An On-line Mapping System for Reclamation History Management and Reporting[1]

Dwight Kinnes[2] and Laura Ackermann

Abstract. The Decker Coal Mine, located in southeastern Montana, employed GIS techniques to develop a detailed database and map interface for the Reclamation History database of the mine. The project consisted of developing a relational database of the Reclamation History, building a mine-wide GIS, and developing an On-line map website and associated on-line report capabilities. Decker developed the Reclamation History database using MS-Access and then joined the database to a shapefile of the reclamation polygons. Decker created a GIS of the Decker mine using various data sources from various departments to provide a comprehensive snapshot of the mine. This GIS became the GIS foundation of an On-line Map interface developed using ArcIMS. The map interface provides company wide access to the Decker mine website. Decker also developed custom reports, with map images of the each Reclamation History polygons. These reports provide Decker the ability to quickly prepare their annual reclamation reports.

Additional Key Words: Coal, ArcIMS, On-line map interface, ArcGIS, GIS

---

[1]Paper was presented at the 2004 Advanced Integration of Geospatial Technologies in Mining and Reclamation, December 7 – 9, 2004, Atlanta, GA.

[2]Dwight Kinnes is Principal Consultant with Highland GeoComputing, LLC, Johnston, IA, 50131; Laura Ackermann is a Senior Environmental Engineer with Decker Coal Company, Decker, MT, 59025

Introduction

The Decker Mine (Decker), operated by Kiewit Mining Group, located in southeastern Montana implemented a detailed GIS to manage their reclamation history database. Decker's objectives for the GIS included: 1) Reorganizing and streamlining their reclamation history database; 2) Including current reclamation area maps with annual reclamation reports; and 3) Providing company wide access to the reclamation history database.

To fulfill Decker's objectives the project was divided into three components: 1) Building a menu driven relational database; 2) Developing a mine wide GIS; and 3) Developing an on-line map delivery and report generating interface.

In conjunction with this project, Decker joined with the Office of Surface Mining (OSM) and the Montana Department of Environmental Quality (MT DEQ) to produce a good reliable model of pre-mine topography for the mine area.

The Decker Mine annually produces approximately 7.3 to 10 million tons of sub-bituminous, low sulfur coal from the northern end of the Powder River Basin (PRB) in Big Horn County, Montana. Decker uses three draglines to expose coal in two seams, the D1 and D2 (Deitz-Anderson).

The Decker Mine historically compiled their reclamation history using numerous, large, and unwieldy spreadsheets and pasted images of each reclamation polygon. These spreadsheets made updating the reclamation history difficult and time consuming. In addition, these spreadsheets did not allow analysis of reclamation history data because each reclamation area is discrete and stored separately from other reclamation areas.

Reclamation History Database

Overview

The Reclamation History database was developed to provide form driven data entry and custom reporting for Decker. The database provides relational database tools for detailed analysis of Decker's reclamation history. The database also reduces time required for data entry and report generation.

The Reclamation History database was created using Access2000. Access2000 provides an inexpensive easy to use a relational database well suited for applications like this. ArcGIS and ArcIMS can directly read Access2000 "MDB" files without data conversion. Therefore, all of the information collected and stored in Access2000 is readily available through a map interface of ArcView or ArcIMS.

While the Reclamation History database is not complex, it provides Decker with essential tools not previously available. The simple ability to access, update and report any reclamation area adds great values to all of the Reclamation History data.

Data Input Tables

A menu driven Reclamation History database was created in Access2000, Figure 1. This Reclamation History database consists of two primary tables. The first table contains information for each reclamation history polygon on the property. The second table contains information for each revegetation transect drawn across the mine area.

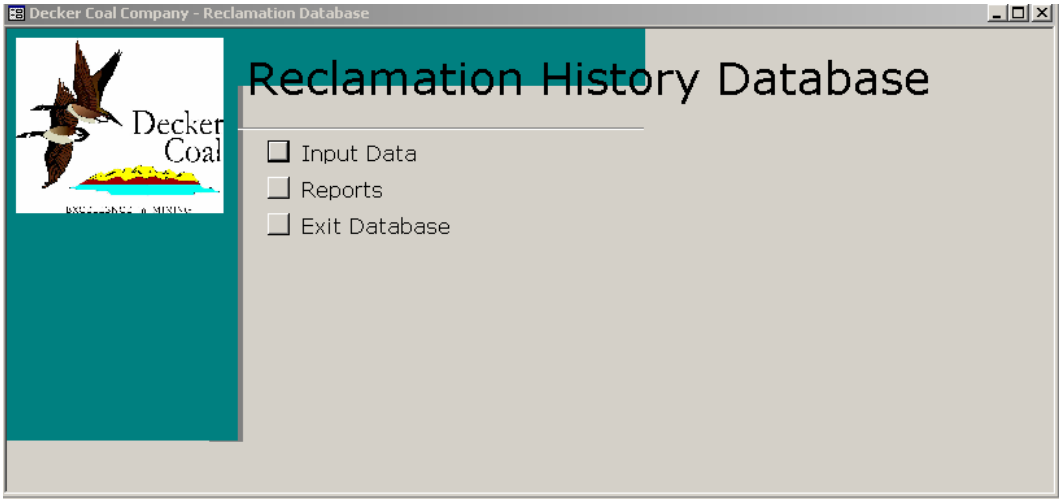


Figure 1. Reclamation History Database Main Menu

Forms for data entry and ease of editing were created for the Reclamation History table, Figure 2 and the Revegetation Transect table, Figure 3. Pull down menus at the top of each form provide easy access to each record in the database.

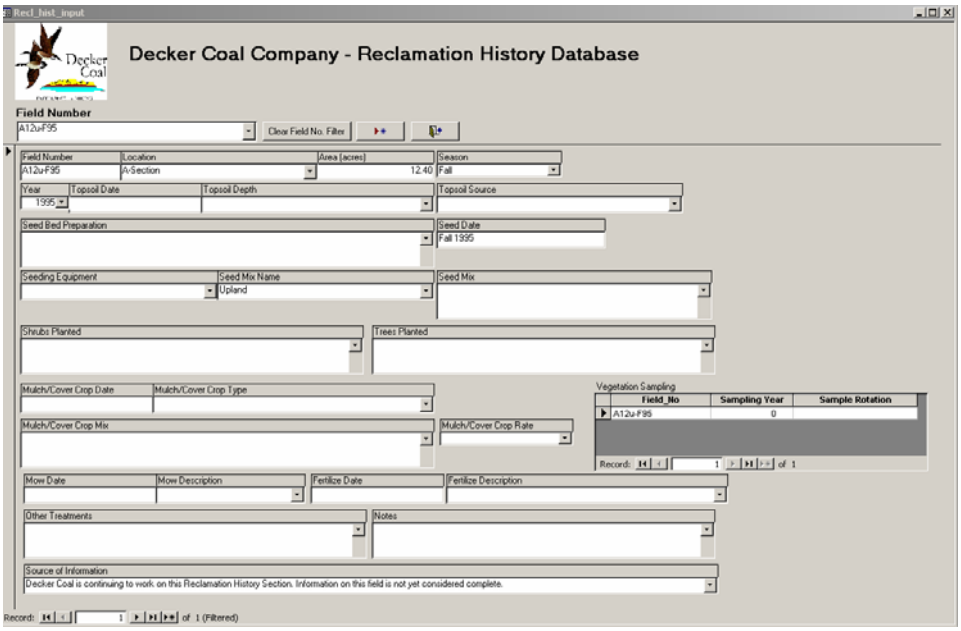


Figure 2. Reclamation History Input Form

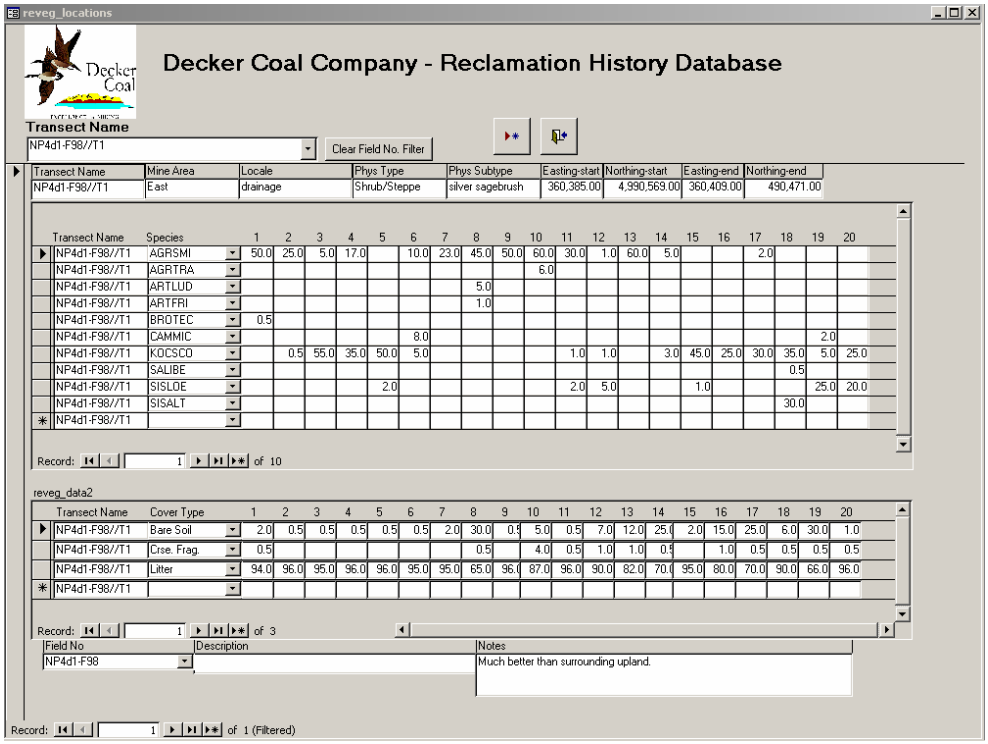


Figure 3. Revegetation Transect Input Form

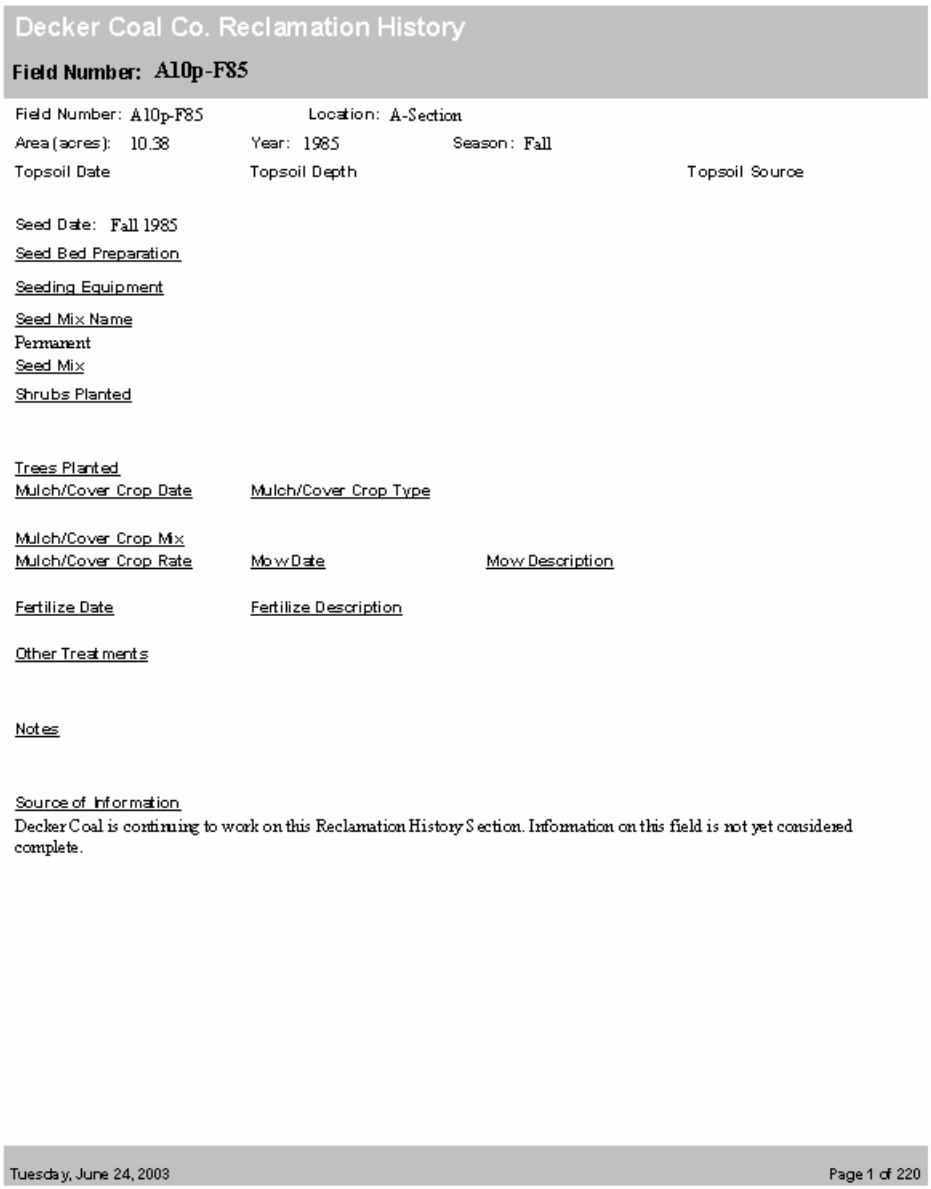
The Reclamation History form contains a subtable containing information regarding annual vegetation sampling and sampling rotation within each specific reclamation area. This subtable provides a "one-to-many" relationship from the reclamation history table to the vegetation sampling table. Thus, vegetation sampling data accumulated over several years remains connected to a single reclamation area.

The Revegetation Transect form also contains subtables storing information regarding each plant species observed along transects and the general ground cover observed along transects. Both of these data tables provide a "one-to-many" relationship to the Revegetation transect table. Thus, numerous plant types and cover types can be stored for each transect.

Some minimal VB-scripting was written to validate fields and calculate sums within the forms. These routines, and features in the forms provide mechanisms for error checking and consistent data entry. Therefore, these tools reduce data input time and help ensure that only clean and correct data is entered into the database.

Database Reports

Simple reports from the database were created for each table, Figure 4 and Figure 5. The reports were created using the general reporting tools in Access2000. These reports, while functional, did not provide the complete solution for Decker, because the database reports do not contain map images of each reclamation polygon. This problem was addressed via the on-line mapping system, described below.



Decker Coal Co. Reclamation History

Field Number: A10p-F85

Field Number: A10p-F85 Location: A-Section

Area (acres): 10.38 Year: 1985 Season: Fall

Topsoil Date Topsoil Depth Topsoil Source

Seed Date: Fall 1985

Seed Bed Preparation

Seeding Equipment

Seed Mix Name

Permanent

Seed Mix

Shrubs Planted

Trees Planted

Mulch/Cover Crop Date Mulch/Cover Crop Type

Mulch/Cover Crop Mix

Mulch/Cover Crop Rate Mow Date Mow Description

Fertilize Date Fertilize Description

Other Treatments

Notes

Source of Information

Decker Coal is continuing to work on this Reclamation History Section. Information on this field is not yet considered complete.

Tuesday, June 24, 2003 Page 1 of 220

Figure 4. Example of Reclamation History Report.

Decker Coal Company - Revegetation Canopy Coverage Report **Transect Name: NP1p-F80//T1**

Transect Name	Mine Area	Field No	locale	Phys Type	Phys Subtype	Easting-start	Northing-start	Easting-end	Northing-end
NP1p-F80//T1	East	NP1p-F80	mixed w/introduced	Steppe grassland	may '78 - dec'83	359,382.00	4,990,424.00	359,373.00	4,990,519.00

Plot Area Classes

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Mean	Freq	Rel Cover
AGRCRI								18.0													0.9	5%	18.0
AGRINT	9.0		2.0	3.0		5.0	3.0	7.0	6.0	15.0	20.0	3.0	15.0	25.0	6.0	8.0	40.0	5.0			8.6	80%	10.8
AGRSMI	25.0	30.0	37.0	30.0	37.0	15.0	22.0	10.0	8.0	15.0	5.0	20.0	14.0	10.0	22.0	24.0	2.0	35.0		15.0	18.8	95%	19.8
BOUCUR						12.0			50.0										25.0	25.0	5.6	20%	28.0
BROJAP	0.5					0.5	0.5				1.0	1.0							0.5		0.2	30%	0.7
HERINT		8.0																			0.4	5%	8.0
OPUPOL		6.0																			0.3	5%	6.0
STICOM												10.0									0.5	5%	10.0
TAROFF							2.0														0.1	5%	2.0
TRADUB															0.5						0.0	5%	0.5
UNK GR					1.0										0.5						0.1	10%	0.8
Community Richness: 11																							
Total Cover	34.5	44.0	39.0	33.0	38.0	32.5	27.5	35.0	64.0	30.0	26.0	34.0	29.0	35.0	29.0	32.0	42.0	40.0	25.5	40.0			
Count	3.0	3.0	2.0	2.0	2.0	4.0	4.0	3.0	3.0	2.0	3.0	4.0	2.0	2.0	4.0	2.0	2.0	2.0	2.0	2.0			
Bare Soil	65.0	40.0	45.0	40.0	30.0	70.0	50.0	48.0	16.0	35.0	55.0	48.0	48.0	25.0	37.0	25.0	15.0	35.0	70.0	40.0	41.9	100%	
Crse. Frag.	2.0	1.0	2.0	1.0	1.0	2.0	1.0	0.5	2.0	2.0	2.0	2.0	1.0	0.5	0.5	2.0	0.5	2.0	5.0	2.0	1.6	100%	
Litter	30.0	55.0	55.0	55.0	65.0	25.0	46.0	48.0	79.0	60.0	40.0	48.0	48.0	70.0	58.0	70.0	80.0	60.0	16.0	55.0	53.2	100%	

Canopy Statistics

Cover 90% C.I.	3.3
T.C. Mean:	35.5
T.C. StDev:	8.5
SPDEN 90% CI	0.3
SPDEN Mean:	2.7
SPDEN StDev:	0.8

Description

Notes Bare field for 20yrs. Old, Low litter for 20yrs. Old.

Tuesday, June 24, 2003 Page 2 of 28

Figure 5. Example of Revegetation Transect Report

The Mine Wide GIS

Overview

Prior to this project, the Decker reclamation history polygons were never linked to the reclamation history data. As such, determining which polygon applied to which record was often a time consuming process. Therefore, a GIS was created in ArcMap (ArcView 8.3 & 9.0) to join the data to the polygons.

Building the GIS

The reclamation area polygons were already created in CAD files within the geological modeling and mine planning system used by Decker. The polygons were exported as a shapefile and joined to the Reclamation History database, Figure 6. The “Field ID” for each reclamation area provides unique values to join the Access2000 database to the Reclamation History polygons. Therefore, the Field ID was manually assigned to each polygon. While tedious, this operation was a one-time process and worth the effort. Once the Field IDs were assigned, all of

the data stored in the Reclamation History database become accessible through ArcMap and ArcIMS.

Additional shapefiles and CAD drawings were compiled into a comprehensive GIS basemap for the Decker Mine. In addition, all of the geological and mining data for the mine were also included as part of the GIS. The drill hole data for the mine is stored in a different Access2000 database developed specifically for the Decker exploration data.

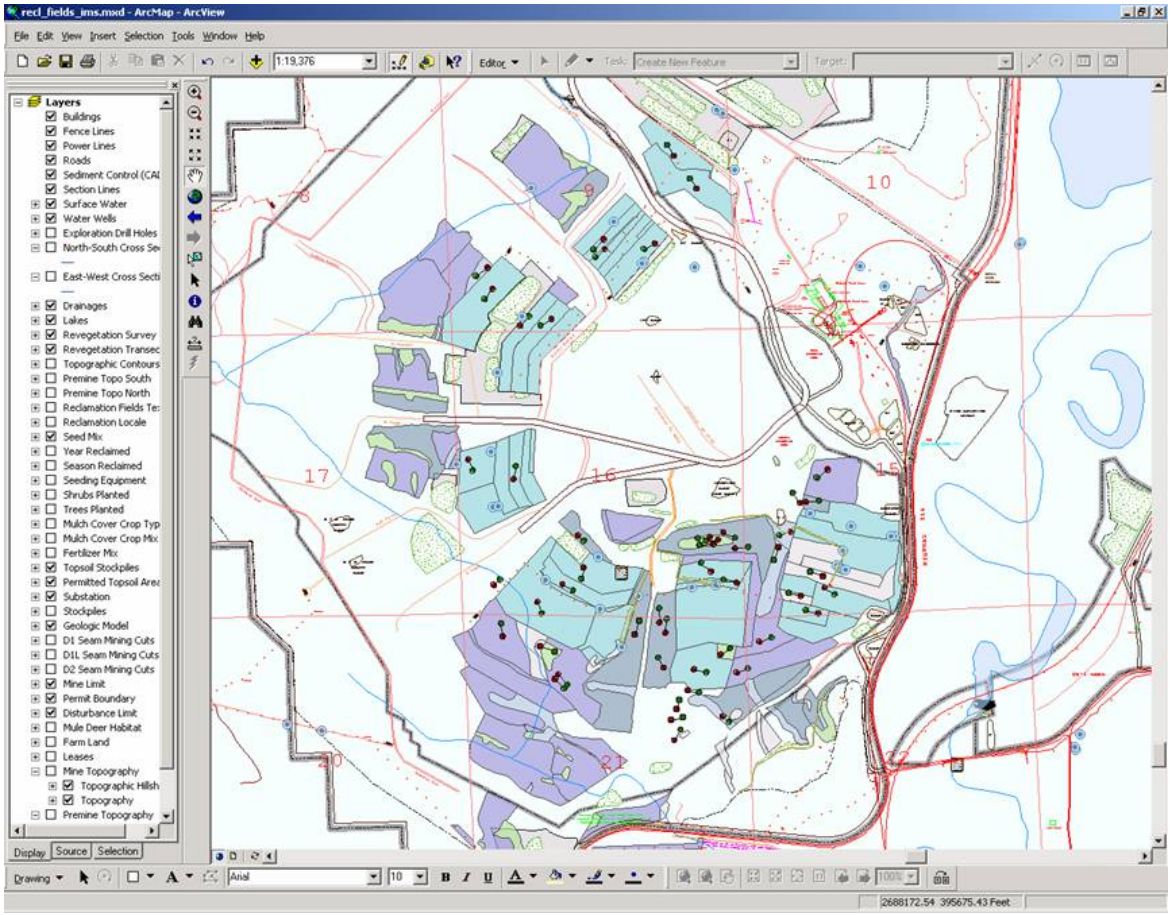


Figure 6. Example of Decker Reclamation History Polygons and Revegetation Transects.

The ability for ArcMap to utilize CAD files, shapefiles, and grid files enabled Decker to use mapping data collected via aerial surveys, mine surveys, and from the public domain with very little extra effort. Not needing to reformat or convert all of their spatial data was an important component for Decker in implementing GIS tools at the mine.

Once trained, the mining staff are now able to produce professional looking maps for bond release, permits and annual reports in a fraction of the time previously required.

OSM and MT DEQ Assistance

For detailed reclamation analysis Decker, the OSM and the MT DEQ all need reliable high quality pre-mine topographic maps. In a joint effort spearheaded by the OSM, Decker provided paper copies of pre-mine topographic maps to the MT DEQ. The MT DEQ had the maps scanned and vectorized via a grant from the OSM.

The MT DEQ provided Decker with CAD files of the vectorized pre-mine topographic data. The CAD files were used directly in ArcMap as part of the mine wide GIS. These data were also then transferred into the geological modeling and mine planning system and converted to a high resolution grid. The high resolution grid is being used for mining volumetrics and was imported into ArcGIS for surface analysis (slope, photogeology, etc.).

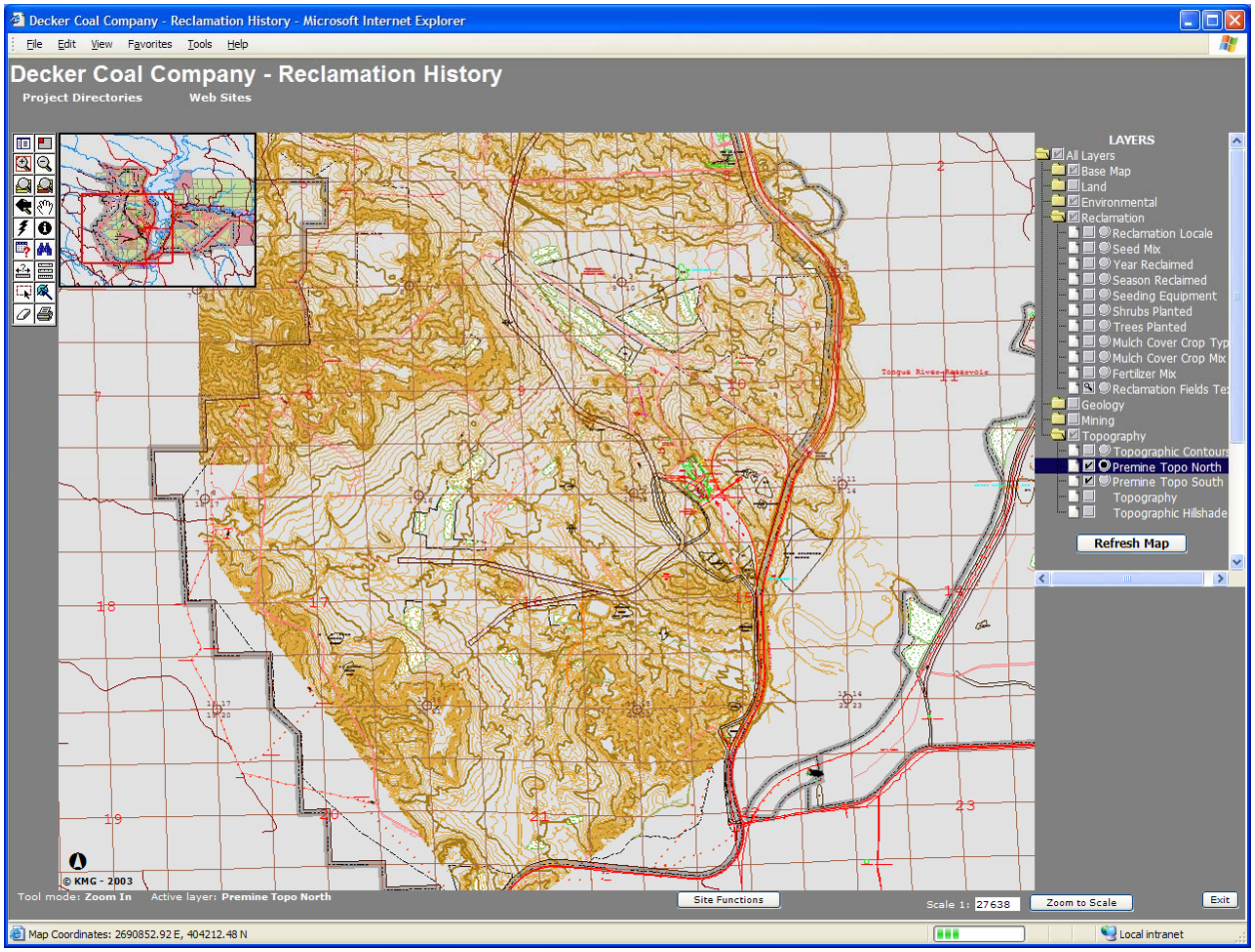


Figure 7. Pre-mining Topography Provided by MT DEQ

Decker On-Line Mapping System

Overview

The final component to the project consisted of building an on-line mapping system for Decker. The on-line mapping system provides access to current reclamation history reports at any time and provides company-wide access to the Mine GIS.

On-line Mapping System

Decker's on-line mapping system was developed using ArcIMS 4.2 and converted to ArcIMS 9.0. The installed system at Decker resides on an ArcIMS server residing in Kiewit's corporate office in Omaha, Nebraska. With the server located in Omaha, mine personnel are not required to administer the server or make backups of the data. Therefore, no additional workloads are placed on already busy mine personnel.

The on-line mapping system uses an ArcMap file as the GIS source(Figure 8). The ArcMap server in ArcIMS provides easy integration of mapping data into ArcIMS. The ArcMap server also allows for detailed symbology available in ArcMap to be displayed via ArcIMS.

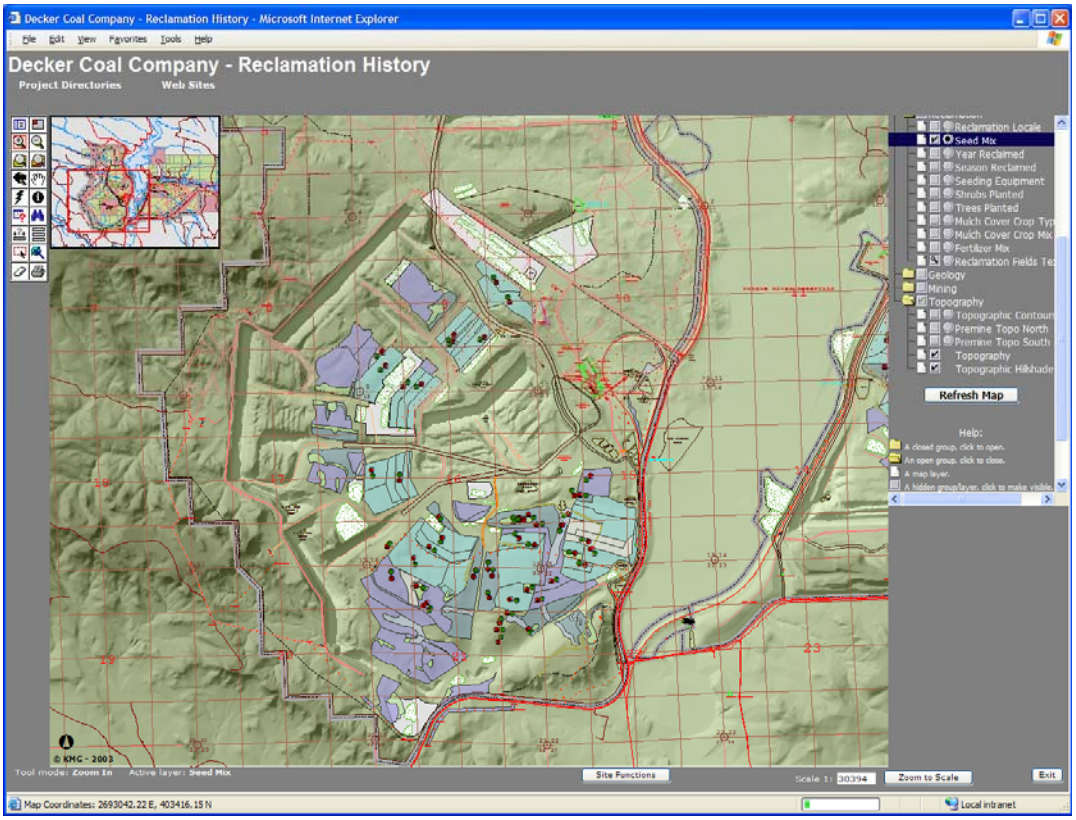
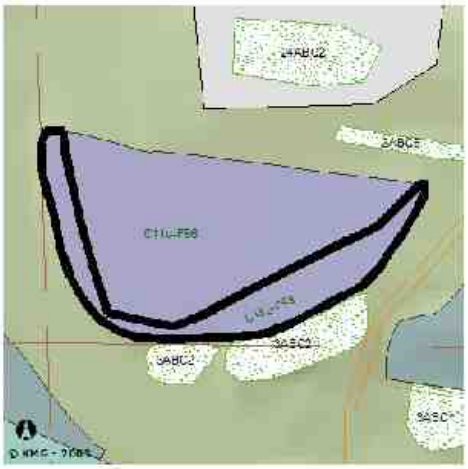


Figure 8. Decker On-line Mapping System with June 2003 Mining Topography.

A number of specific features were programmed into the Decker on-line map system. A detailed Reclamation History report generating routine was developed to imbed an image of each reclamation polygon into each page of the report (Figure 9). The reports generated from the on-line mapping system reduced the time required to produce annual reclamation history reports from several days to several hours.

Field Number: C13u-F98

Field No	C13u-F98
Location	C-Section
Area (acres)	3.26
Season	Fall
Year	1998
Topsoil Request No.	
Topsoil Request Date	
Topsoil Approval Date	
Topsoil Date	
Topsoil Depth	
Topsoil Source	TS# 24ABC
Seed Date	Fall 1998
Seed Bed Preparation	

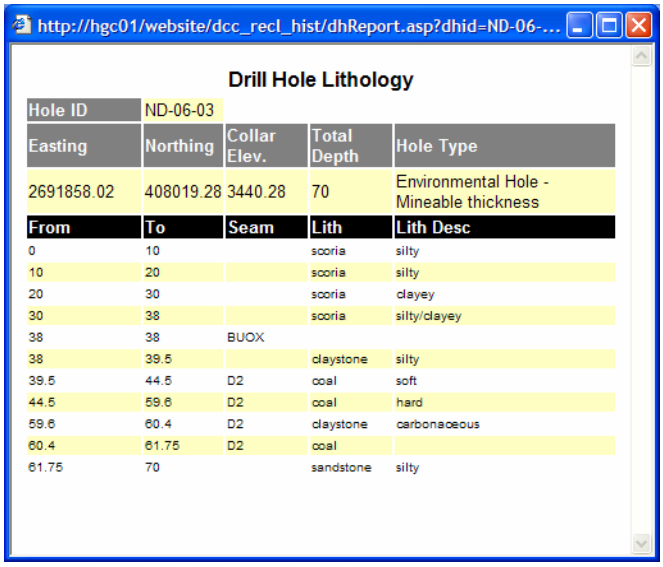


Seeding Equipment	
Seed Mix Name	Upland
Seed Mix Description	(Granite Seed Company was the seed provider in 1998) Purple Prairie Clover, White Yarrow, Blue Grama, Sideoats Grama, Lewis Blue Flax, Sainfoin, Slender Wheatgrass, Green Needlegrass, Needle & Threadgrass, Bluebunch Wheatgrass, Western Wheatgrass, Winter Barley
Shrubs Planted	Basin Big Sagebrush, Winterfat, Fourwing Saltbush
Trees Planted	
Mulch Cover Crop Date	
Mulch Cover Crop Type	
Mulch Cover Crop Mix	
Mulch Cover Crop Rate	
Mowing Description	
Fertilize Description	
Other Treatments	
Notes	
Information Source	1998 Annual Report, L.Ligocki Field Notes, Granite Seed Company seed bag tags
Phase 1 Bond Release	01-13-2004
Phase 2 Bond Release	
Phase 3 Bond Release	

Figure 9. An Example Reclamation History Report Generated from On-line Map System.

The Reclamation History Reports are generated as HTML documents. Decker typically "prints" the reports with a PDF printer driver to files that are incorporated with other annual report documents.

A drill hole summary report was also programmed into the system. The drill hole summary queries an Access2000 drill hole database and generates the summary form (Figure 10). These summaries provide quick, easy and detailed information about every drill hole on the Decker Mine.



http://hgc01/website/dcc_recl_hist/dhReport.asp?dhid=ND-06-...

Drill Hole Lithology

Hole ID	ND-06-03			
Easting	Northing	Collar Elev.	Total Depth	Hole Type
2691858.02	408019.28	3440.28	70	Environmental Hole - Mineable thickness

From	To	Seam	Lith	Lith Desc
0	10		scoria	silty
10	20		scoria	silty
20	30		scoria	clayey
30	38		scoria	silty/clayey
38	38	BUOX		
38	39.5		claystone	silty
39.5	44.5	D2	coal	soft
44.5	59.6	D2	coal	hard
59.6	60.4	D2	claystone	carbonaceous
60.4	61.75	D2	coal	
61.75	70		sandstone	silty

Figure 10. Example Drill Hole Summary
Report generated by the Online Map System

Conclusions

Developing the Reclamation History Database at Decker greatly streamlined processing and managing Decker's reclamation history data. The database also keeps the data organized and provides flexible analytical avenues for Decker.

The mine wide GIS provides Decker the ability to quickly produce high quality maps for annual reports and general mine use. The GIS also provides high quality mapping data available for use in the on-line mapping system.

The on-line mapping system for Decker reduces time required to process and report reclamation history data. The on-line mapping system allows company-wide access to Decker, thus providing another avenue for communication.

Future enhancement of these systems might include mining production statistics, real-time tracking of equipment and access to current mine plans.

Acknowledgements

We acknowledge the management of the Decker Mine for the latitude to implement GIS at the Decker Mine. With a special thanks for George Leupold and Jim Sronce. We would like to acknowledge Angela McDaniel of the Montana DEQ for her effort in providing the pre-mine topography. Finally, we wish to acknowledge the effort of Joe Galetovic, Linda Wagner and Bill Winters at the OSM for the opportunity to present our work and for providing the means for collaborating with the Montana DEQ. Their spirit and enthusiasm keeps communication between the mines and regulatory agencies of the western US professional and productive.