HALF YEARLY COMPLIANCE REPORT TO THE CONDITIONS OF ENVIRONMENTAL CLEARANCE

(2 X 660 MW COAL BASED THERMAL POWER PLANT)

ODISHA POWER GENERATION CORPORATION LIMITED,
BANAHARAPALI, ODISHA

OPGC
Power for Progress

SUBMITTED TO

Ministry of Environment, Forest & Climate Change,

Indira Paryavaran Bhawan,

Jor Bagh Road,

New Delhi,

India-110003

ODISHA POWER GENERATION CORPORATION LTD.
(A Joint Venture of Govt. Odisha & AES Corp., USA)

2 X 660 MW Thermal Power Project Office: Resource Centre, Ib Thermal Power Station,
Dist.: Jharsuguda – 768234, Odisha, Ph.: 06645-222212 Web: www.opgc.co.in

OPGC II – MOEF – 2014 - 3133
Date: [10th Dec , 2014]

To:

The Director (Thermal),
Ministry of Environment, Forests & Climate Change
Govt. of India,
Indira Paryavaran Bhawan,
Jor Bagh Road,
New Delhi- 110003

Subject : Compliance of terms towards environmental clearance given to Expansion of existing Coal based thermal power plant of OPGC by addition of 2X660 MW (Unit 3 & 4) at Banharpali in Jharsuguda District, in Odisha.

Your Ref. no. **: i)** **MoEF letter no. J-13011/59/2008-IA.II (T) dated 04.02.2010**
: ii) **MoEF letter no. J-13011/59/2008-IA.II (T) dated 22.01.2014**
Our letter no. **: ii)** **This office letter No. OPGC: 2589/WE dated 21.10.2010**
: iii) **This office letter No.OPGC:2680/WE dated 30.11.2011**
: iv) **This office letter No.OPGC-4084/WE dated 03.07.12**
:v) **This office letter No.OPGC-397/WE dated 13.02.2013**
: vi) **This office letter No.OPGC-006/WE dated 09.01.2014**
: vii) **This office letter No. OPGC II – MOEF – 2014 - 1421 dated 02.07.2014**
: viii) **This office letter No. OPGC II – MOEF – 2014 – 3133/WE dated 10.12.2014**

Dear Sir,

In continuation to our letter under references above, the compliances to the terms set in the environmental clearance is attached herewith.

Encl: As above.

Thanking You.

Yours Faithfully,

(Ron McParland)
Executive Director (Construction)
(On behalf of Odisha Power Generation Corporation LTD. Unit 3 and 4 Expansion project)

2 X 660 MW Thermal Power Project Office: Resource Centre, Ib Thermal Power Station,
Dist.: Jharsuguda – 768234, Odisha, Ph.: 06645-222212 Web: www.opgc.co.in

Copy to:-

1. The Director (S), Govt. Of India, Ministry of Environment & Forests, Eastern Regional Office, A/3, Chandrasekharpur, Bhubaneswar-751023.
2. The Member Secretary, State Pollution Control Board, Orissa, Paribesh Bhawan, Nilakantha Nagar, A/118, Unit-8, Bhubaneswar-751012.
3. Regional Office, State Pollution Control Board, Orissa, Plot No. 370/5971, At –Babubagicha (Cox Colony) St. marry Hospital Road, PO-Industrial Estate, Jharsuguda, Dist. -Jharsuguda - 768203
4. The Incharge, Eastern Zonal Office, Central Pollution Control Board, 247, Deshpran Shesmal Road, CII Building, 1st floor, Kolkata-7000331.
5. The Managing Director, Orissa Power Generation Corporation Ltd.
6. The Director (Operation), Orissa Power Generation Corporation Ltd.

CONTENTS

MoEF EC COMPLIANCE REPORT

Clause No.	Major Environment Clearance Condition	OPGC II Status
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.	Noted
4. (ii)	The height of the existing ash pond shall not be increased to accommodate fresh disposal of ash slurry.	• The height of existing ash pond will not be increased to accommodate fresh disposal of ash slurry from the subject project (unit 3 & 4).
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 got approved by PCCF (WL)/ CWLW, Odisha on 12th June, 2014. • The payment for execution of SSWLCP was done on 18.07.2012 to Odisha CAMPA account. • **(Annexure-1)**
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.	Hydro-geological study of the Ash Pond and nearby areas was studied by SGS India Pvt Ltd during April 2014. 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 of IS standard 10500 and WHO permissible limits. The ground water reservoir is substantial in the area. The report was submitted before State Pollution Control Board, Odisha. This study shall be conducted on annual basis covering plant area & results shall be submitted before the regional office & SPCB. **(Annexure – 2)**.
4. (v)	A twin flue stack of 275 m height shall be provided with continuous online monitoring equipments for SOx, NOx and RSPM (PM2.5 & PM10). Exit velocity of flue gases shall riot be less than 22 m/sec. Mercury emissions from stack shall also be monitored on periodic basis.	• The design requirements have already been incorporated in the plant design specifications. • Mercury emission if any will be monitored periodically on commissioning of the Plant.

MoEF EC COMPLIANCE REPORT

Clause No.	Major Environment Clearance Condition	OPGC II Status
4. (vi)	High Efficiency Electrostatic Precipitators (ESPs) shall be installed to ensure that particulate emission does not exceed 50 mg/Nm3.	The design requirements have already been incorporated in the plant design specifications
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.	The design requirements have already been incorporated in the plant design specifications
4. (viii)	Utilisation of 100% Fly 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.	Noted for compliance
4. (ix)	Fly ash shall be collected in dry form and storage facility (silos) shall be provided. Unutilized fly ash shall be disposed off in the ash pond in the form of slurry form. Mercury and other heavy metals (As, Hg, Cr, 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 off in low lying area.	• The design requirements have already been incorporated in the plant design specifications. • Effluent emanating from the existing ash pond of the running plant (2x210 MW) 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. • Ash generated from the plant will be disposed only in designated area.
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.	The design requirements will be incorporated in the design specifications of ash pond.
4. (xi)	For disposal of Bottom Ash in abandoned Manohar mines it shall be ensured that the bottom and sides of the mined out areas are 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.	• The design requirements will be incorporated in the design specifications. • State Pollution Control Board will be informed in advance before undertaking filling of mine using ash.

MoEF EC COMPLIANCE REPORT

OPGC
Power for Progress

Clause No.	Major Environment Clearance Condition	OPGC II Status
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 is being 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.
4. (xiii)	COC 5.0 will be adopted.	The design requirements have already been incorporated in the plant design specifications.
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.	Sewage will be treated in existing sewage treatment plant. Treated sewage is being used for raising greenbelt/plantation.
4. (xv)	A sewage treatment plant shall be provided and the treated sewage shall be used for raising greenbelt/plantation.	Sewage will be treated in existing sewage treatment plant. Treated sewage is being 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. • CGWB authority via letter no. 613 dated 06/07/2013 has asked to comply on certain points. • The compliance report submitted vide letter no 580 with enclosure on 17.02.2014.

MoEF EC COMPLIANCE REPORT

OPGC
Power for Progress

Clause No.	Major Environment Clearance Condition	OPGC II Status
4. (xvii)	Adequate safety measures shall be provided in the plant area to 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.	The design requirements have already been incorporated in the plant design specifications
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 shall be made in consultation with Dept. of Explosive. • 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. • Disaster management plan shall be prepared before going for storage and handling of the oil.
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.	Noted.
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.	Noted

Clause No.	Major Environment Clearance Condition	OPGC II Status
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 shall be submitted to the Ministry. Tree density shall not less than 25QO per ha with survival rate not less than 70 %.	The requirements are addressed in the drawing number D-56 (already submitted on 30th November 2011).The tree plantation will be taken up on completion of the construction of Plant.
4. (xxii)	First Aid and sanitation arrangements shall be made for the drivers and other contract workers during construction phase.	Noted
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.	• The design requirements for control of noise in the work areas have already been incorporated in the plant design specifications. • PPE is being provided in OPGC for all personnel exposed to work in noisy area. • Periodic health check has already been implemented in OPGC.
4. (xxiv)	Regular monitoring of ground level concentration of So2, NOx, RSPM (PM2.5 & PM10) 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.	• In OPGC ground level concentrations are being monitored at six locations as agreed with SPCB and monthly periodic reports are submitted to SPCB. • Ambient air is also being monitored on continuous basis by two online ambient air monitoring station & result of analysis are transmitted to SPCB server on real time basis. Periodic reports are being submitted to the Regional Office of MoEF.
4. (xxv)	A good action plan for R&R (if applicable) with package for the project affected persons be submitted and implemented as per prevalent R&R policy within three months form the date of issue	Not applicable as there is no displacement of villages for the Plant.

Clause No.	Major Environment Clearance Condition	OPGC II Status
	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 Crore 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 CSR Committee constituting of directors of OPGC has been formed by order of the OPGC Board as per guidelines of the Companies Act 2013. A comprehensive CSR Policy and annual CSR Plan listing projects to be implemented and budget involved, are under finalisation and proposed to be placed before the CSR Committee for recommendation and approval of the Board, which is expected to be completed in June'2014. The CSR plan is being prepared, keeping in view the directives of MoEF. Implementation shall be carried out thereafter. The CSR plan for the current year shall be communicated on approval of OPGC Board.
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.	OPGC, as a part of its CSR, have been carrying out similar activities since its inception and these CSR activities are being augmented year on year. • A community skill development centre has been set up for skill up gradation for self employment opportunity. • A plan has been proposed for conducting livelihood arrangement study for SHG and farmer community.

MoEF EC COMPLIANCE REPORT

Clause No.	Major Environment Clearance Condition	OPGC II Status
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 near by villages and schools shall be undertaken in a time bound manner.	OPGC, as a part of its CSR, have been carrying out similar activities since its inception and these CSR activities are being augmented year on year. • OPGC have been supplying drinking water through tankers during summer in the nearby villages since last 10 years. • Seventeen peripheral villages are provided piped drinking water throughout the year.
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 after the completion of the project.	Adequate space for construction of labour colony has already been earmarked outside the plant boundary. Infrastructure for provision of water supply and electricity has already been made. Other infrastructural requirement is being provided by the construction contractor. .
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 concerned Panchayat, Zila Parisad / 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.

Clause No.	Major Environment Clearance Condition	OPGC II Status
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, S02, NOx (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.
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 hard copies as well by e-mail) to the respective Regional Office of MOEF, the respective Zonal Office of CPCB and the SPCB.	Reporting already commenced since October 2010.
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.

Clause No.	Major Environment Clearance Condition	OPGC II Status
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 environment of the environmental clearance conditions on their website and update the same periodically and simultaneously send the same bye-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, it's Regional Office, Central Pollution Control Board, State Pollution Control Board and the Regional Office, OSPCB. • Web hosting of EC Compliance status is being done.
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 basis. Criteria pollutants levels including NOx (from stack & ambient air) shall be displayed at the main gate of the power plant.	• Reporting already commenced since October 2010. • Web-hosting of compliance of stipulated in the EC conditions being done. • Criteria pollutants levels NOx (from stack & ambient air) will be displayed at the main gate of the power plant on commissioning of Plant.
4. (xxxviii)	Separate funds shall be allocated for implementation of environmental protection measures along with item-wise break-up. These cost 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.
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	The financial closure was done 23rd Nov, 2012. NTP was issued to BHEL and BGRE on 26th March, 2014.

Clause No.	Major Environment Clearance Condition	OPGC II Status
	of land development work and commissioning of plant.	
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.	Noted

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.	Noted and will be complied.
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. The same monitoring shall be carried out through IIT, Madras.
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.	Noted for compliance.
d	Fugitive emissions shall be controlled to prevent impact on agricultural or non-agricultural land.	Adequate dust suppression measures like water sprinkling is being done at the construction site. However sufficient sprinklers will be installed to suppress fugitive dust from vehicular movement and coal handling area.

e	No ground water shall be extracted for use in operation of the power plant even in lean season.	Noted for compliance.
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.	Noted for compliance.
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.	Noted for compliance.
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 ascertained by the State Pollution Control Board and implementation done in close co-ordination with the State Pollution Control Board.	Noted for compliance.
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. 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 re-examine the risk involved through and expert agency and do the needful in consultation with Regional office MoEF and SPCB.
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.	Noted for compliance.

ANNEXURE 1

ODISHA POWER GENERATION CORPORATION LTD.
(A Joint Venture of Govt of Odisha & AES Corp, USA)

Zone-A, 7th Floor, Fortune Towers, Bhubaneswar - 751 023, Odisha
Ph: 0674-2303765 - 66 Fax: 0674 - 2303755
Web: www.opgc.co.in

Letter No- 2161 WE,

dt 19.07.2014

To
The Divisional Forest Officer,
Jharsuguda Forest Division,
Dist: Jharsuguda.

Sub:- **Approval of Site Specific Wild Life Conservation Plan in respect of Ib Thermal Power Station, Banharpalli in Jharsuguda district by M/S OPGC Ltd.**

Demand for Site Specific Wildlife Conservation Plan.

Ref: **Your Letter No 1826/ Dated 30.06.2014.**

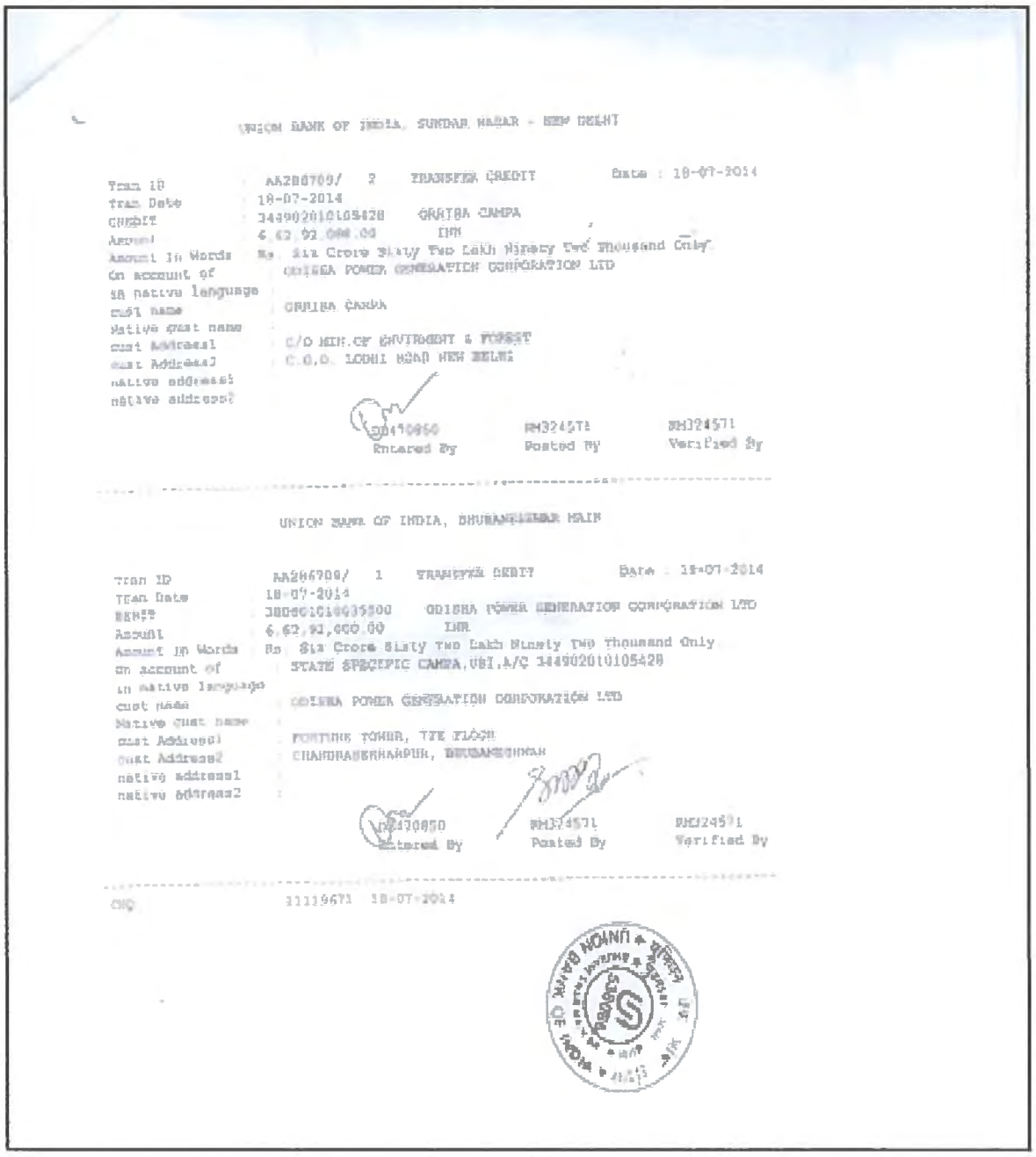
Sir,

With reference to the letter and subject cited above we are informing herewith that we have directly credited through Transaction Id No- AA286709 dt 18.07.2014 amounting to Rs 6,62,92,000/ (Rupees Six Crores SixtyTwo Lakhs Ninty Two Thousand) only drawn on Union Bank Of India, Main Branch, Bhubaneswar deposited with Odisha State CAMPA in Account Number- 344902010105428 of Union Bank Of India, Sundarnagar, New Delhi, 110003CGO (IFSC Code- UBIN0534498) through JV towards deposit of Site Specific Wildlife Conservation Plan Fund. You are requested to submit the confirmation against the above payment for our Records & Audit.

Thanking you.

Yours faithfully,
(P. N. Subudhi) 19/7/2014
Sr. Asst. Manager (Finance)Projects

Encl: As above.
Copy to: 1) PCCF (WL), & Chief Wild Life Warden, Odisha.
2) RCCF, Sambalpur Circle, Odisha
3) Sr. Assistant Manager (Fin) cum DDO for information
4) Sr. Manager (Mines) for information & necessary action
5) DGM (Civil), ITPS, Banharpalli, Jharsuguda for information
6) Sr. Manager (Mechanical) Corporate Office



UNION BANK OF INDIA, SUNDAR NAGAR - NEW DELHI

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Tran Date : 18-07-2014
CR/DR : 344902010105428 ORATBA CAMPA
Amount : 6,62,92,000.00 INR
Amount In Words : Rs. Six Crore Sixty Two Lakh Ninety Two Thousand Only
On account of : ODISHA POWER GENERATION CORPORATION LTD
In native language :
Cust name : ORRISA CAMPA
Native cust name :
Cust Address1 : C/O MIN.OF ENVIRONMENT & FOREST
Cust Address2 : C.G.O. LODHI ROAD NEW DELHI
native address1 :
native address2 :

Entered By RM324571 Posted By RM324571 Verified By

UNION BANK OF INDIA, BHUBANESWAR MAIN

Tran ID : AA286709/ 1 TRANSFER DEBIT Date : 18-07-2014
Tran Date : 18-07-2014
DR/CR : 380901010035300 ODISHA POWER GENERATION CORPORATION LTD
Amount : 6,62,92,000.00 INR
Amount In Words : Rs. Six Crore Sixty Two Lakh Ninety Two Thousand Only
On account of : STATE SPECIFIC CAMPA,UBI,A/C 3449020101054 28
In native language :
Cust name : ODISHA POWER GENERATION CORPORATION LTD
Native cust name :
Cust Address1 : FORTUNE TOWER, IST FLOOR
Cust Address2 : CHANDRASEKHARPUR, BHUBANESWAR
native address1 :
native address2 :

Entered By RM324571 Posted By RM324571 Verified By

CHQ 31119671 18-07-2014

ANNEXURE-2

FINAL REPORT

HYDROGEOLOGICAL STUDIES AT ASH POND A, B AND C, IB THERMAL POWER STATION, JHARSUGUDA DISTRICT, ODISHA

CLIENT NAME:

IB THERMAL POWER STATION, JHARSUGUDA DISTRICT, ODISHA

PROJECT REFERENCE NUMBER:
IN/ES-HG/2013-02
(VERSION 1.2)

PREPARED BY:

SGS India Private Limited
226, Udyog Vihar Phase- I
Gurgaon – 122 016, Haryana, India

Tel: +91 124 6776300
Fax: +91 124 6776403/04

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WHEN YOU NEED TO BE SURE

SGS

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1. INTRODUCTION

Odisha Power Generation Corporation Ltd. (OPGC) was incorporated as a wholly owned Government of Odisha Company on November 14, 1984 under the Companies Act. 1956. Government of Odisha as part of the reform process in the energy sector, had divested 49% of its share capital in favour of a strategic investor namely AES corporation, USA in the month of January, 1999.

The existing business activity of OPGC is confined to generation of 420 MW (Unit 1 & Unit 2) of electricity from its plant IB Thermal Power Station (ITPS) located in the district of Jharsuguda. The two units of 210 MW each at ITPS are running successfully for last 12 years. As part of its growth plan, OPGC has accorded top priority for the setting up of two more units 2x660 MW (Units- 3&4) at the same location. OPGC is also developing the captive coal block (Manoharpur & Dip side of Manoharpur) allocated to it in IB Valley area for the expansion at ITPS.

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. Another ash pond C is under construction and is located in between A & B ash ponds.

The hydrogeological study is being conducted for all three ash pond areas to know the subsurface geological features, aquifers and ground water characteristics.

The location map of the study area is given in the ***Figure 1*** and a Pond layout shown in the ***Figure 2.***

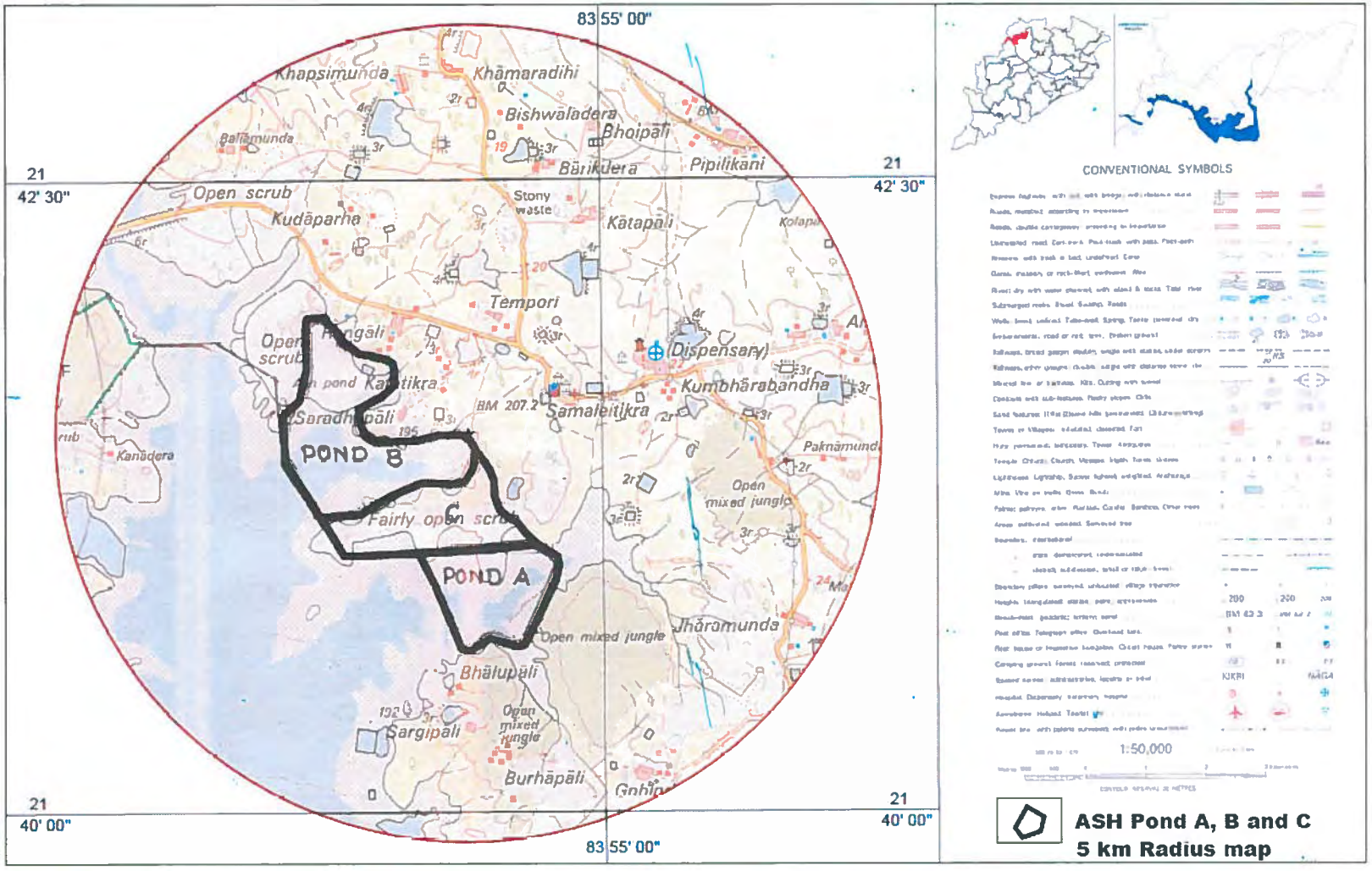


FIGURE 1: THE STUDY AREA MAP

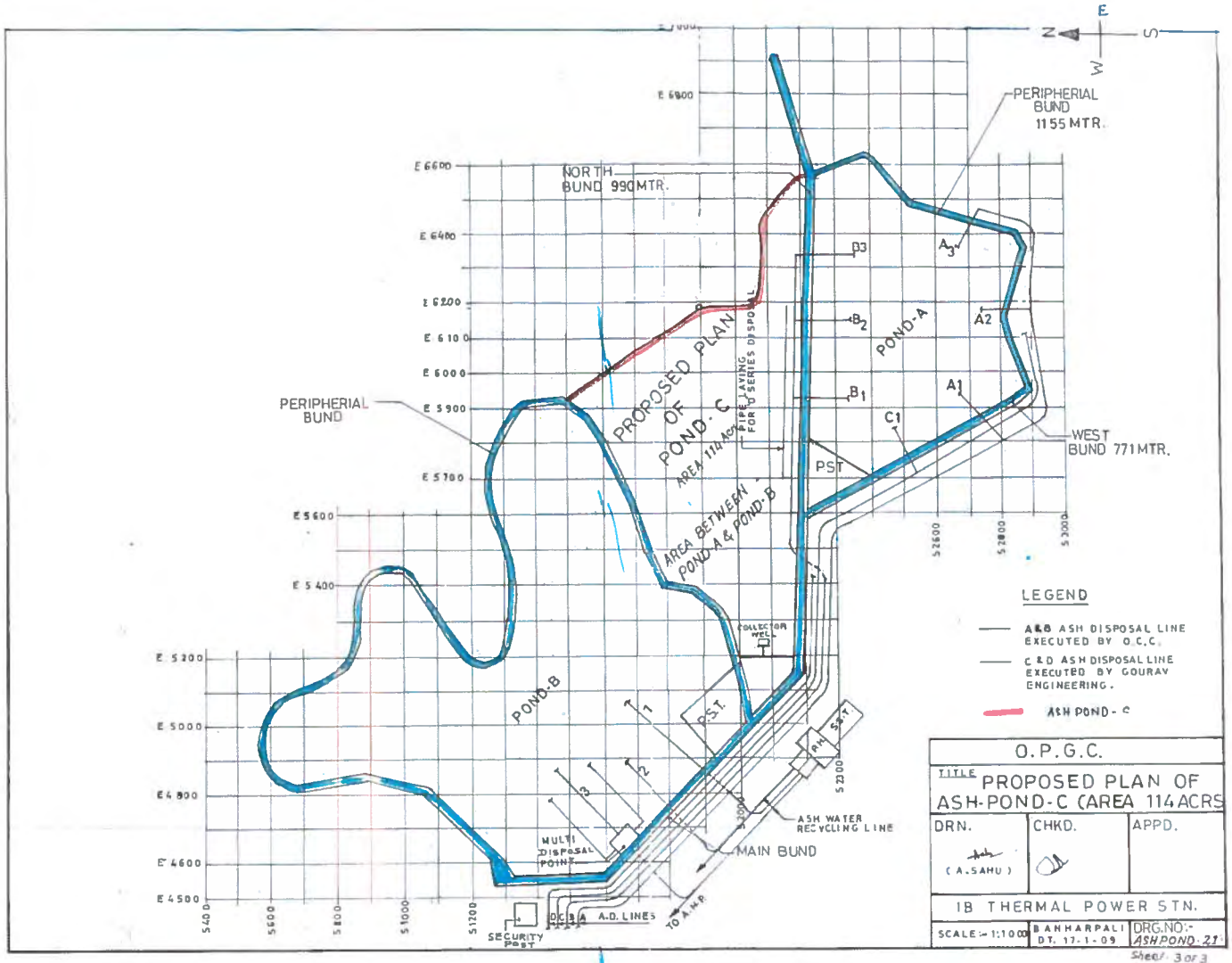


FIGURE 2: ASH POND A, B AND IN BETWEEN ASH POND C SHOWING LAYOUT PLAN MAP AT IB THERMAL POWER STATION, JHARSUGUDA.

OPGC (ITPS) has invited SGS India to carryout Hydrogeological study of the ash pond area and accordingly, **SGS India Private Limited (SGS)** has carried out the Hydrogeological studies to understand the aquifer characteristics, delineation of subsurface features and groundwater level from the ash pond area and its surroundings. The study involves, Hydrogeological, geophysical investigation and water & soil testing. The study results area are summarized in this report.

The Study was undertaken between 22nd April & 29th April 2014 by SGS India.

2. OBJECTIVES AND SCOPE OF WORK

The principal objective of the study is to understand the hydrogeological features including groundwater level and leaching behavior and any contamination exists from the Ash pond A, B and C at IB thermal power station, Jharsuguda, Odisha.

The scopes of work include;

- Delineating subsurface geological features in & around the Ash pond location.
- Possibility in groundwater quality and soil contamination from the Ash pond.
- Groundwater table, groundwater and surface water quality
- Leaching behaviour due to ash pond operation.

The secondary data received from OPGC for correlation with the primary data collected during hydrogeology studies

- Previous soil investigation (geotechnical study) reports related to ash pond C
- Water analysis reports for the ash pond and surrounding areas including seepage water analysis reports from ash pond.

3. DESCRIPTION OF STUDY AREA

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 500 acre and is bounded by 21°41'4.09"N latitude and 83°53'54.29"E longitude at a height of 185–210m above mean sea level. The site is at about 4km by road from IB Thermal Power plant towards east & southeast direction and 14 km North of Hirakud dam. The toposheet (scale 1:50000) as shown in figure 1 shows that the Ash pond area lies adjacent to back water of Hirakud river. The general slope of the ash pond area is from East to West, which is about 8 to 10m elevation difference.

The salient features of both ponds are as follows.

Ash Pond A:	
Area	88.57 acres (3, 58,427 sq.m)
Structure	Clayey Sand (Embankment) Compacted ash (filling material) Sand (Blanket)
Elevation	197 m.
Coordinates	Latitude: 21°40'52.00"N Longitude: 83°54'28.38"E
Any protection layer	Nil
Ash Pond B:	
Area	150 acres (6, 07,035 sq.m)
Structure	Clayey Sand (Embankment) Compacted ash (filling material) Sand (Blanket
Elevation	202 m
Coordinates	Latitude: 21°41'22.41"N Longitude: 83°53'55.00"E
Any protection layer	Nil

3.1. TOPOGRAPHY

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. Refer ***Figure 3, 4 and Plate 1*** for base map & image of reclaimed ash pond B, as a part of reclamation process, ash mound is prepared to accommodate more ash at the center of the reclaimed ash pond B.

PLATE 1: ASH POND B (RECLAIMED BY PARTIAL VEGETATION)

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 ash pond layout map is given in ***Figure 5***.

The stability test of ash pond A & B was conducted by OPGC by engaging Department of Civil Engineering, IIT Madras during April 2011.

Currently, ash pond C is under construction which is located in between ash pond A & ash pond B adopting HDPE liner at the bottom and sides to avoid seepage of ash pond water.

3.1.1. STATIC STABILITY ANALYSIS OF THE ASH POND

The ash pond was analysed for static stability using plane strain model using PLAXIS 8. The compressibility characteristics of the foundation layer below the embankment is found be quite insignificant when compared to the foundation soil.

The major portion of the embankment is made up of burrow material (Clayey sand) up to the level of EL 199 m and compacted ash for the proposed construction (i.e. rising of level from EL 202 m to 205 m). This 3 m level rising is to be carried out by compacted ash embankment with nominal earth cover

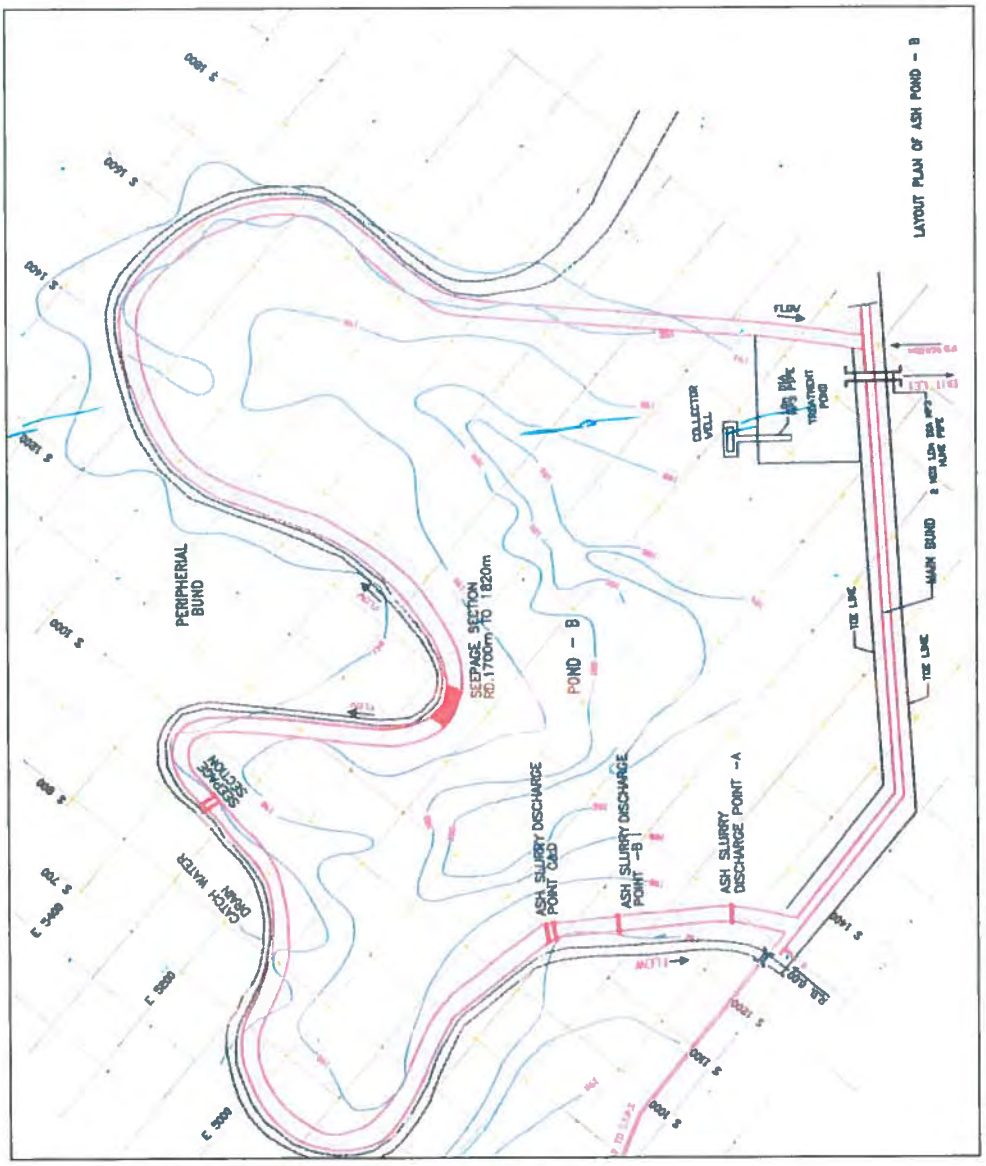


FIGURE 3: CONTOUR BASE MAP OF THE ASH POND B

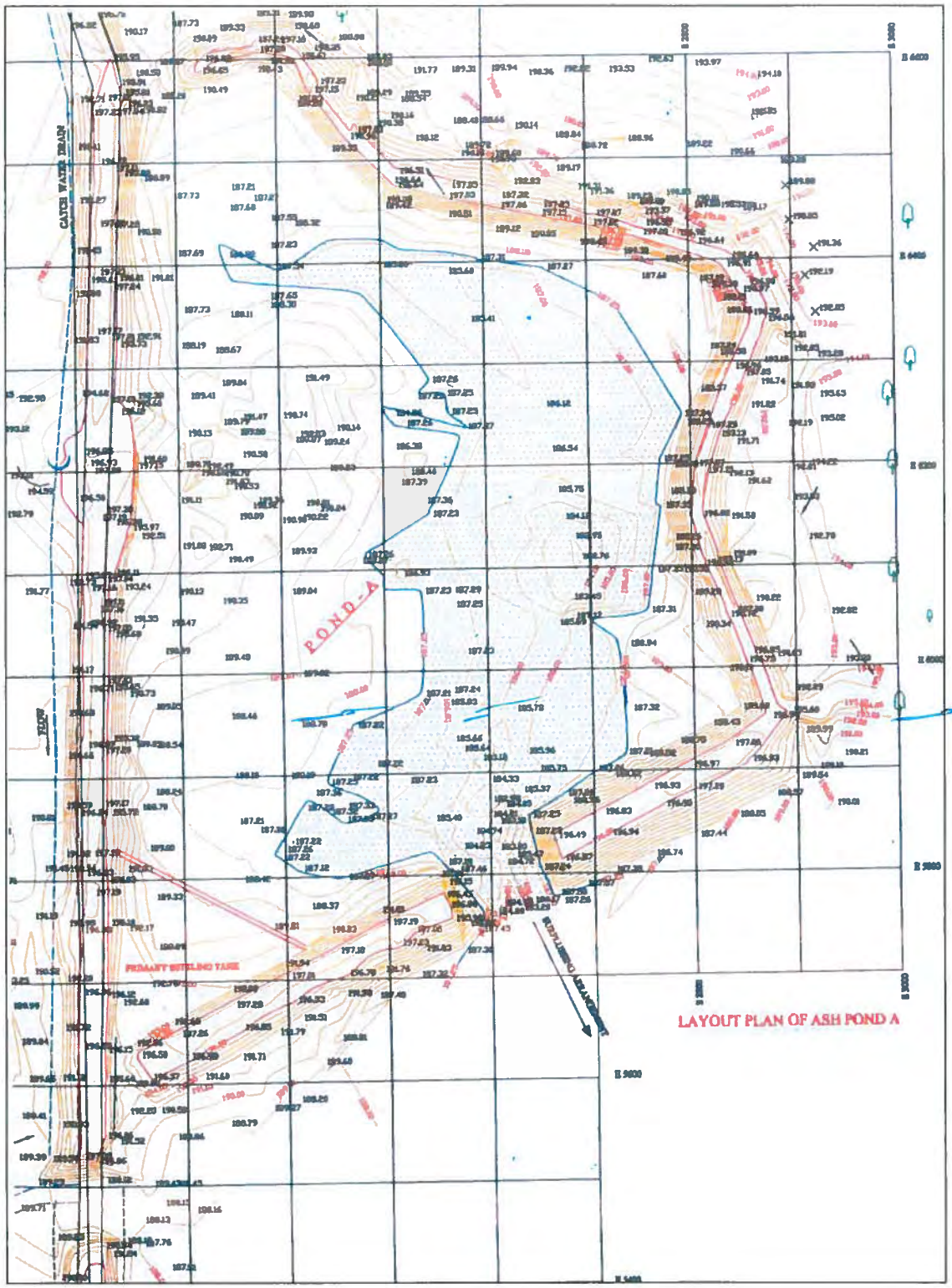


FIGURE 4: CONTOUR MAP OF THE ASH POND A

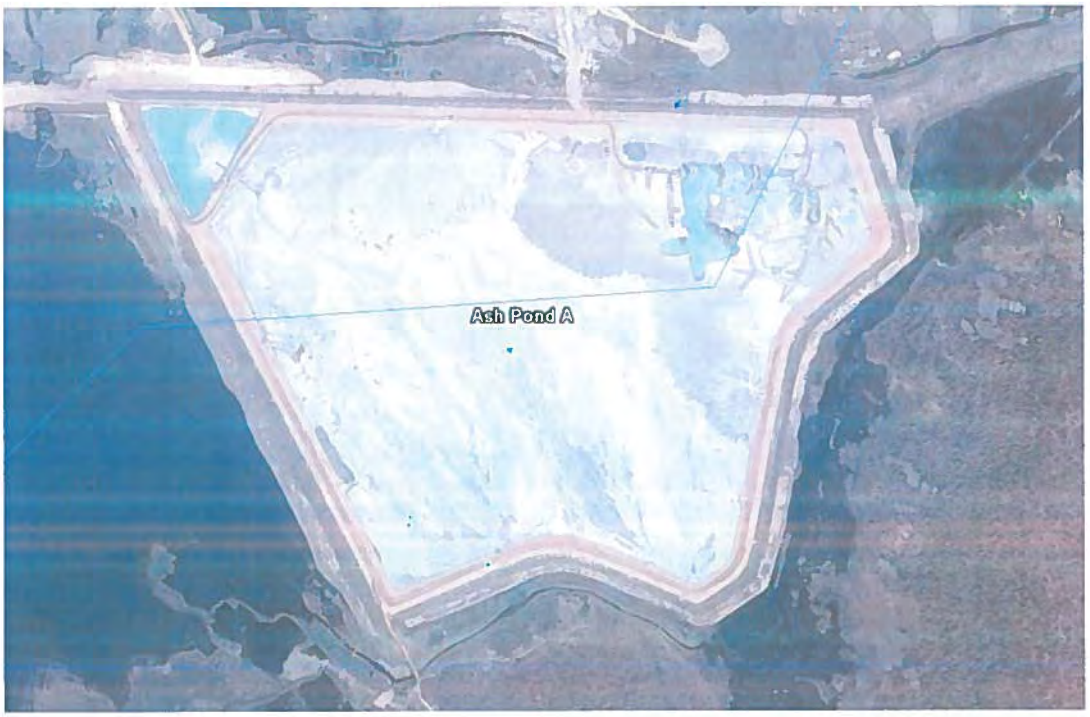


PLATE 2: PRESENTLY ACTIVE ASH POND A

3.2. GEOLOGY

Lithologically, the area comprises formations of Gondwana group (Boulder bed, Sandstone, Shale and coal seams etc.), Laterites to alluvial deposits of Quaternary age. Sedimentary formations (sandstone, shale and clay) equivalent of Barakar formation of the southern part of the study area is covered by the Archeans, whereas the northern part is covered by the Gondwanas[1]. The laterites of both high and low level occur extensively in the state. The brief descriptions of major geological formations are given below ***Table 1.***

TABLE 1: GEOLOGICAL FORMATIONS OF JHARSUGUDA DISTRICT

Semi-Consolidated Formation			
Geological Age	**Rock formation**		**Districts**
Palaeozoic – Mesozoic	Gondwana Group	Boulder bed, Sandstone, Shale and coal seams etc.	Jharsuguda,

[1] *Source: Kamal Jeet Singh (Gondwana Formation of IB river valley Odisha) 2006.*

3.3. CLIMATE

The area experiences a sub-tropical climate with characterized as tropical with hot summers and mild winters. Rainfall occurs mainly during the monsoon stretching between Mid-junes to September. The climate of the entire basin is 'tropical monsoon type' with four distinct seasons, i.e., summer from March to May, Monsoon from June to September, Post-monsoon from October to November, and winter from December to February[2]. The temperature gradually rises from end of February to May, sometimes, up to 44 ºC to 45 ºC. December and January are the coldest months when the mercury reaches to around 8 ºC.

3.4. DRAINAGE

The drainage in the study area is mostly dendrite in nature and it is mostly controlled by the Hirakud Reservoir. The study area is located within the Hirakud reservoir watershed. River Mahanadi with its tributary IB is the major river flowing through IB Valley, Jharsuguda area and the many of the streams forms the northern boundary of Hirakud reservoir has a number of such streams running in north-south direction. The drainage map of the study area is given in the ***Figure 6.***

[2] Debiprasad Taudia (Rapid environmental impact assessment using remote sensing and geographic information systems: A case study of river Ib Barrage, Odisha)

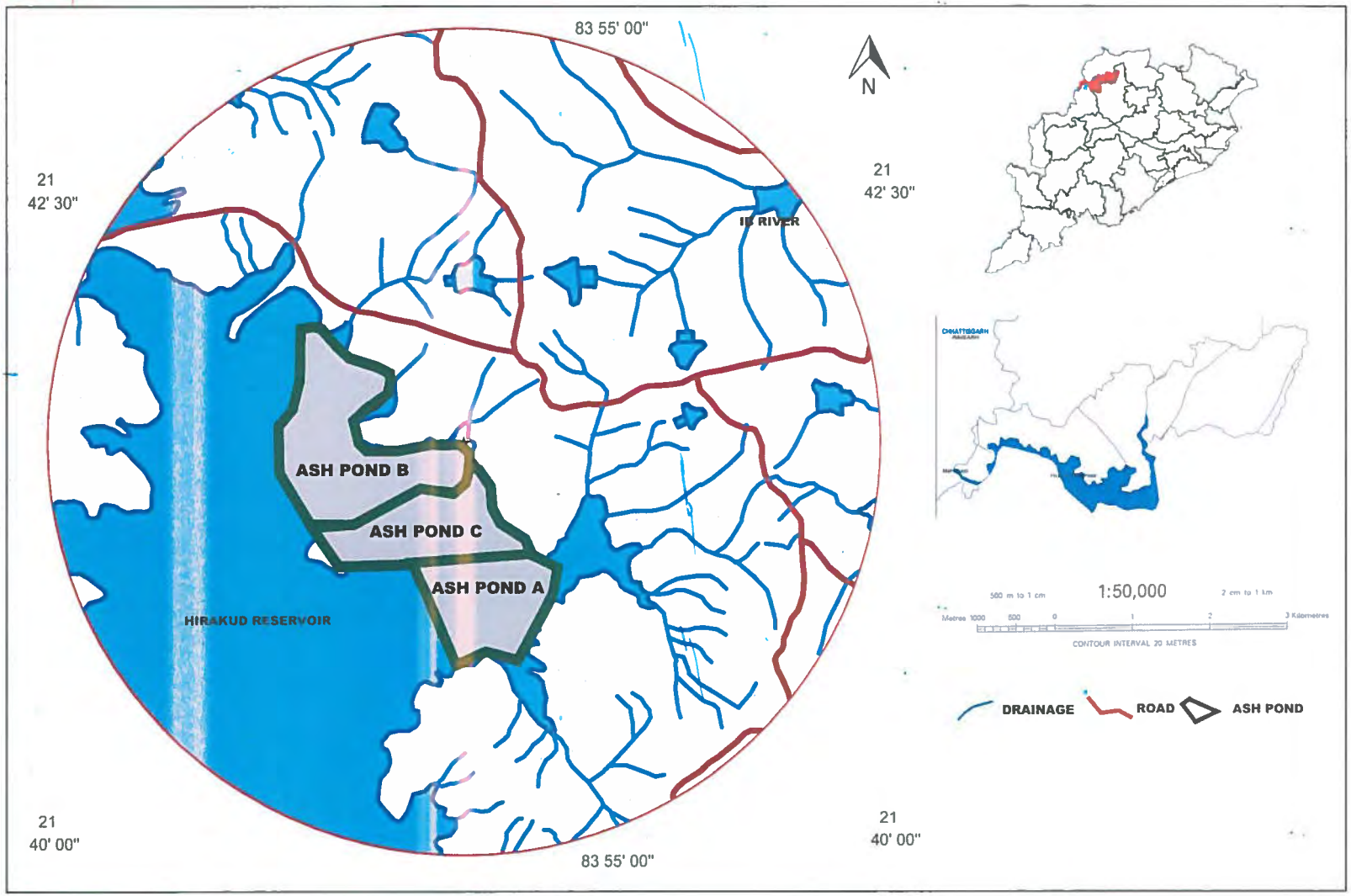


FIGURE 5: DRAINAGE MAP OF ASH POND AREA

3.5. SOIL

There are mainly two types of soil viz lateritic soil and alluvium soil predominantly exists in the ash pond area. These soils are generally residual and have poor fertility.[3]

3.5.1. LATERITE AND LATERITIC SOILS

The lateritic soils occur extensively towards northern Jharsuguda plateau; this is attributed to the comparatively flat uplands favouring greater illuviation of iron and manganese and excessive leaching of bases. Around the periphery of Hirakud reservoir low level ground and laterite are observed in study area of Ash pond.

3.5.2. ALLUVIAL SOILS

Alluvial soils are observed in limited areas of the ash pond and mostly occurring in levees of Hirakud and IB River. Besides localized ones along the stream terraces have stratified alluvial material deposited along the stream banks.

3.6. HYDROGEOLOGY OF THE REGION

The semi-consolidated Gondwana sandstones form moderately good aquifers when it is weathered and fractured. Diverse hydrogeological conditions have been observed over the area due to variations in rock types, geology and structures. The rock types ranging in age from Achaeans to Recent, The classified rock formation of Boulder bed Sandstone, Shale and Coal seams, ground water occurs in weathered residuum and deeper loosely cemented friable and fractured sandstone. Ground water occurs under phreatic condition at shallow depth and under semi-confined to confined conditions at deeper depth in the hydrogeological units.

The rocks belonging to consolidated unit are devoid of any primary porosity from the hydrogeological point of view but consist of secondary porosity, developed subsequently by the tectonic and structural movement and also due to weathering and erosion process. The weathered residuum of consolidated rocks form ground water reservoir at shallow depth and are designated as shallow aquifers while fractures, joints etc act as ground water reservoir at deeper depths and this ground water bearing zones at deeper depth are designated as deeper aquifers.

The aquifers in semi-consolidated formation are mainly formed by the weathered and fractured sand stones in Gondwana rocks, and semi-consolidated and loosely cemented sand stone or sand layers in Tertiary deposits of Jharsuguda district. Ground water occurs

[3] Soils of Jharsuguda District: 2009 (*Dr. Antaryami Mishra)*

under water table condition in shallow aquifers. The shallow aquifers in Gondwana rocks are formed by weathered and fractured shales, sand stones and normally the thickness of weathered zone is thin. The unconsolidated formations include laterite and recent alluvium.

4. GROUNDWATER LEVEL MEASUREMENT

4.1. GROUNDWATER LEVEL MEASUREMENT USING ELECTRICAL WELL SOUNDER

Ground water level measurement provides information on the effects of climate, land use change and ground water abstractions. Ground water level measurement is carried out nearby Ash pond area during pre monsoon season. Ground water level was measured using Electrical well sounding device ***(Figure 7 & Plate 3)*** and is a simple continuity detector will be used towards measurement. The monitoring and sampling location are shown in ***Figure 8.***

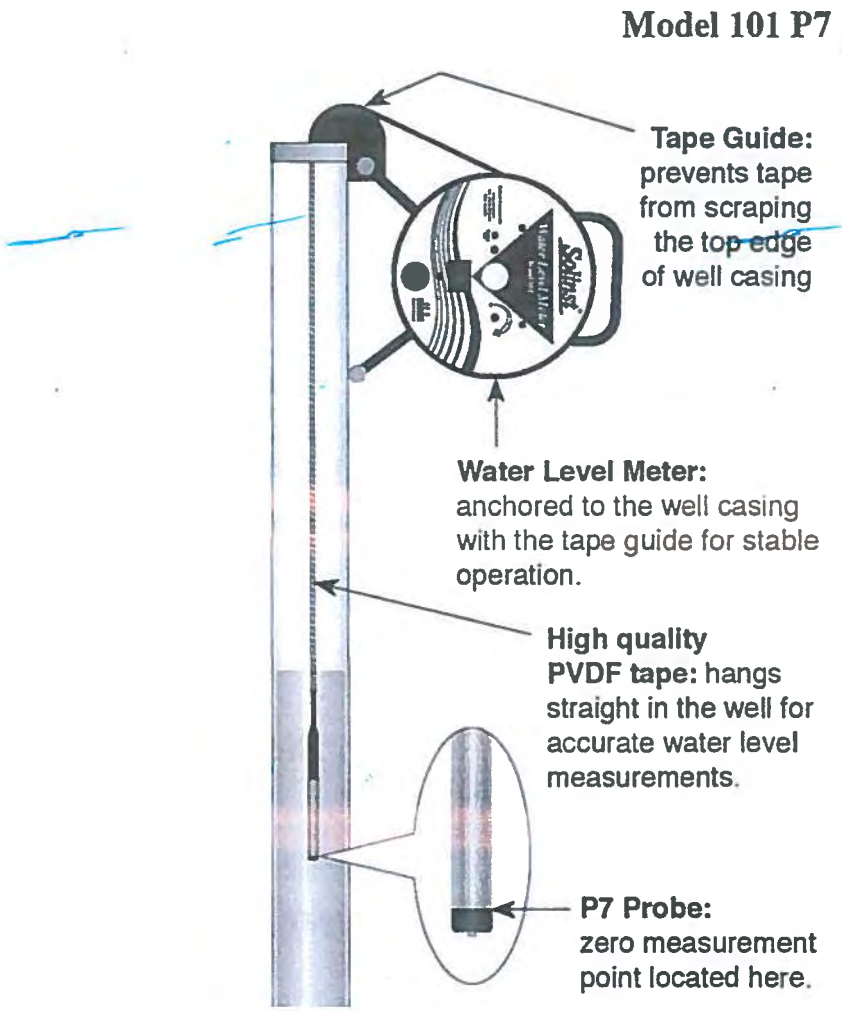


FIGURE 6: CROSS SECTION OF ELECTRICAL WELL SOUNDER

PLATE 3: ELECTRICAL WELL SOUNDER FOR GROUND WATER LEVEL MEASUREMENT

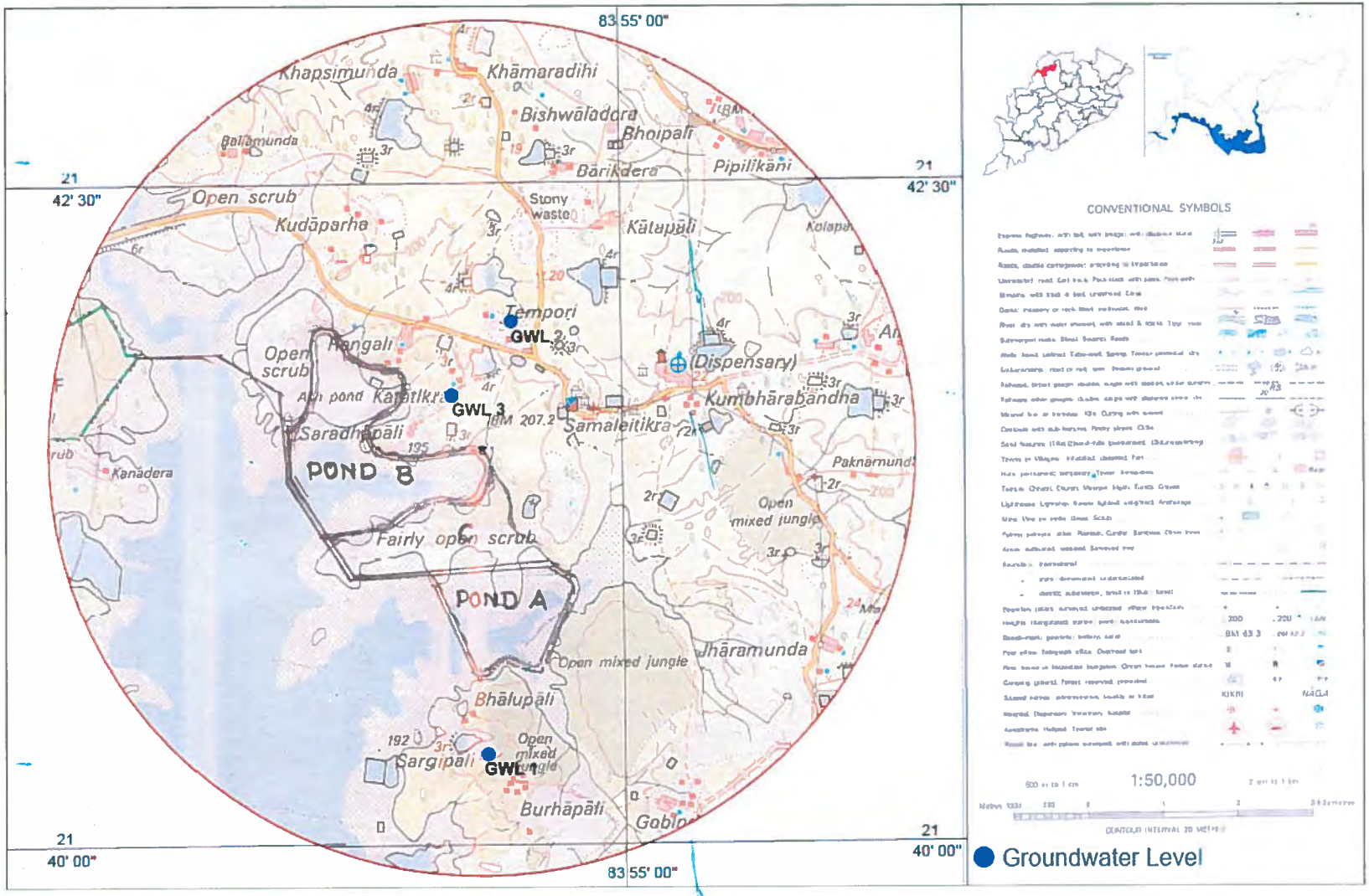


FIGURE 7: GROUND WATER LEVEL MEASURING LOCATIONS NEARBY ASH POND AREA

4.1.1. Depth to Water levels In Ash pond near villages

The groundwater levels were measured at 3 different locations at Bhalupalli, Rengali and Kantatikra villages during the pre monsoon season 2014 and the details are shown in ***Table 2*** and ***Figure 9.***

Table 2: Ground water level measurement Details

Location	Latitude	Longitude	Elevation (in m)	Well type	Well depth (in m)	Water Level (in m)
Bhalupalli	21.6723	83.9074	210	Hand pump	-	19.78
Rengali	21.6995	83.9093	213	Hand pump	30.75	9.31
Kantatikra	21.6949	83.9052	214	Hand pump	74.05	14.42

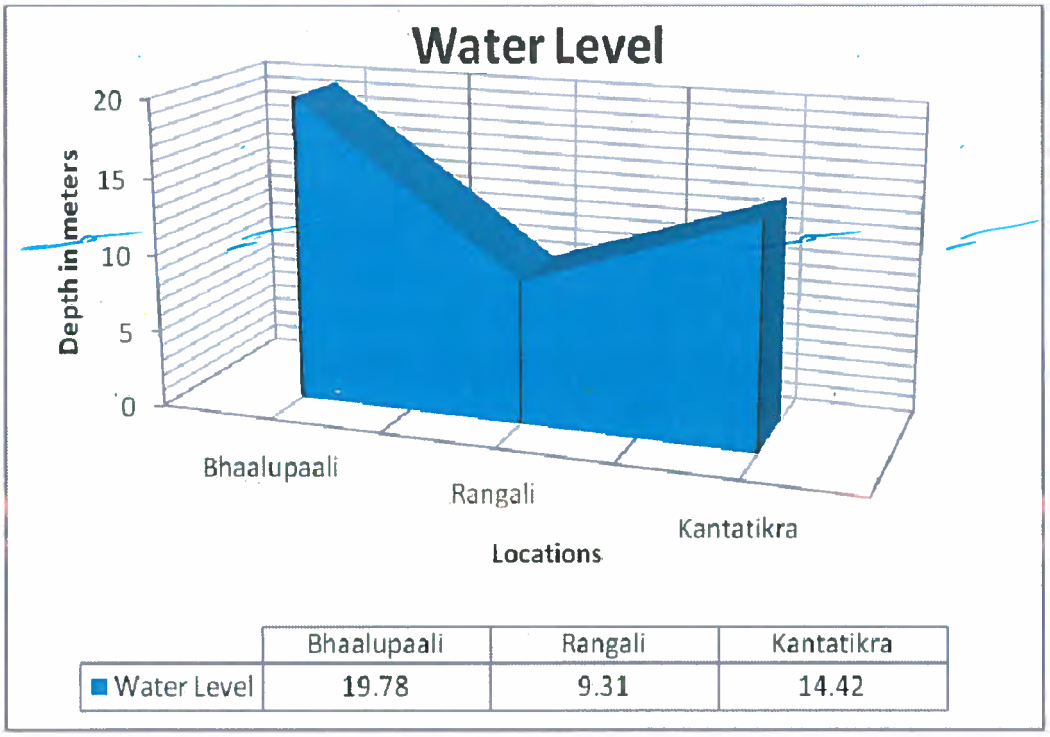


Figure 8: Cross section of Water Level near Ash Pond area

From the above Ground water level measurement, the ground water level range between 9 to 20m and the shallow water table conditions occurred in this area. The groundwater flow direction is towards southeast to northwest following the general sloping pattern.

4.2. GEOPHYSICAL INVESTIGATION METHODS

As a part of geophysical investigation, electrical resistivity technique (vertical electrical sounding – (VES) is used to determine the thickness and composition of the sub-surface formations and to identify water-bearing zones at the study area.

4.2.1. ELECTRICAL RESISTIVITY TECHNIQUE

Electrical resistivity technique is a kind of geophysical investigations. Electrical Resistivity Method for sub surface exploration is by far most reliable, fast and economic in delineating changes in the lithology of sub surface formations. The technique can effectively identify presence of water, clayey, sandy zones and hard rock's.

An electric current 'I' is passed through the ground by connecting with the battery, the terminals of a pair of electrodes AB, driven in the ground and called Current Electrode Pair. The voltage V, developed due to current flow across another pair of electrodes MN, known as Potential Electrode Pair and driven in the ground, is measured.

The ratio between Voltage V and current I is the Resistance R of the ground as per well-known Ohm"s Law between M and N. It may be expressed as.

R = V/I - Ohm's Law

The current flow direction and equi-potential line configuration are shown in ***Figure 10*** & ***Plate 11*** below.

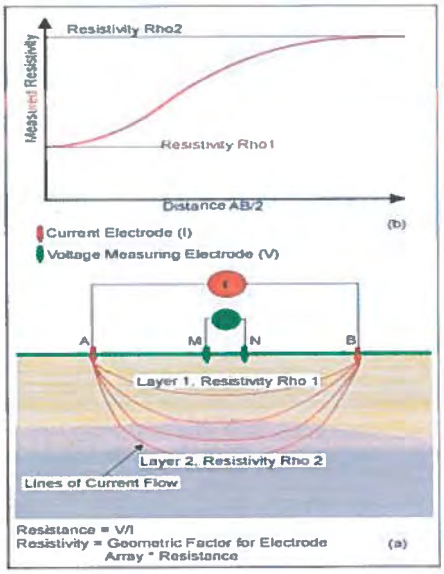


FIGURE 9: SCHLUMBERGER ELECTRODE CONFIGURATION USED IN THE SURVEY

PLATE 4: ELECTRICAL RESISTIVITY SURVEY (SCHLUMBERGER METHOD) WAS CONDUCTED ASH POND AREA

The measured resistance value, R, is ultimately converted to Electrical Resistivity value ρ, by multiplying it with a factor, known as Electrode Spacing Factor 'K'.

$$\rho = K * R$$

Spacing factor K depends upon the relative spacing between current and potential electrode pairs and also upon the electrode arrangements. The reason of converting the resistance to resistivity value is that the resistivity, unlike resistance, is not dependent upon the physical dimension of the medium through which the electric current passes. The resistivity value is related to physical properties of the medium. The relative variation in resistivity value may indicate if the formation is compact, fractured or loose, and many other related physical properties. As the current electrode separation is increased, current lines focuses at deeper level of the sub surface and information of potential difference measured is related to deeper sub surface depth. The variation in resistivity value with increasing current electrode separation is plotted in a log-log graph and is called Vertical Electric Depth Sounding curves. Generally fresh water bearing formation shows higher electrical resistivity value and clayey sediments, a poor ground water bearing zone, indicates low resistivity value. Similarly, if quality of ground water is poor, it is manifested in Vertical Electric sounding curves (VES Curves) with low electrical resistive layer.

With this idea, differentiation can be made about presence of good/poor water bearing zones at different depths in the subsurface.

4.2.2. DEPTH OF INVESTIGATION

The maximum depth of 100m was measured below the ground surface during in this study. As explained above, the separation of current electrode pair decides the sub surface depth to which geo-electric response can be recorded. Under favorable condition, the depth of investigation varies 1/3rd to half of the current electrode spacing. In the present study, the depth of interest was deeper (more than 50 m bgl), current electrode spacing was tried to be kept around 180 m so that response from depth of about 50 m can be recorded clearly.

4.2.3. EQUIPMENT

Resistivity equipment, used for measurement here was SSR-MP-ATS (Make: Integrated Geo Instrument and Services Pvt. Ltd., Hyderabad). It is a dry battery driven unit having power generation up to 2 kVA with matching current controlled system, highly suitable for deeper depth probe in the sub surface the receiver is a highly sensitive unit to record resistance range of 10^{-5} to 10^{4} Ohm with inbuilt stacking facility for achieving better signal to noise ratio.

4.2.4. DATA ANALYSIS AND INTERPRETATION

The fourteen numbers of Schlumberger depth sounding measurements were carried out with maximum current electrode spacing in the study area and reflect the change in lithology, configuration are presented as depicted in ***Table 3,*** and survey location points were plotted in the index map as shown in the ***Figure 11.*** The data have been analyzed to prepare aquifer formation using different software's.

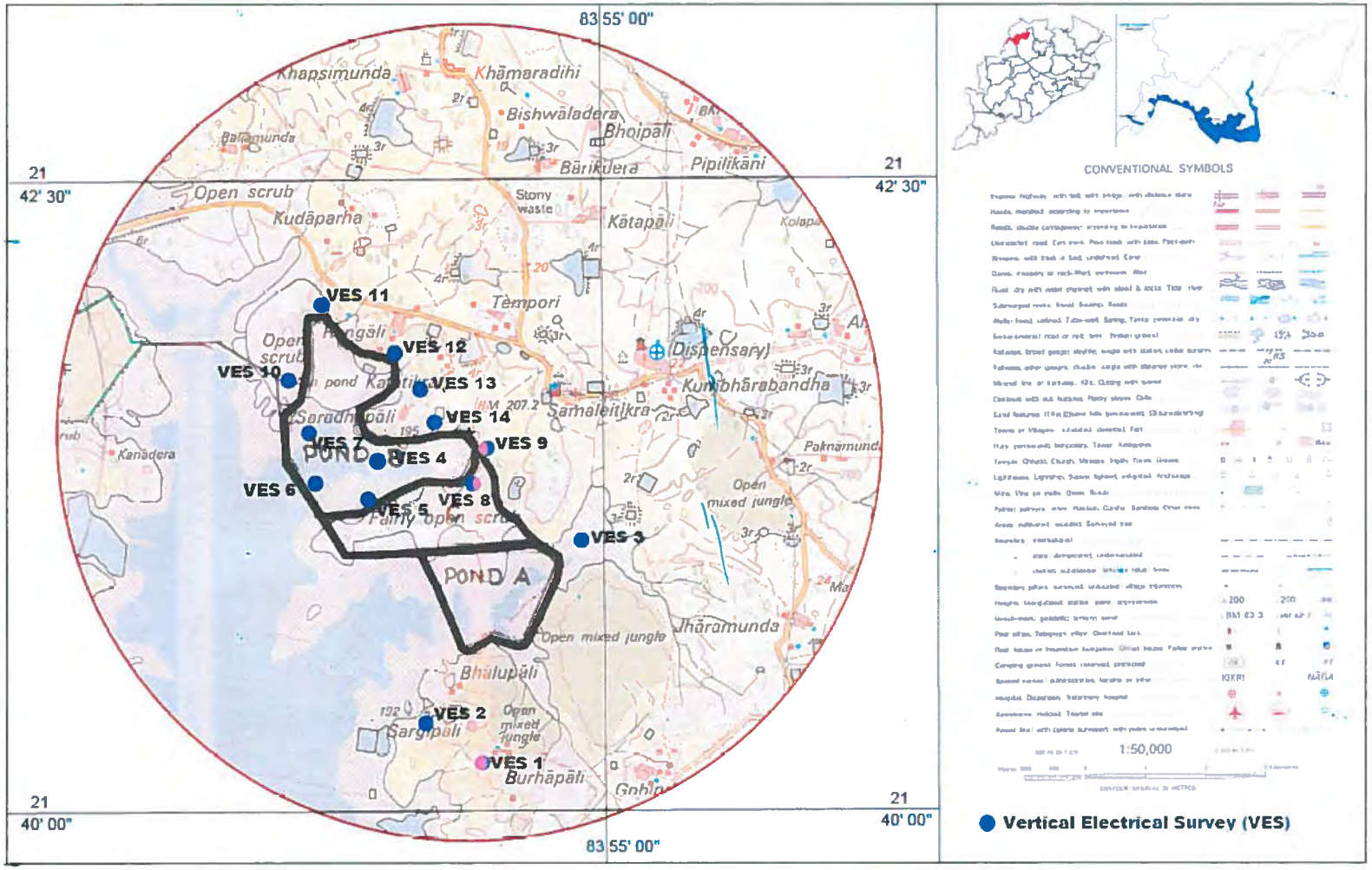


FIGURE 10: LOCATION MAP SHOWING THE GEOPHYSICAL SURVEY POINTS AROUND ASH POND AREA

The field VES curves are converted to geo-electric parameters, which are true resistivity and used for defining the thickness of individual sub surface layers. The true resistivity value of the layer is ultimately converted to lithology of the layer including the expected ground water quality. This is based mainly on field experience, available electric and litholog from the existing wells in the survey area and knowledge on the limitations associated with electrical resistivity survey.

Field data analysis and interpretation have been done at 14 points around Ash pond area and nearby village. The various model prepared to reflect the change in lithology, configuration are presented in ***Figure 12 & 13.***

The first layer is the topsoil is composed of laterite and mixed with loose sediment formation. This layer has resistivity values range from 11 Ωm to 3278 Ωm and a thickness between 0.1m and 3 m depth. It is generally unreliable for groundwater accumulation in all the VES stations.

The second layer is the Feldspathic and mixed medium sandstone and it comprises of wet, moist, dry and thin bedded. The resistivity ranges from 5 Ωm to 9873 Ωm and the thickness various from 1 m and 22 m bgl, having poor hydrogeological characteristics.

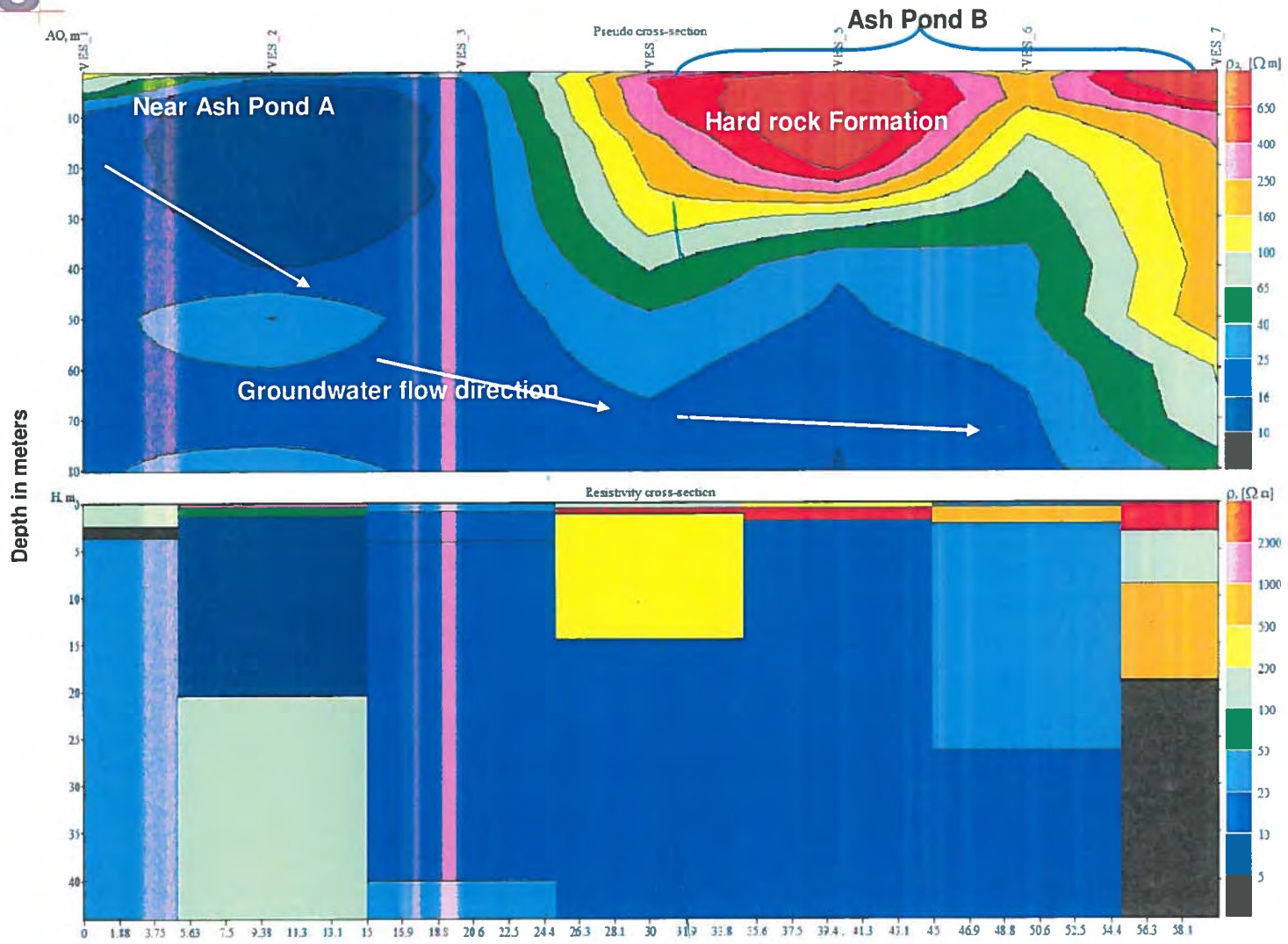
The third layer is partially weathered layer and has resistivity of 7 Ωm and 445 Ωm and a thickness of 6m and 37m, these layers are found in most of the survey stations at ash pond near villages. The VES station fall into silty sand with sand clay formation. This layer is partially convenient for ground water accumulation and hence the aquifer can yield water in sufficient quantity and economical use.

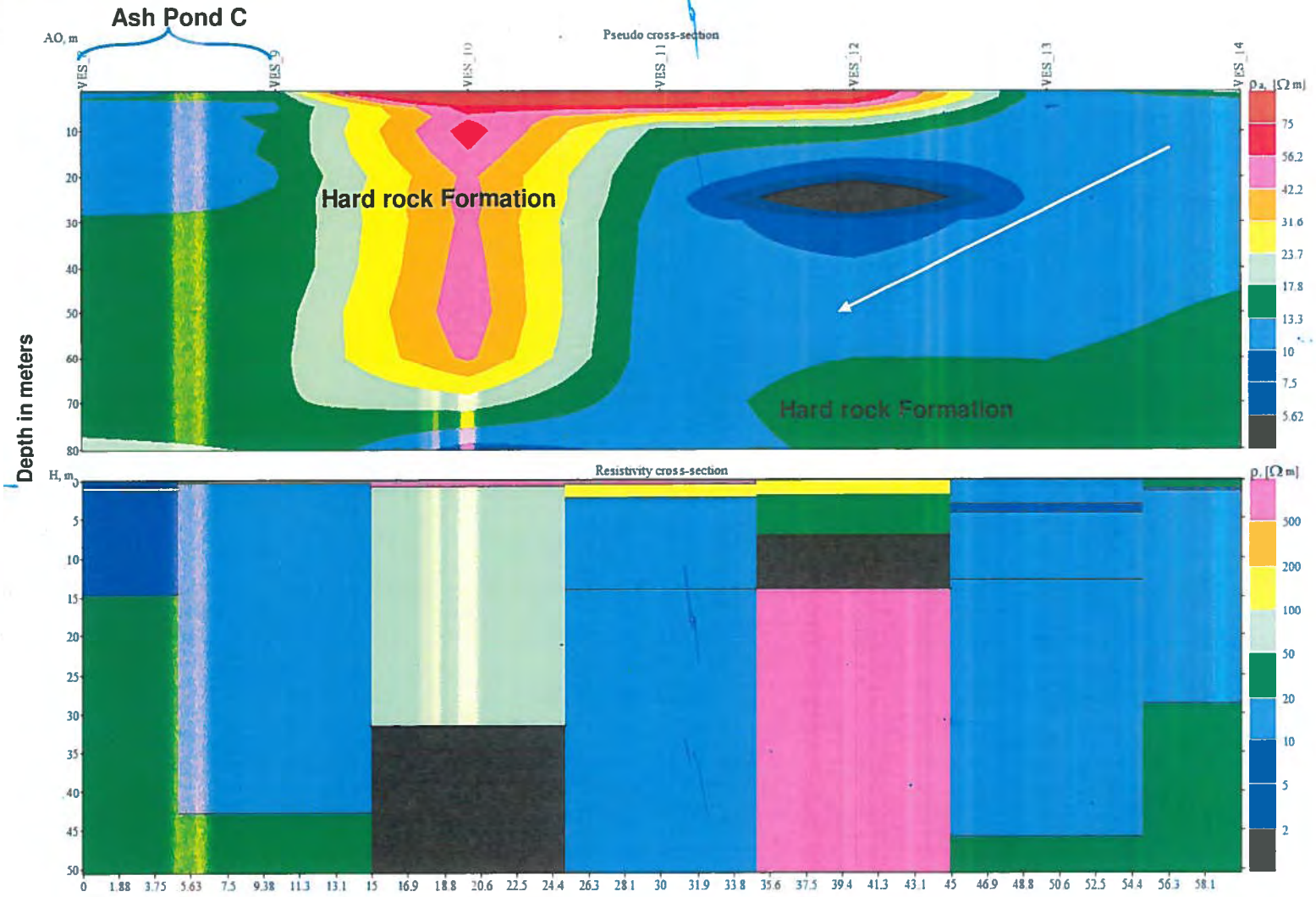
The fourth layer is the weathered layer and the resistivity value ranges from 6 Ωm to 178 Ωm and the thickness various from 6 m and 33m. This layer enhances the accumulation for efficient groundwater potential. It is very favorable and productive in river source of groundwater formation. The weathered/fracture zone gives rise for the convenient flow of water from the aquifer to the earth surface.

TABLE 3: GEOPHYSICAL SURVEY INTERPRETATIONS

VES No	Location	No	Resistivity (ohm-m)	Depth (m)	Thickness (m)	From (m)	To (m)	Tentative Lithology
VES 1	Budapalli N: 21.67014 E: 83.90725 Ele: 219 m	1	175	1	1	0	1	Laterite with mixed sediments
		2	106	3	2	1	3	Feldspathic sandstone
		3	18	25	23	3	25	Silty sand with sandy clay carrying quality of groundwater
		4	28	Inderminate		Below 25		Fine to medium sandstone
VES 2	Bhalupalli N: 21.67264 E: 83.90373 Ele: 204 m	1	1555	0.3	0.3	0	0.3	Laterite with mixed sediments
		2	58	1	1	0	1	Feldspathic sandstone
		3	9	20	19	1	20	Silty sand with sand clay carrying quality of groundwater
		4	178	Inderminate		Below 20		Feldspathic sandstone
VES 3	Behind ASH Pond A near Bhalupalli N: 21.68397 E: 83.91389 Ele: 199 m	1	42	1	1	0	1	Mixed loose sediments
		2	18	4	3	1	3	Alluvium with slity sand mixed with gravel
		3	17	40	36	3	36	silty sand with sandy clay carrying quality of groundwater
		4	32	Inderminate		Below 36		Fine to medium sandstone
VES 4	Inside Ash Pond B N: 21.68974 E: 83.90062 Ele: 214 m	1	100	1	1	0	1	Mixed loose sediments
		2	9873	1	0	1	2	sandstone laterite soil
		3	106	24	23	2	24	Fine to medium sandstone
		4	10	Inderminate		Below 24		Silty sand with sand clay carrying quality of groundwater
VES 5	Inside Ash Pond B N: 21.68699 E: 83.90008 Ele: 207 m	1	325	1	1	0	1	Mixed loose sediments with sandy clay
		2	5092	3	3	1	3	Feldspathic mixed medium sandstone
		3	16	40	37	3	40	Silty sand with sand clay carrying quality of groundwater
		4	12	Inderminate		Below 40		Silty sand with sand clay carrying quality of groundwater
VES 6	Inside Ash Pond B N: 21.68808 E: 83.89616 Ele: 216 m	1	47	0.5	0.5		0.5	Mixed loose sediments with sandy clay
		2	539	2.2	1.7		2.2	Feldspathic mixed medium sandstone
		3	48	26.3	24.1		26	Silty sand with sand clay carrying quality of groundwater
		4	13	Inderminate		Below 26		Silty sand with sand clay carrying quality of groundwater
VES 7	Inside Ash Pond B N: 21.69113 E: 83.89622 Ele: 215 m	1	3278	1	1	0	1	Mixed loose sediments with sandy clay
		2	753	7	6	1	7	Feldspathic mixed medium sandstone
		3	445	27	20	7	27	Feldspathic mixed medium sandstone
		4	6	Inderminate		Below 27		Silty sand with sand clay carrying quality of groundwater

VES No	Location	No	Resistivity (ohm-m)	Depth (m)	Thickness (m)	From (m)	To (m)	Tentative Lithology
VES 8	Ash Pond C (In between pond A & B) N: 21.68495 E: 83.90810 Ele: 199 m	1	11	0.12	0.12	0	0.12	Surface loose sediments
		2	12	3	3	0.12	3	Clayey sand
		3	10	24	21	3	24	Silty sand mixed with gravel carrying quality of groundwater
		4	30	Inderminate		Below 24		Cross-beded sandstone
VES 9	Saradapali (near Ash Pond C & B) N: 21.68833 E: 83.90730 Ele: 197 m	1	63	0.3	0.4	0	0.4	Surface loose sediments
		2	13	2	2	0.4	2	Clayey sand
		3	13	36	34	2	36	Silty sand mixed with gravel carrying quality of groundwater
		4	30	Inderminate		Below 36		Cross- beded sandstone
VES 10	Ash Pond B near Entrance gate N: 21.69447 E: 83.89431 Ele: 205 m	1	2559	1	1	0	1	Laterite with mixed sediments
		2	59	23	22	1	23	Feldspathic sandstone
		3	33	29	6	23	29	Silty sand mixed with gravel carrying quality of groundwater
		4	8	Inderminate		Below 29		Silty sand with sand clay carrying quality of groundwater
VES 11	Kishanpoda village (Ash pond B behind near main road) N: 21.70032 E: 83.89678 Ele: 210 m	1	163	3	3	0	3	Surface loose sediments mixed with gravel
		2	15	16	13	3	16	Silty sand mixed with gravel carrying quality of groundwater
		3	7	22	6	16	22	Silty sand with sand clay carrying quality of groundwater
		4	11	Inderminate		Below 22		Silty sand mixed with gravel carrying quality of groundwater
VES 12	Rengali village (behind Ash pond B) N: 21.69642 E: 83.90147 Ele: 203 m	1	96	3	3	0	3	Surface loose sediments
		2	6	23	21	3	23	Silty sand with sand clay carrying quality of groundwater
		3	49	Inderminate		Below 23		Cross-beded sandstone
VES 13	Saradapali (behind Ash pond B) N: 21.69454 E: 83.90379 Ele: 204 m	1	11	3	3	0	3	Surface loose sediments
		2	5	4	1	3	4	Clayey sand
		3	13	13	8	4	13	Silty sand mixed with gravel carrying quality of groundwater
		4	11	46	33	13	46	Silty sand with sand clay carrying quality of groundwater
		5	30	Inderminate		Below 46		Cross-beded sandstone
VES 14	Saradapali (behind Ash pond B) N: 21.69247 E: 83.90457 Ele: 198 m	1	30	1	1	0	1	Surface loose sediments
		2	5	1	0	1	1.4	Clayey sand
		3	12	29	27	1.4	29	Silty sand mixed with gravel carrying quality of groundwater
		4	20	Inderminate		Below 29		Cross-beded sandstone


Ash Pond B
Pseudo cross-section
Near Ash Pond A
Hard rock Formation
Groundwater flow direction
Depth in meters
Resistivity cross-section


Ash Pond C
Pseudo cross-section
AO, m
VES_8
VES_9
VES_10
VES_11
VES_12
VES_13
VES_14
Depth in meters
Hard rock Formation
Hard rock Formation
ρa, [Ω m]
75
56.2
42.2
31.6
23.7
17.8
13.3
10
7.5
5.62
Resistivity cross-section
H, m
ρ, [Ω m]
500
200
100
50
20
10
5
2
0 1.88 3.75 5.63 7.5 9.38 11.3 13.1 15 16.9 18.8 20.6 22.5 24.4 26.3 28.1 30 31.9 33.8 35.6 37.5 39.4 41.3 43.1 45 46.9 48.8 50.6 52.5 54.4 56.3 58.1

4.2.5. THE SUBSURFACE HYDROGEOLOGY AND LITHOLOGY OF ASH POND AREA

Hydro geologically, the ash pond area's main shallow aquifers include recent alluvial deposits a large potential shallow aquifer corresponds with the alluvial deposits of the IB River and Hirakud reservoir near Ash Pond. Shallow potential bedrock aquifers underlie most of the location near ash pond. Shallow sand and gravel aquifers were observed at surface during field investigations of (Vertical electrical sounding conducted).

Based on geophysical surveys provide the valuable information to understand the sub surface features related to the presence of aquifer.

Description of lithological Variation of Ash pond A, B and C and surrounding villages

The VES interpretation reveals four geo-electric layers across the Ash Pond area: the topsoil consisting of Laterite and mixed sand; the weathered layer which is made up of sandy soil and the bedrock constituting the fractured or fresh basement. The geo-electric sections show subsurface variation in electrical resistivity along the profiles and attempt to correlate the geo-electric sequence across the profiles.

The resistivity values in the order ***VES 1, 2, 3 and 10*** has showing lithological variation of the ash pond A, and surrounding villages (Budapalli and Bhalupalli)

Layers	***Depth in (m)***	***Descriptions***
Top Layers (VES 1, 2, and 3)	0 to 1	laterite and mixed with sediments
Middle Layer	1 to 3	Feldspathic sandstone and mixed with medium to coarse sand
Bottom layers	3 to 35	Silty sand with sandy clay (carrying quality of groundwater)
Below bottom layers	Inderminate - 35	Bottom layer was observed depth of inderminate lithology of sandstone (bedrock) formation.

The resistivity values in the order ***VES 4, 5, 6, and 7*** has showing lithological variation of the ash pond B,

Layers	***Depth in (m)***	***Descriptions***
Top Layers	0 to 1	Mixed loose sediments with sandy clay
Middle Layer	1 to 3	Feldspathic sandstone and mixed with medium to coarse sand
Bottom layers	3 to 40	Silty sand with sandy clay and Gravel (carrying quality of groundwater)
Below bottom layers	Inderminate - 40	Silty sand with sandy clay and Gravel (carrying quality of groundwater)

The resistivity values in the order ***VES 8, 9, 12, 13 and 14*** has showing lithological variation of the ash pond A and B in between C, and surrounding villages (Saradapalli, Rengali). Ash pond C (Under construction) area have alluvial formation likely silty sand mixed with clay and gravel

Layers	***Depth in (m)***	***Descriptions***
Top Layers (VES 1, 2, and 3)	0 to 20	Completed in surficial deposits of mostly sand or gravel, or both, and it's completed in silty clay.
Middle Layer	20 to 25	Silty sand with sandy clay and Gravel (carrying quality of groundwater)
Below bottom layers	25 to 45	Bottom layer was observed depth of inderminate lithology of (Crossbeded sandstone) basement rock.

The weathered formation of consolidated rocks form the source of ground water reservoir at shallow depth and for deeper aquifer are of weathered, fractured zone of cross bedded sandstone and this acts as good ground water reservoir in and around the ash pond area.

4.3. WATER AND SOIL PARAMETERS ANALYSIS

4.3.1. WATER

The water samples at ash pond area, stream water (surface water flow adjacent to ash pond A, B and C towards east) and groundwater towards west and north of ash pond were collected by SGS as shown in the (***Figure 14 & Plate 5).*** The Groundwater, Surface water and surface soil Samples were collected from in and around Ash Pond area at IB Thermal Power Station, Jharsuguda, Odisha for analysis of various heavy metal parameters. The different sampling locations are described below in ***Table 4 and 5.*** Water samples were collected and analysed by following the standard procedures prescribed by APHA 2012 methods. Water analysis was conducted at SGS India Pvt Ltd Gurgaon laboratory.

TABLE 4: GROUNDWATER SAMPLE COLLECTION DETAILS OF NEAR ASH POND AREA

Groundwater sample locations			
Location	**Latitude**	**Longitude**	**Well type**
Bhalupali	21°40'20.30"N	83°54'26.77"E	Hand pump
Rengali	21°41'58.22"N	83°54'9.33"E	Hand pump
Kantatikra	21°41'41.76"N	83°54'18.81"E	Hand pump

TABLE 5: SURFACE WATER AND SOIL SAMPLE COLLECTION DETAILS OF NEAR ASH POND AREA

Soil and surface water Location			
Location	**Latitude**	**Longitude**	**Well type**
Bhalupali Behind Ash Pond A	21°40'36.86"N	83°54'23.94"E	Reservoir water
Ash Pond C	21°41'2.10"N	83°54'6.87"E	Stream water
Ash pond B, near entrance gate	21°41'34.30"N	83°53'36.02"E	Reservoir water

PLATE 5: SURFACE WATER SAMPLE COLLECTION OF ASH POND LEACHEATE AREA

The present study is to evaluate any presence of contamination (heavy metals) or effect of ash pond on the surface and ground water in the region. In this study some of the water samples were collected and analysed to confirm any presence of contamination. Details of the concentration of heavy metals in the groundwater samples near the ash ponds and at the surrounding villages are given in ***Table 6.***

The pH of the water samples ranged from 7.28 to 8.30, indicating slight alkaline during the pre monsoon 2014. The elements concentration analysed in the tube well waters were Copper (Cu), Arsenic (As) and Manganese (Mn) followed by Fluoride (F) and Cadmium (Cd).

Fluoride in the groundwater and surface water of the ash pond area reported insignificant, i.e., from 0.2 to 0.9 mg/l in the ash pond A and surrounding village.

The Manganese contents various from 0.05 to 0.1 mg/L in ground water and from 0.06 to 0.08 mg/Lin surface water samples.

A comparison of data is also made between the concentrations of the trace elements in the waters of the tube wells near the ash pond and those of the tube wells in the villages shown in ***Table 6.*** The concentration of other metals conforms to the normal and nearly similar in the water samples in all locations. Heavy metals of ground water samples and surface water samples in and around Ash Pond area at IB Thermal Power Station Jharsuguda, Odisha conform to the stipulated standards for drinking water quality (IS: 10500).

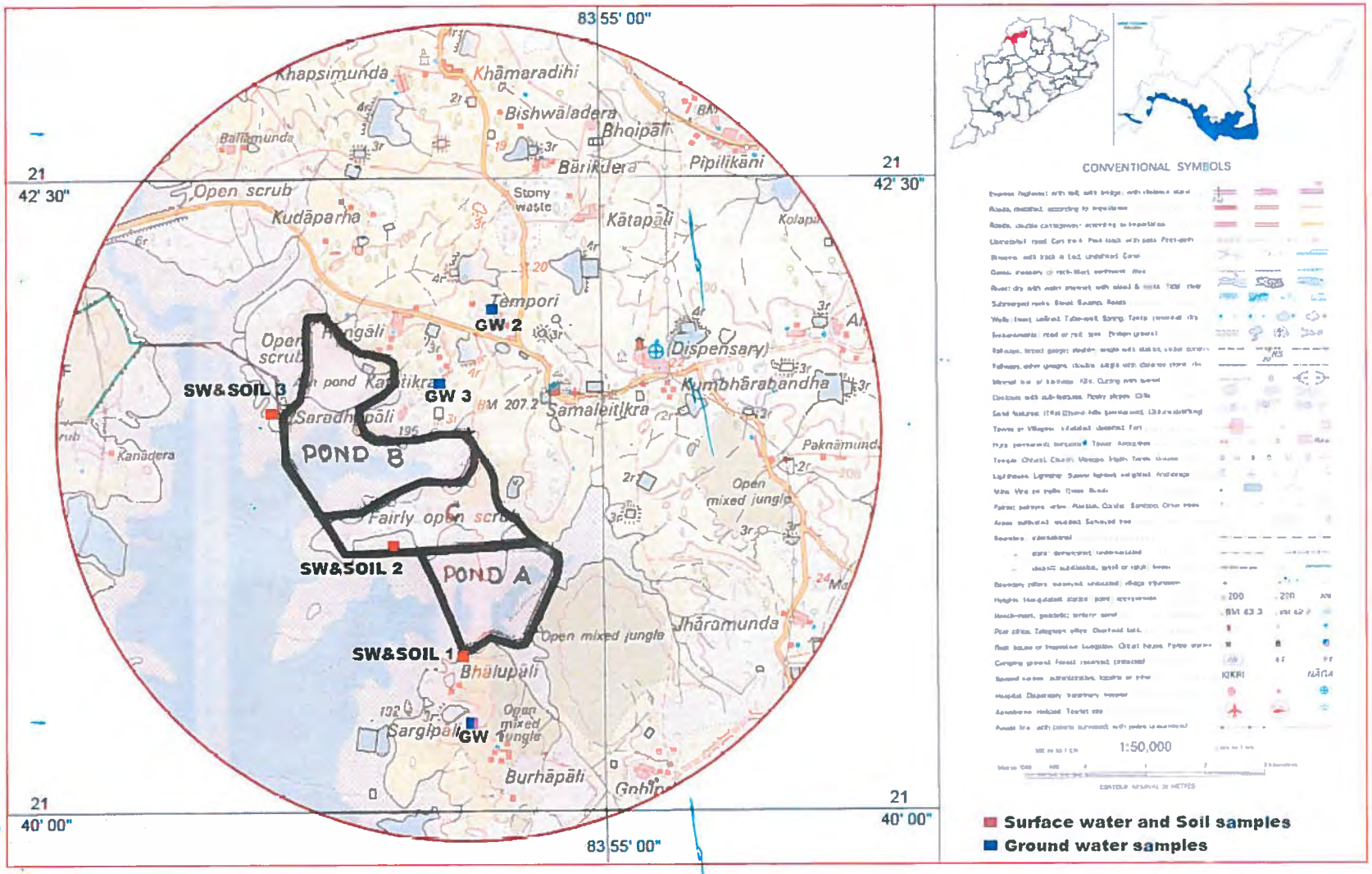


FIGURE 13: LOCATION MAP SHOWING THE GROUNDWATER, SURFACE WATER AND SURFACE SOIL SAMPLES AROUND ASH POND AREA

TABLE 6: HEAVY METALS OF DIFFERENT WATER SAMPLES

Pre monsoon 2013						
Parameters *(mg/L except pH)*	Surface water		Groundwater		IS 10500 Standard Limits for drinking water	
	Reservoir water ash Pond	Pond water near Ash pond A	Tube well Rangali village	Dug well Rangali village	Desirable Limit	Permissible Limit
Copper (Cu)	<0.01	<0.01	<0.01	0.02	0.05	1.5
Cadmium (as Cd)	<0.01	<0.01	<0.01	<0.01	0.01	NR
Lead (as Pb)	<0.01	<0.01	<0.01	<0.01	0.05	NR
Arsenic (as As)	<0.01	<0.01	<0.01	<0.01	0.05	NR
Mercury (as Hg)	<0.005	<0.005	<0.005	<0.005	0.001	NR
Manganese (as Mn)	0.04	<0.01	0.01	0.05	0.1	0.3
Fluoride (as F)	0.64	0.92	0.19	<0.10	1	1.5
pH	8.92	8.65	7.28	6.54	6.5-8.5	6.5-8.5

Pre monsoon 2014					
Parameters *(mg/L except pH)*	Groundwater			IS 10500 Standard Limits for drinking water	
	Bhalupali Village	Rengali Village	Kantatikra Village	Desirable Limit	Permissible Limit
Copper (Cu)	0.04	<0.01	<0.01	0.05	1.5
Arsenic (as As)	<0.01	<0.01	<0.01	0.05	NR
Mercury (as Hg)	<0.005	<0.005	<0.005	0.001	NR
Cadmium (as Cd)	<0.01	<0.01	<0.01	0.01	NR
Manganese (as Mn)	0.05	0.06	0.15	0.1	0.3
Fluoride (as F)	0.08	<0.10	<0.10	1	1.5
Lead (as Pb)	0.01	0.01	<0.01	0.05	NR
Hexavalent Chromium (as Cr+6)	<0.05	<0.05	<0.05	0.05	NR
Trivalent Chromium (Cr+3)	<0.05	<0.05	<0.05	0.05	NR
pH	7.1	7.2	6.9	6.5-8.5	6.5-8.5

Pre monsoon 2014					
Parameters *(mg/L except pH)*	Surface water			IS 10500 Standard Limits for drinking water	
	Reservoir water near ash pond A Bhalupali	Ash Pond C	Reservoir water near ash pond B entrance gate	Desirable Limit	Permissible Limit
Copper (Cu)	<0.01	<0.01	<0.01	0.05	1.5
Arsenic (as As)	<0.01	<0.01	<0.01	0.05	NR
Mercury (as Hg)	<0.005	<0.005	<0.005	0.001	NR
Cadmium (as Cd)	<0.01	<0.01	<0.01	0.01	NR
Manganese (as Mn)	<0.05	0.06	0.08	0.1	0.3
Fluoride (as F)	0.71	0.35	<0.10	1	1.5
Lead (as Pb)	<0.01	<0.01	<0.01	0.05	NR
Hexavalent Chromium (as Cr+6)	<0.05	<0.05	<0.05	0.05	NR
Trivalent Chromium (Cr+3)	<0.05	<0.05	<0.05	0.05	NR
pH	8.1	8.3	7.9	6.5-8.5	6.5-8.5

4.3.2. LEACHATE TEST (SOIL) FOR HEAVY METALS OF ASH POND AREA

Normally it is found that a substantial amount of ground water pollution/contamination is caused by heavy metals leaching from the effluents running through ash pond. The fate and transport of heavy metals in leachates depend upon their variable complexing abilities, the relative concentrations of other constituents and upon the environmental conditions particularly the acidic value. The generation of leachate is a result of percolation of precipitation through open landfill or through cap of the completed site. Leachates contain many contaminants that may have a deleterious effect on ground water. It may bring ecological and health associated risks if poorly managed like contaminating the groundwater. The rate and extent to which such metals will be attenuated by leaching through the soil would be affected by the extent to which soluble complexes are formed between the metals and other components of the leachates.

The total concentration of the element can be used to assess its environmental impact only if it is present in the environment as a single species. However, it is quite difficult to identify individual species and quantify them in the environment. Several heavy metals that may be present in landfill leachates are considered as priority pollutants for ground water resources like Cd. The composition of landfill leachates is dependent on many factors such as the origin, waste composition, climate condition, site hydrology, bacterial activities and duration of generation of wastes. In aquatic environment, the metals will exist as free metal ions, inorganic complexes, organic complexes and associated with colloids. The solubility and mobility of heavy metals are often controlled by complexation with dissolved organic matter. The behavior of metal in polluted ground water due to long term leakage of landfill leachates into the ground water is highly influenced by several factors such as dilution and adsorption on the soil.[4]

The study is to determine the speciation of some selected heavy metals (As, Cd, Mn and Cr) in the ash pond leachate from a Ash pond A and B at IB thermal power station, Jharsuguda, Odisha, with a view to ascertain their impact on the ground waters.

The above mentioned metals have been selected for the study because these metals are of common environmental concern vis-a vis. their ecotoxicology and health hazards to the human beings as well as to aquatic biota. Their speciation is also similar, that is, different

[4] Balaram Pani (2013) Effect of Seasonal Variation on Metal Speciation in Leachate from a Thermal Power Plant Ash Pond: Impact on Ground Waters

chemical forms of these heavy metals are very closely correlated to each other and these metals are more likely to affect the water quality parameter depending on the nature of their chemical forms, distributing patterns order of the stabilities of their complexes and so on. For characterization of heavy metals of the leachate, the samples were collected from the following sites.

Details of the concentration of heavy metals in the Surface soil samples near the ash ponds and at the surrounding villages are given in ***Table 7.***

TABLE 7: HEAVY METALS ANALYSIS OF SURFACE SOIL SAMPLES

Surface soil			
Parameters (mg/kg)	**Bhalupali**	**Ash Pond C**	**Ash pond B entrance gate**
Copper (Cu)	<0.01	<0.01	<0.01
Arsenic (as As)	<0.01	<0.01	<0.01
Cadmium (as Cd)	<0.01	<0.01	<0.01
Manganese (as Mn)	2.9	5.42	<0.01
Lead (as Pb)	<0.01	<0.01	<0.01
Hexavalent Chromium (as Cr+6)	<0.01	<0.01	<0.01
Trivalent Chromium (Cr+3)	<0.01	<0.01	<0.01

From the analysis results, it is found that the concentration of the heavy metals is below <0.01 except for Manganese where the maximum concentration is 5.42mg/kg. There are no specific standards available for soil in India to compare. Overall soil quality of the area does not vary much within the Ash pond and near village area.

5. CONCLUSION

The study undertaken by SGS with the help of Geophysical technique's in delineating the subsurface geological and hydrogeological features, including groundwater level, ground water characteristics and leaching behavior of contamination from the Ash pond A and B at IB thermal power station, Jharsuguda, Odisha.

- An integrated approach has been adopted in this study by utilizing various tools like hydrogeology, geophysics and groundwater chemistry. Geophysical studies were carried out to decipher the aquifer geometry and possible signatures of ash pond on lithology and groundwater regime.

- Water level data along with limited field visit and geophysical surveys are adopted to study the area.
- Based on the available information and the geophysical investigations it is concluded that Ash pond A, B & C is located in an area where shallow aquifers including recent alluvial deposits a large potential shallow aquifer corresponds with the alluvial deposits of the IB River and Hirakud reservoir near Ash Pond. Shallow potential bedrock aquifers underlie most of the location near ash pond. Shallow sand and gravel aquifers were observed which is considered to have medium to good groundwater potential.
- The shallow aquifer weathered underlying formations at around expected below 2-4 m bgl and indicate huge water sources to the Ash pond area. It is covering HDPE liner at the bottom and sides at the new construction of Ash pond C to avoid seepage of ash pond water into neighboring lands or back water.
- Ground water level measurement, the ground water level range between 9 to 20m and the shallow water table conditions occurred in this area. The groundwater flow direction is towards southeast to northwest following the general sloping pattern.
- On the basis of the study of the leaching of heavy metals from ash pond, the following conclusions can be drawn: The concentrations of all the heavy metals under study in the leachate were invariably well below the permissible limits for discharge of effluents as per the Indian standards 10500 and WHO limits for drinking water quality. However, the result obtained for the hand pumps near ash pond area depicts non-detectable contamination level. The good condition of these sampled wells observations reveals that good quality drinking water can still be obtained in the surrounding village area. Also it is suggested that the assessment of the ash pond area and analysis of water samples from hand pumps in the surrounding village's area should be carried out periodically. This will encourage constant assurance of good water availability.
- This also reveals insignificant leaching of heavy metals from ash pond to the ground water, most probably due to low leaching behavior of Pond Ash and alkaline condition of Ash water (>6).

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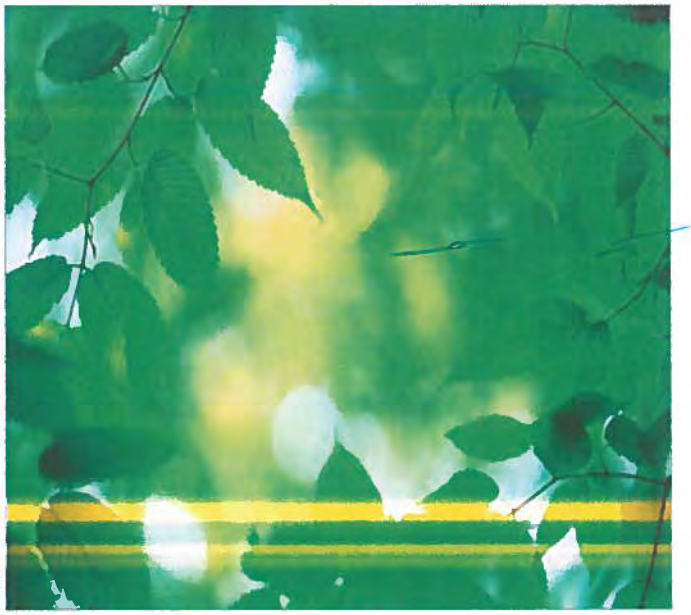

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