Land Restoration/Reclamation Monitoring of more than 5 million cu.m (Coal+OB) Capacity Opencast Coal Mines of Western Coalfields Limited based on Satellite Data for the Year 2011
Land Restoration/Reclamation Monitoring of more than 5 million cu.m (Coal+OB) Capacity Opencast Coal Mines of Western Coalfields Limited based on Satellite Data for the Year 2011

March-2012

Remote Sensing Cell
Geomatics Division
CMPDI, Ranchi
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Executive Summary

1.0 Project
Land restoration / reclamation monitoring of 10 opencast coal mines of Western Coalfields Ltd. (WCL) producing 5 million cu.m. and more (Coal+OB) per year based on satellite data, regularly on annual basis.

2.0 Objective
Objective of the land restoration / reclamation monitoring is to assess the area of backfilled, plantation, social forestry, active mining area, water bodies, and distribution of wasteland, agricultural land and forest in the leasehold area of the project. This will help in assessing the progressive status of mined land reclamation and to take up remedial measures, if any, required for environmental protection.

3.0 Salient Findings

- Out of the total mine leasehold area of 77.93 Km² of the 10 projects Viz. Sasti, Padmapur, Durgapur, Mugoli, Umrer, Ukni, Niljai, New Majri, Pimpalgaon and Ghugus considered for monitoring during year-2011; total excavated area is only 57.11 Km² (73.28%) of which 26.82 Km² area (46.96%) has been planted, 22.10 Km² area (38.70%) has been backfilled and 8.19 Km² area (14.34%) is under active mining. It is evident from the analysis that 85.66% area of the above OC projects have already been reclaimed (biologically and technically) and balance 14.34% area is under active mining. Project wise details are given in Table-1 & Fig-1.

- On comparing the status of land reclamation for the year 2010 with respect to the year 2011 in different projects, it is evident from the analysis that area of land reclamation has increased from 45.48 Km² (Yr. 2010) to 48.92 Km² (Yr. 2011). Out of 10 projects of WCL, maximum land reclamation has been carried out in New Majri project (93.61%) followed by Sasti (92.19%) and Ghugus (91.28%).

- Area of biological reclamation (plantation) has increased from 25.35 Km² (Yr. 2010) to 26.82 Km² (Yr. 2011) where as area of technical reclamation (backfilled area) has increased from 20.13 Km² (Yr. 2010).
2010) to 22.10 Km² (Yr.2011) in WCL. This increase of 3.44 Km² in area of plantation and backfilled is the result of the efforts of the Western Coalfields Ltd taken up towards environmental protection.

- It has been observed that 0.16 Km² area of plantation is reduced in New Majri, with respect to the year 2010, due to dumping of OB on the planted area, due to constraint of OB dumping, which should be avoided in future.
## Table - 1

**Projectwise Land Reclamation Status in Opencast Projects of WCL based on Satellite Data of the year 2011**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Project Name</th>
<th>Leasehold (ii)</th>
<th>Plantation/Vegetation (i)</th>
<th>Backfilled (ii)</th>
<th>Active Mining (iii)</th>
<th>Total Excaveted Area (ii+iii+iv)</th>
<th>Total Reclaimed area (ii+iii)</th>
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<td>25.51</td>
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<tr>
<td>3</td>
<td>DURGAPUR</td>
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<td>79.79 81.17</td>
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<td>66.59</td>
<td>14.17 14.50</td>
<td>85.83 85.50</td>
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<td>NEW MAJRI</td>
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<td>57.46</td>
<td>91.07 93.61</td>
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<td>9</td>
<td>PIMPALGAON</td>
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<td>10</td>
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<td>41.98</td>
<td>95.05 91.28</td>
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<td>77.93</td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

*% Calculated in terms of Total Excaveted Area*

*Based on Satellite Data of the year 2011*
1.0 Background

1.1 Land is the most important natural resource which embodies soil, water, flora fauna and total ecosystem. All human activities are based on the land which is the most scarce natural resource in our country. Mining is a site specific industry and it could not be shifted anywhere else from the location where mineral occurs. It is a fact that surface mining activities do effect the land environment due to ground breaking. Therefore, there is an urgent need to reclaim and restore the mined out land for its productive use for sustainable development of mining. This will not only mitigate environmental degradation, but would also help in creating a more congenial environment for land acquisition by coal companies in future.

1.2 Keeping above in view, Coal India Ltd. (CIL) issued a work order vide letter no. CIL/WBP/Env/2009/2428 dated 29.12.2009 to Central Mine Planning & Design Institute (CMPDI), Ranchi, for monitoring land reclamation status of all the opencast coal mines having production of more than 5 million m³ per annum (coal + OB taken together per annum) based on remote sensing satellite data, regularly on annual basis for sustainable development of mining. Further, another work order vide letter no. CIL/WBP/ENV./2011dated23/08/11 was issued by CIL for monitoring of less than 5 million m³ per annum capacity (Coal +OB) projects from the year 2011 at interval of three years. The result of land reclamation status of all such mines to be put on the website of CIL, (www.coalindia.in), CMPDI (www.cmpdi.co.in) and the concerned coal companies in public domain. Detail report to be submitted to Coal India and respective subsidiaries.

1.3 Land reclamation monitoring of all opencast coal mining projects would also comply the statutory requirements of Ministry of Environment & Forest (MoEF). Such monitoring would not only facilitate in taking timely mitigation measures against environmental degradation, but would also enable coal
companies to utilize the reclaimed land for larger socio-economic benefits in a planned way.

1.4 Present report is embodying the finding of the study based on satellite data of the year 2011 carried out for all the OC projects producing more than 5 mcm (Coal+OB) for Western Coalfields Ltd.

2.0 Objective

Objective of the land reclamation/restoration monitoring is to assess the area of backfilled, plantation, OB dumps, social forestry, active mining area, settlements and water bodies, distribution of wasteland, agricultural land and forest land in the leasehold area of the project. This is an important step taken up for assessing the progressive status of mined land reclamation and for taking up remedial measures, if any, required for environmental protection.

3.0 Methodology

There are number of steps involved between raw satellite data procurement and preparation of final map. National Remote Sensing Centre (NRSC) Hyderabad, being the nodal agency for satellite data supply in India, provides only raw digital satellite data, which needs further digital image processing for extracting the information and map preparation before uploading the same in the website. Methodology for land reclamation monitoring is given in given in figure-2. Following steps are involved in land reclamation/restoration monitoring:
3.1 **Data Procurement:** After browsing the data quality and date of pass on internet, supply order for data is placed to NRSC. Secondary data like leasehold boundary, topo sheets are procured for creation of vector database.

3.2 **Satellite Data Processing:** Satellite data are processed using ERDAS IMAGINE digital image processing s/w. Methodology involves the following major steps:

- **Rectification & Georeferencing:** Inaccuracies in digital imagery may occur due to ‘systematic errors’ attributed to earth curvature and rotation as well as ‘non-systematic errors’ attributed to satellite receiving station itself. Raw digital images contain geometric distortions, which make them unusable as maps. Therefore, georeferencing is required for correction of image data using ground control points (GCP) to make it compatible to Sol toposheet.
• **Image enhancement:**
  To improve the interpretability of the raw data, image enhancement is necessary. Local operations modify the value of each pixel based on brightness value of neighbouring pixels using ERDAS IMAGINE 9.3 s/w. and enhance the image quality for interpretation.

• **Training set selection**
  Training set requires to be selected, so that software can classify the image data accurately. The image data are analysed based on the interpretation keys. These keys are evolved from certain fundamental image-elements such as tone/colour, size, shape, texture, pattern, location, association and shadow. Based on the image-elements and other geo-technical elements like land form, drainage pattern and physiography; training sets were selected/identified for each land use/cover class. Field survey was carried out by taking selective traverses in order to collect the ground information (or reference data) so that training sets are selected accurately in the image. This was intended to serve as an aid for classification.

• **Classification and Accuracy assessment**
  Image classification is carried out using the maximum likelihood algorithm. The classification proceeds through the following steps: (a) calculation of statistics [i.e. signature generation] for the identified training areas, and (b) the decision boundary of maximum probability based on the mean vector, variance, covariance and correlation matrix of the pixels. After evaluating the statistical parameters of the training sets, reliability test of training sets is conducted by measuring the statistical separation between the classes that resulted from computing divergence matrix. The overall accuracy of the classification was finally assessed with reference to ground truth data.
• **Area calculation**
  The area of each land use class in the leasehold is determined using ERDAS IMAGINE v. 9.3 software.

• **Overlay of Vector data base**
  Vector data base created based on secondary data. Vector layer like drainage, railway line, leasehold boundary, forest boundary etc. are superimposed on the image as vector layer in the Arc GIS database.

• **Pre-field map preparation**
  Pre-field map is prepared for validation of the classification result

3.3 **Ground Truthing:**
Selective ground verification of the land use classes are carried out in the field and necessary corrections if required, are incorporated before map finalization.

3.4 **Land reclamation database on GIS:**
Land reclamation database is created on GIS platform to identify the temporal changes identified from satellite data of different cut-off dates.
4.0 Land Reclamation Status in Western Coalfields Ltd.

4.1 Following 10 OC projects producing more than 5 million cubic m. (Coal + OB together) of Western Coalfields Ltd. have been taken up for land reclamation monitoring during the year 2011:

- Sasti
- Padmapur
- Durgapur
- Mugoli
- Umrer
- Ukni
- Niljai
- New Majri
- Pimpalgaon
- Ghugus

4.2 Area statistics of different land use class present in the mine leasehold of the above projects for the year 2011 are shown in the Table - 2. Land use maps derived from satellite data are shown in Plate 1 - 10. Land reclamation status of the above mentioned 10 projects, were also prepared for the year 2009, 2010, and 2011. Year wise changes in the different land use classes based on satellite data are depicted in Bar Charts in Fig. 3 - 12

4.3 Study reveals that 85.66% of mining area has already been reclaimed by WCL out of which 46.96% area has been revegitated and 38.70% area are backfilled. There is an increase of 3.44 Km² reclaimed area in WCL with respect to the year 2010, out of which 1.47 Km² increase in biological reclamation and 1.97 Km² increase in the technical reclamation (barren backfilled).
4.4 After analyzing the satellite data of year 2010 vs. 2011 it is evident that plantation carried out on backfilled area, OB dumps as well as under social forestry in all the mines of WCL has increased from 25.35 Km\(^2\) to 26.82 Km\(^2\) in span of last one year. This increase of 1.47 Km\(^2\) area of plantation in one year time is due to the efforts of WCL towards mine land reclamation.

4.5 It has been also observed that in New Majri project plantation percentage in the year 2011 has reduced by 0.16 km\(^2\) in respect to the previous year i.e. 2010. This has occurred because of dumping of OB on the planted area due to constraint of OB dumping which should be avoided in future.

4.6 Out of 10 projects of WCL, maximum land reclamation has been carried out in New Majri project (93.61%) followed by Sasti (92.19%) and Ghugus (91.28%).
### Table 2

<table>
<thead>
<tr>
<th>Area in Sq Kms</th>
<th>SASTI</th>
<th>PADMASPUR</th>
<th>DURAGPUR</th>
<th>MUGOLI</th>
<th>UKERI</th>
<th>UKNI</th>
<th>NEW MAJI</th>
<th>PRISPAULAGAO</th>
<th>GUHURAS</th>
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<td><strong>TOTAL VEGETATION</strong></td>
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<td>25.53</td>
<td>34.60</td>
<td>26.60</td>
<td>41.22</td>
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<td>5.63</td>
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<td><strong>TOTAL PLANTATION</strong></td>
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<td>24.35</td>
<td>1.87</td>
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**NOTES:**
- **Dense Forest:** Area %
- **Open Forest:** Area %
- **Social Forestry:** Area %
- **Plantation on OB Dump:** Area %
- **Plantation on Backfill:** Area %
- **Total Plantation (Biological Reclamation):** Area %
- **Total Vegetation:** Area %
- **Total Under Active Mining:** Area %
- **Total Under Technical Reclamation:** Area %
- **Total Area Under Active Mining:** Area %
- **Total Area Under Mine Operation:** Area %
- **Total Waste Bodies:** Area %
- **Total Wasteland:** Area %
- **Total Agriculture:** Area %
- **Total Settlement:** Area %
- **Grand Total:** Area %
Plate -3
Plate 4
Plate: 6

Western Coalfields Limited

Title: Land Reclamation Status of UKNI OCP Based on Satellite Data (9/1-IV) of the year 2011

Table:

<table>
<thead>
<tr>
<th>Class</th>
<th>Level-I</th>
<th>Level-II</th>
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<th>%</th>
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Customer:

Western Coalfields Limited
### AREA STATISTICS

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<td><strong>Total Settlement</strong></td>
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<td><strong>Total</strong></td>
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**Legend**

- Rail
- Road
- Lease
Figure- 3

Figure- 4
Figure - 5

STATUS OF LAND RECLAMATION IN DURGAPUR OCP

Figure - 6

STATUS OF LAND RECLAMATION IN MUGOLI OCP
STATUS OF LAND RECLAMATION IN UMRER OCP

Figure -7

STATUS OF LAND RECLAMATION IN UKNI OCP

Figure-8
Figure-9

STATUS OF LAND RECLAMATION IN NILJAI OCP

Figure-10

STATUS OF LAND RECLAMATION IN PIMPALGAON OCP
Figure-11

Figure-12
Photograph -1 : Plantation on OB dump in Sasti OCP

Photograph -2 : Plantation on OB dump in Ghugus OCP
Photograph -3: Plantation on OB dump in Mugoli OCP

Photograph -4: Plantation on OB dump in New-Majri OCP
Photograph -5 : Plantation on backfilled area in Niljai OCP

Photograph -6 : Plantation on backfilled area in Pimpalgaon OCP
Photograph -7: Plantation on OB dump in Ukní OCP

Photograph -8: Plantation on backfilled area in Umrer OCP
Photograph -9 : Plantation on OB dump in Durgapur OCP

Photograph -10 : Plantation on OB dump in Padmapur OCP