoon period. The phytoplankton diversity and their load is given in Table 7.1. By and large the summer (premonsoon) bloom algal dominated by blue green algae and diatoms though the green algal diversity is more (Figure 7.3).

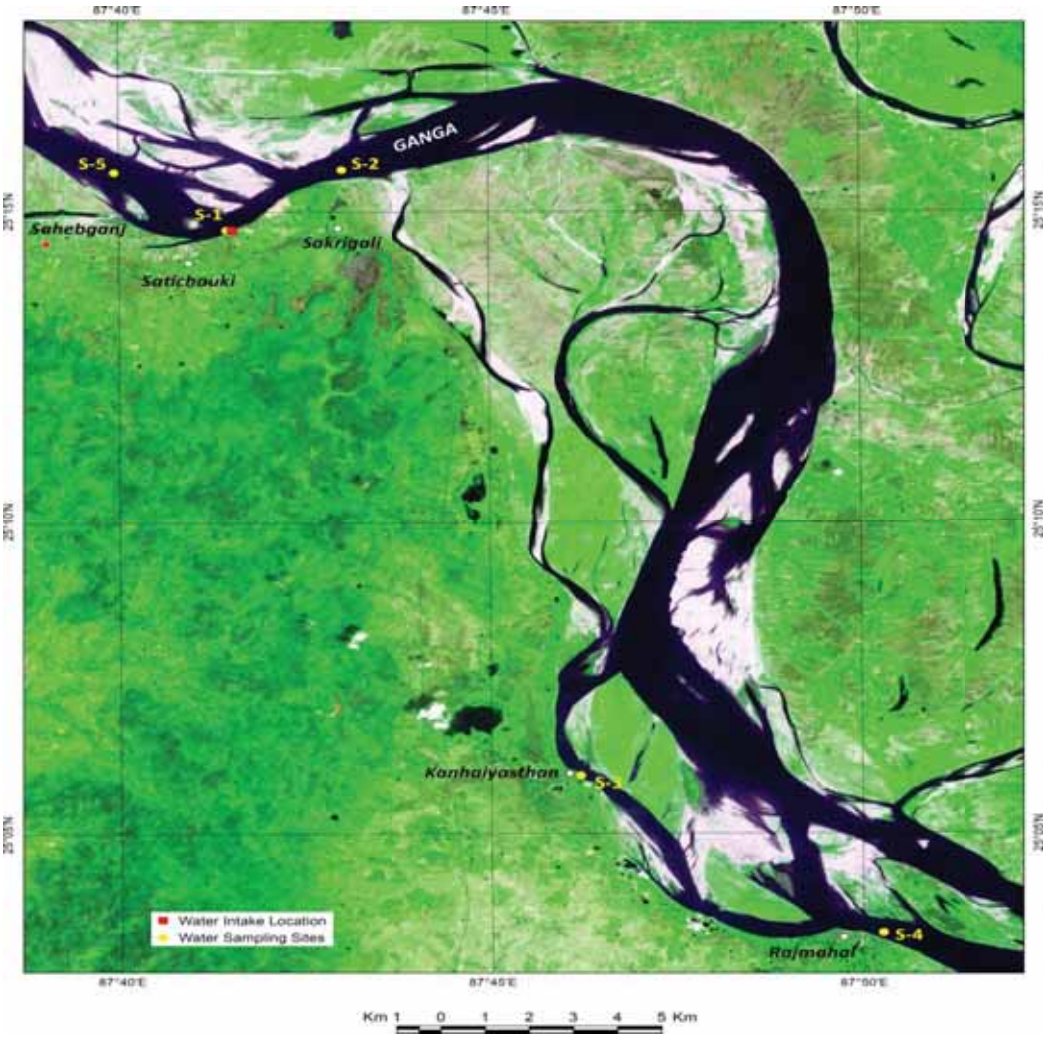


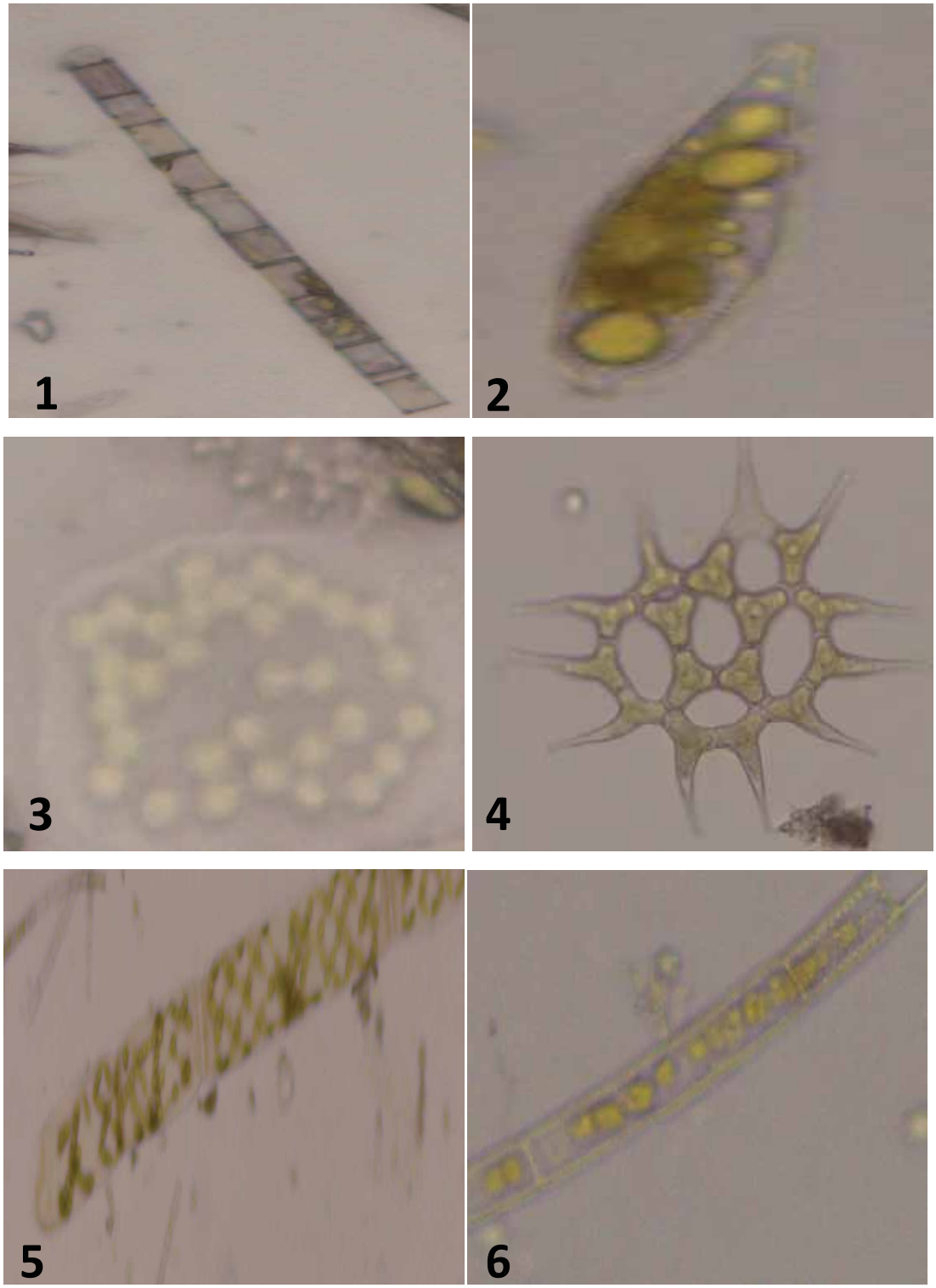
FIGURE 7.2: LOCATION OF ECOLOGICAL SAMPLING STATIONS AT RIVER GANGA

TABLE 7.1: PHYTOPLANKTON DISTRIBUTION IN VARIOUS SAMPLING LOCATIONS

Phytoplankton			Locations of Sampling (With Load unit number per lit)				
			1	2 (D/s)	3 (D/s)	4 (D/s)	5 (U/s)
I	Green Algae (Chlorophyceae):						
	(i)	*Axkistrodesmus* sp.	10	-	10	10	10
	(ii)	*Actinastrum* sp.	-	10	-	10	10
	(iii)	*Pediastrum* sp.	10	10	-	-	-
	(iv)	*Scenedesmus* sp.	20	10	10	-	10
	(v)	*Coelastrum* sp.	-	-	10	10	-
	(vi)	*Spirogyra* sp.	30	30	40	30	40
	(vii)	*Zygnema* sp.	20	40	20	20	30
II	Diatoms (Bacillariophyceae):						
	(i)	*Cymbella* sp.	20	-	10	10	10
	(ii)	*Cyclotella* sp.	10	10	10	10	-
	(iii)	*Fragilaria* sp.	30	40	20	30	40
	(iv)	*Melosira* sp.	40	20	30	20	30
III	Blue Green Algae (Cytenophyceae):						
	(i)	*Microcystis* sp.	80	60	40	50	80
	(ii)	*Anabaena* sp.	10	10	10	-	10
	(iii)	*Merismopedia* sp.	20	-	20	10	20
	(iv)	*Lyngbya* sp.	10	10	-	10	10
	(v)	*Oscillatoria* sp.	30	20	30	20	30
IV	Euglenoids (Euglenophyceae):						
	(i)	*Euglena* sp.	10	-	10	10	10

D/s: Downstream to water intake point; U/s: Upstream to water intake point

[Sampling Location-1 (Satichowki-water intake point proposed); Location-2 (Opposite Sakrigali village); Location-3 (Kanaiathan); Location-4 (Rajmahal Ghat) and Location -5 (Opposite Rampur Village)]



1.*Melosira* sp.; 2. *Euglena* sp.; 3. *Microcystis* sp.; 4. *Pediastrum sp.*; 5, *Spirogyra sp.* 6. *Zygnema sp.*

FIGURE 7.3: VIEW OF SELECTED PHYTOPLANKTON AT RIVER GANGA

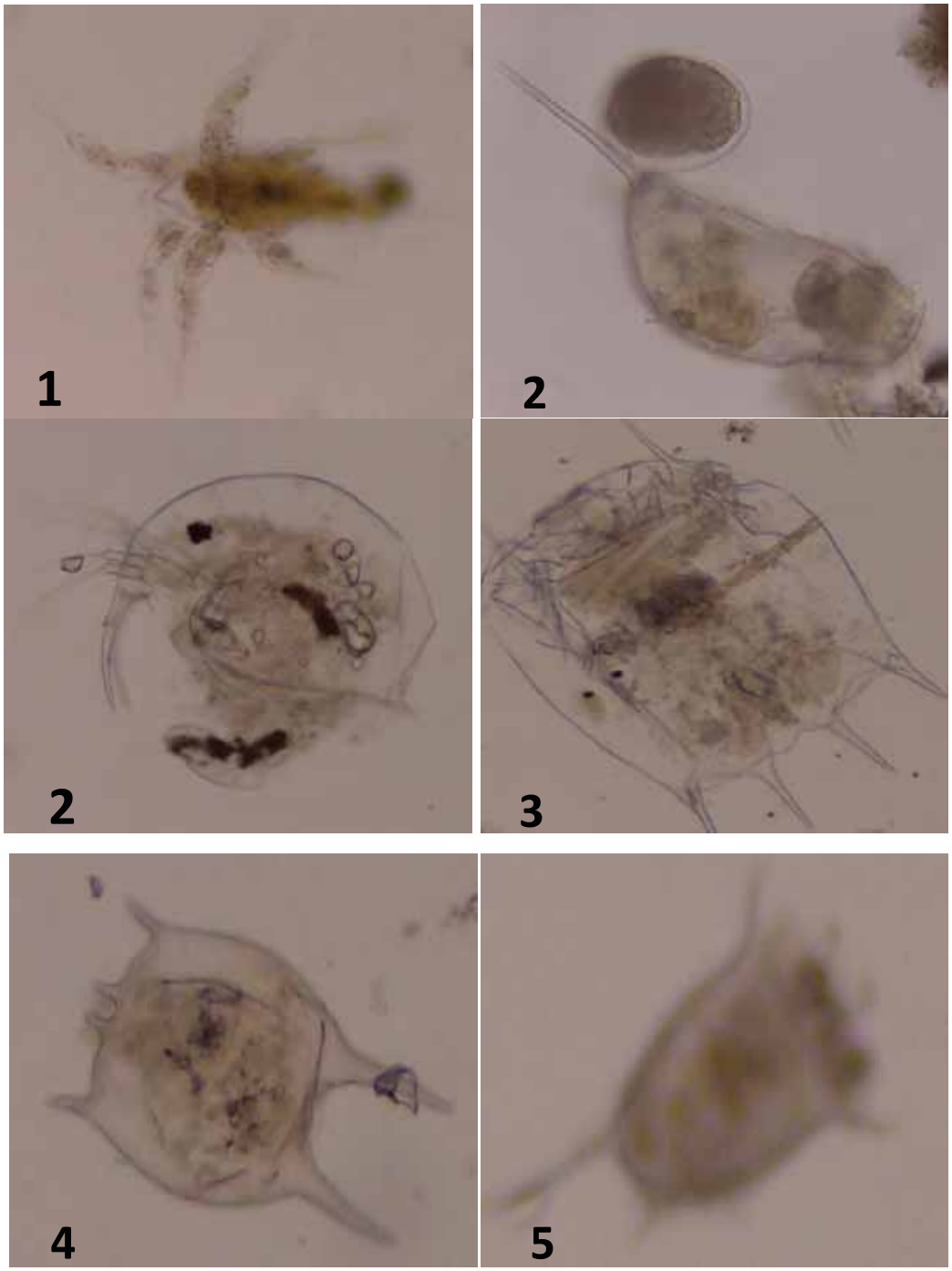
(b) **Zooplankton:** The major zooplanktons are belong to rotifers, cladocerans and copepods. In the present study, rotifer diversity is lesser than cladocera and copepoda. The zooplankton diversity and their load is given in Table 7.2. Figure 7.4 presents signature of selected zooplankton at River Ganga.

TABLE 7.2: ZOOPLANKTON DISTRIBUTION IN VARIOUS SAMPLING LOCATIONS

Zooplankton			Locations of Sampling (With Load unit number per lit)				
			1	2 (D/s)	3 (D/s)	4 (D/s)	5 (U/s)
I	Rotifer:						
	(i)	*Brachionu* sp.	20	10	10	10	20
	(ii)	*Keratella* sp.	10	20	10	20	20
II	Cladocera:						
	(i)	*Bosmina* sp.	10	10	10	10	20
	(ii)	*Moina* sp.	-	10	10	-	10
	(iii)	*Diaphanosoma* sp.	10	-	-	10	10
III	Copepoda:						
	(i)	*Diaptomus* sp.	20	10	10	-	20
	(ii)	*Cyclops* sp.	10	20	-	10	-
	(iii)	*Nauplius* sp.	10	10	10	10	10
	(iv)	*Mesocyclops* sp.	20	10	10	10	10

D/s: Downstream to water intake point; U/s: Upstream to water intake point.

[Location-1(Satichowki-water intake point proposed); Location-2 (Opposite Sakrigali village); Location-3 (Kanaiasthan); Location-4 (Rajmahal Ghat) and Location -5 (Opposite of Rampur Village)]



1. Nauplius sp. , 2. Daphnia sp.; 3 & 4. Brachionus sp.; 5. Keratella sp.

FIGURE 7.4: VIEW OF SELECTED ZOOPLANKTON AT RIVER GANGA

Species Diversity Index: Species Diversity, which measures the bio-diversity and heterogeneity of aquatic ecosystem, was calculated based on the Shanon Weiner's function as follows:

$H = \text{—} \quad {}_2{}^{(n_i / n)}$

Where ,

H= Species Diversity
n_i = Number of individuals of each species in sample
n= Total number of individuals of all species in the sample

As species diversity of a community got two components : (i) species richness, and (ii) species evenness, to calculate evenness Pielou's Index was used.

Pielou's Index of equitability (E): $E = {}^{H}/_{Hmax}$

Where ,

E=Equitability Index (Range 0-1)
H= Observed Species Diversity
H_{max} = Maximum species diversity = Log_2 S
S= Total number of species in the community

The species diversity index and equitability index for phytoplanktons and zooplanktons at the study area is presented in Table 7.3 to 7.6. The analysis reveals that the phytoplankton diversity ranges from 3.27-3.59 whereas the equitability index ranges from 0.80 to 0.88.

The analysis further reveals that the zooplankton diversity ranges from 2.75 to 2.92 whereas the equitability index ranges from 0.87 to 0.92.

TABLE 7.3: SHANON WEINER'S SPECIES DIVERSITY INDEX FOR PHYTOPLANKTONS

S. No	Location ID	Location	North Coordinates	East Coordinates	Diversity Index	Remarks
1.	S-1	Satichauki Khutari	25°14'36.52''	87°41'18.02''	3.57	Intake Point
2.	S-2	Sakrigali	25°15 '39.53''	87°43'00.34''	3.27	Downstream of Intake Point
3.	S-3	Kanhaisthan	25°5 '55.27''	87°46'12.10''	3.59	Do
4.	S-4	Rajmahal	25°3'23.45''	87°50'15.96''	3.56	Do
5.	S-5	Rampur	25°15 '38.50''	87°39'56.57''	3.44	Upstream of Intake Point

TABLE 7.4: PIELOU'S INDEX OF EQUITABILITY FOR PHYTOPLANKTONS

S. No	Location	North Coordinates	East Coordinates	Equitability Index	Remarks
1.	Satichauki Khutari	25°14'36.52''	87°41'18.02''	0.87	Intake Point
2.	Sakrigali	25°15 '39.53''	87°43'00.34''	0.80	Downstream of Intake Point
3.	Kanhaisthan	25°5 '55.27''	87°46'12.10''	0.88	Do
4.	Rajmahal	25°3'23.45''	87°50'15.96''	0.87	Do
5.	Rampur	25°15 '38.50''	87°39'56.57''	0.84	Upstream of Intake Point

TABLE 7.5: SHANON WEINER'S SPECIES DIVERSITY INDEX FOR ZOOPLANKTON

S. No	Location	North Coordinates	East Coordinates	Diversity Index	Remarks
1.	Satichauki Khutari	25°14'36.52''	87°41'18.02''	2.90	Intake Point
2.	Sakrigali	25°15 '39.53''	87°43'00.34''	2.92	Downstream of Intake Point
3.	Kanhaisthan	25°5 '55.27''	87°46'12.10''	2.81	Do
4.	Rajmahal	25°3'23.45''	87°50'15.96''	2.75	Do
5.	Rampur	25°15 '38.50''	87°39'56.57''	2.90	Upstream of Intake Point

TABLE 7.6: PIELOU'S INDEX OF EQUITABILITY FOR ZOOPLANKTON

S. No	Location	North Coordinates	East Coordinates	Euitability Index	Remarks
1.	Satichauki Khutari	25°14'36.52''	87°41'18.02''	0.92	Intake Point
2.	Sakrigali	25°15 '39.53''	87°43'00.34''	0.92	Downstream of Intake Point
3.	Kanhaisthan	25°5 '55.27''	87°46'12.10''	0.89	Do
4.	Rajmahal	25°3'23.45''	87°50'15.96''	0.87	Do
5.	Rampur	25°15 '38.50''	87°39'56.57''	0.92	Upstream of Intake Point

(c) **Periphyton:** A number of filamentous algae exists as periphyton in river stretch. Only a few representative samples were collected and they belong to green and blue green algae. The dominant species were *Spirogyra*, *Zygnema*, *Mouzotia*, *Oedogonium* of green algae and *Oscillatoria*, *Lyngbra*, *Phormidium*, *Nostoc*, *Anabaena* of blue green algae.

(d) **Zoobenthos:** The dominant zoobenthos were polychaetes, oligochaetes, leech, crustacea, insects, gastropods and bivalves. Some important spectes were *Pheretinea* sp (Earthworm); *Macrobrachium melcomsoni*, *M. laperi* (Prawn); *Corixa* sp. (Hemiphera), *Pila globosa*, *Lymnaea* sp., *Digonistoma* sp., *Corbiula* sp., *Scaphula* sp. and *Novoculina* sp. of Gastropods.

(e) **Fish:** The river Ganga supports over 350 fish species of which around 34 included as Indian major carp (*Labeo rohita* (Rahu), *Catla catla* (Catla), *Cirrhinus mrigala* (Mrigal), *Labeo calbasu* (Calbose), large catfishes (*Aorichthys aor*, *A. seenghala*, *Wallago attu*, *Bagarius bagarius*), featherbacks (*Notopterus netopters*, *N. chittala*) and murrels (*Channa marulius*, *C. punctatus*) etc. In addition the river stretch also rich in diverse cyprimids and silurids viz., *Puntius chola*, *P. sarana*, *P. sophore*, *P. ticto*, *Oxygaster bacaila*, *Mystus aor*, *M. vittatus*, *Orupok pado* and *Pangasius pangasius* etc. Hilsa (*Tennualosa ilisha*) occassionally reported to available in monsoon period. Fish landing in the middle stretch of river Ganga decline sharply both qualitatively and quantitatively after creation of Farakka barrage (1975).

(f) **Higher vertebrates:** Among the reptiles, hard and soft shell turtles, Gharial (*Gavialis gangeticus*), water snakes and monitor lizards, etc were report to exist in river Ganga basin. But during our field study we have not seen any of them.

Identically, among the avifauna 162 species are reported to exit in Buxar to Mauiharighat, Katihar. However, during over survey we have noticed the common Herons (viz., *Ardea cinerea rectirostris*, *A. purpurea manilensis*), Egrates (*Egretta alba modesta*), Goose (*Anser anser rubri*, *Anser indicus*), whistling duck (*Dendroggna javanica*), Vulture (*Gyps bengalensis*), Kite (*Milvus migrans*), crane (*Grus grus*), Snipe (*Syphoetides indca*), Green sandpiper (*Tringa ochropus*), common snipe (*capellogallinago gallinago*) and Indian skimmer (*Rynchops albicollis*) and so on.

Amphibian like *Rana limnocharis* and *Rana tigerina* were also exists in river adjoining swamp zone.

One of the most rare, endemic, eudangered and truly charismatic mammals of the river Ganga is the Gangetic dolphin (*Platanista gangetica gangetica*). Over 3500 individuals have been reported in Ganga Brahmaputra river systems. The best sighting location of river dolphin is the middle stretch of Ganga. During our survey, we have noticed around 8 dolphin within the river stretch of 30 kms. Blue bulls, jackels and wild boars are still surviving the sand char to scrub vegetation area.

(g) **Aquatic macrophytes and ther riparian vegetation cover:** A good number of aquatic macrophytes, ferns and riparian vegetation cover were noticed along the river course of study area. They are identified as follows: Water hyacynth (*Eichhornia crassipes*, *Vallisneria sp.*, *Hydrilla verticillata*, *Ceratopteris* sp., *Marsilea quadrifolia*, *Azolla pinnata*, *Ranunculus sceleratus*, *Ipomea aquatica*, *Scirpus articulatus*, *Hygrorhiza aristata*, *Cyperus rotundus*, *Saccharum* sp., *Lemna* sp., *Aponogeton* sp., *Potamogeton* sp., *Ottelia* sp., *Sagittaria sagittifolia* and *Ceraphyllum demersum*.

7.4 ECOLOGICAL IMPACT

There are many factors which may affect the ecological integrity of river Ganga of which anthropogenic activities along the river Ganga is of the prime concern. These causatives are of major concern today with respect to threat of aquatic biodiversity of river Ganga. The some of the major causes includes habitat fragmentation, shrinkage , alteration, Invasion by Alien Species, encroachment, disturbances and malnutrition, etc.

There are multiples causes of habitat alteration viz., river pollution, changing river geomorphology, etc. The high levels of pollutants in the river have their own fatal effects on river biota.

Exotic species like *Cyprirus* carp, filapia, thaimagur, grass carp, brown front influenced very much on riverian biotic distribution. Many such exotic species consume the native wild spcies as food or spread the parasiic diseases.

Since longtime human beings have been encroaching upon river especially by occupying much of the flood plains and parts of river banks for various purposes. In adition, the increased constructions on flood plains have led to altered run off pattern into rivers, increased pollution inflows with runoff, reduced ground water recharge and hence decreased base flows in rivers and curtailed ecological linkages between the river, its flood plains and flood plain wetlands. On the other hand, river bed farming together with modern chemical pesticides such as DDT and HCH, have polluted the river bed, thus affecting the health of the aquatic creatures (especially the hyporpheic biota) and disturbing the breeding sites of higher aquatic animals.

During the field survey it was observed that massive river bed farming of crops and vegetables with pesticides and fertilizer and anthropogenic changes of river connectivity with wetland like Udhuwa wildlife cum bird sanctuary located in the east of Rajmahal towards Farkka.

Frequent disturbances of the Ganga river habitat by anthropogenic activities like intensive fishing, frequent shipping and waste disposal from municipal/township area and so on, often possess serious concern on survibility and population growth of aquatic biota of river.

Eutrophication of river either by inorganic pollutant/organic pollutants lead to loss of riverine biodiversity. Sometimes some essential micronutrients may not be available in river for proper bloom of plankton thus affecting riverian ecosystem food chain.

Based on the above threat assesment, the following essential actions are envisaged to restore the ecological balance of the River Ganga:

(a) Restoration of longitudinal connectivity along with maintenance of environmental flows and sediments throughout the Ganga river network;

(b) Maintenance of lateral and vertical connectivity across rivers and flood plains is also needed to provide breeding sites of fish and other aquatic/amphibious animas and plants as well as the periodic exchange of river biota with flood plain wetlands;

(c) Restoration of unpolluted flow in the river by appropriate measures to control anthropogenic pollution as envisaged under Mission Nirmal Dhara;

(d) Restrictions on anthropogenic alterations of river morphology by gravel and sand mining as well as by river bed and river bank modifications by structural measures;

(e) Elimination of alien invasive spcies from the Ganga river network and establishing norms to prevent future introductions of exotic species.

As the water availability at proposed intake site is very high, the water abstraction of only 36 MCM/year from river Ganga at Satichouki mouza near Sahebganj for proposed Godda Thermal Power Plant (2 x 800 MW) is not likely to have any significant ecological impact. However, it may have some ecological impact in the form of habitat shrinkage and alteration. To combat/compensate the habitat shrinkage sand bars which were formed on the river bed need to be dredged in a periodic interval.

Ganga canal near Sahebgunj township (which has gradually silted out) requires immediate excavation through massive dredging or otherways so that habitats space for aquatic biota including Gangetic dolphin and navigability of the river could be enhanced.

As a long term management options for reduction of river water abstraction by the power plant authority, water runoff facility of proposed midway water storage place (Simik talau, near Karmatola station) should be excavated with appropriate drainage linkage from the neighbouring area. Appropriate water audit in power plant and dry ash disposal system can be explored.

P19: Plankton Sampling at Proposed Intake Site of GTPP at River Ganga

P20: Plankton Sampling at D/S of Proposed Water Intake Site of GTPP

P21: Observation of Fish Catch Near Proposed Water Intake Site of GTPP

8.0 SOCIO-ECONOMIC PROFILE

To assess the socio economic profile the villages falling within 2 km distance along with both the bank of the river Ganga in down stream up to Farakka Barrage have been identified using 2011 census atlas and the list of the same is presented in Annexure 8.1. The demographic profile of these villages along with the downstream of the river Ganga, on both the right and left side bank falling in the districts of Sahibganj in Jharkhand; and Maldah in West Bengal as well as the land use pattern and irrigation facilities have been extracted using the latest census data i.e 2011 and other documents of Department of Water Resource and Irrigation, Government of Jharkhand and have been analysised to assess the existing water usage pattern and livelihood dependency on river Ganga at down stream upto the nearest next barrage from proposed intake location i.e Farakka Barrage. For public consultation to identify and asses the dependency of the local people on river Ganga and likely impact caused due to drawl of water for Godda TPP the questionnaire has been developed and used were used for the purpose (Annexure 8.2).

8.1 DEMOGRAPHIC PROFILE

The villages at the downstream reach of river Ganga lies in Sahibganj, Taljhari, Rajmahal, Borio, Udhwa and Barharwa block of Sahibganj district in Jharkhand and Ratua I, Kaliachak II, Kaliachak III and Manikchak block of Maldah district in West Bengal. The Block-wise demographic profile of the population in the area under influence of the project is attached in the Annexure 8.3.

In total 225 villages lies in this zone. Of these only 158 villages are inhabited. In the district of Sahibganj only 102 villages are inhabited out of the total 140 villages. Whereas, in the district of Maldah, only 56 villages are inhabited out of the total 85 villages lying within 2 km distance from the Ganga river bank on either side. The detail of down stream villages falling under the river reach of Ganga are represented in Table 8.1. Figure 8.1 to 8.3 presents the State/ District wise distribution of downstram villages.

TABLE 8.1: DISTRIBUTION OF VILLAGES IN DOWNSTREAM OF RIVER GANGA

Sl. No.	State	District	Block	No. of Villages		
				Inhabited	Uninhabited	Total
1	Jharkhand	Sahibganj	Sahibganj	7	7	14
2			Taljhari	15	2	17
3			Borio	16	1	17
4			Rajmahal	34	18	52
5			Udhwa	18	6	24
6			Barharwa	12	4	16
7	West Bengal	Maldah	Ratua I	10	0	10
8			Manikchak	28	10	38
9			Kaliachak II	0	13	13
10			Kaliachak III	18	6	24
TOTAL				**158**	**67**	**225**

FIGURE 8.1: DETAIL OF DOWN STREAM VILLEGES UNDER RIVER REACH – DISTRICT: SAHIBGANJ, JHARKHAND

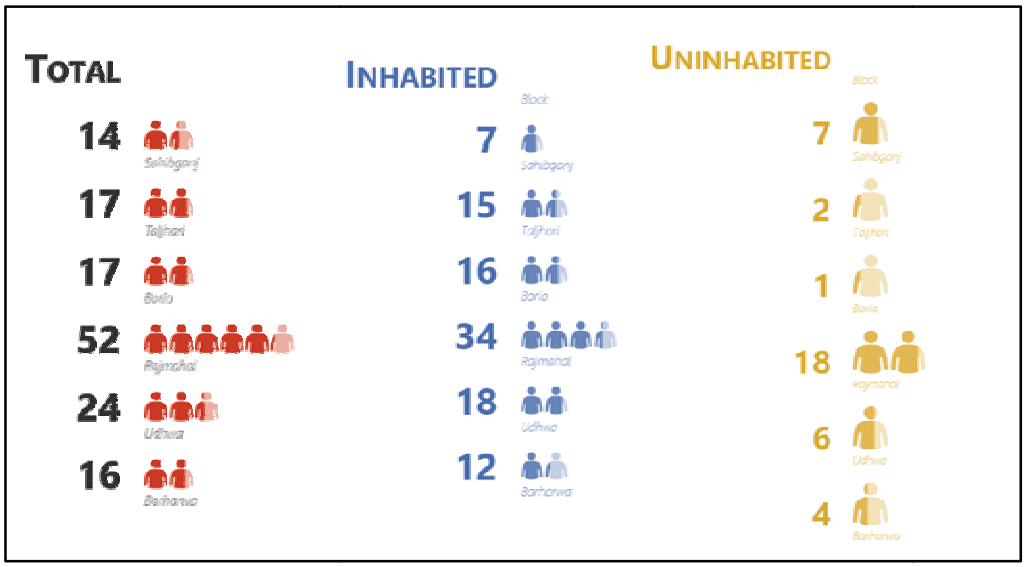


FIGURE 8.2: DETAIL OF VILLEGES UNDER RIVER REACH DISTRICT: MALDAH, WEST BENGAL

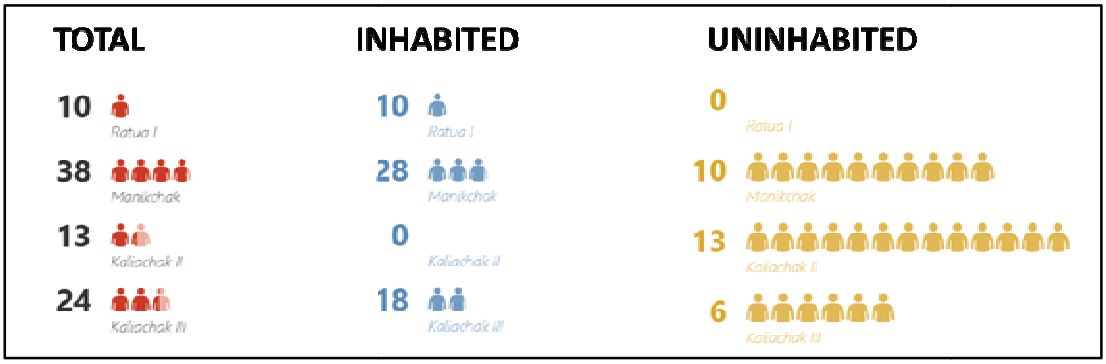
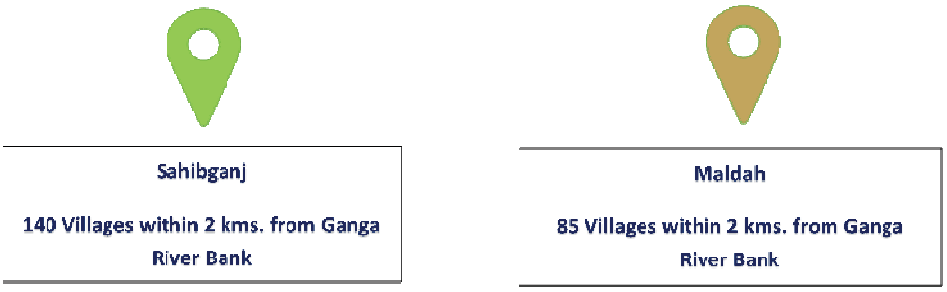


FIGURE 8.3: DETAIL OF VILLAGES UNDER RIVER REACH- OVERALL



As per Census of India, 2011 data, total populations in the villages at the downstream reach lies in Sahibganj district, Jharkhand and Maldah district, West Bengal. The total population (approximate) residing at the downstream reach of propose intake well are 4,64,733 covering a total of 92211 households on both the right and left side bank of the river. On the right-hand side river bank, a total of 35696 households are there ranging in the Sahibgang district, whereas, 56515 households are there in the district of Sahibgang and Maldah in the downstream left-hand bank of the river. The details are depicted in Table 8.2.

TABLE 8.2: DEMOGRAPHIC PROFILE OF VILLAGES IN DOWNSTREAM OF RIVER GANGA

Sl. No.	District	Block	No. of Household			Total Population
			Right Bank	Left Bank	Total	
1	Sahibganj	Sahibganj	2040	128	2168	11429
2		Taljhari	3691	0	3691	19337
3		Borio	2488	0	2488	13019
4		Rajmahal	12107	-	12107	65236
5		Udhwa	13421	-	13421	71647
6		Barharwa	1949	-	1949	9657
7	Maldah	Ratua I	-	9635	9635	46254
8		Manikchak	-	23445	23445	103743
9		Kaliachak II	-	0	0	0
10		Kaliachak III	-	23307	23307	124411

Out of Total population in the downstream study area, about 184353 is the total working population. The right bank has a total population of 77626 and the left bank has a population of 106727. The detail breakup is given in the Table 8.3.

TABLE: 8.3: STATUS OF OCCUPATIONAL PATTERN OF VILLAGES IN DOWNSTREAM OF RIVER GANGA

Sl. No.	District	Block	Total Working Population		TOT_WORK_P	TOT_WORK_M	TOT_WORK_F
			Right Bank	Left Bank			
			4185		4185	2707	1478
1		Sahibganj		310	310	162	148
2		Taljhari	6610	0	6610	4713	1897
3	Sahibganj	Borio	5494		5494	3170	2324
4		Rajmahal	29720		29720	16992	12728
5		Udhwa	27637		27637	17657	9980
6		Barharwa	3980		3980	2523	1457
7		Ratua I	0	15368	15368	11599	3769
8	Maldah	Manikchak	0	37148	37148	26992	10156
9		Kaliachak II	0	0	0	0	0
10		Kaliachak III	0	53901	53901	30217	23684

From the above table it is seen that 63% of the working population is male and the remaining 58% of the population is female. The total main working population in the downstream right-side bank in the districts of Sahibganj and Maldah is 62986 and the population in the left side bank in the district of Maldah in the state of West Bengal is about 64164.

The detailed break-up of the population is given in the Table 8.4. It is observed that the blocks on the left-side bank has the highest number of non-working population of about 168288 as compared to the blocks on the right-side bank accounting for 112699 people.

On the left side bank about 42563 people are economically engaged as compared to 15607 people in the right-side bank mainly comprising of the households belonging to the blocks in Sahibganj district.

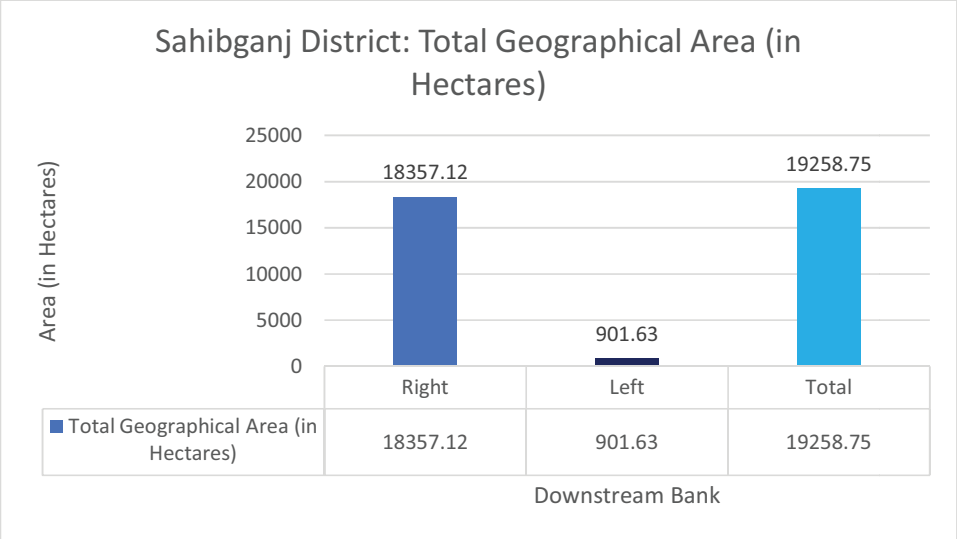
TABLE 8.4: STATUS OF OCCUPATIONAL PATTERN OF VILLAGES IN DOWNSTREAM OF RIVER REACH OF GANGA

Sl. No.	District	Block	Total Main Working Population		Left Bank			Right Bank		
			Right Bank	Left Bank	MAINWORK_P	MARGWORK_P	NON_WORK_P	MAINWORK_P	MARGWORK_P	NON_WORK_P
1	Sahibganj	Sahibganj	2978	168	168	142	297	2978	1207	7244
2		Taljhari	6610	0	0	0	0	6610	967	12727
3		Borio	4100	0	0	0	0	4100	1394	7525
4		Rajmahal	22157	0	0	0	0	22157	7563	35516
5		Udhwa	24540	0	0	0	0	24540	3097	44010
6		Barharwa	2601	0	0	0	0	2601	1379	5677
7	Maldah	Ratua I	0	10268	10268	5100	30886	0	0	0
8		Manikchak	0	19343	19343	17805	66595	0	0	0
9		Kaliachak II	0	0	0	0	0	0	0	0
10		Kaliachak III	0	34385	34385	19516	70510	0	0	0
Total			**62986**	**64164**	**64164**	**42563**	**168288**	**62986**	**15607**	**112699**

8.2 LAND USE PATTERN

In the downstream side of the intake location of river Ganga, in the district of Sahibganj, Jharkhand, the total geographical area of the villages within 2 km. distance from either side of the river bank is 19258.75 hectares (Figure 8.4).

FIGURE 8.4: STATUS OF GEOGRAPHICAL AREA OF DOWNSTREAM VILLAGES UNDER RIVER REACH OF GANGA



Of this area, 18357.12 hectares lies in the right-hand side bank, covering villages in the blocks of Sahibganj; Taljhari; Rajmahal; Borio; Udhwa; and Barharwa and the remaining in the left-hand side bank, in the block of Sahibganj. This is depicted in the fig. above and the details of the geographical area is block-wise is shown in the Table 8.5.

TABLE 8.5: BLOCK WISE DISTRIBUTION OF GEOGRAPHICAL AREA OF DOWNSTREAM VILLAGES UNDER RIVER REACH OF GANGA

Block	Right River Bank	Total Geographical Area (in Hectares)
Sahibganj	Right	3388.42
Sahibganj	Left	901.63
Talghari	Right	2021.71
Rajmahal	Right	7341.14
Borio	Right	1120.07
Udhwa	Right	3162.78
Barharwa	Right	1323
Total		**19258.75**

Of the 19258.75 hectares in Sahibganj district, about 272 hectares is forest coverage and 10232.66 hectares is the net sown area. The detailed land distribution is shown in the Figure 8.5 and Table 8.6.

FIGURE 8.5: LANDUSE PATTERN OF DOWNSTREAM VILLAGES UNDER RIVER REACH OF GANGA

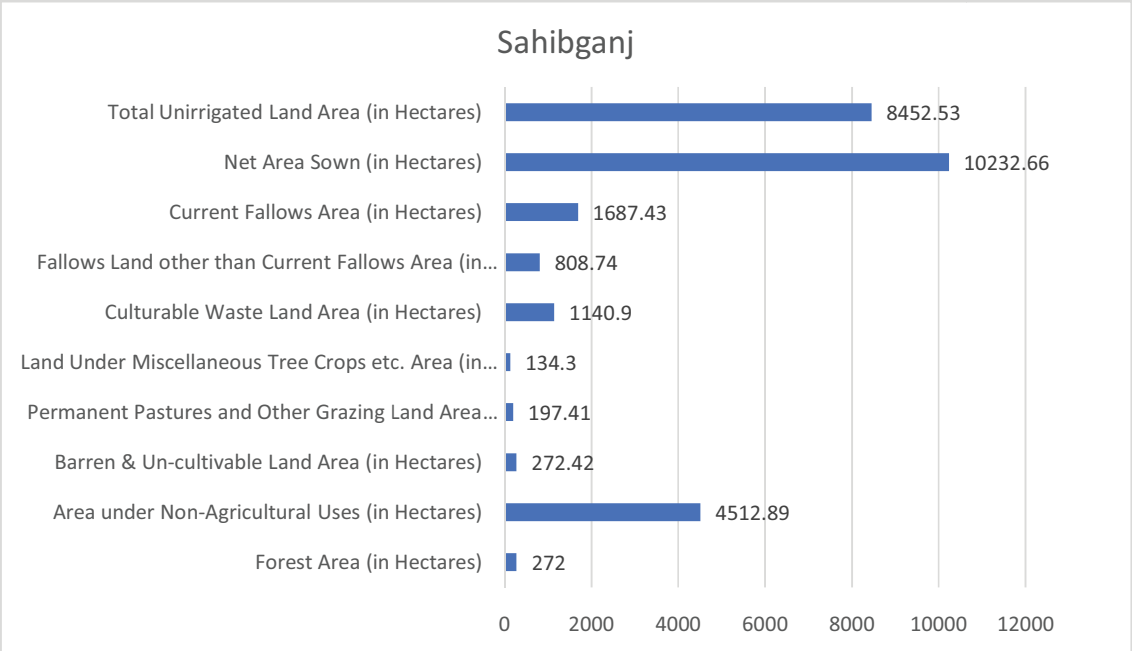


TABLE 8.6: LANDUSE PATTERN OF DOWNSTREAM VILLAGES UNDER RIVER REACH OF GANGA

District	Forest Area (in Hectares)	Area under Non-Agricultural Uses (in Hectares)	Barren & Un-cultivable Land Area (in Hectares)	Permanent Pastures and Other Grazing Land Area (in Hectares)	Land Under Miscellaneous Tree Crops etc. Area (in Hectares)	Culturable Waste Land Area (in Hectares)	Fallows Land other than Current Fallows Area (in Hectares)	Current Fallows Area (in Hectares)	Net Area Sown (in Hectares)	Total Unirrigated Land Area (in Hectares)
Sahibganj	272	4512.89	272.42	197.41	134.3	1140.9	808.74	1687.43	10232.66	8452.53

P22: Public Consultation to Identify Impact of Drawl of Water from River Ganga

P23: Socio-Economic Survey of PAPs of Proposed Water Intake System of GTPP

P24: Cultivation of Vegetable During Lean Season on River Bank of Ganga at D/S of Intake Site

9.0 IMPACT ASSESSMENT STUDY- DOWN STREAM USERS

9.1 PROLOUGE

As a part of the study, probable downstream users impacts associated with the proposed withdrawal of water from River Ganga have been identified. For evaluation of impacts due to the proposed project, the baseline data has been utilized.

9.2 PROBABLE IMPACT ON DOWNSTREAM USERS AFTER WITHDRAWAL OF WATER FROM RIVER GANGA

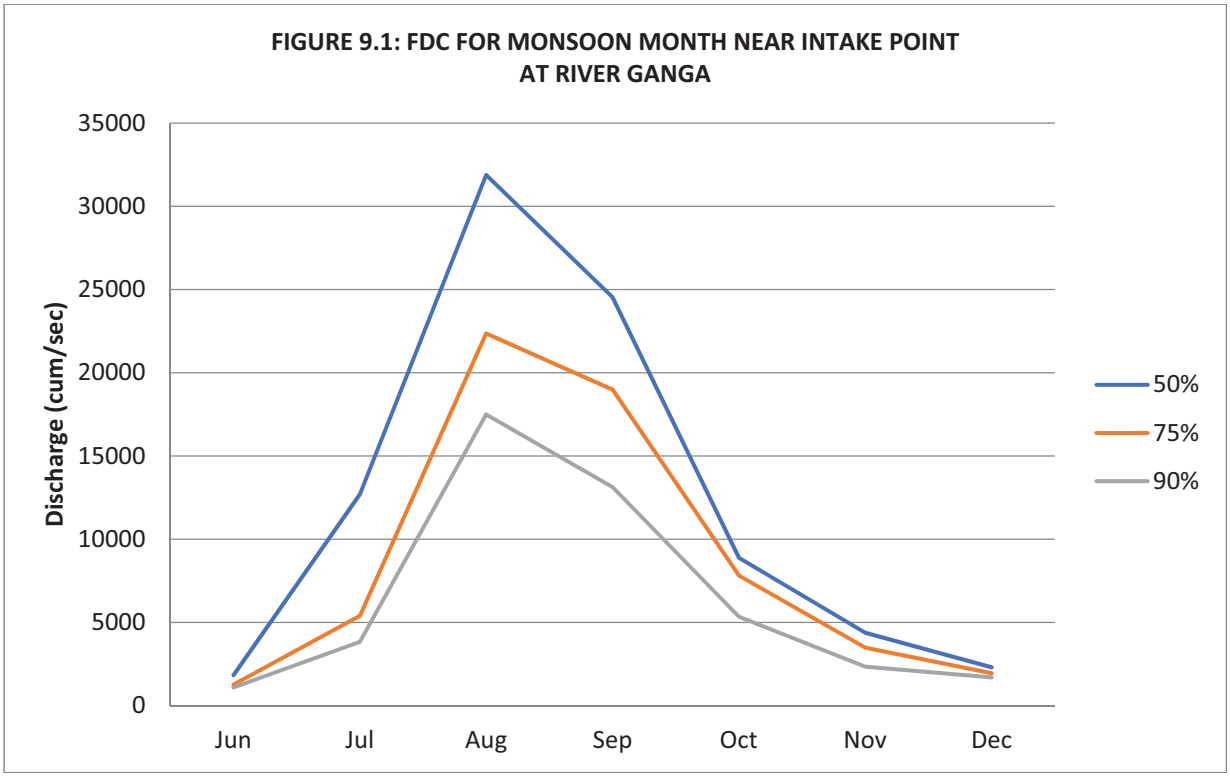
Mainly the water is used for irrigation, drinking and other domestic purposes by downstream users. Due to proposed withdrawal of water from Ganga River, water availability during the monsoon and winter season will not be affected for downstream users as per the water availability study as sufficient water is available in the river. But it may affect up to certain extent during the summer/lean season. However, water drawl is not proposed during lean season. After tapping of water from the River, there will be no major negative impacts on the water availability of the river and also the d/s competing users.

Impact due to proposed water drawl for Godda TPP on water availability, water quality, ecology as well as socio-economy of local people at downstream of the intake point has been assessed on the basis of data collected from CWC for nearest GD&Q site Azmabad for the year 2006-2016. The impact on water availability at downstream due to proposed withdrawl of water for Godda TPP is presented in Table 9.1. It is clearly seen from the analysis of discharge data that the water availability at intake site stretch of river Ganga from June to December varies from 1700 to 17492 cum/sec at 90% dependability (Figure 9.1). However, the average discharge required to pumped is only 3.0 m^3/s (including sediment flushing which will come back in the river) for proposed thermal power plant. The analysis of change in the water flow at downstream of intake point after the proposed withdrawl of water for Godda TPP from river Ganga varies from 0.01 to 0.21% at 75% dependability, whereas 0.01 to 0.25% at 90% dependability of flow. As the overall change in the water flow at downstream of the intake point is likely to be 0.020% at 75% dependability and 0.03% at 90% dependability. Therefore APJL can withdraw the 36 MCM water from the proposed intake site without affecting the downstream users.

TABLE 9.1: IMPACT OF WATER DRAWL FOR GTPP ON WATER AVALIBILITY AT DOWN STREAM OF PROPOSED INTAKE SITE

Sl. No.	Month	Proposed Withdrawl	Monthly Water Discharge (m3/s)		Monthly Water Discharge (MCM)		% Flow Withdrawal	
		Quantiy (in MCM)	75% Dependability	90% Dependability	75% Dependability	90% Dependability	75% Dependability	90% Dependability
1	January	0	1,285	1,026	3,441.74	2,748.04	0.00%	0.00%
2	February	0	1,074	867	2,598.22	2,097.45	0.00%	0.00%
3	March	0	811	752	2,172.18	2,014.16	0.00%	0.00%
4	April	0	824	731	2,135.81	1,894.75	0.00%	0.00%
5	May	0	951	748	2,547.16	2,003.44	0.00%	0.00%
6	June	7	1,259	1,098	3,263.33	2,846.02	0.21%	0.25%
7	July	6	5,392	3,840	14,441.93	10,285.06	0.04%	0.06%
8	August	4	22,357	17,492	59,880.99	46,850.57	0.01%	0.01%
9	September	4	18,985	13,132	49,209.12	34,038.14	0.01%	0.01%
10	October	4	7,820	5,342	20,945.09	14,308.01	0.02%	0.03%
11	November	5	3,492	2,342	9,051.26	6,070.46	0.06%	0.08%
12	December	6	1,948	1,700	5,217.52	4,553.28	0.11%	0.13%
Overall		**36**			**174,904.36**	**129,709.38**	**0.02%**	**0.03%**

FIGURE 9.1: FDC FOR MONSOON MONTH NEAR INTAKE POINT AT RIVER GANGA



There are seven numbers of small and medium weirs constructed in lower Ganga basin. The storage capacity of dams/barrages/weirs are mostly filled in June & mid of July month. The store water is used for agricultural and ground water recharge in these regions.

Thus substantial quantity of water shall overflow the anicuts during monsoon and flows towards the downstream of propose intake structure and finally disposal in the River Ganga.

10.0 WATER MANAGEMENT AND CONSERVATION PLAN

The water management & conservation plan for the proposed thermal power plant of APJL has been prepared with a view to help in conserving water during lean season/drought situations and ultimately reduce the demand of fresh water consumption from the River Ganga as they are allowed to withdraw water on during monsoon season. However, the plan may not be limited to lean season, but shall be followed all the year round.

After construction of the intake well and other alied infrastucture, 36 MCM will be made available for Godda thermal power plant. The Government of Jharkhand allows APJL to store water at some other place by developing the headwork site and pickup weir. Moreover, in order to reduce fresh water demand for the proposed power plant, some of the water conservation steps will be followed as recapturing & recycling this water for has a significant potential for water savings.

The following water conservation steps shall be implemented during lean months for water conservation and reducing the ultimate water demand:

- APJL should construct a bigger reservoir for storing water, so that sufficient water can be stored that will be utilized during summer season, when enough water is not available.

- APJL will do Rain harvesting, which may play an important role in conservation of water.

- Closed circuit cooling system should be adopted for the thermal power plant to optimize fresh water requirement.

- In the Conventional Thermal Power Plants apart from cooling towers, water is also consumed in ash handling process. Bottom Ash from the boilers will be converted to slurry using the partially treated wastewater in water impounded bottom ash hopper and transported to co processing units for disposal. Work up on proposed methods – Dry Ash Handling, HCSD for unutilized ash, FGD make up from blow down and treated water for AHP & CHP

- Moreover, in order to reduce the water demand in fly ash handling and disposal, a dry phase pneumatic conveying system is also adopted.

- The major waste-water generated from the plant like DM Plant discharge will be treated in a Waste Water Treatment Plant and recycled for its reuse in the Plant. No discharge of liquid waste is foreseen from the proposed power plant. The coal pile area runoff water during monsoon season will be led to a well-designed Coal Setting pond. Coal particles will settle down in the Pond and clear water will be allowed to overflow to the Central Monitoring Basin for treatment in the Effluent Treatment Plant (ETP) of the Power Project.

- Automation of control systems shall be done as far as possible to reduce water losses.

- The rain water is collected separately in the Storm Water Drain running all around the project. Rain Water Harvesting Pit would be connected to the Storm Water Drain. Excess rain water will flow to common collection pit from where water can be pumped for use in the ash handling system.

- Regular maintenance of pumps and valves shall be carried out.

- Water audits shall be carried out regularly and records of water consumption and wastewater generation shall be maintained.

11.0 SUMMARY AND CONCLUSIONS

11.1 SUMMARY

Adani Power (Jharkhand) Limited [AP(J)L], has been formed to develop 2x800 MW coal based Thermal Power Plant (TPP) in Jharkhand. The estimated annual water requirement for proposed Power Plant is 36 MCM, which is proposed to be drawn from Ganga River. The Proposed Power Plant Project site is located near Motia, Gangta, Gaighat & other adjacent villages in Godda District of Jharkhand. However, the intake site is nearly 90 km from the proposed Power Plant site at River Ganga in Sahebganj district.

The study has been carried out in order to identify the likely impacts on water availability and downstream users due to withdrawal of water from the River Ganga. All the impacts associated with the withdrawal of water from the River Ganga which were likely to have an effect on the availability of water and downstream competing users have been identified and studied in detail.

SUMMARY OF IMPACTS

(A) Positive impacts

The foremost positive impact of the project is increase in agricultural production as the water from the river would be pumped into intermittent reservoir which will help in increasing the water table of that area. Irrigated agriculture besides providing food security, contributes substantially to conditions that favors improved infrastructure facilities like education, hospitals, roads and other communications allowing better access. Economic progress permits rural households a greater purchasing power. This in turn shall lead to increased commercial and industrial activities in the region. Increased production has impacts at national level too. Besides adding to GNP of the nation, excess grains produced are then transported to deficient regions.

(B) Negative impacts

Sr. No	Impact	Remarks
1.	Impact on ecology due to the withdrawal of water for the proposed Thermal power plant	After the construction of intake well, there will be no major negative impacts on the ecology as 36 MCM water will be allocated for the proposed thermal power plants. Moreover, in post construction of Intake well condition, the untapped catchment area will have significant discharge, which will be available for the survival of existing aquatic life- fishes, arthropods,

		reptiles and seasonal amphibians in the river after withdrawal of water for the proposed thermal power plant and other downstream users.
2.	Impacts on Floral community	Due to construction of intake well and other allied infrasrtructure, some positive impacts are envisaged which are as follows: • The wetlands resulting from accumulation of water due to storage at intermittent reservoir can be used to grow some medicinal plants. • Some aquatic plants may serve the purpose of providing green manure and help in increasing yield of the area.
3.	Impact on Hydrogeology	Due to construction of the intake well and other allied infrasrtructure, some positive impacts are envisaged which are as follow; • The ground water table will be quietly increased from its previous position, which benefits the nearby users as water availability gets improved in that area which finally leads to an increase in the crop yield.

11.2 CONCLUSIONS

The proposed Thermal Power Project is coal based located at Village Motia, Godda district, state Jharkhand, India. The study has been carried out in order to identify the likely impacts on downstream users due to withdrawal of water from River Ganga due to the proposed Thermal Power Plant. All the impacts associated with the Project likely to have an effect on the water availability and downstream users.

There are numbers of weirs already constructed on River Ganga, which may play an important role to sustain the biological life of river body.

Considering the scenario of likely impacts, there are some impacts on the ecological environment of the River Ganga which shall be mitigated naturally with due course of time as ecological cycle has a self-sustaining capacity. Moreover, there are insignificant impacts on the downstream users due to the additional water withdrawal due to the proposed TPP. Further, the project proponent i.e. APJL also undertakes CSR activities which shall have beneficial impacts on the socio-economic environment.

Looking to the overall project scenario, it has been noticed that the project in totality may be considered environmentally safe.

Final Report

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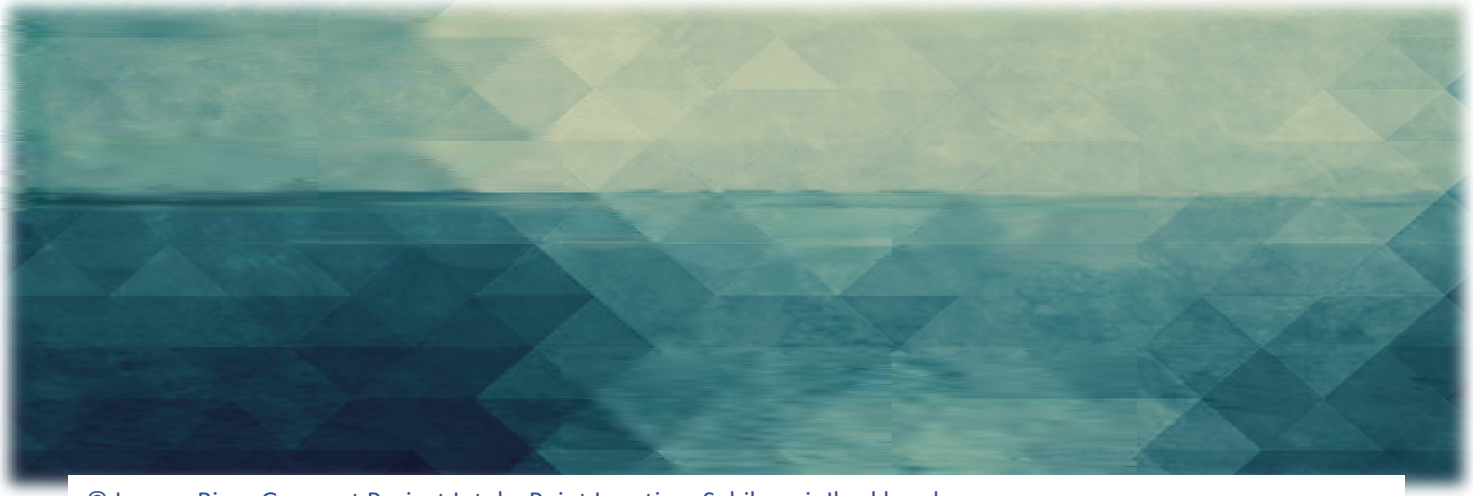

© Image: River Ganga at Project Intake Point Location, Sahibganj, Jharkhand

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