

Geospatial Tracking of Coal Bond Release in Wyoming

Wyoming Pilot Project - GIS/GPS/Remote Sensing Technology for Bond Release

Cooperative Effort between:

- Wyoming Department of Environmental Quality (WDEQ)
- Powder River Coal Company (PRCC)
- Office of Surface Mining/Technical Innovation and Professional Services (OSM/TIPS)

Project Objective

Implement a GIS based system to track and verify the reclamation and bond release status at the North Antelope/Rochelle Mine and Caballo Mine. The pilot project would test the use of GIS, GPS and Remote Sensing technologies in the tracking/verification of reclamation and bond release status.

Major Tasks/Action Items – Completed

- June/03– Kick-off Meeting and Pilot Project Proposal Signoff
- July – Needs Assessment performed/developed from DEQ’s “Guideline No. 20 – Bond Release Procedures for Coal Mining Operations”
 - GIS directory structure developed on WY DEQ Intranet Drive
 - GPS training/development for both Cheyenne & Sheridan
 - GIS digital data requested from Powder River Coal Co. (PRCC)
 - Remote Sensing Imagery Ordered and Received for both North Antelope/Rochelle (NARM) and Caballo Mines

Major Tasks/Action Items – Completed cont.

- August – GIS electronic data received from PRCC
 - Geo Data Base schema developed and start of geoprocessing of GIS data
- Sept. -OSM provided GIS and Remote Sensing training – Denver (both DEQ and PRCC)
- Oct/Present - Developed MetaData criteria and applied it to the GIS Data
 - Continued GeoProcessing GIS data
 - GPS gathered data sets for both mines
 - Caballo Bond Application (Nov.03)

GIS Data Identified from Needs Assessment

Existing & Post Mine Topography

Permit Boundaries

Proposed and Approved Bond Release Boundaries (Area, Phase 1, Phase 2, Phase 3 & Sediment Control)

Post Mining - Hydrology, Vegetation, Wildlife, Structures & Land Use

Topsoil Redistribution Verification

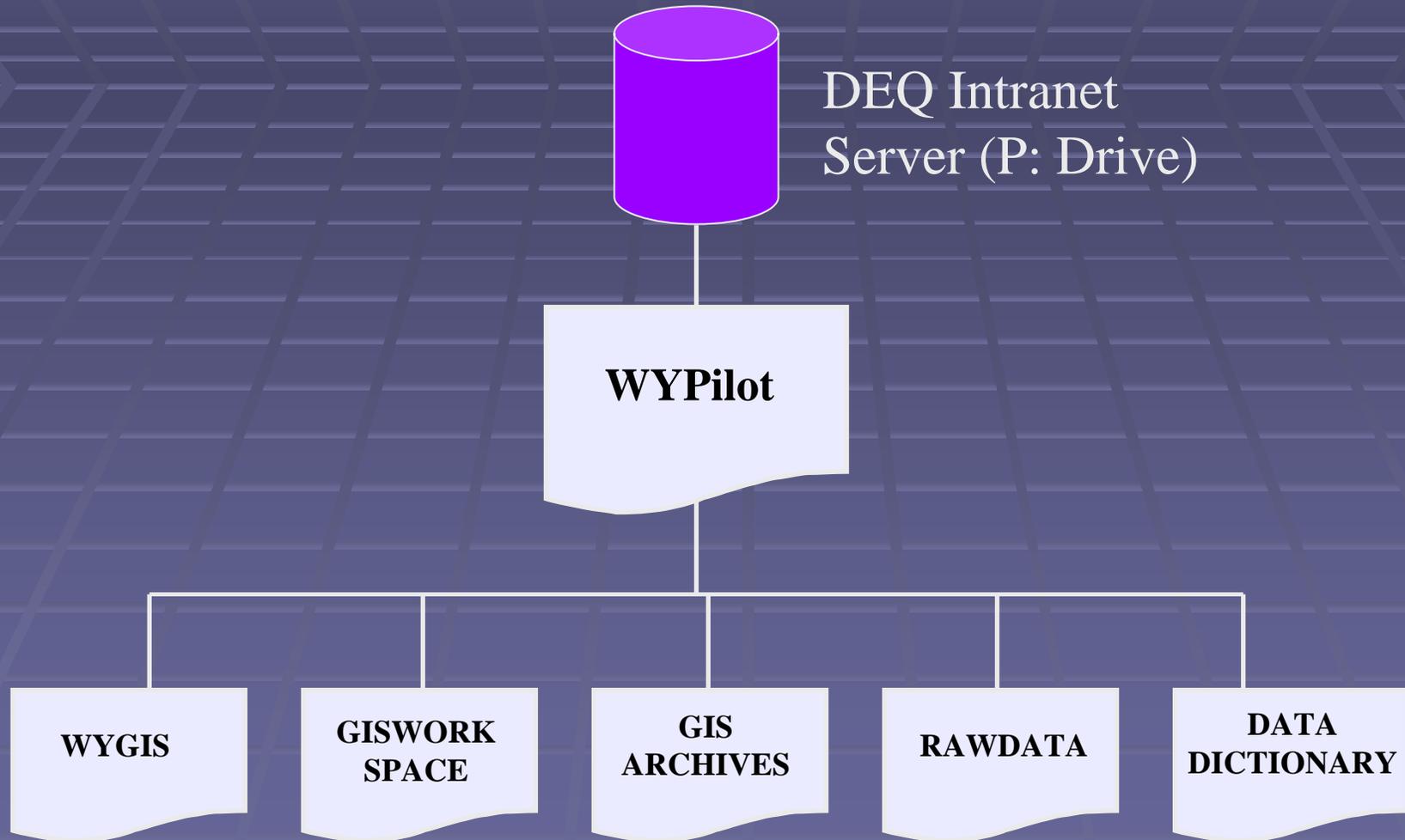
Aerial Imagery

Surface Ownership

Special Permit Commitments

GPS – Slope, Topsoil depth, Wildlife structures, etc.

GIS Data Organization on WY DEQ Server



WYGIS

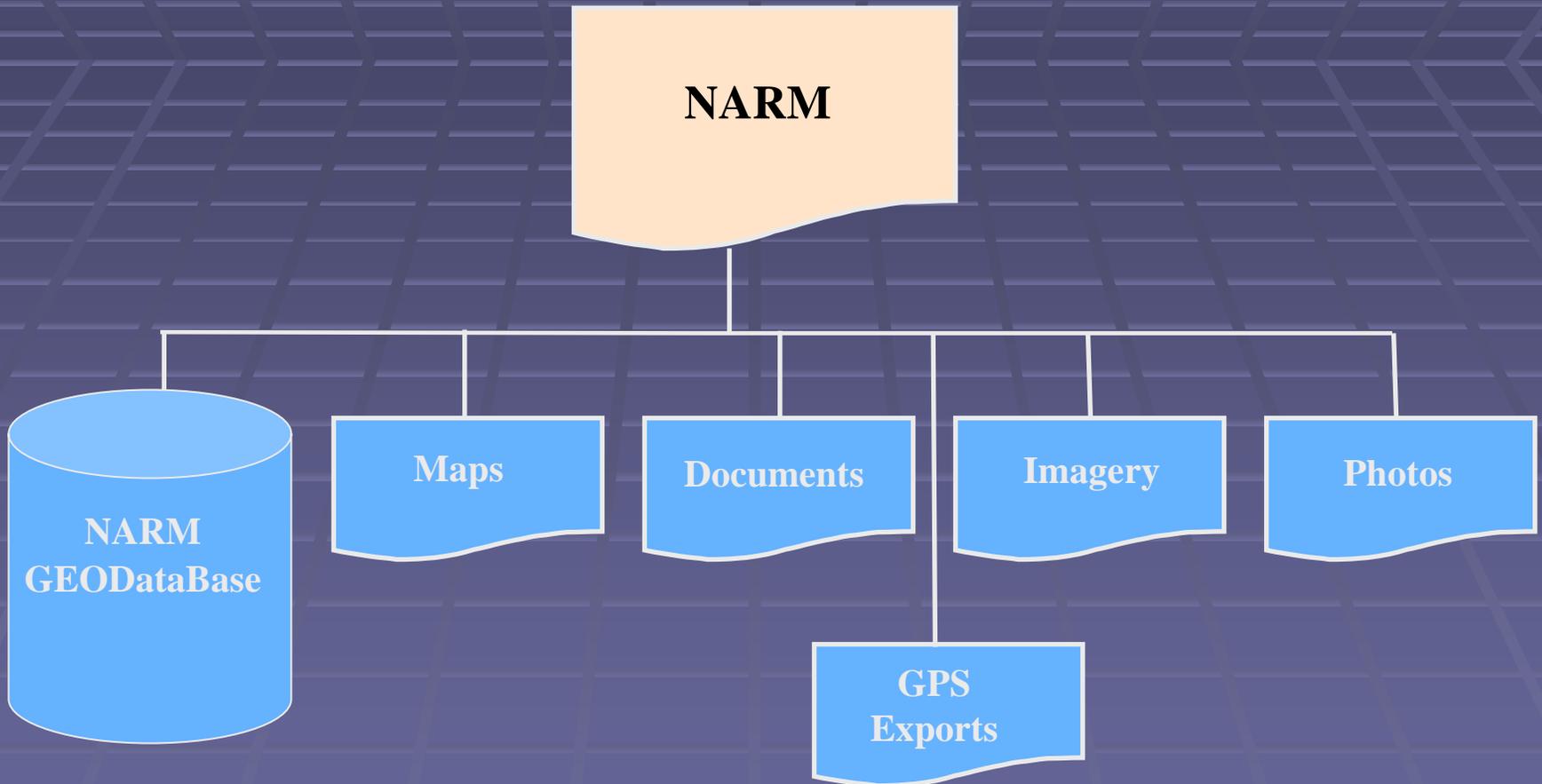
```
graph TD; WYGIS[WYGIS] --- NARM[NARM]; WYGIS --- Caballo[Caballo]; WYGIS --- Logos[Logos];
```

NARM

Caballo

Logos

Production Area for North Antelope/Rochelle Mine (NARM)



Upcoming Major Tasks/Action Items

- Finalize GPS data dictionary
- OSM/WDEQ develop standard maps and analytical methods
- Continue geoprocessing of GIS and GPS gathered data
- Continue training on advance GIS and GPS methods
- Review usage of technology for Bond Release and Reclamation
- Develop final report

Christine Mielnicki
Wyoming AML Project Officer

Wyoming Coal Facts

- Total of 54 Coal Permits Since the Conception of the Environmental Quality Act of 1973
- Currently 34 Active Permits, 88% Permits are 20+ yrs
- Permit Size 279 – 38,000 acres
- Average Permit 20-30 Volumes, 200 Full Size Maps
- Any one Term (5 years) can have 40 changes on average

Wyoming Bond Release

BOND RELEASE CATEROGIES

- 1
- 2
- 3
- 4
- 5

BOND RELEASE TYPES

Areal AR Area
Phase I
Phase II
Sediment Control
Phase III

BOND RELEASE REQUIREMENTS

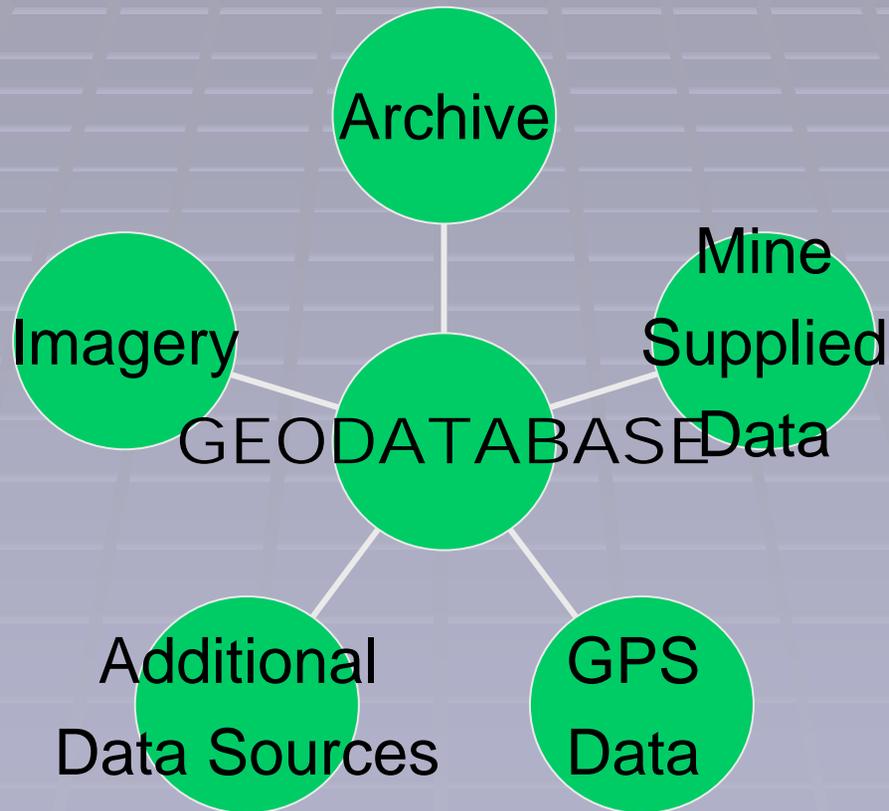
Topography
Slope Stability
Sediment Control
Vegetation
Shrub Density
Time

What Type of Data Do We Need?

Previously Identified

- Bond Release Criteria for Each Phase
- Cadastral Data
- PM Topography & Aerial Photos
- Mine Specific Information
- Photographic Documentation
- Approval Letters
- Extemporaneous/Support Data

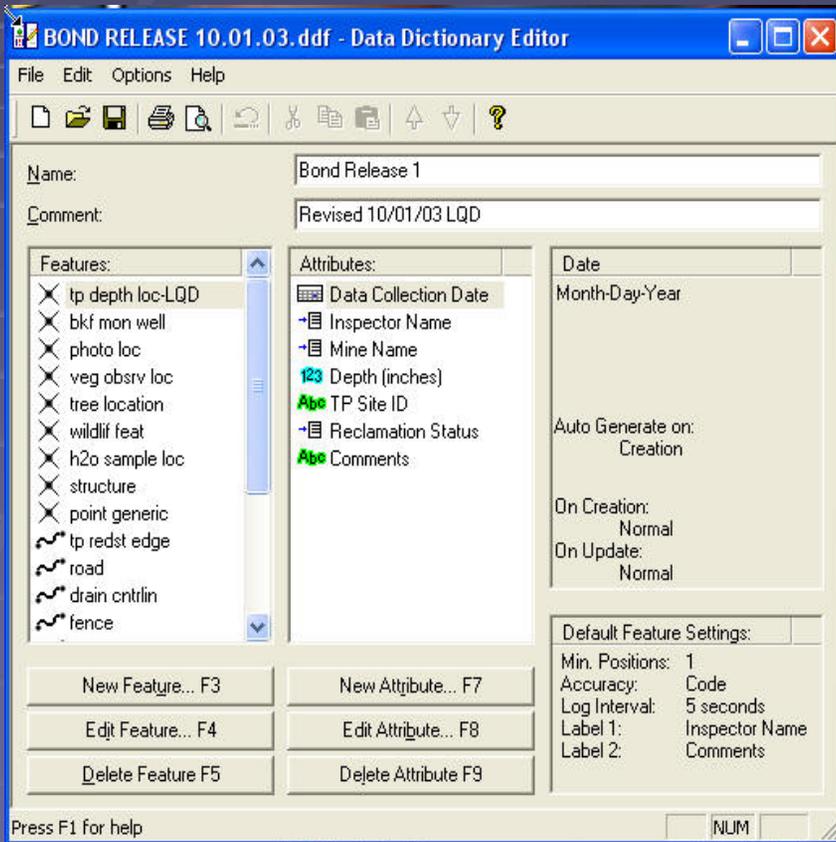
THE GIS MODEL



Step 1: Getting Started

Pathfinder 3.0 Software

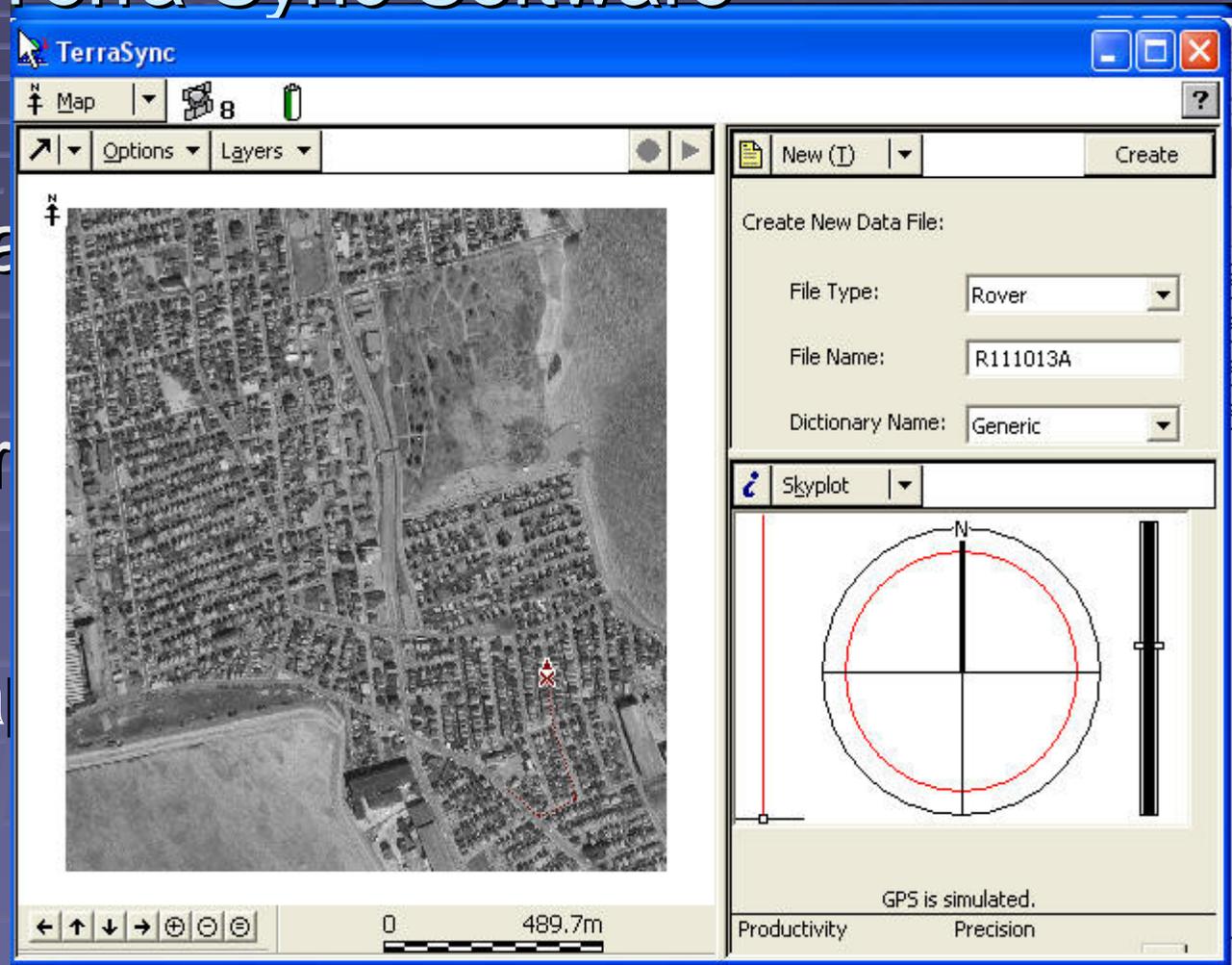
Build a Data Dictionary



- Identify Features as Points, Lines and Polygons
- Define Attributes for Each Feature

Step 2: Upload Background Files Terra Sync Software

Set Coordinates
Match File
Load Background
Choose Shape



Step 2: Data Collection & Download

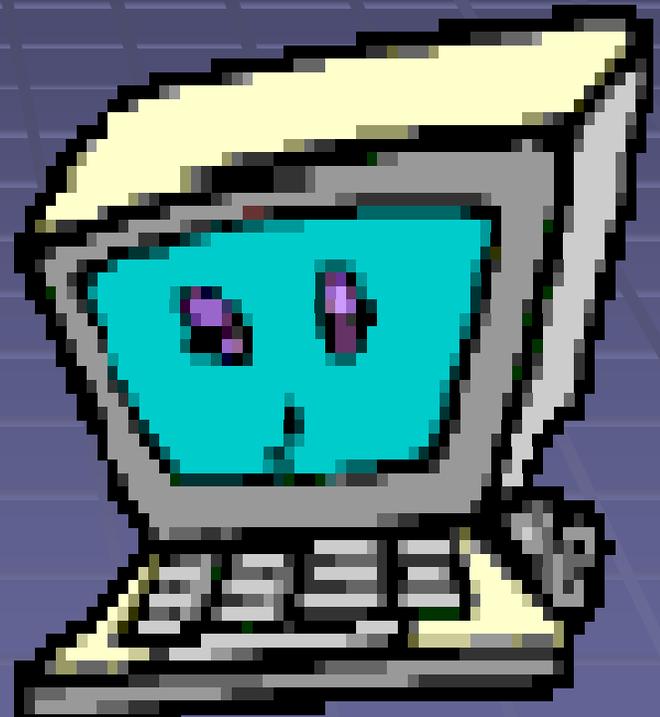
Terra Sync



Active Sync



Pathfinder Office

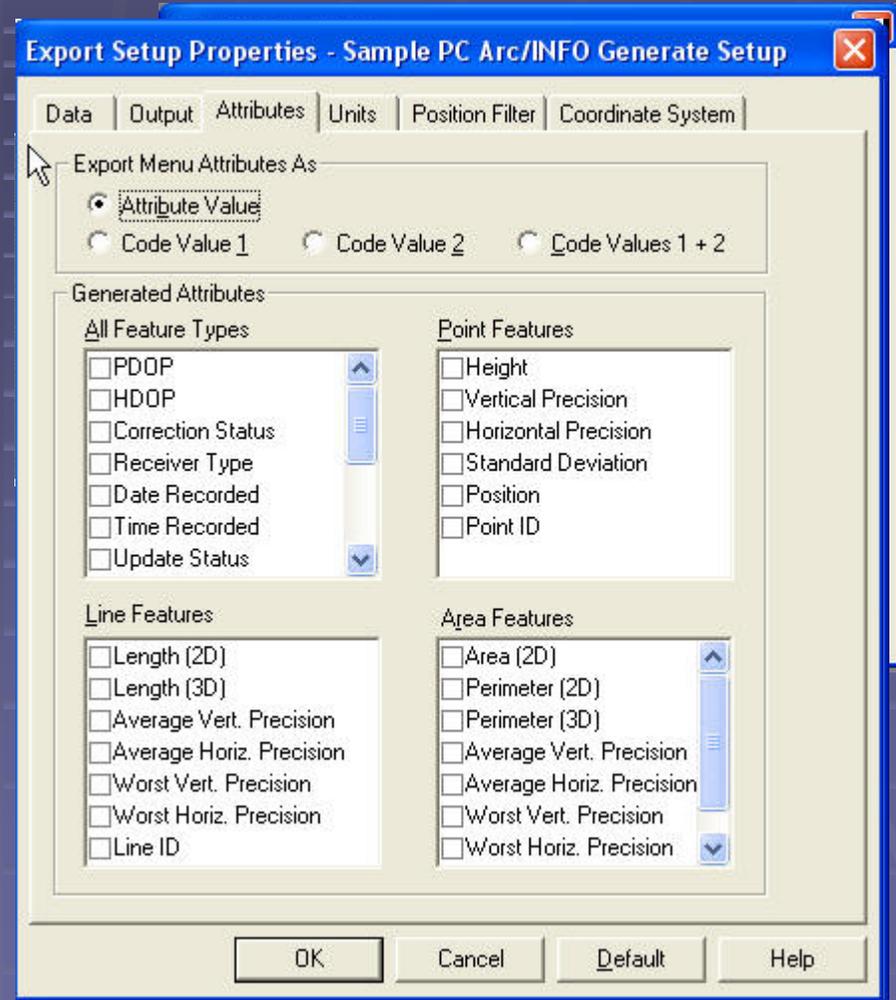


Geo Explorer XT

Desktop or Laptop

Step 3: File Preparation

- Differentially Correct Data
 - Identify Nearest Base Station
 - Set Coordinate System
- Export as Shapefile
 - Check Attributes to be Carried Over



GIS GEODATABASE

North Antelope Rockpile Mine

Current as of February 3, 2004

| GIS LAYER | | GIS ATTRIBUTES | | GPS Layers | | GPS Attributes |
|-----------------------------------|--------------|-----------------------|--|---------------------------|-----------------------|--------------------------------------|
| <u>Layer Name (Feature Class)</u> | <u>Type</u> | <u>Attribute Name</u> | <u>Attribute Properties</u> | <u>Feature Class Name</u> | <u>Attribute Name</u> | <u>Attribute Properties</u> |
| Permit Boundary | Polygon | Permit Number | (6 character text field) (calculated, floating point, double precision) | | | |
| | | Acreage | (double precision) | | | |
| | | Mine Name | (50 character text field) | | | |
| Bond_Release_Category | Polygon | Bond Category | (text, 15 character, 1-5 bond release categories and surface land) | | | |
| | | Acreage | (calculated, floating point, double precision) | | | |
| Permit_Topography | Line/Contour | Elevation | (calculated, numeric 4 digit, double precision) | | | |
| Existing_Topography | Line/Contour | Elevation | (calculated, numeric 4 digit, double precision) | | | |
| Area_Bond_Release_Application | Polygon | Poly_ID | (6 character text, YY-###) (calculated, floating point, double precision) | | | |
| | | Acreage | (double precision) | | | |
| | | LQD_Date | (date field, corresponds to LQD date stamp of submission) | | | |
| | | Comments | (50 Character text) | | | |
| Area_Bond_Release_Approved | Polygon | Poly_ID | (6 character text, YY-###, must match Proposed Bond Release Areas ID Code) (calculated, floating point, double precision) | | | |
| | | Acreage | (double precision) | | | |
| | | LQD_Date | (date field, corresponds to LQD approval letter date) | | | |
| | | Comments | (100 character text field) (Hotlink to LQD Approval Letter on P:drive, in Docs folder) | | | |
| | | Hotlink | | | | |
| Topsoil_Verification_Line | Line | Date | (calculated date field) | tp redist edge | Date | (generated date field) |
| | | Inspector_Mine_Name | (20 character text) (20 Character text) | Inspector Name | Inspector Name | (Walkers, Rogaczewski) (CM, Name) |

primary key field, Global Unique, Indexed, Indexed, Unique, No Null, Substred Only

| Field Name | Type | Properties | Field Name | Type | Properties |
|---------------------|--------------|--|---------------------|--------------|--|
| Permit_Number | Polygon | (6 character text field) (calculated, floating point, double precision) | Permit_Number | Polygon | (6 character text field) (calculated, floating point, double precision) |
| Acreage | Polygon | (double precision) | Acreage | Polygon | (double precision) |
| Mine_Name | Polygon | (50 character text field) | Mine_Name | Polygon | (50 character text field) |
| Bond_Category | Polygon | (text, 15 character, 1-5 bond release categories and surface land) | Bond_Category | Polygon | (text, 15 character, 1-5 bond release categories and surface land) |
| Elevation | Line/Contour | (calculated, numeric 4 digit, double precision) | Elevation | Line/Contour | (calculated, numeric 4 digit, double precision) |
| Poly_ID | Polygon | (6 character text, YY-###) (calculated, floating point, double precision) | Poly_ID | Polygon | (6 character text, YY-###) (calculated, floating point, double precision) |
| Acreage | Polygon | (double precision) | Acreage | Polygon | (double precision) |
| LQD_Date | Polygon | (date field, corresponds to LQD date stamp of submission) | LQD_Date | Polygon | (date field, corresponds to LQD date stamp of submission) |
| Comments | Polygon | (50 Character text) | Comments | Polygon | (50 Character text) |
| Poly_ID | Polygon | (6 character text, YY-###, must match Proposed Bond Release Areas ID Code) (calculated, floating point, double precision) | Poly_ID | Polygon | (6 character text, YY-###, must match Proposed Bond Release Areas ID Code) (calculated, floating point, double precision) |
| Acreage | Polygon | (double precision) | Acreage | Polygon | (double precision) |
| LQD_Date | Polygon | (date field, corresponds to LQD approval letter date) | LQD_Date | Polygon | (date field, corresponds to LQD approval letter date) |
| Comments | Polygon | (100 character text field) (Hotlink to LQD Approval Letter on P:drive, in Docs folder) | Comments | Polygon | (100 character text field) (Hotlink to LQD Approval Letter on P:drive, in Docs folder) |
| Hotlink | Polygon | | Hotlink | Polygon | |
| Date | Line | (calculated date field) | Date | Line | (calculated date field) |
| Inspector_Mine_Name | Line | (20 character text) (20 Character text) | Inspector_Mine_Name | Line | (20 character text) (20 Character text) |

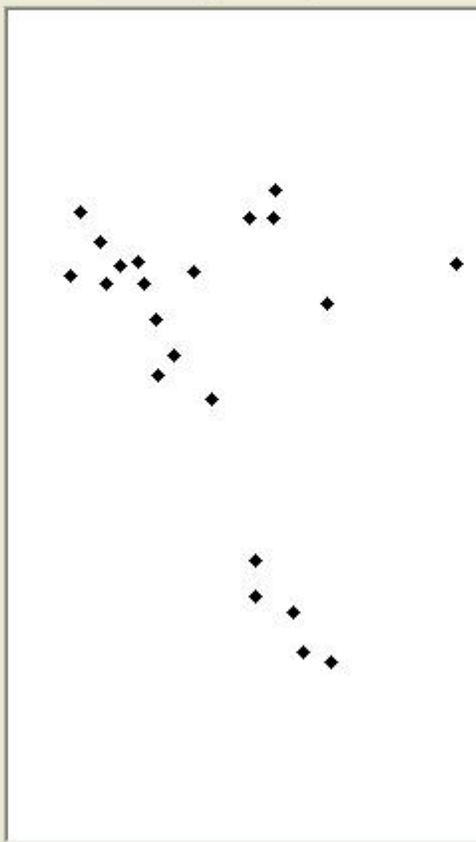


Location: P:\WyoPilot\WyoGIS\Narm\GIS_Database\NARM.mdb\Topsoil_Verification_Points

Stylesheet: FGDC ESRI

- NARM.mdb
 - Generic
 - Area_Bond_Release_Applicati
 - Area_Bond_Release_Approv
 - Bond_Release_Category
 - Cadastral_Anno
 - Cadastral_Survey
 - Erosion
 - Erosion_Feature
 - Existing_Topography
 - Generic_GPS_line
 - GW_Restoration
 - Permit_Boundary
 - Permit_Topography
 - Photo_Location
 - Post_Mine_Drainage_Basins
 - Post_Mine_Streams
 - Slope_Line
 - Surface_Ownership
 - SW_Feature_Line
 - Topsoil_Verification_Points
 - Transportation
 - Tree_Restoration
 - Wildlife_Feature_Point
 - Wildlife_Feature_poly
- GPSExports
- Imagery

Contents Preview Metadata



Preview: Geography

Feature Class Properties

General Fields Indexes Subtypes Relationships

| Field Name | Data Type |
|------------|-----------|
| OBJECTID | Object ID |
| Shape | Geometry |
| Data_Colle | Date |
| Inspector_ | Text |
| Mine_Name | Text |
| TP_Site_ID | Text |
| Reclamatio | Text |
| Comments | Text |

Click any field to see its properties.

Field Properties

Alias OBJECTID

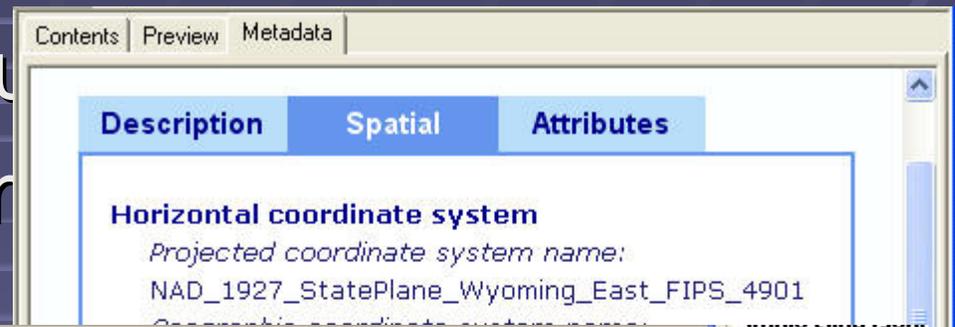
Import...

To add a new field, type the name into an empty row in the Field Name column, click in the Data Type column to choose the data type, then edit the Field Properties.

OK Cancel Apply

MetaData

- Provides Data about
- Can be Collected in XML, FGDC, ISO
- Useful



A screenshot of a metadata editor window titled 'Editing Post_Mine_Drainage_Basins'. The window has a blue title bar and a menu bar with options: Identification, Data Quality, Data Organization, Spatial Reference, Entity Attribute, Distribution, and Metadata Reference. Below the menu bar is a sub-menu bar with options: General, Contact, Citation, Time Period, Status, Spatial Domain, Keywords, Browse Graphic, Security, and Cross Reference. The main area contains several text input fields with red error messages:

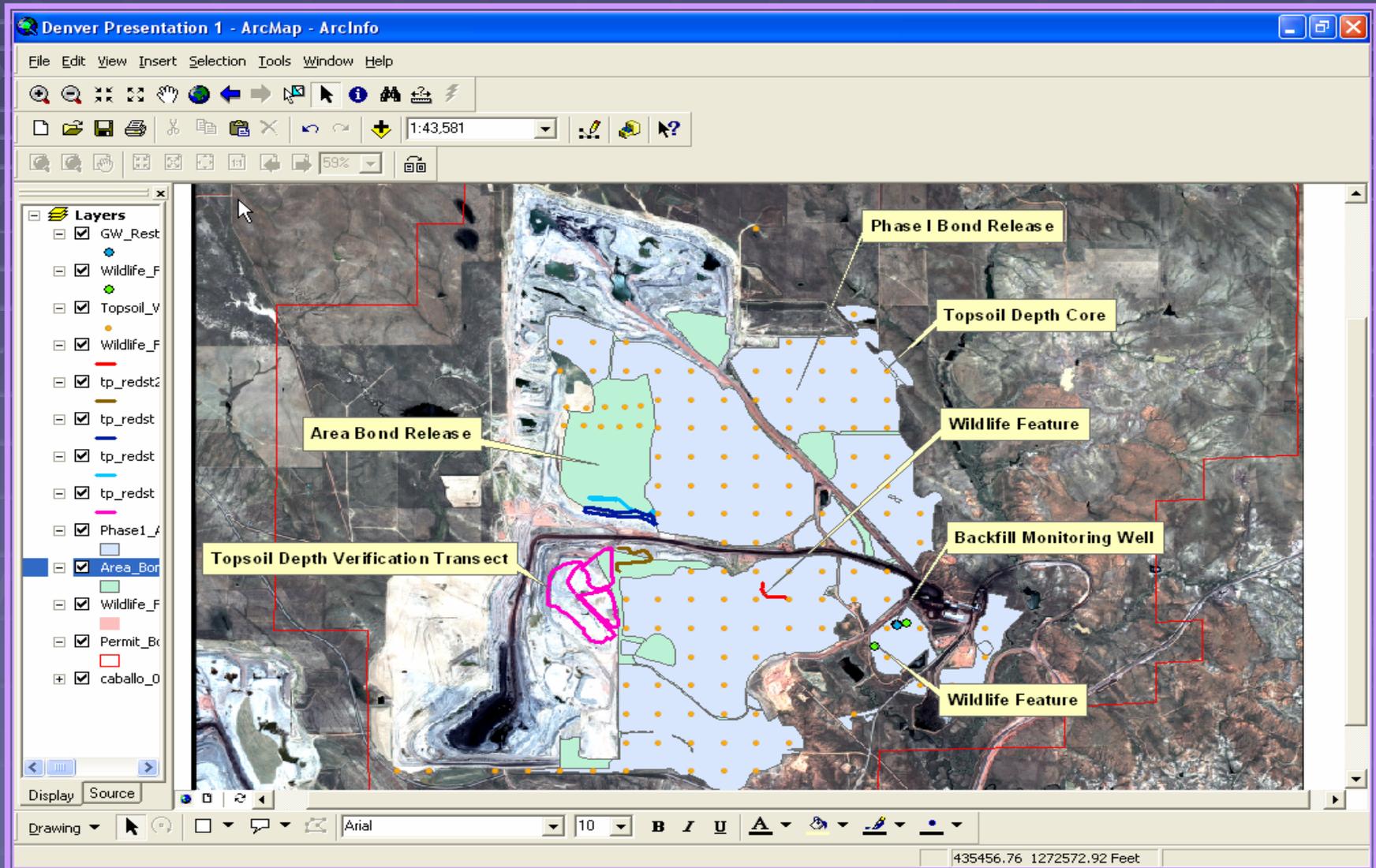
- Description:**
 - Abstract: REQUIRED: A brief narrative summary of the data set.
 - Purpose: REQUIRED: A summary of the intentions with which the data set was developed.
 - Language: en
 - Supplemental Information: (empty)
- Access Constraints:** REQUIRED: Restrictions and legal prerequisites for accessing the data set.
- Use Constraints:** REQUIRED: Restrictions and legal prerequisites for using the data set after access is granted.
- Data Set Credit:** (empty)
- Native Data Set Environment:** Microsoft Windows 2000 Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 8.3.0.800

Marcelo Calle
Wyoming LQD Hydrologist

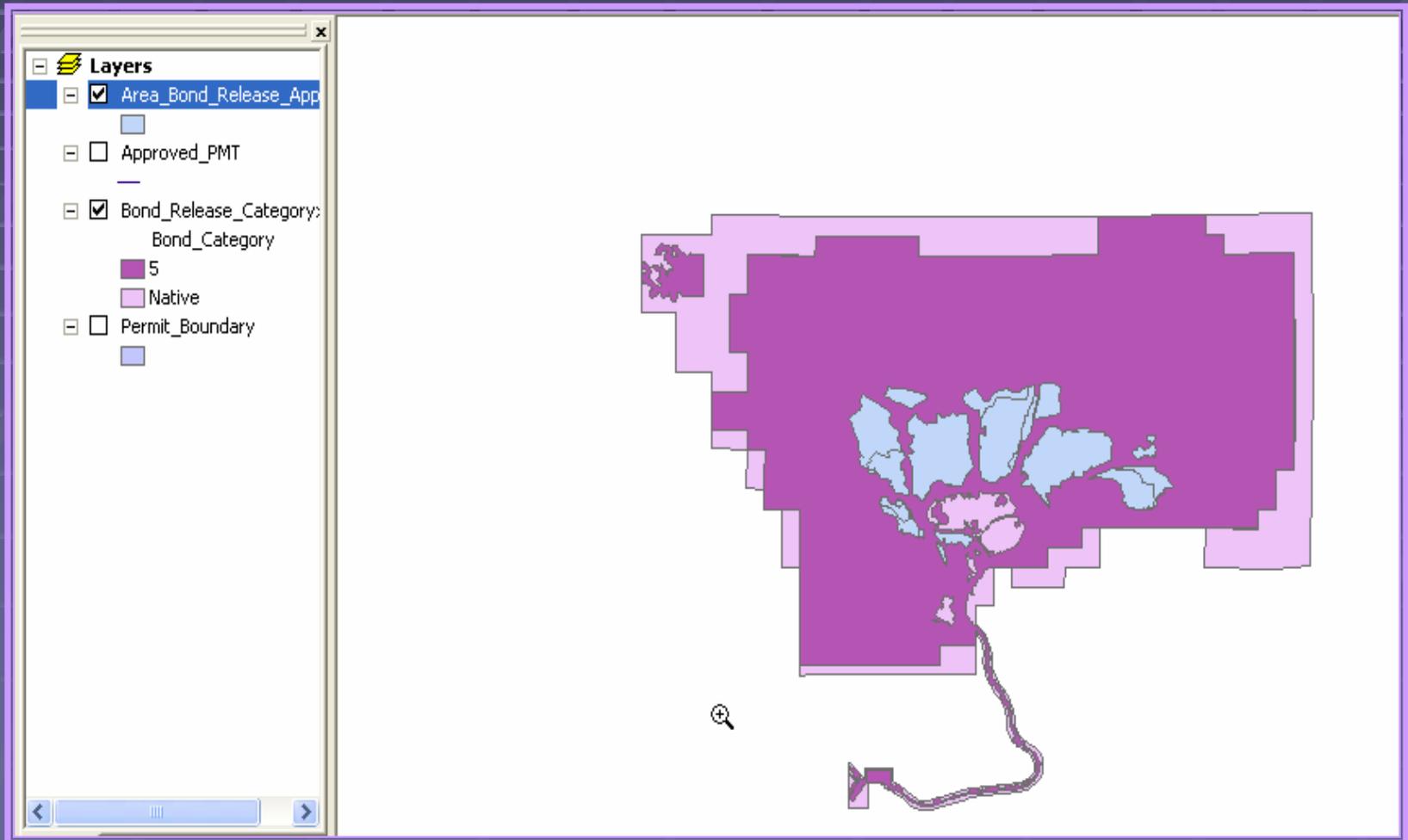
Part Two: Applications

- Bond Release **Tracking**
- **Verification** of Regulatory Commitments
- Geospatial **Analysis** that Assists the Bond Release Process

Bond Release Tracking



Inventory of Incremental Bond Release



Topsoil Redistribution Tracking

The screenshot displays a GIS application window with a map and an attribute table. The map shows a mine site with several blue diamond-shaped points representing topsoil verification points. The background is a light blue color, and there are several irregular shapes representing land parcels or features. The attribute table, titled "Attributes of Topsoil_Verification_Points", contains the following data:

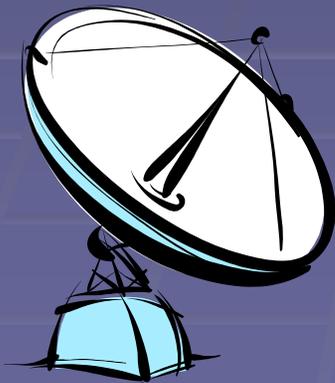
| OBJECTID* | Shape* | Data_Colle | Inspector | Mine_Name | Depth | TP_Site_ID | Reclamatio | Comments |
|-----------|--------|------------|-----------|-----------|-------|------------|------------|----------|
| 4 | Point | 9/9/2003 | Waitkus | NARM | 30 | 090903-04 | Mulched | |
| 5 | Point | 9/9/2003 | Waitkus | NARM | 18 | 090903-05 | Cover Crop | |
| 6 | Point | 9/9/2003 | Waitkus | NARM | 23 | 090903-06 | Mulched | |
| 7 | Point | 8/13/2003 | Waitkus | NARM | 30 | 081303-01 | Cover Crop | |
| 8 | Point | 8/13/2003 | Waitkus | NARM | 37 | 081303-02 | Mulched | barley |
| 9 | Point | 8/13/2003 | Waitkus | NARM | 21 | 081303-03 | Mulched | |
| 10 | Point | 8/13/2003 | Waitkus | NARM | 21 | 081303-04 | Mulched | |

The interface also shows a "Layers" panel on the left with the following layers checked:

- Topsoil_Verification_Point
- Area_Bond_Release_App
- Bond_Release_Category
 - Bond_Category
 - 5
 - Native



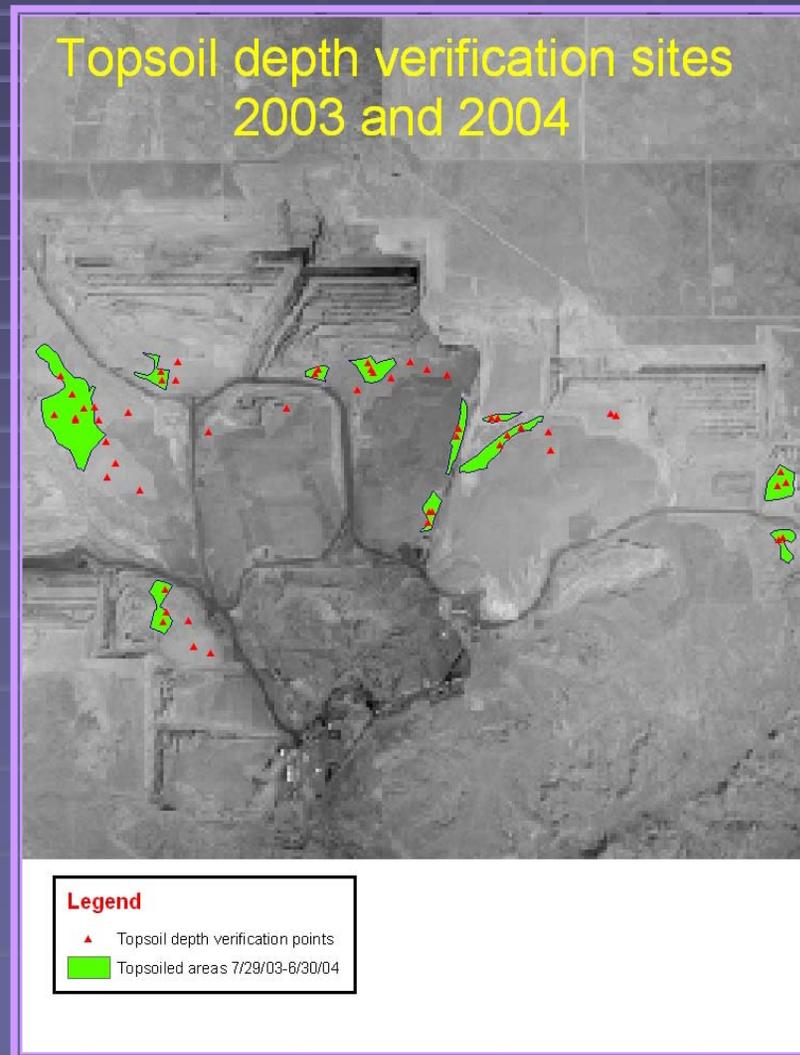
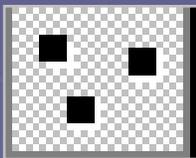
Verification of Regulatory Commitments



December 28, 2004

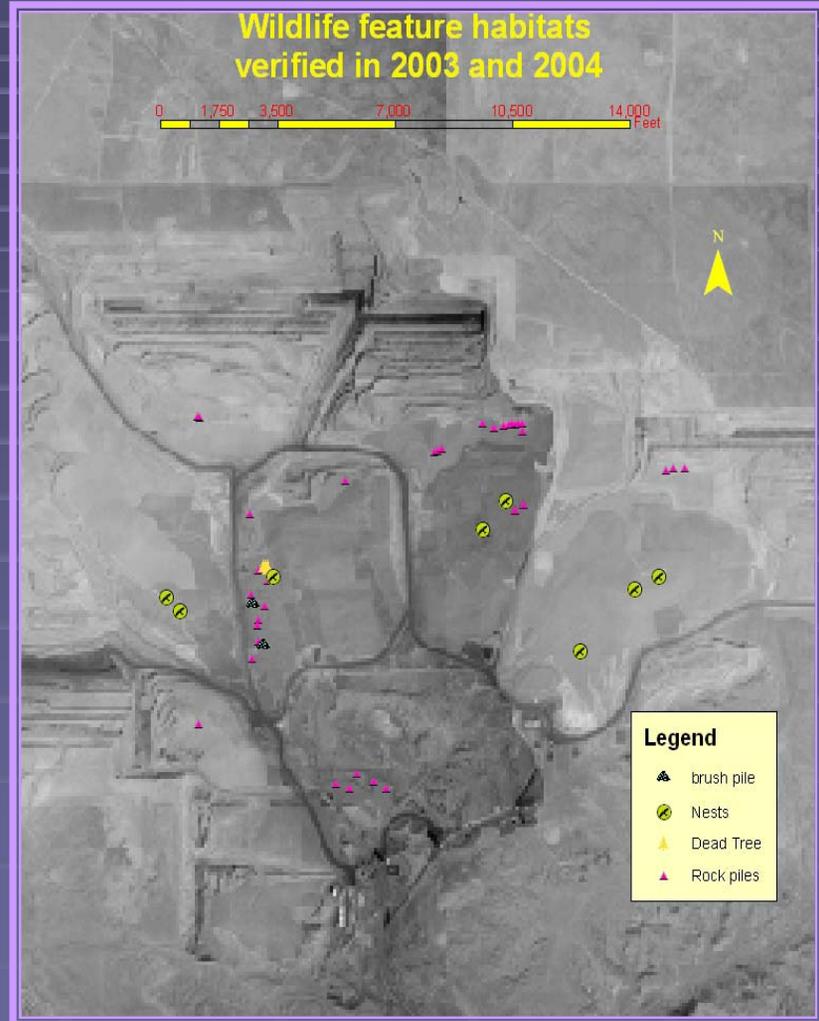
Topsoil Verification

- Point Verification
- At least one point per 50 acres



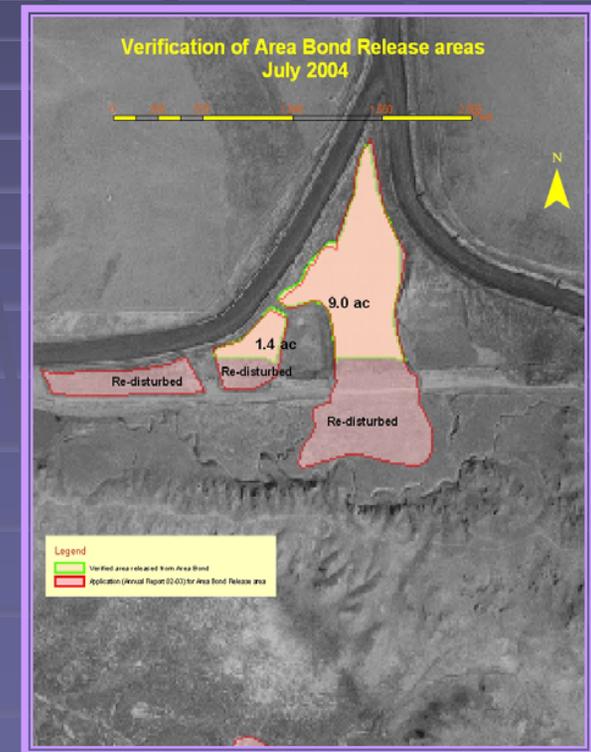
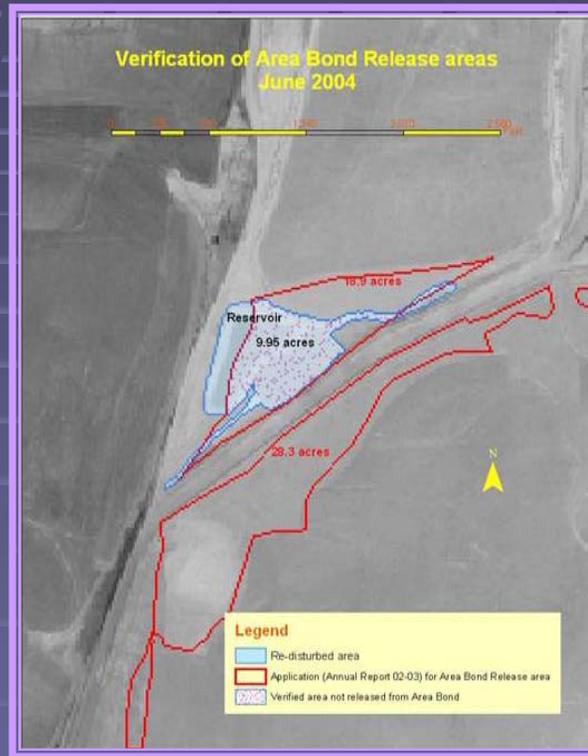
Wildlife Feature Habitat

- The permit commitment is to restore one wildlife feature per 40 acres.
- The presence of wildlife features (rock piles, nests, dead trees, shrub piles) were verified in the field in 2003 and 2004.



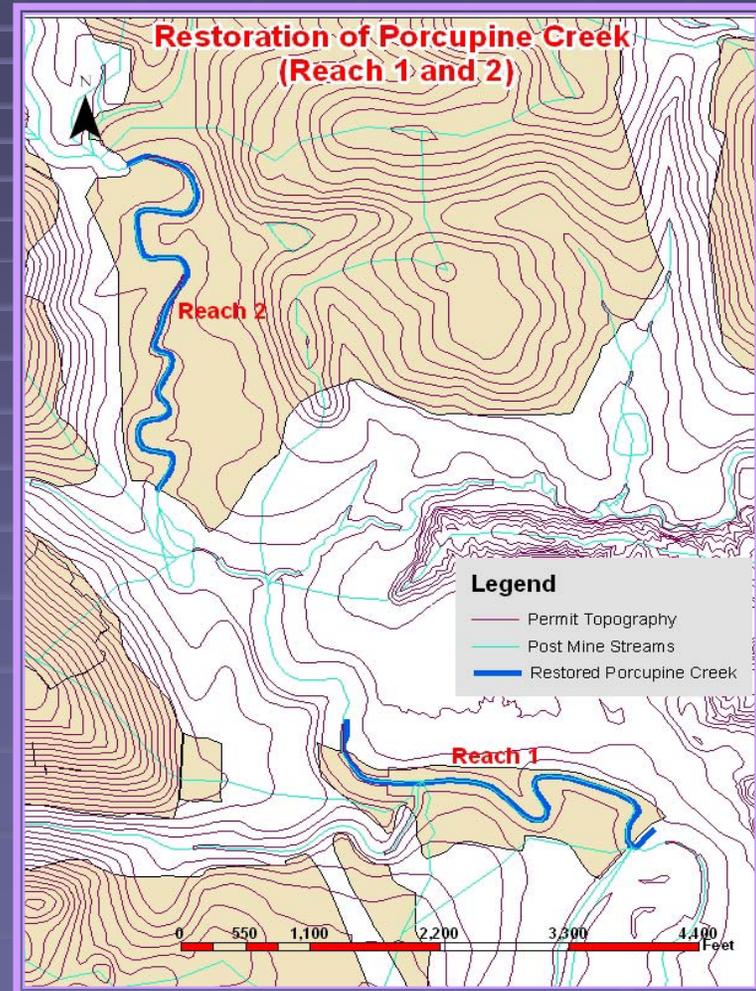
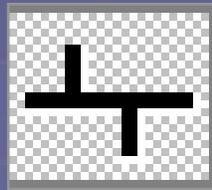
Area Bond Application

- Polygon Verification
- Does the area submitted reflect on the ground conditions?



Restoration of Creek Channels

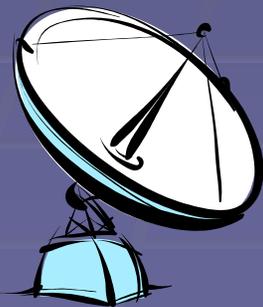
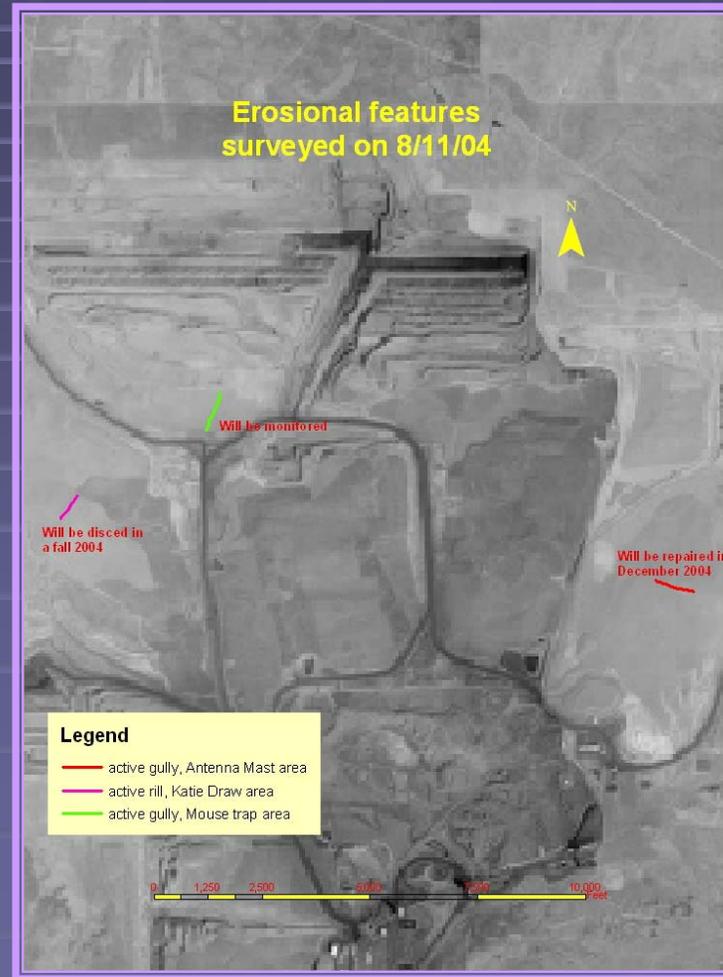
- The center line of the restored Reach 1 and Reach 2 of the Porcupine Creek was verified in the field.

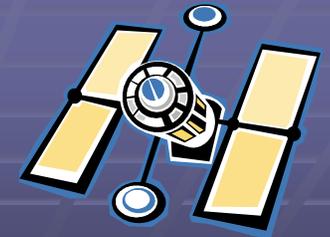


Erosion Features

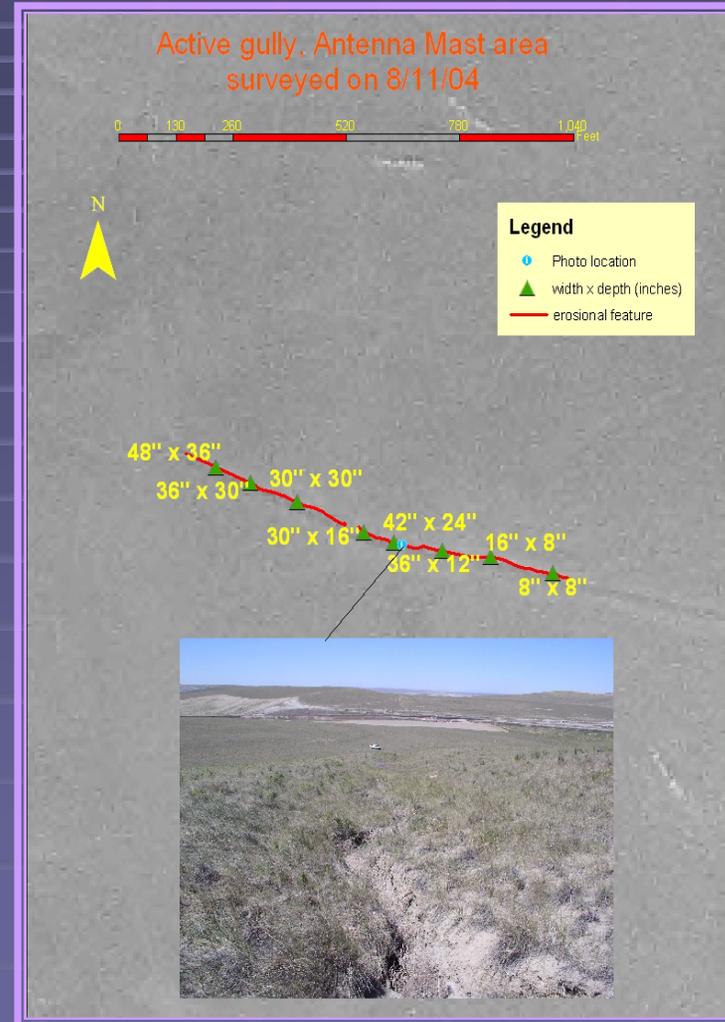
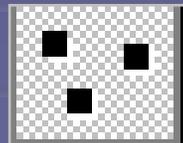
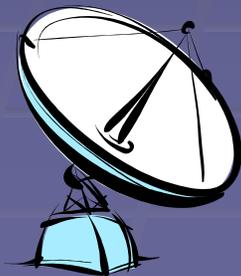
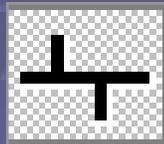


- The length of the erosional feature was measured.

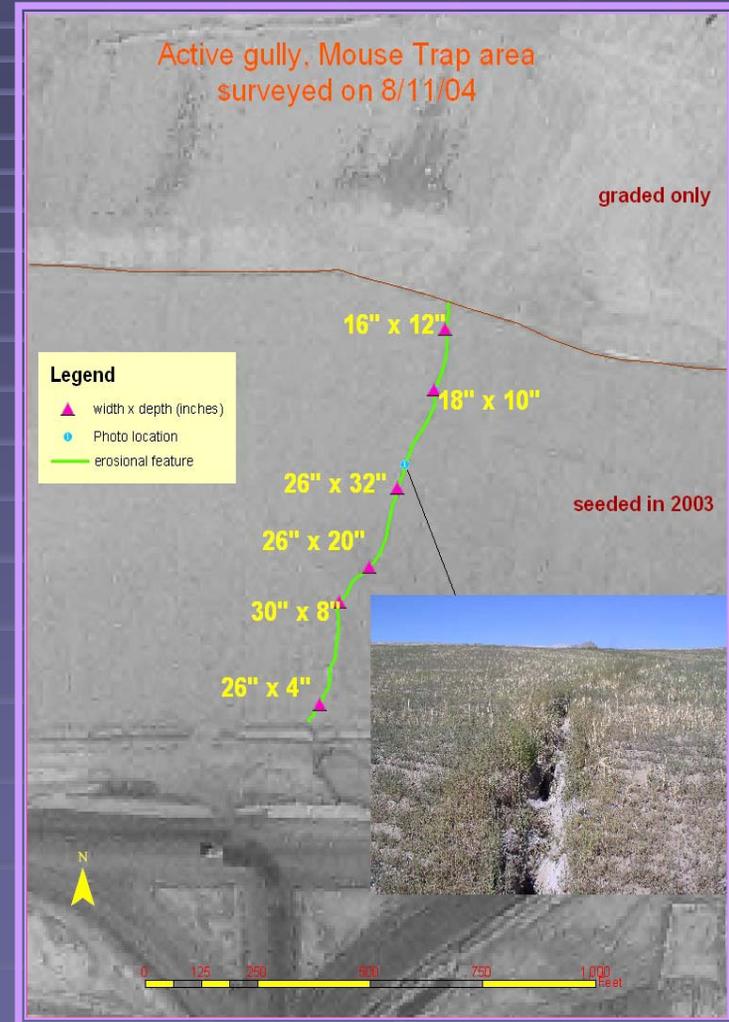




- Points were collected and the depth and width of the feature was measured.



- The recorded position of the point will allow returning to the same point in the future to monitor the development of the erosion and provide the appropriate action.

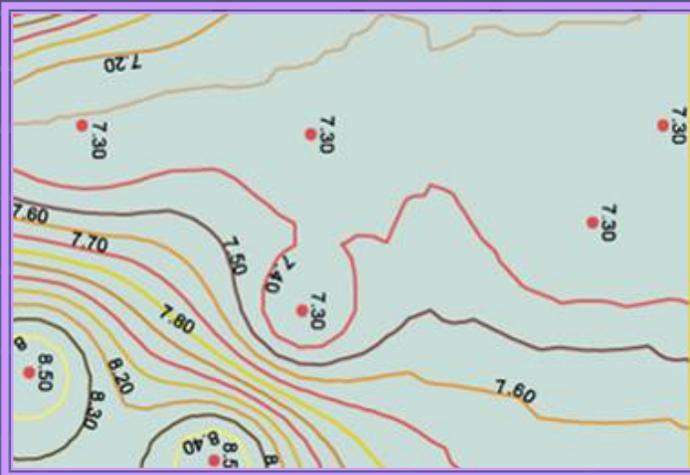


Geospatial Analysis

- What tools does the GIS offer that can be used to make our job easier, more productive and more quantitative ?
- What layers do we have in the Geodatabase that demonstrate useable spatial properties?

Spatial Analyst

- Interpolate to Raster



Vector (x, y, z)

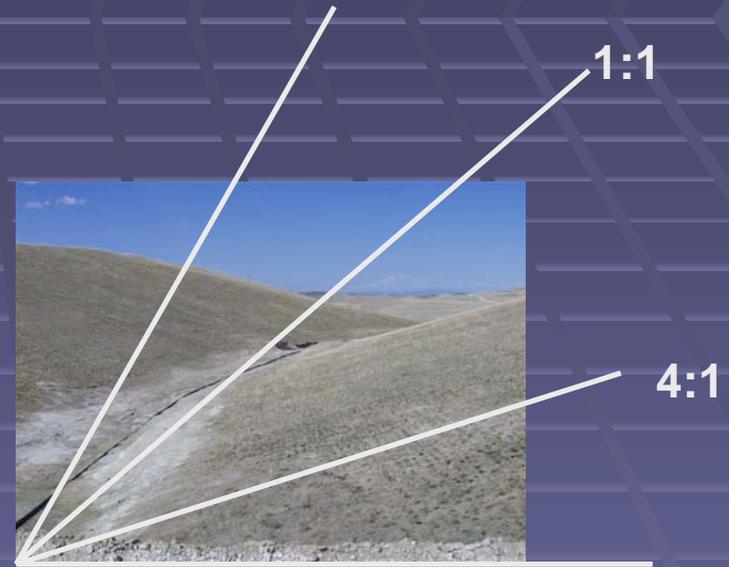


Raster (cell based)

Spatial Analyst

- Surface Analysis

Slope



Cut and Fill (volumetrics)



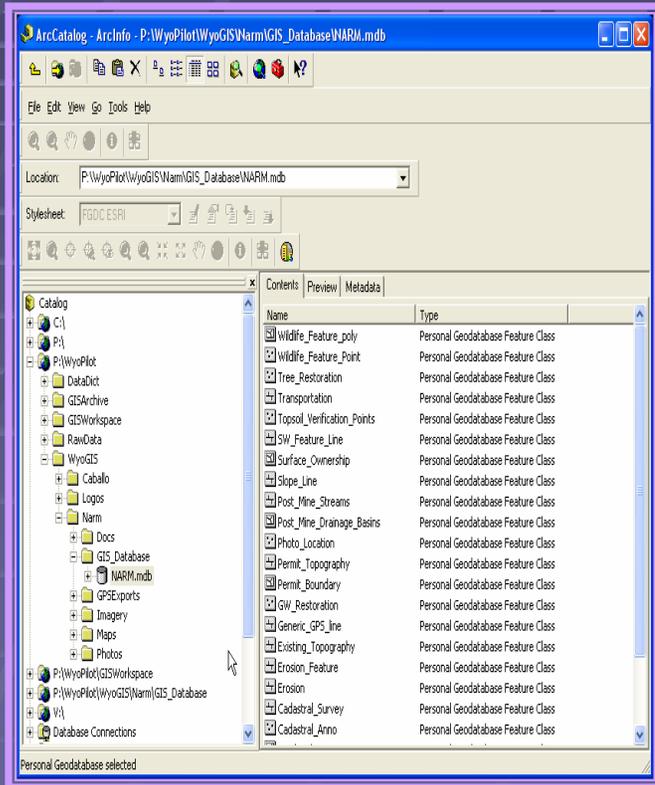
Spatial Analyst

- Raster Calculator

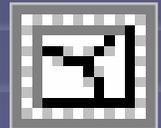
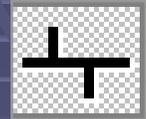
Perform a Wide Variety of Cell
vs. Cell Operations

Calculate Differences

What Layers Do We Have ?



- Permit Topography
- As Built Topography
- Area Bond Release Application
- Area Bond Release Approved
- Topsoil Verification Points



What We Came Up With ?

December 28, 2004

- *The reclaimed acreage has been backfilled and rough graded to the approved post mining topography. Upland areas should be \pm 20 feet of the approved.*



- A method to compare and evaluate the “As Built” Topography to the Approved Post Mine Topography (PMT)

- *The backfilled and rough graded slopes meet the approved permit commitments. Generally 4 or 5:1*



- A method to evaluate slope commitments

- *Verification that the approved topsoil commitments were achieved*



- A methodto evaluate topsoil replacement commitments



Spatial Analyst



3D Analyst



Editor

Location: P:\WyoPilot\GISWorkspace\NARM\Marcelo\Work\Clipept_Output.shp

Stylesheet: FGDC ESRI



Layers

- Clipex
- Applic
- Apprc
- Analy
- Existir
- narm,
- Re
- Gr
- Blu
- pmt_p
- ext_p
- Applic
- Va
- 1
- 7

- area1.shp
- Area
- bigcli
- calc2
- Clip_exist.shp
- Clip_permit.shp
- Clipaprov.shp
- Clipexpt_Output.shp
- Clippmt
- ctour2.s
- ctour3.s
- cutfil
- cutfil2
- diff
- exist
- idw19
- idw23
- permit
- slope2
- Caballo.mdb
- NARM.mdb
- Generic

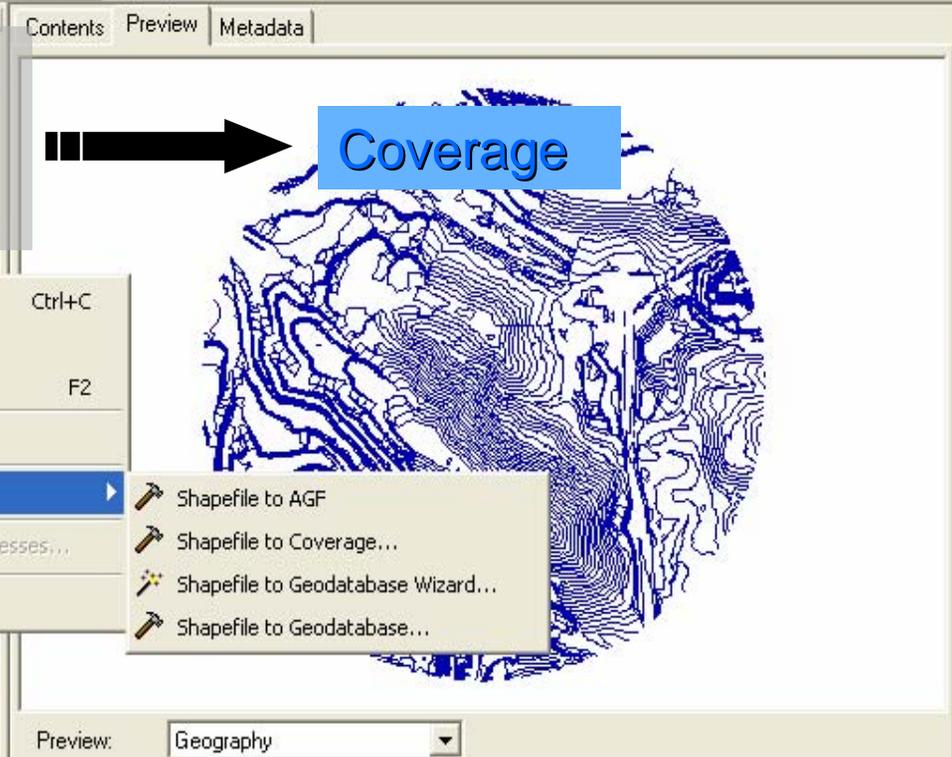
Export .shp

- Copy Ctrl+C
- Delete
- Rename F2
- Create Layer...
- Export**
- Review/Rematch Addresses...
- Propertjes...

- Shapefile to AGF
- Shapefile to Coverage...
- Shapefile to Geodatabase Wizard...
- Shapefile to Geodatabase...

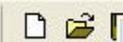


Coverage



Display Source

Drawing



Arc

```

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(JUN 1987), FAR Section 52.227-19 (JUN 1987), and/or FAR Section
12.211/12.212 [Commercial Technical Data/Computer Software] and DFARS
Section 252.227-7015 (NOV 1995) [Technical Data] and/or DFARS Section
227.7202 [Computer Software], as applicable. Contractor/Manufacturer is
Environmental Systems Research Institute, Inc., 380 New York Street,
Redlands, CA 92373-8100, USA.

Arc:
Arc: w
Current location: c:\workspace
Arc: w P:
WARNING: New location is not a workspace.
Arc: w wyopilot\gisworkspace\narm\marcelo\work
Arc: lc
Workspace: P:\WYOPILOT\GISWORKSPACE\NARM\MARCELO\WORK

Available Coverages
-----
CLIP_EXIST      CLIP_EXT      CLIP_PERMIT   CLIP_PMT
EXIST_PTS      EXT_PTS      E_PTS        PERMIT_PTS
PMT_PT

Arc: arcpoint
Usage: ARCPOINT <in_cover> <out_point_cover> <ALL ! LINE> <spot_item>
      <weed_tolerance>

Arc:

Application Difference
Value

```

Spatial Analyst



3D Analyst

Editor

Arc:

Arc: w P:

Available Coverages

Arc: arcpoint

Arc:

Application Difference

Workstation\Arc

Line_Coverage

Point_Coverage



Display Source

Drawing [Cursor] [Symbol] [Font: Arial] [Size: 10] [Bold] [Italic] [Underline] [Color] [Line Style]

[Zoom In] [Zoom Out] [Home] [Previous View] [Next View] [Full Screen] [Scale: 100%]

Standard toolbar with icons for file operations, navigation, and editing. A scale bar shows 1:30,173.

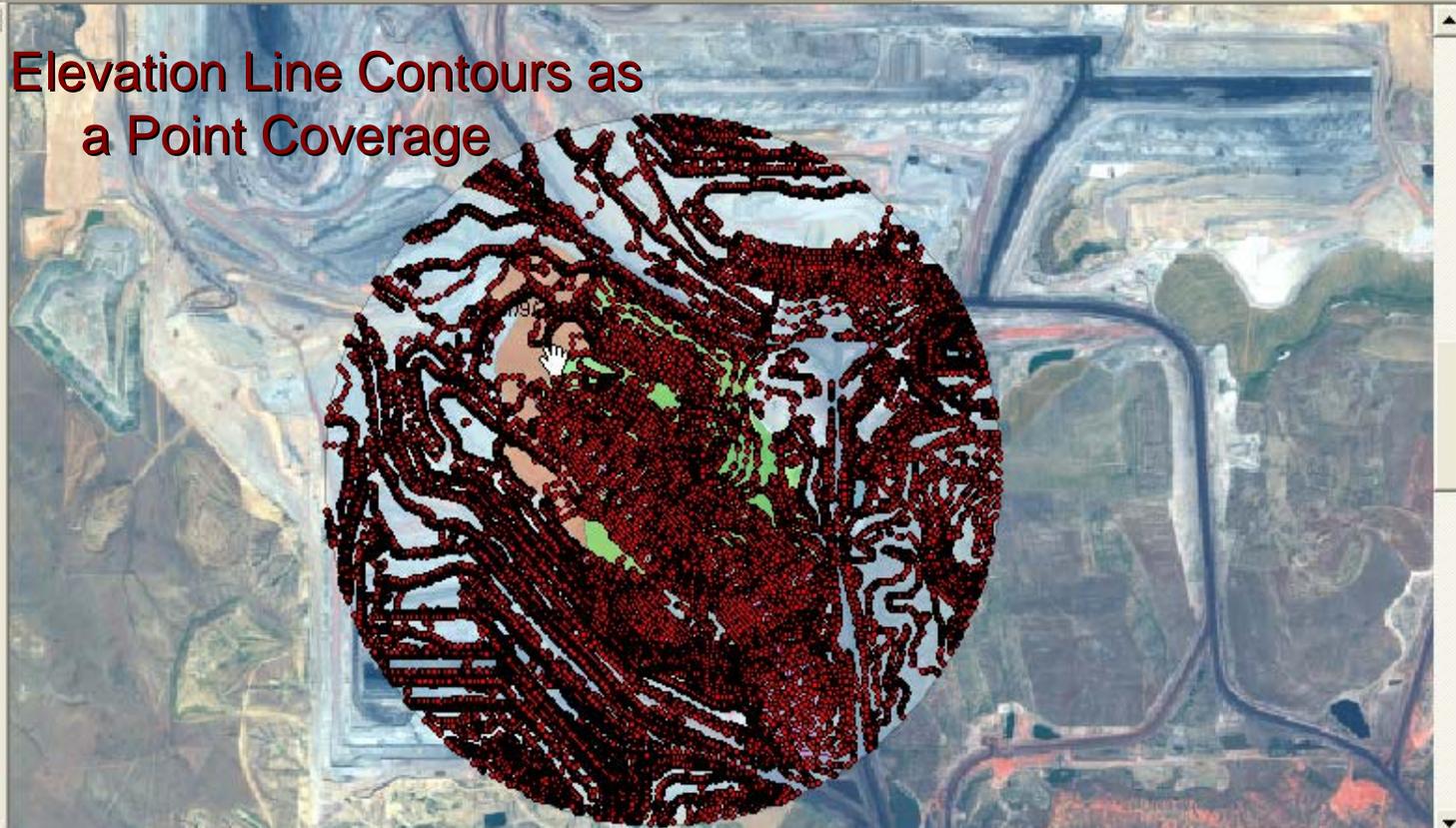
Spatial Analyst toolbar with a dropdown menu set to 'Application Difference' and a legend icon.

Navigation toolbar with icons for zooming, panning, and navigating between layers.

3D Analyst toolbar with a dropdown menu set to 'idw19' and various analysis icons.

Editor toolbar with a dropdown menu set to 'Create New Feature' and a target dropdown set to 'Existing_Topography'.

Layers panel showing a list of map layers with checkboxes and color swatches. The layers include: ext_pts point, Clipext_Output, Application Area, Approved Area, Analysis Area, Existing_Topography, narm_07_12_03_quickbird_nat (RGB Composite with Red, Green, and Blue bands), pmt_pt point, ext_pts point, and Application Difference Value.

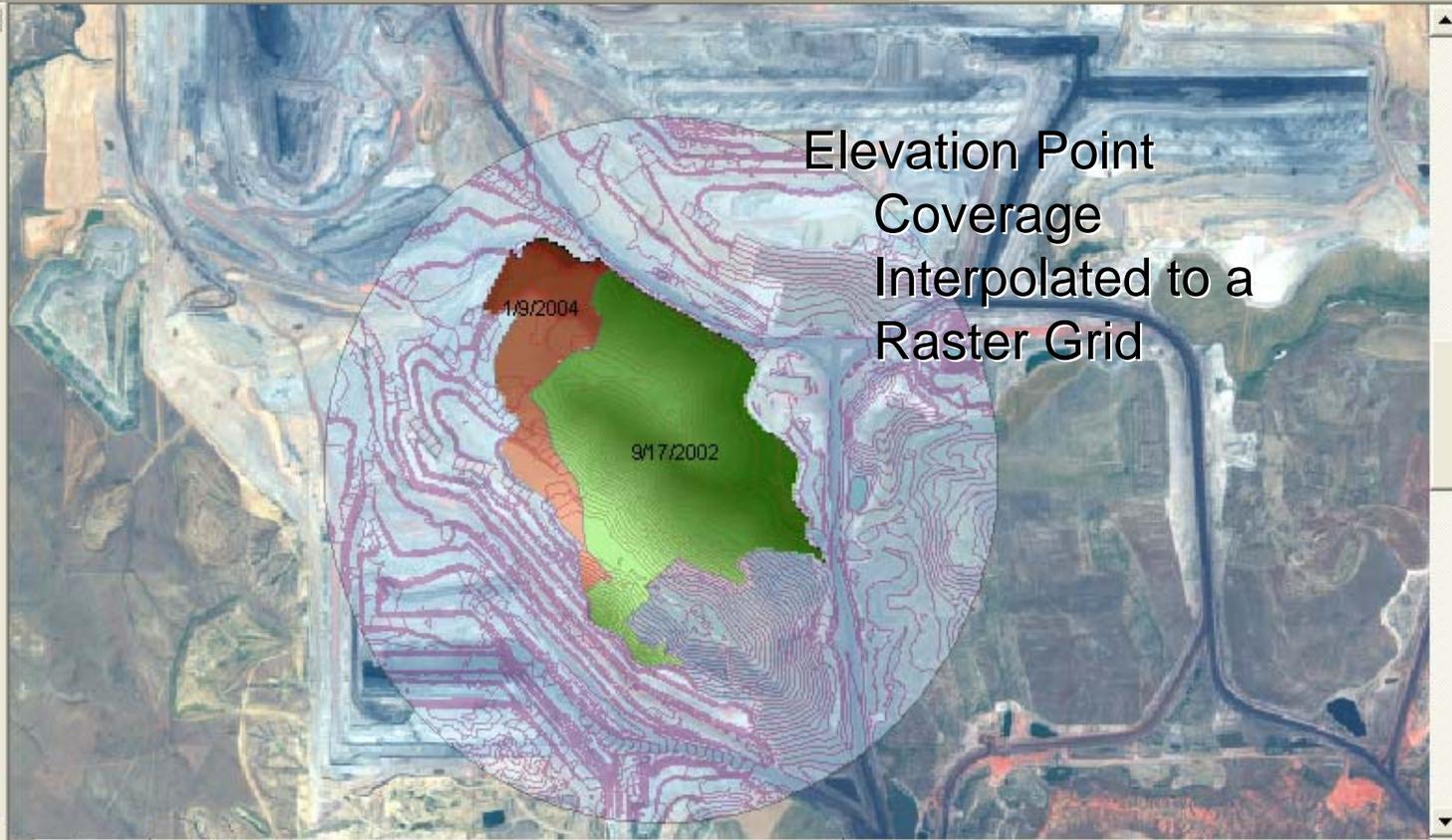


Display and Source tabs, drawing toolbar, and text formatting options (font: Arial, size: 10, bold, italic, underline).

Navigation and zoom toolbar with a zoom level set to 100%.

Layers

- Application Area
- Approved Area
- Clipext_Output
- exist
Value
High : 4870.000000
Low : 4596.327637
- idw23
Value
High : 4880.000000
Low : 4609.312500
- ext_pts point
- Analysis Area
- Existing_Topography
- narm_07_12_03_quickbird_nat



Standard toolbar with icons for file operations, editing, and navigation. A scale of 1:23,308 is displayed.

Spatial Analyst toolbar. Layer: Application Difference

Navigation toolbar with icons for pan, zoom, and other map navigation functions.

3D Analyst toolbar. Layer: idw19

Editor toolbar. Task: Create New Feature. Target: Existing_Topography

Layers panel showing a list of layers with their respective symbology and values.

- Application Area
- Approved Area
- Clipext_Output
- Application Difference
 - Value
 - 135.5 - -77.3
 - 77.2 - -43.7
 - 43.6 - -25.8
 - 25.7 - -8.6
 - 8.5 - 27.1
- Approved Difference
 - <VALUE>
 - 15.6 - -3.8
 - 3.7 - 0.7
 - 0.8 - 5.8
 - 5.9 - 13.9
 - 14.0 - 30.8
- idw23
 - Value
 - High : 4880.000000

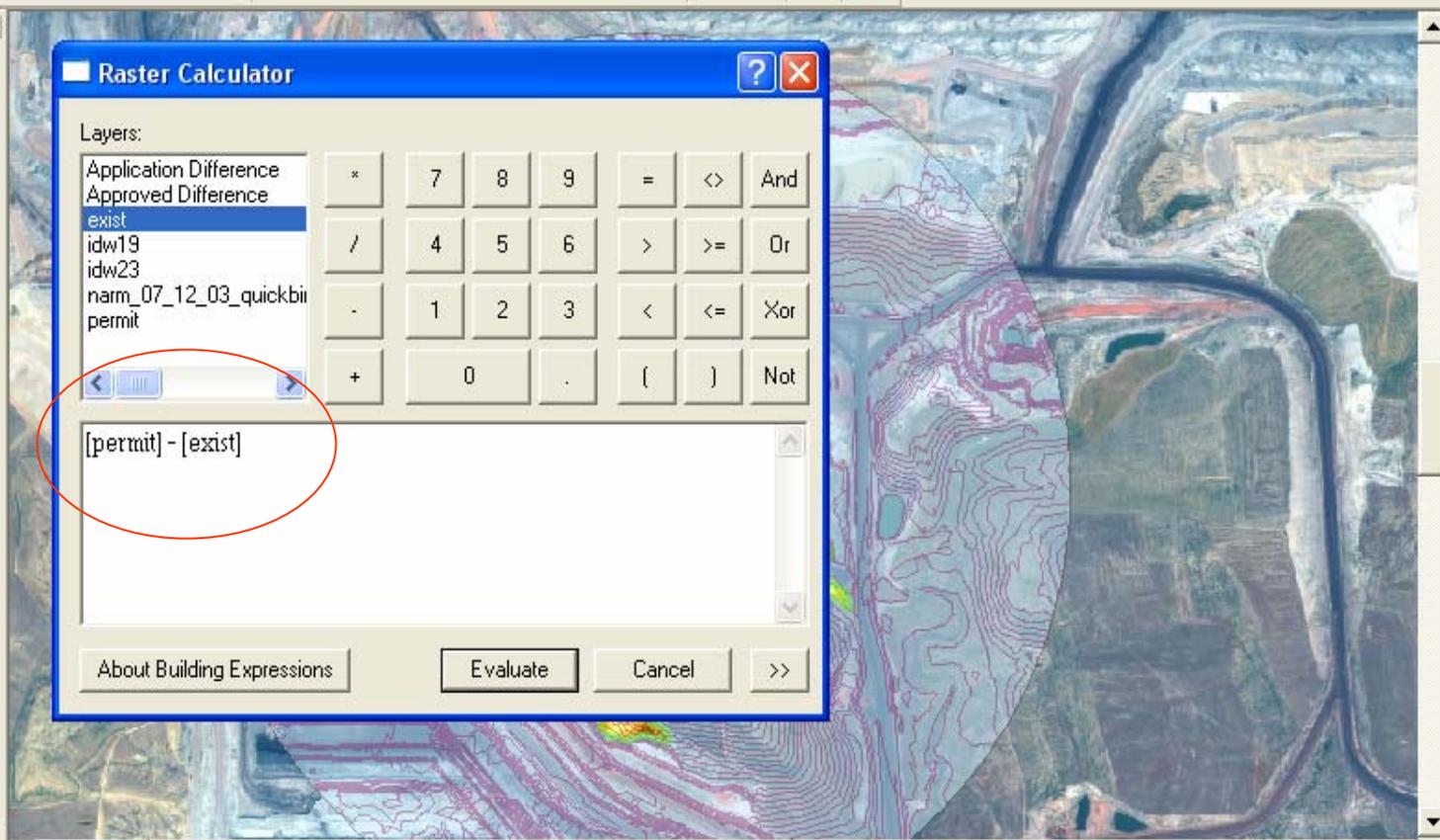
Raster Calculator dialog box showing a list of layers and a mathematical expression.

Layers:

- Application Difference
- Approved Difference
- exist
- idw19
- idw23
- nam_07_12_03_quickbi
- permit

Expression: [permit] - [exist]

Buttons: About Building Expressions, Evaluate, Cancel, >>

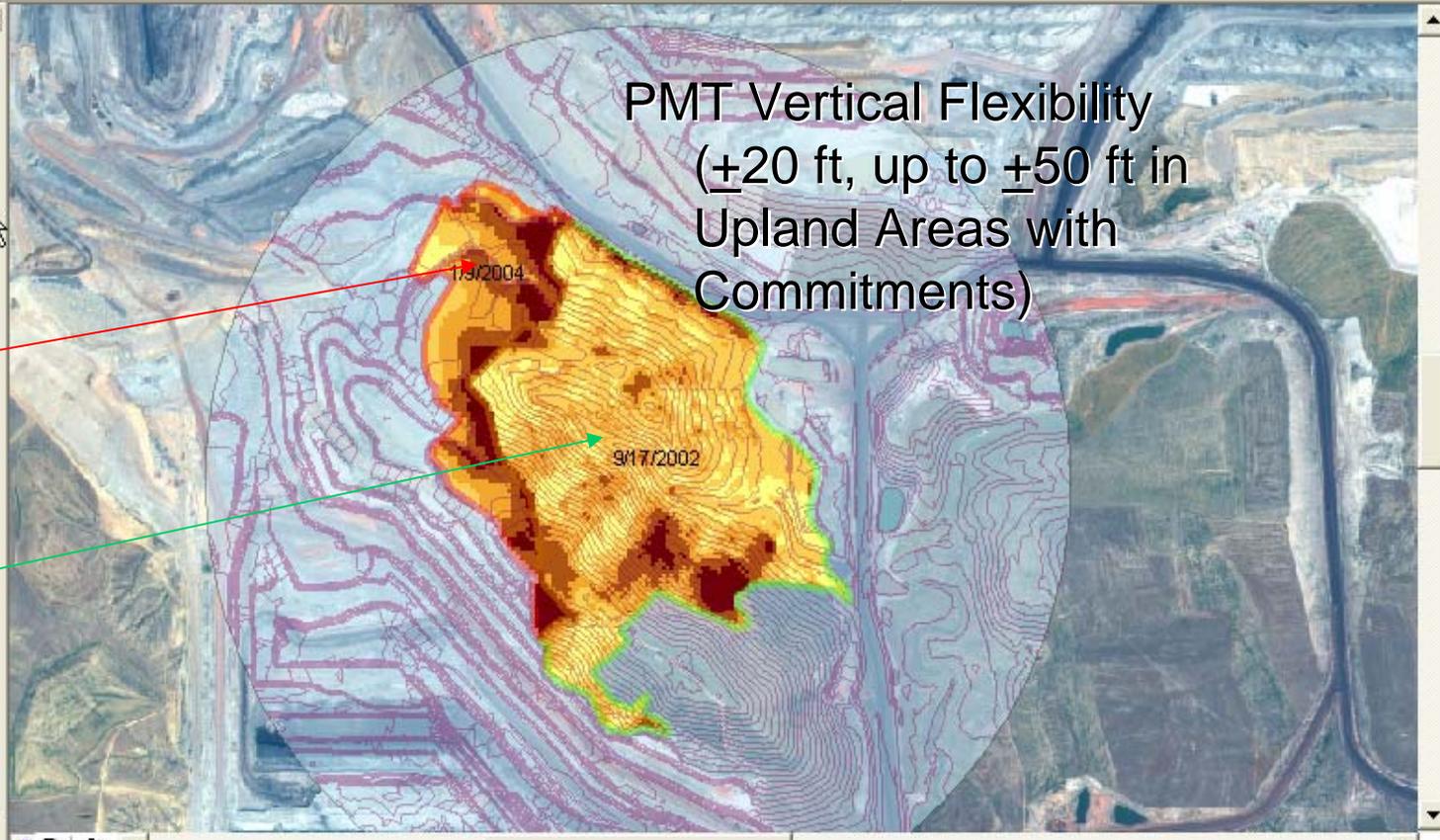


Drawing toolbar with icons for text, lines, and other drawing tools. Font: Arial, Size: 10.

Standard toolbar with icons for navigation and zoom. Zoom level: 100%.

Layers

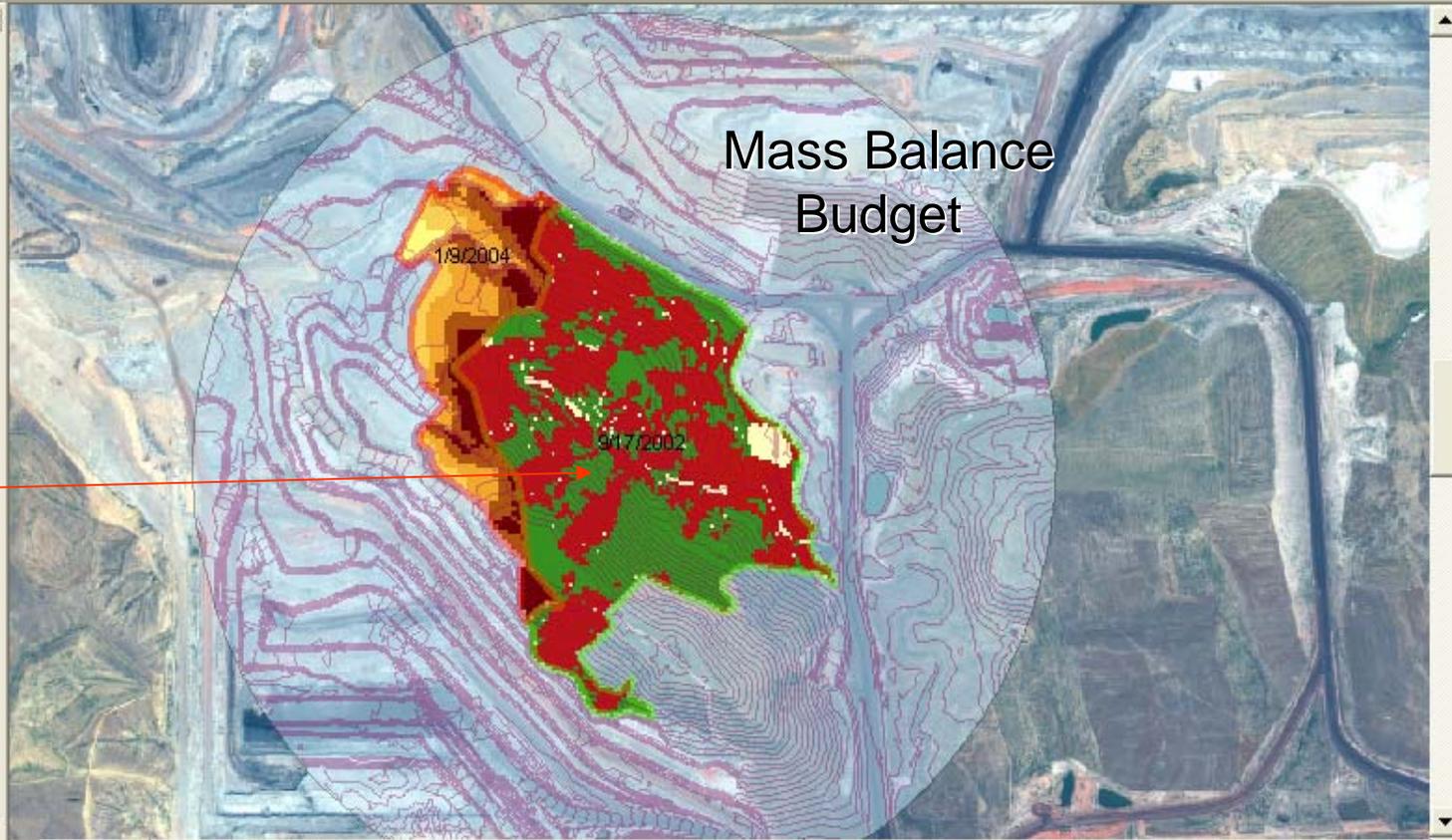
- Application Area
- Approved Area
- Clipext_Output
- Application Difference
 - Value
 - 135.5 - -77.3
 - 77.2 - -43.7
 - 43.6 - -25.8
 - 25.7 - -8.6
 - 8.5 - 27.1
- Approved Difference
 - <VALUE>
 - 15.6 - -3.8
 - 3.7 - 0.7
 - 0.8 - 5.8
 - 5.9 - 13.9
 - 14.0 - 30.8
- idw23
 - Value
 - High : 4880.000000



PMT Vertical Flexibility
(±20 ft, up to ±50 ft in
Upland Areas with
Commitments)

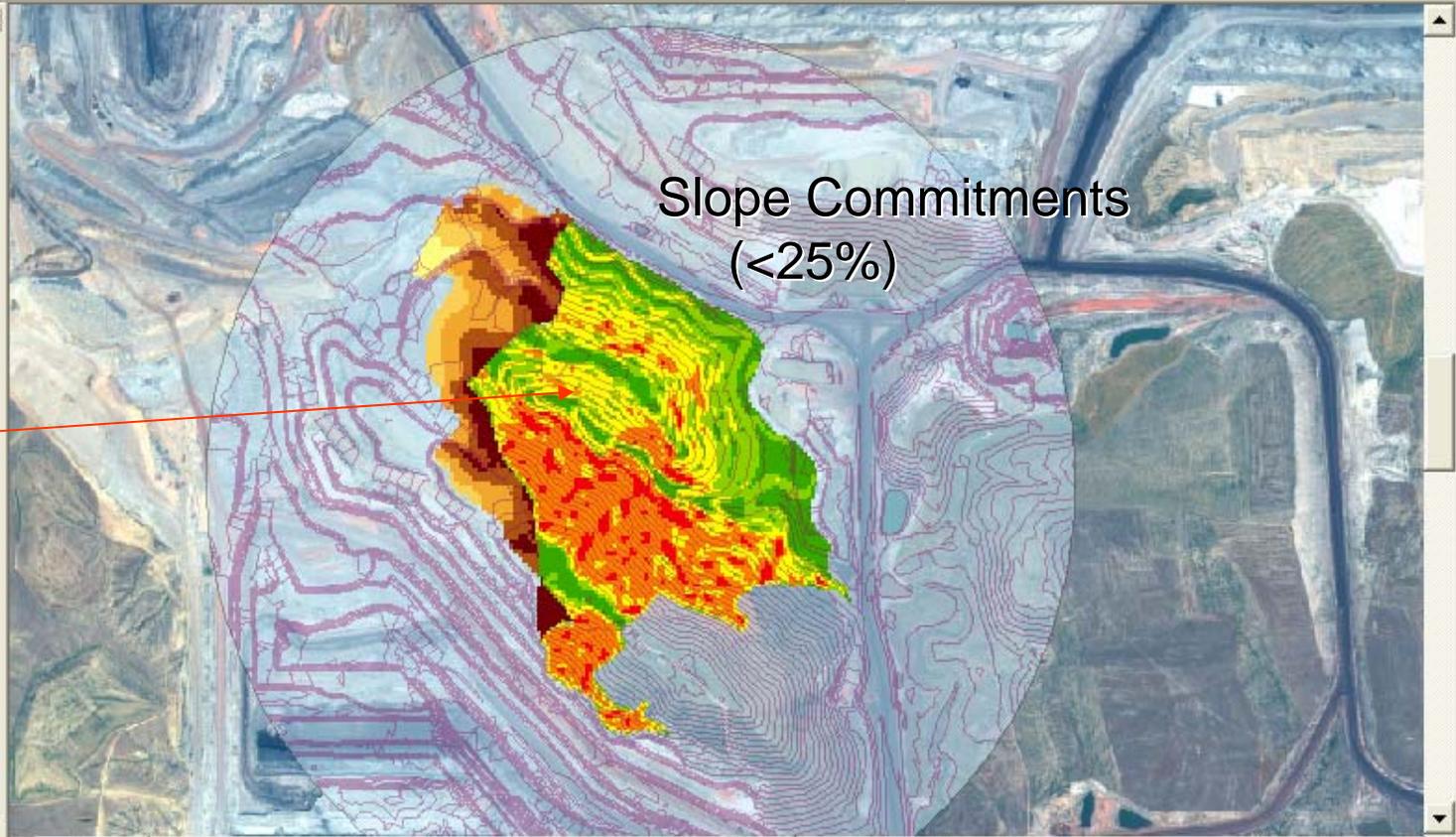
Layers

- Export_tpsol
- Permit_Topography
- Application Area
- Approved Area
- Clipext_Output
- Cutfill between idw19idw23
 - Volume
 - 17,124,024.05 - -0.09
 - 0.090000000 - 0.09
 - 0.090000000 - 18,000,000
- IDW of Export_tpsol
 - <<VALUE>
 - 19.00349808 - 21.0010761
 - 21.00107618 - 22.9986542
 - 22.99865427 - 24.9962323
 - 24.99623236 - 26.9938104
 - 26.99381045 - 28.9913885
 - 28.99138854 - 30.9889666



Layers

- Topsoil_Verification_Points
- Application Area
- Approved Area
- Clipext_Output
- Slope of idw19
 - <VALUE>
 - 0 - 3
 - 4 - 6
 - 7 - 8
 - 9 - 11
 - 12 - 21
- Application Difference
 - Value
 - 135.5 - -77.3
 - 77.2 - -43.7
 - 43.6 - -25.8
 - 25.7 - -8.6
 - 8.5 - 27.1
- Approved Difference



Map toolbar with icons for file operations, navigation, and a scale of 1:23,308.

Spatial Analyst toolbar with a dropdown menu set to 'Layer: Slope of idw19'.

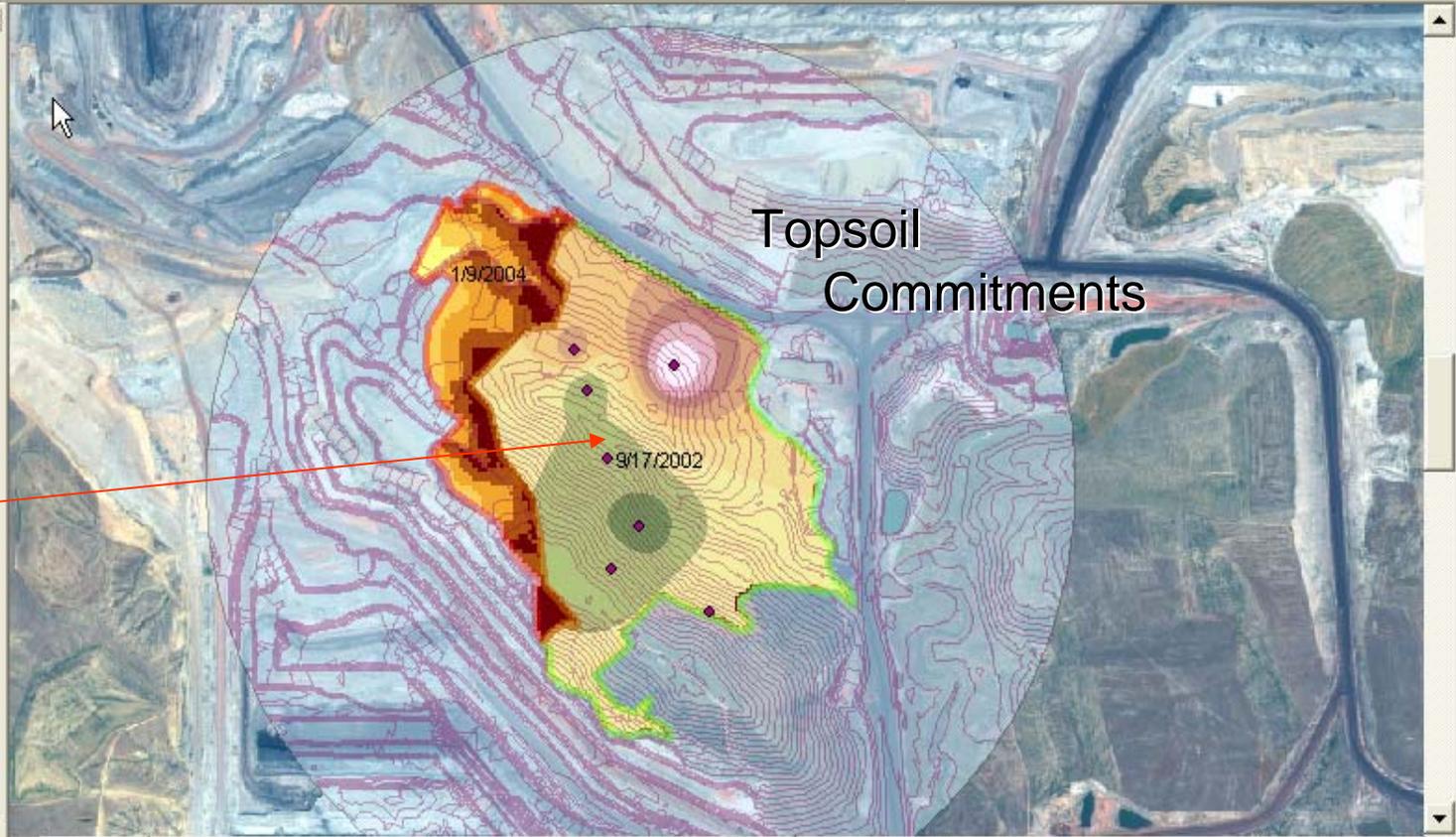
Navigation toolbar with icons for zooming and panning.

3D Analyst toolbar with a dropdown menu set to 'Layer: Slope of idw19'.

Editor toolbar with a dropdown menu set to 'Task: Create New Feature'.

Layers panel showing a list of map layers. The 'IDW of Export_tpsoil' layer is selected and its legend is expanded, showing a color-coded scale from 19.00349808 to 34.98412282. A red circle highlights this legend.

- Export_tpsoil
- Application Area
- Approved Area
- Clipext_Output
- IDW of Export_tpsoil
<VALUE>
 - 19.00349808 - 21.0010761
 - 21.00107618 - 22.9986542
 - 22.99865427 - 24.9962323
 - 24.99623236 - 26.9938104
 - 26.99381045 - 28.9913885
 - 28.99138854 - 30.9889666
 - 30.98896663 - 32.9865447
 - 32.98654473 - 34.9841228
 - 34.98412282 - 36.9817005
- Slope of idw19
<VALUE>
 - 0 - 3
 - 4 - 6



Drawing toolbar with icons for text, lines, and shapes. The font is set to Arial, size 10.

Map navigation toolbar with a scale of 100%.

Key Lessons

- Plan Model Prior to Any Data Collection
- Training
- Established Communication with Mine, Consultants and Regulatory Agency
- Be Flexible and Adjust for Unknowns
- Build a Tight Data Dictionary
- Implement Desktop Management Practices

Recommendations

- Build a Tight Data Dictionary
- Implement Desktop Management Practices
- Develop Map Standards
- Implement Analytical Methods
- Continue Training of Advanced GPS & GIS Methods
- Refer to Bond Release Regulations Often

Questions and Comments

December 28, 2004