Agenda
Indo-US Working Group on Coal
Lignite Deposits in India - NLC

AGENDA POINTS

- **Dump Slope Stability Studies**
- **Seepage Water Control in Overburden Benches**
- **Automation of Mine Working systems with Conventional Mining Equipments**
- **Study on usage of Long Boom Draglines**
- **Clean Coal Technologies (CBM & UCG)**
- **TA for Mine-III for finding Alternate Mining Tech. for Mine-III Project**

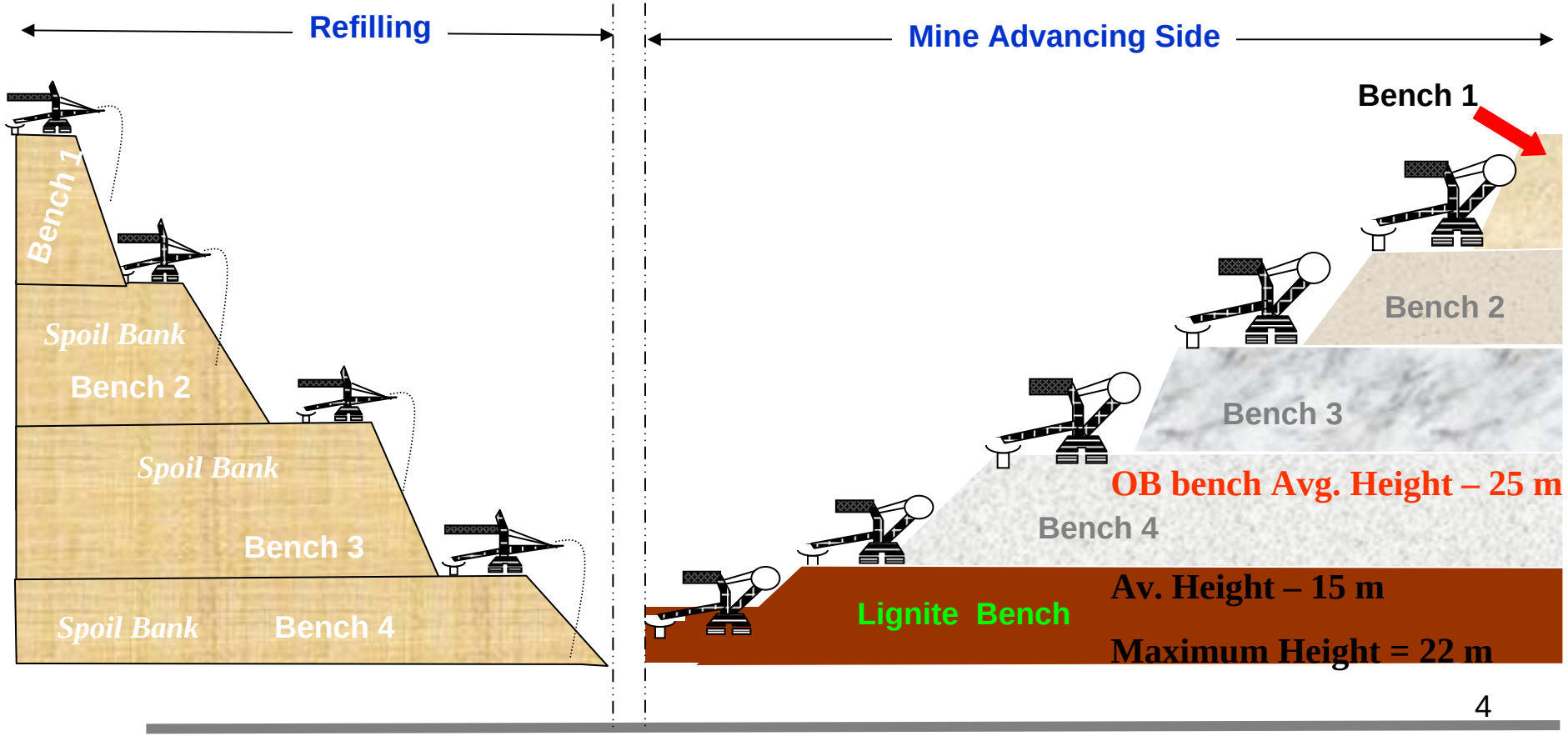
GEOLOGY AND GEO- HYDROLOGY OF NLC MINES

- The main Overburden formations consists of argillaceous and Ferruginous sandstone and clays with aquifer sands .
- The sandstones constitute a major portion of the overburden and they are fine to coarse grained.
- The annual rainfall varies between 860 mm and 2070 mm with an average of 1200 mm.
- A huge reservoir of ground water exists below the entire lignite bed, exerting an upward pressure of 6 to 8 kg/cm^2, which is tackled by an effective ground water management system.
- The pressure of the artesian aquifer is being controlled by pumping (around 28,000 gallons per minute).
- Drawdown requirement depends upon the disposition of the bottom of lignite.

METHOD OF MINING

Opencast continuous mining system using

- Bucket Wheel Excavators
- Spreaders
- Conveyor Systems



SALIENT FEATURES OF MINE WORKING

- **Overburden thickness : 72 to 110 m,**
- **Lignite thickness : 10 to 23 m.**
- **Number of Excavation Benches : 5**
- **Height of Excavation Bench : 20 – 25 m**
- **METHOD OF WORKING : Opencast Mining utilizing Specialized Mining Equipments like Bucket Wheel Excavators, (1400 lit & 700 lit capacity) for Excavation, Belt Conveyor for transportation and Spreaders (20000 &11000T / hr) for dumping.**

ANNUAL OB DUMPING QUANTITY
(Million m^3)

DUMPING	MINE-I	MINE-IA	MINE-II
INTERNAL	24.9	22.0	33.0
EXTERNAL	22.1	NIL	18.0
TOTAL	47.0	22.0	51.0

AVERAGE GEO-TECHNICAL PROPERTIES OF THE OVERBURDEN SOIL

Geotechnical properties	Lateritic soil	Variegated sandy clay	Clay	Sandstone
Water content %	10 - 13	5 - 13	9 - 24	3 - 12
Liquid limit %	36 - 44	36 - 50	55 - 90	-
Plastic limit %	16 - 20	16 - 22	22 -32	-
Consistency index	1.0 - 1.3	1.2 - 1.6	0.9 - 1.6	-
Degree of saturation %	50 - 85	30 - 90	25 - 85	20 - 90
Average density (t/m^3)	2.0	1.9 -2.3	2.0 - 2.3	2.0 - 2.4

AVERAGE GEO-TECHNICAL PROPERTIES OF THE OVERBURDEN SOIL

Geotechnical properties	Lateritic soil	Variegated sandy clay	Clay	Sandstone
Grain size distribution				
SL & CL %	15 - 45	45 - 70	-	15 - 30
SN %	85 - 55	55 - 30	-	85 - 70
Cohesion (kg/Sq.cm)	6 - 9	2.5 - 10	2.0 - 9.0	3.0 - 1.6
Compressive strength (kg/cm2)	12 - 18	5 - 20	4 - 20	6 - 32
Angle of internal friction (degrees)	18 - 30	15 - 35	-	25 - 40
Coefficient of permeability (cm/sec)	$1.0x10^{-4}$ - 10^{-5}	10^{-5} - 10^{-7}	-	10^{-4} - 10^{-6}
Swell factor				
Dry condition	1.5	1.4 - 1.6	1.5 - 1.6	1.3 - 1.5
Wet condition	2.0	2.0 - 2.2	2.2 - 2.4	1.7 - 2.1

SL = SILT CL = CLAY SN = SAND

Dump Slope Stability Studies

Dump Failures at NLC Mines

1. In Mine-II, way back in 1985 at the southern side of T-6 conveyor area a heavy subsidence at the top of the dump occurred. Simultaneously with the subsidence activities, the southern slope as well as the adjacent ground surface were " Pushed up" gradually with small trees and plants were lifted up "en-masse" without being topped down or disturbed . The height of the upheaval was about 10m .
2. In Mine-II, during March 2005 area near S6 drive head / toe of present dump heaving was noticed.
3. During March 2006 circular cracks developed along S6 shifting side and followed subsidence the dump toe is also moved gradually.
4. Around 4 lakh m3 of dumped soil slided during October – 2002 in the dump yard of New Surface bench, Mine-I. Toe of the dump moved to a distance of around 530 m along thesloping ground.

5. The second dump slope failure had occurred at the bottom bench of Mine-I, just by the side of the inner track of Spreader-320. The Spreader 320 was working on soil dump containing ad mixture of sand, clay, carbonaceous clay with patch of local seam lignite, it was slightly wet. It happened, while dumping was being performed through spreader 320 with a combination of B6 Conveyor and tripper car, at 26m from B6 Conveyor along the direction of the conveyor.

6. Dump slide occurred during May – 2005 in the dump yard of bottom bench, Mine-IA. An area of about 70m x 80m was moved about 25m.

SLIDING OF DUMPS

SLIDING OF DUMPS

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GUIDANCE / TECHNIQUES REQUIRED

1. **Due to confined aquifer, water seepage on lignite floor is unavoidable and waste is dumped in watery floor. Hence *suitable technology and dump management* is required.**
2. ***Stabilization of dumps* considering SME technology.**
3. ***Slope monitoring techniques/ measures* for Variations in Soil Condition, Excessive Seepage due to Higher Permeability, Seismic Instability etc.**
4. **Active Mining Zone– *System of monitoring* for any *instability of dumps of total height of 60m* or more.**
5. **Other effective *methodology of managing high dumps*.**

SEEPAGE WATER CONTROL IN OVERBURDEN BENCHES

1) In the Neyveli Lignite Basin a Semi-confined aquifer is persisting apart from the sub-surface water and the confined aquifers.

2] The seepages from these water sources are steady and have a growing impact as listed below:

- Trafficability of the equipments, machineries and vehicle hampered due to the slushy formation.
- The walls of the benches become weak due to the flowing of wall soil along with the seepage.
- Reduction in the productivity of the overburden, due to limitation imposed by wet grounds on movement of machineries.

•Hampering the material flow in the conveyors.

•Instability in dumping yard owning to the slushy nature of overburden soil material.

•The problem is at its high at the parting of Overburden and Lignite.

3) The details regarding the above seepage is as follows:

a) Quantity of Seepage is 1600 GPM. An attempt is being made to drill percolation wells in overburden to control the water seepage. Totally 39 borewells of diameter ranging 24/12 inches have been equipped with 50, 100 and 200 GPM pumps. Thereby the seepage has been brought down from 1600 GPM to 400 GPM

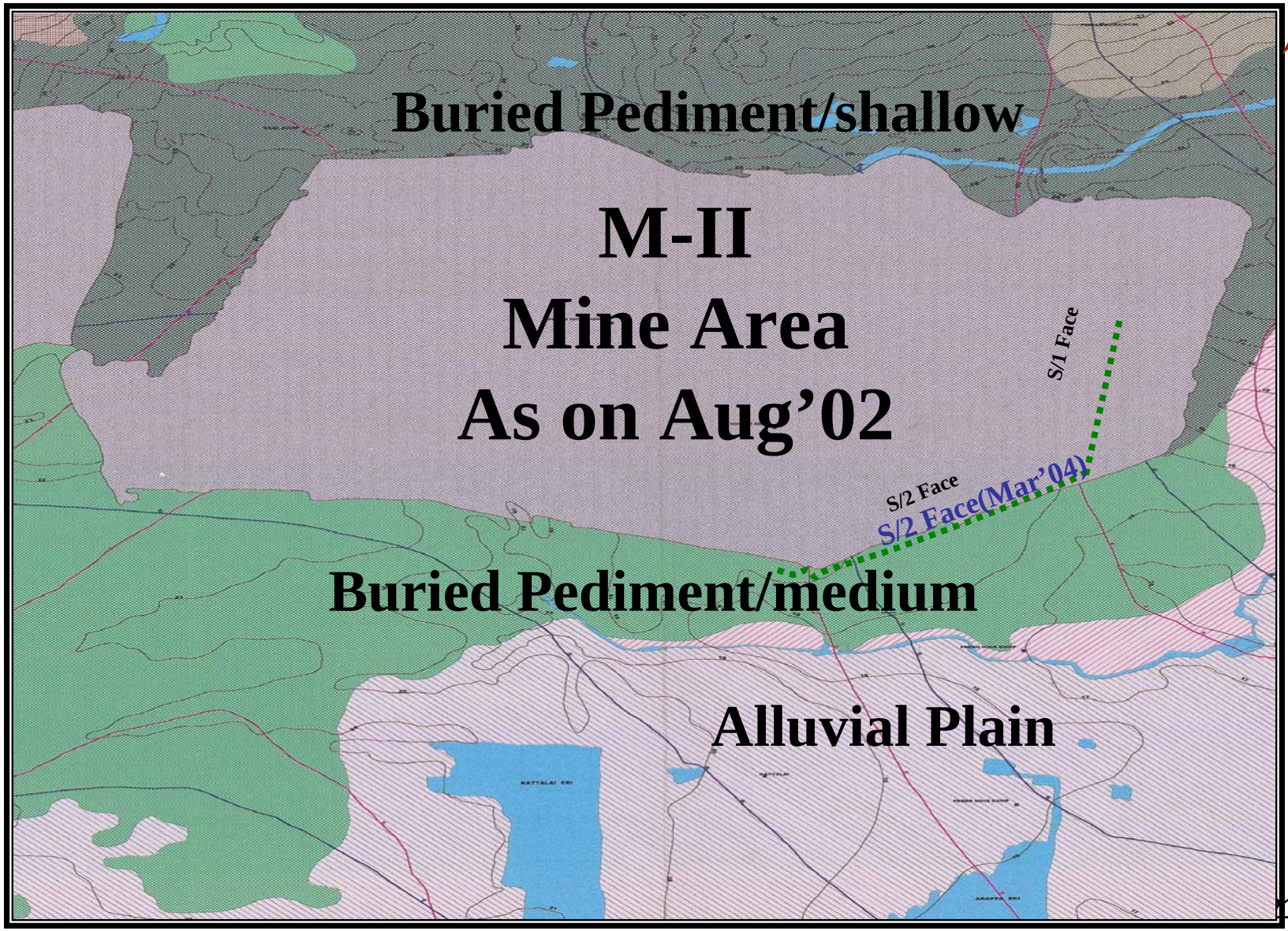
b) Proximity of Paravanar River Pediments:

Working presently in the previous Paravanar River Pediments.

4) Expertise is required for fixing of the design parameters with respect to spacing, diameter of holes etc and equipping the same for the required pumping capacity.

5) It was observed that similar situation has been prevailing in Jewett Mine of Westmoreland Coal Company in Texas State. The methodology seems workable at Neyveli also to control the seepage water in the overburden benches.

HYDROGEOMORPHOLOGY PLAN BASED ON LANDSAT IMAGERY



SCENARIO PRIOR TO SEEPAGE CONTROL IN TOP BENCH OF MINE -II

SCENARIO PRIOR TO SEEPAGE CONTROL IN TOP BENCH, MINE-II

SCENARIO PRIOR TO SEEPAGE CONTROL IN TOP BENCH

EFFECTS OF SEEPAGE IN THE DUMP YARD

Automation / improvement of Mine Working Systems with Conventional Mining Equipments

1) Operation of Excavation Equipments
2) Modernised Development in Electrical Drives of Mining Equipments - Usage of AC Drives in Mining Equipments instead of DC Drives for the following advantages as claimed:
   a) Higher Productivity
   b) Less Maintenance
   c) Higher Energy Efficiency
   d) Excellent Compatibility with the Mine Distribution Systems.

The experience of US Companies in obtaining these advantages if any with quantification is required

Study on usage of Long Boom Draglines

1) Open Aquifer (Sump) width required from lignite face is around 200 metres.

2) Economics of dragline with long boom and practical implications for deploying in cyclone/monsoon prone areas in Lignite operation.

3) Stickiness of overburden material in the dragline bucket – discharge time.

4) Quantum of handling/Annum =

4 Million m^3 to 8 Million m^3

5) Availability of such suitable Draglines in US with the details of regarding sizes, capacity and manufacturers.

Clean Coal Technologies

INTRODUCTION

- **Neyveli Lignite Corporation Limited, being a large power producing company, desires to develop various source of energy.**

- **Till now entire power generation of NLC is through Lignite mined from its mines.**

- **In order to diversify and also with a view to exploit vast deep seated and un-mineable lignite resource , NLC started its endeavour to enter into field of Underground Coal Gasification and CBM from Lignite.**

CLEAN COAL TECHNOLOGIES

To gainfully utilize the vast potential of lignite deposits which are uneconomical for conventional mining, the following Non-conventional / Clean Coal technologies are considered.

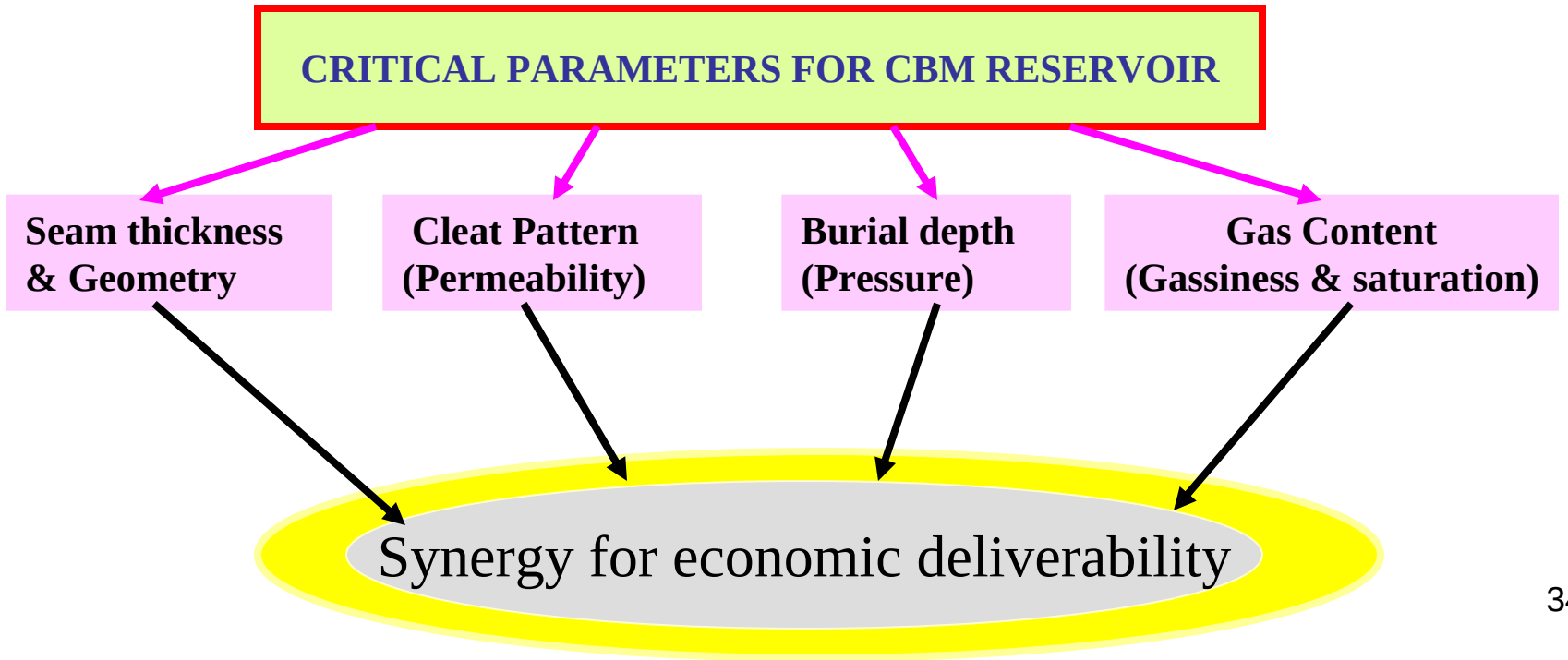
- **Coal Bed Methane (CBM)**
- **Underground Coal Gasification (UCG)**

COAL BED METHANE

(C B M)

COAL BED METHANE

- **CBM is a natural gas produced by bio-thermogenic degradation of buried plant material during the process of coal formation**
- **Methane is associated with all coals including lignite.**
- **Coal and lignite beds are both source and reservoirs.**



TYPES OF CBM RESERVOIR

1. **VCBM - Virgin Coal Bed Methane**

2. **AMM - Abandoned Mine Methane**

3. **CMM - Coal Mine Methane.**

TAMILNADU LIGNITE FIELD AS CBM RESOURCE:

Tamilnadu has the largest established resource of LIGNITE in country. These are mainly developed in three Basins:

1. BAHUR	**Bahur**	**574.39 MT**
	Kudikadu	**133.38 MT**
	West of Bahur	**58.60 MT**
	Total	**766.37 MT**
2 NEYVELI	**Kulanchawadi block**	**175.00 MT**
	Neyveli Block	**4150.00 MT**
	Jayamkondam Block	**1168.00 MT**
	Veeranam Block	**1342.45 MT**
	Total	**6835.45 MT**
3 MANNARGUDI	**Mannargudi**	**23257.59 MT**

Comparison of Lignite deposits of Tamilnadu / Mannargudi and Powder River Basin, Wyoming, USA

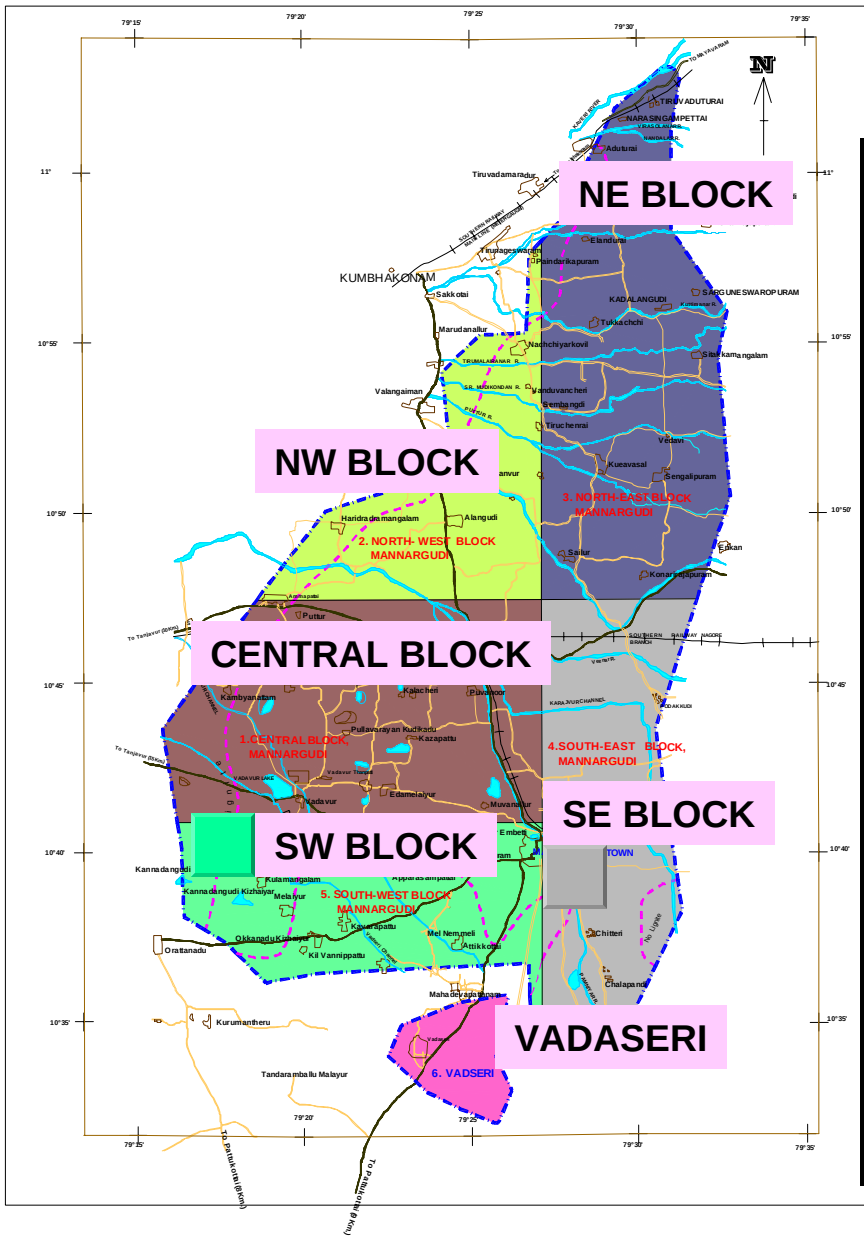
Parameters	Lignite deposits of Tamilnadu / Mannargudi	Lignite of Powder River Basin, USA
Depositional Environment	Deltaic lacustrine setting.	Deltaic lacustrine setting.
Geological Age	Mio-Pilocene	Palaeocene
Depth Range	150 –600 m	60 –200 m
Average Thickness of seams	45 m	30 m
Ash	2 - 12	Low to moderate
Reflectance	0.35 – 0.41	0.34 – 0.39
Hydro-geological conditions	Lignite seams associated with aquifer zones	Lignite itself act as aquifer between less permeable sand stones
Gas content	1 - 2 m^3 /t	1-74 Scft/t (0.03 – 2.3 m^3 /t
Permeability	NA	Very favourable 1 – 10 m/d

CBM Prospects- Mannargudi,Tamilnadu

- **With vast lignite resource at deeper depth,Mannargudi block has commercial potential for development as CBM field.**

- **At the instance of NLC the Mannargudi lignite deposit is being studied for CBM through promotional exploration programme in Thiruvarur block, adjoining to Mannargudi Block .Initial results are encouraging.**

MANNARGUDI LIGNITE FIELD



PARTICULARS		QUALITY OF LIGNITE	
Period of exploration	Since 1990	M%	40-50
Agency explored	MOC, GOI	A%	4-12
No. of Boreholes	Over 600	VM%	18-23
OB thickness Range m.(Min. & Max)	145-515	FC%	17-22
Lignite thickness Range m.(Min. & Max)	1-100	CV K.cal/kg	2200-3500
		S%	0.7-1.4

4 splits:A,B,C & D. A&B merge in central and eastern part forms Composite; Av. thick split A=6.7, B=5.4, C=6.0, D=4.0 & Composite=35.7 m.

Av.parting A&B=13.1,B&C=9.6, C&D=12.9, Composite-C=21.8 m. av.CV=2900

Geological Reserve (MT) within 300m depth	8636	
Geological Reserve (MT) within 400m depth	18933	
Total Geological Reserve (MT) and area in sq.km	22660	750

Reserve Category	Central block=PROBABALE; NW,NE,SE,SW blocks=POSSIBLE
Advantage	Huge quantity of reserves, Possible CBM associate

MANNARGUDI LIGNITE FIELD
SALIENT FEATURES

- Area - 750 Sq.kms
- Depth of occurrence - 145 to 550 m
- Lignite Thickness range - 0.50 to 100 m
- Overburden : Alluvium, unconsolidated, assorted Sandstone, Clays, sandy clay, clayey sandstone, silt and aquifer sand.
- Lignite Resource - 23000 MT
- Lignite Quality - Moisture % - 40 to 50
  Ash % - 3 to 10
  VM % - 22 to 24
  FC % - 18 to 20
  GCV(KCal/Kg.) - 2500 to 3200

GEOHYDROLOGICAL CONDITIONS

- **Groundwater in Mannargudi lignite field occurs in water table, unconfined and confined conditions.**
- **The aquifers in the area generally consists of unsorted sands which vary in grain size from fine to very coarse grained & gravelly nature at places, with alternating clay beds.**
- **The aquifer zones are occurring above and below the lignite horizon.**
- **The depth to Water level/ piezometric head varies from 5metre to more than 20 meters**
- **The Transmissibility of the aquifers generally range from 10 to 1500 m^2/day**
- **The quality of groundwater is good to acceptable quality for irrigation and domestic uses.**

- Mannargudi block being largest lignite field has attracted NLC's interest.

- NLC has requested Ministry of Coal and Govt.of Tamilnadu for allotment of Mannargudi Block to it on Nomination Basis.

- **NLC will need assistance from United States** as Mannargudi Lignite Field is geologically similar to Powder River Basin of Wymong State in USA.

Assistance is required in the following fields:

1. **EXPLORATION AND ESTIMATION OF GAS IN PLACE (GIP)**

2. **METHODS TO EXTRACT METHANE FROM COAL/LIGNITE:**

Development of Coal Mine Methane in NLC's Leasehold area.

- In Neyveli basin total available reserves of Lignite for CBM development is 5500 MT.
- Likely gas reserves is 8250 MCM.
- Geological setup is similar to Powder River basin of USA
- 2400 MT reserves are already in NLC's leasehold. Additionally 1000 MT in Jayamkondam is applied for lease.
- The above areas can be taken for immediate studies.

A study for CBM in NLC lease hold area can be advantageous for

* The study can start immediately

* If suitable, surrounding area can be added for resources.

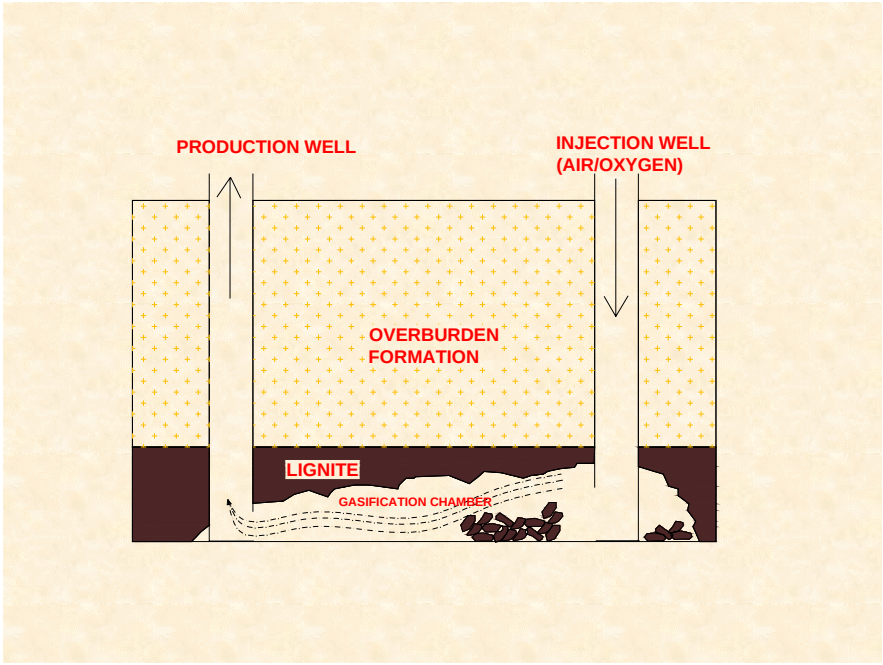
* Carbon sequestration can be possible in CBM voids - held in getting carbon credits.

Assistance required from USA for Exploration and Development of Coal Mine Methane in Neyveli Lignite Mines Area.

UNDERGROUND COAL GASIFICATION

(UCG)

UNDERGROUND COAL GASIFICATION



UCG is the insitu conversion of unworkable (deep seated, thin seam, steep dipping) coal/lignite into a combustible product gas.

UCG operation is initiated by drilling two adjacent boreholes into the coal seam and injecting pressurised oxidants like hot air, oxygen or steam into the coal seam, igniting the coal seam and recovering the combustion gasses through the adjacent borehole. The connectivity between the injection and producer wells are made by special linking techniques.

USES OF PRODUCT GAS

- **The UCG gases consists mainly a mixture of Hydrogen, Carbon-monoxide, Methane, Carbon-dioxide and higher Hydrocarbons.**

- **The raw gas after processing can be utilized for power generation in Integrated Gas combined cycle power plant of suitable capacity. The gas is also suitable for industrial heating or hydrogen and natural gas production.**

- **NLC is interested in UCG and subsequent use of gas in generating power.**

NLC's UCG PROJECT

NLC is pursuing two projects for pilot study for UCG in lignite.

1. **UCG Project under Coal S&T**

2. **UCG Project under NLC and ONGC Joint venture.**

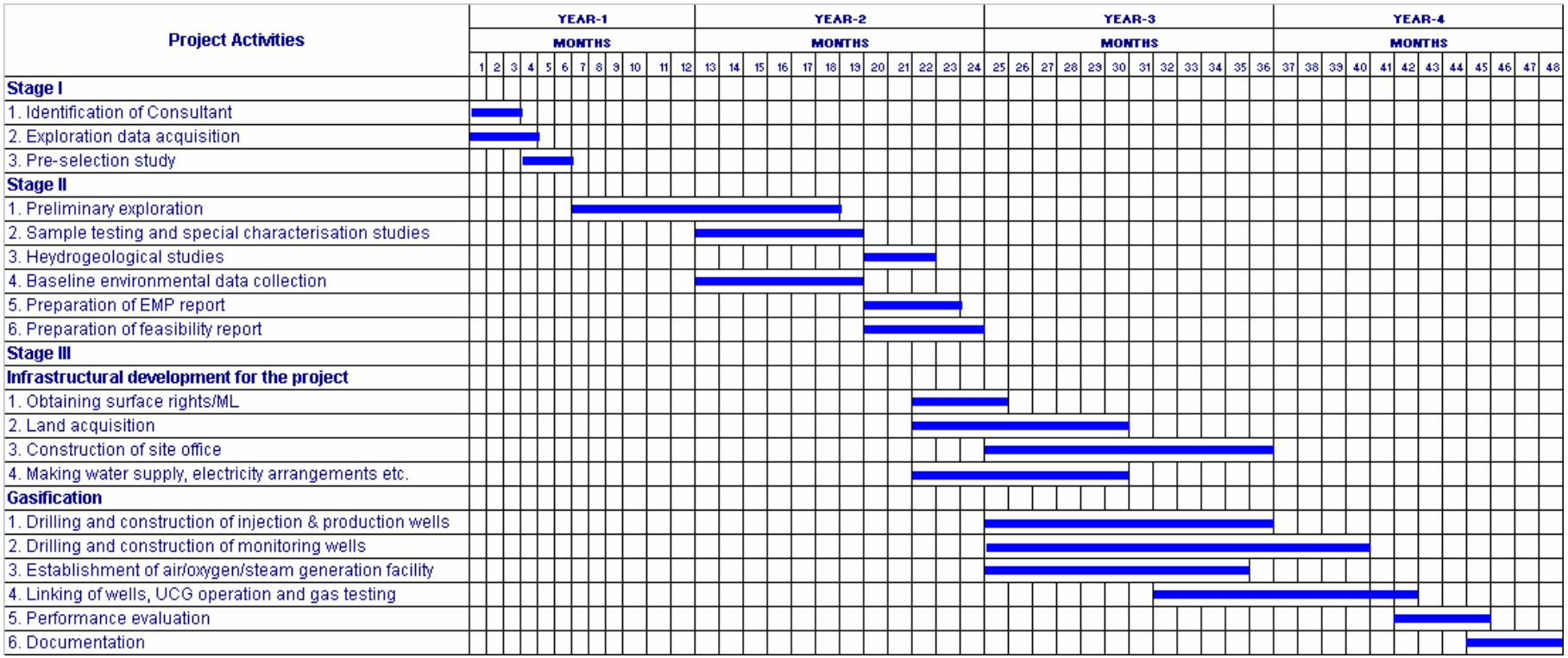
1. Project funded by Coal S&T, NLC and DST

A UCG study project is to be undertaken in a suitable lignite block in Rajasthan.

- **Approved cost of the project : Rs.125 Lakhs**
- **Project duration : 4 years**
- **If the project studies are proved successful, commercial UCG operation would be initiated for utilization of the product gas in a suitable Integrated Gas Combined cycle(IGCC)Power plant.**

A project titled "Underground Coal Gasification (UCG) and its Utilization for power generation studies in lignite deposits in Rajasthan" is proposed to be undertaken by Neyveli Lignite Corporation Limited in association with Internationally reputed UCG expert agency under Coal S&T grant of Ministry of Coal, Government of India.

TIME SCHEDULE



Assistance required from USA for Consultancy Services for UCG Pilot studies undertaken by NLC through Coal S&T

2 . NLC-ONGC UCG Projects

- **NLC has entered into an understanding with ONGC for undertaking a UCG project in deep seated lignite deposit in India.**
- **Certain lignite blocks in Tamil Nadu ,Gujarat and Rajasthan is being considered for undertaking preliminary UCG studies to assess their suitability.**
- **The UCG studies will lead in deciding the future strategy about UCG development.**

Consequent to the Indo-US working group meeting on 04.04.2006 letters were issued to following experts seeking assistance in UCG and CBM by NLC.

Mr.Ravi Upadhye, Ph.D; PE
Deputy Materials Program Leader for
Energy &Environment
University of California
Livermore, CA 94551.

Shri. Ajay Kumar,
Economic Advisor, American Embassy,
Chanakyapuri, New Delhi110 021

Jonathan R.Kelafant
Senior Vice President
ArligtonVA 2203
PH/FAX (908) 252-9650

Kumar M.Sellakumar
President
ETAA Energy,INC
Bridge water NJ 08807

Reminder letter was also issued during Nov'06 to Mr.Jonathan R.Kelafant and Mr.Kumar M.Sellakumar for CBM Study in Mannargudi Lignite Deposit

Reply awaited

Feasibility Study Preparation for Mine –III Alternate Mining Technology

Availing USTDA Grant

Mine –III Project

- NLC has proposed to open Mine –III of 8 MTPA with linked 1000 MW TPS-III and GOI accorded sanction for Advance Action Proposal.

- Feasibility Study for Mine –III was prepared adopting SME technology by NLC but Cost of Mining of lignite with SME technology was on higher side.

- To reduce the Production cost, NLC started exploring Alternate Technologies particularly CME technology.

- It is learnt that CME technology with higher size Equipments are successfully operating in US in large opencast mines.

USTDA (US Trade and Development Agency) Grant

- In an informal session, US consulate officials has come forward and showed interest in extending help to NLC to make use of CME expertise available at US

- Further it was expressed that the existence of service based and equipment based mining related companies are available in US for taking up the Feasibility Study and subsequent development of business opportunities.

USTDA – NLC Grant Agreement

- In further development, an agreement between the Govt. of USA, acting through USTDA and NLC was signed on 13.03.2006 for the Grant value of US $ 360,000 for the Technical Assistance for preparation of Feasibility Study on Alternate Mining Technology for Mine-III.

RFP

- Based on the agreement, a Request For Proposal (RFP) for the Technical Assistance on behalf of NLC, is hosted in the website of Federal Business Opportunities on 21.06.2006.

Response for RFP

- Three US consultancy firms have responded for the RFP viz:

1. Taylor – Dejongh & Tecolotes De La Noche Consulting, Washington DC
2. John T. Boyd Company, Pittsburg, Penn State &
3. Norwest Corporation, Salt Lake City, Utah

Award of Contract

- Under the Grant, M/s Norwest Corporation, Utah was selected for preparation of Feasibility Study on Alternate Mining Technology for Mine-III.
- The contract agreement was signed on 08.12.2006
- All the required Particulars viz, geological data, topographical features of Mine III and Power Plant areas, relevant reports prepared by NLC, etc., have been furnished to M/s.Norwest Corporation as envisaged in the Contract Agreement.

Report Submission

- M/s Norwest Corporation has submitted the
  1. Inception Report on 22.12.06.
  2. Interim Report on 29.03.07
- M/s Norwest Corporation is expected to submit the:
  1. Draft Report by July, 2007 &
  2. Final Report by September,2007

Extension of Technology

NLC may implement the selected technology for Mine-III project by M/s Norwest Corporation for NLC's Jayamkondam Project (Capacity of the Mine is 13.5 MTPA of Lignite and 94.5 Million Cubic Metres of Overburden) also, due to the similar Geological and Hydrological conditions.

Thank You