Geomorphic Principles Applied to Reclamation at Navajo Mine

BHP Billiton
Navajo Mine
Mine Design Group
May 20, 2014
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New Mexico Coal: Overview

Overview

- The San Juan and Navajo coal mines are located near Farmington, New Mexico and supply two different local coal fired power plants.

- **San Juan:**
  - Underground longwall operation
  - 100% owned by BHP Billiton
  - Annual production of 6-8 million tons to San Juan Generating Station
  - Current Contract through 2017

- **Navajo:**
  - Open-cut dragline operation with coal supplied by railroad to the Four Corners Power Plant
  - Annual production of 7-9 million tons through December 2013
  - Annual Production post June 2013 approximately 6 million tons
New Mexico Coal

• La Plata Mine
• San Juan Mine
• Navajo Mine
• Farmington Office
Regional Topography

San Juan Mine Drainages

La Plata Mine Drainages

Navajo Mine Hosteen Area Drainages
New Mexico Coal’s Geomorphic History – La Plata Mine

Buckeye and Elk Point (Panel 5 Highwall)
• Deepest final pit at La Plata Mine
• 210 feet deep
New Mexico Coal’s Geomorphic History – San Juan Mine

Photograph of Cottonwood Area during landform construction.
Arrow shows landmark reference.

Photograph of Cottonwood Area during mining operations.
Arrow shows landmark reference.
Navajo Mine Overview

- Operations began in 1963
- Approximately 6 million tons of annual production
- Delivered quality of
  - 8,700 BTU/lb
  - 23% Ash
  - Sulfur < 1%
- Sole supplier to Four Corners Power Plant (FCPP)
- Owned by the Navajo Transitional Energy Company, LLC (NTEC)
- Operated by BHP Billiton through December 2016
- Current coal sales contract through 2016
- Newly approved coal sales contract between NTEC and FCPP from 2016 to 2031
- Significant resources available for future growth
Navajo Mine – Earthmoving Operations

C. Brandt, Production Planner, Mine Design Group, May 2014
Navajo Mine Geomorphic Design Objectives

Perm Standards
- Ensured slopes in design meet permit standards
- Overall slope percentages and acres comparable to the pre-mining area

Land Form
- Utilized current spoils topography to increase diversification of design land forms
- Improved slopes in particular areas to enhance sustainability
- Defined ridges and valleys while honoring the major drainage routes
- Applied geomorphic principles where practicable

Improvement In Erosion Control Structures For Sustainability
- Designed down-drains for a 100 year 6 hour storm event
- Reduced the need for terraces and down-drains in final reclamation
Navajo Mine Past Geomorphic Reclamation

Chinde Main Channel and Chinde Branch 2 Geomorphic Reclamation
Navajo Mine Present Geomorphic Reclamation
FSC revision design challenges include:

- Working towards an overall balanced design surface while maintaining the material balance in the specific pit areas
- Reducing down drains along final pit tie-in areas
- Tying into previously reclaimed areas and drainages
- Managing the final pit reclaimed channel drainage grades
- Integrating geomorphic principles into an area where this type of reclamation was not previously planned
Triangulation using Vulcan of the Area 3 Post-mining topography.

Note the final dragline pits and spoil peaks.
Area 2 FSC – Hosteen/Yazzie Pits

Previous FSC

Revised FSC

10' Contours

5' Contours
Area 2 FSC – Barber Pits

Previous FSC

Revised FSC

10' Contours

5' Contours
Area 2 Predicted Sediment Yields

**Previous Design**
- Pre-mine=31,293 tons
- Post-mine=18,926 tons
- Decrease in sediment yield of 12,367 tons

**New Design**
- Pre-mine=31,845 tons
- Post-mine=19,491 tons
- Decrease in sediment yield of 12,354 tons
Chinde Drainage Density
Pre-mine drainage density Chinde Arroyo – 1.4 miles/sq. mile for entire drainage area and 2.8 miles/sq. mile for area disturbed by mining
Previous Drainage Density Design – 4.7 miles/sq. mile
Revised Drainage Density Design – 4.6 miles/sq. mile

Hosteen Drainage Density
Pre-mine drainage density Hosteen Arroyo – 3.18 miles/sq. mile for entire drainage area and 2.8 miles/sq. mile for area disturbed by mining
Previous Drainage Density Design Hosteen Arroyo – 6.1 miles/sq. mile
Revised Drainage Density Design Hosteen Arroyo – 5.2 miles/sq. mile

Barber Drainage Density
Pre-mine drainage density Barber Arroyo – 1.75 miles/sq. mile for entire drainage area and 1.46 miles/sq. mile for area disturbed by mining
Previous Drainage Density Design Barber Arroyo – 6.7 miles/sq. mile
Revised Drainage Density Design Barber Arroyo – 5.3 miles/sq. mile

South Barber Drainage Density
Pre-mine drainage density South Barber Arroyo – 5.93 miles/sq. mile for entire drainage area
Previous Drainage Density Design South Barber Arroyo – Barber and South Barber were previously combined
Revised Drainage Density Design South Barber Arroyo – 5.6 miles/sq. mile
**Channel Grades**

**Chinde**
- Previous FSC – 0.76% slope
- Revised FSC – 0.91% slope

**Hosteen**
- Previous FSC – 1.43% slope
- Revised FSC – 0.80% slope

**Barber**
- Previous FSC – previous drainage combined into South Barber Channel
- Revised FSC – 0.41% slope

**South Barber**
- Previous FSC – 0.91% slope
- Revised FSC – combined with Barber Channel
## Previous FSC Slope Distribution by Area

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<tr>
<th>Percent</th>
<th>Acres</th>
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<tr>
<td></td>
<td>Area 2</td>
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<tr>
<td>0-2.9%</td>
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<tr>
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<td>Total</td>
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### Revised FSC Slope Distribution by Area

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<tr>
<td>Total</td>
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Figure 12.3-2
Area 2 Slope Histogram

Distribution

Slope Range (% Slope)

0-2.9% 34.9% 26.9%
3-5.9% 28.3% 27.6%
6-8.9% 20.4% 14.3%
9-11.9% 11.6% 8.4%
12-14.9% 6.6% 5.1%
15-19.9% 4.1% 4.3%
>20.0% 5.5% 2.2%

FSC
Pre-mine
Figure 12.3-2
Area 2 Slope Histogram

<table>
<thead>
<tr>
<th>Slope Range (%)</th>
<th>FSC</th>
<th>Pre-mine</th>
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<td>28.8%</td>
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Benefits

FSC revision design benefits include:

- Achieved overall material balance
  - North pit areas balance
  - South pit areas balance
- Increased reclamation productivity
- Overall land form diversity has been improved
- Removed terraces in certain areas
- Changed land form slopes in areas of concern from convex to concave
- Removed a total of 4 down drains from final reclamation
- Applied geomorphic principles to increase diversity and sustainability
- Overall decrease in the modeled sediment yield
Acknowledgements

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Ron Van Valkenburg, Contractor

GEOMAT, Contractor, Farmington, NM 87402


Carlson Software (2012). Carlson Natural Regrade Program. Maysville, KY.