

ODISHA POWER GENERATION CORPORATION LTD.

(A Government Company of the State of Odisha)
CIN: U40104OR1984SG001429

1b Thermal Power Station

Banharpali, Dist.: Jharsuguda, Odisha - 768 234, India
Plant Manager : (+916645) 289266, Fax: (+916645) 222-230
Factory Manager : (+916645) 222224, Fax: (+916645) 222-230



LTR No: OPGC II – MOEF&CC – 2018 – 0313

Date: 24.05.2019

**The Director (Thermal),
Ministry of Environment, Forests & Climate Change
Indira Paryavaran Bhawan
Jor Bagh Road
New Delhi - 110 003**

Sub: Submission of half yearly compliance report to the conditions mentioned in the Environment Clearance granted to Expansion of existing coal based thermal power plant of OPGC by addition of 2 X 660 MW (unit 3 & 4) at Banharpali in Jharsuguda district of Odisha.

**Your Ref.: MoEF Letter No J-13011/59/2008-IA.II (T) dated 04.02.2010
MoEF Letter No J-13011/59/2008-IA.II (T) dated 22.01.2014
MoEF Letter No J-13011/59/2008-IA.II (T) dated 16.01.2015**

Dear Sir

Kindly find the attached Compliance report to the conditions mentioned in Environment Clearance granted to Expansion of existing coal based thermal power plant of OPGC by addition of 2 X 660 MW (unit 3 & 4).

Thanking you,

Yours Faithfully,


Alok Mukherjee
Director (Operations)
OPGC Ltd.

Enclosure: Environment Clearance Compliance Report

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CC:

1. The Director(s), Govt. Of India, Ministry of Environment, Forest & Climate Change. Eastern Regional Office, A/3, Chandrasekharpur, Bhubaneswar-751023
2. Member Secretary, State Pollution Control Board, Odisha, Paribesh Bhawan, Nilakantha Nagar, A/118, Unit -8, Bhubaneswar-751012
3. Regional Office, State Pollution Control Board, Odisha, Plot No- 370/5971, At- Babubagicha, (Cox Colony) St. Merry Hospital Road, Po- Industrial Estate, Dist- Jharsuguda-768203
4. The In charge, Eastern Zonal Office, Central Pollution Control Board, Southernd Conclave, Block 502, 5th & 6th Floors, 1582 Rajdanga Main Road, Kolkata - 700 107 (W. B.)

Corporate Office : Zone-A, 7th Floor, Fortune Tower
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**HALF YEARLY COMPLIANCE REPORT TO THE
CONDITIONS OF ENVIRONMENT CLEARANCE
(2 X 660 MW COAL BASED THERMAL POWER PLANT)
(UNIT 3 & 4)**

**ODISHA POWER GENERATION CORPORATION LIMITED
BANA HARAPALI, JHARSUGUDA, ODISHA**



SUBMITTED TO

**Ministry of Environment, Forest & Climate Change
Indira Paryavaran Bhawan
Jor Bagh,
New Delhi,
India - 110003**

TABLE OF CONTENT

Sl.No	PARTICULARS	Annexure
1	Environment Clearance compliance report	-- (1-11)
2	Hydro geological study report	1 (1-15)
3	Tentative Fly ash utilisation Plan	2
3	Amended EC	3
4	District Plantation monitoring committee report	4
5	Year wise Plantation details	5
6	CSR projects details	6

**ENVIRONMENT CLERANCE COMPLIANCE STATUS REPORT
IB THERMAL POWER STATION, EXPANSION UNITS (UNIT 3&4)
(OCTOBER 2018 – MARCH 2019)**

<i>Clause No.</i>	<i>EC Conditions</i>	<i>Compliance Status</i>
4. (i)	It shall be ensured that natural drainage in the area is not disturbed due to any activity associated with operation or development of the power plant.	The original natural drainage status has been maintained in the project area. The same will not be disturbed in future.
4. (ii)	The height of the existing ash pond shall not be increased to accommodate fresh disposal of ash slurry.	- The height of the existing ash pond will not be increased to accommodate fresh disposal of ash slurry from the expansion (Unit 3 & 4). - Ash from Units 3 & 4 shall not be disposed in that time existing ash ponds i.e. (Ash Pond A & B).
4. (iii)	Wildlife conservation plan prepared in consultation with the office of the concerned Chief Wildlife Warden shall be implemented before any expansion activity is undertaken. The status of implementation shall be submitted to the Regional Office of the Ministry within six months and from time to time.	- The Site-Specific Wild Life Conservation Plan (SSWLCP) for the power plant has been prepared and got approved from Chief Wildlife Warden, Odisha on dtd. 12th June 2014. - The payment of amount Rs 6,62,92000 for execution of SSWLCP was made on 18.07.2014 to Odisha CAMPA account. This payment was communicated to Forest Dept; Odisha vide our letter no 2161/WE on Dtd 19.07.2014. - Besides the above, OPGC has already spend Rs 66 lakh towards plantation activities against the plantation requirement mentioned in approved wild life management plan
4. (iv)	Hydro-geological study of the area shall be reviewed annually, and results submitted to the Ministry and concerned agency in the State Govt. In case adverse impact on ground water quantity and quality is observed, immediate mitigating steps to contain any adverse impact on ground water shall be undertaken.	- First hydrogeological study was carried out in the year 2014-15. In the study, no such adverse impact was observed. The report was submitted to the Ministry & OSPCB. Thereafter yearly review study has been conducted with no observance of adverse impact so far. - Now, a comprehensive detailed Hydrogeological study covering the plant and ash pond area was carried out during 2018-19. No adverse impact was observed from the study. The report is enclosed as Annexure-1. - Piezometers have been installed in existing ash pond and periodic monitoring is being carried out. Six nos. of Bore wells have been constructed in the identified locations covering all directions of the plant and ash pond for collection of water samples.
4. (v)	A twin flue stack of 275 m height shall be provided with continuous online monitoring equipment's for SO _x , NO _x and RSPM (PM _{2.5} & PM ₁₀). Exit velocity of flue gases shall not be less than 22 m/sec. Mercury emissions from stack shall also be monitored on periodic basis.	- A twin flue stacks of 275 meters height have been constructed with sampling port hole and safe access arrangement for carrying out manual monitoring 2 nos of CEMS have been installed at the twin flue stack for monitoring of SO_x, NO_x and PM parameters and real time data being transfer to SPCB, CPCB. Exit velocity of flue gas has been designed with 25 m/sec. - Mercury emission will be monitored periodically after

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IB THERMAL POWER STATION, EXPANSION UNITS (UNIT 3&4)
(OCTOBER 2018 - MARCH 2019)**

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		commissioning of the Plant. Application has been submitted on 01.12.2015 via letter no 3534 for correction of RSPM to PM.
4. (vi)	High Efficiency Electrostatic Precipitators (ESPs) shall be installed to ensure that particulate emission does not exceed 50 mg/Nm ³ .	High efficiency ESPs are designed and installed to ensure PM emission less than 50 mg/Nm³.
4. (vii)	Adequate dust extraction system such as cyclones/ bag filters and water spray system in dusty areas such as in coal handling and ash handling points, transfer areas and other vulnerable dusty areas shall be provided.	- Dust extraction systems (Bag Filters) have been provided at Crusher House, Boiler Bunkers, Transfer Towers and vents of Ash Silos to control the fugitive dust emission. - Dust Suppression Systems (DSS- Dry Fog and Water sprinkling) have been installed at Track hopper, Transfer towers. - Rain Gun type water sprinkling systems have been installed at Coal stock yard.
4. (viii)	Utilisation of 100% Ash generated shall be made from 4th year of operation of the plant. Status of implementation shall be reported to the Regional Office of the Ministry from time to time.	Ash Management plan furnished as Annexure -2. Status of implementation shall be reported to the Regional Office and OSPCB from time to time after taking the Units to Operation with coal firing.
4. (ix)	Fly ash shall be collected in dry form and storage facility (silos) shall be provided. Unutilized fly ash shall be disposed of in the ash pond in the form of slurry form. Mercury and other heavy metals (As, Hg, Cr, and Pb etc.) will be monitored in the bottom ash as also in the effluents emanating from the existing ash pond. No ash shall be disposed of in low lying area.	- Pneumatic conveyer system with 3 nos of dry ash storage silos have been constructed for storage of ash and for its further utilisation and disposal. - Unutilised fly ash will be disposed in the ash pond through HCSD system and Bottom ash will be disposed through LCSD system. - Effluent emanating from the existing ash pond is being recycled and reused for fresh slurry making. No ash pond effluent is being discharged outside. The heavy metal in ash and nearby ground water being monitored periodically. - No ash shall be disposed in low laying area without taking consent from OSPCB
4. (x)	Ash pond shall be lined with HDP/LDP lining or any other suitable impermeable media such that no leachate takes place at any point of time. Adequate safety measures shall also be implemented to protect the ash dyke from getting breached.	HDPE lining has been provided in the ash pond. Dyke safety measures has been addressed during design and construction of ash pond to protect the ash dykes from getting breached. During operation of ash pond, adequate safety measure will also be implemented to avoid breaching of ash dykes.
4. (xi)	For disposal of Bottom Ash in abandoned Manoharpur mines it shall be ensured that the bottom and sides of the mined-out areas are	The requirement will be implemented, and approval/ clearances will be taken from State Pollution Control Board before undertaking filling of mine void using

**ENVIRONMENT CLERANCE COMPLIANCE STATUS REPORT
IB THERMAL POWER STATION, EXPANSION UNITS (UNIT 3&4)
(OCTOBER 2018 – MARCH 2019)**

<i>Clause No.</i>	<i>EC Conditions</i>	<i>Compliance Status</i>
	adequately lined with clay before Bottom Ash is filled up. The project proponent shall inform the State Pollution Control Board well in advance before undertaking the activity.	ash.
4. (xii)	Closed cycle cooling system with natural draft cooling towers shall be provided. The Effluents shall be treated as per the prescribed norms.	- Considering the ambient conditions, the plant has been designed with induced draft cooling tower. This deviation request was submitted to Director (Thermal), MoEF vide letter No.565 dated 8 -March-2010 - Considering our request, MoEF has granted its permission for use of Induced Draft Cooling System via EC Amendment dated 22/01/2014. The permission is enclosed as Annexure 3 - The blow down of the IDCT will be utilised in ash handling and dust suppression purpose.
4. (xiii)	COC 5.0 will be adopted.	The design requirements have already been incorporated for environmental compliance.
4. (xiv)	The treated effluents conforming to the prescribed standards only shall be re-circulated and reused within the plant. There shall be no discharge outside the plant boundary except during monsoon. Arrangements shall be made that effluents and storm water do not get mixed.	200 KLH ETP has been installed for treatment and utilisation of waste water generated from the plant. - Zero discharge is being adhered except the period of monsoon. - Effluent drains have been segregated from the Storm water drains.
4. (xv)	A sewage treatment plant shall be provided, and the treated sewage shall be used for raising greenbelt/plantation.	- Existing 1 MLD sewage treatment plant is operating at less than 50 % load. With the proposed expansion activity additional 24% load will be added and it is conveniently accommodated in the existing STP capacity. - Treated sewage will be used for raising greenbelt/plantation.
4. (xvi)	Rainwater harvesting should be adopted. Central Groundwater Authority/ Board shall be consulted for finalization of appropriate rainwater harvesting technology within a period of three months from the date of clearance and details shall be furnished.	The detail study on rain water harvesting technology has already been completed in May-2012 and the report is already finalised. The same was submitted to Central Ground Water Board for review and advice vide letter No. 1612/WE dated 28-June 13. After compliance submission against the observation raised by CGWB and further verification, finally approval accorded by CGWB vide letter no – 5-22/SER/CGWA/2017-18-1455 on dated 07.12.2017. After getting the approval of the technology, the rain harvesting pond design and construction activity is in process. It is planned to complete the harvesting pond by 31st December 2019.
4. (xvii)	Adequate safety measures shall be provided in the plant area to	Details of fire protection arrangement at coal yard with lay out map has been submitted to Regional Office,

**ENVIRONMENT CLERANCE COMPLIANCE STATUS REPORT
IB THERMAL POWER STATION, EXPANSION UNITS (UNIT 3&4)
(OCTOBER 2018 - MARCH 2019)**

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	check/minimize spontaneous fires in coal yard, especially during summer season. Copy of these measures with full details along with location plant layout shall be submitted to the Ministry as well as to the Regional Office of the Ministry.	MoEF & CC Adequate fire hydrant system has been installed in the Coal stock yard and Track hopper site to control spontaneous fire.
4. (xviii)	Storage facilities for auxiliary liquid fuel such as LDO and/ HFO/LSHS shall be made in the plant area in consultation with Department of Explosives, Nagpur. Sulphur content in the liquid fuel will not exceed 0.5%. Disaster Management Plan shall be prepared to meet any eventuality in case of an accident taking place due to storage of oil.	- Storage Facilities for auxiliary liquid fuel has been made in consultation with Dept. of Explosive, Nagpur. Further, the facilities shall be brought into operation after getting valid license from Dept. of Explosive, Nagpur. - As regards to Sulphur content, EAC (Thermal) in its monthly meeting held on 18th/19th November 2013 has accorded its consent for the use of commercially available fuel oil. - Emergency response plan has been prepared to handle any emergency
4. (xix)	Regular monitoring of ground water (especially around ash pond and plant areas) shall be carried out by establishing a network of existing wells and constructing new piezometers. Monitoring around the ash pond area shall be carried out particularly for heavy metals (Hg, Cr, As, Pb) and records maintained and submitted to the Regional Office of this Ministry. The data so obtained should be compared with the baseline data so as to ensure that the ground water quality is not adversely affected due to the project.	- Piezometers have been installed in existing ash pond and 6 nos of Bore wells have been constructed in the identified locations covering all directions of the plant and ash pond for collection of water sample. - Periodic monitoring for heavy metals is being carried out in the ground water samples from ash pond and surrounding area and reports are being submitted to the Regional Office. - The comparison of the ground water samples near the existing ash pond & nearby surrounding villages' shows that the concentration of heavy metals is within the permissible limits.
4. (xx)	Monitoring surface water quantity and quality shall also be regularly conducted, and records maintained. The monitored data shall be submitted to the Ministry regularly. Further, monitoring points shall be located between the plant and drainage in the direction of flow of ground water and records maintained. Monitoring for heavy metals in ground water shall be undertaken.	Surface water and ground water quality monitoring is being done regularly. The points for monitoring in the direction of flow of ground water has been determined from the Hydro geological report and monitoring is being carried out accordingly.
4. (xxi)	Green Belt consisting of 3 tiers of plantations of native species around plant and at least 100 m width shall be raised. Wherever 100 m width is not feasible a 50 m width shall be raised, and adequate justification	- The requirements are addressed in the drawing number D-56 (already submitted on 30th November 2011). - District Plantation monitoring committee lead by Ex. Vice Chancellor Sambalpur University & Wild Life Warden along with Additional Chief Conservator of Forest, Asst. Director Horticulture, Asst. Environment

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(OCTOBER 2018 – MARCH 2019)**

<i>Clause No.</i>	<i>EC Conditions</i>	<i>Compliance Status</i>
	shall be submitted to the Ministry. Tree density shall not less than 2500 per ha with survival rate not less than 70 %.	Engineer OSPCB & Chief Co-ordinator Eco Club of Jharsuguda has verified the plantation/green belt status through site visits which comes to be 34.6% till Feb'18. - The District Plantation committee report mentioning 34.6% green cover is enclosed as Annexure-4 for reference. - Further to augment the existing greenbelt, 10142 nos of saplings have been planted in 2018-19 financial year and subsequently, proposal have been moved for planting 5000 nos of saplings inside the plant premises during 2019-20 financial year. Year wise plantation details till 2018-19 is enclosed as Annexure-5.
4. (xxii)	First Aid and sanitation arrangements shall be made for the drivers and other contract workers during construction phase.	Well-equipped first aid/sanitation facility has been provided at the project site.
4. (xxiii)	Noise levels emanating from turbines shall be so controlled such that the noise in the work zone shall be limited to 75 dBA. For people working in the high noise area, requisite personal protective equipment like earplugs/ear muffs etc. shall be provided. Workers engaged in noisy areas such as turbine area, air compressors etc shall be periodically examined to maintain audiometric record and for treatment for any hearing loss including shifting to non-noisy/less noisy areas.	- Arrangements for control of noise in the working areas have been taken in the plant by provision of acoustic enclosures, silencers etc. Sufficient ear protection PPE will be provided for all personnel exposed to work in noisy area. - Periodic health check will also be carried out for all employees & contractors
4. (xxiv)	Regular monitoring of ground level concentration of SO ₂ , NO _x , RSPM (PM _{2.5} & PM ₁₀) and Hg shall be carried out in the impact zone and records maintained. If at any stage these levels are found to exceed the prescribed limits, necessary control measures shall be provided immediately. The location of the monitoring stations and frequency of monitoring shall be decided in consultation with SPCB. Periodic reports shall be submitted to the Regional Office of this Ministry. The data shall also be put on the website of the company.	The project is located inside the existing plant premises. Four online AAQ monitoring stations to monitor PM₁₀, PM_{2.5}, SO₂, NO_x & CO has been installed within impacted zone. Results are transmitted to SPCB server on real time basis. Other than this, Ambient Air Quality is also being monitored through five permanent ambient air quality stations and the location of the stations are decided earlier in consultation with the Regional Office. Periodic monitoring shall be performed for ambient Hg. Necessary control measures shall be implemented in case any exceedances are observed. Monitoring reports are being submitted on periodic basis.
4. (xxv)	A good action plan for R&R (if applicable) with package for the project affected persons be	R & R plan is not applicable as there is no displacement of people due to establishment of the project.

**ENVIRONMENT CLERANCE COMPLIANCE STATUS REPORT
IB THERMAL POWER STATION, EXPANSION UNITS (UNIT 3&4)
(OCTOBER 2018 - MARCH 2019)**

Clause No.	EC Conditions	Compliance Status
	submitted and implemented as per prevalent R&R policy within three months from the date of issue of this letter.	
4. (xxvi)	An amount of Rs 24.36 Crores shall be earmarked as one-time capital cost for CSR programme. Subsequently a recurring expenditure of Rs 4.87 Crores per annum shall be earmarked as recurring expenditure for CSR activities. Details of the activities to be undertaken shall be submitted within one month along with road map for implementation.	A revised /updated list of projects amounting to Rs. 26.91 Crores has been approved by the CSR committee in its 22nd meeting dated 06th April 2019. A copy of the updated list of projects is attached herewith which includes projects that are completed, in progress and yet to start. (Annexure -6) Once the construction project work is over, action plan for spending Rs. 4.87 Crores per annum will be developed based on people's needs and local development priorities.
4. (xxvii)	As part of CSR programme the company shall conduct need-based assessment for the nearby villages to study economic measures with action plan which can help in upliftment of poor section of society. Income generating projects consistent with the traditional skills of the people besides development of fodder farm, fruit bearing orchards, vocational training etc. can form a part of such programme. Company shall provide separate budget for community' development activities and income generating programmes. This will be in addition to vocational training for individuals imparted to take up self-employment and jobs.	Need based assessment have been conducted by CSR team of OPGC which was followed by a baseline survey taken up by a professional agency. The project list of Rs. 26.91 Crores provides the details of projects to be undertaken for development of local people as per their expressed needs and priorities.
4. (xxviii)	The project proponent shall also adequately contribute in the development of the neighbouring villages. Special package with implementation schedule for providing fluoride free potable drinking water supply in the nearby villages and schools shall be undertaken in a time bound manner.	This remains high on OPGC'S agenda. The approved project list sheds adequate light on how OPGC has planned elaborately to provide lasting and sustainable water solutions to people of nearby villages. A scientific Hydrology study was conducted to guide the process of project implementation. OPGC has also started mobilising people's opinion and support for sustainable water solutions in collaboration with experts and Jharsuguda district authority.
4. (xxix)	Provision shall be made for the housing of construction labour within the site with all necessary infrastructure and facilities such as fuel for cooking, mobile toilets, mobile STP, safe drinking water, medical health care, crèche etc. The housing may be in the form of temporary structures to be removed	Well-equipped labour colony has been provided for construction labours outside the plant boundary. Infrastructure for provision of water supply, toilets, sewage soak pits with septic tank, health care facility and electricity has already been made.

**ENVIRONMENT CLERANCE COMPLIANCE STATUS REPORT
IB THERMAL POWER STATION, EXPANSION UNITS (UNIT 3&4)
(OCTOBER 2018 – MARCH 2019)**

<i>Clause No.</i>	<i>EC Conditions</i>	<i>Compliance Status</i>
	after the completion of the project.	
4. (xxx)	The project proponent shall advertise in at least two local newspapers widely circulated in the region around the project, one of which shall be in the vernacular language of the locality concerned within seven days from the date of this clearance letter, informing that the project has been accorded environmental clearance and copies of clearance letter are available with the State Pollution Control Board/Committee and may also be seen at Website of the Ministry of Environment and Forests at http://envfor.nic.in .	Complied. Published in Sambad (Odiya) & New India Express (English) in March 2010.
4. (xxxi)	A copy of the clearance letter shall be sent by the proponent to concern Panchayat, ZilaParisad / Municipal Corporation, urban local Body and the Local NGO, if any, from whom suggestions/representations, if any, received while processing the proposal. The clearance letter shall also be put on the website of the Company by the proponent.	Complied in March 2010.
4. (xxxii)	A separate Environment Management Cell with qualified staff shall be set up for implementation of the stipulated environmental safeguards.	A separate Environment Management Cell with qualified staff has already been functioning for the purpose.
4. (xxxiii)	The proponent shall upload the status of compliance of the stipulated EC conditions, including results of monitored data on their website and shall update the same periodically. It shall simultaneously be sent to the Regional Office of MOEF, the respective Zonal Office of CPCB and the SPCB. The criteria pollutant levels namely, RSPM, SO ₂ , NO _x (ambient levels as well as stack emissions) shall be displayed at a convenient location near the main gate of the company in the public domain.	- The status of compliance is being uploaded in Website and reports are also being sent to the said offices. - LED display boards are installed at the Plant main gate for display environmental information. Website path http://www.opgc.co.in/env/half_comp_powerplant.asp
4. (xxxiv)	The project proponent shall also submit six monthly reports on the status of compliance of the stipulated EC conditions including results of monitored data (both in	This is being complied since October 2010.

**ENVIRONMENT CLERANCE COMPLIANCE STATUS REPORT
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(OCTOBER 2018 - MARCH 2019)**

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	hard copies as well by e- mail) to the respective Regional Office of MOEF, the respective Zonal Office of CPCB and the SPCB.	
4. (xxxv)	The environment statement for each financial year ending 31st March in Form-V as is mandated to be submitted by the project proponent to the concerned State Pollution Control Board as prescribed under the Environment (Protection) Rules, 1986, as amended subsequently, shall also be put on the website of the company along with the status of compliance of EC conditions and shall also be sent to the respective Regional Offices of the Ministry by e-mail.	Form V submission and web-hosting will be commenced on commissioning of Plant.
4. (xxxvi)	The project proponent shall submit six monthly reports on the status of the implementation of the stipulated environmental safeguards to the Ministry of Environment and Forests, its Regional Office, Central Pollution Control Board and State Pollution Control Board. The project proponent shall upload the status of compliance of the environmental clearance conditions on their website and update the same periodically and simultaneously send the same by e-mail to the Regional Office, Ministry of Environment and Forests.	- Reporting already commenced since October 2010. The compliance report is being sent to Ministry of Environment and Forests, its Regional Office, Central Pollution Control Board, State Pollution Control Board and the Regional Office, OSPCB. - Web hosting of EC Compliance status is being done. - Website path http://www.opgc.co.in/env/half_comp_powerplant.asp
4. (xxxvii)	Regional Office of the Ministry of Environment & Forests will monitor the implementation of the stipulated conditions. A complete set of documents including Environmental Impact Assessment Report and Environment Management Plan along with the additional information submitted from time to time shall be forwarded to the Regional Office for their use during monitoring. Project proponent will up-load the compliance status in their website and up-date the same from time to time at least six-monthly bases. Criteria pollutants levels including NO _x (from stack & ambient air) shall be displayed at the	- Reporting already commenced since October 2010. - Web-hosting of compliance of stipulated in the EC conditions being done. - Criteria pollutants levels NO_x (from ambient air) is being displayed at the main gate of the power plant.

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IB THERMAL POWER STATION, EXPANSION UNITS (UNIT 3&4)
(OCTOBER 2018 - MARCH 2019)**

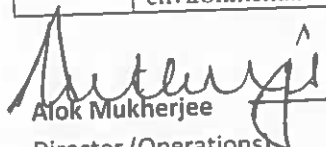
<i>Clause No.</i>	<i>EC Conditions</i>	<i>Compliance Status</i>
	main gate of the power plant.	
4. (xxxviii)	Separate funds shall be allocated for implementation of environmental protection measures along with item-wise break-up. These costs shall be included as part of the project cost. The funds earmarked for the environment protection measures shall not be diverted for other purposes and year-wise expenditure should be reported to the Ministry.	The project cost includes the provision for implementation of environmental protection measures as required. It is made strictly for environment protection measure.
4. (xxxix)	The project authorities shall inform the Regional Office as well as the Ministry regarding the date of financial closure and final approval of the project by the concerned authorities and the dates of start of land development work and commissioning of plant.	The financial closure of the project was done on 23rd November 2012. NTP was issued to BHEL and BGRE on 26th March 2014.
4.(xxxx)	Full cooperation shall be extended to the Scientists/Officers from the Ministry / Regional Office of the Ministry at Bangalore / CPCB/ SPCB who would be monitoring the compliance of environmental status.	It is being done.

**ENVIRONMENT CLERANCE COMPLIANCE STATUS REPORT
IB THERMAL POWER STATION, EXPANSION UNITS (UNIT 3&4)
(OCTOBER 2018 – MARCH 2019)**

Additional Recommendations to OPGCL by MoEF in EC amendment dated 22.01.2014		
S. No	Recommendations	Compliance status
a	A long-term study of radio activity and heavy metals contents on coal to be used shall be carried out through a reputed institute. Thereafter, mechanism for an inbuilt continuous monitoring for radio activity and heavy metals in coal and fly ash (including bottom ash) shall be put in place.	The study and monitoring shall be conducted after the commissioning of the plant.
b	Continuous monitoring for heavy metals in and around the existing ash pond area shall be immediately carried out by reputed institutes like IIT Kanpur.	The monitoring has been periodically carried out through reputed and accredited agency (M/S SGS India Ltd., Visiontek Consultancy Services,)/Institutions (IIT, Chennai)
c	Harnessing solar power within the premises of the plant particularly at available roof tops shall be undertaken and status of implementation shall be submitted periodically to the Regional Office of the Ministry.	Shall be complied.
d	Fugitive emissions shall be controlled to prevent impact on agricultural or non-agricultural land.	- Adequate dust control measures have been implemented to prevent impact during construction phase - Adequate dust suppression systems (water sprinklers & Dry Fog) have been installed to suppress fugitive dust in coal and ash handling area for the operational stage
e	No ground water shall be extracted for use in operation of the power plant even in lean season.	Ground water is not being used.
f	Minimum required environmental flow suggested by the Competent Authority of the State Govt. shall be maintained in the Channel/ Rivers (as applicable) even in lean season.	Minimum required environmental flow is being maintained as per the water agreement with Water Resource Department.
g	No water bodies including natural drainage system in the area shall be disturbed due to activities associated with the setting up/operation of the power plant.	No water bodies are being disturbed due to project or will be disturbed in future due to operation.
h	Fly ash shall not be used for agricultural purpose. No mine void filling will be undertaken as an option for ash utilization without adequate lining of mine with suitable media such that no leachate shall take place at any point of time. In case, the option of mine void filling is to be adopted, prior detailed study of soil characteristics of the mine area shall be undertaken from an institute of repute and adequate clay lining shall be	- Ash Management plan to be furnished is attached as Annexure – 2. - For mine void filling of ash, prior detailed study of soil characteristics of the mine area shall be undertaken from an institute of repute and adequate clay lining shall be ascertained in close co-ordination with the State Pollution Control Board.

ENVIRONMENT CLERANCE COMPLIANCE STATUS REPORT
IB THERMAL POWER STATION, EXPANSION UNITS (UNIT 3&4)
(OCTOBER 2018 - MARCH 2019)

Additional Recommendations to OPGCL by MoEF in EC amendment dated 22.01.2014		
S. No	Recommendations	Compliance status
	ascertained by the State Pollution Control Board and implementation done in close co-ordination with the State Pollution Control Board.	
i	Three tier green belts shall be developed all around Ash Pond over and above the Green Belt around the plant boundary.	- Green belt already exists all along the plant boundary. Details stated in condition no 4.xxi. - For Ash Pond, SPCB Odisha advised not to go for any plantation on the ash pond dykes looking towards the risk of dyke failure due to tree root channelling. However, OPGC will further examine and go for plantation in surrounding area.
j	A common Green Endowment Fund shall be created, and the interest earned out of it shall be used for the development and management of green cover of the area.	Shall be complied.
k	It shall be ensured that in-built monitoring mechanism for the schemes identified is in place and annual social audit shall be got done from the nearest government institute of repute in the region. The project proponent shall also submit the status of implementation of the scheme from time to time.	- Baseline Survey has been completed by Sutra Consultancy Services, Bhubaneswar and the Final report is already available with OPGC. Monitoring is regularly done by OPGC CSR team. - Projects are currently under execution and appropriate time to get them evaluated by an external agency is not yet ripe. Impact measurement will be done in due course. An internal monitoring mechanism is already in place. As recommended, a proposal will be put up before OPGC Board of Directors to consider getting social audit conducted once all the approved projects have been successfully executed.
l	An Environmental Cell shall be created at the project site itself and shall be headed by an officer of the company of appropriate seniority and qualification. It shall be ensured that the head of the Cell shall directly report to the Head of the Organization.	A separate Environment Management Cell with qualified staff has already been functioning for the purpose. A senior qualified officer heads the Cell who directly reports to Unit Head.
m	The project proponent shall formulate a well laid Corporate Environment Policy and identify and designate responsible officers at all levels of its hierarchy for ensuring adherence to the policy and compliance with the conditions stipulated in this clearance letter and other applicable environmental laws and regulations.	OPGC has got well formulated EHS Policy. Also identified and designated responsible officers at all levels of its hierarchy for ensuring adherence to the policy and compliance with the conditions stipulated in this clearance letter and other applicable environmental laws and regulations.


Alok Mukherjee
Director (Operations)
OPGC Ltd.

**HYDROGEOLOGICAL STUDIES OF ASH PONDS,
PLANT SITE & ITS SURROUNDING AREA OF IB
THERMAL POWER STATION**

OF

**M/S. ODISHA POWER GENERATION CORPORATION
LIMITED**

AT

**BANHARPALI VILLAGE IN LAKHANPUR BLOCK OF
JHARSUGUDA DISTRICT,
ODISHA**

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ISO 14001:2004
ISO 9001:2008
OHSAS 18001:2007

HYDROGEOLOGICAL STUDIES OF ASH POND, PLANT SITE AND ITS SURROUNDING AREAS OF ODISHA POWERGENERATION CORPORATION LIMITED NEAR VILLAGE BANHARPALI, TEHSIL LAKHANPUR, DISTRICT JHARSUGUDA, ODISHA

Chapter-1

Introduction

1. Introduction: IB Thermal Power Station (ITPS) is a coal-based thermal power plant located near village Banharpali in Lakhanpur tehsil of Jharsuguda district of Odisha. The power plant is operated by the state owned Odisha Power Generation Corporation which was incorporated on November 14, 1984. OPGC started as a wholly owned Government Company of the State of Odisha with the main objective of establishing, operating & maintaining thermal power generating stations. Its installed capacity is of 420 MW (2x210). The construction of two more units of capacity 1320 MW (2x660) by the side of existing plant premise is under final stage of completion.

1.2. Historical background: Odisha Power Generation Corporation Limited (OPGC) was incorporated on November 14, 1984. OPGC started as a wholly owned Government Company of the State of Odisha. In the pursuit of its objective, OPGC established IB Thermal Power Station having two units of 210 MW each in the Ib valley area of Jharsuguda District in the State of Odisha. These Units have become operational since 1994 (1st Unit) and 1996 (2nd Unit) respectively. The entire generation from these units is committed to Gridco - the state owned Power Transmission & Trading Company on the basis of a long-term power purchase agreement. As a part of the reform in the energy sector of the state, 49% of the equity was divested in favour of a strategic investor AES Corporation, USA in early 1999. OPGC with its present ownership structure is unique of its kind in the country and has excellent track record of plant performance and earnings. Today OPGC has firmly established its credentials as a successful power generating company both technically & commercially by providing safe, clean & reliable power

1.3. Scope of work: The Odisha Power Generation Corporation Limited (OPGC) has proposed to carry out Hydrogeological studies of ash ponds and plant site of Thermal Power Station located at Banhrapali, in Jharsuguda district of Odisha and its surrounding areas within 10 km radius with the following scope of works.

Study Area-The area of studies is OPGC existing Ash Ponds & Plant Site (both operational and construction sites) and its surrounding areas. Study period- schedule will be Pre-monsoon, monsoon and post monsoon period.

Detailed comprehensive study(1st year) and yearly review for subsequent two years.

A. 1stYear Study:

1. Using the topography data, contour maps of the study area and meteorological data, estimate catchment area which potentially contributes to tile surface runoff. Verify the adequacy of existing drainage pattern of surface runoff,
2. Study of topography, drainage in core and buffer zone (10 km radius).
3. Collection and analysis of available meteorological, geological, Hydrogeological and demographic data and land uses/crop pattern data,
4. Study of regional geology and geology of study area cross sections and mapping.
5. Study of surface satellite imagery for land use pattern in study area.
6. Establish the ground water potentiometric elevations using available boreholes/wells in and around the sites.
7. Identification of aquifers and their thickness.
8. Establish the subsurface layer(s) information.
9. Using the subsurface layers information and potentiometric elevations, the ground water level contours will be developed, Using these information, find the direction of ground water flow and its variation throughout the years of the phreatic aquifer and probable discharge and recharge zones.
10. Conducting infiltration tests,
11. Conducting pumping test at site.
12. Conducting APT (Aquifer performance test) in each pumping well.
13. Collection of historical water level data and water level trend analysis.
14. Sampling and monitoring of the ground water quality and surface water quality, its chemical composition w.r.t pH; Electrical Conductivity, TDS, Alkalinity, Na, Ca, Mg, K, SO₄²⁻, F⁻, As, Pb, Hg, and other heavy metals.

15. Minimum ten water samples and five soil samples testing
16. Based on all the above data, the contaminant impact on ground water as well as on reservoir water will be assessed
17. Preparation of a comprehensive hydrogeological report as per the guidelines of Ministry of Environment Forest and Climatic Change (MoEF & CC), Government of India

B. Post study yearly monitoring & review

1. Study of Ground Water periodically (pre & post monsoon and during monsoon) from available bore wells,
2. Ground & Surface Water sampling and analysis as per guideline of MoEF& CC,
3. Impact on Ground Water due to the existing Project, Operating Plant & Ash Pond
4. Preparation and Submission of report,

1.4. Description of the study area: There are two centers of the study. First one is plant site which is located near Banharpali village and other one is ash pond site located near Bhalupali village, nearly 3.5 km away from the plant site in Lakhanpur tehsil of Jharsuguda district. Besides these a detail hydrogeological study has been carried out in 10 km radius buffer zone of the plant site as well as ash pond site. Description of location of each one is as below.

1. Ash pond site: The study site is located at near Bhalupali and behind Rengali village in Jharsuguda district. The location is marked on survey of India Toposheet as shown in Figure 1. The total ash pond area is about 390 acres and is bounded by 83°54'3.82"E to 83°54'48.05"E longitude and 21°41'15.52"N to 21°41'55.82"N latitude and falls under survey of India topo sheet No 64O/14. Its elevation is 185-210m above mean sea level. The site is at about 4km by road from IB Thermal Power plant towards east and southeast direction and 14 km North of Hirakud dam. Its location is shown in map No-1 and in the vicinity map (Map-2). The general slope of the ash pond area is from East to West, which is about 8 to 10m elevation difference. As a part of the thermal power station, two ash ponds (Ash pond A & ash pond B) exist at about 4km towards east and southeast direction. The salient features of both ponds are as below.

Table-1.1: The salient features of both ash ponds

Ash Pond A :	Details				
Area	150 acres (607050m ²)				
Structure	Compacted Soil made starter dyke (Embankment) , Sand Chimney, Stone patching provided in the dyke , Toe wall and garland drain around the dyke				
Elevation	197 m				
Coordinate		Extreme Point	Longitude	Latitude	
		Northern	83°54'16.49"E	21°41'55.82"N	
		Southern	83°54'15.59"E	21°41'26.33"N	
		Western	83°54'3.82"E	21°41'44.12"N	
		Eastern	83°54'33.44"E	21°41'39.19"N	
Any protection layer	Nil				
Ash Pond B :					
Area	240 acres (971280 m ²)				
Structure	Clayey Sand (Embankment)Compacted ash (filling material) and Sand (Blanket)				
Elevation	202 m				
Coordinates		Extreme Point	Longitude	Latitude	
		Northern	83°54'33.35"E	21°41'34.99"N	
		Southern	83°54'47.09"E	21°41'15.52"N	
		Western	83°54'16.91"E	21°41'27.38"N	
		Eastern	83°54'48.05"E	21°41'18.62"N	
Any protection layer	Nil				

2. Plant Location: IB Thermal power plant is located in Banharpali Village of Lakhanpur Tehsil of Jharsuguda District of Odisha State, India. It is located 37 KM towards west from District headquarters Jharsuguda and 320 KM from State capital Bhubaneswar.

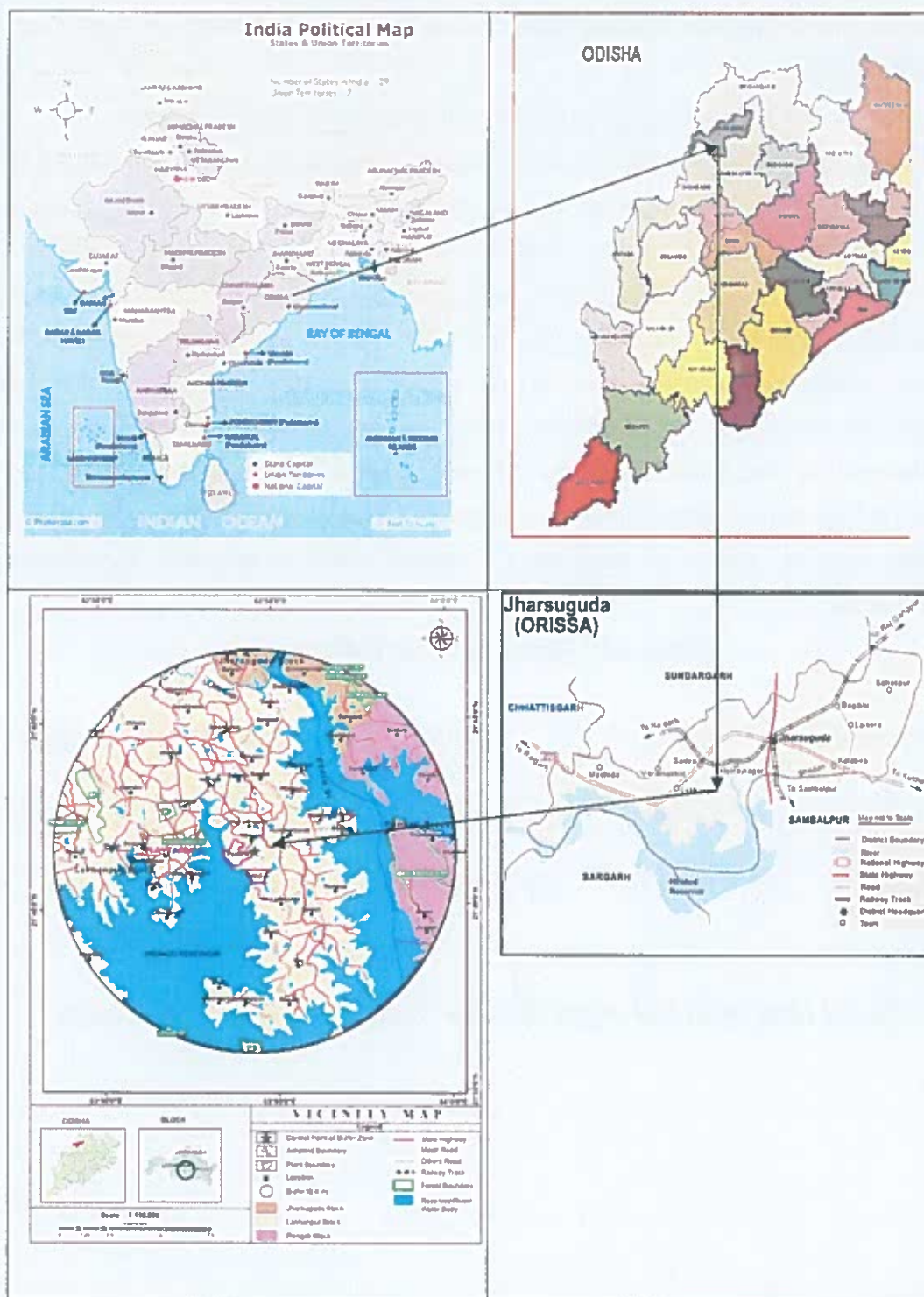
Location of Ash pond site and power plant site is shown in Map No-1 and 2.

3. Buffer zone: For the detail hydrogeological investigation and to assess aquifer geometry, its hydraulic properties and its characteristics, evaluation of ground water resource, assessment of quality of ground water, and to explore the possibility of suitable ground water abstraction structures and suitable means of artificial recharge structures, an area of 314.516 sq km has been chosen as circular area of 10 km radius keeping the eastern point of ash ponds area (64O/14, 83° 54' 35" East longitudes and 21° 41' 33" North latitudes) of Lakhanpur tehsil of Jharsuguda district in the centre. The area falls under Survey of India Toposheet No. 64O/13 and 64O/14. This area is called buffer zone or present area of investigation or study area. Buffer zone is shown in map No-1.1. Buffer zone is bounded by following coordinates

Table-1.2 : Coordinates of buffer zone

Coordinates	North	South	East	West
Longitude	83° 54' 32.04"	83° 54' 32.04"	84° 01' 11.88"	83° 48' 39.24"
Latitude	21° 46' 53.04"	21° 36' 3.61"	21° 41' 53.52"	21° 41' 53.52"

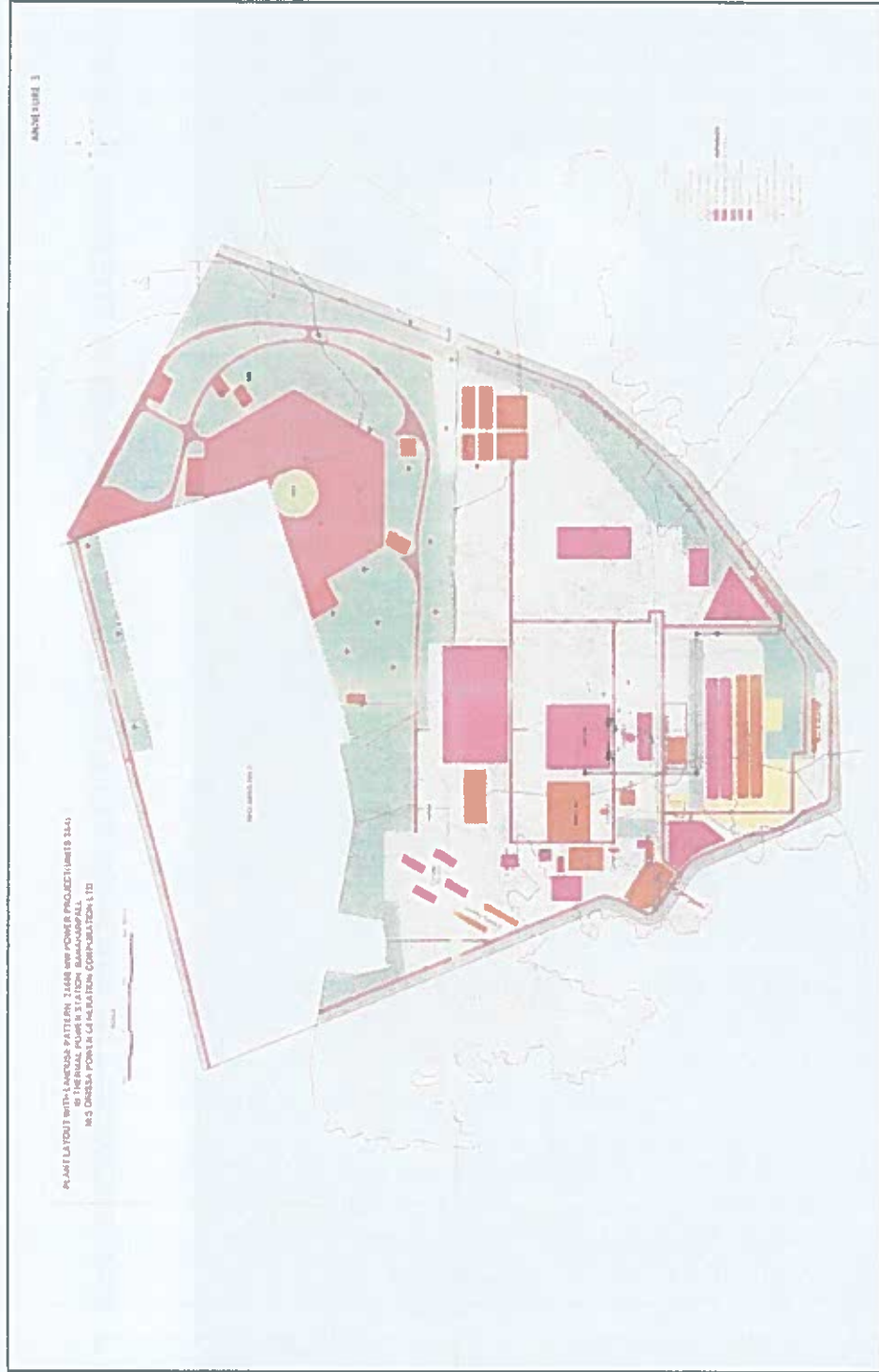
Block wise area coverage of buffer zone is shown on next page



Map-1.1: Map Showing Location of Study Area



MAP-1.2: MAP SHOWING LOCATION OF PLANT SITE &ASH PONDS OF IB THERMAL POWER PLANT



MAP-1.3: LAY OUT PLAN OF PLANT SITE

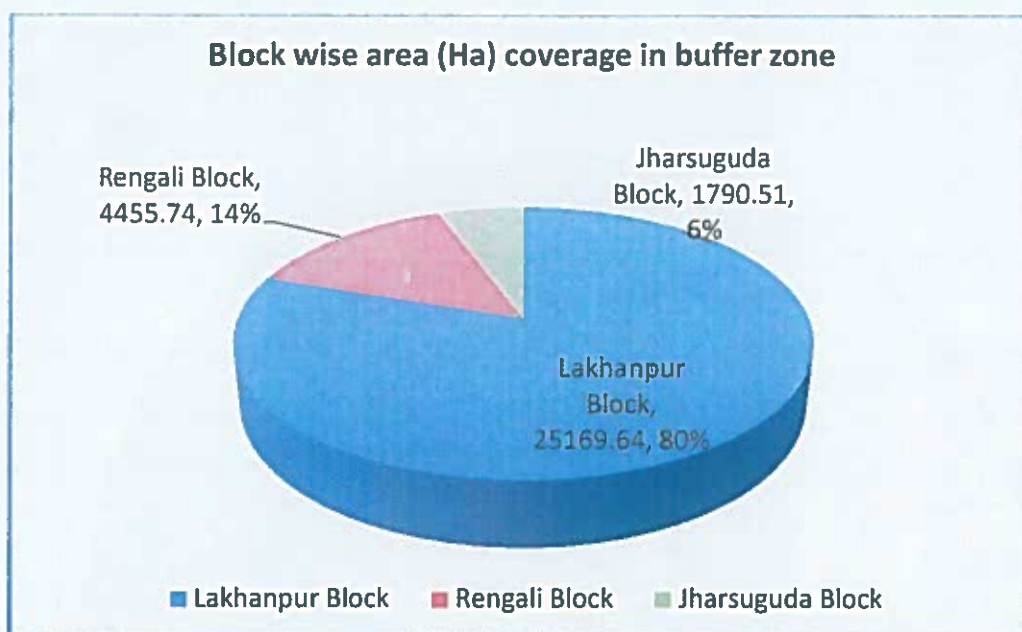


Fig- 1.1: Block wise area coverage in buffer zone

1.5. Objective and Methodology of study:

Objective: The following objectives were taken into account for hydro-geological investigation of the study area.

1. To assess the present hydrological scenario of the study area.
2. To find out aquifer geometry in the area.
3. To evaluate the status of ground water condition in the area.
4. To evaluate the hydraulic behavior of the aquifer system in the area.
5. To assess the ground water resources of the area.
6. To find out the hydro chemical character of water resources in the present area.
7. Requirement of possibility in ground water quality and soil contamination due to plant and ash pond activities.

Methodology for Study: To achieve the goal, it becomes essential to evaluate the exact hydro-geological conditions, aquifer parameters and aquifer geometry etc. for this purpose data were collected from the reports available in Central and state Government departments.

The geology of the area and subsurface conditions has been interpreted based on the exploratory data and geological studies made by Directorate of Ground Water Development, Govt. of Odisha & other central government agencies.

Intensive well inventory of the area have been undertaken to measure the status of the water table in the study area.

The water samples were collected for analysis in order to establish the water quality.

To evaluate the aquifer parameter pump test have been conducted in surrounding area where the rate of depletion in water level at constant pumping rate were observed. The aquifer parameters were calculated using standard analytical technique to field conditions of testing site.

The hydro-chemical behaviour of ground water has been evaluated based on the analytical results of the water sample collected in the field.

Beside the above, technique of remote sensing and GIS were adopted for the preparation of various thematic maps. This powerful tool provides reliable multi spectral, multi-temporal information on various natural resources in spatial format. It has an important role in effective mapping and periodic monitoring of natural resources and environmental processes. In this regard following steps were followed.

1. Data pertaining to Use of Remote Sensing Data: IRS P6, LISS III, Precision
2. Geo-coded data and Topo sheet NO 64O/13 and 64O/14.
3. Preparation of base map from topo sheet.
4. Data analysis using visual interpretation techniques by IRDAS software.
5. Ground truth studies or field checks.
6. Digitization and finalization of the map.
7. Topology construction in GIS environment and preparation of various thematic maps.
8. Area calculation for statistics generation.

Chapter-2

Hydrometeorology

The area is characterized by extreme climate with very hot (42 °C) summer and very cold winter (4°C) winter. It experiences tropical and humid climate which shows three distinct seasons viz summer, rainy and winter. The summer is very hot and dry starting from March and continues till end of May or early June. The rainy season lasts from early June to end of September. October and November are the post monsoon months followed by a cold winter which lasts till end of February.

2.1. Rainfall: The south - west monsoon is the principal source of the rain fall in the area. The average annual rain fall of the area is 1283.8mm. The rain fall data of Jharsuguda district for the period of last 5 years (2013 to 2017) has been taken into consideration. The monthly and yearly patterns of rain fall during last 5 years (2013-2017) in the area are graphically represented in Fig-2A and 2B. Mean Annual rainfall in Jharsuguda district for the same period is tabulated below.

Table-2.1: Monthly and yearly rainfall pattern in Jharsuguda district.
(Source of Rainfall data: IMD)

Year/ month	2013	2014	2015	2016	2017	Average
Jan	1.4	0	13.2	0.3	10.7	5.12
Feb	9.6	12.1	3.5	19.5	0	8.94
Mar	6.8	6.8	3	18.7	6	8.26
Apr	35.4	3.2	34	0.1	2	14.94
May	17.1	16.2	7.5	16	63.5	24.06
Jun	175.8	87.3	182	77.4	209.4	146.38
Jul	411.1	411.4	487	257.2	413.6	396.06
Aug	267.9	420.7	444	422	300	370.92
Sep	165.2	284.5	260.5	263.8	236.1	242.02
Oct	193.5	39.7	3.3	35.1	90.7	72.46
Nov	0	0	0	0	0.1	0.02
Dec	0	0.9	25.5	0	0	5.28
Total	1283.8	1282.8	1463.5	1110.1	1332.1	1283.8

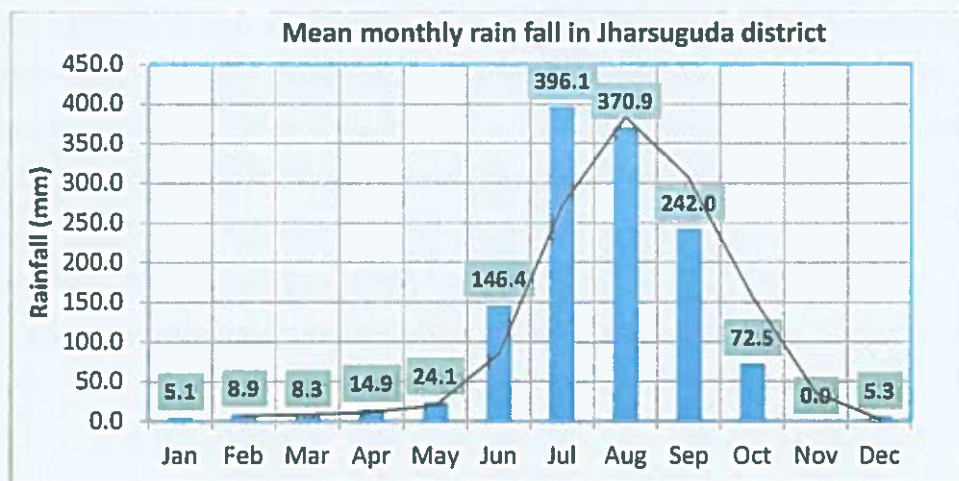


Fig-2A: Mean monthly rain fall in Jharsuguda district

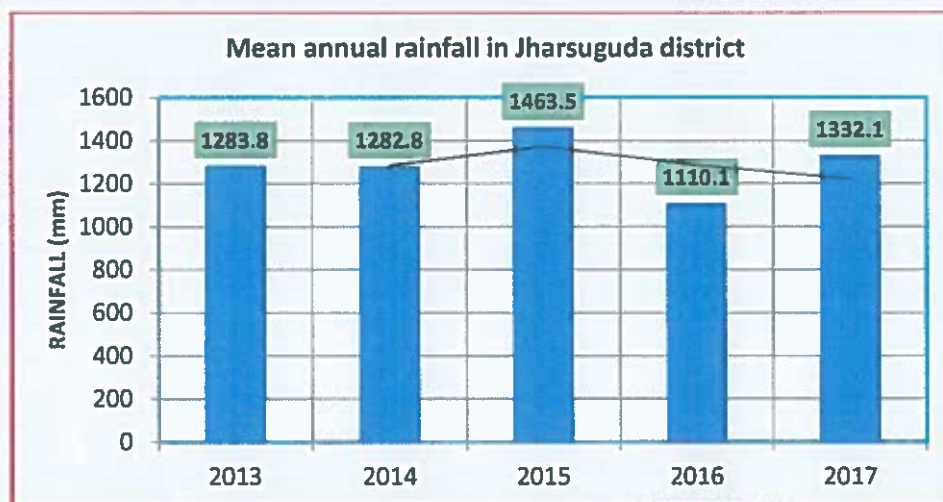


Fig-2B: Mean annual rainfall in Jharsuguda district

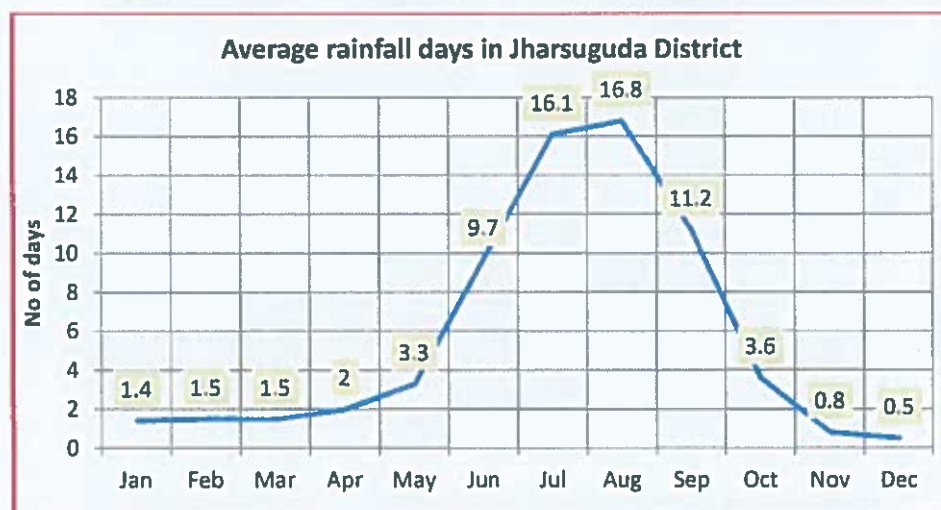


Fig-2C: Average rainfall days in Jharsuguda District

2.2. Temperature: The area experiences a wide variation in temperature in respect of both day and night and seasonal. Generally, winter starts from late November and continues till mid of February. December is the coldest month. In Jharsuguda district monthly minimum temperature varies from 11.9°C to 27.4°C with the general of 20.50°C and monthly maximum temperature varies from 27.2°C to 41.9°C with the general mean of 32.62°C. In summer day and night temperature increases rapidly from March and by the end of the May the daily maximum temperature goes up to 41.9 °C. The data shows that the temperature goes up to maximum of 41.9°C in summer and comes down to a minimum of 11.9°C in winter. Data pertaining to temperature variation is tabulated and graphically shown below -

Table-2.2: Variation in minimum and maximum temperature at Jharsuguda.

Month	Average Temperature (°C)	Minimum Temperature (°C)	Maximum Temperature (°C)
Jan	19.9	12.3	27.5
Feb	22.3	14.5	30.2
Mar	26.9	18.7	35.1
Apr	31.5	23.7	39.4
May	34.6	27.4	41.9
Jun	32.1	26.8	37.4
Jul	27.6	24.6	30.7
Aug	27.6	24.6	30.6
Sep	27.8	24.4	31.3
Oct	26.4	21.6	31.2
Nov	22.2	15.5	28.9
Dec	19.5	11.9	27.2
Average	26.53	20.50	32.62

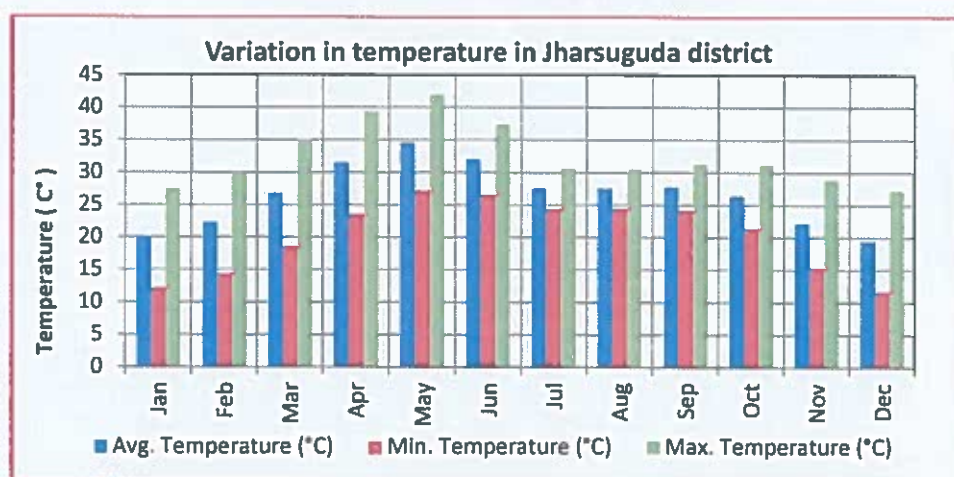


Fig-2D: Variation of temperature in Jharsuguda district

2.3. Relative Humidity: In general air is dry except in monsoon period. Monthly mean relative humidity varies from 40 to 86 %. The monthly mean temperature data is shown as below-

Table-2.3: Variation in morning and evening relative humidity (%) at Jharsuguda

Month	RH %	Month	RH %	Month	RH %	Month	RH %
Jan	61	Apr	40	Jul	86	Oct	77
Feb	55	May	40	Aug	86	Nov	67
Mar	45	Jun	61	Sep	85	Dec	64

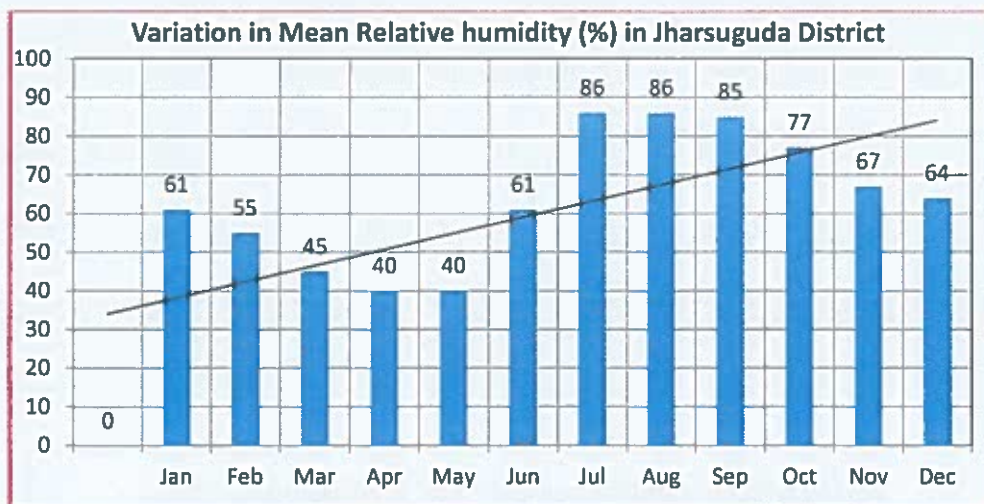


Fig-2E: Variation in Mean Relative humidity (%) in Jharsuguda District

2.4. Wind Velocity: In general wind velocity is moderate with some increase in speed in summer and monsoon season. Winds are mostly blown from southwest to Northeast directions during monsoon period. In the cold season winds are mainly from west or north while in the summer wind blows from variable directions. Generally, wind speed varies from 14-28 Km/Hr. for 250 days and rests of the days are calm.

2.5. Cloudiness: Nearly during eight months period of winter and summer sky is clear and bright except a few days when it shows light cloud. During monsoon moderate to heavy clouds are common.

2.6. Potential Evapotranspiration: The Potential Evapotranspiration is maximum in the month of May and minimum in the month of December.

Source of data: Temperature and Relative Humidity: Directorate of Economics and Statistics, Wind velocity, Cloudiness and potential evaporation, department of agriculture, Govt. of Odisha.

Chapter-3

Demography, Cropping Pattern and Land Use Pattern

Collection of Data: As the study area falls under Lakhanpur block of Jharsuguda district all the data pertaining to demography, cropping pattern, Irrigation potential and land use pattern of Lakhanpur block has been shown in following paragraphs.

3.1: Demographic Data: Total population of Lakhanpur tehsil is 142047 with 72097 male, 69950 female and 15024 children. The SC & ST population of the block comes to 27281 (19.2 %) & 46508 (32.7%) respectively. The details are tabulated as below.

Table-3.1: Demographic data of Lakhanpur block District –Jharsuguda.

(Source: Directorate of Economics and Statistics, Govt. of Odisha)

Block	Male	Female	Children	Total	SC	ST	Others	Total
Number	72097	69950	15024	157071	27281	46508	68258	142047
%age	45.90	44.53	9.57	100	19.2	32.74	48.05	100

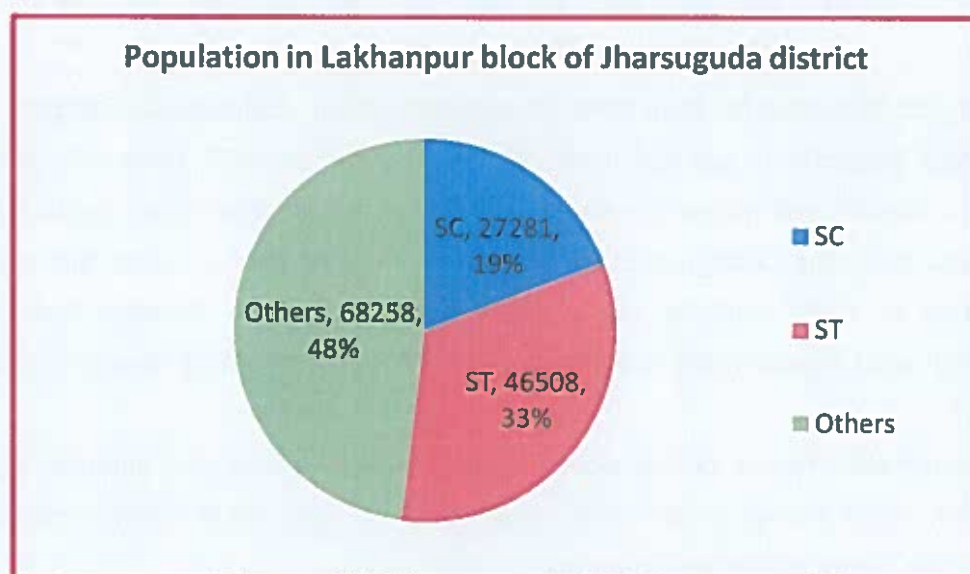


Fig-3. A: Population in Lakhanpur block of Jharsuguda district

3.2: Cropping pattern: Crop wise area coverage and irrigation status in Lakhanpur tehsil as collected for district agricultural planning of Jharsuguda district, Govt. of Odisha, is as below.

Table-3.2: Crop wise irrigation status in lakhanpur block

Crop	Kharif (Area in Ha)			Rabi (Area in Ha)			Total Area (Area in Ha)		
	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total	Irrigated	Rainfed	Total
Cereals	5123.5	3719	8842.5	210	0	210	5333.5	3719	9052.5
Coarse cereals	0	368	368	20	0	20	20	368	368
Pulses	0	1726	1726	240	840	1080	240	2566	2806
Oil seeds	0	758	758	375.6	475	850.6	375.6	1233	1608.6
Fibres	0	15	15	0	0	0	0	15	15
Other crops	2815	1837.9	6284	525	810	2350	3340	3647.9	6987.9
Total	7938.5	8423.9	16362.5	1370.6	3125	4510.6	9309.10	11548.9	20858.0

Table-3.3: Crop wise irrigation status in lakhanpur blocks (contd.)

Crop type	Kharif (Area in Ha)		
	Irrigated	Rain fed	Total
Fruit crop	0	1632	1632
Vegetable crops	1200	1251	2451
Loose flowers	15	5	20
Cut flowers	4	0	4
Plantation crops	0	313	313
Spices	307	357	664
Total	1526	3558	5084

3.3. Land Use Pattern: It is as below.**Table-3.4: Land use pattern in Lakhanpur block**

Particulars		Area(Ha)
Total geographical area (ha)		98197
Area under agriculture	Gross cropped area	20858
	Net sown area	24000
	Cropping intensity (%)	86.91
Area under forest		9514
Waste land & area under other uses		64683

Chapter-4

Soil, Drainage, Topography and Geomorphology and Land Use Pattern

4.1.1 Soil Types: The soils of the study area have been developed mostly from massive granitic formations Precambrian age and sandstone and shale types of sedimentary formations of Carboniferous and Lower Permian period. These soils are gray to red colour, medium texture, containing gravels, and quartz, sand and ferruginous concretions. Its physical and chemical characteristics markedly show a little variation in the area. Based on the physical and chemical characteristics, mode of the origin, and its nature of occurrence, soil of the area have been recognized as Alfisols, Inceptisols and Entisols etc. Description of each type of soil is as below.

1. Alfisols (Matured red and lateritic soil): The Alfisols, in the buffer zone, include red sandy soils and red loamy soils and red gravelly and lateritic soil. These are matured red and lateritic soil. These soils predominantly occupy high and medium land throughout the buffer zone. Alfisols are neutral to slightly acidic in nature (pH varies from 5.5 to 7.0). The characteristic features of red soils are (i) light texture, porous and friable structure, (ii) absence of lime kankar and free carbonates and (iii) soluble salts in small quantity usually not exceeding 0.05%. These are usually deficient in nitrogen, phosphate, organic matter and lime. These soils are suitable for cultivation of paddy and other crops.

2. Inceptisols or Mixed Gray Soil: These are the most dominating soils in buffer zone. These soils are reddish colored soils having pH range in 6.2 to 6.95. Texturally these soils are sandy having mostly fine grained sands mixed with, moderately sluggish clays containing altered and decomposed feldspars minerals. Fertility is generally moderate as moisture holding capacity is good.

3. Entisols or Unaltered soil with coarse parent materials: These are the least dominating soils in buffer zone. These soils are generally found along river courses and nala channels. These are reddish gray colored soils having pH range in 6.0 to 7.00. Fine sand and silts are generally mixed to form loam. Fertility is generally good.

4. Unclassified soil like mud flats: The red clayey soil covers the northern and central part of buffer zone. Texture of this type of soil is clayey to loamy and in composition deficient in nitrogen, phosphoric acid and humus.

Soils of the buffer zone are generally having average to good fertility status. All common types of crops can be grown in the area.

A generalized statistical data of occurrence of these soils are as below-

Table-4.1: Occurrence of Soils in Area

S. No	Soil Types	Area (km2)	Percentage
1	Alfisols: Matured Red & lateritic soil	30.5	9.71
2	Inceptisols:-Mixed gray soil	254.2	80.91
3	Entisols: Unaltered soil with Coarse parent materials	4.62	1.47
4	Unclassified soil	25.2	8.02

Soils are shown in map No-4.1.

Soils are graphically represented in a pie diagram as below.

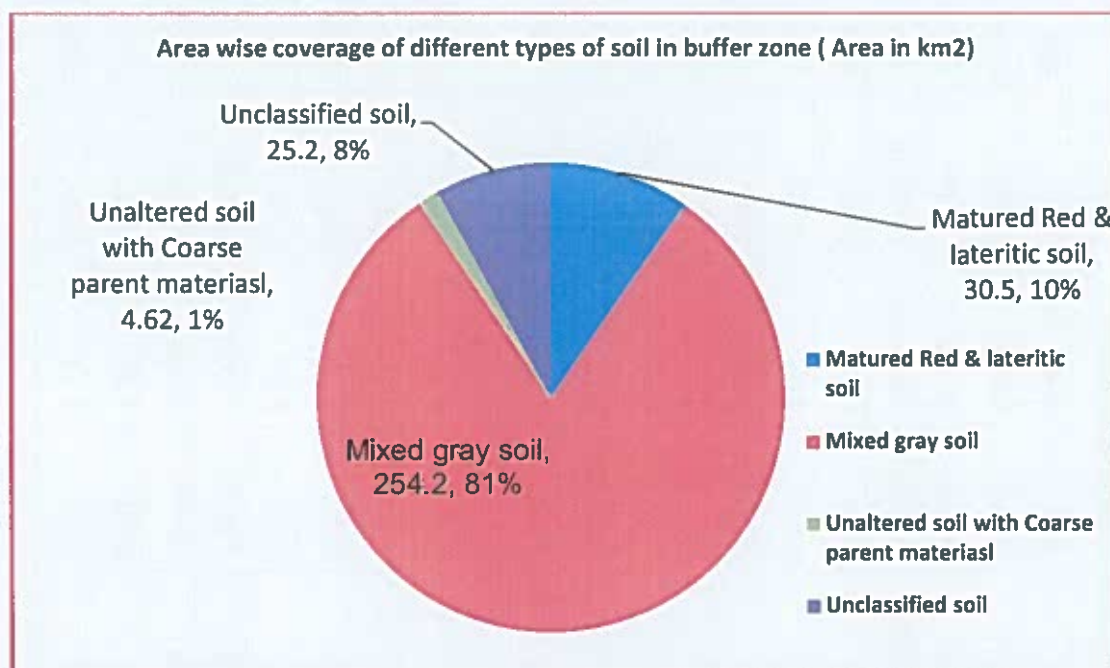


Fig-4A: Area wise coverage of different types of soil in buffer zone (Area in km2)

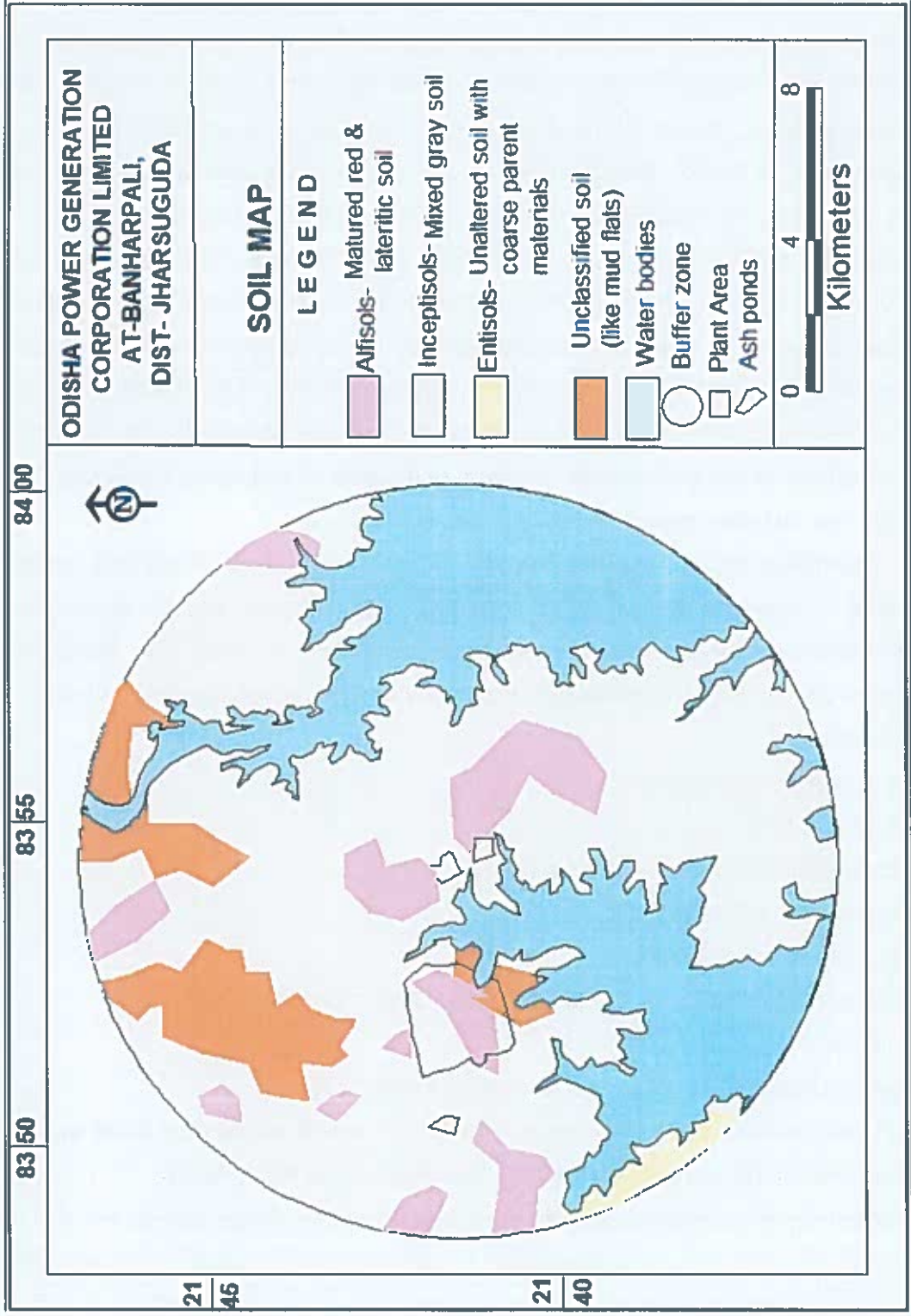
4.1.2: Chemical analysis result of soils: Seven number of samples were collected by auguring methods down to a depth of 30 cm below ground surface. Locations of these samples and their chemical analysis are tabulated below.

Table 4.2: Location of soil samples

Sample No	Location	Sample No	Location
S-1	Near BGRE benching plant	S-5	Between ash pond A&B
S-2	Ware house site	S-6	West of Sahajbahal
S-3	Near Ash pond A (Bhaludole)	S-7	West of Rengali village
S-4	Near Ash Pond B		

Table-4.3; Soil Analysis Report

S. No	Parameters	Units	S-1	S-2	S-3	S-4	S-5	S-6	S-7
1	Soil Texture	-	Clayey sandy	Clayey sandy	Clayey sandy	Clayey sandy	Clayey sandy	Clayey sandy	Sandy clayey
2	Colour	Yellowish	Reddish	Yellowish	Reddish	Yellowish	Reddish	Yellowish	
3	pH		6.95	6.90	6.88	6.78	6.55	6.85	6.92
4	EC	(μ S/Cm)	122	178	112.5	116	168.5	120.3	1.30
5	Bulk Density	(gm/cc)	1.04	1.22	1.12	1.18	1.085	1.066	1.27
6	Sand	%	47	56	46	44	52	50	43
7	Silt	%	24	22	29	23	22	28	30
8	Clays	%	29	22	25	33	26	22	27
9	Organic matters	%	1.55	1.76	1.89	1.82	1.55	1.38	1.63
10	Nitrogen	(mg/kg)	2.6	2.5	2.8	3.12	2.56	2.48	2.45
11	Phosphorous	(mg/kg)	1.1	1.5	1.2	1.35	1.45	1.28	1.36
12	Potassium	(mg/kg)	0.88	0.69	1.02	0.85	0.92	0.78	0.88
13	Magnesium	(mg/kg)	2.58	2.36	2.58	2.65	2.45	2.84	2.69
14	Chloride	(mg/kg)	48.55	125.6	128.35	108.56	120.35	122.5	146.8
15	Copper	(mg/kg)	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
16	Zinc	(mg/kg)	1.56	2.25	2.06	1.88	1.95	2.15	2.42
17	Boron	(mg/kg)	0.06	0.08	0.10	0.12	0.06	0.05	0.075



MAP-4.1: SOIL MAP

4.2: Drainage: The drainage of the study area is mainly controlled by the Ib river which is a tributary of Mahanadi river. IB river flows along eastern part of buffer zone with flow direction from north to south and falls into Hirakud Reservoir. Hirakud reservoir is marked in buffer zone covering its major part in southern portion of buffer zone. In the study area other sub tributaries and nalas are also significant during both monsoon and post monsoon period. Most of them are either intermittent streams or contain a little water during dry season. The drainage analysis of the study area implies that the highest order of stream segments is of 5th order as per the classification of Strahler (1952). A decrease in number of channel's with increase in stream order is found. The drainage density of the study area is medium. The factors controlling the drainage density are lithology, infiltration capacity, vegetation cover, climate, surface features like relief, slope etc. and runoff intensity index. The hard rocks like granites which occurring in part of the study area are more resistant to stream erosion and gives low drainage density. In comparison to granitic terrain area occupied by sedimentaries has higher drainage density. The overall drainage pattern of the study area is dendritic in nature. and the drainage is influent in nature, which contribute to the groundwater recharge of the area in addition to the rainfall.

Drainage map of buffer zone is shown as map No 4.2.

4.2.1: Quantification of surface runoff: For quantification of surface runoff generated in monsoon season water shed map was prepared encompassing ash ponds. Catchment area of water shed was computed as 1292 Ha. Following calculation can be done for estimation of runoff by applying simple formula as below.

Runoff- CIA

Where C is catchment factor

I is the rainfall in m.

A is the catchment area of water shed in m².

Catchment area: 1292 0000 m²

Rainfall: 1284 mm or 1.284 m

So runoff generated will be = $12920000 \times 1.284 \times 0.80 = 12961344 \text{ m}^3$

Or 12.96 MCM

So in water shed total runoff generation will be 12.96 MCM.

Similarly in Plant area of 88.57 Acres or 358430 m², runoff will be 0.36 MCM and in ash pond area of 150 acres or 607050 m², the same will be 0.609 MCM

Water shed map of core zone encompassing ash ponds are shown as map No 4.3

4.3. Topography: The study area represents a wide physiographic variation, marked by hills, isolated hillocks, and undulating plains. A part of Hirakud reservoir having 185.6 Kms is an important landmark in the area. The hills and isolated hillocks are also present in a scattered manner in buffer zone occurring as linear ridges or residual ridges trending E - W. The general elevation of land surface ranges from less than 100m to more than 450m above mean sea level. Most part of the study area has slope 10- 20m/km.

4.3.1: Topography of ash pond: It is a plain area with the general topography sloping towards the south and south west. Rengali and Kantaritika villages are the nearby villages situated adjacent to the ash pond B and at an elevation of 185 & 200 m (amsl) respectively. Towards northeastern side of ash pond, the land is more or less flat in nature where agricultural activity is practiced. The ash pond B is fully exhausted and reclaimed by partial vegetation using grass species. 'Regarding ash pond A, which is presently active and the ash generated at OPGC is unloaded in the form of ash slurry in it. The pond ash from Ash pond A is removed and transported to nearby industries for their consumption in cement industry and brick making.

The drainage pattern is dentritic.

4.3.2: Topography of plant area: Topographical plant area is characterized by a bit undulation and flat pediments with general elevation ranging from 200 to 220 msl from eastern to western boundary. The drainage pattern is dentritic.

4.4. Geomorphology: Physiographically the area is characterized by a moderately degraded pediplanes with moderate undulation terrain and sporadically scattered and elongated hills and mounds. The area is mainly represented by all varieties of land forms such as pediplanes, pediments, isolated hillocks, denudated outcrops and undulating plains etc. Moderately resistant rock constitutes the ridge ranges rising to a maximum height of 382 m. above M.S.L in Chandangiri Dungri. In general elevation ranges from 180 to 220 m m a m s l. The wide spread undulating planes in the area is traversed by Hirakud reservoir in the southern part of buffer zone. The general slope of the area is from north to south.

Satellite remote sensing techniques coupled with aerial photo interpretation have been utilized for identification of various terrain features like geological structures, hydro geomorphic units and fractures/lineaments etc. The area has been divided into various hydro geomorphic units based on visual interpretation of IRS-LISS-III F.C.C. on 1:2, 50,000 Scale and aerial photo interpretation on 1:25,000

scale. The study area falls in the Ib river sub basin. The area presents moderate physiographic variations characterized by highly rugged and moderately undulating and planes topography. The geomorphological map of the area is given in map as Map-4.4

Hydro geomorphological maps prepared from land sat (and IRS-LISS-III data and from aerial photo interpretation, described in the following hydromorphic units. Their area wise occurrences in buffer zone are as below.

Table-4.4: Occurrence of various hydro geomorphic units in buffer zone

S. No	Hydrogeomorphic features	Area (Ha)	%
1	Pediment	13331.38	42.44
2	Water Body	11720.63	37.31
3	Pediplain	3755.20	11.95
4	Denudational Hills	2513.13	8.00
5	Flood Plain	95.56	0.30
	Total	31415.89	

Burried Pediments: This hydro geomorphic unit is the most dominating occurring in the entire study area and cover almost 42.44% (13331.38 Hectares) of study area. It is characterized by undulated topography, moderate slope, thin alluvial cover, higher elevation as compared to pediplanes. It is identified on remotely sensed data by its light red to red tone with irregular boundary outline, elongated shape, gentle slope and moderate relief. The thickness of the hydro geomorphic zone varies from place to place and favours a good amount of water to circulate within this zone before reaching the deeper zones. This is traversed by numerous fractures and joints especially in the granitic terrain. Saturated thickness of aquifers varying from 15-20 m. favors good amount of water to circulate within their zone before reaching the groundwater reservoir consisting of deeper fractured zones. Groundwater potential is poor to moderate and this unit is suitable for dug wells and dug-cum-bore wells. Drainage pattern is dendritic, with low drainage density. Land use is largely agricultural activity with small patches of natural vegetation, but at some places scrubland is also found.

Pedi planes: Pedi planes form the second most predominant unit widely distributed in entire buffer zone and cover nearly 3755.20 hectares (11.95%). These pediplanes are defined by lithology consisting of unconsolidated sediments of sand, silt and gravels at the top followed by sedimentary formations. It is delineated on IRS FCC by its bright red to white tone exhibited by cropland and fallow land respectively. It shows smooth texture and extensive agricultural activity. It shows sharp contact with buried pediment with irregular boundary outline. The major land use activity is agriculture. However at places natural tree cover is also reported intermingled with cropland. The relief is defined by gently slopping surface towards the south defined by the course of Ib River. These pediplanes mostly present gently undulating topography with a thickness of weathered residuum 15 to 25 meter. These weather zones form very good shallow aquifers.

Denudational Hills: The denudational hills are the third dominating hydro geomorphic unit and occupy almost 8 % (2513.13Hectares) of land in study area. These are mostly subjected to denudation due to prolonged weathering. Precambrian rocks represent this geomorphic landform in the area and are identified by their high relief. Rate of infiltration is very poor except along fractures/joints. These generally act as run-off zone and are located in south eastern part of the study area.

Flood pane: This unit is having very little dominance in the area (95.56Ha) i.e.0.30%. These are made by the river deposits during flood period.

Lineaments: Major lineaments are picked up from satellite data interpretation. Most of them are trending in NE-SW and NNE-SSW direction.

Graphical representation of the area occupied by various geomorphic units is shown in the following pie diagram.

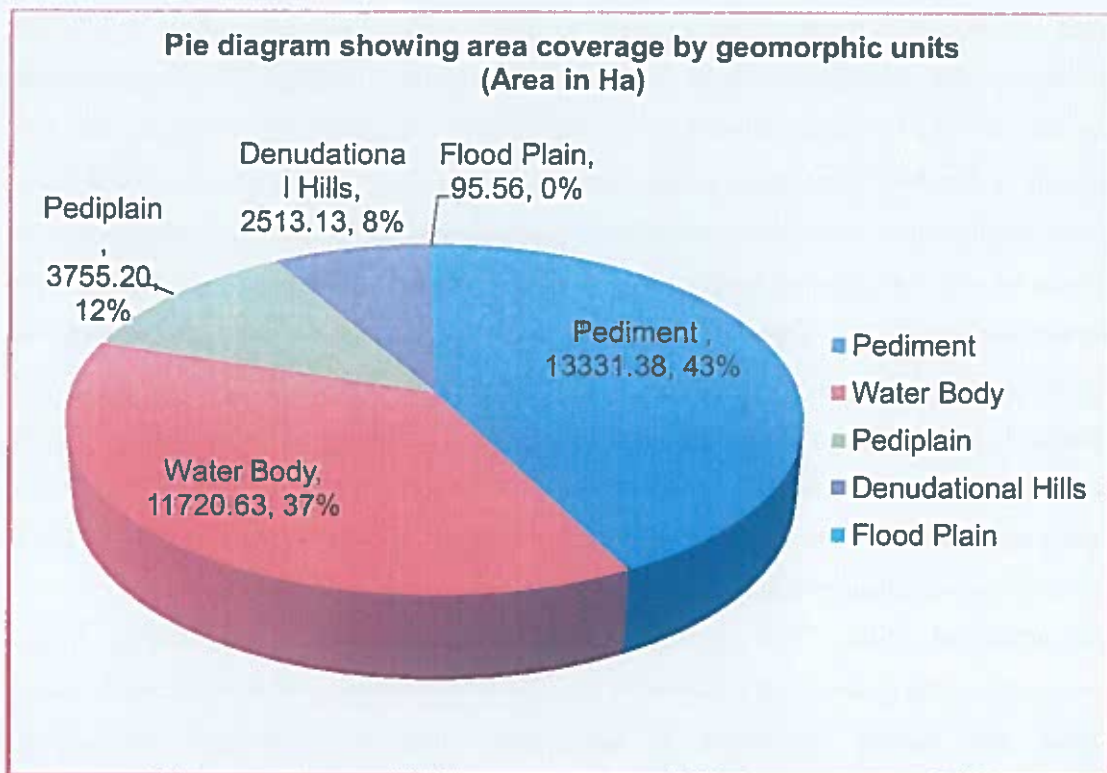
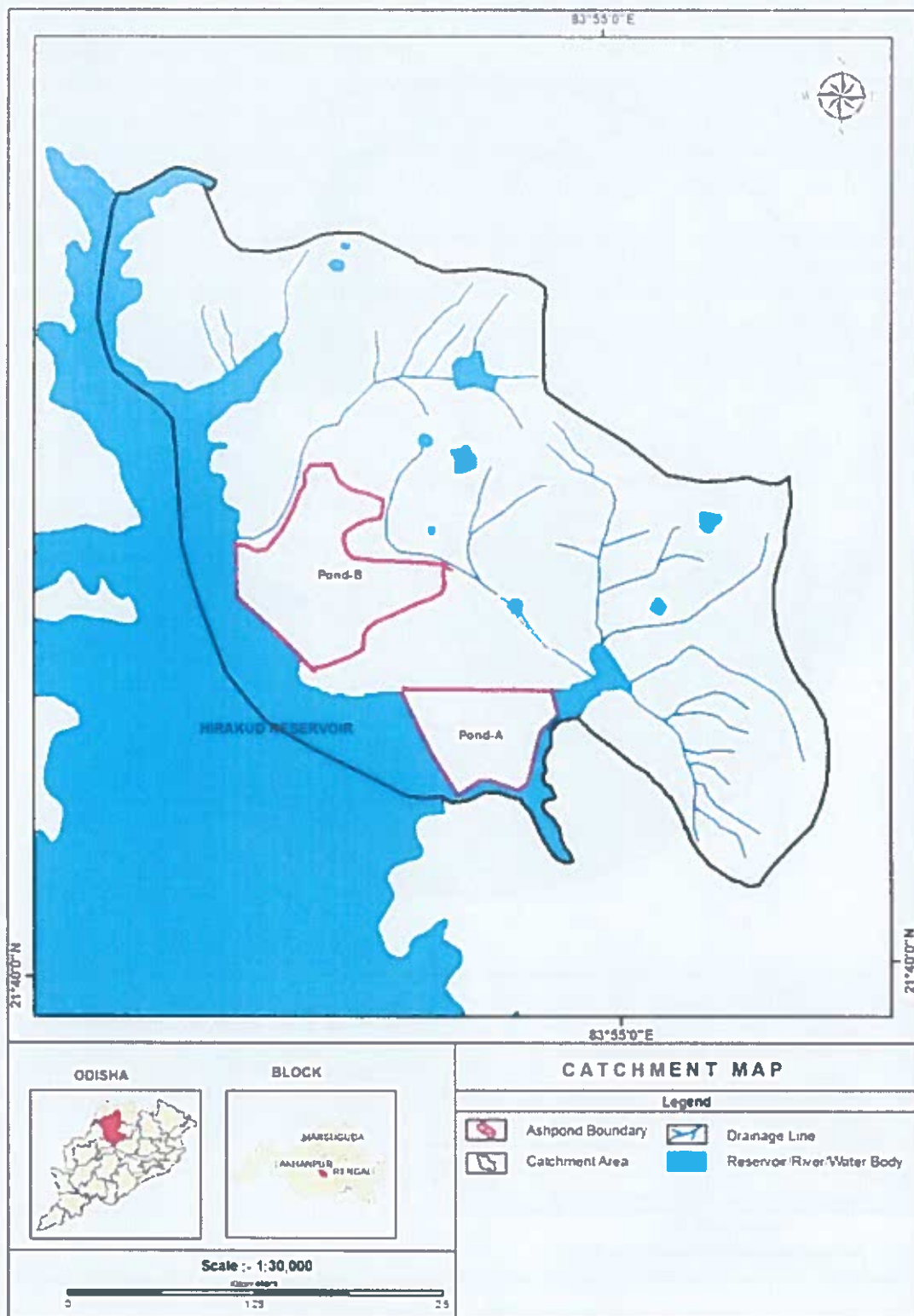


Fig-4B: Area coverage by Geomorphic units

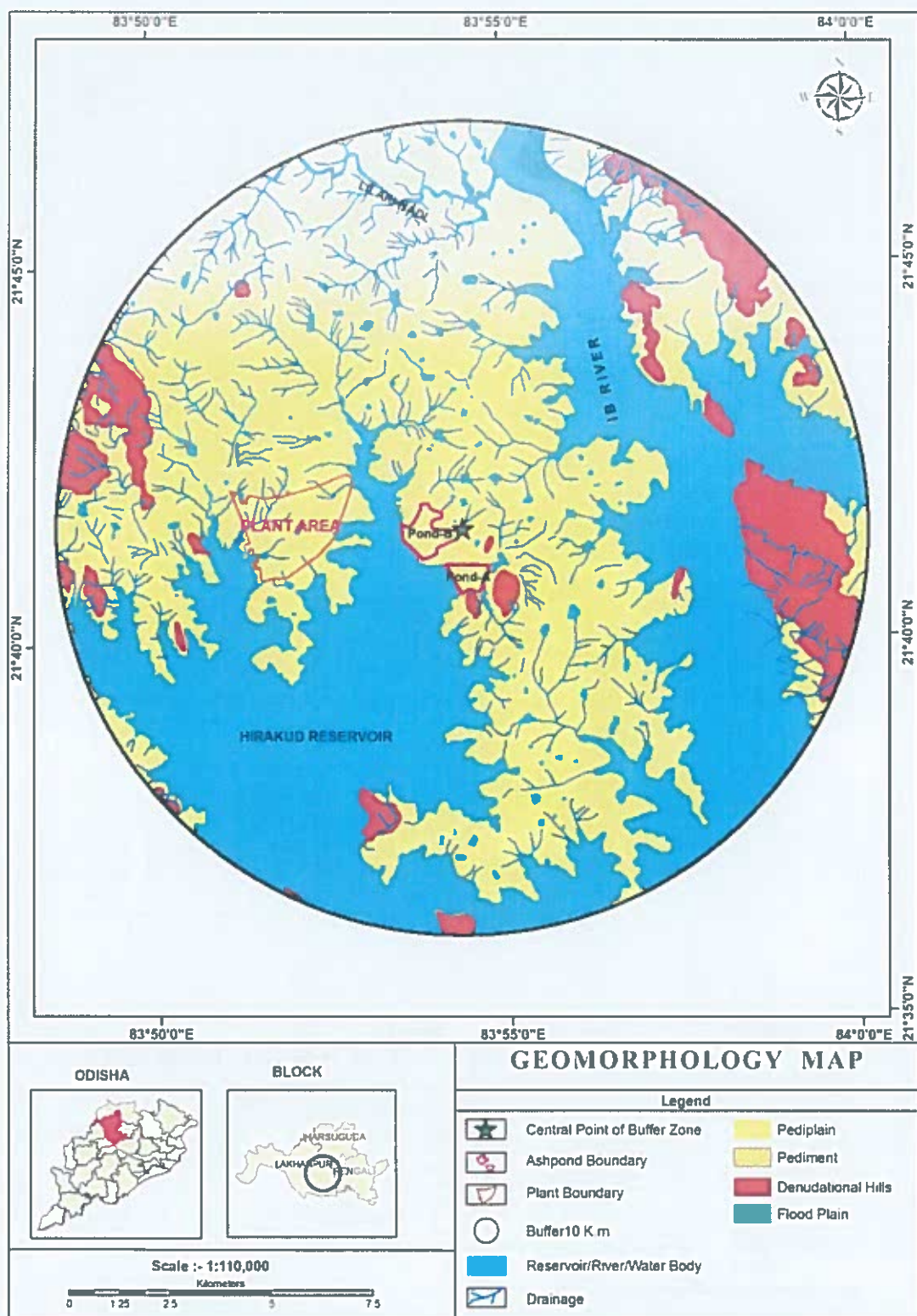
Geomorphological map of the area is shown in map No-4.4.



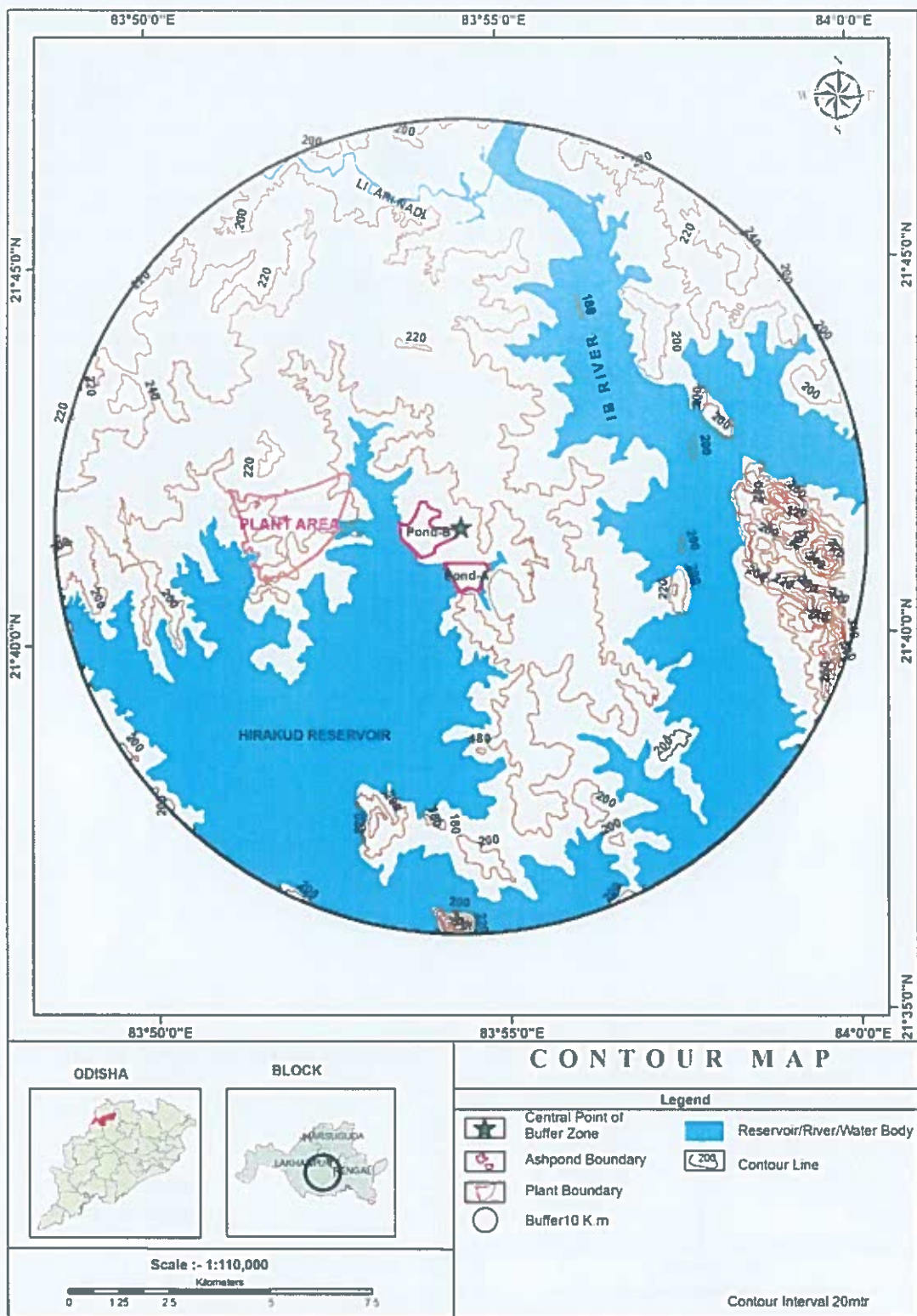
MAP-4.2: DRAINAGE MAP



MAP-4.3: WATER SHED MAP



MAP-4.4: GEOMORPHOLOGICAL MAP



MAP-4.5: CONTOUR MAP OF BUFFER ZONE

4.5: Land Use Pattern: The dynamic pattern of human uses of the land resource is collectively known as land use pattern, which depends upon natural resources, natural hazards, socio- cultural and economic factors. The land use for agricultural purpose primarily depends upon topography, soil types (i.e. fertility) and irrigation potential. The land use for silviculture depends upon growing need of forest products, suitability of lands for other use and climatic factors. The land use for urbanization and industrialization depends upon morphology, resources availability and socio - economic factors. The tropical monsoon climate with good rainfall and soil type, of the area make it ideal for vegetation growth and development. The forest of the area can be classified as "Dry deciduous forest". Out of the total geographical area of 314 sqkm, an area of about 28.92 sqkms (9.2%) is covered by forests. These forests are characterized by Teak, Bamboo, and Sal etc.. Besides these Babul, Harida, Bahada, Mahua, Simuli, Palash and Chakhunda etc are also found. Being nearer to the human habitation, these forests have suffered severely with respect to deforestation in almost all parts of the buffer zone. The land use pattern of the buffer zone is shown in following table and map No 4.6.

Table-4.5: land Use pattern in buffer zone

S.No	Land use features	Area (Ha)	%
1	Agriculture Land	10076.11	32.07
2	Ash Pond	221.30	0.70
3	Dense Forest	2892.08	9.21
4	Industrial Area	595.23	1.89
5	Land with scrub	3467.87	11.04
6	Plantation	674.87	2.15
7	Settlement	1157.28	3.68
8	Swampy/Marshy Area	233.27	0.74
9	Reservoir/River/Water bodies	12097.89	38.51

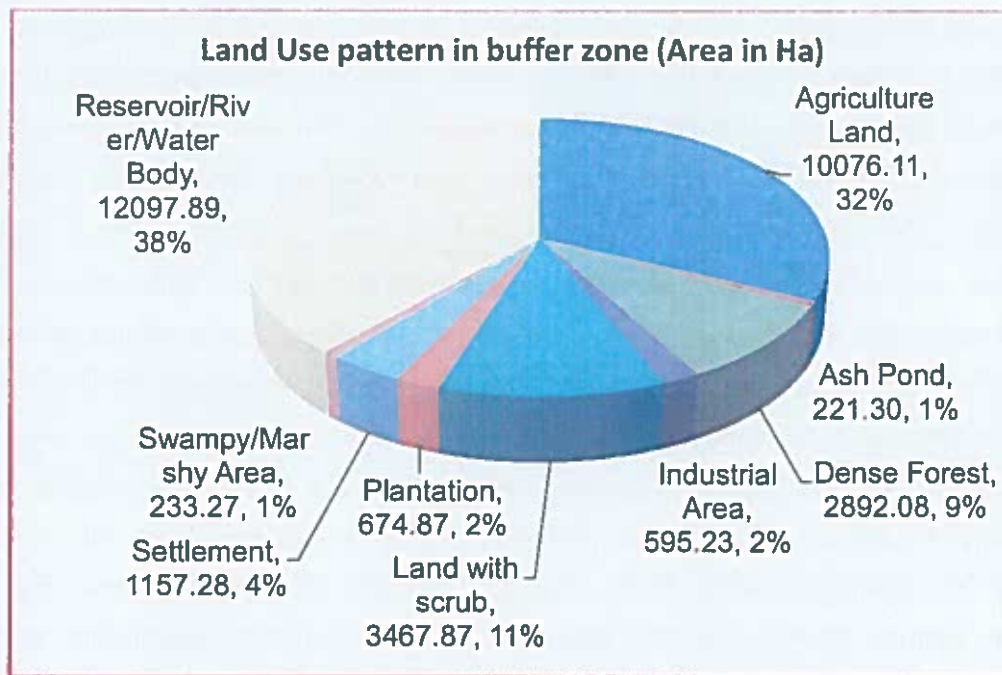
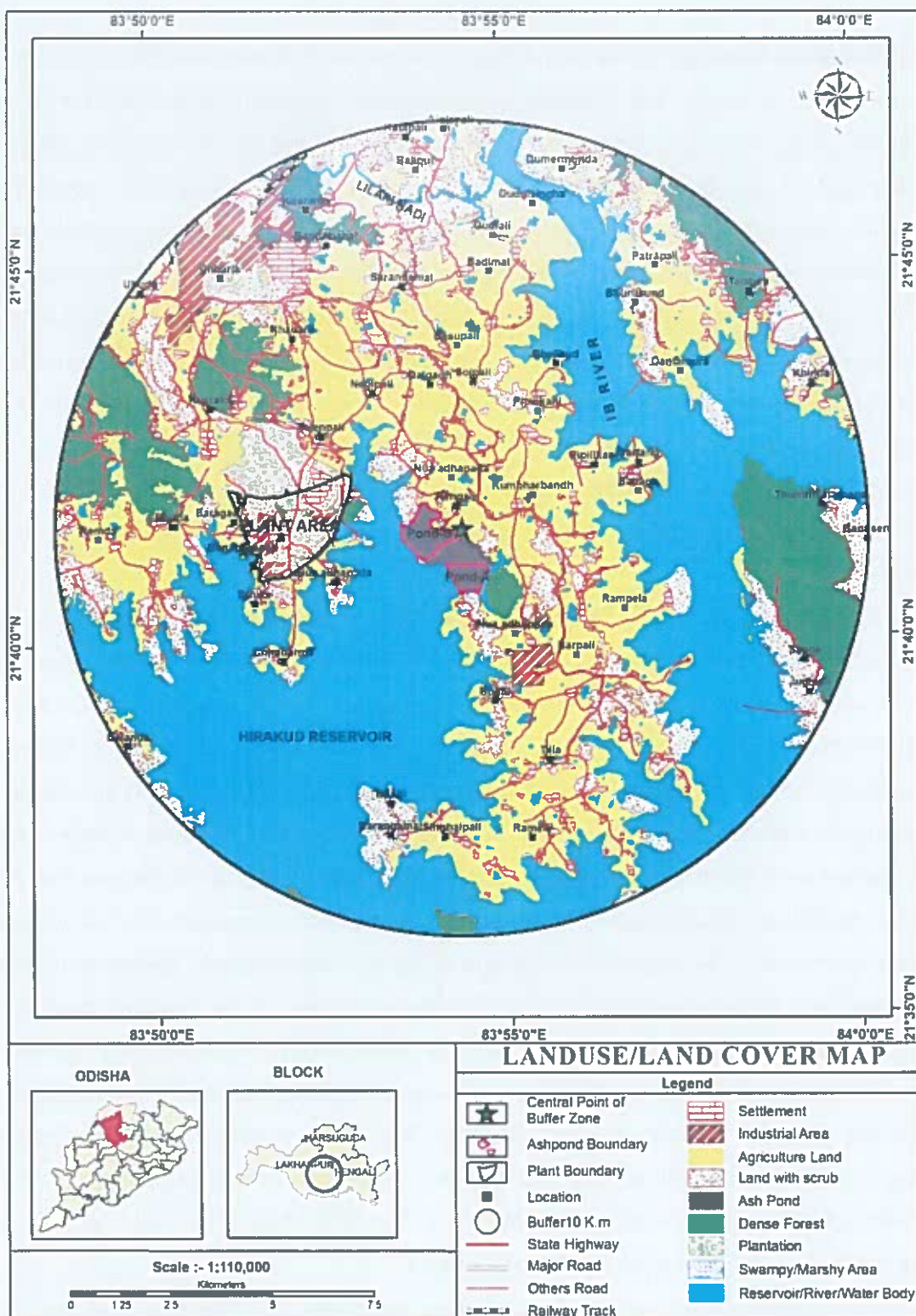


Fig-4C: Land Use pattern in buffer zone (Area in Ha)



MAP-4.6: LAND USE AND LAND COVER MAP OF BUFFER ZONE.

Chapter- 5

General Geology

5.1: Regional Geology: IB valley geology is considered as regional geology around present area of study. The Ib-valley coalfield derives its name after the river Ib, a tributary of the river Mahanadi and represents a part of the NE-SW trending master basin belt of the Son-Mahanadi valley. The river flows in a general southerly direction through the coalfield and discharges into Hirakud reservoir, which has submerged the southern fringe of the coalfield. The Ib-valley comprises Hingir basin in the north and the Rampur basin in the south. Though the Gondwana sediments spread further north-west into the adjoining parts of Chhatisgarh state and comprise the Mand-Raigarh and the Korba coalfields, the limits of the Ib-valley coalfield are defined by political boundary and covers parts of Sambalpur, Jharsuguda and Sundargarh districts of Odisha. The coalfield extends over an area of 1460 sq km and is bounded by latitudes 21°31'N and 22°14'N and longitudes 83°32'E and 84°10'E.

5.2: Geology of IB Valley: The Geological map of the Ib-valley coalfield area is shown in the following map. The stratigraphic succession as shown in following table starts with Precambrian rocks at the base. Gondwana Formations consisting mainly the Talchir, Karharabari, Barakar, lower Kamthi (Raniganj) and upper Kamthi Formation overlie the Precambrian rocks and at the top recent deposits are found. The upper Kamthi Sediments are of Triassic and other are of Permian time. The Karharabari and Barakar Formations are the major coal bearing formations the Ib-valley coalfields, though rare occurrence of coal seams in Raniganj Formation has been reported by GSI. Based on the status of present knowledge of surface and sub-surface data, there appears to be a total of 5 coal seams in the Ib-valley coalfield. The Ib-seam, being the bottommost seam is successively overlain by the Rampur seam, the Lajkura seam, the Parkhani seam and the Belpahar seam. Out of these, only the Ib seam belongs to the Karharabari Formation whereas the other seams belong to the Barakar Formation. The Belpahar and Parkhani seams possess a poor reserve of coal and are intersected with a number of dirt bands for which emphasis has not been given on the study of these seams.

Gondwana sedimentary rocks spread further northwest into the adjoining part of Chhatisgarh and comprise the Mand-Raigarh and Korba coalfields. The low hillocks formed by the Kamthi beds are the prominent topographic features of this basin. The

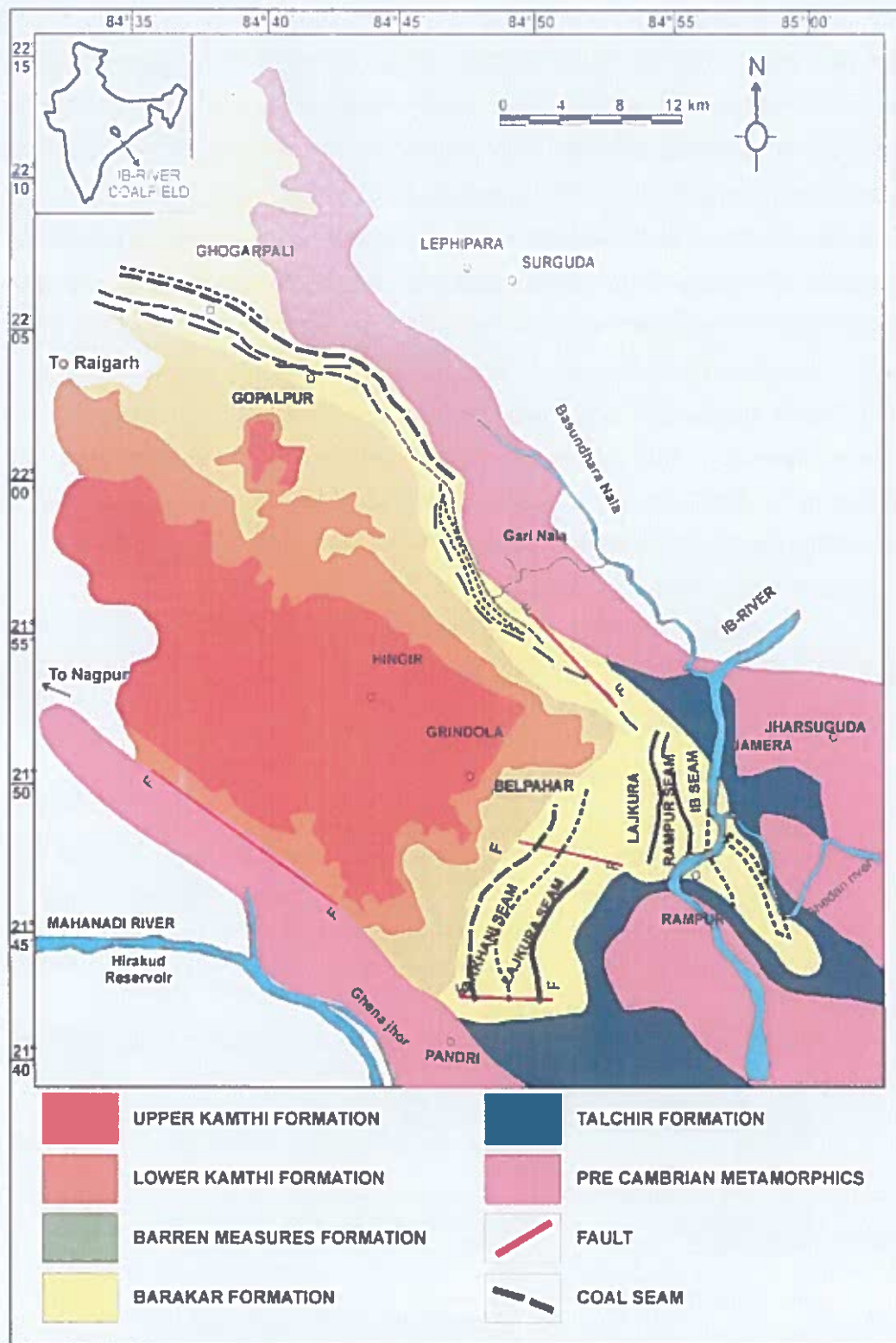
trend of the Gondwana basin is in close parallelism to the structural grain of the Precambrian rocks. The Ib River coalfield shows a westerly plunging synclinal flexure, which is like a half elliptical basin closed towards the northwest and having an axial trend in a NW-SE direction. This coalfield represents a synformal basin with an arcuate long northern limb. The Gondwana strata of this basin are affected by a large number of normal faults and the southern boundary of the basin is marked by the Southern Boundary Fault juxtaposing the Barren Measures and Raniganj formations against Precambrian rocks. The most important fault system in this basin is a set of longitudinal faults, which are aligned generally in a NW-SE to E-W direction. These are parallel to the axial trace of basement fold structures and are often contemporaneous with the sedimentation (GSI, 1997). This coalfield was also considered to be free from igneous activity and resultant devolatilization of coal in spite of its high geothermic gradient. Geology of Ib valley is shown in map No-5.1

Discretion of existing stratigraphic formations is as below.

Table-5.1: Stratigraphic Succession in IB valley

Group	Age/Formation	Lithology	Thickness in metre
Quaternary	Recent & sub-recent	Alluvium, laterite, gravels and conglomerate	
Gondwana Group	-----unconformity----- <u>Upper Permian</u> Kamthi (Upper)	Pebbly sandstone, ferruginous sandstone and red shales	Up to 100
	Kamthi (Middle) or Raniganj	Fine grained sandstone, silt stone, coal seams (thin).	60 – 80
	Kamthi (Lower) or Barren Measures	Grey shales, carbonaceous shales, sandstone, clay and ironstone nodules	300
	<u>Lower Permian</u> Barakar	Grey sandstone, carbonaceous shale, silt stone with thick coal seams and fire clay	300-600
	Karharbari	Grey sandstone, carbonaceous shale, Black carbonaceous sandstone, pebble bed, coal seams	90-125
	<u>Upper Carboniferous</u> Talcher	Diamictite, greenish sandstone, olive and chocolate shales, rhythmites.	60 - 150
	-----unconformity----- <u>Pre cambrian</u> Proterozoic	Quartzite, schist, slate, sandstone, shale	
Chattisgarh Group	-----unconformity----- Archaean	Basic dykes, Granite ,gneisses, migmatites , schists, amphibolites	

Source: All geological informations have been collected from GSI, Govt. of India



MAP-5.1: MAP SHOWING GEOLOGICAL MAP OF IB VALLEY (after GSI)

Precambrian basement: The Precambrian rocks, over which the Gondwana sediments were deposited, are exposed all around this basin. Migmatitic granite gneisses, amphibolites, schists and quartzites are generally found in this basin, which are traversed by pegmatites and vein quartz.

Talchir Formation: Several parallel and continuous exposures of Talchir rocks extend in a south-easterly direction and join up with those of the Talcher coalfield. It comprises greenish sandstones with dispersed clasts and rhythmites with groove casts, fine-grained ripple laminated sandstones and olive and chocolate coloured needle shales. Thickness is around 130 metres.

Karharbari Formation: Sandstone sequence occurring above the Talchir Formation with a gradational contact has been referred as Karharbari Formation on purely lithostratigraphic considerations as any Karharbari type mega-fossil has not been recorded so far. This sequence contains one thin coal seam, the Ib seam. The thickness of the Karharbari Formation varies from 90 to 125 m.

The strata of Karharbari Formation are restricted to the north-western margin around Siarmal and Gopalpur areas and gradually wedge out towards the centre of the basin, where they are not observed. These are the product of rapid sinking and quick deposition and comprise proximal facies containing conglomerates, carbonaceous sandstone with unaltered feldspar grains and thin coal bands (below Ib seam) (GSI, 1997).

Barakar Formation: It occurs as a crescent shaped area west of the river Ib. The outcrop extends from west of Rajapur in the north to south of Ubra in the south-east of the Ib River. A narrow strip of Barakar beds extends for a length of about 15 km up to the Bhedan River. This formation comprises a series of low, parallel ridges of sandstone bodies interspaced with valleys occupied by shale and coal seams. The Barakar sequence consists of grayish white to pink, medium to coarse grained, micaceous, sub-arkosic sandstones with calcareous and ferruginous cement, grey micaceous shale, carbonaceous shale, alternating bands of shale and sandstone, fireclay and thick coal seams. Sandstones are generally current bedded. Flaser bedding and penecontemporaneous deformation structures like slump balls, load casts, sand dykes, minor folds and faults are observed. Maximum thickness is around 600 metres. The thickness of Barakar Formation is not uniform in the Ib River basin. These strata are about 500 m thick in the central Ib basin, while in the north-western Himgir sub-basin they never exceed 350 m (GSI, 1997). However, Barakar

Formation may be classified into Lower and Upper Barakar on the basis of palaeobiology.

Upper Member: Interbanded sequence of fine to medium grained sandstone, grey shale, claystone, siltstone, carbonaceous shale, fireclay and thick coal seams with major ironstone bands.

Lower Member: Arkosic, coarse to granular to pebbly sandstone with minor grey shale and carbonaceous shale horizon with thick coal seams

Barren Measures Formation: In course of investigation in western Brajarajnagar, Chaudhury (1988) reported the development of Barren Measures conformably overlying the Barakar strata at Kusranoi area. The lithological attributes of these sediments are in close accordance with the Barren Measures of Damodar Valley. Earlier maps included this within the Barakar Formation. The formation comprises mostly grey shales, carbonaceous shales, sandstones and clay ironstone shales. It is generally devoid of coal seams, though some lensoid coal bands are occasionally recorded. Typical Barren Measures microfossil assemblages dominated by striated disaccates and monosaccates miospores (*Densipollenites* sp. and *Striatopodocarpites* sp.) are recorded in these strata, which strongly supports its assignment to Barren Measures Formation (GSI, 1997).

Kamthi Formation: The Kamthi Formation has an overlapping relationship with underlying sediments covering a large area of Ib River basin. During investigation through drilling by Geological Survey of India in the northern part of Ib River coalfield, Chaudhury (1988) has indicated that Kamthi Formation can be classified into Lower and Upper parts. The lower part has been compared with Raniganj Formation. Raniganj Formation (=Lower Kamthi) is reported to be coal bearing. Chaudhury (1988) first reported the development of this Formation in the southern limb in Rohini area and distinguished it as Raniganj (Lower Kamthi) Formation. The continuity of this formation was proved later in the northern limb of the basin (GSI, 1997).

The upper part has been denoted as Upper Kamthi Formation. The Permian sediments show conformable relationship up to the Raniganj (Lower Kamthi) Formation, which marks the termination of Permian sedimentation. Overlying the Raniganj (Lower Kamthi) strata with an unconformity, the rocks of Upper Kamthi Formation rest on the lensoid bodies of conglomerate and initiate with red shale bed. This formation, except for few red shale beds, is arenaceous comprising coarse-

grained sandstone mingled with pebbles and reworked clasts and shows large scale tabular and trough cross bedding (GSI, 1997)

Laterite and Recent gravel: Laterite occurs as patches and attains a thickness of 3 to 4 m at places. It is generally restricted to areas occupied by the Barakar beds. Irregular bodies of recent gravel and conglomerate occur on the higher contours in the proximity of the Ib River. The deposit is predominantly made up of well-rounded quartzite boulders and pebbles of diverse shape and is lateralised at places.

5.3: Geology OF Jharsuguda district: The area exposes a wide spectrum of rock types. The Peninsular Gneiss comprising augen gneiss and migmatite represent the oldest rocks of Archaean to Lower Proterozoic age in the area. They occupy a gently undulating terrain east of Jharsuguda. A small body of massive granite, the Tamparkola granite, of Lower Proterozoic age occurs as an isolated exposure near Dulesra. A narrow linear strip of metasedimentary rocks consisting of quartzite, quartz-sericite schist, phyllite and mica schist occurring near Laikera belongs to Upper Bonai Group of Lower Proterozoic age. Well consolidated, soft and foliated rocks of Gangpur Group of Lower Proterozoic age comprising phyllite and mica schist are well exposed here. A practically un metamorphosed sedimentary sequence of rocks occur near to the western corner of the district. This sedimentary sequence can be broadly divisible into a sequence of shale, calcareous shale and quartzite forming the Raipur Group and coarse sandstone and quartzite forming the Chandarpur Group of the Chhattisgarh Super Group. The Gondwana Super Group of sedimentary rocks are confined to fault bounded basin and occur in the central part of the district around Belpahar, Brajarajnagar areas. Among Talcher and Barakar Formations of Lower Gondwanas, the latter is the store house of 'bituminous coal' in the region. Kamthi Formation consisting of conglomerate, sandstone, shale, red clay etc. represents the Upper Gondwanas in the area.

Soil, alluvium and laterite are the younger formations in the area. Laterite occurs in small, isolated, irregular outcrops, spread almost all over the above rock types. The unclassified soil/alluvium of the Quaternaries occupy large area in the Mahanadi river valley and over the gneissic country, east of Jharsuguda.

Non coking coal seams are associated with the Barakar Formation in the Ib river basin. The total reserve in the Ib-River Coalfield (Jharsuguda, Sambalpur, Sundargarh) is measured in the order of 21681.68 million tonnes, a substantial chunk of which occurs in this district. Presently, coal from this coal field feeds the

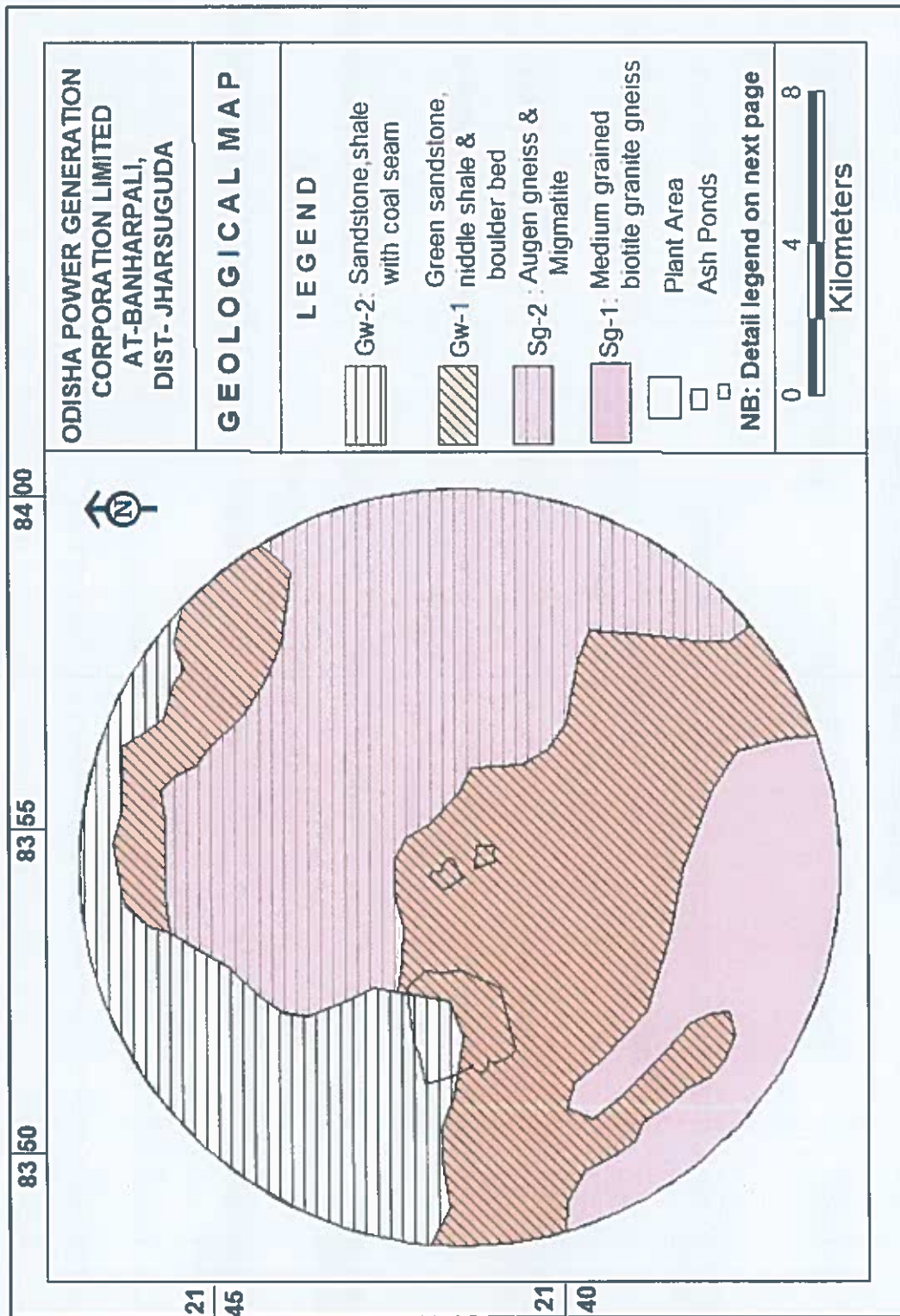
thermal power station at Banaharpalli, located in the district. Fireclay occurs in the Ib River Coalfield in the form of lenticular bands in the Barakar Formation. Fireclay deposits are reported from Belpahar, Jurabag, Darliapali and several other places. Tata Refractories Ltd. (TRL) is a major refractory plant in the state which thrives on the produce of the Belpahar fireclay mine. Diamond investigation is currently underway in the region based on encouraging results of the indicator minerals. Kuremal and Lakhanpur are some of the areas delineated for prospecting of diamond.

The district is divisible into three distinct geomorphic units: (i) pediplain, the gentle undulating plains in the south, (ii) ridges and valleys and (iii) denudational hills, the hilly terrain with rocky mounds and deep valleys. The drainage pattern is dendritic to sub-dendritic with a moderate drainage density and is primarily controlled by the Mahanadi, Ib and Bhedan rivers. Mahanadi river flows across the western part of the district, whereas, Ib and Bhedan rivers drain the eastern side and meet downstream. Mahanadi and Ib rivers finally drain the vast expanse of Hirakud reservoir.

5.4: Geology of Buffer zone: The buffer zone exposes lithological variation in terms of only four types of rocks. The Peninsular Gneiss comprising augen gneiss and migmatite represent the oldest rocks of Archaean to Lower Proterozoic age in the area. They occupy a gently undulating terrain in eastern part of buffer zone. A practically unmetamorphosed sedimentary sequence of Gondwana super group of rocks occur near to the north western part of buffer zone. The Gondwana Super Group of sedimentary rocks are confined to fault bounded basin and occur in the North western and south central part of buffer zone. Among Talcher and Barakar Formations of Lower Gondwanas, the latter is the store house of 'bituminous coal' in the region. Following geological succession is found in buffer zone

Table-5.2: A generalized geological succession in buffer zone.

Group	Age/Formation	Lithology
Lower Permian	Barakar	Grey sandstone, carbonaceous shale, with coal seams and fire clay
Upper Carboniferous	Talcher	Greenish sandstone, middle shales, and boulder beds.
Peninsular gneiss (Younger phase)	Archaean to Lr. Proterozoic	Augen gneiss and migmatite
Peninsular gneiss (Older Phase)	Archean	Medium grained biotite granite gneiss



MAP-5.2: GEOLOGICAL MAP OF BUFFER ZONE

LEGEND FOR GEOLOGICAL MAP

SYMBOL	LITHOLOGY	GEOLOGICAL UNIT	AGE	NATURE & CHARACTERISTICS
 Gw-2	Sandstone, shale with coal seams	Barakar formation (Gondwana Super group)	Permian	Soft layered sediments with rolling topography
 Gw-1	Green sandstone, needle shale & boulder bed	Talcher Formation (Gondwana Super group)	Carboniferous to Permian	Soft layered sediments with rolling topography
 Sg-2	Augen gneiss & Migmatite	Peninsular gneiss (Younger phase)	Archaean to Lower Proterozoic	Hard, compact, massive to foliated rocks
 Sg-1	Medium grained biotite granite gneiss	Peninsular gneiss (Older phase)	Archaean	Hard, compact, massive to foliated rocks

Source: All geological informations have been collected from GSI, Govt. of India

Chapter-6

Hydrogeology

6.1: Introduction: The occurrence and movement of ground water by and large, depends on the hydrogeological condition of the sub-surface formation. These natural deposits vary greatly in their lithology, thickness of weathering, texture and structure which in turn influence their hydrogeological characteristics. Depending upon the geological setup of the study area, water bearing and water yielding properties, three major hydrogeological units have been identified in the area.

1. Consolidated formation
2. Semi-consolidated formation
3. Unconsolidated formation

Hydrogeological properties of each formation is as below

Consolidated formations: Consolidated formations include rocks of Peninsular gneiss Super Group of Archaean to lower Proterozoic periods consisting of mainly medium grained biotite granite gneiss and Augen gneisses etc. These rocks are very hard and compact, and lack primary porosity. Due to intense weathering and fracturing secondary porosity developed in these rocks which form the repository and passage for movement of ground water. Ground water is stored mainly in the secondary porosity resulting from weathering and fracturing of the rocks. The aquifer materials are highly heterogeneous in character showing both vertical and lateral variations. The weathered residuum forms the main repositories of ground water, which occurs under water table conditions and circulates through deeper fractures and fissures. In these formations ground water occurs under water table condition in weathered part and under semi-confined to confined condition in deeper fractured parts of the rocks. The water yielding capacity of fractured rocks largely depends on the extent of fracturing, openness and size of fractures and extent of their interconnections into the near surface weathered zone.

Semi-Consolidated Formations:

These are represented by the rocks of Gondwana super group. Which occur as patches in north western and south central part of the buffer zone. Sandstone and shale are the main component of this group. Sandstone on weathering gives rise to loose sandy products. Groundwater occurs under water table condition in the shallow aquifers and in semi confined to confined condition in deeper aquifer. The

rocks mostly belong to Talcher formation overlain by thin cover of Barakar formation at places with a maximum thickness of 48.75 meter (as per data collected from the shallow bore wells). The thin cover of Talcher formation and Barakar formation act as good shallow ground water repository in the area. The Talcher formation due to hard and compact in nature and poorly developed joints and fractures etc do not form any good aquifer either at shallow or deeper depth.

Unconsolidated Formation:

The alluvial deposits of recent origin occur as thin discontinuous patches along the prominent drainage channels Ib river and its associated nalas. These mainly consist of silt, sand with gravel and pebble, which form potential shallow aquifers tapped through dug wells.

6.2. Water Bearing Properties of Major Litho Units:

6.2.1. Granite and Granite Gneisses: These are most predominant rock types in the area occupying undulating terrain and low-lying areas and covers almost 46% of the buffer zone. But for the purpose of hydrogeological studies area around the present water sheds have also been considered to assess the broad hydrogeological behavior of aquifer system. These are intensely weathered and highly jointed. The weathered residuum ranges in thickness from 12.6 to 18.2 m, average being 15.32 m and forms the phreatic aquifers suitable for development through open wells. The average yield of open well is 30 m³/ day. The water saturated fracture zones constitute deeper aquifers which are developed through bore well. Ground water development potentiality of these rocks is good. In these formations Pre-monsoon water level varies from 5.28 to 7.22 m and during Post-monsoon it varies from 1.85 to 5.4 m. The seasonal fluctuation has been observed from 1.65 to 2.56 m with an average of 2.11 m. Data of shallow bore wells indicate the length of casing pipe used vary from 12.6 to 18.2 m. Yield in shallow tube wells vary from 0.5 lps to 1.6 lps, while in case of deeper aquifer it vary from 0.6 to 0.8 lps, Transmissivity has been computed as 0.38 m²/day to 0.63 m²/day in bore wells at Banharpali. The granitic rocks form the most potential aquifers both at shallow and deeper depth. Ground water may be developed through dug, dug cum bore and bore wells. The available data on existing ground water structures indicate that ground water development is mainly through dug wells, shallow and deep bore wells. The potentiality of the

deeper aquifers has been explored by deep drilling down to a maximum of depth of 120 m. It is found that though saturated fracture was encountered at the depth range of 35 to 120 m but majority of the fractures are restricted within 100 m depth. The maximum numbers of fracture zones were encountered in the depth range of 34 to 90 m. Generally, 2 to 3 fractures are encountered during drilling of a bore well constructed up to 120 m. This indicates the occurrence of saturated fracture within 100 m depth is very common. Details of data regarding bore wells constructed by State Govt. agencies are tabulated below.

Table-6.1:-Details of Shallow bore wells in Granite-gneiss formations in buffer zone

S.No	Location	Depth (mbgl)	Length of Casing (mbgl)	Fracture's depth (mbgl)	SWL (mbgl)	Yield lps
1	Gudiali	39.2	14.7	32.50,37.50	6.3	0.5
2	Pipilikani	35.7	15.7	32.60,34.30	7.22	0.8
3	Kumbharbandh	23.5	12.6	17.60,22.50	5.75	1.2
4	Ramela	45.8	16.2	22.80,35.60,42.30	5.48	1
5	Balanda	46.1	14.5	28.30,44.70	6.52	1.6
6	Basupali	43.7	18.2	36.20,44.50	5.28	0.6

6.2.2. Sandstone and Shales: These are the semi-consolidated formation belonging to Lower Gondwana group of Rocks. Sandstone on weathering gives rise to loose sandy products. Groundwater occurs under water table condition in the shallow aquifers and in semi confined to confined condition in deeper aquifer. The average depth of weathering is 7.05 m. Depth of water level varies from 5.68 to 5.88 during Pre-monsoon period and from 2.48 to 2.85 m during Post-monsoon period. The seasonal fluctuation has been observed from 3.03 to 3.20 m with an average of 3.12 m. Depth of open well varies from 7.35 to 6.75 m. Diameter of well is generally 1.25-1.5 m. In shallow tube wells depth varies from 28.75 to 48.75 m with an average of 37.30 m. In these tube wells yield varies from 0.3 to 2.5 m³/hr. Deep tube wells in the area were constructed for exploration purpose up to depth of 153.85 m.

Two to three sets of ground water potential zones were encountered and yield varies from 9 to 12.6 m³/hr. details of some of shallow tube wells constructed for drinking water for rural areas are as below

Table-6.2: - Details of Shallow bore wells in Sandstones and shales formations in Buffer zone.

S.No	Location	Depth (mbgl)	Length of Casing (mbgl)	Fractur's depth (mbgl)	SWL (mbgl)	Yield Ips
1	Kirarama	46.5	22.4	32.50,44.50	7.16	0.75
2	Patrapali	45.6	22.5	26.80,44.0	6.48	0.75
3	Ubuda	42.8	23.6	29.50,41.0	5.88	1.5
4	Bandhbahal	41.2	18.2	27.50,39.80	6.12	0.5
5	Talabira	40.5	20.6	34.50,38.60	5.67	1.2
6	Kusraloi	34.5	12.6	21.30,32.60	6.06	0.6
7	Telenpali	36.8	13.5	23.60,35.8	6.55	0.75
8	Rengali	32.5	12.4	15.70,31.30	5.68	0.5
9	Remda	28.3	13.6	15.70,27.50	6.45	1
10	Baragad	32.6	22.3	24.50,30.80	7.23	2
11	Banaharapali	40.25	21.2	22.50,38.50	6.25	2.5
12	Bhutia	36.4	14.5	17.50,35.60	4.92	0.3
13	Barpali	26.8	12.6	15.60,25.40	5.67	0.5
14	Tilia	36.8	12.4	25.6,30.20,36.80	6.34	0.5
15	Katapali	38.5	20.6	26.0,37.50	4.72	1.5
16	Khadam	44.5	22.5	28.5,34.70,43.50	5.7	0.5

6.3. Aquifer characteristics of deeper aquifers: To assess the aquifer characteristics in the area six numbers of exploratory wells (three numbers in granite-gneiss formations and three in sandstone and shale formations) were conducted to assess the aquifer parameters and its geometry. The principle behind the estimation of Transmissivity of deeper aquifer of a bore well is that the recovery of water level in a well after the pump is shut off can be simulated by continuing pumpage as before, and recharging by an imaginary recharge well at the same rate during the recovery period. Under such conditions the residual drawdown s' , i.e. the

difference between the drawdown component due to continued pumpage and the recovery component due to recharge is given by Theis (1935):

$$s = \frac{Q}{4\pi T} \left[\log_e \left(\frac{4Tt}{r_w^2 S} \right) - \log_e \left(\frac{4Tt'}{r_w^2 S'} \right) \right]$$

Where Q = constant discharge

s' = residual drawdown

r_w = effective radius of well in which the water level recovery is measured.

t = time since pumping started

t' = time since pumping stopped

If storage coefficient remains constant and equal (S during pumping = S' during recovery) and $u = r^2 S / 4Tt'$ is sufficiently small, the above equation is simplified to

$$s = \frac{2.303Q}{4\pi T} \log_{10} \frac{t}{t'}$$

The procedure for data analysis is to plot s' against t/t' in semi- logarithmic paper, with s' on the arithmetic scale and t/t' on the log scale. After the value of t' becomes sufficiently large, the observed data should fall on a straight line. The slope of this line gives the value of $\log_{10} t/t'$. For convenience, the value of t/t' is chosen one log cycle apart, so that its logarithm becomes unity. The above equation is simplified to:

$$T = \frac{2.303Q}{4\pi \Delta s'}$$

Where Q = constant discharge, in m^3/day and $\Delta s'$ = change in residual drawdown in meters per log cycle of t/t'

Due to limited facilities available, measurement during pumping could not be taken. After stopping the pump recovery measurements were taken. The data obtained during recovery was plotted on a semi log graph paper. The t / t' - (Ratio of time since pump started and time since pump stopped) was plotted on logarithmic scale and residual draw down data on normal Y scale. A straight line matching the points was drawn. An arbitrary point is taken on slope of the graph and accordingly another point is also fixed at a difference of one log cycle.

6.4: Aquifer characteristics of deeper aquifers: Pumping tests were carried out in bore wells constructed in the different formation in different seasons viz. Post Monsoon, Pre-monsoon and Monsoon seasons etc.

Aquifer characteristics of deeper aquifers during Post Monsoon Period: Pumping tests carried out in bore wells constructed in the different formation show that water level varies from 2.73 m to 6.10 m. Yield of the wells varies from 2.16 m³/hr to 5.76 m³/hr. Transmissivity value varies from 0.38 m²/day to 1.75 m²/day. The specific capacity varies from 0.98 to 3.10 l p m /m of drawdown. The results of the pumping tests are summarized below.

Table- 6.3: Summarized details of pumping tests conducted in bore wells

Particulars	Test-1	Test-2	Test-3	Test-4	Test-5	Test-6
Location	Banharpali	Banharpali	Banharpali	Balanda	Pipalikani	Kumharbandha
Formation	Sst & Shale	Sst & Shale	Sst & Shale	Biotite Gr.Gneiss	Augen gneiss	Augen gneiss
Depth (m)	100	100	100	120	110	120
Casing length (mbgl)	20	20	25	25	22.50	15
Water Level (mbgl)	2.73	6.10	4.5	5.85	4.75	5.25
Duration of pumping (min)	160	120	120	150	180	150
Yield (m ³ /hr)	2.16	2.88	2.7	4.5	5.4	5.76
Pumping Water Level (m)	39.52	37.45	38.52	36.56	31.25	36.17
Residual Draw Down (m)	36.79	31.35	34.02	30.71	26.50	30.92
$\Delta S = m$	25.20	20.0	24.50	10.25	13.60	17.60
Transmissivity m ² /day	0.38	0.63	0.5	1.11	1.75	1.44
Specific capacity (lpm/m)	0.98	1.53	1.32	3.44	2.80	3.10

The details of tests carried out in different seasons along with data and graphs are shown as below.

Season	Data in Graphs	Data in table
Post Monsoon	From graph 6.4 A to 6.4 F	From Table 6.4 A to 6.4 F
Pre- Monsoon	From graph 6.4 G to 6.4 L	From Table 6.4 G to 6.4 L
Monsoon	From graph 6.4 M to 6.4 R	From Table 6.4 M to 6.4 R

FIG-6.4 A: Plotting of RDD vs t/t' Data for a Yield Test in bore well near cooling tower at Banharpali (I)

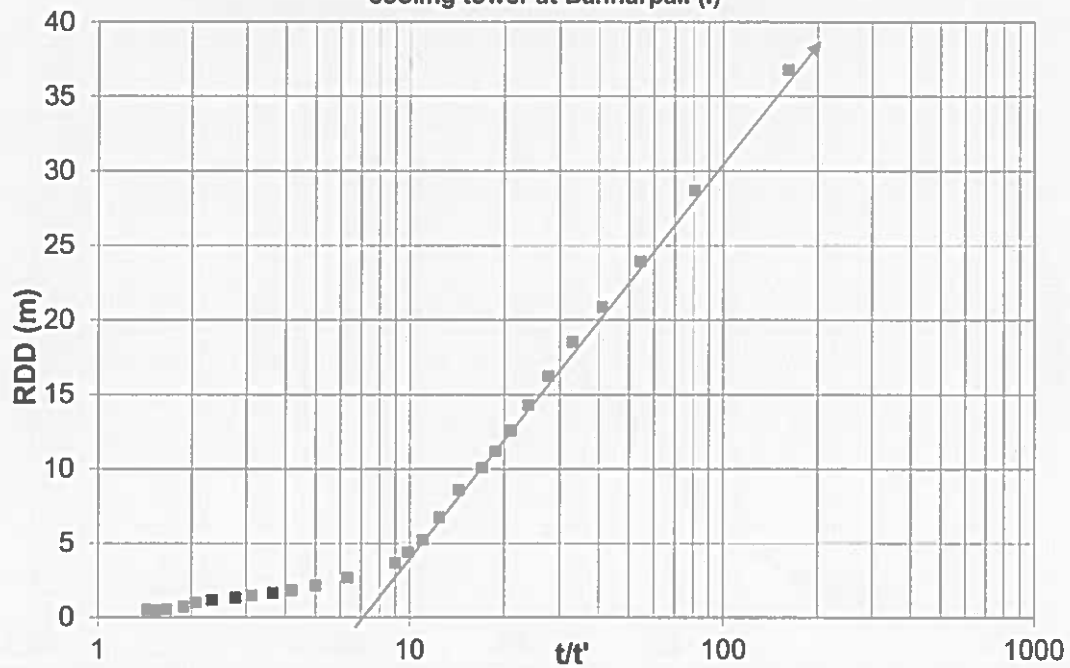


Fig-6.4 B : Plotting of Data RDD vs t/t' for a Yield Test in a Bore Well near learning center at Banharpali (II)

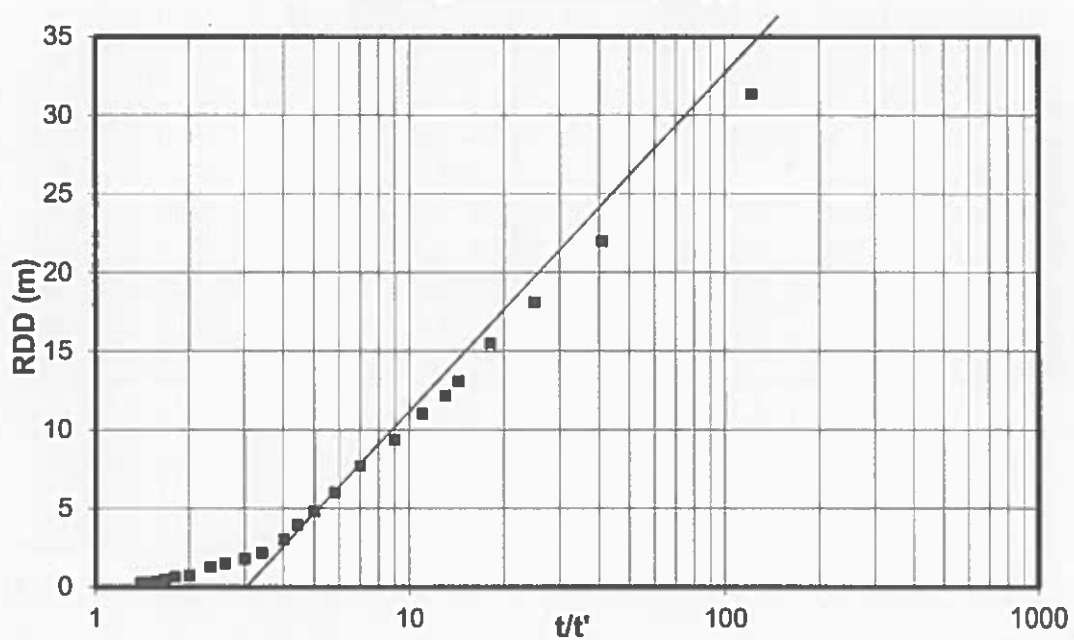


Fig-6.4 C: Plotting of RDD vs t/t' for a Yield test in a Bore Well near Loco Filling Station at Banharpali (III)

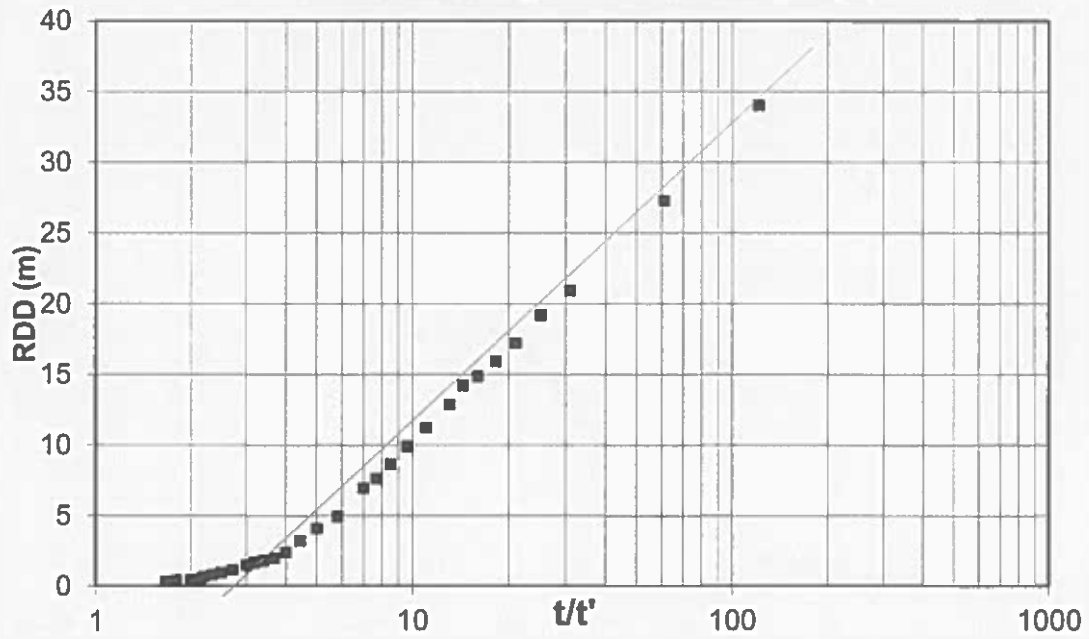
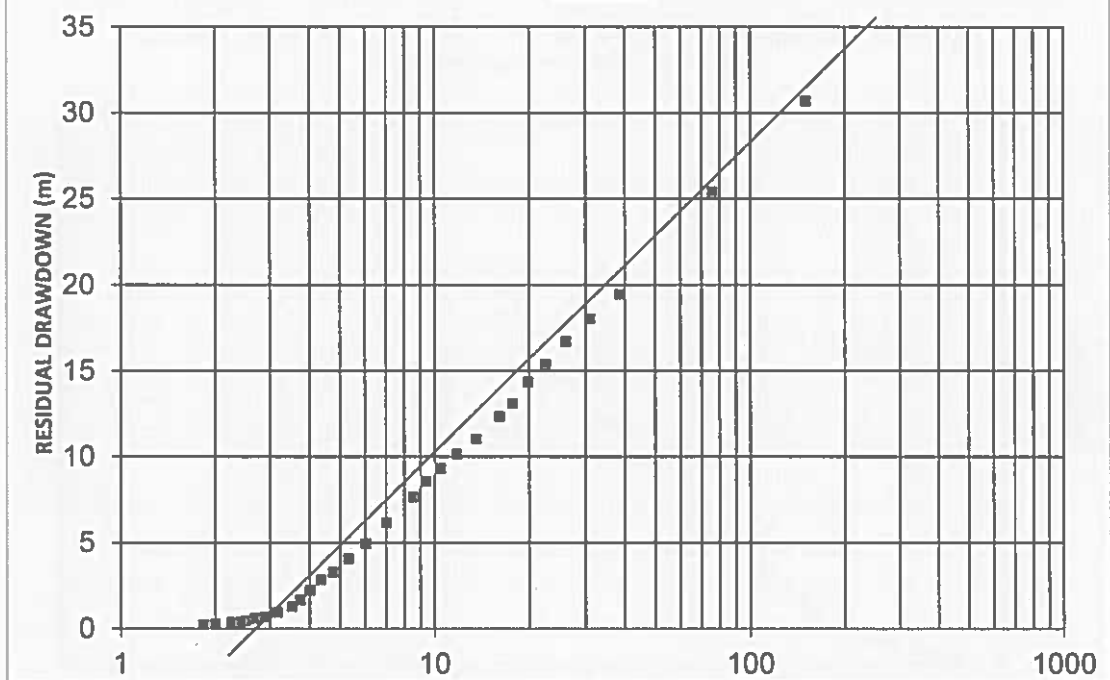


Fig:6.4 D: Data plot of RDD vs t/t' RDD(m) for yield test in a bore well at Balanda



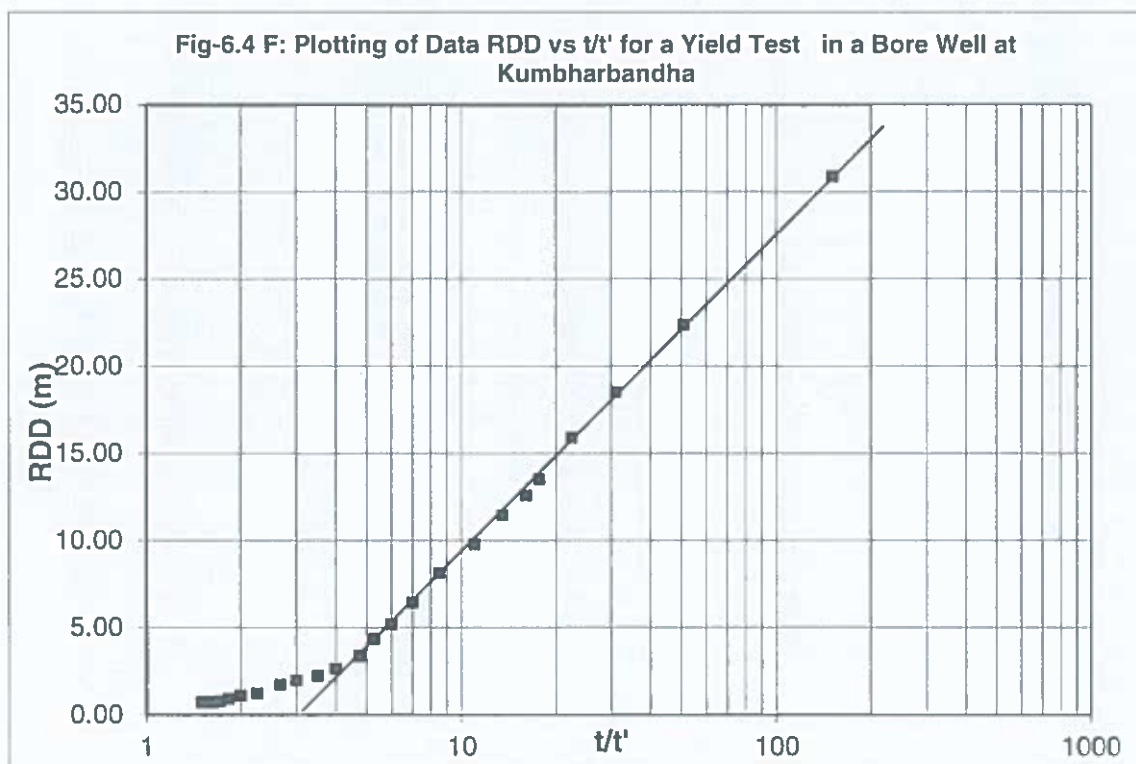
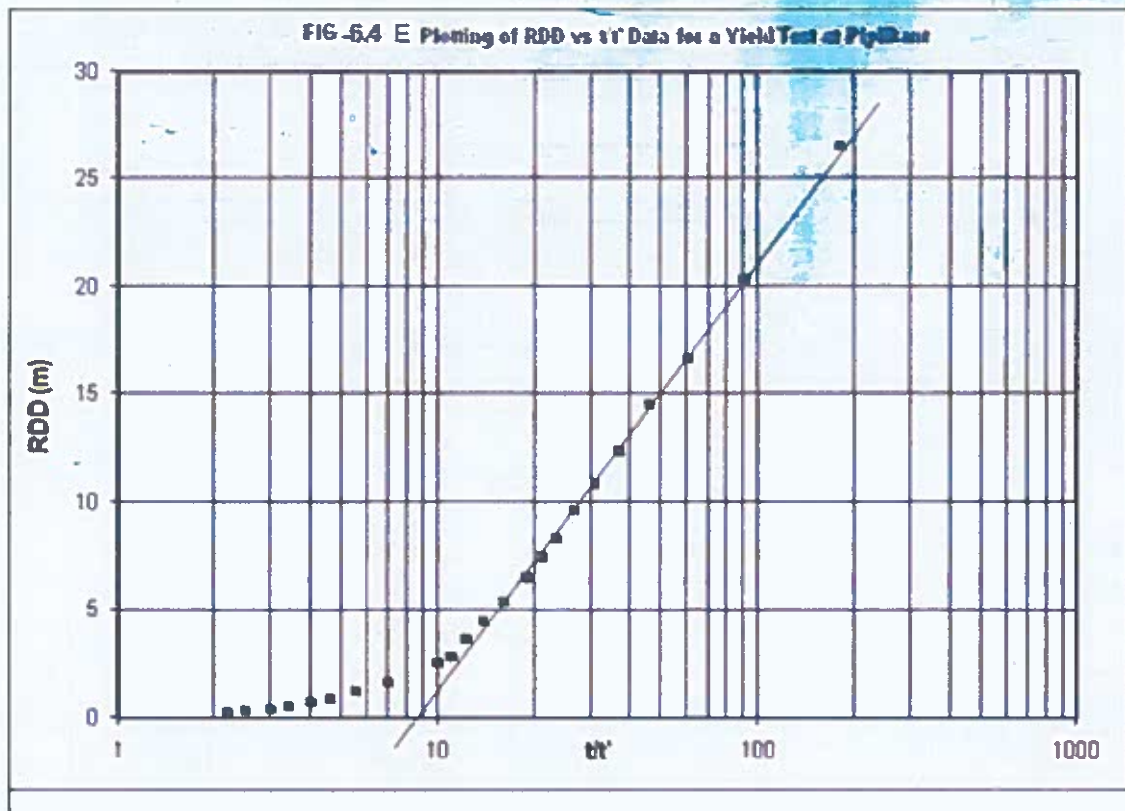


Table- 6.4A: AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL AT-BANHARPALI (Near Cooling Tower), DISTRICT – JHARSUGUDA (Post-Monsoon Period)

(A) HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	2.16
Location	Banharpali (I)	Pumping water level (m)	39.52
Formation	Sst & shale	Residual drawdown (m)	36.79
Depth (m)	100	ΔS (m)	25.20
Water level (m b g l)	2.73	Transmissivity (m ² /day)	0.38
Duration of pumping(min)	160	Specific capacity l p m /min/m	0.98

(B) Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
161	1	161	39.52	36.79
162	2	81	31.43	28.7
163	3	54.33	26.68	23.95
164	4	41.00	23.62	20.89
165	5	33.00	21.26	18.53
166	6	27.67	18.96	16.23
167	7	23.86	17.03	14.3
168	8	21.00	15.33	12.6
169	9	18.78	13.93	11.2
170	10	17.00	12.83	10.1
172	12	14.33	11.33	8.6
174	14	12.43	9.48	6.75
176	16	11.00	7.97	5.24
178	18	9.89	7.15	4.42
180	20	9.00	6.42	3.69
190	30	6.33	5.44	2.71
200	40	5.00	4.89	2.16
210	50	4.20	4.58	1.85
220	60	3.67	4.36	1.63
235	75	3.13	4.24	1.51
250	90	2.78	4.05	1.32
280	120	2.33	3.88	1.15
310	150	2.07	3.74	1.01
340	180	1.89	3.48	0.75
400	240	1.67	3.28	0.55
460	300	1.53	3.24	0.51
520	360	1.44	3.25	0.52

**Table- 6.4B: AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL
AT-BANHARPALI (Near learning center), DISTRICT – JHARSUGUDA
(Post-Monsoon Period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	2.88
Location	Banharpali-II	Pumping water level (m)	37.45
Formation	Sst & shale	Residual drawdown (m)	31.35
Depth (m)	100	ΔS (m)	20
Water level (m b g l)	6.10	Transmissivity (m ² /day)	0.63
Duration of pumping(min)	120	Specific capacity l p m /min/m	1.53

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	37.45	31.35
123	3	41	28.1	22
125	5	25	24.2	18.1
127	7	18.14	21.6	15.5
129	9	14.33	19.18	13.08
130	10	13.00	18.26	12.16
132	12	11.00	17.12	11.02
135	15	9.00	15.45	9.35
140	20	7.00	13.8	7.7
145	25	5.80	12.1	6
150	30	5.00	10.9	4.8
155	35	4.43	10.05	3.95
160	40	4.00	9.12	3.02
170	50	3.40	8.28	2.18
180	60	3.00	7.9	1.8
195	75	2.60	7.62	1.52
210	90	2.33	7.38	1.28
240	120	2.00	6.85	0.75
270	150	1.80	6.75	0.65
300	180	1.67	6.6	0.5
330	210	1.57	6.46	0.36
360	240	1.50	6.42	0.32
390	270	1.44	6.41	0.31
420	300	1.40	6.4	0.3

**Table-6.4C: AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL
AT-BANHARPALI (Near Loco Filling Station), DISTRICT – JHARSUGUDA
(Post-Monsoon Period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	2.7
Location	BANHARPALI (III)	Pumping water level (m)	38.52
Formation	Sst & shale	Residual drawdown (m)	34.02
Depth (m)	100	ΔS (m)	24.50
Water level (m b g l)	4.5	Transmissivity (m ² /day)	0.5
Duration of pumping(min)	120	Specific capacity l p m /min/m	1.32

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	38.52	34.02
122	2	61	31.78	27.28
124	4	31	25.45	20.95
125	5	25	23.66	19.16
126	6	21	21.68	17.18
127	7	18.14	20.42	15.92
128	8	16.00	19.37	14.87
129	9	14.33	18.7	14.2
130	10	13.00	17.36	12.86
132	12	11.00	15.7	11.2
134	14	9.57	14.42	9.92
136	16	8.50	13.14	8.64
138	18	7.67	12.1	7.6
140	20	7.00	11.42	6.92
145	25	5.80	9.42	4.92
150	30	5.00	8.58	4.08
155	35	4.43	7.67	3.17
160	40	4.00	6.88	2.38
165	45	3.67	6.46	1.96
170	50	3.40	6.27	1.77
175	55	3.18	6.16	1.66
180	60	3.00	5.96	1.46
190	70	2.71	5.66	1.16
200	80	2.50	5.44	0.94
210	90	2.33	5.28	0.78
220	100	2.20	5.16	0.66
225	105	2.14	4.98	0.48
240	120	2	4.92	0.42
270	150	1.8	4.88	0.38
300	180	1.67	4.79	0.29

**Table-6.4D: AQUIFER PERFORMANCE TEST (TEST) CONDUCTED IN A BORE WELL
AT- BALANDA, DISTRICT – JHARSUGUDA
(Post-Monsoon Period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	4.5
Location	Balanda	Pumping water level (m)	36.56
Formation	Biotite gr. gneiss	Residual drawdown (m)	30.71
Depth (m)	120	ΔS (m)	18.25
Water level (m b g l)	5.85	Transmissivity (m ² /day)	1.11
Duration of pumping(min)	150	Specific capacity l p m /min/m	2.44

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
151	1	151	36.56	30.71
152	2	76	31.28	25.43
154	4	38.5	25.34	19.49
155	5	31	23.92	18.07
156	6	26	22.58	16.73
157	7	22.43	21.26	15.41
158	8	19.75	20.22	14.37
159	9	17.67	18.98	13.13
160	10	16.00	18.22	12.37
162	12	13.50	16.92	11.07
164	14	11.71	16.02	10.17
166	16	10.38	15.18	9.33
168	18	9.33	14.44	8.59
170	20	8.50	13.52	7.67
175	25	7.00	12.04	6.19
180	30	6.00	10.83	4.98
185	35	5.29	9.95	4.1
190	40	4.75	9.15	3.3
195	45	4.33	8.74	2.89
200	50	4.00	8.12	2.27
205	55	3.73	7.56	1.71
210	60	3.50	7.16	1.31
220	70	3.14	6.82	0.97
230	80	2.88	6.56	0.71
240	90	2.67	6.48	0.63
250	100	2.50	6.32	0.47
255	105	2.43	6.28	0.43
270	120	2.25	6.24	0.39
300	150	2	6.16	0.31
330	180	1.83	6.12	0.27
390	240	1.63	6.1	0.25

**Table- 6.4E : AQUIFER PERFORMANCE TEST (TEST-5) CONDUCTED IN A BORE
WELL AT- PIPLIKANI, DISTRICT – JHARSUGUDA
(Post-Monsoon Period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	5.4
Location	Piplikani	Pumping water level (m)	31.25
Formation	Augen gneiss	Residual drawdown (m)	26.50
Depth (m)	110	ΔS (m)	13.60
Water level (m b g l)	4.75	Transmissivity (m ² /day)	1.75
Duration of pumping(min)	180	Specific capacity l p m /min/m	2.88

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
181	1	181	31.25	26.5
182	2	91	25.05	20.3
183	3	61	21.4	16.65
184	4	46	19.25	14.5
185	5	37	17.1	12.35
186	6	31	15.57	10.82
187	7	26.7	14.37	9.62
188	8	23.5	13.05	8.3
189	9	21	12.21	7.46
190	10	19	11.23	6.48
192	12	16	10.1	5.35
194	14	13.9	9.19	4.44
196	16	12.25	8.37	3.62
198	18	11	7.57	2.82
200	20	10	7.27	2.52
210	30	7	6.39	1.64
220	40	5.5	5.97	1.22
230	50	4.6	5.62	0.87
240	60	4	5.46	0.71
255	75	3.4	5.28	0.53
270	90	3	5.13	0.38
300	120	2.5	5.07	0.32
330	150	2.2	5.01	0.26
400	220	1.8	5.01	0.26

**Table- 6.4F: AQUIFER PERFORMANCE TEST (TEST- 6) CONDUCTED IN A BORE WELL AT- KUMBHARBANDHA, DISTRICT – JHARSUGUDA
(Post-Monsoon Period)**

(A) HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	5.76
Location	Kumbharbandha	Pumping water level (m)	36.17
Formation	Augen gneiss	Residual drawdown (m)	30.92
Depth (m)	120	ΔS (m)	17.60
Water level (m b g l)	5.25	Transmissivity (m ² /day)	1.44
Duration of pumping(min)	150	Specific capacity l p m /min/m	3.10

(B) Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
151	1	151	36.17	30.92
153	3	51	27.64	22.39
155	5	31	23.77	18.52
157	7	22.43	21.16	15.91
159	9	17.67	18.78	13.53
160	10	16.00	17.85	12.60
162	12	13.50	16.72	11.47
165	15	11.00	15.05	9.80
170	20	8.50	13.38	8.13
175	25	7.00	11.70	6.45
180	30	6.00	10.46	5.21
185	35	5.29	9.62	4.37
190	40	4.75	8.64	3.39
200	50	4.00	7.88	2.63
210	60	3.50	7.48	2.23
225	75	3.00	7.23	1.98
240	90	2.67	6.96	1.71
270	120	2.25	6.46	1.21
300	150	2.00	6.35	1.10
330	180	1.83	6.17	0.92
360	210	1.71	6.03	0.78
390	240	1.63	5.98	0.73
420	270	1.56	5.99	0.74
450	300	1.5	5.97	0.72

FIG-6.4 G: Plotting of RDD vs t/t' Data for a Yield Test at Banharpalli (I) during Pre-Monsoon 2018

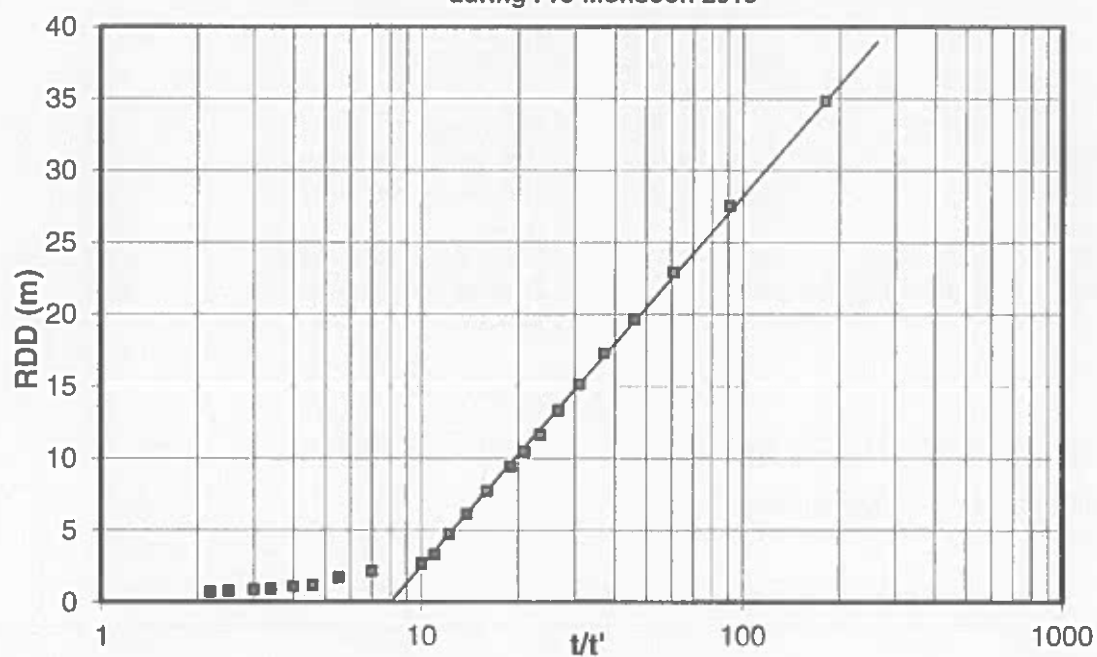


Fig-6.4 H: Plotting of Data RDD vs t/t' for a Yield Test in a Bore Well at Banharpalli (II) during Pre-Monsoon 2018

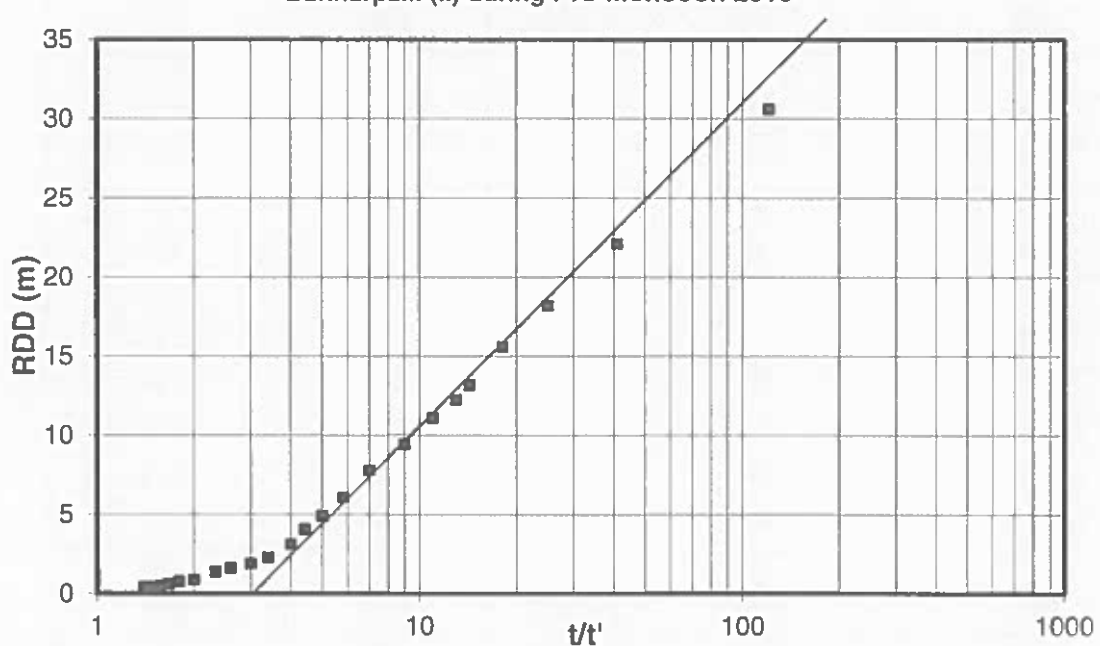


Fig-6.4 I : Plotting of RDD vs t/t' for a Yield test in a Bore Well at Banharpalli (III) during Pre-Monsoon 2018

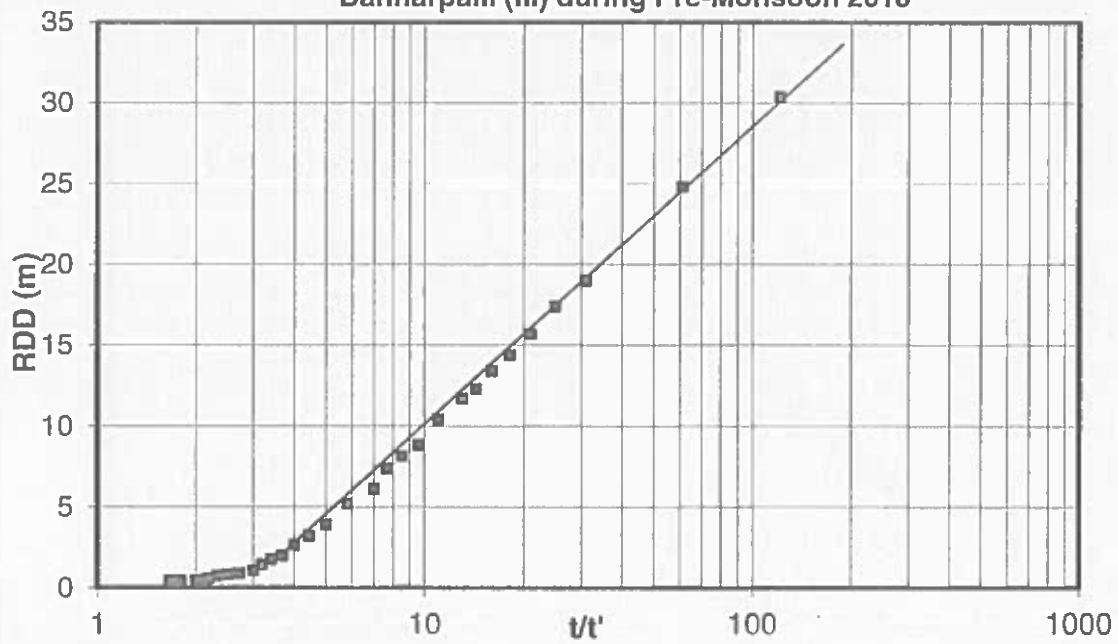


Fig-6.4 J : Data plot of RDD vs t/t' RDD(m) for yield test in a bore well at Balanda during Pre-Monsoon 2018

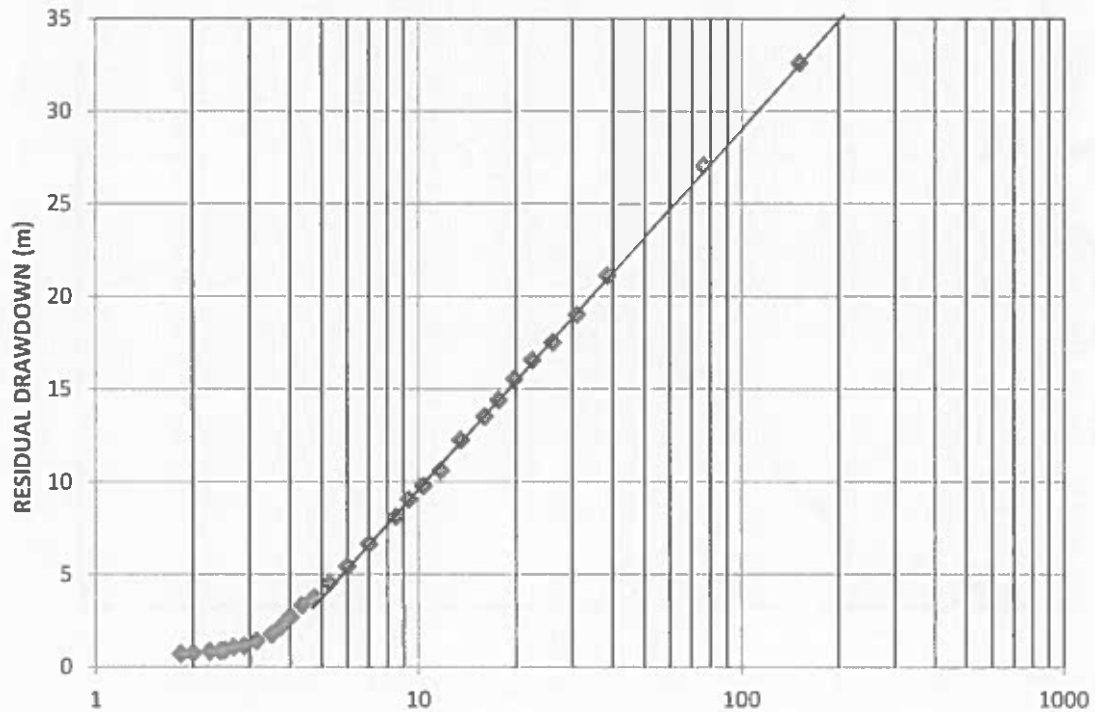


Fig- 6.4 K: Plotting of Data RDD vs t/t' for a Yield Test in a Bore Well at Piplikani during Pre-Monsoon 2018

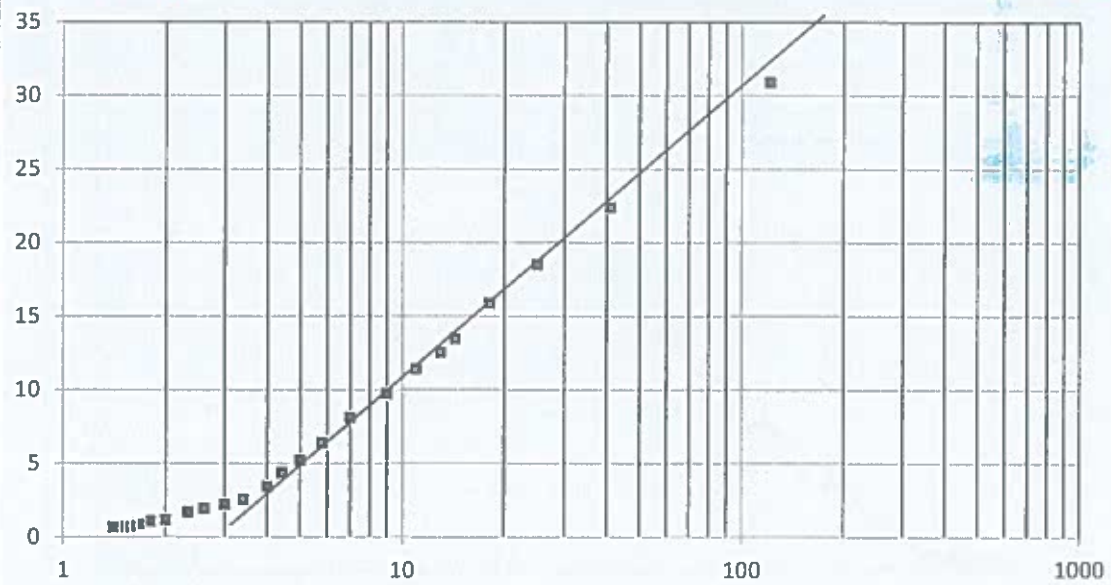
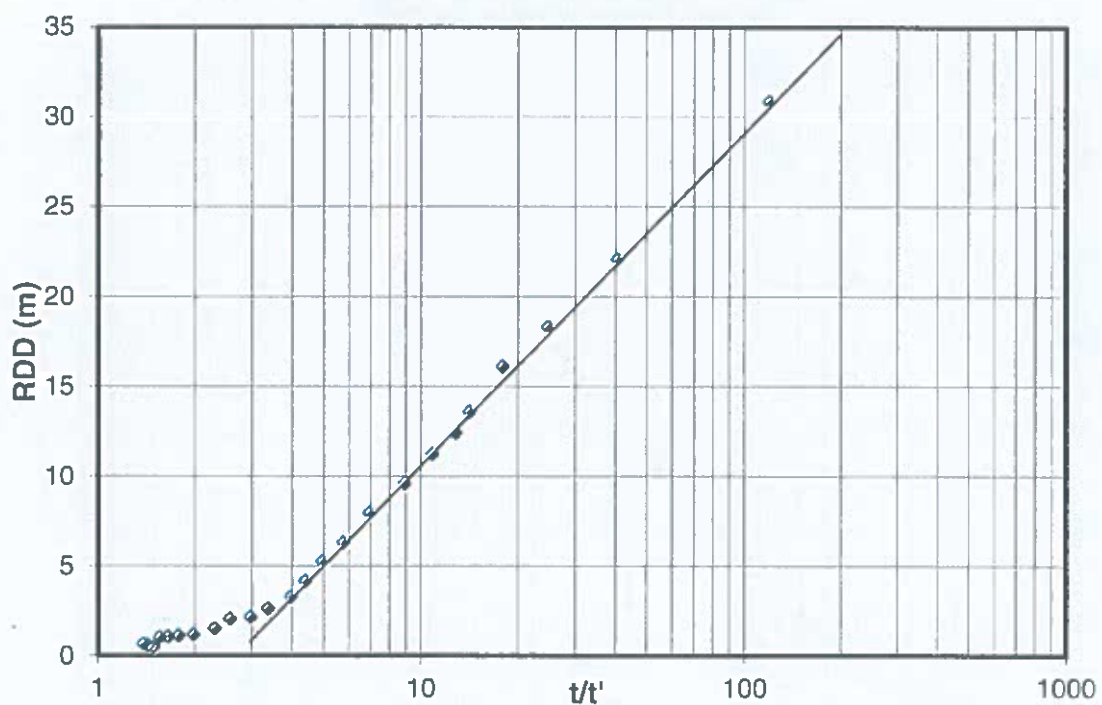


Fig-6.4 L: Plotting of Data RDD vs t/t' for a Yield Test in a Bore Well at Kumbhabandha during Pre-Monsoon 2018



**Table- 6.4G: AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL
AT-BANHARPALI (Near Cooling Tower), DISTRICT – JHARSUGUDA
(Pre- Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	2
Location	Banharpali (I)	Pumping water level (m)	40.15
Formation	Sst & shale	Residual drawdown (m)	34.85
Depth (m)	100	ΔS (m)	27.05
Water level (m b g l)	5.3	Transmissivity (m ² /day)	1.17
Duration of pumping(min)	180	Specific capacity l p m /min/m	0.96

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
181	1	181	40.15	34.85
182	2	91	32.85	27.55
183	3	61	28.23	22.93
184	4	46	24.96	19.66
185	5	37	22.62	17.32
186	6	31	20.45	15.15
187	7	26.7	18.62	13.32
188	8	23.5	16.96	11.66
189	9	21	15.78	10.48
190	10	19	14.75	9.45
192	12	16	13.05	7.75
194	14	13.9	11.45	6.15
196	16	12.3	10.06	4.76
198	18	11	8.62	3.32
200	20	10	8.02	2.72
210	30	7	7.44	2.14
220	40	5.5	7.02	1.72
230	50	4.6	6.52	1.22
240	60	4	6.42	1.12
255	75	3.4	6.25	0.95
270	90	3	6.18	0.88
300	120	2.5	6.12	0.82
330	150	2.2	6.06	0.76

**Table- 6.4H: AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL
AT-BANHARPALI (Near learning center) , DISTRICT – JHARSUGUDA,
(Pre- Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	2.5
Location	Banharpali-II	Pumping water level (m)	38.15
Formation	Sst & shale	Residual drawdown (m)	30.65
Depth (m)	100	ΔS (m)	18.85
Water level (m b g l)	7.5	Transmissivity (m ² /day)	2.09
Duration of pumping(min)	120	Specific capacity l p m /min/m	1.4

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	38.15	30.65
123	3	41	29.6	22.1
125	5	25	25.7	18.2
127	7	18.14	23.1	15.6
129	9	14.33	20.68	13.18
130	10	13.00	19.76	12.26
132	12	11.00	18.62	11.12
135	15	9.00	16.95	9.45
140	20	7.00	15.3	7.8
145	25	5.80	13.6	6.1
150	30	5.00	12.4	4.9
155	35	4.43	11.55	4.05
160	40	4.00	10.62	3.12
170	50	3.40	9.78	2.28
180	60	3.00	9.4	1.9
195	75	2.60	9.12	1.62
210	90	2.33	8.88	1.38
240	120	2.00	8.35	0.85
270	150	1.80	8.25	0.75
300	180	1.67	8.1	0.6
330	210	1.57	7.96	0.46
360	240	1.50	7.92	0.42
390	270	1.44	7.91	0.41
420	300	1.40	7.9	0.4

**Table-6.4 I : AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL
AT-BANHARPALI (Near Loco Filling St), DISTRICT – JHARSUGUDA ,
(Pre- Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	2.5
Location	BANHARPALI (III)	Pumping water level (m)	36.85
Formation	Sst & shale	Residual drawdown (m)	30.4
Depth (m)	100	ΔS (m)	19.52
Water level (m b g l)	6.5	Transmissivity (m ² /day)	2.02
Duration of pumping(min)	120	Specific capacity l p m /min/m	1.37

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	36.85	30.4
122	2	61	31.25	24.8
124	4	31	25.45	19
125	5	25	23.85	17.4
126	6	21	22.15	15.7
127	7	18.14	20.85	14.4
128	8	16.00	19.88	13.43
129	9	14.33	18.78	12.33
130	10	13.00	18.2	11.75
132	12	11.00	16.88	10.43
134	14	9.57	15.3	8.85
136	16	8.50	14.6	8.15
138	18	7.67	13.85	7.4
140	20	7.00	12.6	6.15
145	25	5.80	11.7	5.25
150	30	5.00	10.4	3.95
155	35	4.43	9.7	3.25
160	40	4.00	9.12	2.67
165	45	3.67	8.46	2.01
170	50	3.40	8.23	1.78
175	55	3.18	7.92	1.47
180	60	3.00	7.52	1.07
190	70	2.71	7.35	0.9
200	80	2.50	7.3	0.85
210	90	2.33	7.2	0.75
220	100	2.20	7.06	0.61
225	105	2.14	6.96	0.51
240	120	2	6.92	0.47
270	150	1.8	6.9	0.45
300	180	1.67	6.9	0.45

**Table-6.4 J : AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL
AT- BALANDA, DISTRICT – JHARSUGUDA, (Pre- Monsoon period)
(Pre- Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m³/hr	3.85
Location	Balanda	Pumping water level (m)	39.22
Formation	Biotite gr. gneiss	Residual drawdown (m)	32.62
Depth (m)	120	ΔS (m)	20.2
Water level (m b g l)	6.6	Transmissivity (m ² /day)	1.107
Duration of pumping(min)	150	Specific capacity l p m /min/m	1.967

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
151	1	151	39.22	32.62
152	2	76	33.68	27.08
154	4	38.5	27.72	21.12
155	5	31	25.64	19.04
156	6	26	24.12	17.52
157	7	22.43	23.18	16.58
158	8	19.75	22.16	15.56
159	9	17.67	21.02	14.42
160	10	16.00	20.12	13.52
162	12	13.50	18.86	12.26
164	14	11.71	17.22	10.62
166	16	10.38	16.38	9.78
168	18	9.33	15.64	9.04
170	20	8.50	14.72	8.12
175	25	7.00	13.24	6.64
180	30	6.00	12.03	5.43
185	35	5.29	11.15	4.55
190	40	4.75	10.35	3.75
195	45	4.33	9.94	3.34
200	50	4.00	9.32	2.72
205	55	3.73	8.76	2.16
210	60	3.50	8.36	1.76
220	70	3.14	8.02	1.42
230	80	2.88	7.76	1.16
240	90	2.67	7.68	1.08
250	100	2.50	7.52	0.92
255	105	2.43	7.48	0.88
270	120	2.25	7.44	0.84
300	150	2	7.36	0.76
330	180	1.83	7.32	0.72
390	240	1.63	7.3	0.7

**Table- 6.4 K : AQUIFER PERFORMANCE TEST (TEST-5) CONDUCTED IN A BORE WELL AT- PIPLIKANI , DISTRICT – JHARSUGUDA(Pre- Monsoon period)
(Pre- Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m³/hr	5
Location	Piplikani	Pumping water level (m)	38.15
Formation	Augen gneiss	Residual drawdown (m)	30.95
Depth (m)	110	ΔS (m)	18.6
Water level (m b g l)	7.2	Transmissivity (m ² /day)	1.18
Duration of pumping(min)	120	Specific capacity l p m /min/m	2.69

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	38.15	30.95
123	3	41	29.6	22.4
125	5	25	25.7	18.5
127	7	18.14	23.1	15.9
129	9	14.33	20.68	13.48
130	10	13.00	19.76	12.56
132	12	11.00	18.62	11.42
135	15	9.00	16.95	9.75
140	20	7.00	15.3	8.1
145	25	5.80	13.6	6.4
150	30	5.00	12.4	5.2
155	35	4.43	11.55	4.35
160	40	4.00	10.62	3.42
170	50	3.40	9.78	2.58
180	60	3.00	9.4	2.2
195	75	2.60	9.12	1.92
210	90	2.33	8.88	1.68
240	120	2.00	8.35	1.15
270	150	1.80	8.25	1.05
300	180	1.67	8.1	0.9
330	210	1.57	7.96	0.76
360	240	1.50	7.92	0.72
390	270	1.44	7.91	0.71
420	300	1.40	7.9	0.7

**Table- 6.4 L: AQUIFER PERFORMANCE TEST (TEST- 6) CONDUCTED IN A BORE WELL AT- KUMBHARBANDHA, DISTRICT – JHARSUGUDA (Pre- Monsoon period)
(Pre- Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m³/hr	4.75
Location	Kumbharbandha	Pumping water level (m)	38.4
Formation	Augen gneiss	Residual drawdown (m)	30.8
Depth (m)	120	ΔS (m)	18.8
Water level (m b g l)	7.6	Transmissivity (m ² /day)	1.1
Duration of pumping(min)	120	Specific capacity l p m /min/m	2.57

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	38.4	30.8
123	3	41	29.6	22
125	5	25	25.85	18.25
127	7	18.14	23.65	16.05
129	9	14.33	21.13	13.53
130	10	13.00	19.96	12.36
132	12	11.00	18.78	11.18
135	15	9.00	17.13	9.53
140	20	7.00	15.5	7.9
145	25	5.80	13.85	6.25
150	30	5.00	12.8	5.2
155	35	4.43	11.7	4.1
160	40	4.00	10.82	3.22
170	50	3.40	10.18	2.58
180	60	3.00	9.7	2.1
195	75	2.60	9.62	2.02
210	90	2.33	9.08	1.48
240	120	2.00	8.7	1.1
270	150	1.80	8.65	1.05
300	180	1.67	8.6	1
330	210	1.57	8.56	0.96
360	240	1.50	8.02	0.42
390	270	1.44	8.11	0.51
420	300	1.40	8.2	0.6

FIG-6.4 M: Plotting of RDD vs t/t' Data for a Yield Test at Banharpalli (I) during Monsoon 2018

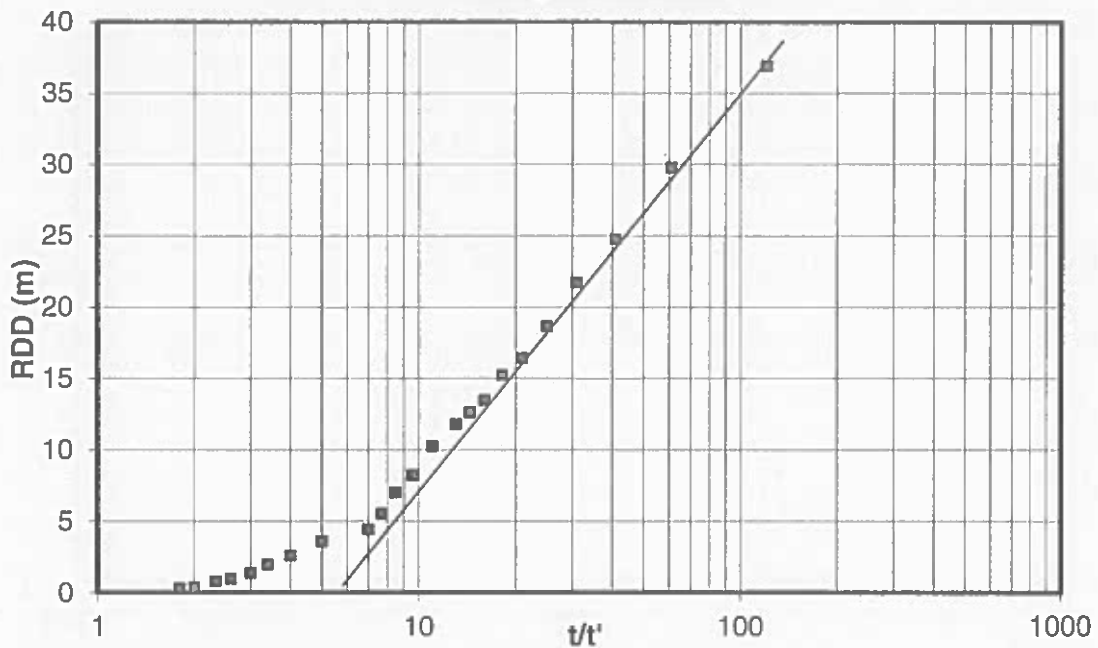


Fig-6.4 N: Plotting of Data RDD vs t/t' for a Yield Test in a Bore Well at Banharpalli (II) during Monsoon 2018

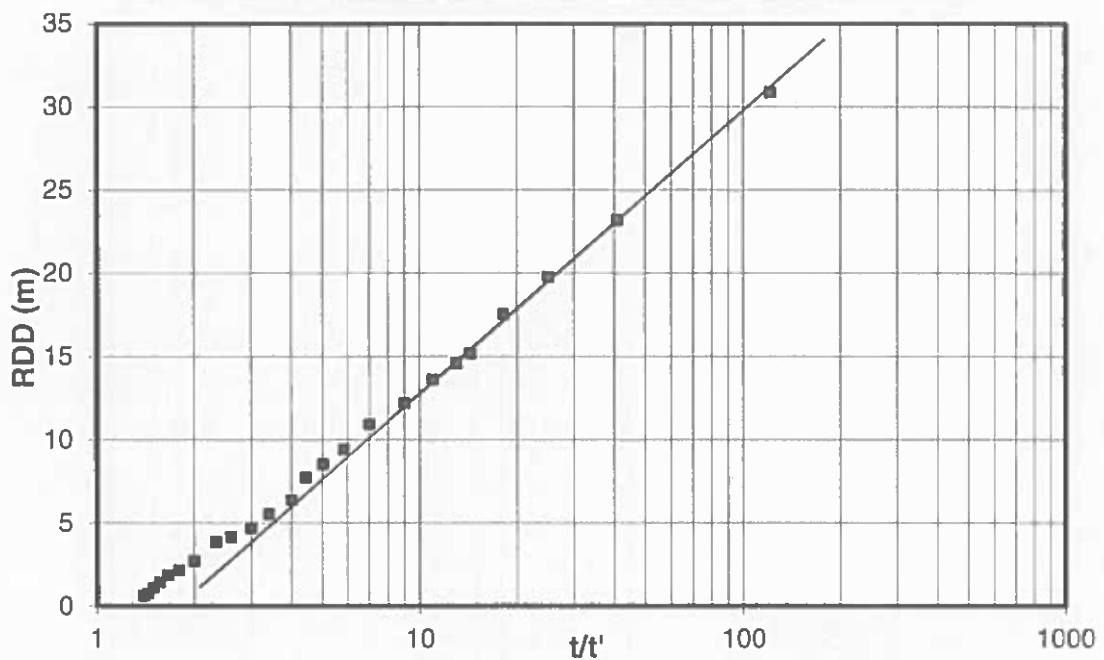


Fig-6.4 O : Plotting of RDD vs t/t' for a Yield test in a Bore Well at Banharpalli (III) during Monsoon 2018

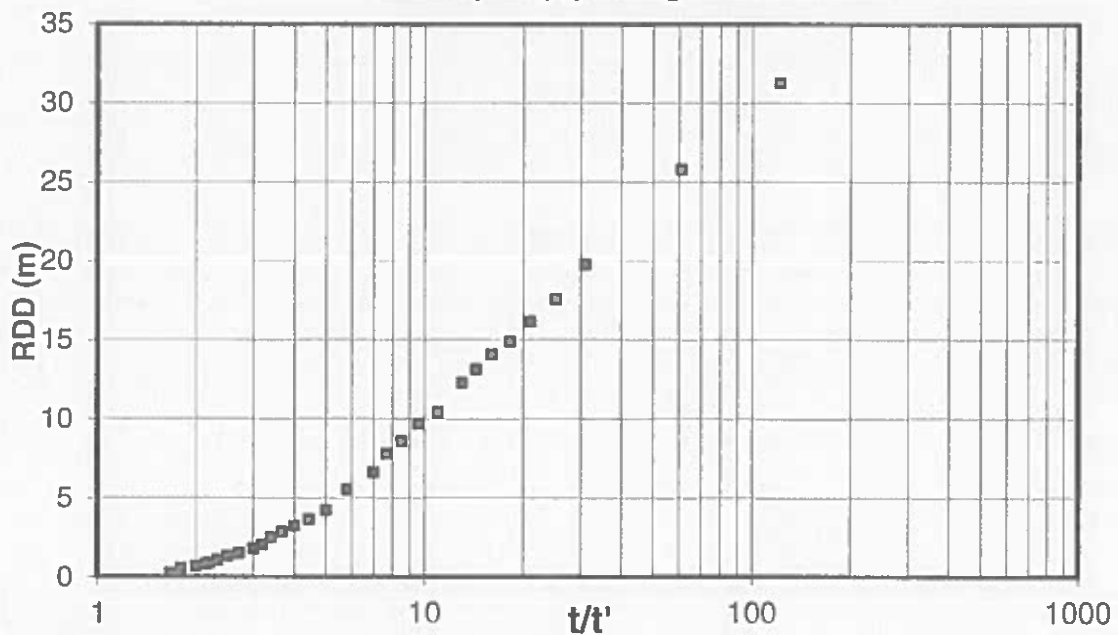


Fig-6.4 P : Data plot of RDD vs t/t' RDD(m) for yield test in a bore well at Balanda during Monsoon 2018

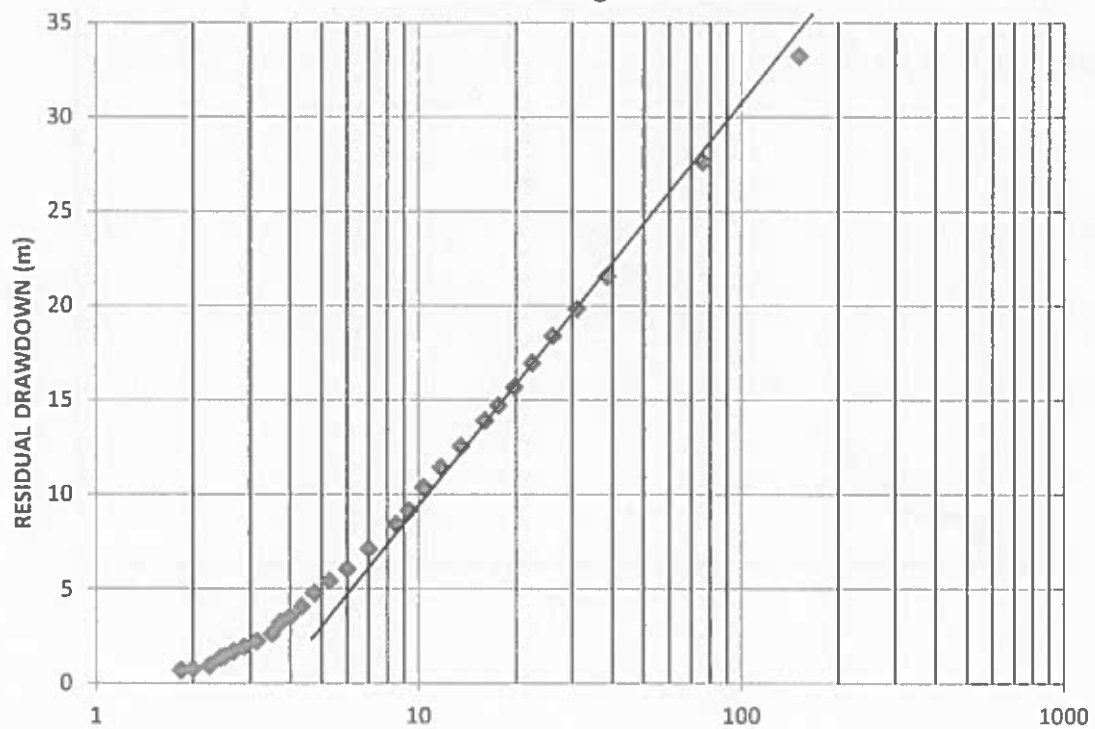


Fig-6.4 Q: Plotting of Data RDD vs t/t' for a Yield Test in a Bore Well at Piplikani during Monsoon 2018

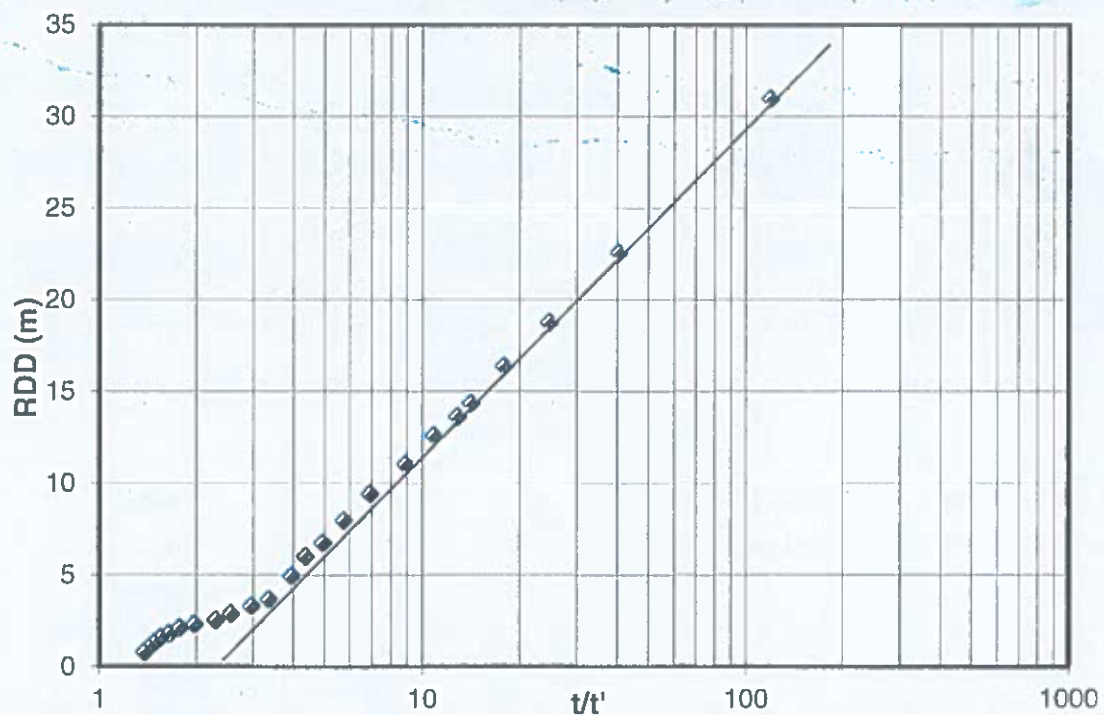


Fig-6.4 R: Plotting of Data RDD vs t/t' for a Yield Test in a Bore Well at Kumbhabandha during Monsoon 2018

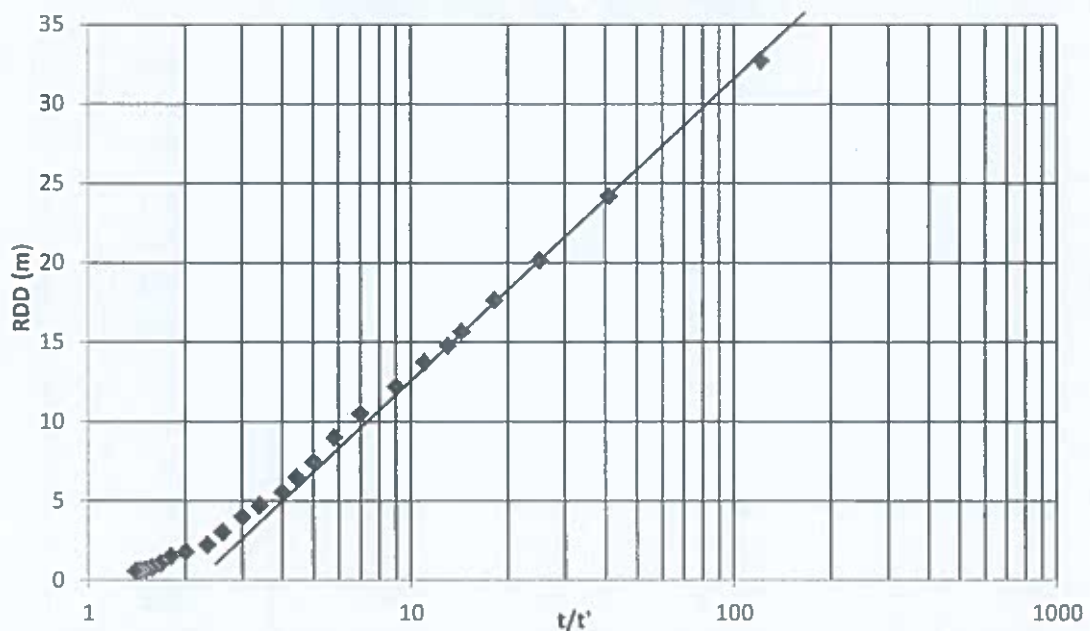


Table- 6.4 M: AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL AT-BANHARPALI (Near Cooling Tower), DISTRICT – JHARSUGUDA (Monsoon period)

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m³/hr	2.5
Location	Banharpali (I)	Pumping water level (m)	38.72
Formation	Sst & shale	Residual drawdown (m)	36.92
Depth (m)	100	ΔS (m)	26.5
Water level (m b g l)	1.8	Transmissivity (m ² /day)	0.41
Duration of pumping(min)	120	Specific capacity l p m /min/m	1.12

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	38.72	36.92
122	2	61	31.58	29.78
123	3	41	26.58	24.78
124	4	31	23.52	21.72
125	5	25	20.48	18.68
126	6	21	18.25	16.45
127	7	18.1	17.06	15.26
128	8	16	15.3	13.5
129	9	14.3	14.42	12.62
130	10	13.0	13.6	11.8
132	12	11.0	12.1	10.3
134	14	9.6	10.05	8.25
136	16	8.5	8.86	7.06
138	18	7.7	7.36	5.56
140	20	7.0	6.25	4.45
150	30	5.0	5.4	3.6
160	40	4.0	4.4	2.6
170	50	3.4	3.8	2
180	60	3.0	3.2	1.4
195	75	2.6	2.8	1
210	90	2.3	2.6	0.8
240	120	2	2.2	0.4
270	150	1.8	2.1	0.3

**Table- 6.4 N: AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL
AT-BANHARPALI (Near learning center) , DISTRICT – JHARSUGUDA,
(Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	3
Location	Banharpali-II	Pumping water level (m)	33.12
Formation	Sst & shale	Residual drawdown (m)	30.87
Depth (m)	100	ΔS (m)	16
Water level (m b g l)	2.25	Transmissivity (m ² /day)	0.82
Duration of pumping(min)	120	Specific capacity l p m /min/m	1.62

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	33.12	30.87
123	3	41	25.46	23.21
125	5	25	22.02	19.77
127	7	18.14	19.78	17.53
129	9	14.33	17.42	15.17
130	10	13.00	16.83	14.58
132	12	11.00	15.85	13.6
135	15	9.00	14.43	12.18
140	20	7.00	13.18	10.93
145	25	5.80	11.66	9.41
150	30	5.00	10.77	8.52
155	35	4.43	9.98	7.73
160	40	4.00	8.62	6.37
170	50	3.40	7.78	5.53
180	60	3.00	6.92	4.67
195	75	2.60	6.4	4.15
210	90	2.33	6.1	3.85
240	120	2.00	4.95	2.7
270	150	1.80	4.4	2.15
300	180	1.67	4.12	1.87
330	210	1.57	3.67	1.42
360	240	1.50	3.36	1.11
390	270	1.44	3.02	0.77
420	300	1.40	2.88	0.63

**Table-6.4 :AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL
AT-BANHARPALI (Near Loco Filling St), DISTRICT – JHARSUGUDA,
(Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	5
Location	BANHARPALI (III)	Pumping water level (m)	34.12
Formation	Sst & shale	Residual drawdown (m)	31.32
Depth (m)	100	ΔS (m)	19.8
Water level (m b g l)	2.8	Transmissivity (m ² /day)	1.11
Duration of pumping(min)	120	Specific capacity l p m /min/m	2.66

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	34.12	31.32
122	2	61	28.6	25.8
124	4	31	22.57	19.77
125	5	25	20.4	17.6
126	6	21	18.96	16.16
127	7	18.14	17.7	14.9
128	8	16.00	16.88	14.08
129	9	14.33	15.93	13.13
130	10	13.00	15.08	12.28
132	12	11.00	13.25	10.45
134	14	9.57	12.5	9.7
136	16	8.50	11.4	8.6
138	18	7.67	10.6	7.8
140	20	7.00	9.4	6.6
145	25	5.80	8.32	5.52
150	30	5.00	7.02	4.22
155	35	4.43	6.45	3.65
160	40	4.00	6.05	3.25
165	45	3.67	5.69	2.89
170	50	3.40	5.34	2.54
175	55	3.18	4.88	2.08
180	60	3.00	4.6	1.8
190	70	2.71	4.32	1.52
200	80	2.50	4.12	1.32
210	90	2.33	3.85	1.05
220	100	2.20	3.68	0.88
225	105	2.14	3.62	0.82
240	120	2	3.48	0.68
270	150	1.8	3.35	0.55
300	180	1.67	3.06	0.26

**Table-6.4 P : AQUIFER PERFORMANCE TEST (TEST-) CONDUCTED IN A BORE WELL
AT- BALANDA, DISTRICT – JHARSUGUDA,
(Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	5
Location	Balanda	Pumping water level (m)	36.45
Formation	Biotite gr. gneiss	Residual drawdown (m)	33.25
Depth (m)	120	ΔS (m)	20
Water level (m b g l)	3.2	Transmissivity (m ² /day)	1.100
Duration of pumping(min)	150	Specific capacity l p m /min/m	2.510

Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
151	1	151	36.45	33.25
152	2	76	30.83	27.63
154	4	38.5	24.76	21.56
155	5	31	23.02	19.82
156	6	26	21.59	18.39
157	7	22.43	20.16	16.96
158	8	19.75	18.88	15.68
159	9	17.67	17.92	14.72
160	10	16.00	17.12	13.92
162	12	13.50	15.76	12.56
164	14	11.71	14.64	11.44
166	16	10.38	13.59	10.39
168	18	9.33	12.35	9.15
170	20	8.50	11.64	8.44
175	25	7.00	10.32	7.12
180	30	6.00	9.25	6.05
185	35	5.29	8.62	5.42
190	40	4.75	7.98	4.78
195	45	4.33	7.25	4.05
200	50	4.00	6.74	3.54
205	55	3.73	6.42	3.22
210	60	3.50	5.81	2.61
220	70	3.14	5.42	2.22
230	80	2.88	5.12	1.92
240	90	2.67	4.88	1.68
250	100	2.50	4.62	1.42
255	105	2.43	4.52	1.32
270	120	2.25	4.12	0.92
300	150	2	3.95	0.75

**Table- 6.4 Q : AQUIFER PERFORMANCE TEST (TEST-5) CONDUCTED IN A BORE
WELL AT- PIPLIKANI , DISTRICT – JHARSUGUDA
(Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	6
Location	Piplikani	Pumping water level (m)	34.52
Formation	Augen gneiss	Residual drawdown (m)	30.92
Depth (m)	110	ΔS (m)	17.4
Water level (m b g l)	3.6	Transmissivity (m ² /day)	1.51
Duration of pumping(min)	120	Specific capacity l p m /min/m	3.23

(A) Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	34.52	30.92
123	3	41	26.1	22.5
125	5	25	22.3	18.7
127	7	18.14	19.9	16.3
129	9	14.33	17.88	14.28
130	10	13.00	17.16	13.56
132	12	11.00	16.12	12.52
135	15	9.00	14.55	10.95
140	20	7.00	12.95	9.35
145	25	5.80	11.48	7.88
150	30	5.00	10.26	6.66
155	35	4.43	9.55	5.95
160	40	4.00	8.45	4.85
170	50	3.40	7.18	3.58
180	60	3.00	6.84	3.24
195	75	2.60	6.42	2.82
210	90	2.33	6.08	2.48
240	120	2.00	5.85	2.25
270	150	1.80	5.64	2.04
300	180	1.67	5.32	1.72
330	210	1.57	5.12	1.52
360	240	1.50	4.84	1.24
390	270	1.44	4.58	0.98
420	300	1.40	4.32	0.72

**Table- 6.4 R: AQUIFER PERFORMANCE TEST (TEST- 6) CONDUCTED IN A BORE WELL AT- KUMBHARBANDHA, DISTRICT – JHARSUGUDA
(Monsoon period)**

HYDROGEOLOGICAL DATA

Particulars	Details	Discharge m ³ /hr	6
Location	Kumbharbandha	Pumping water level (m)	35.85
Formation	Augen gneiss	Residual drawdown (m)	32.75
Depth (m)	120	ΔS (m)	18
Water level (m b g l)	3.1	Transmissivity (m ² /day)	1.46
Duration of pumping(min)	120 minutes	Specific capacity l p m /min/m	3.05

(C) Recovery data: as below

Time (min) since pump started (t)	Time (min) since pump stopped (t')	t/t'	DTWL (m)	RDD (m)
121	1	121	35.85	32.75
123	3	41	27.3	24.2
125	5	25	23.25	20.15
127	7	18.14	20.75	17.65
129	9	14.33	18.75	15.65
130	10	13.00	17.88	14.78
132	12	11.00	16.84	13.74
135	15	9.00	15.3	12.2
140	20	7.00	13.6	10.5
145	25	5.80	12.1	9
150	30	5.00	10.58	7.48
155	35	4.43	9.6	6.5
160	40	4.00	8.65	5.55
170	50	3.40	7.82	4.72
180	60	3.00	7.11	4.01
195	75	2.60	6.15	3.05
210	90	2.33	5.32	2.22
240	120	2.00	4.89	1.79
270	150	1.80	4.62	1.52
300	180	1.67	4.16	1.06
330	210	1.57	3.88	0.78
360	240	1.50	3.78	0.68
390	270	1.44	3.72	0.62
420	300	1.40	3.68	0.58

6.5.: Ground Water Table and Ground Water Flow Direction in buffer zone:

6.5.1: Pre-Monsoon period:

1. **Ground Water Flow Direction in buffer zone:** From the Hydrogeological map it is evident that ground water table contours varies from 200 m to 210 m amsl. In south western part it is from NE to SW direction but in north eastern part it from SE to NWW. General ground water flow direction is towards SW direction. Hydraulic gradient varies from 0.01 to 0.0015 with a mean value of 0.0058.
2. **Ground Water Flow Direction in plant area:** In plant area water table remains at 205 m amsl and flow direction is towards SW.
3. **Ground Water Table and Flow Direction in ash pond area:** In ash pond area water table remains at 205 m amsl and flow direction is towards SW.

6.5.2: Post - Monsoon period:

1. **Ground Water Flow Direction in buffer zone:** Ground water table contours varies from 205 m to 215 m amsl. In most part of buffer zone it remains between 205 and 210 m amsl. In general ground water flow direction is towards south but in eastern part it shows toward NE indicating water divider around ash pond area.
2. **Ground Water Flow Direction in plant area:** In plant area water table remains at 210 m amsl and flow direction is towards south.
3. **Ground Water Table and Flow Direction in ash pond area:** In ash pond area water table remains around 210 m amsl and flow direction is towards SW.

6.5.3: Monsoon Period:

1. **Ground Water Flow Direction in buffer zone:** Ground water table contours varies from 205 m to 210 m amsl in major part of buffer zone except in a few patches in western part where it shows 2015 m amsl. In general ground water flow direction is towards south.
2. **Ground Water Flow Direction in plant area:** In plant area water table varies from 205 to 215 m amsl. and flow direction is towards south.
3. **Ground Water Table and Flow Direction in ash pond area:** In ash pond area water table remains between 205 and 210 m amsl and flow direction is towards south.

6.6: Field Photographs: These are as below:



Photographs showing collection of ground water sample from bore well



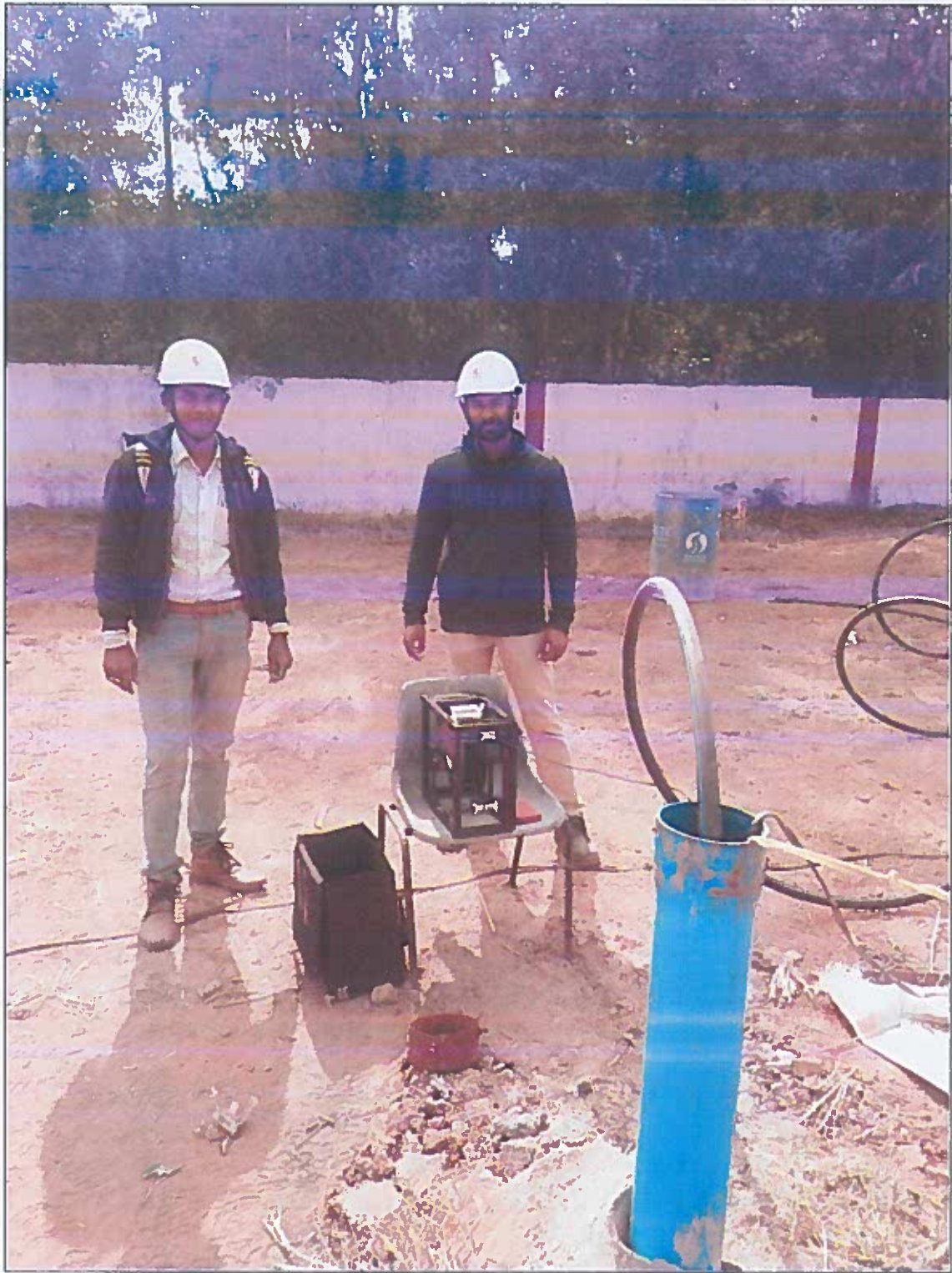
Photographs showing collection of ground water sample from bore well



Photograph showing collection of ground water sample from bore well



Photograph showing depth to water level in a bore well in core zone.



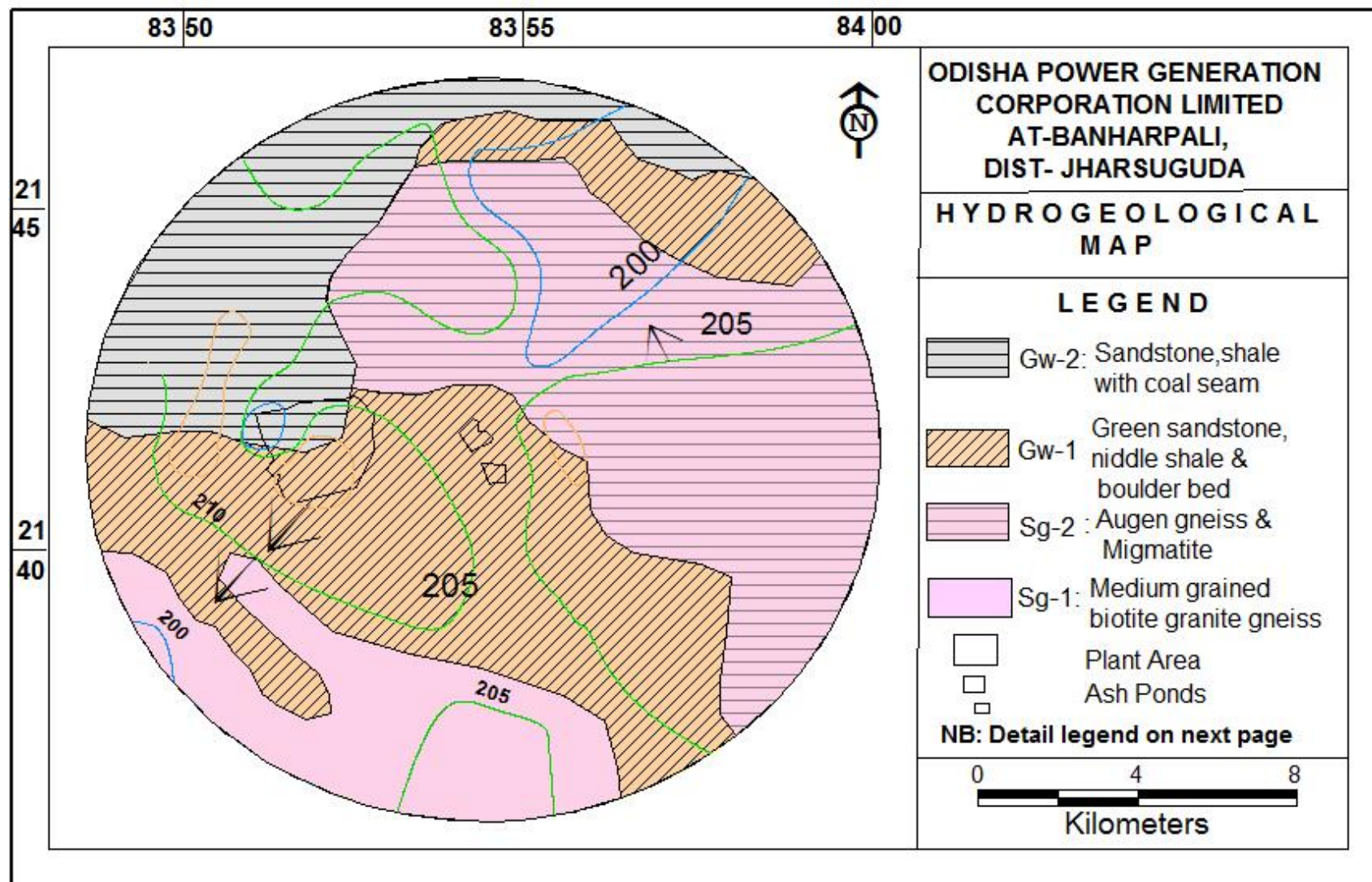
Photograph showing depth to water level in a bore well in core zone.



Photograph showing measurement of discharge of bore well during pumping test.

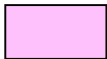


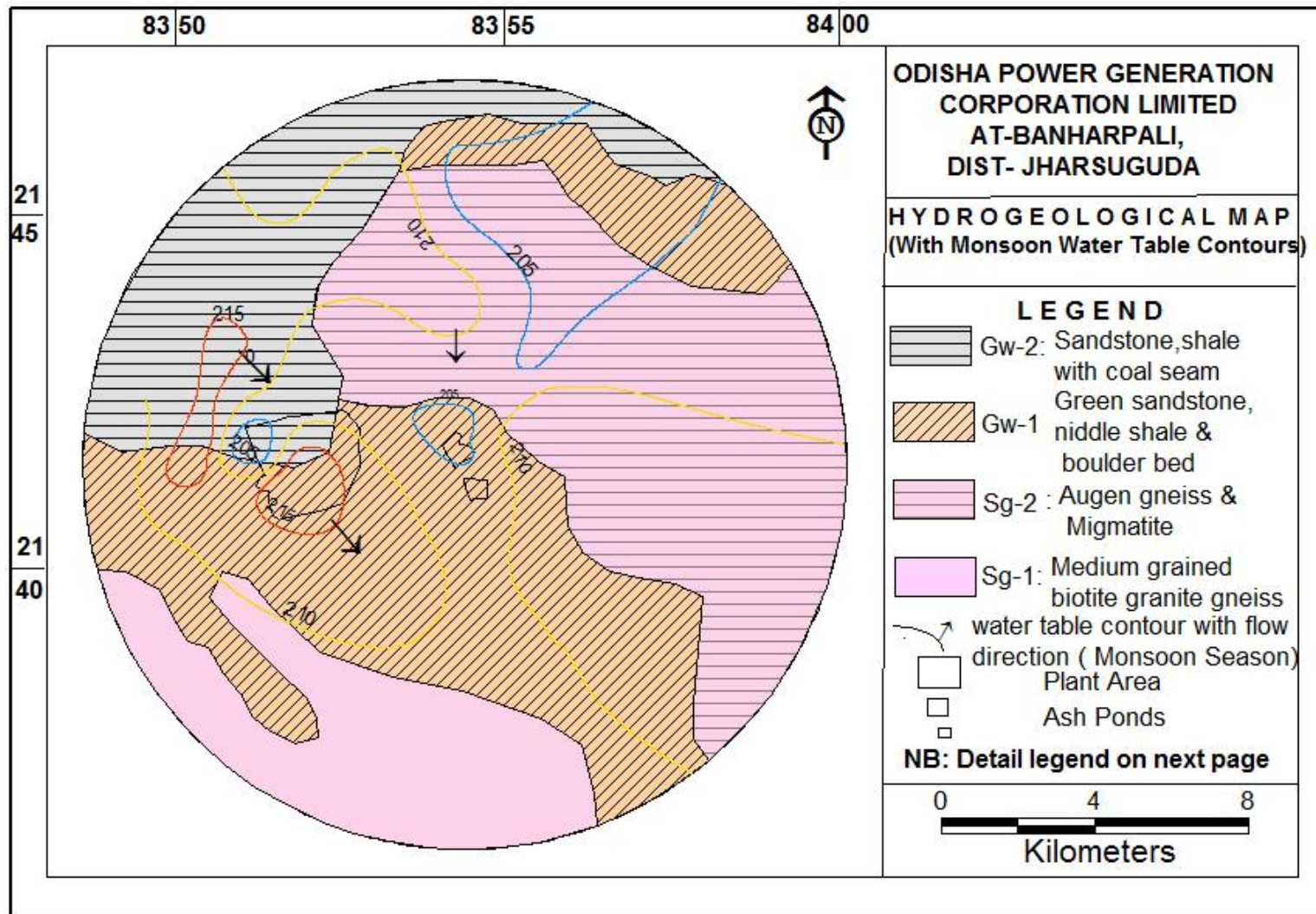
Photograph showing collection of ground water sample from bore well



Map-6.1: HYDROGEOLOGICAL MAP WITH PRE-MONSOON WATER TABLE CONTOURS

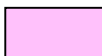
LEGEND FOR HYDROGEOLOGICAL MAP(WITHPRE-MONSOON WATER TABLE CONTOURS)

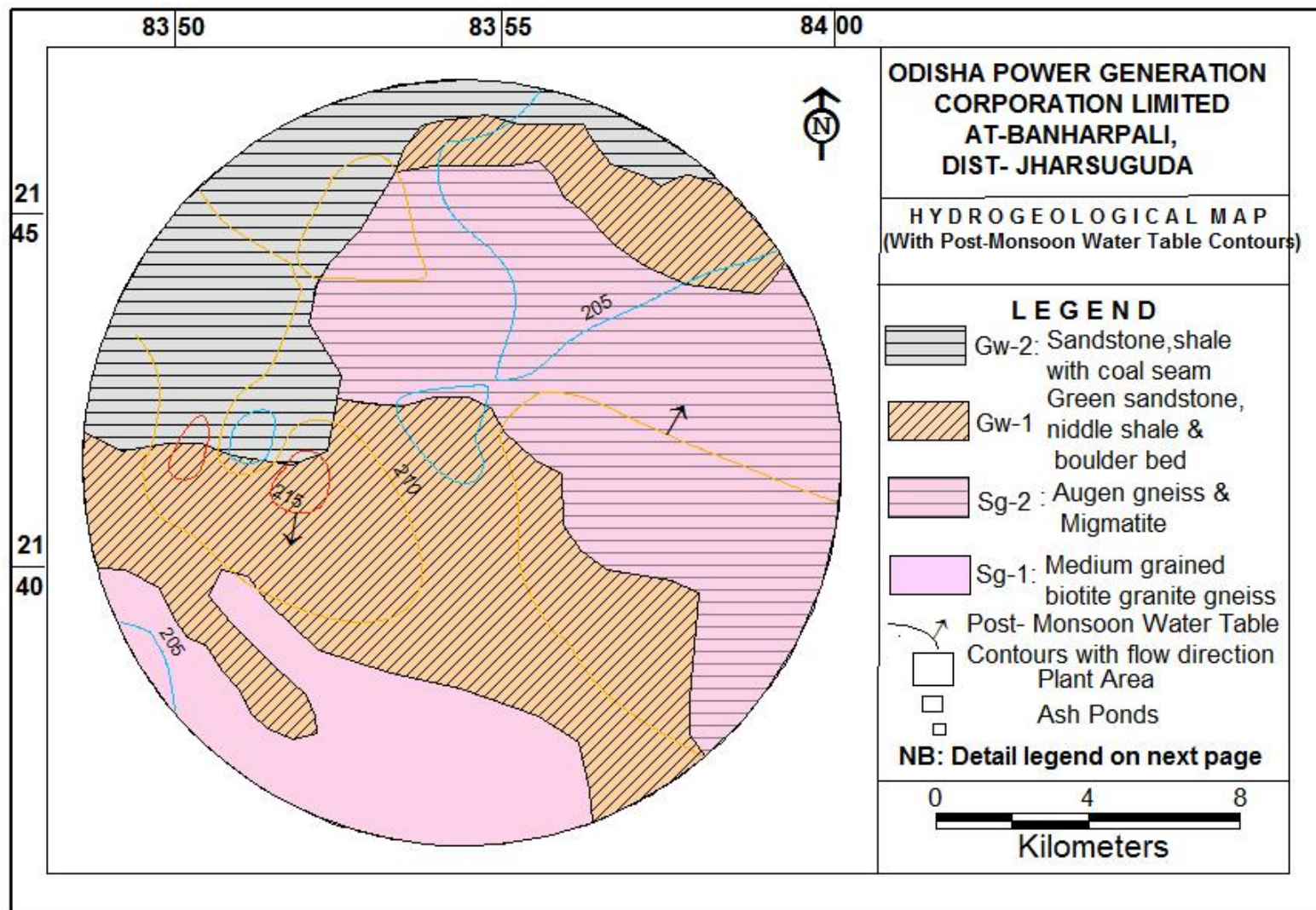
SYMBOL	LITHOLOGY	GEOLOGICAL UNIT	AGE	Ground Water potential
 Gw-2	Sandstone, shale with coal seams	Barakar formation (Gondwana Super group)	Permian	Ground water occurs at shallow depth in weathered formations under phreatic condition and at deeper depth in fracture and joints developed due to secondary porosity under confined condition. Yield varies from 25 To 30 m ³ / day in unconfined aquifer and 2.16 to 2.88 m ³ / hr in confined aquifers.
 Gw-1	Green sandstone, needle shale & boulder bed	Talcher Formation (Gondwana Super group)	Carboniferous to Permian	
 Sg-2	Augen gneiss & Migmatite	Peninsular gneiss (Younger phase)	Archaean to Lr Proterozoic	Ground water occurs at shallow depth in weathered formations under phreatic condition and at deeper depth in fracture and joints developed due to secondary porosity under confined condition. Yield varies from 25 To 30 m ³ / day in unconfined aquifer and from 4.5 to 5.8 m ³ /hr in confined aquifers.
 Sg-1	Medium grained biotite granite gneiss	Peninsular gneiss (Older phase)	Archaean	
205-m 	Pre- Monsoon Water table contour and Ground water flow direction			
	Buffer zone			



Map- 6.2: HYDROGEOLOGICAL MAP WITH MONSOON WATER TABLE CONTOURS

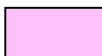
LEGEND FOR HYDROGEOLOGICAL MAP (WITH MONSOON WATER TABLE CONTOURS)

SYMBOL	LITHOLOGY	GEOLOGICAL UNIT	AGE	Ground Water potential
 Gw-2	Sandstone, shale with coal seams	Barakar formation (Gondwana Super group)	Permian	Ground water occurs at shallow depth in weathered formations under phreatic condition and at deeper depth in fracture and joints developed due to secondary porosity under confined condition. Yield varies from 25 To 30 m ³ / day in unconfined aquifer and 2.16 to 2.88 m ³ / hr in confined aquifers.
 Gw-1	Green sandstone, needle shale & boulder bed	Talcher Formation (Gondwana Super group)	Carboniferous to Permian	
 Sg-2	Augen gneiss & Migmatite	Peninsular gneiss (Younger phase)	Archaean to Lr Proterozoic	Ground water occurs at shallow depth in weathered formations under phreatic condition and at deeper depth in fracture and joints developed due to secondary porosity under confined condition. Yield varies from 25 To 30 m ³ / day in unconfined aquifer and from 4.5 to 5.8 m ³ /hr in confined aquifers.
 Sg-1	Medium grained biotite granite gneiss	Peninsular gneiss (Older phase)	Archaean	
205-m 	Pre- Monsoon Water table contour and Ground water flow direction			
	Buffer zone			



Map- 6.3: HYDROGEOLOGICAL MAP WITH POST- MONSOON WATER TABLE CONTOURS

LEGEND FOR HYDROGEOLOGICAL MAP (WITH POST -MONSOON WATER TABLE CONTOURS)

SYMBOL	LITHOLOGY	GEOLOGICAL UNIT	AGE	Ground Water potential
 Gw-2	Sandstone, shale with coal seams	Barakar formation (Gondwana Super group)	Permian	Ground water occurs at shallow depth in weathered formations under phreatic condition and at deeper depth in fracture and joints developed due to secondary porosity under confined condition. Yield varies from 25 To 30 m ³ / day in unconfined aquifer and 2.16 to 2.88 m ³ / hr in confined aquifers.
 Gw-1	Green sandstone, needle shale & boulder bed	Talcher Formation (Gondwana Super group)	Carboniferous to Permian	
 Sg-2	Augen gneiss & Migmatite	Peninsular gneiss (Younger phase)	Archaean to Lr Proterozoic	Ground water occurs at shallow depth in weathered formations under phreatic condition and at deeper depth in fracture and joints developed due to secondary porosity under confined condition. Yield varies from 25 To 30 m ³ / day in unconfined aquifer and from 4.5 to 5.8 m ³ /hr in confined aquifers.
 Sg-1	Medium grained biotite granite gneiss	Peninsular gneiss (Older phase)	Archaean	
205-m 	Post- Monsoon Water table contour and Ground water flow direction			
	Buffer zone			

Chapter-7

Ground Water Regime Monitoring

7.1: Introduction: 22 No of shallow bore wells were selected for measuring water level. Locations of these wells are shown in map No-12. The details of these wells are tabulated in below. Three times measurements were taken for this purpose. First time measurement was taken in the month of April '2018 (during first week) for Pre-monsoon purposes and second time in the month of July '2018 (during first week) for Monsoon and third time in the month of November 2018 (During last week) for Post-monsoon. The details of water level variation are as below.

7.2. Water level monitoring:

Pre-monsoon Water level:-

Pre-monsoon water level varies from 4.72 to 7.23 m below ground level. The minimum water level was recorded at Katapali village and maximum at Bargarh village. The average pre - monsoon water level is 6.07 meter below ground level.

Monsoon Water level:-

Monsoon water level varies from 0.78 meter below ground level to 2.1 meter below ground level, being minimum at Ubuda village and maximum at Kirarama. The average water level (post monsoon period) is 1.26 meter below ground level.

Post-monsoon Water level:-

Post- monsoon water level varies from 1.24 meter below ground level to 3.45 meter below ground level, being minimum at Bhutia village and maximum at Kararama. The average water level (post monsoon period) is 2.14 meter below ground level.

Fluctuation in water level:-

Pre and post monsoon water levels were considered for evaluation of seasonal fluctuation in water level. Thus fluctuation in water level varies from 2.72 (at Basupali) to 5.34 (at Piplikani). The average fluctuation is 3.92 meters.

7.3: Details of all these data are shown as below.

Table -7.1 : Water level in different season

Parameters	Pre Mon	Monsoon	Post-mon
Min	4.72	0.78	1.24
Max	7.23	2.1	3.45
Mean	6.07	1.26	2.14

Table -7.2 : Water level Fluctuations in different season

Parameters	Water Level Fluctuation with respect to different season		
	Pre Monsoon – post Monsoon	Pre monsoon – Monsoon)	(Post Monsoon -Monsoon)
Min	2.72	3.76	0.39
Max	5.34	6.16	1.89
Mean	3.92	4.81	0.89

Table -7.3 : Water Table variation in different season

Parameters	Water Table		
	Pre-monsoon	Monsoon	Post Monsoon
Min	196.27	201.64	200.45
Max	213.38	217.45	217.06
Mean	204.38	209.19	208.30

Maps pertaining to locations of observation wells, pre monsoon, post monsoon water levels and seasonal fluctuations are shown in maps No 7.1 to 7.7.

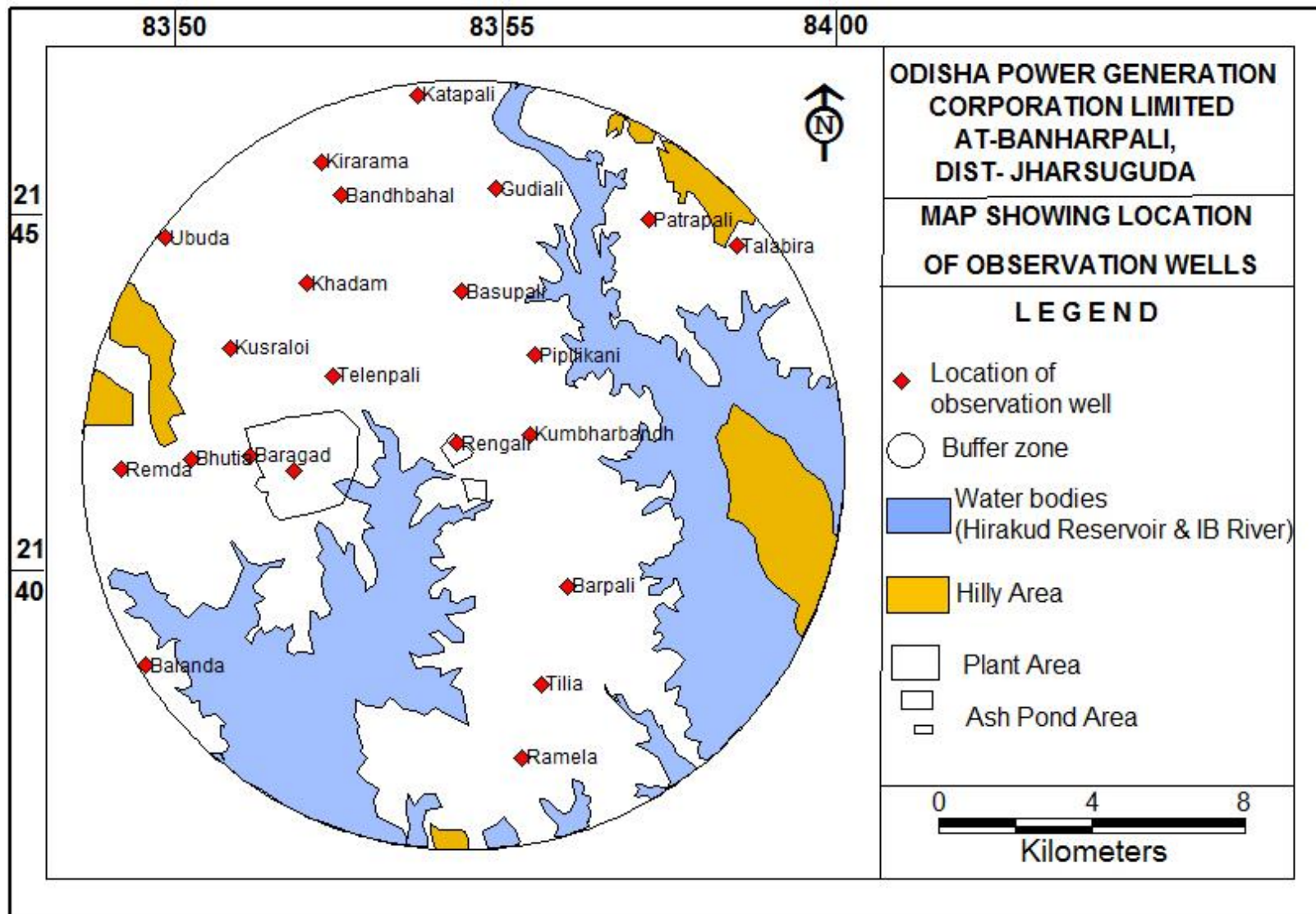
**Table-7.4: HYDROGEOLOGICAL DATA OF OBSERVATION WELLS
ESTABLISHED FOR GROUND WATER REGIME MONITORING**

S.No	Location	Longitude	Latitude	Location details	Lithology
1	Kirarama	83°52'16.45"	21°45'44.83"	Ad to Manoj pradhan house	Sst, Shale & Coal seam
2	Gudiali	83°54'54.96"	21°45'22.62"	Guduali Sebashram school	Augen gneiss & migmatite
3	Patrapali	83°57'13.66"	21°44'56.36"	Adjacent to Bhim Munda house	Sandstone,Shale & Coal seams
4	Ubuda	83°49'53.60"	21°44'40.89"	Premise of UPUG School	Sandstone,Shale & Coal seams
5	Bandhbahal	83°52'33.48"	21°45'16.56"	Near Electric sub station	Sandstone,Shale & Coal seams
6	Talabira	83°58'33.75"	21°44'33.83"	Adjacent to Angan wadi centre	Sandstone, Shale & Boulder bed
7	Kusraloi	83°50'52.32"	21°43'07.94"	Primary school	Sandstone,Shale & Coal seams
8	Telenpali	83°52'25.84"	21°42'44.45"	Primary school	Sandstone,Shale & Coal seams
9	Pipilikani	83°55'30.72"	21°43'01.77"	Adjacent to Angan wadi centre	Augen gneiss & migmatite
10	Rengali	83°54'19.36"	21°41'47.32"	Near Upendra Sahoo house	Sandstone, Shale & Boulder bed
11	Remda	83°49'13.72"	21°41'25.03"	Near Govind Pradhan house	Sandstone, Shale & Boulder bed
12	Baragad	83°51'10.62"	21°41'37.26"	Primary school	Sandstone,Shale & Coal seams
13	Banaharapali	83°51'50.00"	21°41'24.04"	Project UP School	Sandstone, Shale & Boulder bed
14	Kumbharbandh	83°55'25.66"	21°41'54.79"	Primary school	Augen gneiss & migmatite
15	Bhutia	83°50'17.22"	21°41'34.48"	Near Samlei Temple	Sandstone, Shale & Boulder bed
16	Barpali	83°56'00.11"	21°39'46.46"	Primary school	Sandstone, Shale & Boulder bed
17	Tilia	83°55'35.96"	21°38'23.66"	Adjacent to Niranjn Seth House	Sandstone, Shale & Boulder bed
18	Ramela	83°55'18.96"	21°37'21.56"	Adjacent to Angan wadi centre	Medium grained sandstone
19	Balanda	83°49'36.11"	21°38'40.12"	Balanda UP School	Medium grained sandstone
20	Katapali	83°53'42.86"	21°46'41.48"	Sibanand Ashram	Sandstone,Shale & Coal seams
21	Basupali	83°54'22.79"	21°43'55.14"	Adjacent to Angan wadi centre	Augen gneiss & migmatite
22	Khadam	83°52'02.77"	21°44'02.68"	Near youth club	Sandstone,Shale & Coal seams

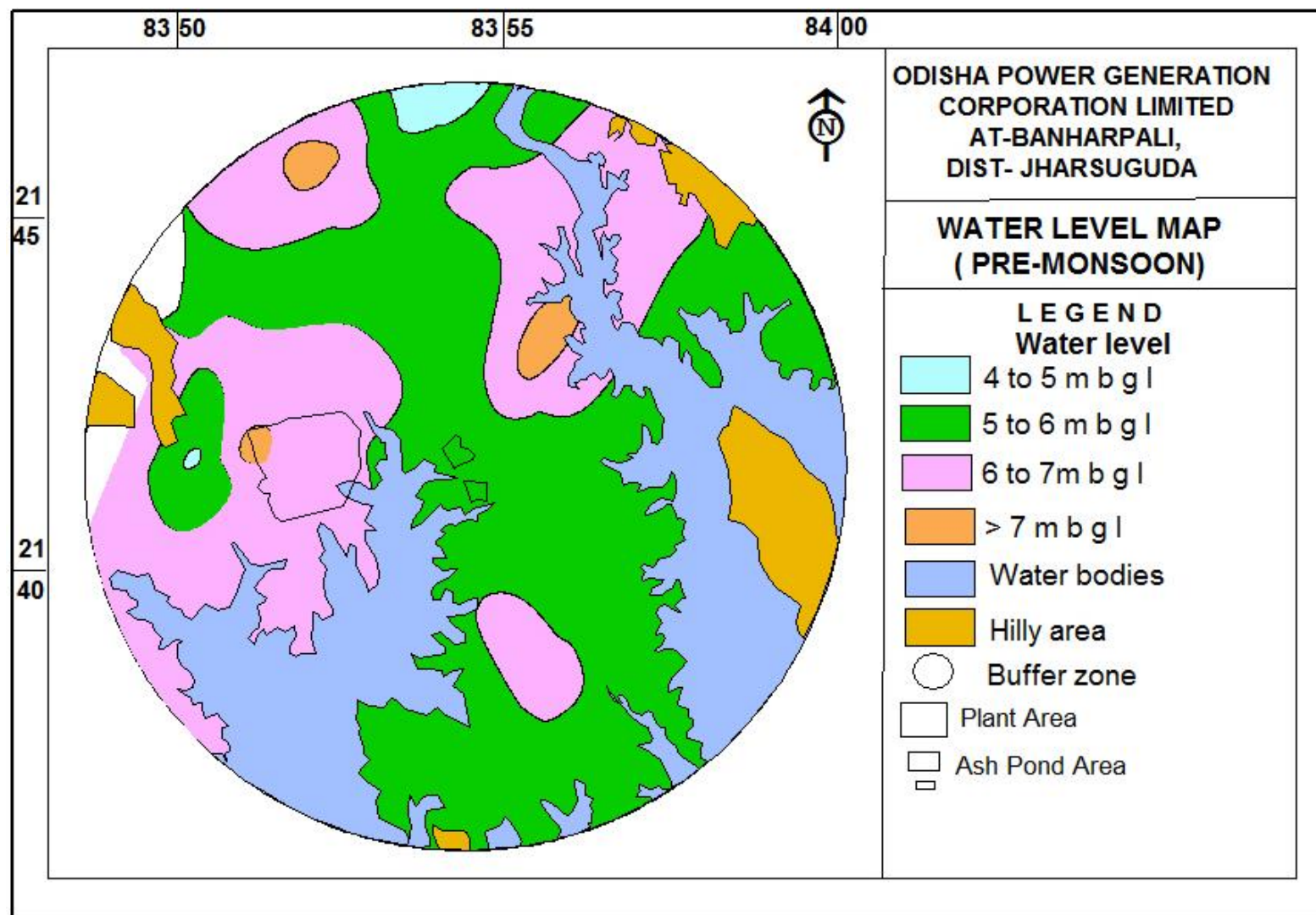
S.No	Location	Depth (mbgl)	Casing Length (mbgl)	Fracture depth (mbgl)	Yield (IPS	Pre-monsoon water level (mbgl)	Monsoon Water level (m)	Post-monsoon water level (mbgl)
1	Kirarama	46.5	22.4	32.50,44.50	0.75	7.16	2.1	3.45
2	Gudiali	39.2	14.7	32.50,37.50	0.5	6.3	1.85	2.45
3	Patrapali	45.6	22.5	26.80,44.0	0.75	6.48	1.25	3.14
4	Ubuda	42.8	23.6	29.50,41.0	1.5	5.88	0.78	1.46
5	Bandhbahal	41.2	18.2	27.50,39.80	0.5	6.12	1.22	2.45
6	Talabira	40.5	20.6	34.50,38.60	1.2	5.67	1.38	2.75
7	Kusraloi	34.5	12.6	21.30,32.60	0.6	6.06	0.84	1.78
8	Telenpali	36.8	13.5	23.60,35.8	0.75	6.55	1.12	1.65
9	Pipilikani	35.7	15.7	32.60,34.30	0.8	7.22	1.06	1.88
10	Rengali	32.5	12.4	15.70,31.30	0.5	5.68	1.24	2.15
11	Remda	28.3	13.6	15.70,27.50	1	6.45	1.45	2.37
12	Baragad	32.6	22.3	24.50,30.80	2	7.23	1.86	3.05
13	Banaharapali	40.25	21.2	22.50,38.50	2.5	6.25	0.92	1.64
14	Kumbharbandh	23.5	12.6	17.60,22.50	1.2	5.75	1.48	2.07
15	Bhutia	36.4	14.5	17.50,35.60	0.3	4.92	0.85	1.24
16	Barpali	26.8	12.6	15.60,25.40	0.5	5.67	1.35	2.16
17	Tilia	36.8	12.4	25.6,30.20,36.80	0.5	6.34	1.15	1.75
18	Ramela	45.8	16.2	22.80,35.60,42.30	1	5.48	1.35	2.06
19	Balanda	46.1	14.5	28.30,44.70	1.6	6.52	0.85	1.65
20	Katapali	38.5	20.6	26.0,37.50	1.5	4.72	0.96	1.49
21	Basupali	43.7	18.2	36.20,44.50	0.6	5.28	1.45	2.56
22	Khadam	44.5	22.5	28.5,34.70,43.50	0.5	5.7	1.1	1.89

Table-7.4, continued

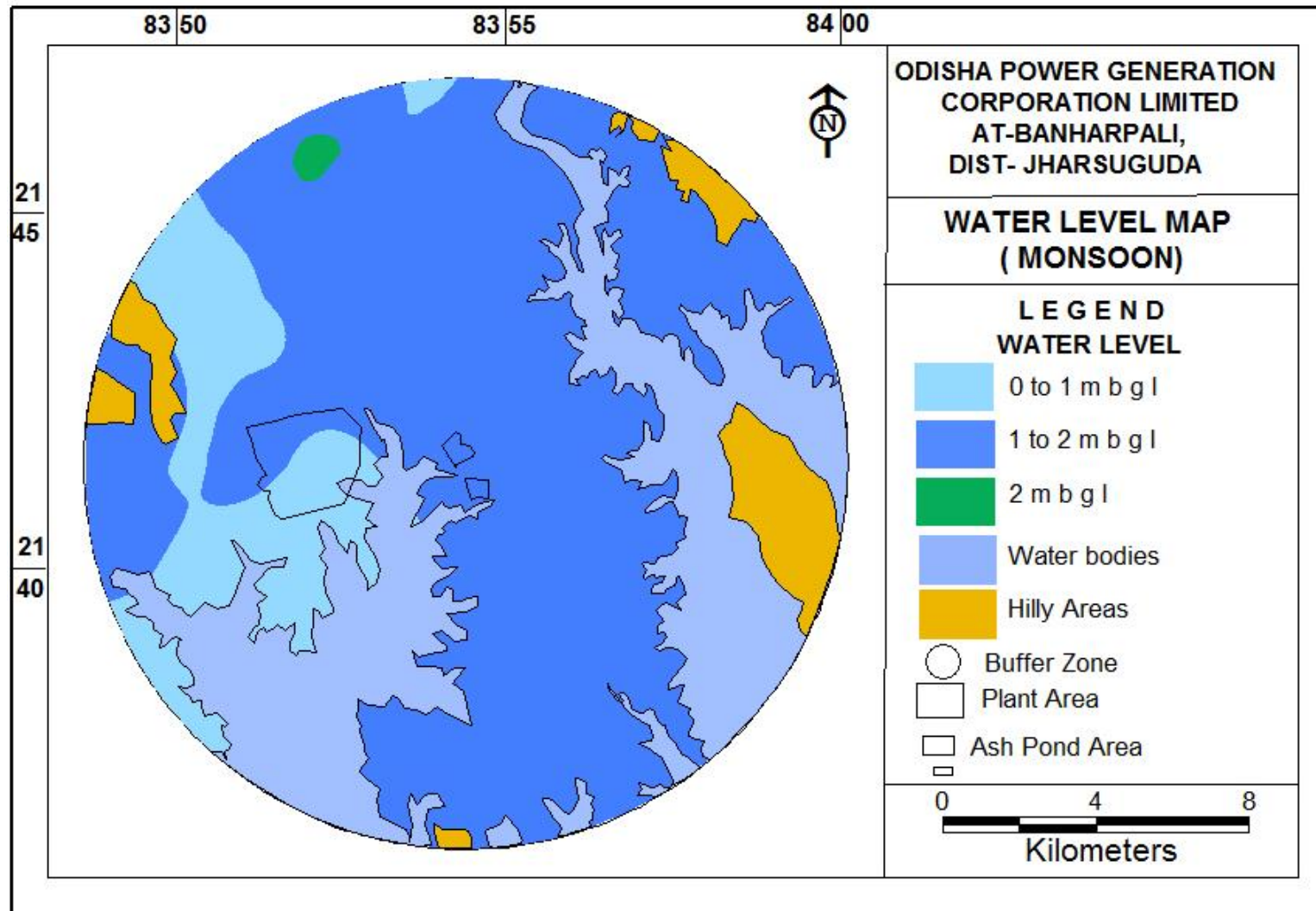
S.No	Location	Water level Fluctuation (m)			Water table (mamsl)		
		Pre monsoon- Monsoon	Monsoon- Post- Monsoon	Pre-monsoon – Post Monsoon	Pre monsoon	Monsoon	Post Monsoon
1	Kirarama	5.06	1.35	3.71	203.34	208.4	207.05
2	Gudiali	4.45	0.6	3.85	197.3	201.75	201.15
3	Patrapali	5.23	1.89	3.34	198.97	204.2	202.31
4	Ubuda	5.1	0.68	4.42	206.42	211.52	210.84
5	Bandhbahal	4.9	1.23	3.67	209.28	214.18	212.95
6	Talabira	4.29	1.37	2.92	201.93	206.22	204.85
7	Kusraloi	5.22	0.94	4.28	210.24	215.46	214.52
8	Telenpali	5.43	0.53	4.9	200.25	205.68	205.15
9	Pipilikani	6.16	0.82	5.34	198.23	204.39	203.57
10	Rengali	4.44	0.91	3.53	200.02	204.46	203.55
11	Remda	5	0.92	4.08	203.85	208.85	207.93
12	Baragad	5.37	1.19	4.18	196.27	201.64	200.45
13	Banaharapali	5.33	0.72	4.61	211.35	216.68	215.96
14	Kumbharbandh	4.27	0.59	3.68	210.45	214.72	214.13
15	Bhutia	4.07	0.39	3.68	213.38	217.45	217.06
16	Barpali	4.32	0.81	3.51	209.73	214.05	213.24
17	Tilia	5.19	0.6	4.59	202.26	207.45	206.85
18	Ramela	4.13	0.71	3.42	205.02	209.15	208.44
19	Balanda	5.67	0.8	4.87	199.88	205.55	204.75
20	Katapali	3.76	0.53	3.23	204.73	208.49	207.96
21	Basupali	3.83	1.11	2.72	207.22	211.05	209.94
22	Khadam	4.6	0.79	3.81	206.15	210.75	209.96



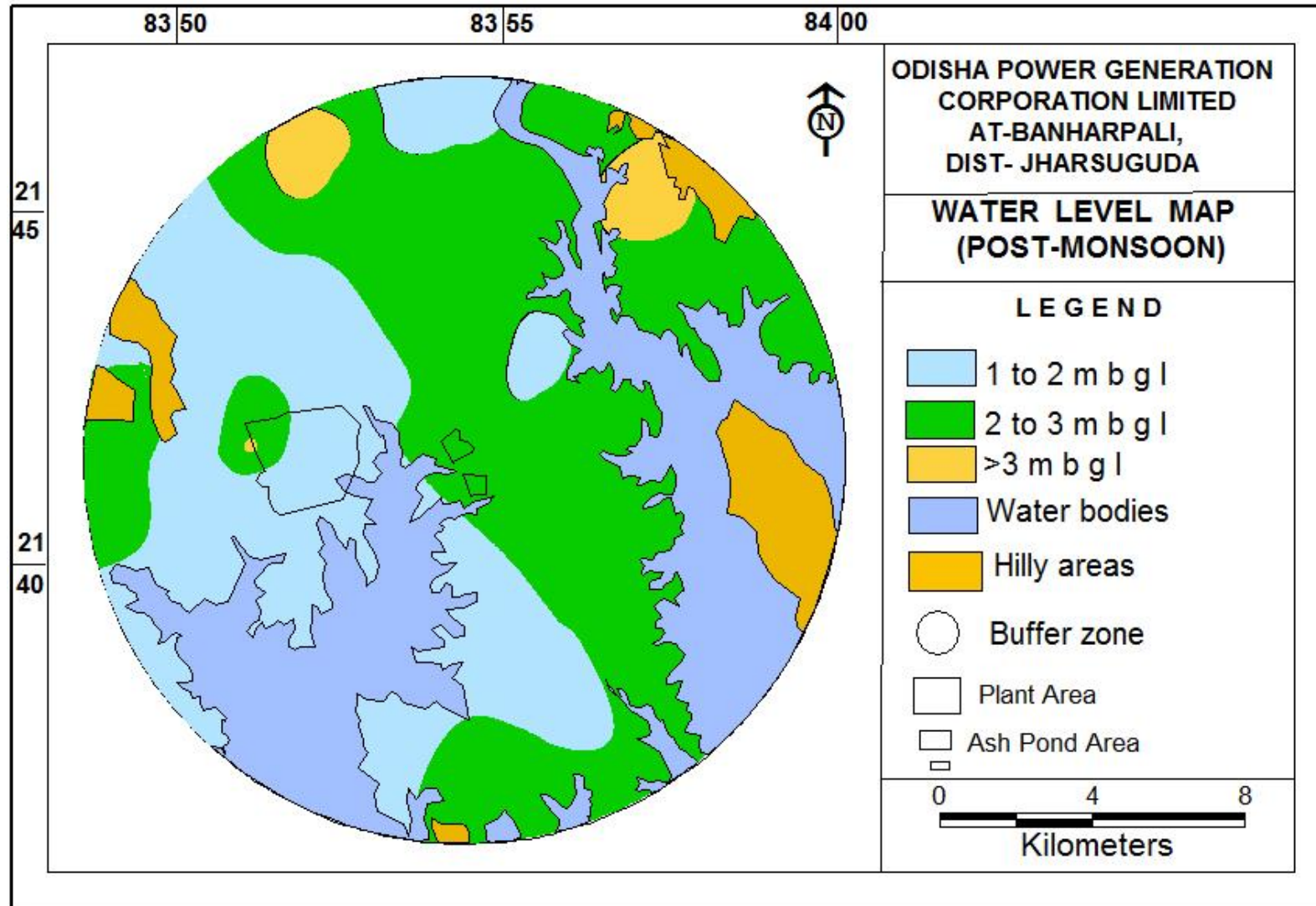
MAP NO-7.1: MAP SHOWING LOCATION OF OBSERVATION WELL FOR GROUND WATER LEVEL MONITORING



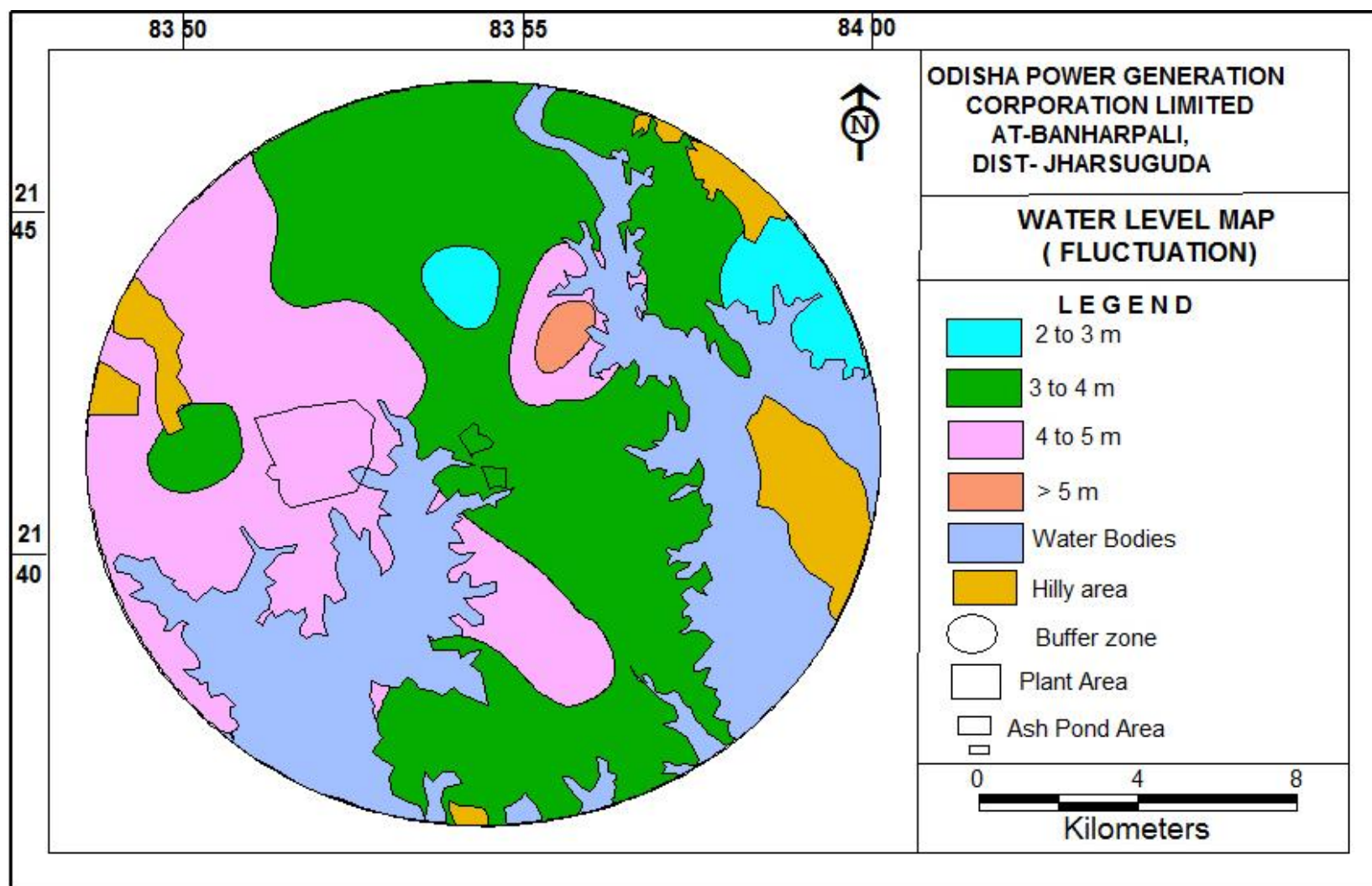
MAP NO-7.2 : MAP SHWING PRE-MONSOON WATER LEVEL



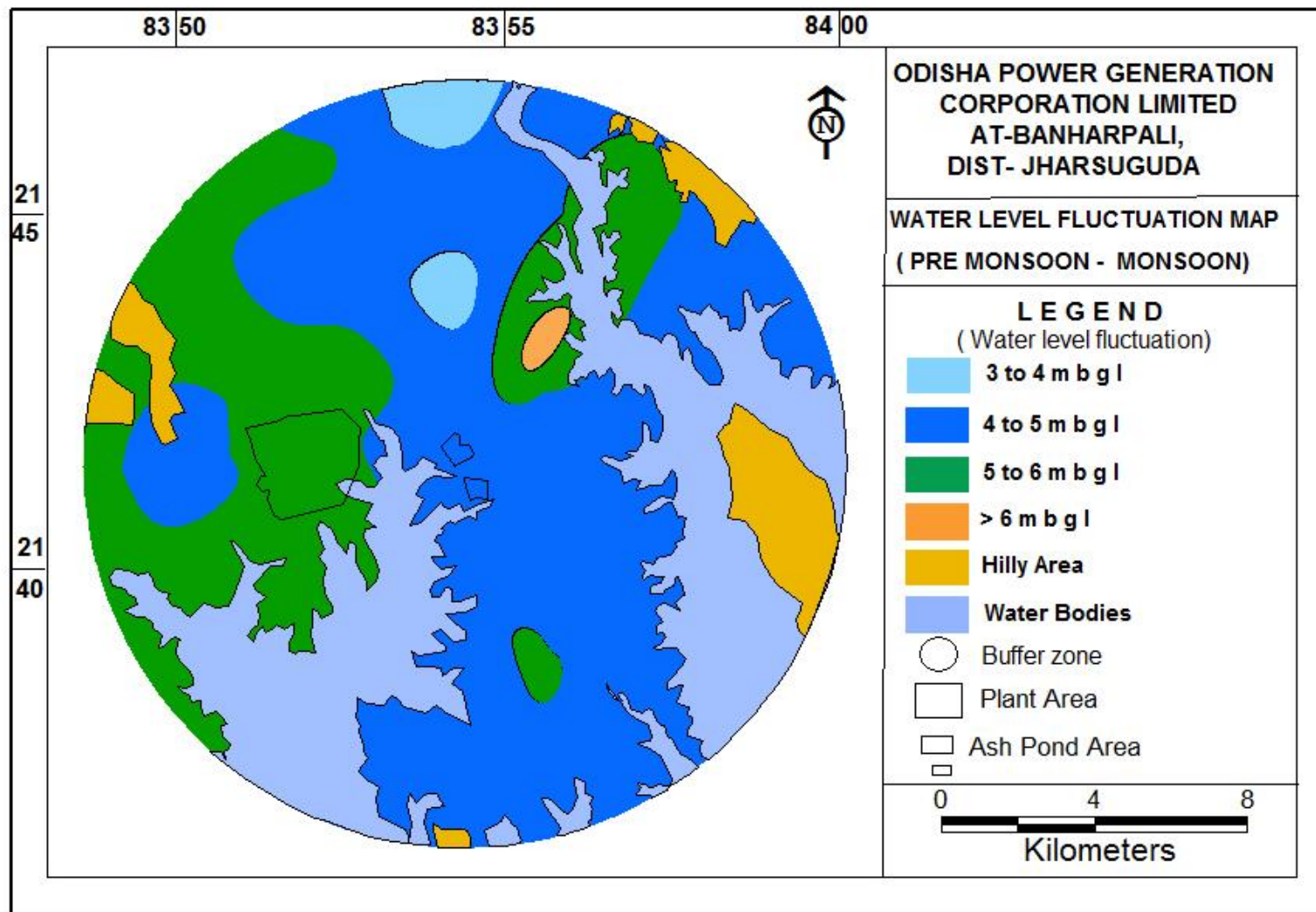
MAP NO- 7.3 : MAP SHWING MONSOON WATER LEVEL



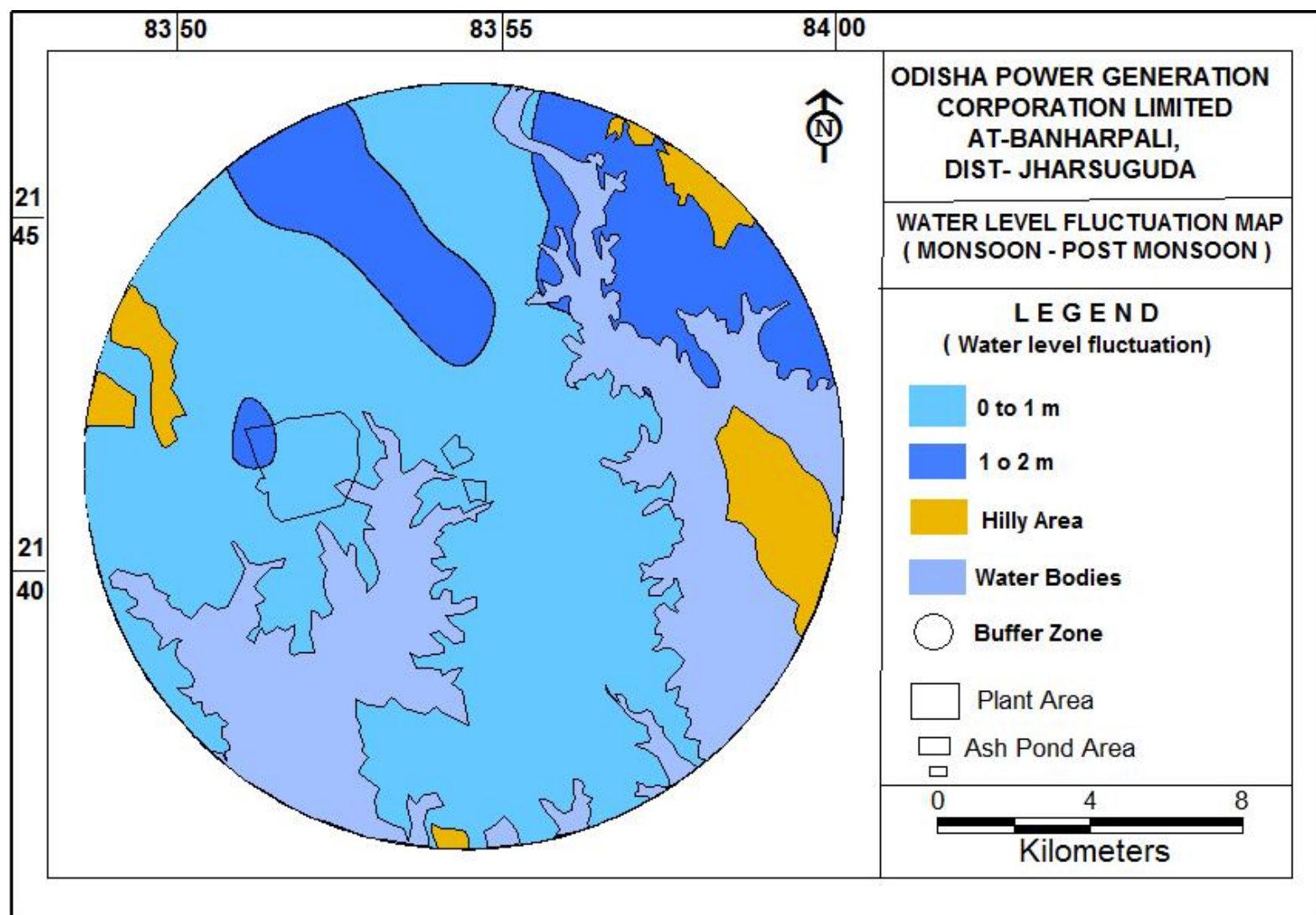
MAP NO-7.4 : MAP SHOWING POST MONSOON WATER LEVEL



MAP NO – 7.5 : MAP SHOWING WATER LEVEL FLUCTUATION (PRE-MONSOON AND POST MONSOON SEASON)



MAP NO -7.6 : MAP SHOWING WATER LEVEL FLUCTUATION (PRE-MONSOON AND MONSOON SEASON)



MAP NO – 7.7: MAP SHOWING WATER LEVEL FLUCTUATION (MONSOON AND POST- MONSOON SEASON)

7.4 Historical water level monitoring data: There are 4 No of national hydrograph stations established in Jharsuguda district. These are monitored 4 times in a year i.e. January, April (Pre-monsoon period), August (monsoon period) and November (post-monsoon period). Station close to present study area is Lakhanpur. So water level graph of Lakhanpur station is shown below.

Table- 7.5: Water level (mbgl) data of Lakhanpur Well

Year	Jan	April	Aug	Nov
1995	4.8	6.3	2.35	3.35
1996	4.45	6.35	2.06	3.96
1997	5.29	6.25	1.73	4.55
1998	4.2	6.46	3.02	4.1
1999	5.05	6.35	1.98	4.1
2000	4.98	6.28	3.02	4.82
2001	5.63	6.43	1.75	4.62
2002	5.29	5.55	2.95	4.15
2003	5.52	6.21	1.42	2.24
2004	4.4	5.79	2.5	3.33
2005	4.53	5.63	1.86	3.55
2006	5.63	5.99	1.21	2.44
2007	4.85	5.8	1.9	3.24
2008	4.91	6.14	2.76	4
2009	4.68	7.02	2.35	3.74
2010	5.01	6.16	3.02	4.83
2011	4.75	5.88	1.49	3.64
2012	4.8	6	1.49	3.6
2013	5.15	6.85	2.55	2.85
2014	4.6	5.7	2.35	3.8
2015	4.75	5.7	2.85	4.05
2016	4.75	5.4	2.65	3.45
2017	3.98	5.72	2.8	3.45
Minimum	3.98	5.4	1.21	2.24
Maximum	5.63	7.02	3.02	4.83
Average	4.87	6.09	2.26	3.73

Source: Central Ground Water Board

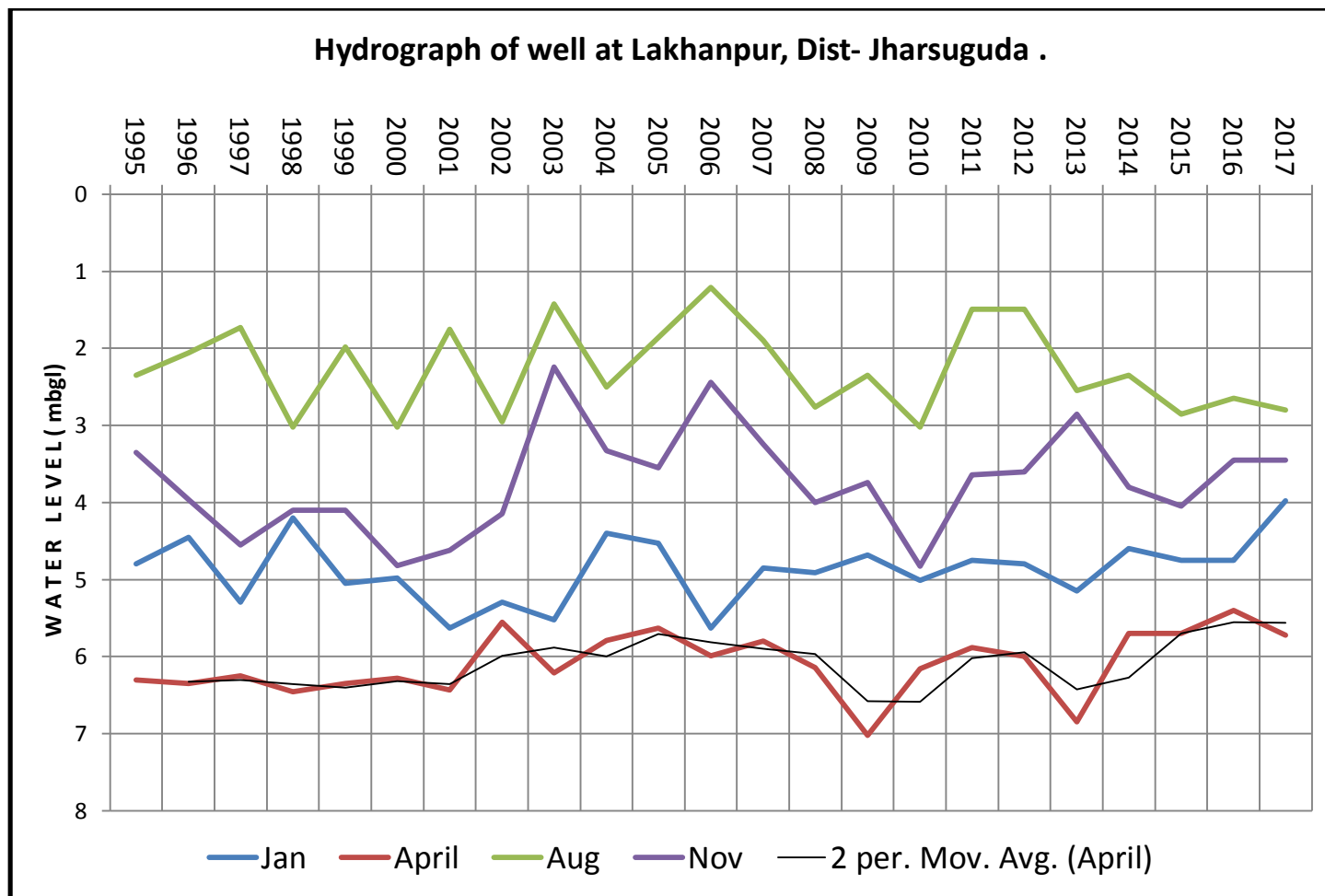


FIG-7.1: HYDROGRAPH OF LAKHANPUR GROUND WATER MONITORING STATION

Chapter-8

Ground Water Quality

8.1: Introduction: It is highly essential to assess the quality of ground water of the area and accordingly its suitability for various purposes viz drinking, irrigation and industrial purposes etc. In order to assess the chemical quality, groundwater samples from different part of the study area during pre- monsoon period have been collected and analyzed for various parameters. So in order to assess the quality of ground water in the present area 12 nos. of water samples (4 Nos. from open wells and 4 nos. from shallow tube wells and 4 nos. from deep tube wells available in the area were collected and analyzed by adopting standard method of chemical analysis. The result of the chemical analysis of ground water is shown in table-8.3 A,B and C. A comparison of the quality of open wells and tube wells and range variation of different chemical constituents are tabulated below:-

**Table -:8.1 -Range of Various Chemical Constituents Analyzed in Water
Samples collected from different sources in the buffer zone.**

Chemical Parameters	Open Wells			Shallow bore Wells			Deep/bore tube wells		
	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Temperature ° C	26.5	28	27.25	27	28	27.625	26.5	28	27.375
pH	7.1	7.8	7.4625	7.6	7.85	7.75	7.6	8.25	8.0125
Sp Cond	360	650	456.25	314	495	399.5	256	460	340.5
Bicarbonates (mg/l)	76	258	179.75	105	220	159	102	244	148.75
Chloride (mg/l)	18	62	42.75	14	65	33.75	18	25	21.25
Sulphate (mg/l)	3.6	35	16.275	0	8.5	3.475	3.6	5.6	4.55
Nitrate (mg/l)	4.5	22.6	12.025	0.2	5.6	3.45	2.5	14.5	6.1
Fluoride (mg/l)	0.35	0.6	0.50	0.45	0.85	0.6	0.3	0.6	0.7
Total Hardness (mg/l)	36	180	113.5	88	155	122.25	85	188	121
Calcium (mg/l)	15	45	29.75	18	50	31	22	55	31.25
Magnesium (mg/l)	10.5	30	20.375	7.3	16	11.95	7.5	14	10.875
Sodium (mg/l)	16	45	29.625	13	45	29.5	5.6	24	14.9
Potassium (mg/l)	5.5	12	7.525	3.5	6.5	5.025	4.5	5.8	5.075
Iron (mg/l)	0.14	0.12	0.19	0	0.16	0.021	0.22	0.15	0.14
TDS (mg/l)	215	372	266.25	188	289	245.25	156	277	205.75

From the above table following inference can be drawn-

Table-8.2: comparison of the ground water quality with national Standard

Parameters	Drinking water standard (IS-10500-2012)	
	Desirable limit	Permissible limit
pH	6.5 to 8.5	NR
EC	750	1500
CO ₃	-	-
HCO ₃	-	-
Cl	250	1000
SO ₄	200	400
NO ₃	45	NR
F	1.0	1.5
TH	200	600
Ca	75	200
Mg	30	NR
Na	No guideline	-
K	No guideline	-
TDS		

Note : All parameters are in mg/liter except EC which is in $\mu\text{S}/\text{cm}$ at 25°C

NR- No Relaxation

A perusal of concentration of various chemical constituents of water indicate that Ground water is most suitable for all the purposes viz. drinking, domestic, irrigation and Industrial purposes. It is concluded that all the parameters are well within the prescribed norms for drinking water and suitable for human consumption as well as for all purposes as per requirement of the industry.

Table-8.3A: CHEMICAL ANALYSIS DATA OF WATER SAMPLES FROM OPEN WELLS

S. No	Location	Temp	pH	EC	HCO ₃	Cl	SO ₄	NO ₃	F	TH	Ca	Mg	Na	K	Fe	TDS
1	Kirarama	28	7.8	430	210	29	14.5	6.5	0.6	180	45	18	16	12	0.21	250
2	Ubuda	27.5	7.75	385	76	62	3.6	22.6	0.6	142	15	23	17.5	7	0.13	228
3	Telenpali	26.5	7.1	360	175	18	12	4.5	0.35	96	30	10.5	40	5.6	0.12	215
4	Rengali	27	7.2	650	258	62	35	14.5	0.8	36	29	30	45	5.5	0.17	372

N.B: All parameters are in mg/l except EC which is in $\mu\text{S}/\text{cm}$ at 25°C.

Table-8.3B: CHEMICAL ANALYSIS DATA OF WATER SAMPLES FROM SHALLOW BORE WELLS

S.No	Location	Temp	pH	EC	HCO ₃	Cl	SO ₄	NO ₃	F	TH	Ca	Mg	Na	K	Fe	TDS
1	Banharpali	28	7.85	430	116	65	2.8	4.5	0.6	88	18	16	45	5.2	0.15	270
2	Basupali	27.5	7.6	495	220	14	8.5	3.5	0.7	130	20	16	42	6.5	0.17	289
3	Bhutia	27	7.85	314	105	38	2.6	5.6	0.5	116	36	8.5	18	3.5	0.22	188
4	Gudiali	28	7.7	359	195	18	0	0.2	0.4	155	50	7.3	13	4.9	0.18	234

N.B: All parameters are in mg/l except EC which is in $\mu\text{S}/\text{cm}$ at 25°C.

Table-8.3C: CHEMICAL ANALYSIS DATA OF WATER SAMPLES FROM DEEP BORE WELLS

S.NO	Location	Temp	pH	EC	HCO ₃	Cl	SO ₄	NO ₃	F	TH	Ca	Mg	Na	K	Fe	TDS
1	Banharpali	28	8.1	356	124	24	4.5	3.8	0.4	85	22	8	24	5.5	0.14	215
2	Balanda	27.5	8.1	256	125	18	4.5	3.6	0.5	112	24	14	5.6	4.5	0.18	156
3	Piplikani	26.5	7.6	460	244	18	3.6	2.5	0.5	188	55	14	14	4.5	0.11	277
4	Kumarbandha	27.5	8.25	290	102	25	5.6	14.5	0.6	99	24	7.5	16	5.8	0.16	175

N.B: All parameters are in mg/l except EC which is in $\mu\text{S}/\text{cm}$ at 25°C.

8.2: Ground water quality in core and adjacent area: Beside the above 7 No of water samples were also collected from core zone and its adjacent and adjoining areas in buffer zone. Locations of these samples and their analysis are shown in following tables

Table -8.4 A: Particulars of ground water sample collection from core zone and its adjoining / adjacent areas

S. No	Particulars	Details	S. No	Particulars	Details
1	Name of Industry	OPGC	6	Sample Analysis (Post-monsoon)	Dec,2018
2	Source of samples	Bore wells	7	Sample collection (Monsoon)	July,2018
3	Sample Collected by	VCSPL representative	8	Sample Analysis (Monsoon)	July,2018
4	Sampling Location	OPGC plant Area, Core & Buffer zone	9	Sample collection (Pre-monsoon)	Apr,2018
5	Sample collection (Post-monsoon)	Nov,2018	10	Sample Analysis (Pre-monsoon)	Apr,2018

Table 8.4B: Locations of ground water samples

Sample code	Location
GW-1	B/W Near MGR refueling station
GW-2	B/W Near BGRE batching plant near plantation site
GW-3	B/W Behind learning center
GW-4	B/W Near Ash Pond Area (close to western bund of Ash Pond A)
GW-5	B/W of Bargarh village
GW-6	B/W of Rengali village
GW-7	B/W of Kusraloi village

Table-8.5: Result of Ground Water Quality (during Post Monsoon Season)

Sl. No.	Parameter	Unit	Testing Methods	Standard as per IS:10500	Analysis Results						
					GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7
Essential Characteristics											
1.	Colour	Hazen	APHA 2120 B, C	5	CL	CL	CL	CL	CL	CL	CL
2.	Odour	--	APHA 2150 B	Agreeable	U/O	U/O	U/O	U/O	U/O	U/O	U/O
3.	Taste	--	APHA 2160 C	Agreeable	AL	AL	AL	AL	AL	AL	AL
4.	Turbidity	NTU	APHA 2130 B	1	0.45	0.5	0.6	0.45	0.8	0.75	0.60
5	Temperature °C	-	-		25	26.5	25.5	27	26	24	27
6	pH	--	APHA 4500H ⁺ B	6.5-8.5	7.6	8	8	7.6	7.7	7.8	8.1
7	Sp conductance (EC) μS/cm (25°C)	μS/cm (25°C)	APHA 2540 C	1500	533	435	484	723	514	686	482
8	HCO ₃	mg/l	APHA 2540 C	300	281	232	207	214	275	189	183
9	Chloride (as Cl)	mg/l	APHA 4500Cl ⁻ B	250	18	7	21	71	14	96	46
10	Sulphate as SO ₄	mg/l	APHA 4500 SO ₄ ²⁻ E	200	21	25	28	36	19	6	2
11	Nitrate as NO ₃	mg/l	APHA 4500 NO ₃ ⁻ E	45	0	3	18.3	45	4	3.2	20.9
12	Fluoride as F	mg/l	APHA 4500F ⁻ C	1.0	0.3	0.4	0.4	0.6	0.4	0.3	0.2
13	Total Hardness (as CaCO ₃)	mg/l	APHA 2340 C	200	187	195	175	170	160	140	175
14	Alkalinity	mg/l	APHA 2320 B	200	64	70	77	84	88	80	79
15	Calcium as Ca	mg/l	APHA 3500Ca B	75	62	50	68	86	46	74	66
16	Magnesium as Mg	mg/l	APHA 3500Mg B	30	11	17	10	11	10	13	2
17	Sodium as Na	mg/l		No guideline	32	15.7	10	51	50.5	44.1	39.6
18	Potassium as K	mg/l		No guideline	1.3	0.4	0.6	0.8	1.2	4.7	1.3
19	Iron (as Fe)	mg/l	APHA 3500Fe, B	0.3	0.21	0.25	0.2	0.25	0.24	0.25	0.25
20	Total Dissolved Solids	mg/l	APHA 2540 C	500	321.4	262.3	291.9	436.0	309.9	413.0	290.2
21	Residual Free Chlorine	mg/l	APHA 4500Cl, B	0.2	ND	ND	ND	ND	ND	ND	ND
Trace / heavy and other elements											
22	Copper as Cu	mg/l	APHA 3111 B,C	0.05	BDL	BDL	BDL	BDL	BDL	BDL	BDL

23	Manganese as Mn	mg/l	APHA 3500Mn B	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL
24	Phenolic Compounds as C ₆ H ₅ OH	mg/l	APHA 5530 B,D	0.001	BDL	BDL	BDL	BDL	BDL	BDL	BDL
25	Mercury as Hg	mg/l	APHA 3500 Hg	0.001	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	Cadmium as Cd	mg/l	APHA 3111 B,C	0.003	BDL	BDL	BDL	BDL	BDL	BDL	BDL
27	Selenium as Se	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
28	Arsenic as As	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
29	Cyanide as CN	mg/l	APHA 4500 CN ⁻ C,D	0.05	ND	ND	ND	ND	ND	ND	ND
30	Lead as Pb	mg/l	APHA 3111 B,C	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
31	Zinc as Zn	mg/l	APHA 3111 B,C	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL
32	Anionic Detergents as MBAS	mg/l	APHA 5540 C	0.2	ND	ND	ND	ND	ND	ND	ND
33	Chromium as Cr ⁺⁶	mg/l	APHA 3500Cr B	0.05	BDL	BDL	BDL	BDL	BDL	BDL	BDL
34	Mineral Oil	mg/l	APHA 5220 B	0.01	ND	ND	ND	ND	ND	ND	ND
35	Aluminium as Al	mg/l	APHA 3500Al B	0.03	BDL	BDL	BDL	BDL	BDL	BDL	BDL
36	Boron	mg/l	APHA 4500B, B	0.5	BDL	BDL	BDL	BDL	BDL	BDL	BDL
37	Poly Aromatic Hydrocarbon as PAH	µg/l	APHA 6440 B	0.0001	BDL	BDL	BDL	BDL	BDL	BDL	BDL
38	Pesticides	µg/l	APHA 6630 B,C	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent

Note: ND: Not Detected, BDL (Below Detection Limits).

Value of below detection limit (BDL) for different trace elements are as below.

Elements	Cu	Mn	Phenolic comp.	Hg	Cd	Se	As	Pb	Zn	Cr ⁺⁶	Al	B	Poly Aromatic Hydrocarbon
BDL values	0.01	0.01	0.0001	0.0001	0.0001	0.001	0.001	0.001	0.05	0.01	0.005	0.01	0.00005

Table-8.6: Result of Ground Water Quality (during Monsoon Season)

Sl. No.	Parameter	Unit	Testing Methods	Standard as per IS:10500	Analysis Results							
					GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	
Essential Characteristics												
1.	Colour	Hazen	APHA 2120 B, C	5	CL	CL	CL	CL	CL	CL	CL	
2.	Odour	--	APHA 2150 B	Agreeable	U/O	U/O	U/O	U/O	U/O	U/O	U/O	
3.	Taste	--	APHA 2160 C	Agreeable	AL	AL	AL	AL	AL	AL	AL	
4.	Turbidity	NTU	APHA 2130 B	1	0.8	0.6	0.6	0.75	0.65	0.80	0.80	
5	Temperature °C	-	-		26	27	25	26	28	25	26	
6	pH	--	APHA 4500H ⁺ B	6.5-8.5	7.8	8.27	8	8.1	8	8.3	8.2	
7	Sp conductance (EC) $\mu\text{S/cm}$ (25°C)	$\mu\text{S/cm}$ (25°C)	APHA 2540 C	1500	470	394	450	690	450	610	418	
8	HCO ₃	mg/l	APHA 2540 C	300	177	128	201	244	183	248	110	
9	Chloride (as Cl)	mg/l	APHA 4500Cl ⁻ B	250	43	18	32	43	39	28	39	
10	Sulphate as SO ₄	mg/l	APHA 4500 SO ₄ ²⁻ E	200	9	6.6	11	17.9	5	20.3	8	
11	Nitrate as NO ₃	mg/l	APHA 4500 NO ₃ ⁻ E	45	4.2	3.5	4.2	3.4	3.7	2.5	1.6	
12	Fluoride as F	mg/l	APHA 4500F ⁻ C	1.0	0.7	0.6	0.7	0.5	0.5	0.4	0.2	
13	Total Hardness (as CaCO ₃)	mg/l	APHA 2340 C	200	135	110	160	170	195	165	133	
14	Total Alkalinity	mg/l	APHA 2320 B	200	145.1	104.9	164.8	100	150	190.2	90.2	
15	Calcium as Ca	mg/l	APHA 3500Ca B	75	34	30	34	32	34	48	38	
16	Magnesium as Mg	mg/l	APHA 3500Mg B	30	12	9	18	26	27	23	9	
17	Sodium as Na	mg/l		No guideline	46.8	17.2	22	13.3	8	46.1	15.5	
18	Potassium as K	mg/l		No guideline	0.2	0.3	0.5	0.2	0.4	0.1	1.4	
19	Iron (as Fe)	mg/l	APHA 3500Fe, B	0.3	0.3	0.25	0.2	0.25	0.25	0.25	0.28	
20	Total Dissolved Solids	mg/l	APHA 2540 C	500	233	145	218	274	205	353	166	
21	Residual Free Chlorine	mg/l	APHA 4500Cl, B	0.2	ND	ND	ND	ND	ND	ND	ND	
Trace / heavy and other elements												

22	Copper as Cu	mg/l	APHA 3111 B,C	0.05	BDL	BDL	BDL	BDL	BDL	BDL	BDL
23	Manganese as Mn	mg/l	APHA 3500Mn B	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL
24	Phenolic Compounds as C ₆ H ₅ OH	mg/l	APHA 5530 B,D	0.001	BDL	BDL	BDL	BDL	BDL	BDL	BDL
25	Mercury as Hg	mg/l	APHA 3500 Hg	0.001	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	Cadmium as Cd	mg/l	APHA 3111 B,C	0.003	BDL	BDL	BDL	BDL	BDL	BDL	BDL
27	Selenium as Se	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
28	Arsenic as As	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
29	Cyanide as CN	mg/l	APHA 4500 CN ⁻ C,D	0.05	ND	ND	ND	ND	ND	ND	ND
30	Lead as Pb	mg/l	APHA 3111 B,C	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
31	Zinc as Zn	mg/l	APHA 3111 B,C	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL
32	Anionic Detergents as MBAS	mg/l	APHA 5540 C	0.2	ND	ND	ND	ND	ND	ND	ND
33	Chromium as Cr ⁺⁶	mg/l	APHA 3500Cr B	0.05	BDL	BDL	BDL	BDL	BDL	BDL	BDL
34	Mineral Oil	mg/l	APHA 5220 B	0.01	ND	ND	ND	ND	ND	ND	ND
35	Aluminium as Al	mg/l	APHA 3500Al B	0.03	BDL	BDL	BDL	BDL	BDL	BDL	BDL
36	Boron	mg/l	APHA 4500B, B	0.5	BDL	BDL	BDL	BDL	BDL	BDL	BDL
37	Poly Aromatic Hydrocarbon as PAH	µg/l	APHA 6440 B	0.0001	BDL	BDL	BDL	BDL	BDL	BDL	BDL
38	Pesticides	µg/l	APHA 6630 B,C	Absent	Abse nt	Abse nt	Absent	Absent	Absent	Absent	Absen t

Note: ND: Not Detected, BDL (Below Detection Limits).

Value of below detection limit (BDL) for different trace elements are as below.

Elements	Cu	Mn	Phenolic comp.	Hg	Cd	Se	As	Pb	Zn	Cr ⁺⁶	Al	B	Poly Aromatic Hydrocarbon
BDL values	0.01	0.01	0.0001	0.0001	0.0001	0.001	0.001	0.001	0.05	0.01	0.005	0.01	0.00005

Table- 8.7 : Result of Ground Water Quality (during Pre-monsoon Season)

Sl. No.	Parameter	Unit	Testing Methods	Standard as per IS:10500	Analysis Results							
					GW-1	GW-2	GW-3	GW-4	GW-5	GW-6	GW-7	
Essential Characteristics												
1.	Colour	Hazen	APHA 2120 B, C	5	CL	CL	CL	CL	CL	CL	CL	
2.	Odour	--	APHA 2150 B	Agreeable	U/O	U/O	U/O	U/O	U/O	U/O	U/O	
3.	Taste	--	APHA 2160 C	Agreeable	AL	AL	AL	AL	AL	AL	AL	
4.	Turbidity	NTU	APHA 2130 B	1	0.75	0.8	0.6	0.9	0.6	0.8	0.8	
5	Temperature °C	-	-		27	25.5	26	28	27	26	27	
6	pH	--	APHA 4500H ⁺ B	6.5-8.5	8.2	8.2	8.1	8.06	7.96	8.03	7.9	
7	Sp conductance (EC) µS/cm (25°C)	µS/cm (25°C)	APHA 2540 C	1500	620	480	570	800	590	760	550	
8	HCO ₃	mg/l	APHA 2540 C	300	128	226	256	165	177	232	128	
9	Chloride (as Cl)	mg/l	APHA 4500Cl ⁻ B	250	96	21	57	174	85	96	124	
10	Sulphate as SO ₄	mg/l	APHA 4500 SO ₄ ²⁻ E	200	20.3	14	18	7.5	38.2	60.5	3	
11	Nitrate as NO ₃	mg/l	APHA 4500 NO ₃ ⁻ E	45	1.6	3.6	0.8	2.6	3.6	1.5	1.4	
12	Fluoride as F	mg/l	APHA 4500F ⁻ C	1.0	0.4	0.7	0.6	0.7	0.3	0.6	0.7	
13	Total Hardness (as CaCO ₃)	mg/l	APHA 2340 C	200	165	170	140	172	150	155	100	
14	Alkalinity	mg/l	APHA 2320 B	200	104.9	185.3	180	135.3	145.08	190.2	104.9	
15	Calcium as Ca	mg/l	APHA 3500Ca B	75	50	30	42	68	40	50	50	
16	Magnesium as Mg	mg/l	APHA 3500Mg B	30	10	23	28	25	12	24	18	
17	Sodium as Na	mg/l		No guideline	52.4	34.7	40.8	43.9	65.2	32.4	32	
18	Potassium as K	mg/l		No guideline	1.8	1.9	0.6	0.6	0.3	1.4	0.3	
19	Iron (as Fe)	mg/l	APHA 3500Fe, B	0.3	0.15	0.19	0.2	0.21	0.12	0.19	0.14	

20	Total Dissolved Solids	mg/l	APHA 2540 C	500	295	238	314	411	329	400	291
21	Residual Free Chlorine	mg/l	APHA 4500Cl, B	0.2	ND	ND	ND	ND	ND	ND	ND
Trace / heavy and other elements											
22	Copper as Cu	mg/l	APHA 3111 B,C	0.05	BDL	BDL	BDL	BDL	BDL	BDL	BDL
23	Manganese as Mn	mg/l	APHA 3500Mn B	0.1	BDL	BDL	BDL	BDL	BDL	BDL	BDL
24	Phenolic Compounds as C ₆ H ₅ OH	mg/l	APHA 5530 B,D	0.001	BDL	BDL	BDL	BDL	BDL	BDL	BDL
25	Mercury as Hg	mg/l	APHA 3500 Hg	0.001	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	Cadmium as Cd	mg/l	APHA 3111 B,C	0.003	BDL	BDL	BDL	BDL	BDL	BDL	BDL
27	Selenium as Se	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
28	Arsenic as As	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
29	Cyanide as CN	mg/l	APHA 4500 CN ⁻ C,D	0.05	ND	ND	ND	ND	ND	ND	ND
30	Lead as Pb	mg/l	APHA 3111 B,C	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL
31	Zinc as Zn	mg/l	APHA 3111 B,C	5	BDL	BDL	BDL	BDL	BDL	BDL	BDL
32	Anionic Detergents as MBAS	mg/l	APHA 5540 C	0.2	ND	ND	ND	ND	ND	ND	ND
33	Chromium as Cr ⁺⁶	mg/l	APHA 3500Cr B	0.05	BDL	BDL	BDL	BDL	BDL	BDL	BDL
34	Mineral Oil	mg/l	APHA 5220 B	0.01	ND	ND	ND	ND	ND	ND	ND
35	Aluminium as Al	mg/l	APHA 3500Al B	0.03	BDL	BDL	BDL	BDL	BDL	BDL	BDL
36	Boron	mg/l	APHA 4500B, B	0.5	BDL	BDL	BDL	BDL	BDL	BDL	BDL
37	Poly Aromatic Hydrocarbon as PAH	µg/l	APHA 6440 B	0.0001	BDL	BDL	BDL	BDL	BDL	BDL	BDL
38	Pesticides	µg/l	APHA 6630 B,C	Absent	Absen t	Absent	Absen t	Absent	Absent	Absent	Absen t

Note: ND: Not Detected , BDL (Below Detection Limits) Values.

Value of below detection limit (BDL) for different trace elements are as below.

Elements	Cu	Mn	Phenolic comp.	Hg	Cd	Se	As	Pb	Zn	Cr ⁺⁶	Al	B	Poly Aromatic Hydrocarbon
BDL values	0.01	0.01	0.0001	0.0001	0.0001	0.001	0.001	0.001	0.05	0.01	0.005	0.01	0.00005

8.3: Surface water quality in Hirakud Reservoir: 3 No of water samples from Hirakud reservoir were collected and analysed by adopting standard method of analysis. Locations of these samples and their analysis are shown in following tables

Table -8.8: Particulars of Surface water (Hirakud Reservoir) samples.

S. No	Particulars	Details
1	Name of Industry	OPGC
2	Source of samples	Hirakud reservoir
3	Sample Collected by	VCSPL representative
4	Sampling Location& Code	S-1: Hirakud Reservoir Upstream S-2: Hirakud Reservoir Down stream S-3 :Hirakud Reservoir Down stream
5	Sampling Period (Post- Monsoon)	Nov,2018
6	Sampling Period (Monsoon)	July,2018
7	Sampling Period (Pre- Monsoon)	Apr,2018

Note: Some of the trace elements are found below detection limits. The Value of below detection limit (BDL) for different trace elements are as below.

Elements	BDL values
Cu	0.01
Mn	0.01
Phenolic Compounds as C ₆ H ₅ OH	0.0001
Hg	0.0001
Cd	0.0001
Se	0.001
As	0.001
Pb	0.001
Zn	0.05
Cr+6	0.01
Al	0.005
B	0.01
Poly Aromatic Hydrocorbon	0.00005

Table-8.9 : Result of Surface water (Hirakud Reservoir) samples (During Post- Monsoon Season)

Sl.No.	Parameter	Unit	Testing Methods	Standard as per IS:10500	SW-1	SW-2	SW-3
1	Colour	Hazen	APHA 2120 B, C	5	CL	CL	CL
2.	Odour	--	APHA 2150 B	Agreeable	U/O	U/O	U/O
3.	Taste	--	APHA 2160 C	Agreeable	AL	AL	AL
4.	Turbidity	NTU	APHA 2130 B	1	01.5	2.6	1.8
5	Temperature °C	-			26.5	24.5	25
6	pH	--	APHA 4500H ⁺ B	6.5-8.5	7.8	7.9	7.95
7	Sp conductance (EC)	µS/cm (25°C)	APHA 2540 C	1500	150	134	166
8	HCO ₃	mg/l	APHA 2540 C	300	37	49	67
9	Chloride (as Cl)	mg/l	APHA 4500Cl ⁻ B	250	35	11	14
10	Sulphate as SO ₄	mg/l	APHA 4500 SO ₄ ²⁻ E	200	6.5	4.2	3.5
11	Nitrate as NO ₃	mg/l	APHA 4500 NO ₃ ⁻ E	45	2.5	5.9	0
12	Fluoride as F	mg/l	APHA 4500F ⁻ C	1.0	0.7	0.6	0.7
13	Total Hardness (as CaCO ₃)	mg/l	APHA 2340 C	200	95	65	65
14	Alkalinity	mg/l	APHA 2320 B	200	64.0	70.0	77.0
15	Calcium as Ca	mg/l	APHA 3500Ca B	75	12	20	22
16	Magnesium as Mg	mg/l	APHA 3500Mg B	30	11	4	2
17	Sodium as Na	mg/l	APHA 3500Na B	No guideline	7.7	1.7	5.7
18	Potassium as K	mg/l	APHA 3500K B	No guideline	0.5	0.9	0.9
19	Iron (as Fe)	mg/l	APHA 3500Fe, B	0.3	0.25	0.0	0.15
20	Total Dissolved Solids	mg/l	APHA 2540 C	500	86	78	99
21	Residual Free Chlorine	mg/l	APHA 4500Cl, B	0.2	ND	ND	ND
22	Copper as Cu	mg/l	APHA 3111 B,C	0.05	BDL	BDL	BDL
23	Manganese as Mn	mg/l	APHA 3500Mn B	0.1	BDL	BDL	BDL
24	Phenolic Compounds as C ₆ H ₅ OH	mg/l	APHA 5530 B,D	0.001	BDL	BDL	BDL
25	Mercury as Hg	mg/l	APHA 3500 Hg	0.001	BDL	BDL	BDL

26	Cadmium as Cd	mg/l	APHA 3111 B,C	0.003	BDL	BDL	BDL
27	Selenium as Se	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL
28	Arsenic as As	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL
29	Cyanide as CN	mg/l	APHA 4500 CN ⁻ C,D	0.05	ND	ND	ND
30	Lead as Pb	mg/l	APHA 3111 B,C	0.01	BDL	BDL	BDL
31	Zinc as Zn	mg/l	APHA 3111 B,C	5	BDL	BDL	BDL
32	Anionic Detergents as MBAS	mg/l	APHA 5540 C	0.2	ND	ND	ND
33	Chromium as Cr ⁺⁶	mg/l	APHA 3500Cr B	0.05	BDL	BDL	BDL
34	Mineral Oil	mg/l	APHA 5220 B	0.01	ND	ND	ND
35	Aluminium as Al	mg/l	APHA 3500Al B	0.03	BDL	BDL	BDL
36	Boron	mg/l	APHA 4500B, B	0.5	BDL	BDL	BDL
37	Poly Aromatic Hydrocarbon as PAH	µg/l	APHA 6440 B	0.0001	BDL	BDL	BDL
38	Pesticides	µg/l	APHA 6630 B,C	Absent	Absent	Absent	Absent

Note: ND: Not Detected, BDL (Below Detection Limits)

Table-8.10: Result of Surface water (Hirakud Reservoir) samples (During Monsoon Season)

Sl.No.	Parameter	Unit	Testing Methods	Standard as per IS:10500	SW-1	SW-2	SW-3
1	Colour	Hazen	APHA 2120 B, C	5	CL	CL	CL
2.	Odour	--	APHA 2150 B	Agreeable	U/O	U/O	U/O
3.	Taste	--	APHA 2160 C	Agreeable	AL	AL	AL
4.	Turbidity	NTU	APHA 2130 B	1			
5	Temperature °C	-			24	25	26
6	pH	--	APHA 4500H ⁺ B	6.5-8.5	7.9	7.8	8.1
7	Sp conductance (EC)	µS/cm (25°C)	APHA 2540 C	1500	100	91	140
8	HCO ₃	mg/l	APHA 2540 C	300	43	18	49
9	Chloride (as Cl)	mg/l	APHA 4500Cl ⁻ B	250	4	18	7
10	Sulphate as SO ₄	mg/l	APHA 4500 SO ₄ ²⁻ E	200	8	2.4	15
11	Nitrate as NO ₃	mg/l	APHA 4500 NO ₃ ⁻ E	45	2	0.6	5.5
12	Fluoride as F	mg/l	APHA 4500F ⁻ C	1.0	0.1	0.45	0.6
13	Total Hardness (as CaCO ₃)	mg/l	APHA 2340 C	200	50	30	55
14	Alkalinity	mg/l	APHA 2320 B	200	35.3	14.75	40.2
15	Calcium as Ca	mg/l	APHA 3500Ca B	75	16	8	16
16	Magnesium as Mg	mg/l	APHA 3500Mg B	30	2	2	4
17	Sodium as Na	mg/l	APHA 3500Na B	No guideline	0.4	5.4	6.8
18	Potassium as K	mg/l	APHA 3500K B	No guideline	0	0.4	0.2
19	Iron (as Fe)	mg/l	APHA 3500Fe, B	0.3	0.1	0.09	0.11
20	Total Dissolved Solids	mg/l	APHA 2540 C	500	58	48	83
21	Residual Free Chlorine	mg/l	APHA 4500Cl, B	0.2	ND	ND	ND
22	Copper as Cu	mg/l	APHA 3111 B,C	0.05	BDL	BDL	BDL
23	Manganese as Mn	mg/l	APHA 3500Mn B	0.1	BDL	BDL	BDL
24	Phenolic Compounds as C ₆ H ₅ OH	mg/l	APHA 5530 B,D	0.001	BDL	BDL	BDL
25	Mercury as Hg	mg/l	APHA 3500 Hg	0.001	BDL	BDL	BDL
26	Cadmium as Cd	mg/l	APHA 3111 B,C	0.003	BDL	BDL	BDL

27	Selenium as Se	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL
28	Arsenic as As	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL
29	Cyanide as CN	mg/l	APHA 4500 CN ⁻ C,D	0.05	ND	ND	ND
30	Lead as Pb	mg/l	APHA 3111 B,C	0.01	BDL	BDL	BDL
31	Zinc as Zn	mg/l	APHA 3111 B,C	5	BDL	BDL	BDL
32	Anionic Detergents as MBAS	mg/l	APHA 5540 C	0.2	ND	ND	ND
33	Chromium as Cr ⁺⁶	mg/l	APHA 3500Cr B	0.05	BDL	BDL	BDL
34	Mineral Oil	mg/l	APHA 5220 B	0.01	ND	ND	ND
35	Aluminium as Al	mg/l	APHA 3500Al B	0.03	BDL	BDL	BDL
36	Boron	mg/l	APHA 4500B, B	0.5	BDL	BDL	BDL
37	Poly Aromatic Hydrocarbon as PAH	µg/l	APHA 6440 B	0.0001	BDL	BDL	BDL
38	Pesticides	µg/l	APHA 6630 B,C	Absent	Absent	Absent	Absent

Note: ND: Not Detected, BDL (Below Detection Limits)

Table-8.11: Result of Ground Water Quality (during Pre-monsoon Season)

Sl.No.	Parameter	Unit	Testing Methods	Standard as per IS:10500	SW-1	SW-2	SW-3
1	Colour	Hazen	APHA 2120 B, C	5	CL	CL	CL
2.	Odour	--	APHA 2150 B	Agreeable	U/O	U/O	U/O
3.	Taste	--	APHA 2160 C	Agreeable	AL	AL	AL
4.	Turbidity	NTU	APHA 2130 B	1			
5	Temperature °C	-			16	19	20
6	pH	--	APHA 4500H ⁺ B	6.5-8.5	7.2	7.5	7.9
7	Sp conductance (EC)	µS/cm (25°C)	APHA 2540 C	1500	90	81	99
8	HCO ₃	mg/l	APHA 2540 C	300	32	10	32
9	Chloride (as Cl)	mg/l	APHA 4500Cl ⁻ B	250	5	21	16
10	Sulphate as SO ₄	mg/l	APHA 4500 SO ₄ ²⁻ E	200	9	3.1	12
11	Nitrate as NO ₃	mg/l	APHA 4500 NO ₃ ⁻ E	45	9	2.1	6.2
12	Fluoride as F	mg/l	APHA 4500F ⁻ C	1.0	0.1	0.2	0.3
13	Total Hardness (as CaCO ₃)	mg/l	APHA 2340 C	200	50	30	55
14	Alkalinity	mg/l	APHA 2320 B	200	42.2	31.2	51.2
15	Calcium as Ca	mg/l	APHA 3500Ca B	75	23	19	12
16	Magnesium as Mg	mg/l	APHA 3500Mg B	30	6	4	9
17	Sodium as Na	mg/l	APHA 3500Na B	No guideline	0.5	4.6	7.1
18	Potassium as K	mg/l	APHA 3500K B	No guideline	0.1	0.2	0.2
19	Iron (as Fe)	mg/l	APHA 3500Fe, B	0.3	ND	ND	ND
20	Total Dissolved Solids	mg/l	APHA 2540 C	500	61	54	91
21	Residual Free Chlorine	mg/l	APHA 4500Cl, B	0.2	ND	ND	ND
22	Copper as Cu	mg/l	APHA 3111 B,C	0.05	BDL	BDL	BDL
23	Manganese as Mn	mg/l	APHA 3500Mn B	0.1	BDL	BDL	BDL
24	Phenolic Compounds as C ₆ H ₅ OH	mg/l	APHA 5530 B,D	0.001	BDL	BDL	BDL
25	Mercury as Hg	mg/l	APHA 3500 Hg	0.001	BDL	BDL	BDL
26	Cadmium as Cd	mg/l	APHA 3111 B,C	0.003	BDL	BDL	BDL
27	Selenium as Se	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL

28	Arsenic as As	mg/l	APHA 3114 B	0.01	BDL	BDL	BDL
29	Cyanide as CN	mg/l	APHA 4500 CN ⁻ C,D	0.05	ND	ND	ND
30	Lead as Pb	mg/l	APHA 3111 B,C	0.01	BDL	BDL	BDL
31	Zinc as Zn	mg/l	APHA 3111 B,C	5	BDL	BDL	BDL
32	Anionic Detergents as MBAS	mg/l	APHA 5540 C	0.2	ND	ND	ND
33	Chromium as Cr ⁺⁶	mg/l	APHA 3500Cr B	0.05	BDL	BDL	BDL
34	Mineral Oil	mg/l	APHA 5220 B	0.01	ND	ND	ND
35	Aluminium as Al	mg/l	APHA 3500Al B	0.03	BDL	BDL	BDL
36	Boron	mg/l	APHA 4500B, B	0.5	BDL	BDL	BDL
37	Poly Aromatic Hydrocarbon as PAH	µg/l	APHA 6440 B	0.0001	BDL	BDL	BDL
38	Pesticides	µg/l	APHA 6630 B,C	Absent	Absent	Absent	Absent

Note: ND: Not Detected , BDL (Below Detection Limits) Values.

Chapter-9

Assessment of ground water resources

9.1: Introduction: Ground water being a dynamic and replenishable resource is generally estimated based on the component of annual recharge, which could be subjected to development by means of suitable ground water structures. Present area comprises granitic rocks of Precambrian period and sedimentary rocks of Gondwana super Group. Rainfall along with recharge from Hirakud Reservoir and Ib river and its associated streams and its adjoining nalas are the main source of ground water recharge. Though there are various methodologies available for computation of Ground Water Resources, but each one has its own ifs & buts. Keeping all the parameters into consideration Government Agencies (Ground Water Survey and Investigation Department, Govt. of Odisha and Central Ground Water Board) had computed block-wise ground water resources for the whole state of Odisha. Buffer zone comprises three blocks namely Jharsuguda sadar and Lakhanpur block of Jharsuguda district and Rengali Blocks of Sambalpur district.

So accordingly ground water resources of only three blocks (Lakahnpur, Jharsuguda and Rengali blocks) have been considered. Here an effort has been made to compute the ground water resource of present area on pro-rata basis.

9.2: Ground Water Resources of Buffer zone: It is tabulated as below.

Table- 9.1: Computation of Ground Water Resources of the Area.

Particulars / Block	Jharsuguda block	Lakhanpur block	Rengali Block
Net Annual Ground Water Availability	3182	5729	4145
Existing Gross Ground Water Draft for Irrigation	844.98	1316.96	661.56
Existing Gross Ground Water Draft for domestic & Industrial Supply	603.03	453.03	341.43
Existing Gross Ground Water Draft for all uses	1448.01	1769.99	1002.99
Provision for domestic & industrial requirement supply for next 25 years	692	648.60	433.35
Net Ground Water Availability for future irrigation development	1645.02	3763.44	3050.09
Stage of Ground Water Development	45.01	30.90	24.20

Table-9.2: Computation of Ground Water Resources of the Area.

S. No	Block	Net Annual Ground Water Availability (Ham)	Existing Gross GW Draft for all Uses (Ham)	Stage of G W Development In (%)
1	Jharsuguda	3182.00	1448.00	45.51
2	Lakhanpur	5729.00	1790.00	31.24
3	Rengali	4145.00	1003.00	24.20

Table-9.2: Computation of Ground Water Resources of the Area (contd.)

S. No	Block	Geographical Area (Ha)	Rechargeable Geographical Area (Ha) of Block falling in buffer zone (Ha)	Net Annual Ground Water Availability (Ham)	Existing Gross Ground Water Draft for all Uses (Ham)
1	Jharsuguda	35064	1958.00	177.69	80.86
2	Lakhanpur	67373	13167.00	1119.64	349.83
3	Rengali	38678	2057.00	220.44	53.34
	Total			1517.77	484.03

Stage of Ground Water Development =

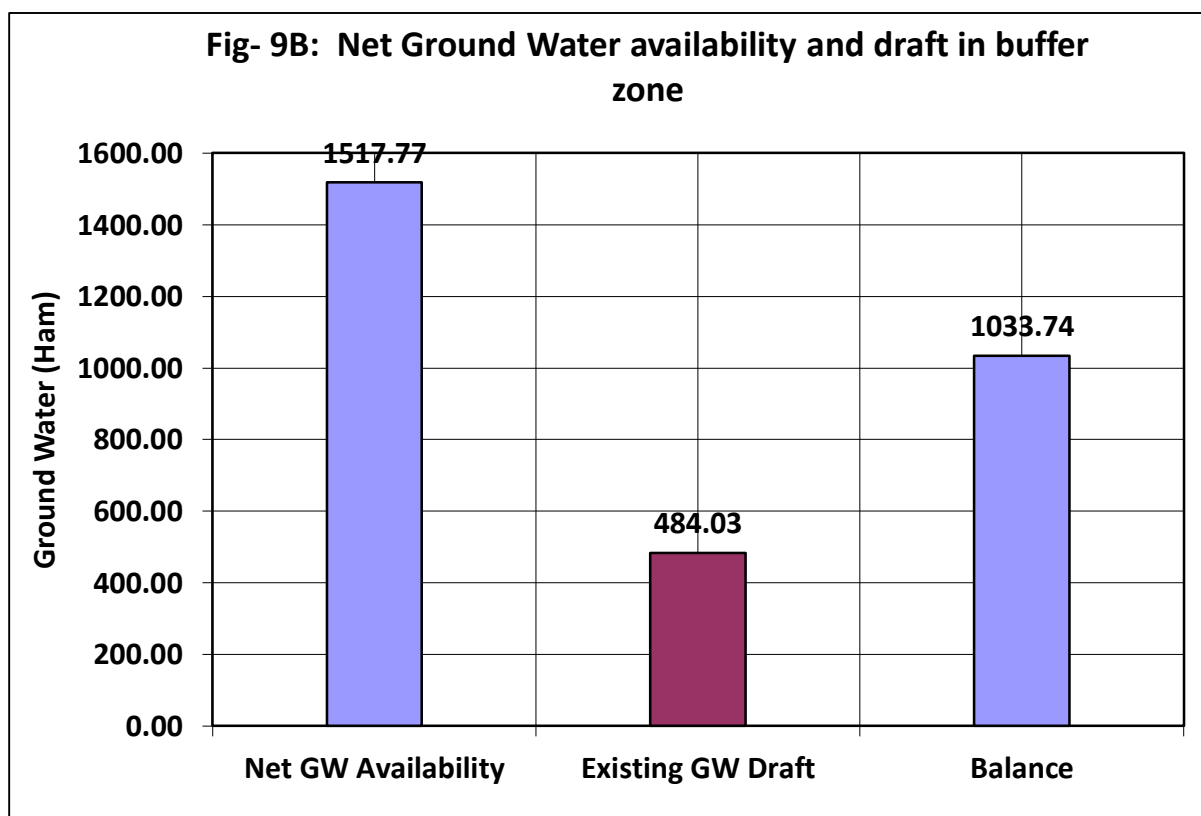
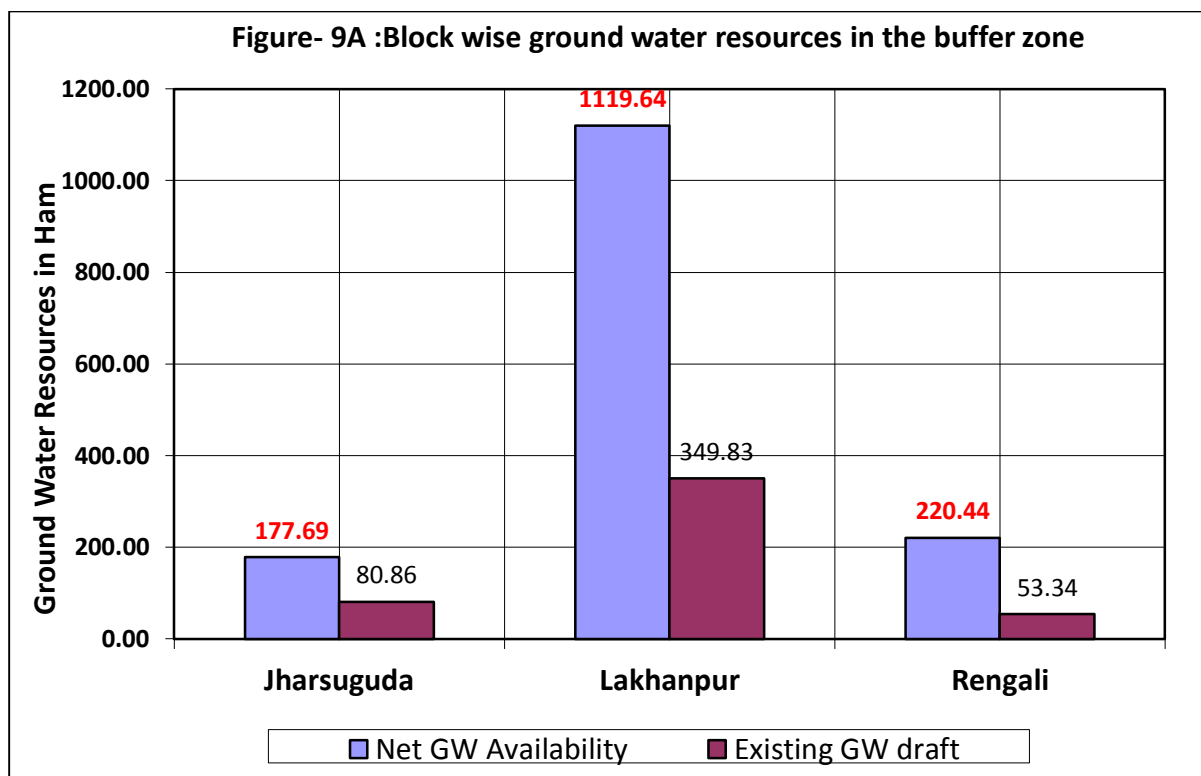
(Existing Gross Ground Water Draft / Net Annual Ground Water Availability) X100

= (484.03/1517.77) X100 = 32 %

So Stage of Ground Water Development in the area is 32 %

Thus from the above computation it can be inferred that net annual ground water availability in the area is 1518 Ham and existing ground water draft for all uses is 484 Ham.

Thus the stage of G W development is **32%**. As per the criteria for categorization of area made by Central Ground Water Authority for the development point of view, present study area falls under safe category as its stage of Ground Water Development is only 32%. Ample scope exist for development of ground water. It will not have any appreciable impact on ground water resources in the area.



Chapter-10

CONCLUSION:

Govt. of Odisha owned company Odisha Power Generation Corporation Limited (OPGC) runs **Ib Thermal Power Station (ITPS)**, a coal-based thermal power plant near village Banharpali in Lakhanpur tehsil of Jharsuguda district of Odisha. The company has proposed to carry out hydrogeological studies of ash pond areas and plant areas of Thermal Power Station.

For the hydrogeological study an area of 3145.16 sq km was taken as circular area of 10 km radius keeping the eastern point of ash ponds area (64O/14, 83° 54' 35" East longitudes and 21° 41' 33 " North latitudes) of Lakhanpur block of Jharsuguda district in the centre. The area falls under Survey of India Toposheet No. 64O/13 and 64O/14. Topographically plant area is characterized by a bit undulation and flat pediments with general elevation ranging from 180 to 220 msl from eastern to western boundary.

Physiographically the area is characterized by a moderately degraded pediplanes with moderate undulation terrain and sporadically scattered and elongated hills and mounds. The area is mainly represented by all varieties of land forms such as pediplanes, pediments, isolated hillocks, denudated outcrops and undulating plains etc. Moderately resistant rock constitutes the ridge ranges rising to a maximum height of 382 m. above M.S.L.

The drainage of the study area is mainly controlled by the Ib river which is a tributary of Mahanadi River. IB River flows along eastern part of buffer zone with flow direction from north to south and falls into Hirakud Reservoir. Hirakud reservoir is marked in buffer zone covering its major part in southern portion of buffer zone. The drainage pattern is dendritic. Surface runoff generation potential of water shed comprising its all three ash ponds is 13.85 MCM. In plant area runoff may be 0.360 MCM while in ash ponds it will be 0.609 MCM.

Average annual rain fall in the area is 1284 mm and temperature varies from 12 ° C in winter to 41.9 ° C in summer.

Mainly four types of soils are dominant in the area. These are Alfisols (matured red and lateritic soil), Inceptisols (mixed gray soils) and Entisols or Unaltered soil with coarse parent materials and unclassified soil like mud flats etc. Chemical analysis of 7 No of soil samples indicates that all chemical constituents fall under normal limit of their value and suitable for all types of crops.

Geologically the area is predominantly underlain by four types of rocks. The Peninsular Gneiss comprising augen gneiss and migmatite represent the oldest rocks of Archaean to Lower Proterozoic age in the area. They occupy a gently undulating terrain in eastern part of buffer zone. A practically un metamorphosed sedimentary sequence of Gondwana super group of rocks comprising Talcher and Barakar formations occur near to the north western part of buffer zone. The Gondwana Super Group of sedimentary rocks is confined to fault bounded basin and occur in the north western and south central part of buffer zone.

Ground water is stored mainly in the secondary porosity resulting from weathering and fracturing of the rocks. The aquifer materials are highly heterogeneous in character showing both vertical and lateral variations. The weathered residuum form the main repository of ground water, which occurs under water table conditions and circulates through deeper fractures and fissures. Ground Water occurs under unconfined condition in phreatic aquifers and semi confined to confined conditions in the deeper fractures zones. The interconnected joints and fractures in the underlying hard rocks facilitate circulation of ground water and in turn form deeper aquifers.

The yield in these formations varies from 1.8 to 5.8. m³ /hr in bore wells. Aquifer parameters vary widely in confined condition. Transmissivity varies from 0.38 to 0.63 m/day in sandstones while from 1.4 to 1.75 m/day in granitic formations. Specific capacity varies from 0.98 to 1.58 L/ min / m of drawdown in sandstones while from 2.8 to 3.44 L/min/m of drawdown in granitic formations.

Generally two to four sets of fractures are encountered in the depth range of 30 to 120 m below ground level. Pre monsoon water level varies from 4.72 to 7.23 m b g l. with its mean values as 6.07 m bgl while monsoon water level varies from 0.78 to 2.1 m bgl with its mean value as 1.26 m b g l. Post monsoon water level varies from 1.24 to 3.45 m b g l with its mean value as 2.14 m b g l. Water level fluctuations between pre monsoon and post monsoon seasons were computes as 2.72 m (minimum) to 5.34 m (maximum) with mean value of 2.92 m. Similarly, Water level fluctuations between pre monsoon and monsoon seasons were computes as 3.76 m (minimum) to 6.16 m (maximum) with mean value of 4.81 m. Similarly, Water level fluctuations between post monsoon and monsoon seasons were computes as 0.39 m (minimum) to 1.89 m (maximum) with mean value of 0.89 m

Water table varies from 200 m to 210 m amsl in general with a sporadic exception of 215 m amsl at few places. Ground water flow direction in south western part is from NE to SW direction but in north eastern part it is from SE to NWW. General ground water flow direction is towards SW direction. Hydraulic gradient varies from 0.01 to 0.0015 with a mean value of 0.0058.

As per estimated ground water resources in buffer zone the annual net availability of ground water is 1517.77 Ham and the existing draft is 484.03 Ham. The stage of ground water development is 32%. So the area falls under “safe” category.

Hydraulic conductivity is very poor due to which there will be no effect on ground water quality and ground water resources. Ground water quality is potable and also suitable for all purposes. .

***** E N D *****

ANNEXURE-2
TENTATIVE ASH UTILISATION PLAN

Unit - 000' MT

Expected Qty of Ash generation per annum – 2900

Sl. No	Utilization Heads	1st Year	2 nd Year	3rd Year	4th Year
1	Captive ash bricks/blocks manufacturing	15	15	15	15
2	Outside Bricks plants	10	20	25	30
3	Construction in nearby highway projects, other road projects & Land development.	20	250	250	200
4	Cement plants.	20	120	120	120
5	Ready -Mixed Concrete.	10	10	10	10
6	Filling in low lying area /nearest mine void / concurrent backfilling in captive mine void	505	1035	1610	2525
Quantity of Ash Utilization		580	1450	2030	2900
Unutilized Ash to be disposed in Ash disposal Area.		2320	1450	870	--
% of Ash Utilization		20%	50 %	70 %	100%

The industry will take all possible steps to achieve the targets , however the ash offtake demand from the end user agencies may bring risk towards achieving the targets.

File No. 2



J-13011/59/2008 -IA.II (T)
Government of India
Ministry of Environment & Forests

BY SPEED POST

Paryavaran Bhawan
CGO Complex, Lodi Road
New Delhi 110 003
Dated: 22.01.2014

To

M/s Odisha Power Generation Corporation Ltd.
Zone A, 7th Floor, Fortune Towers,
Bhubaneswar 751 023,
Odisha.

Ph: 0674-2303765; Fax: 0674-2303755/56

Sub: Expansion of existing Coal Based Thermal Power Plant by addition of 2x660 MW (Unit 3 & 4) at Village Banaharpalli, in Jharsuguda Distt., in Orissa by M/s Odisha Power Generation Corporation Ltd. - reg. Amendment and Extension of validity of Environmental Clearance.

Sir,

This has reference to your letters dated 05.06.2013 and 18.09.2013 requesting for amendment and extension of validity of environmental clearance accorded for the above mentioned project.

2. The matter was placed before the Expert Appraisal Committee (Thermal Power) in its 4th Meeting held during November 18-19, 2013. In acceptance of the recommendation of the Expert Appraisal Committee (Thermal Power) and in view of the information/clarification furnished by you, with respect to the above mentioned power project, the following amendments are made in two conditions i.e. (xii) & (xviii) specified in the earlier EC accorded to you vide our letter of even no. dated 04.02.2010.

- a) The condition no. (xii) of Para No.4 shall be read as *"Closed cycle cooling system with induced draft cooling towers shall be provided. The Effluents shall be treated as per the prescribed norms" instead of*

"Closed cycle cooling system with natural draft cooling towers shall be provided. The Effluents shall be treated as per the prescribed norms."

- b) The condition no. (xviii) of Para No.4 shall be read as *"Storage facilities for auxiliary liquid fuel such as LDO and/ HFO/LSHS shall be made in the plant area in consultation with Department of Explosives, Nagpur. Disaster Management Plan shall be prepared to meet any eventuality in case of an accident taking place due to storage of oil" instead of*

"Storage facilities for auxiliary liquid fuel such as LDO and/ HFO/LSHS shall be made in the plant area in consultation with Department of Explosives, Nagpur. Sulphur content in the liquid fuel will not exceed 0.5%. Disaster Management Plan shall be prepared to meet any eventuality in case of an accident taking place due to storage of oil."

3. Further, under Para no.1 of this Ministry's letter of even no. dated 01.02.2010, after the condition no. (xi), the following conditions shall be inserted:

- (xii) A long term study of radio activity and heavy metals contents on coal to be used shall be carried out through a reputed institute. Thereafter, mechanism for an in built continuous monitoring for radio activity and heavy metals in coal and fly ash (including bottom ash) shall be put in place.
- (xiii) Continuous monitoring for heavy metals in and around the existing ash pond area shall be immediately carried out by reputed institutes like IIT Kanpur.
- (xiii) Harnessing solar power within the premises of the plant particularly at available roof tops shall be undertaken and status of implementation shall be submitted periodically to the Regional Office of the Ministry.
- (xiv) Fugitive emissions shall be controlled to prevent impact on agricultural or non-agricultural land.
- (xv) No ground water shall be extracted for use in operation of the power plant even in lean season.
- (xvi) Minimum required environmental flow suggested by the Competent Authority of the State Govt. shall be maintained in the Channel/ Rivers (as applicable) even in lean season.
- (xvii) No water bodies including natural drainage system in the area shall be disturbed due to activities associated with the setting up/operation of the power plant.
- (xviii) Fly ash shall not be used for agricultural purpose. No mine void filling will be undertaken as an option for ash utilization without adequate lining of mine with suitable media such that no leachate shall take place at any point of time. In case, the option of mine void filling is to be adopted, prior detailed study of soil characteristics of the mine area shall be undertaken from an institute of repute and adequate clay lining shall be ascertained by the State Pollution Control Board and implementation done in close co-ordination with the State Pollution Control Board.
- (xix) Three tier green belt shall be developed all around Ash Pond over and above the Green Belt around the plant boundary.
- (i) A common **Green Endowment Fund** shall be created and the interest earned out of it shall be used for the development and management of green cover of the area.
- (ii) It shall be ensured that in-built monitoring mechanism for the schemes identified is in place and annual social audit shall be got done from the nearest government institute of repute in the region. The project proponent shall also submit the status of implementation of the scheme from time to time.
- (iii) An Environmental Cell shall be created at the project site itself and shall be headed by an officer of the company of appropriate seniority and

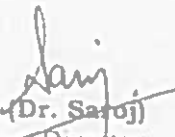
qualification. It shall be ensured that the head of the Cell shall directly report to the Head of the Organization.

(iii) The project proponent shall formulate a well laid Corporate Environment Policy and identify and designate responsible officers at all levels of its hierarchy for ensuring adherence to the policy and compliance with the conditions stipulated in this clearance letter and other applicable environmental laws and regulations.

4. All other conditions mentioned in this Ministry's letter of even no. dated 04.02.2010 shall remain the same.

5. Regarding the extension of validity of environmental clearance, since the validity will only expire in Feb, 2015, you may request this Ministry along with updated Form I only before 6 months from expiry of the validity of EC, if required.

This issues with the approval of the Competent Authority.


(Dr. Saroj)
Director

Copy to

1. The Secretary, Ministry of Power, Shram Shakti Bhawan, Rafi Marg, New Delhi 110001.
2. The Secretary (Environment), Environment Department, Government of Orissa, Bhubaneswar.
3. The Chairman, Central Electricity Authority, Sewa Bhawan, R.K. Puram, New Delhi-110066.
4. The Chairman, Orissa State Pollution Control Board, A-118, Nilkanta Nagar, Unit - VIII, Bhubaneswar- 751 012.
5. The Chairman, Central Pollution Control Board, Parivesh Bhawan, CBD-cum-Office Complex, East Arjun Nagar, Delhi- 110032.
6. The Chief Conservator of Forests, Regional Office (EZ), Ministry of Environment & Forests, A/3, Chandeseekhampur, Bhubaneswar - 751023.
7. The District Collector, Jharsuguda District, Orissa.
8. Guard file.


(Dr. Saroj)
Director

Report of Plantation Monitoring Committee
of the
District Environment Society, Jharsuguda
for the year 2017-18

Report of the Plantation Monitoring Committee of the District Environment Society, Jharsuguda-2017-18.

INTRODUCTION

The Jharsuguda District Environment Society constituted a Plantation Monitoring committee on 30.04.2013 with Prof. DR. Naik, Former Vice-Chancellor, Sambalpur University and Honorary Wildlife warden for Jharsuguda District as its Chief. The ACF, Jharsuguda Forest Division, the Chief Co-ordinator of the Eco-Club Co-ordination Committee and representatives from the State Pollution Control Board and Horticulture Department were other members. Since then the committee is inspecting industrial premises at least twice every year for monitoring the plantation activity. The report submitted by the committee was discussed in the Review meeting held on 20.12.2016 with the Collector as the Chairman. It was decided that the Plantation Monitoring Committee should inspect the industrial premises and submit its report for further action.

Inspection (2017-18):

The Plantation Monitoring Committee comprising of Prof. D.R. Naik, Former Vice-Chancellor, Sambalpur University and Honorary Wildlife Warden, Sri. P.K. Dhal, ACF, Jharsuguda Forest Division, Sri Prahallad Naik, Chief Co-ordination, Eco-Club Co-Ordination Committee, Sri Devadutta Mohanty, Assistant Environment Engineer, State Pollution Control Board and a representative of the Horticulture Department inspected in the various industrial premises as per the following schedule.

Date	Industries/Mines inspected
04.10.2017	MCL Lakhanpur Area, OPGC, Banharpali Ltd., TRL, Krosaki Ltd.
07.10.2017	Vedanta (Sesa Sterlite) Limited, Ultratech Cement Ltd., Sven Star Steel Ltd., MCL Ib Valley Area, Gobal Coalwashery.
23.08.2017	SMC Power Generation Limited, L.N. Metallic's, MCL Orient Area

General Remarks

- (1) It was not intended to conduct the census of trees planted over the years. An overall estimation of the greenery in the accessible areas within the industrial premises was made. In addition, patches of vacant Govt. land outside their premises assigned to some of them for creating 'green belt' were also inspected. Care was taken to note the species of tree planted.
- (2) It was found that some of the Industries/Mines have not been able to meet the 33.3% mandatory requirement. The concerned Industries have been advised to make up the deficiency by the end of 2017-18.
- (3) It was noted that some Industries have planted trees like Eucalyptus and Acacia over extensive areas. These species are not environment friendly. Hence the concerned Industries were advised to undertake intercropping with other species of trees such as Neem, Jamun, Karanja, Simaruba, Jackfruit and such other species with thick foliage and big crown. In due course, Eucalyptus and Acacia may be eliminated.

(4) As Principal Chief Conservator of Forest, Odisha has allotted target of 1,25,000 nos. of seedlings to be planted during 2017-18 under Corporate Sector in Jharsuguda District, a scheme has been prepared by the Divisional Forest Officer, Jharsuguda for raising Urban/ Peri-Urban plantation which will be funded by MCL & Vedanta (Sesa Sterlite) Ltd. Copy of the scheme has been forwarded to the appropriate authority of MCL & Vedanta (Sesa Sterlite) Ltd. vide Letter No.4411 and Date 14.12.2016 and Letter No.1016 dt. 29.03.2017 respectively. However, MCL Authorities have provided required funds the DFO, Jharsuguda for raising one lakh saplings for plantation in Urban/ Peri-Urban area of Jharsuguda District.

Table showing the Area covered and Number of Saplings planted by various Industries/Mines:

Sl No.	Name of Industries/ Mines	Total land Acquired (Ac)	33.3% of area (Ac)	Land planted (Ac) up to 2016-17	Plantation Achieved during 2017-18		Total area planted inside premises (Ac) up to 2017-18	Total nos. Of saplings planted during 2017-18 (inside & outside)	Remarks/ percentage Achieved
					Inside premises (Ac/No)	Outside premises (Ac/Km)			
1	SMC Power Ltd.	284	94.57	93.8	5.1	0	96.92	2000	34.12%
2	TRL Krosaki	386	128.53	135.0	1.54	0	136.4	1000	35.33%
3	Global Washery	21.17	7.04	7.9	0	0	7.9	0	37.31%
4	Ultratech Cement Ltd.	165.25	55.02	55.02	0	0	55.02	0	33.33%
5	Vedanta (Sesa Sterlite)	2371.0	789.54	615.6	19.0	0	624.6	18000	26.34%
6	OPGC Ltd.	1227.5	408.75	207.0 (210.0 Ac natural forest)	7.0	0	424.0	1000	34.60% (4000 nos seedling distributed)
7	MCL Ib Valley, Area	3474.558	1158.07	458.62	0	0	458.62	0	13.19%
8	MCL Orient, Area	3472.422 (surface braking area-247.5)	82.41	143.97	0	0	143.97	0	58.16%
9	MCL Lakhanpur, Area	3610.13	1202.17	1084.32	3.51	0	1087.83	5625	30.13%
10	Seven Star Steel	59.0	19.65	21.5	1.62	0	23.12	1200	39.18%
11	LN-Metallic's	25.41	8.46	12.0	1.4	0	13.4	900	52.73%
Total: -								29,725	

Comments on the Plantation Activities of Different Industries & Mines:

1. Ultratech Cement Ltd.:

- A) Saplings Planted on the embankments of the reservoir and along the railway track are well maintained. The 11 acres patch lately planted during the previous season was inspected. The area was inaccessible and filled with grass. This area would be inspected again. They are advised to clean up the tall grass and take adequate care of the saplings.
- B) They have done plantation in the Arda Gramya Jungle (about 4 acres). Many of the saplings are dead. They need to be replaced with neem, Karanj, and such other saplings.
- C) The Avenue plantation from Dhutra village to Badpulia is not visible. Proper maintenance of the saplings is necessary.
- D) No plantation has been taken up during 2017-18.

2. Seven Star Steels Ltd.:

- A) Maintenance of plantation sites satisfactory.
- B) Damaged tree-guard/gabion for the Avenue plantation may be repaired/replaced.

3. LN Metallic's:

- A) Maintenance satisfactory. Care may be taken during the dry season to ensure survival of the saplings planted during the Current year. Fire-line should be maintained to check possible fire accident having summer.

4. SMC Power Generation Ltd.:

- A) Maintenance satisfactory. It is nice to see their greenery getting greener. Sustained efforts are necessary to keep it up.
- B) They have a nursery of their own. They are also providing sapling in the neighbouring areas. Preparatory work for the nursery may be started in January. However, the current year plantation work not up to the Mark.

5. Vedanta (Sesa- Sterilite) Ltd.:

- A) They have done plantation over an extensive area of their ash Pond dyke and in very small patches inside the premises of plant area. The area was inaccessible, but the greenery was visible.
- B) They have developed a nursery. Preparation for the necessary may be started in January.
- C) They may prepare a sketch map showing the green belt and number the different sectors for proper assessment of their greenery.
- D) Plantation done lately during the previous season may be properly maintained before the next inspection.
- E) Spacing between saplings should be 2 m. to 2.5m.
- F) As they have planted very small size seedlings, they have been advised to procure seedlings from Forest Department nursery from next year.

6.OPGC:

- A) Maintenance of plantation sites satisfactory.
- B) Saplings planted in the extension area are small. Special care need to be taken for their maintenance.
- C) They have nursery for their own use and for distribution among the local community.

7.Global Coal Washery:

- A) Maintenance of plantation sites satisfactory.
- B) Plantation in the railway siding remains to be inspected.

8.MCL Ib Valley Area:

- A) No plantation has been done by during 2017-18

9. MCL Lakhanpur Area:

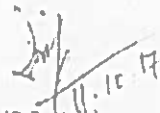
- A) Plantation sites of 2016-17 satisfactory. Replacement of the dead sapling advised.
- B) Plantation of the current season is satisfactory an about 20,000 saplings has been planted.

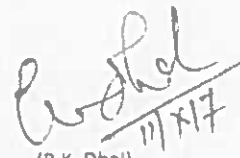
10.MCL Orient Area:

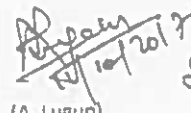
They reported that they have distributed saplings to different educational institutions. These institutions have to be inspected for on the spot verification. They have planted around 200 saplings in the colony area. They may be assigned Govt. land for plantation.

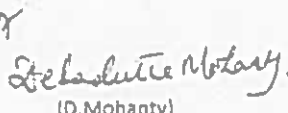
11.TRL-Krosaki:

- A) Plantation satisfactory.
- B) They have a well maintained nursery.


(D.R. Naik)
Ex VC & Honorary
WL Warden


(P.K. Dhal)
ACF, Jharsuguda
Forest Division


(A. Lugun)
A.D Hort.culture
Jharsuguda


(D. Mohanty)
Asst. Env. Engineer
Jharsuguda


(Prashad Naik)
Chief Co-ordinator,
Eco-Club, Jharsuguda

Annexure- V (A)
IB THERMAL POWER STATION
SUMMERY OF GREEN BELT & PLANTATION, till Mar 2019

- Total Plantation & colony Area-1227.5 acres
- Greenbelt & High-Density Trees- 424 acres
- % Greenbelt & High-Density Trees- 34.6
- Total trees planted- 322134 Nos.
- Total trees survived-237429 Nos.
- % of survival-73.7

Plantation & sapling distribution

Year	Planted	Sapling distributed
2012-13	350	2000
2013-14	1300	6000
2014-15	3000	5000
2015-16	700	4480
2016-17	8200	15000
2017-18	1885	4000
2018-19 (till Mar' 19)	10725	4600

*Compensatory plantation of 260 acres has been done in Deogarh area.

Besides, a nursery of 25000 capacity has been developed


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Annexure-V (B)

Annexure- V (B)							
ODISHA POWER GENERATION CORPORATION LTD							
IB THERMAL POWER STATION							
YEAR WISE TREE PLANTATION DETAILS OF OPGC AT ITPS							
Location	Name of Agency	Year	No. of trees planted	Name of the Species	No. of trees alive	Plant Area	Green Belt & High density natural green belt
Colony, Guest House, Halipad, Periphery, Pump House, Filter House, Stores etc	Local agencies	1991-92/92-93	12,000	Akashia	9,550		
Periphery of Boundary Wall (Green Belt)	O.P.G.C	1992-93/93-94	38,500	Sirish	23,300		
Vacant place in front of SBI, Old Hanuman Temple back side of Store yard, colony road side	Sidhartha agency, Jharsuguda	1993-94/94-95	23,800	Chhatim	15,000		
Back side of Autobase, Falsamunda village area	Sidhartha agency, Brukshyaropan Samiti, Jharsuguda	1994-95/95-96	20,000	Kadamba	15,000		
Coal yard side, either sides of main roads, Plant boundary, Railway lines, inside area between D.M. Plant, R.W pump house and compound wall	Departmentally		37,000	Panash	31,155		
Both sides of Rly. inline out side the plant boundary and Ash Pond area.	Green channel, Brukshyaropan Samiti & 3 Nos. of Club and Yubak Sangha	1995-96/96-97	40,000	Neem			
Jhawn & Plantation coal handling plant area & other species on both sides of roads inside plant.	Departmentally		34,500	Bottle brush			
Fuel Oil Pump house area, School, Hospital, Police station Outer periphery of children Parks, Playgrounds etc.	Local agencies		5,500	Bottle Palm			
Ash Pond	Total:-			Chakunda			
Both side of Security road.	Brukshyaropan Samiti		5,000	Jhaun			
	Departmentally		5,000	Sisoo			
	Brukshyaropan Samiti		5,000	Golmohar			
	Departmentally		5,000	Eucalyptus			
	Total			Gambhari			
Ash Pond		1998-99/99-00	5,500	Jarul	15,500		
				Litchi	4,500		
Ash Pond	By agencies	2000-2001	5,058	Amba	0		
CHP & Plant	-do-		5,966	Baula	4,842		
Colony	-do-		11,500	Radhachuda	10,000		
Ash Filling Area (low lying area), Colony Warehouse, SVM School (ITPS), Rengali School	-do-	2006-07	1,800	Deodaru	1200		
Inside Plant campus	-do-	2007-08	3,000	Karanja	2300		
Distribution of fruit bearing tree in Periphery villages	-do-	2008-09	4,000	Pjuli	2100		
Block Plantation in association with District Environmental Society	Majhi		3,000	Saguan	2500		
Fruit bearing tree plantation at Gujapar and in Schools	do		350	Baxa	50		
CHP & Learning Centre on Earth Day	Self	2009-10	120	Mandar	75		
World Env Day	Self		150	Rangani	90		
Govt. Land near Rengali Nursery	Karunakar Sahu		5000	Areca Palm	2000		
Vatarika & Adhapada Mandir- 150 nos fruit & flower tree, Inside Colony vacant place- 100 neem trees, World Env day- 150 neem & Devdaru tree inside Plant Premises, Gujapahar- 200 Fruit bearing trees, 800 Fruit bearing, Radha Chuda etc planted in Binika & Banaharpali through villagers	Self & through villagers	2010-11	1500	Juniperous	900	1227.5	425
				china Palm			
				Musunda			
				Karabira			
				Golan			
				Thuja			
Vacant space in between Boiler area scrap yard & clarifiers	Self	2010-11	100		70		
Inside Colony Vacant Places	Self	2011-12	150		100		

Vacant space at Coal Handling Plant	Self	2012-13	350	Neem, Devdaru	200
Distribution of fruit bearing & Forest plant species in Periphery villages, 2000 nos	Self	2012-13	2000	Teak, Mango, Lemon	1000
Avenue Plantation at Banharipali & Ash Pond Road & 100 nos inside Plant premises	Self	2013-14	1300	Kadamba, Limba, Karanga, Radhachuda, Teak, Devdaru etc	900
Sapling Distribution, 6000 nos	through nearby villagers		6000	Teak, Guava, Jackfruit, Dalimb etc	3000
Sapling Distribution, 5000 nos	through nearby villagers	2014-15	5000	Teak, Guava, Teak etc	2500
Block & Avenue Plantation (OPGC old Pump House vacant space, old Adhapada Shiv Temple premises near Banaharpali & Tarrini Temple premises at Pump House Para)	Self		3000		1050
Sapling Distribution	through nearby villagers, 4480 nos	2015-16	4480	Teak, Baula, Guava, Lemon, Karanj etc	2100
Plantation inside Plant and Colony	Self		700		650
Plantation inside Plant and Colony	Self	2016-17	200	Baula, Mango	192
Plantation inside Plant	Self		8000	Karanja, Neem, Baula	8000
Saplings Distributed, 15000 nos	Others			Grafted Mango, Guava, Teak, etc	
Plantation inside plant & township * 4000 Nos of mango sapling distributed	Self	2017-18	1885	Kadamba, Neem, Bakul, Siris & Karanja	1880
2018-19 till Mar'19 (Gap Plantation)	Self	2018-19	10725	Baula, Neem, Karanj, Mango, Arjun, Sisoo, Teak	10725
Total			322,134		237,429
% Survival				73.7	
Green Belt%				34.6	

In addition to above plantation at ITPS, Compensatory Afforestation has been done by OPGC over 260 Ha. non-forest land in Deogarh, through Forest Department, Govt. Of Odisha.


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Head-EHS

CSR PROJECT STATUS

Annexure 6

S.N	Project Theme	Project Description	Name of the Village	Name of Gram Panchayat	Oper. Area	Approved Budget by CSR Committee & 80D in Rs. Lakhs	Project Status As on 20-09-2018
1	Water & Sanitation	Drinking water project	Sarbahal	Sanghumda	MGR	16.00	Awarded & Ongoing
2		Water Sanitation & Hygiene (WASH) Project	08 villages of Telenpali G.P	Telenpali	Power Plant	359.00	Completed
3		Water Sanitation & Hygiene (WASH) Project	08 Villages of Kusuraloi G.P	Kusuraloi	MGR	416.00	Awarded & Ongoing
4		Water Sanitation & Hygiene (WASH) Project	22 Villages of Tilia G.P	Tilia	N. Ash Pond	600.00	Awarded & Ongoing
5		Water Sanitation & Hygiene (WASH) Project at Rengali Village in all 05 Hamlet & habitations	Rengali	Kumarbandh	Power Plant	125.00	Awarded & Ongoing
6		Installation of drinking water project	Beleituda	Rajpur	MGR	22.00	Awarded & Ongoing
7		Toilet for Girls in High School	Phatapali	Tilia	N. Ash Pond	5.00	Completed
8		Kumarbandh Education Complex (School & College) Drinking Water Project	Kumarbandh	Kumarbandh	Power Plant	5.00	Completed
9		Kumarbandh College Sanitation Project	Kumarbandh	Kumarbandh	Power Plant	10.00	Completed
10		Kumarbandh Police Station Sanitation Project	Kumarbandh	Kumarbandh	Power Plant	5.00	Completed
11		Construction of Toilet Facility at District Police Line	Jharsuguda	Jharsuguda	Power Plant	30.00	Completed
12		Drinking water Project at Bhaludole & Sargipali village	02 Villages	Kumarbandh	Power Plant	20.00	Estimate Stage
13	Education	Cycle stand for 100 Children in High School	Phatapali	Tilia	N. Ash Pond	5.00	Completed
14		Construction of High School Building	Remenda	Remenda	Power Plant	40.00	Completed
15		Construction of School Building & Anganwadi Centre	Telenpali	Telenpali	Power Plant	25.00	Completed
16		Construction of 02 Additional Class Rooms in High School	Banharpali	Telenpali	Power Plant	15.00	Completed

S.N	Project Theme	Project Description	Name of the Village	Name of Gram Panchayat	Oper. Area	Approved Budget by CSR Committee & BOD in Rs. Lakhs	Project Status As on 20-09-2018
17	E	Construction of Cycle Stand at U.P. School	Banharpali	Telenpali	Power Plant	5.00	Completed
18		Construction of two Classrooms at School	Bargad	Kusuraloi	MGR	15.00	Awarded & Ongoing
19		Basic materials to Primary School Hostel (PSH) at Kanaktura (Sundargarh District)	Kanaktura	Kanaktura	MGR	4.00	Completed
20		Leveling of Pathway at Kantatikira Project U.P School	Kantatikira	Kumarbandh	Power Plant	1.25	Awarded & Ongoing
21	Rural Development	Deepening of village pond at Saradhapali village	Saradhapali	Kumarbandh	Power Plant	2.75	Awarded & Ongoing
22		Construction of Kalyan Mandap	Kechubahal	Chandnimal	MGR	35.00	Awarded & Ongoing
23							
		Excavation of new Pond	Sarbahal	Sanghumda	MGR	10.00	Awarded & Ongoing
24		Deepening of village Pond	Kanaktura	Kanaktura	MGR	5.00	Completed
25		Construction of Bathing Ghat	Kechubahal	Chandnimal	MGR	3.00	Completed
26		Renovation of Pond (Gheemunda) Rohidas Para	Chandnimal	Chandnimal	MGR	5.00	Completed
27		Digging of village Pond	Gaudmal	Gaudmal	MGR	12.00	Completed
28		Renovation of Pond & Construction of Bathing Step (Bada Kanta)	Rajpur	Rajpur	MGR	10.00	Completed
29		Deepening of Village Pond	Ambdhar	Rajpur	MGR	10.00	Completed
30		Construction of New School Building	Sarbahal	Sanghumda	MGR	14.00	Awarded & Ongoing
31		Repair and Annual Maintainance Contract (AMC) of Street Light		Rajpur	MGR	15.00	Estimate Stage
32		Repairing of Road from Telenpali gate to Pump House Chawk	Telenpali	Telenpali	Power Plant	45.00	Cancelled
33		Construction of Road to village	Gaudmal	Gaudmal	MGR	12.00	Awarded & Ongoing
34		Construction of Community Centre	Chandnimal	Chandnimal	MGR	10.00	Awarded & Ongoing
35		Construction of Community Centre	Sarbahal	Sanghumda	MGR	10.00	Completed
36							
		Construction of community centre	Junanimunda	Rajpur	MGR	8.00	Awarded & Ongoing
37		Construction of community centre	Beleituda	Rajpur	MGR	8.00	Awarded & Ongoing
38							
		Ramela Pada Community Centre	Badsarua	Tilia	N. Ash Pond	8.00	Completed
39							
		Phatapali (Saharapada) Community Centre	Phatapali	Tilia	N. Ash Pond	8.00	Completed

S.N	Project Theme	Project Description	Name of the Village	Name of Gram Panchayat	Oper. Area	Approved Budget by CSR Committee & BOD in Rs. Lakhs	Project Status As on 20-09-2018
40		Community Centre (Near Bus Stand)	Tilia	Tilia	N. Ash Pond	8.00	Completed
41		Community Centre (near Tilia market)	Nuapada	Tilia	N. Ash Pond	8.00	Completed
42		Community Centre at Pudhipali	Tilia	Tilia	N. Ash Pond	8.00	Completed
43		Community Centre	Binika	Telenpali	Power Plant	8.00	Completed
44		Bhagabanpali Kanta (Birtia) Renovation	Bhagbanpali	Tilia	N. Ash Pond	4.00	Completed
45		Singhda bandh Pond Renovation	Singheipali	Tilia	N. Ash Pond	4.00	Completed
46		Shabandh (Kantatikira) Pond Renovation	Kantatikira	Tilia	N. Ash Pond	4.00	Completed
47		Thorapali Pond Renovation	Thorapali	Tilia	N. Ash Pond	4.00	Completed
48		Sivakanta Bathing Steps (two)	Badsarua	Tilia	N. Ash Pond	3.50	Completed
49		Nua Kanta Bathing Steps (two)	Pudhipali	Tilia	N. Ash Pond	3.50	Completed
50		Pipal Kanta Bathing Steps (two)	Kantatikira	Tilia	N. Ash Pond	3.50	Awarded & Ongoing
51		Tali Kanta Bathing Steps (two)	Phatapali	Tilia	N. Ash Pond	3.50	Completed
52		Renovation of pond at Charnal	Nuapada	Tilia	N. Ash Pond	7.00	Completed
53		Rengali Bandha 02 Bathing Steps	Rengali	Kumarbandh	Power Plant	3.50	Completed
54		Pond Renovation	Bhaludole	Kumarbandh	Power Plant	4.00	Awarded & Ongoing
55		Pond Renovation	Banikdera	Kumarbandh	Power Plant	4.00	Completed
56		Pond Renovation	Kantapali	Kumarbandh	Power Plant	4.00	Completed

S.N	Project Theme	Project Description	Name of the Village	Name of Gram Panchayat	Oper. Area	Approved Budget by CSR Committee & BOD in Rs. Lakhs	Project Status As on 20-09-2018
57		Dunguri Kisan Pada Pond Renovation & 02 Bathing Steps	Rengali	Kumarbandh	Power Plant	7.00	Completed
58		Sajni Kanta Pond Renovation	Budhapali	Kumarbandh	Power Plant	4.00	Completed
59		Birtia Kanta Renovation and 02 Bathing Steps	Barihapali	Sunari	Power Plant	7.00	Completed
60		Renovation of Rani Sagar Pond	Old Adhapada	Telenpali	Power Plant	4.00	Completed
61		Telenpali Upper Bandh 02 Bathing Ghats	Telenpali	Telenpali	Power Plant	3.50	Completed
62		Construction of Community Centre	Sargipali	Kumarbandh	Power Plant	15.00	Completed
63		Construction of Community Centre	Kantatikira	Kumarbandh	Power Plant	10.00	Completed
64		Electrification of Village(Part of WASH Project)	Sahareipada	Telenpali	Power Plant	7.00	Completed
65		Construction of Bus Stop	Kusuraloi	Kusuraloi	MGR	5.00	Completed
66		Construction of Kalyan Mandap at Suitable Place	Telenpali G.P	Telenpali	Power Plant	30.00	Awarded & Ongoing
67		Kalyan Mandap at Ambdhar	Ambdhar	Rajpur	MGR	35.00	Estimate Stage
68		LED Street Light on Main Road	Banharpali	Telenpali	Power Plant	5.00	Completed
69		LED Street Light on Main Road	05 G.P	05 G.P	Power Plant	150.00	Completed
70		Installation of High Mast light	Adhapada	Kusuraloi	MGR	9.00	Completed
71		2.1 K.M LED Street Light on Main Road	Belpahar Municipality	Belpahar Municipality	MGR	30.00	Completed
72		LED Street Light Project in Tilia Revenue Village (including all its hamlets/ constituent padas)	Tilia	Tilia	N. Ash Pond	50.00	Awarded & Ongoing
73		Erection/ Construction of New Electrical Infrastructure in Bargad Village near ITPS	Bargad	Kusuraloi	Power Plant	50.00	Estimate Stage
74		Bus Stop at Telenpali Market Bus Stand	Telenpali	Telenpali	Power Plant	5.00	Completed
75		Renovation of Asthai Kanta	Adhapada	Kusuraloi	MGR	10.00	Completed
76		Deepening of Village Pond & 02 Bathing Steps	Phalsamunda	Kusuraloi	MGR	7.00	Completed
77		Deepening of Naik Kanta	Khandsa	Kusuraloi	MGR	4.00	Completed
78		Renovation of Village Pond	Bargad	Kusuraloi	MGR	4.00	Completed

S.N	Project Theme	Project Description	Name of the Village	Name of Gram Panchayat	Oper. Area	Approved Budget by CSR Committee & BOD in Rs. Lakhs	Project Status As on 20-09-2018
79		Multi-purpose Training Hall Inside PHC Building along with Filtered Drinking Water Facility	Adhapada	Kusuraloi	MGR	15.00	Completed
80		06 (six) Bathing Ghats in four villages of Kushraloi	Kerualbahal etc	Kusuraloi	MGR	10.00	Completed
81		Community Centre	Adhapada	Kusuraloi	MGR	11.00	Completed
82		Repair/ Extension of Community Centre	Phalsamunda	Kusuraloi	MGR	5.00	Completed
83		Tali Kanta Irrigation Project	Telenpali	Telenpali	Power Plant	25.00	Completed
84		Construction of Canal from Asthai Kanta to Goucharmal at Adhapada	Adhapada	Kusuraloi	MGR	15.00	Completed
85		Big Community Centre/ Kalyan Mandap project in Tilia Revenue Village	Tilia	Tilia	N. Ash Pond	34.00	Awarded & Ongoing
86		Electrification of Dhobadera & Sapali Village	02 Villages	Telenpali	Power Plant	36.00	Completed
87		Physical Monitoring of projects, documentation, training and capacity building, overheads, etc.	Baseline survey in peripheral villages	37 villages	11 G.P's	Power Plant	20.00
88	Production of Video Films		37 villages	11 G.P's	Power Plant	10.83	Completed
89	Physical Monitoring of projects, documentation, training and capacity building, overheads, etc.		-	-	Power Plant	19.17	Awarded & Ongoing
Total CSR Budget (OPGC II- Unit 3&4) Approved by CSR Committee						2691.00	