The Use of GIS at the Line Creek Mine

David Beranek, Sr. Env. Planner
Bill Kovach, Sr. Env. Planner

Luscar LTD., Line Creek Mine
Box 2003
Sparwood, B.C.
V0B 2G0

ABSTRACT

At the Line Creek Mine, the use of a Geographical Information System (GIS) started as a spin-off from a research program that was attempting to determine the net impact of the mine on wildlife habitat. The project involved manually overlaying the mine disturbance on top of the mine's 1:20,000 Wildlife Habitat Capability biophysical map. Upon doing this, it quickly became evident that we needed to step up from the use of overlays and planimeters to that of a GIS.

In 1997, Line Creek started using the PAMAP Software of PCI Solutions. Initially we started with the importation of the Wildlife Habitat Capability biophysical map. However, we quickly expanded the database to include the Vegetation biophysical map; the Terrain Assessment biophysical map; original topography; present day topography; mine plans; bighorn sheep telemetry data; fish telemetry data; sampling data et cetera.

With the extensive database, Line Creek now is in a very good position to begin assessing the impact of the mine on the environment from a number of different perspectives. This paper will summarize the trials and tribulations of working with GIS and put forward a few of the resulting products.

INTRODUCTION

Site Description

The Line Creek Coal Mine Operation is located in south-eastern B.C. about 15 kilometers north of Sparwood. The export mine produces both metallurgical and thermal coal. The company has a diversity of markets throughout the world. Annual production is approximately 2.1 million tonnes of metallurgical coal and 700,000 tonnes of thermal coal.

Construction of the mine commenced in May of 1980 and was completed in 1982. Mining began in July of 1981 with the first train leaving the site in February of 1982. The mine is an open pit operation with multiple pits ranging from 1500 meters in elevation to 2100 meters in elevation. Mining is performed with traditional truck and shovel and the coal is transported to the processing plant via a 10.5 kilometer cable belt.
Reclamation Program

In conjunction with start up of mining, Line Creek initiated their environmental management program. As part of this program, the company undertook an extensive biophysical inventory of the mine's Elk Valley coal properties. The inventory included a terrain analysis, vegetation mapping and a wildlife inventory. The biophysical inventory has played an integral role in providing information for long term planning of land use related to coal exploration and mining, including assessment of environmental impacts and determination of reclamation objectives.

The primary reclamation objective is to re-establish self-supporting spring, summer and fall habitat for elk and bighorn sheep, to an equal or greater level of productivity than existed prior to mining. These two species are and were common to the area both now and prior to mining and consequently the target species for Line Creek's reclamation efforts (B.C. Research 1977, TAESCO 1982, and TAESCO 1983). By restoring the habitat for these two key wildlife species, it is expected that other wildlife species will benefit as well, since the complex of wildlife species within a plant community generally have similar habitat requirements (Green and Yonge, 1984).

In 1996, after fifteen years of mining, there was a need to quantify more specifically the net impact of mining on the land base. Instead of simply reporting the total area of mine disturbance, the disturbance could be assessed and described according to its original biophysical rating. After struggling with various methods including the use of planimeters and digitizers; to the use of various mine computer software packages such as Autocad, it was concluded that the simplest and most efficient method to meet our objectives was with the use of a geographical information system (GIS).

GIS Implementation Project

Line Creek began a GIS implementation in early 1996 following a University of Lethbridge student project that included utilizing a portion of the company's biophysical data. Following this, the company purchased PAMAP GIS 4.2, and began the process of expanding the database by inputting the remainder of the biophysical data and available mine plans. In 1997, the database sat idle while Line Creek worked with PCI Pacific to summarize the data in the database and to establish output requirements. This process carried on into 1998, leading to the start of the GIS Implementation Project entitled, "Phase I: Data Inventory and Requirements Analysis". In 1999, the Implementation Project continued with Phase II and the production of a Data Dictionary and Guide.

During this time frame, through workshops and numerous discussions, a number of requirements were established resulting in a list of products that could be attained given the available data and analysis that had been specified. The general goals of implementing the project are as follows:

1. to simplify the procedure of generating maps and tables for annual reclamation reports
2. use GIS to assess, monitor, and analyze reclamation efforts
3. storing land-based data relevant to reclamation efforts in a more accessible and secure format than exists at present

PHASE I: DATA INVENTORY and REQUIREMENT ANALYSIS

System Products
In the early stages of Phase I there were a number of important products identified of the GIS. The products represent maps, tabular information, summary statistics, and the results of the analysis that will be produced using the system. The maps may be either simply output of information stored in a system or maybe the results of analysis through operations such as polygon overlays et cetera. System products identified include:

- ungulate home ranges (sheep and elk)
- telemetry data (sheep and elk)
- calculation of area lost to disturbance shown by species and habitat class
- mapping and analysis in support of annual reclamation reports
- updating of biophysical maps within disturbed areas
- permanent sample-site(s) map(s)
- analysis and output of biophysical maps
- sensitivity maps output
- mapping of riparian areas / fish habitat

For each system product or output listed, the following information is provided:

- a description of the analysis/output and how it is used to support reclamation efforts
- the data required to generate the product
- if relevant, the portion of the data that will be used
- in general terms, what steps are required to be performed
- if available, details on the format the output will take
- an estimation of the priority of the product (high, medium, or low)
- any other relevant information

Objectives
The objectives of the GIS implementation are as follows:

1. Production of maps, summary statistics, and analysis in support of annual reclamation reporting.
2. Support for reclamation planning, monitoring and decision-making. The quality of decision-making should improve because of the software's ability to model and analyze land-based information.
3. Archiving of data for future output and analysis. To allow for future analytical uses of the data, the data inventory includes information not immediately required for analysis or output, but whose existence in the GIS data set will make the system adaptable for future uses.
Each system product fits into one or more of the three listed objectives. The relationship between the products and the objectives are detailed in Figure I.

Figure I: Relationship between Products and Objectives
Data Decomposition

Following the identification of the analytical and output requirements, PCI put the data through a decomposition process to better understand the nature of analysis or processes and the outputs required of the GIS. PCI broke the requirements down into core data and processes and developed the flow chart as seen in Figure II.

Figure II: Flow Chart Demonstrating Data Decomposition
Data Inventory

PCI also performed an inventory of the data in a very structured manner designed to determine information that allowed the information to be described in detail and to assess the procedures required to input the information into the GIS. During the inventory the following information was gathered:

- purpose of the map or data, including a general description of what is stored
- the 'ownership' or source of the data within Line Creek
- who was/is responsible for the collection and update of the data
- the format of the data ie. if it is in digital format, specifications of the digital information
- identification of work that would be required to convert data to a format usable in PAMAP GIS 5.2

PHASE II: DATA DICTIONARY and GUIDE

In 1999, the GIS implementation project continued with the development of a comprehensive data dictionary governing spatial data and attribute data as identified in Phase I. The data dictionary covered all data associated with objective 1, which is information required to support Annual Reclamation Reporting. Data associated with objectives 2 and 3 will be added in subsequent amendments.

The Data Dictionary details the data modelled in the Line Creek GIS and describes the following:

- logical data entities stored in the GIS
- data storage and representation within PAMAP GIS
- topological and other relationships between data in the system
- general mapping and data update rules

The Line Creek Mine Reclamation GIS data set is be projected in UTM Zone 11 using the North American Datum 83 (NAD 83).

Logical Data Diagram

Figure III is a logical data diagram which shows the physical relationships between data in the system.

Data Entities

The description of each data entity in the data diagram is formatted as follows:

<table>
<thead>
<tr>
<th>BUSINESS ENTITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description of business entity</td>
</tr>
<tr>
<td>Feature(s)</td>
</tr>
<tr>
<td>Description of feature(s)</td>
</tr>
<tr>
<td>History:</td>
</tr>
<tr>
<td>Source of data, where applicable</td>
</tr>
</tbody>
</table>
Data Storage and Representation

This section in the dictionary describes where data is stored in the GIS data sets. It also describes some of the relationships between features such as topological relationships. Data is organized by data type and describes line, point, area, and raster data. PAMAP GIS graphical index tables are also described which control the manner in which data and annotation is represented in a map.

Figure III: Logical Data Diagram
Description of Database Attributes and Values

All user defined database attributes are listed in tables along with domain rules (listing of possible values) for a given data set. An example of this type of description is in Table I.

Table I: User Defined Database Attribute

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Data Type</th>
<th>Length</th>
<th>Description</th>
<th>Req'd</th>
<th>Unique</th>
<th>Domain Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAGID</td>
<td>Character</td>
<td>20</td>
<td>Unique ID: Link to PAMAP Internal Database</td>
<td>Yes</td>
<td>Yes</td>
<td>Any alphanumeric value</td>
</tr>
<tr>
<td>Dtype</td>
<td>Character</td>
<td>3</td>
<td>Type of PAMAP internal attribute database</td>
<td>Yes</td>
<td>No</td>
<td>PLY; PNT; VEC</td>
</tr>
<tr>
<td>Level</td>
<td>Numeric</td>
<td>2</td>
<td>Internal PAMAP database level number</td>
<td>Yes</td>
<td>No</td>
<td>Integer values 1 to 64 inclusive</td>
</tr>
<tr>
<td>Sheep ID</td>
<td>Number (long)</td>
<td>4</td>
<td>Numeric value identifying collar</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Date</td>
<td>Date/Time</td>
<td>8</td>
<td>Date of relocation</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

PAMAP GIS Feature Classes and Feature Groups

All of the Line Creek data were provided with feature class definitions as on Table II. The table contains only a small portion of the total feature classes. As feature classes are dependent on the data loading cycle, the feature class grid will be completed over the duration of the project.

Table II: Feature Class Definitions

<table>
<thead>
<tr>
<th>Feature Class Name</th>
<th>VL</th>
<th>Types</th>
<th>GI</th>
<th>CI</th>
<th>AI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lease Area Boundary</td>
<td></td>
<td>2DLine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1998 Sheep Telemetry Vector</td>
<td></td>
<td>2DPoint</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wildlife BSA Boundary</td>
<td></td>
<td>2DLine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetation Inventory Unit Boundary</td>
<td></td>
<td>2DLine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fisheries Telemetry Location</td>
<td></td>
<td>2DPoint</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The feature grid identifies the feature class that defines each feature group. Use of any feature group will affect all feature class data entities associated with it. Table III is a shortened feature class grid.

Table III: Shortened Feature Class Grid

<table>
<thead>
<tr>
<th>Feature Group Name</th>
<th>Feature Classes</th>
<th># FCs in Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wildlife BSA Boundary</td>
<td>Wildlife BSA Boundary Study Area Boundary</td>
<td>2</td>
</tr>
<tr>
<td>Terrain BSA Boundary</td>
<td>Terrain BSA Boundary Study Area Boundary</td>
<td>2</td>
</tr>
<tr>
<td>Fisheries BSA Boundary</td>
<td>Fisheries BSA Boundary Study Area Boundary</td>
<td>2</td>
</tr>
<tr>
<td>Vegetation Inventory Unit Boundary</td>
<td>Vegetation Inventory Unit Boundary Study Area Boundary</td>
<td>2</td>
</tr>
</tbody>
</table>
**Data Linkages and Relationships**

Relationships between data are either topological or derived. A topological relationship is where a feature class or feature group is used to form GIS topology. A derived relationship is where a set of data is derived through interpolation or other means. This can be one of polygon, point, or line topology and essentially means the linking of spatial data to records in an attribute database. In the case of polygon topology, a feature group will be used as the boundaries of a polygon cover.

**Polygon Topology**

Polygons are formed in PAMAP GIS by running the program Convert Vectors to Polygons using a feature group and a polygon database level. Table IV is a sub-list of Area Features (generalized name for the polygon cover) and the Feature Group that forms the boundary lines of the polygon cover.

<table>
<thead>
<tr>
<th>Area Feature</th>
<th>Feature Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wildlife BSA</td>
<td>Wildlife BSA Boundary</td>
</tr>
<tr>
<td>Vegetation Inventory</td>
<td>Vegetation Inventory Unit Boundary</td>
</tr>
<tr>
<td>Fluvial Processes SI</td>
<td>Derived Data</td>
</tr>
<tr>
<td>Fisheries SI</td>
<td>Derived Data</td>
</tr>
</tbody>
</table>

**Derived Data**

Derived data is created as a result of processing and analysis routines in PAMAPGIS. Table V is a sub-list of the linkages of derived data. The table lists the resultant data, the formula by which the data was formed and the contributing data such as a polygon cover, a feature group, or a surface cover.

<table>
<thead>
<tr>
<th>Feature Group Name</th>
<th>Feature Classes</th>
<th># FCs in Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEM</td>
<td>Interpolated</td>
<td>DEM Point Data</td>
</tr>
<tr>
<td>Terrain BSA Boundary</td>
<td>Derived</td>
<td>DEM Surface Cover</td>
</tr>
<tr>
<td>Vegetation Inventory Unit Boundary</td>
<td>Interpolated</td>
<td>1998 Sheep Relocation</td>
</tr>
</tbody>
</table>

**Mapping Standards and Update Procedures**

To ensure that new data is more consistent and as accurate as existing data, a set of mapping standards was developed. This was necessary because PAMAP GIS provides no way of forcing data to conform to a set of standards. Such things as feature class tables, index tables, as well as level diagrams also assist in this process.

The mapping standards include:

- map boundaries and coordinate resolution
- datum and projection
- scale
• map specifications
• topology
  • database tags-spatial link to attribute data
  • quality of data-vector cleaning
  • topology formation
  • digitizing and importing data

**Map Updating Procedures**

The final section of the data dictionary deals with map updating procedures. This section describes, for each entity in the data set, the methods and procedures required to update the data. This includes:

• source
• frequency of update
• reason for update
• method for update archiving procedure and destination of archived data

**FUTURE DIRECTION**

**Phase II Year 2 - GIS System Design and Implementation**

1. Incorporation of additional data into the system data dictionary and data standards as required.

2. Loading of remaining data into the Line Creek GIS that includes but will not necessarily be limited to the following:
   • Biophysical Sensitivity Assessment- Sensitivity Index Map
   • Additional TRIM Base Map Information
   • Aerial Photography
   • Ownership
   • Permanent Sample Plot Sites
   • Historic Radio Telemetry
   • Historic Home Ranges
   • Wildlife Observations
   • Fisheries investigations

3. Design of analysis and output for system objectives 2 and 3, which include 'Reclamation Planning and Decision Support' and 'Data Archiving and Future Applications'.

4. To continue with the training of Line Creek environmental staff. Training will include reviews of the previous year's activities and work on additional analytical requirements.

5. To produce a Line Creek Mine GIS Users Manual complete with documentation, incorporating data collected in Phase II, Year 2 and modifications to the data dictionary and standards. The manual will explain the data dictionary and standards; update procedures and other operational issues.
REFERENCES


PCI PACIFIC, 1998, Line Creek Mine GIS Implementation Project, Phase I Data Inventory and Requirements Analysis, prepared for Luscar Ltd. Line Creek Mine
