

Status Report: USGS Coal Assessment of the Powder River Basin, Wyoming



**James A. Luppens¹ , Timothy J. Rohrbacher², Jon E. Haacke²,
David C. Scott², and Lee M. Osmonson²**

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This report is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards and stratigraphic nomenclature. Any use of trade names is for descriptive purposes only and does not imply endorsement by the U.S.G.S.

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U.S. Department of the Interior
U.S. Geological Survey

¹ USGS, Reston, VA
²USGS, Denver, CO

Figure 1. Title Slide: “Status Report: USGS Coal Assessment of the Powder River, Wyoming” by James A. Luppens , Timothy J. Rohrbacher, Jon E. Haacke, David C. Scott, and Lee M. Osmonson; U.S. Department of the Interior, U.S. Geological Survey.

USGS Coal Program

- Current and future coal assessments – not just another in-place coal resource number.
- Regional estimates of economically recoverable coal will be an integral part of current and future assessments.
- How much economically recoverable coal do we have left?



Figure 2. Objectives of the current and future USGS coal assessment programs. An inventory of the estimated economically recoverable coal provides a better foundation for energy planning than simply relying on in-place coal resources.

Importance of Coal Assessment Project

- National energy reliance and energy policy
- Regional energy and economic planning
- Federal lands inventory
- Coal bed methane (CBM) exploration and development
- Carbon sequestration



Figure 3. Importance of USGS coal assessment project to energy policy and research.

Current and Future Coal Assessment Work, Where do we go from here?

- Reserve investigations require more up front geology and engineering work.
- However, new, highly automated regional mine modeling and economic programs developed by the USGS facilitate the reserves evaluation.
- The USGS assessment methodology was formally evaluated by an external review panel with an open file report published in February, 2005 Rohrbacher, T. J., and others, 2005 (<http://pubs.usgs.gov/of/2005/1076>).
- Builds on the digital geologic framework of past coal resource assessments.
- Started next coal assessment phase in the greater Powder River Basin (PRB) in FY2005.



Figure 4. The direction of current and future USGS coal assessments.

Regional Coal Resource Evaluation Overview

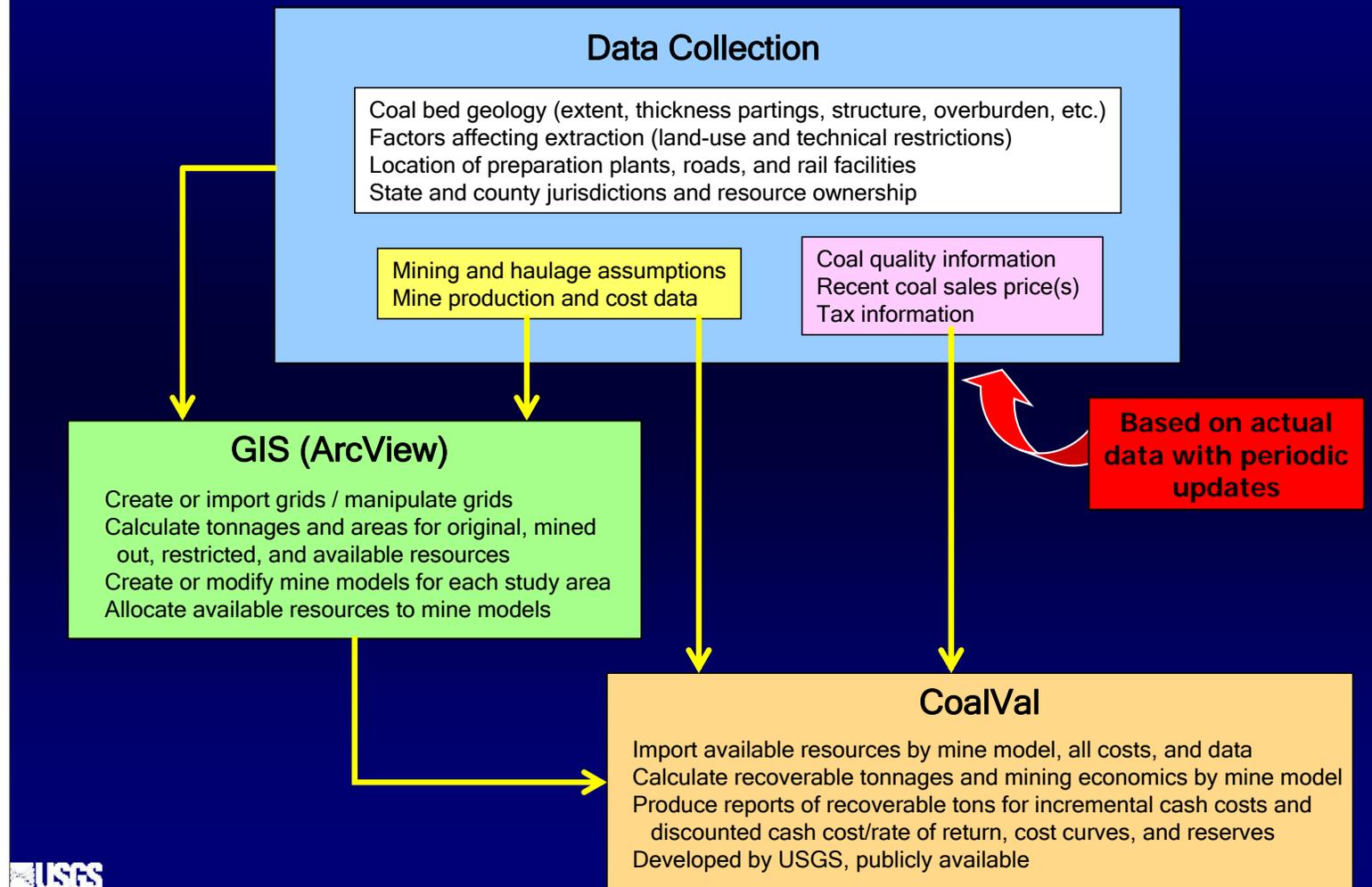


Figure 5. The USGS coal assessment project is designed to provide regional estimates of economically recoverable resources (reserves). Data collection and geological modeling are typically the most time intensive phase. Once the geology model is complete, the GIS program allocates the available coal resources to the various mine models. Finally, a program developed in-house called CoalVal performs the economic analyses.

Environmental, Societal, and Technical Restrictions to Mining in the Gillette Coal Field, Wyoming

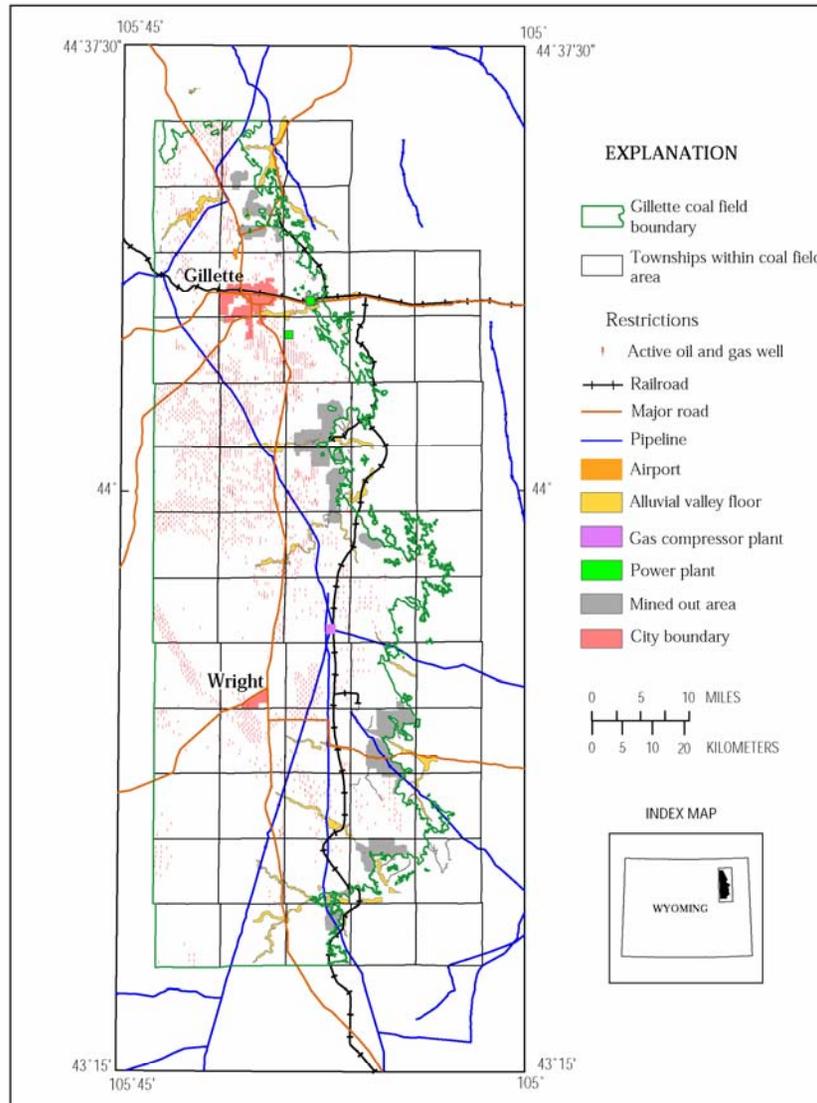


Figure 6. In addition to subtracting previously mined out resources, coal restricted by societal and environmental constraints are subtracted to determine the remaining available resources. An economic analysis of the available resources yields an estimate of reserves for the study area.

The GIS Process of Merging Layers or Themes of Data into More Meaningful Interpretations

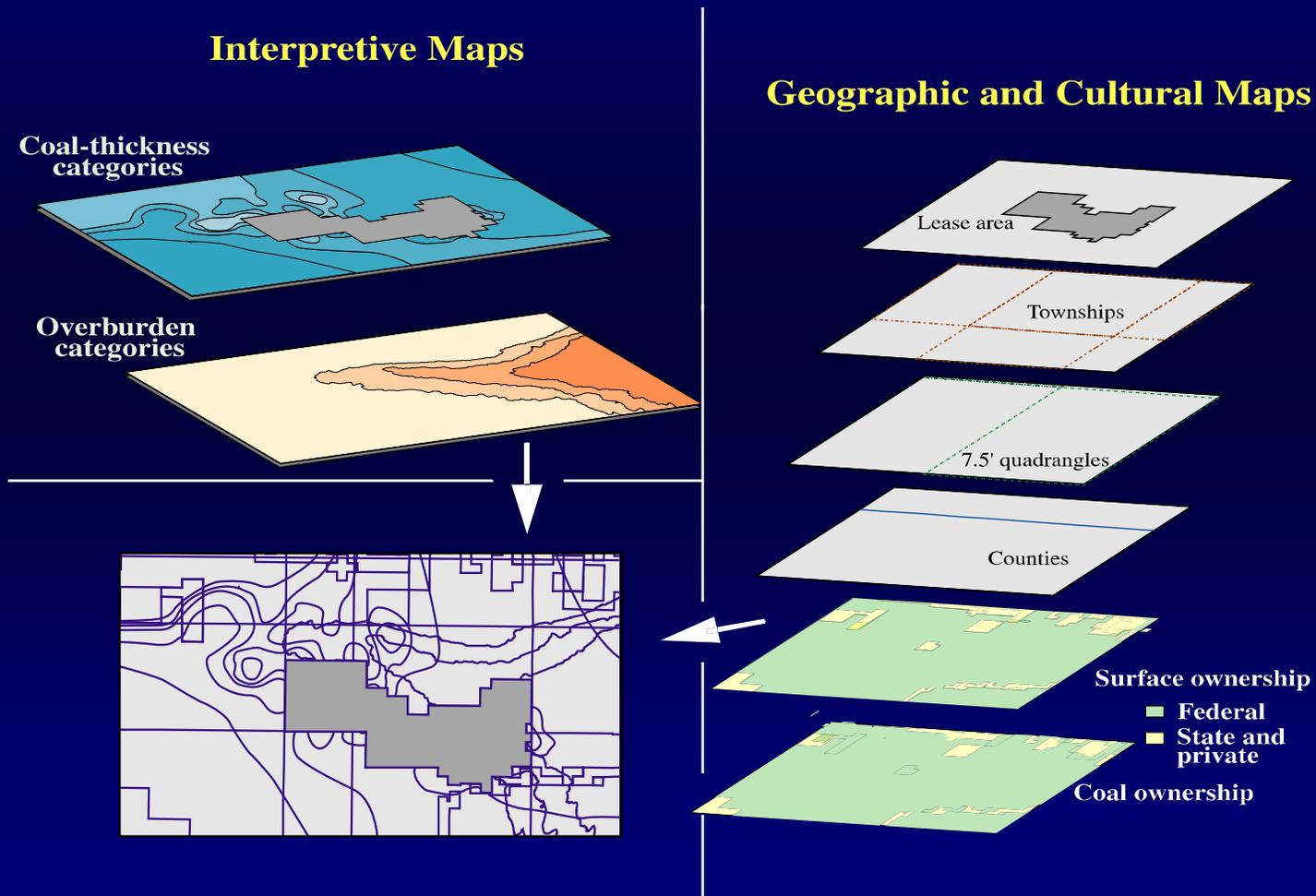


Figure 7. The availability of GIS coverages for land, restrictions, geology, etc. greatly facilitate the evaluation process.

Available Resource Areas Input into CoalVal

GIS study assigns coal to mine models.

Coal tons are imported by county into resource areas for each mine model.

Results from GIS are:

Acreage

In Situ Tons Coal

In Situ Tons Parting

| Area ID | 7475 | 7476 |
|--------------------|--|--|
| Area Name | Greene, PA LW72 | Greene, PA LW96 |
| Mine Model | Greene County, PA Greene County, PA Longwall 72"-96" Pittsburgh Seam | Greene County, PA Greene County, PA Longwall > 96" Pittsburgh Seam |
| Mining Data | A: 131,855.00 C: 1,531,998,848.00 P: 79,160,816.00 Washed: Yes G: Longwall 72"-96" Pittsburgh Seam Life: 10 | A: 4,435.00 C: 64,859,416.00 P: 3,897,185.00 Washed: Yes G: Longwall > 96" Pittsburgh Seam Life: 10 |
| Area Acres | 131,855 | 4,435 |
| Mine Tons Coal | 1,531,998,848 | 64,859,416 |
| Mined Tons Parting | 79,160,816 | 3,897,185 |
| Washed? | <input checked="" type="checkbox"/> | <input checked="" type="checkbox"/> |
| Mine Life | 10 | 10 |

Listing of all Areas:

- Lewis, WV LW72
- Lewis, WV LW96
- Upshur, WV LW42
- Upshur, WV LW72
- Gilmer, WV LW42
- Gilmer, WV LW72
- Gilmer, WV LW96
- Putnam, WV LW42
- Putnam, WV LW72
- Kanawha, WV LW42
- Kanawha, WV LW72
- Washington, PA LW42
- Washington, PA LW72
- Washington, PA LW96
- Greene, PA LW42
- Greene, PA LW72**
- Greene, PA LW96
- Jefferson, OH LW72



Figure 8. The first step in an economic evaluation is importing the coal volumes into CoalVal from the GIS mine models. This example is from an evaluation of the Pittsburgh coal bed in Pennsylvania, but the types of data imported are the same. CoalVal is scheduled for publication in 2006

CoalVal - Mine Model Equipment

Mine Model

File Reports Tools Help

CoalVal ? Truck-Shovel

Mine Model **Salaried and Hourly Employees, Equipment, and Mine Assumptions**

Salaried Employees Hourly Employees **Equipment** Mine Model Assumptions

Capital Equipment Grouping **Equipment Group -- Production Equipment**

Group Heading: Production Equipment

Change Group: < >

Current Equipment List:

| |
|-------------------------------------|
| Coal Shovel, 68 cy, 64' boom-5280hp |
| Overburden Shovel, 52 cy, 5280hp |
| Coal Truck, 255t, 193cy, 22'dmp h |
| OB Haul Truck, 255t,193cy, 22'dmpht |
| OB Drill, +9", 230kw, 450hp,60"rods |
| Coal Drill, 6",trk mtd,75hp,25'rods |
| Front End Lder,33cy,22'dmpht,1800hp |
| Dozer, 14.8' blade, 370 hp, ripper |
| Dozer, 17.3' blade, 520 hp, ripper |
| Dozer, 21' blade, 770 hp, ripper |
| Dozer, rubtired, 15.2'blade, 450hp |
| Comptr Haul Dispatch Sys, per unit |
| Spare OB Haul Truck, 255t, 193cy |

Equipment Name and Use:
Select equipment by name
Equipment: Coal Shovel, 68 cy, 64' boom-5280
or by ID
Equipment ID: 805
Equipment Use: Production

Property Type:
 None Tangible
 Real

R&M and F&L per Hour:
R&M per Hour: \$79.09
F&L per Hour: \$77.92

Equipment Cost and Dep Term:
Unit Cost: \$9,150,000
Depreciation Years: 10

Shifts:
Units Shift 1: 1.0
Units Shift 2: 1.0
Units Shift 3: 1.0
#Units Shift 4: 0.0
Hours Worked/Shift: 8.0
Sorting Code: 0

Ordered ? Help

Add Mine Model Data Items

Arrange Equipment Order

Add Equipment to a Equipment Group Truck & Shovel 6:1 \ Truck-Shovel

Figure 9. CoalVal provides a series of tables to add and cost out mine equipment.

CoalVal Mine Model Assumptions

Mine Model sets:

- Mine productivity
- Recovery rates
- Out-of-seam dilution
- Other misc. costs

Figure 10. Mine models assumptions including productivity, dilution, and recovery rates are also entered. All data is based on published regional statistics and actual equipment pricing costs, as well as input from and verification of assumptions by coal mines in the region.

Mine Model Employees

The screenshot shows the 'CoalVal' software interface for 'Truck-Shovel'. The main window title is 'Mine Model'. The menu bar includes 'File', 'Reports', 'Tools', and 'Help'. The interface is divided into several sections:

- CoalVal** logo and a question mark icon.
- Mine Model** section with tabs: 'Salaried and Hourly Employees, Equipment, and Mine Assumptions' (selected), 'Salaried Employees', 'Hourly Employees' (selected), 'Equipment', and 'Mine Model Assumptions'.
- Hourly Employee Groupings** section with a tab: 'Hourly Employee Group -- Production' (selected).
- Grouping Name:** 'Production' (text box) and 'Change Group:' (button).
- Select Employee by Type or by Employee ID** section containing a table.
- Employee Details:** section with fields for 'Grade Name' (5), 'Rate' (\$24.91), and a checkbox for 'Mechanic' (unchecked). The 'Reference' field contains 'Western Mine Engineering'.
- Add Mine Model Data Items** button.

The table below shows the data for the 'Hourly Employees' group:

| Employee Type | Employee ID | Hours Per Shift | # Employees Shift 1 | # Employees Shift 2 | # Employees Shift 3 | # Empl |
|--------------------------|-------------|-----------------|---------------------|---------------------|---------------------|--------|
| Electric Shovel Operator | 347 | 8 | 4 | 4 | 4 | |
| Dragline/Shovel Oiler | 348 | 8 | 4 | 4 | 4 | |
| Shovel Operator-Coal | 369 | 8 | 1 | 1 | 1 | |
| Shovel Oiler-Coal | 371 | 8 | 1 | 1 | 1 | |
| Truck Driver | 352 | 8 | 30 | 30 | 30 | |
| Truck Driver-Coal | 370 | 8 | 5 | 5 | 5 | |
| Drill Operator | 349 | 8 | 6 | 5 | 3 | |

At the bottom of the window, there is a status bar with the text: 'Add Hourly Employees to a Hourly Group' and 'Truck & Shovel 6:1 \ Truck-Shovel'. The USGS logo is visible in the bottom left corner.

Figure 11. Input for the manpower table is also regionally-based from published labor statistics and mining company information. CoalVal will be published with all the basic tables completed as place markers; however, it will be the user's responsibility to supply current information.

CoalVal - Discounted Cash Flow Summary

Material Flow Tracking Summary

| Resource ID | Mine Life | Coal FOB to Market | HurdleRate | Threshold Price |
|----------------------|-----------|--------------------|------------|-----------------|
| N. App. Basin: LW42" | 10 | 422,133,400 | 10.00 % | \$26.18 |

| | Coal | Parting In Place Tonnage | Dilution | Total |
|---|-------------|-----------------------------|------------|-------------|
| In Place Total | 642,789,824 | 29,590,659 | 53,801,199 | 726,181,682 |
| from Whole LPU's | 600,339,621 | 27,636,476 | 50,248,137 | 678,224,234 |
| from Carry Over | 42,450,203 | 1,954,184 | 3,553,062 | 47,957,448 |
| Annual In Place Tonnage per LPU | | | | |
| LW Part of LMU | 3,772,545 | 173,668 | 315,760 | 4,261,974 |
| CM Part of LMU | 2,230,851 | 102,697 | 186,721 | 2,520,269 |
| Totals | 6,003,396 | 276,365 | 502,481 | 6,782,242 |
| Annual Run of Mine Tonnage per LPU | | | | |
| LW Part of LMU | 2,867,134 | 131,988 | 239,978 | 3,239,100 |
| CM Part of LMU | 1,494,670 | 68,807 | 125,103 | 1,688,580 |
| Totals | 4,361,805 | 200,795 | 365,081 | 4,927,680 |
| In Place Tonnage Carry Over (CO) | | | | |
| LW Part of CO | 26,675,786 | 1,228,013 | 2,232,750 | 30,136,550 |
| CM part of CO | 15,774,417 | 726,171 | 1,320,311 | 17,820,899 |
| Recovered Carry Over | | | | |
| LW Part of CO | 20,273,598 | 933,290 | 1,696,890 | 22,903,778 |
| CM Part of CO | 10,568,859 | 486,535 | 884,608 | 11,940,002 |
| Out of Wash Plant Carry Over | | | | |
| Wash Plant Recovery Rate | 89% | 11% | 11% | |
| LW Part of CO | 18,043,502 | 99,862 | 181,567 | 18,324,931 |
| CM Part of CO | 9,406,285 | 52,059 | 94,653 | 9,552,997 |
| Total | 27,449,786 | 151,921 | 276,220 | 27,877,928 |
| Out of Wash Plant to Market | | | | |
| from whole LPU's | 388,200,604 | 2,148,501 | 3,906,366 | 394,255,472 |
| from Carry Over | 27,449,786 | 151,921 | 276,220 | 27,877,928 |
| Total | 415,650,391 | 2,300,423 | 4,182,586 | 422,133,400 |

Fractional Report

Number LPU's Based on User Entered Mine Life
10.71

Number LPU's Based on Calculated Mine Life
10.71

Calculated Mine Life
10

Mineable Resource Recover Rate
(from mine model)

76%

67%

Mine Model Name:

Longwall 42"-72" Pittsburgh Seam

Quality

| | |
|----------------|---------|
| Revised BTU | 12,178 |
| BTU | 13,670 |
| Revised Sulfur | 2.57 % |
| Sulfur | 2.90 % |
| Revised Ash | 18.28 % |
| Ash | 8.16 % |



Figure 12. The final result of the economic evaluation is a report summing the number of tons at a threshold price (including a discounted rate of return) for each area and mine model for the entire project area.

Coal Resource/Reserve Cost Curve

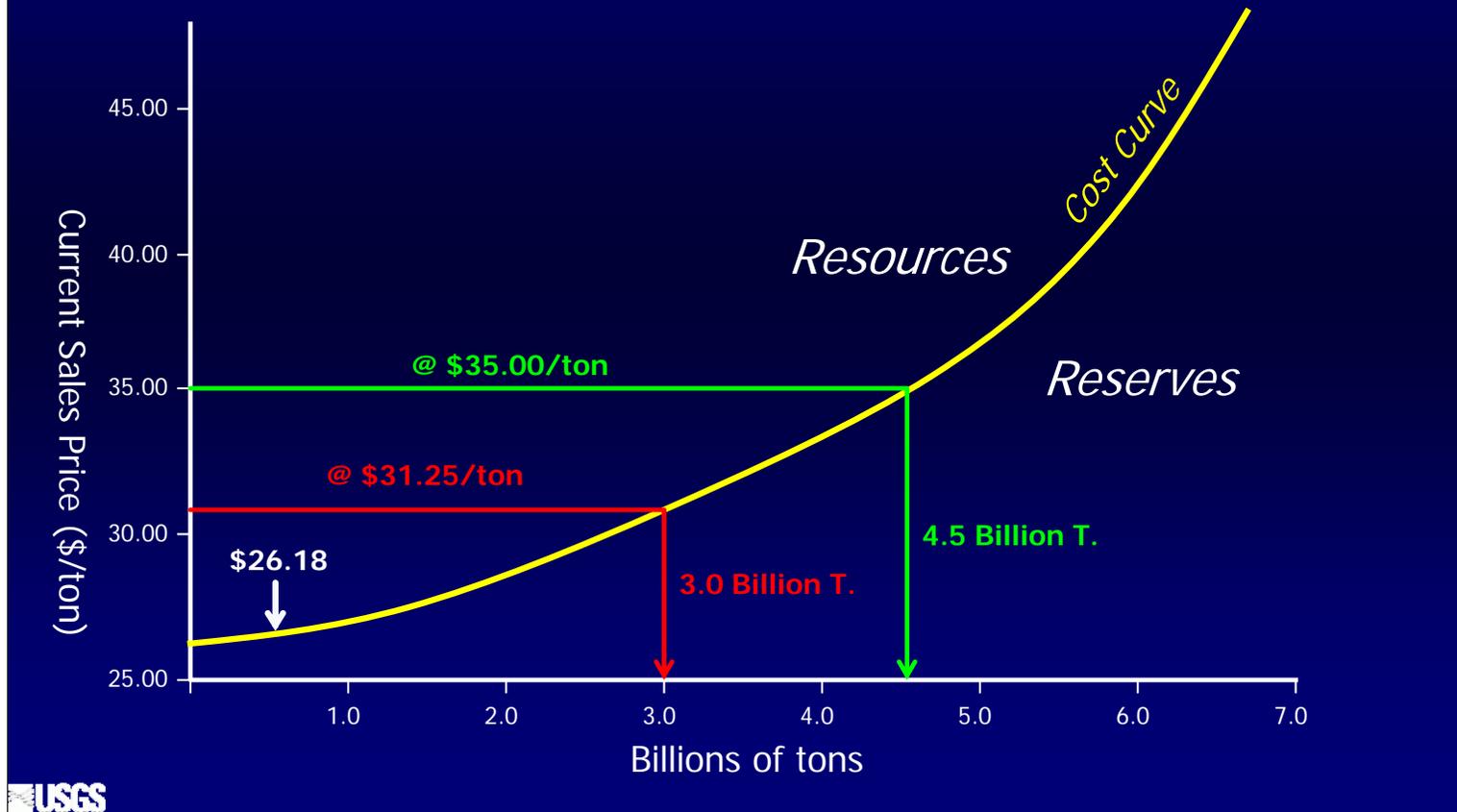
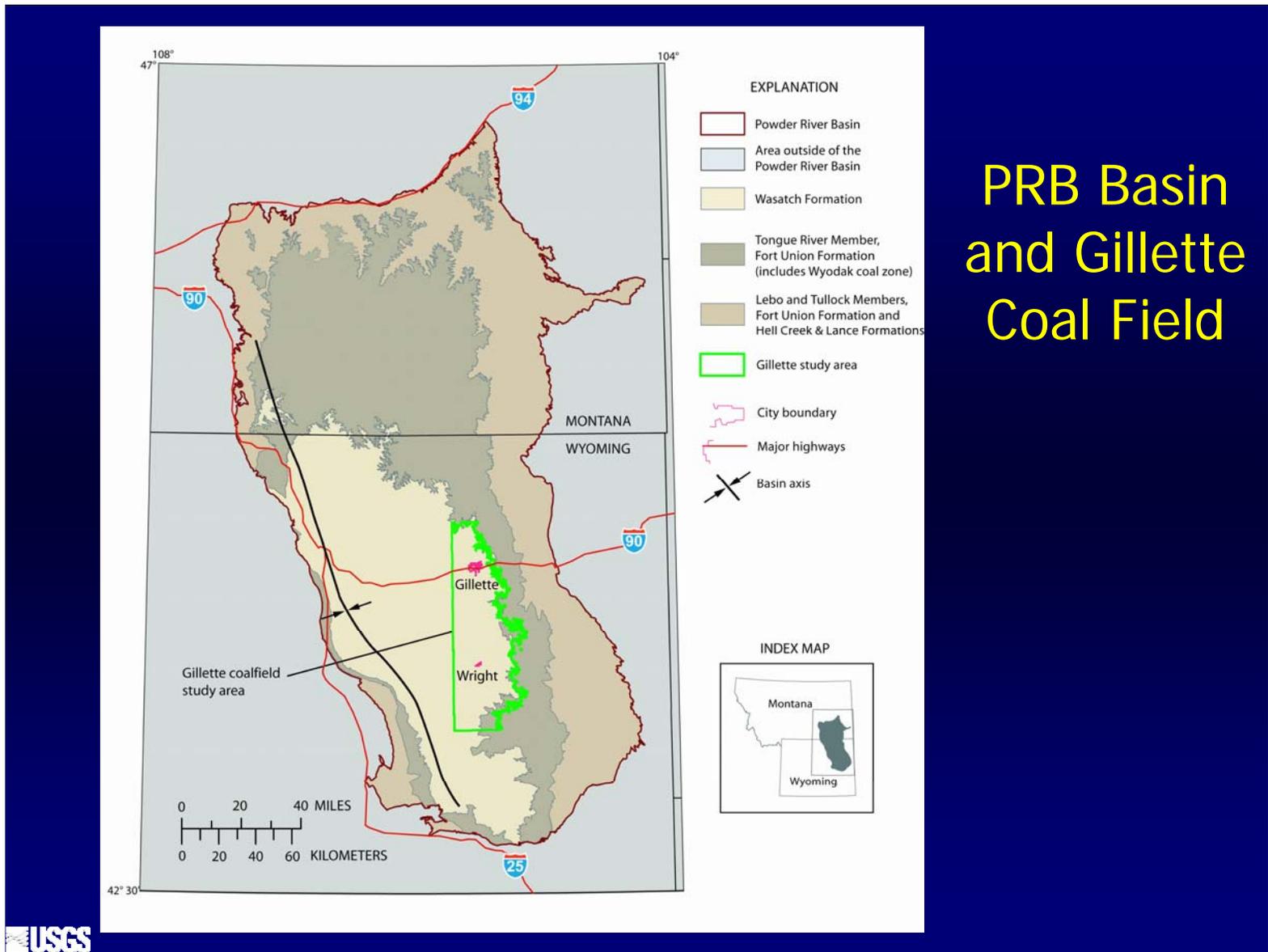


Figure 13. Once the cost of all the available tons are determined, a resource cost curve can be derived. Given a current sales price of \$31.25/ton, about 3 billion tons would be economic. Any coal tons with a threshold price of \$31.25 or less would be considered reserves. Thus, the block shown in fig. 12 at \$26.18 falls into the reserves category. If the price were to increase to \$35.00/ton, and additional 1.5 billion tons would added to the reserves category. It must be stressed, that the determination of reserves is an ongoing process that must be revalidated as market and mining costs, and other economic and technological factors change.



PRB Basin and Gillette Coal Field

Figure 14. This is the location of the Gillette Coal Field, Wyoming where the initial PRB coal assessment project is starting. The Powder River Basin (PRB) represents the single most productive coal basin in the US, producing nearly 40% of the nation's coal. Just the Wyoming portion of the basin produced 403 million tons in 2005 (U.S. Bureau of Land Management, 2006). Furthermore, the announced additional coal development is significant. Peabody's new School Creek mine (60 miles south of Gillette) alone is expected to come on-line in late 2008 producing 30 million to 40 million short tons/yr (Platts Coal Outlook, 2006).

Current PRB Assessment Status

- Current Database:

| | | |
|---------------------|----------|----------------------|
| Original | – | 2,200 points |
| New oil & gas wells | – | 2,330 points |
| New CBM wells | – | <u>7,470 points</u> |
| TOTAL | – | 12,000 points |

- Two Geologists for approximately one year
- About 4,000 points from WY Geological Survey
- Plan to complete Gillette coalfield assessment by Dec., 2006
- Assessment of the north and northwest portions of the PRB will begin following completion of the Gillette coal field evaluation.



Figure 15. The current USGS PRB assessment status. When completed, the resulting database should provide one of the most extensive drill hole compilations for the PRB available to the public. The slides in this next section represent preliminary assessment work and may be modified for the final report.

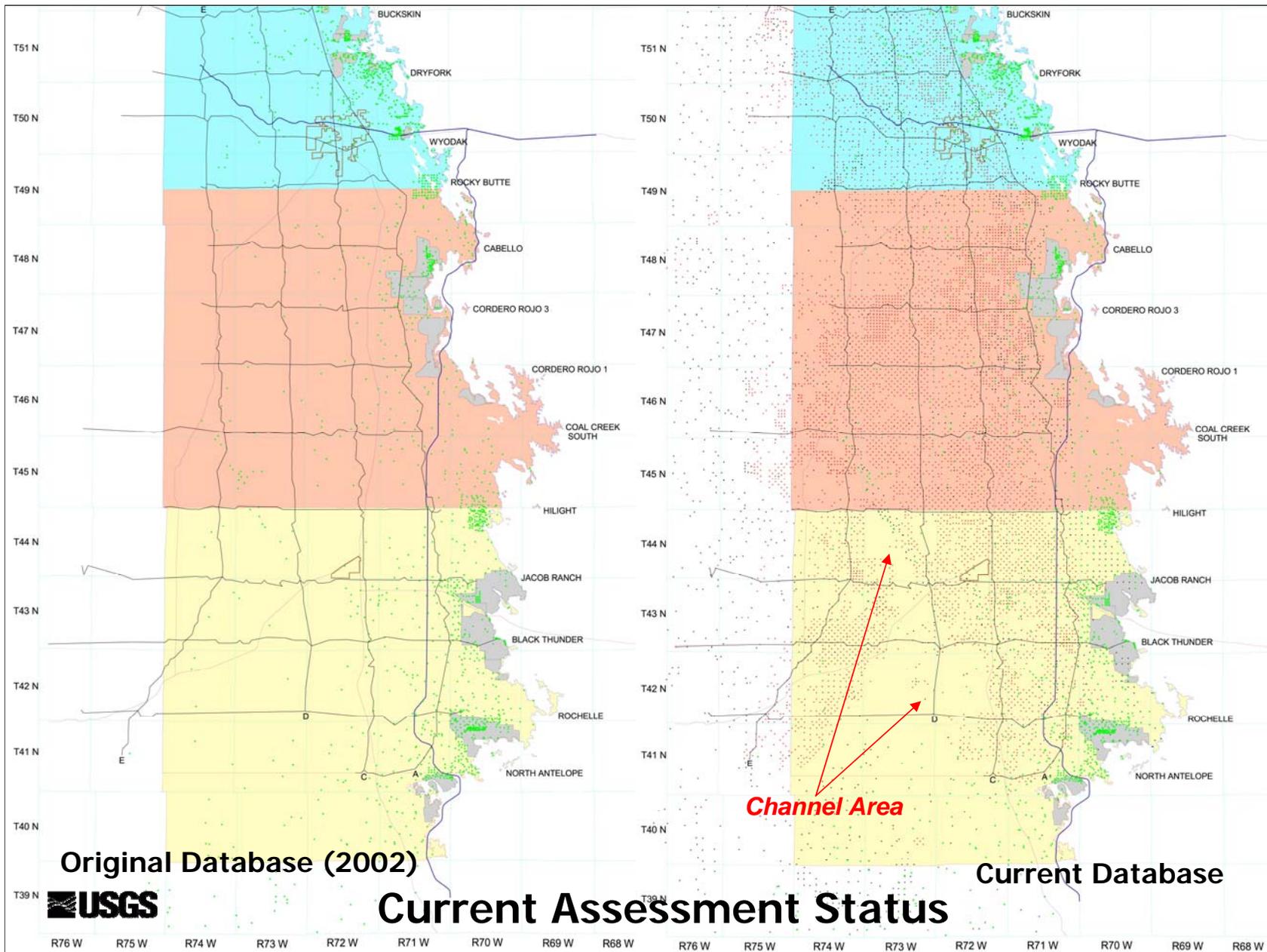


Figure 16. Comparison of the original Gillette coal field assessment coal assessment drill hole database (Ellis and others, 2002) to the current assessment database. The extensive drilling activity associated with coal bed methane (CBM) development has resulted in a relatively dense drilling pattern which, by itself, helps define the limits of a significant channel area where the coal beds are thin or absent.

Preliminary Assessment Results

- Minor changes in coal bed correlations
- Major down-dip channel will be a restriction to surface mining



Figure 17. The preliminary interpretation of the massive amount of new data has resulted in several significant findings. Both are related to the channel geometry defined by the substantial amount of new drilling information.

Previous Coal Bed Correlations

(USGS Miscellaneous Investigations Series, Map I-1959-B)

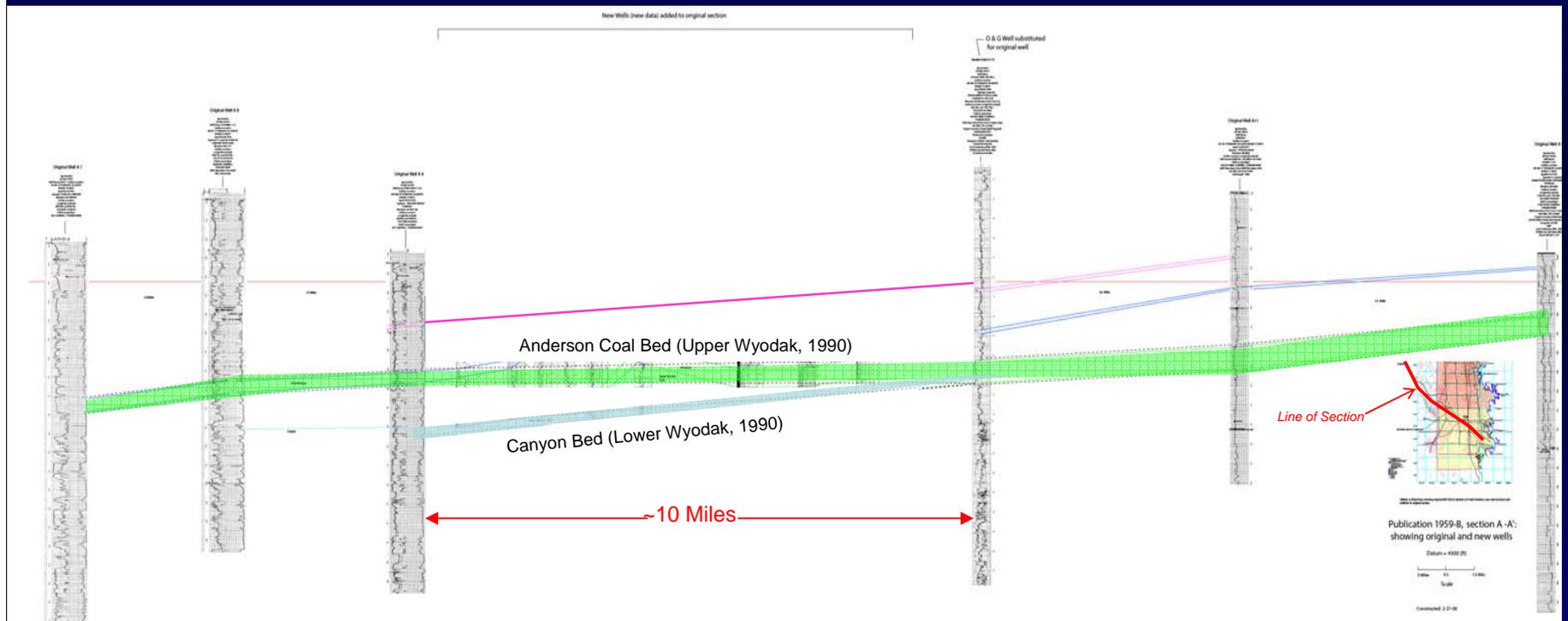


Figure 18. A portion of a published NW-SE cross section through the channel area based on widely-spaced well logs (Pierce, F. W., and others, 1990).

Correlation Changes with Infill Drilling (USGS Miscellaneous Investigations Series, Map I-1959-B)

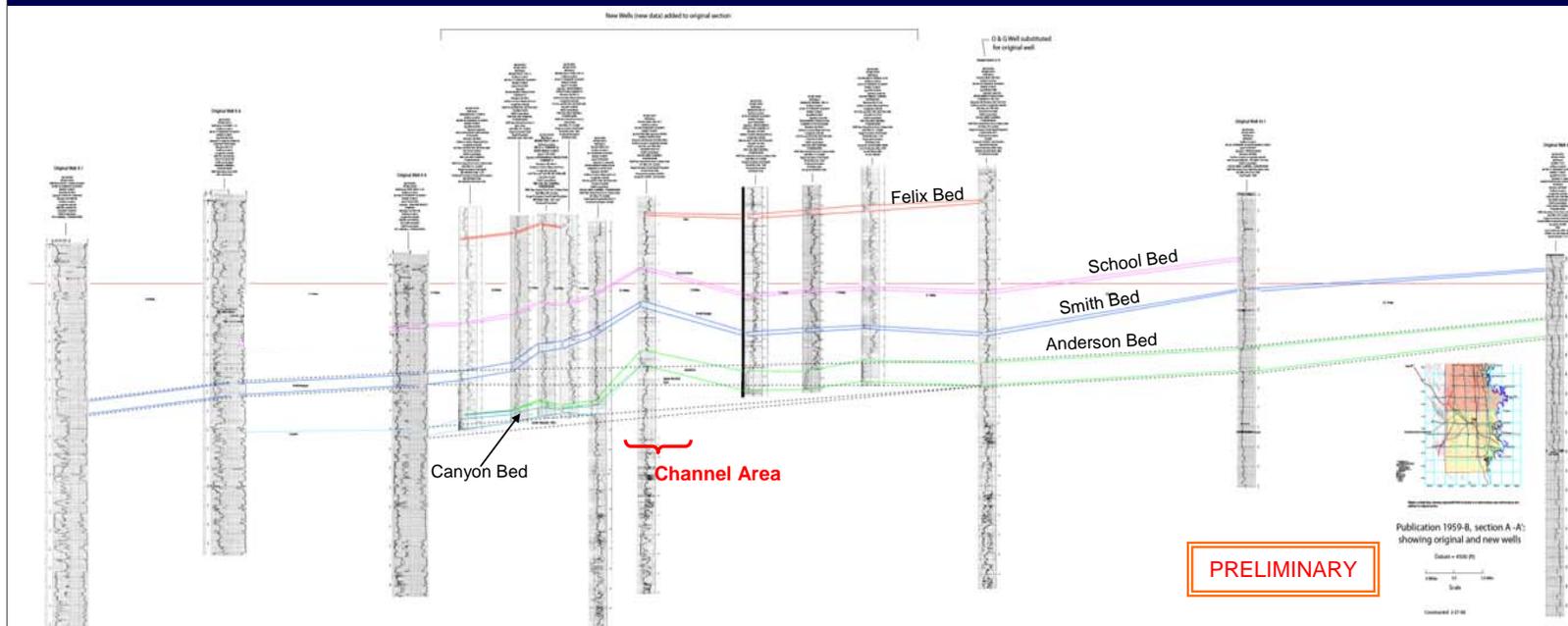
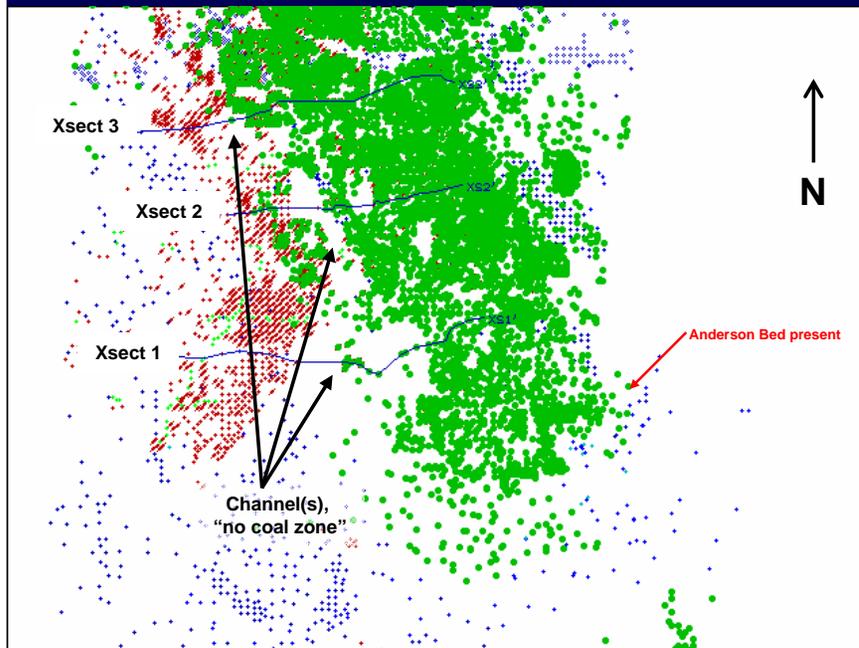


Figure 19. Closer-spaced drilling reveals minor revisions in the coal bed correlations. Dotted lines indicate previous correlations. The Anderson/Canyon coal beds, which are the major beds in the current mining areas of the Gillette coal field split, thin, and (or) are absent in and immediately adjacent to the channel areas. The Smith coal bed thickens rapidly west of the major channel area. Both the Smith and the Anderson/Canyon beds are all part of the Anderson-Wyodak coal zone after Flores and others (1999).

East-West Cross Sections Through Channel area



PRELIMINARY

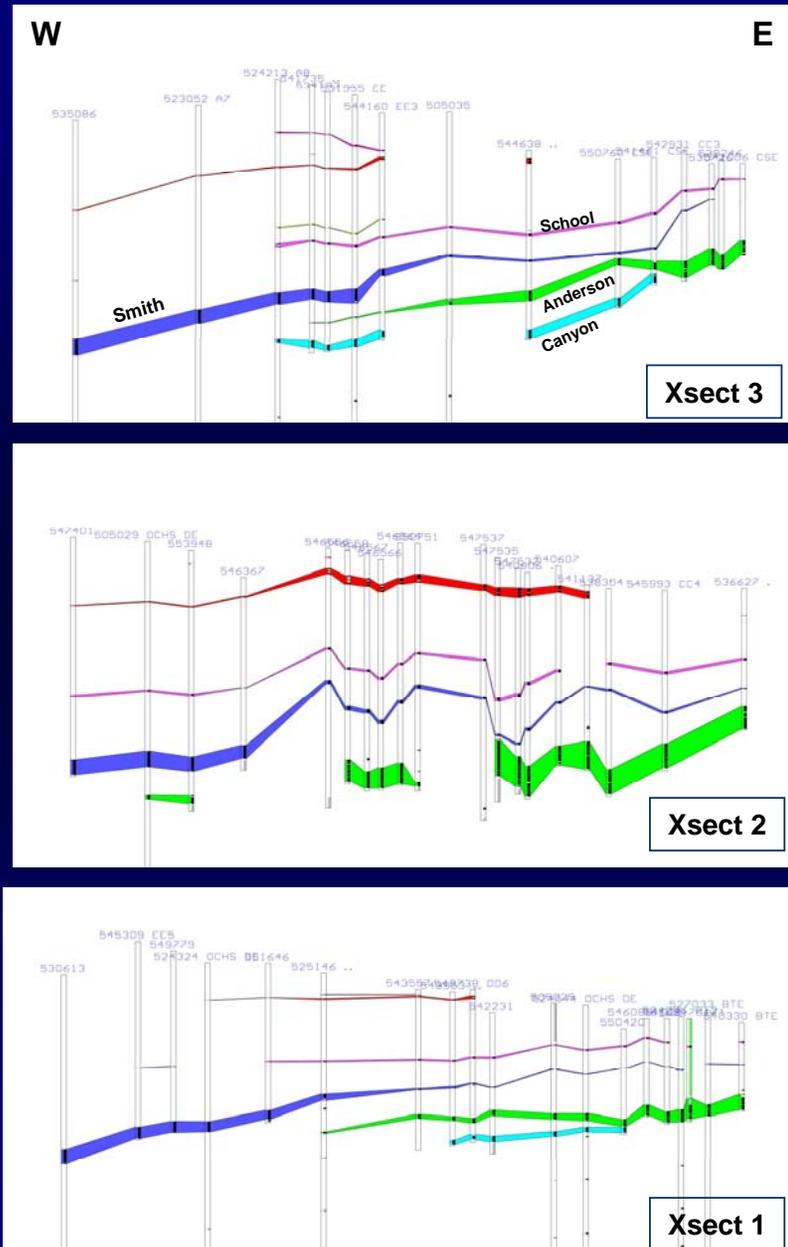


Figure 21. East-west cross sections through the channel confirm the scenario shown in figs. 19 and 20 where the Smith thickens and the Anderson/Canyon (Wyodak) beds are thin or absent westward. Drill holes with the Anderson bed present are displayed with a solid green dot to create a simple areal distribution map. Structural highs in the Smith coal can indicate the presence of an underlying Wyodak “no-coal zone” (Ashley, M., 2006).

Comparison of Anderson Bed - 2002 Study and Current Assessment

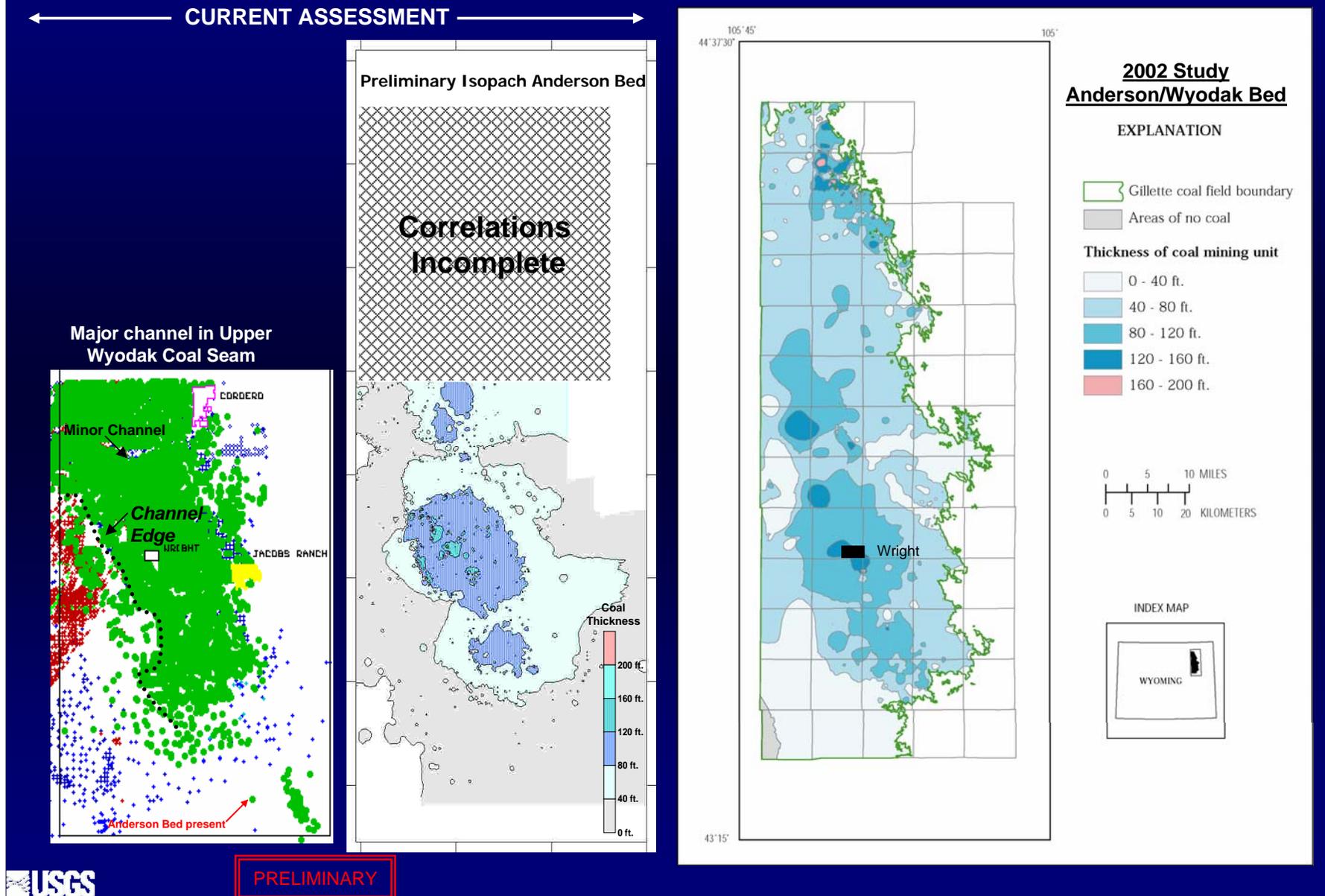
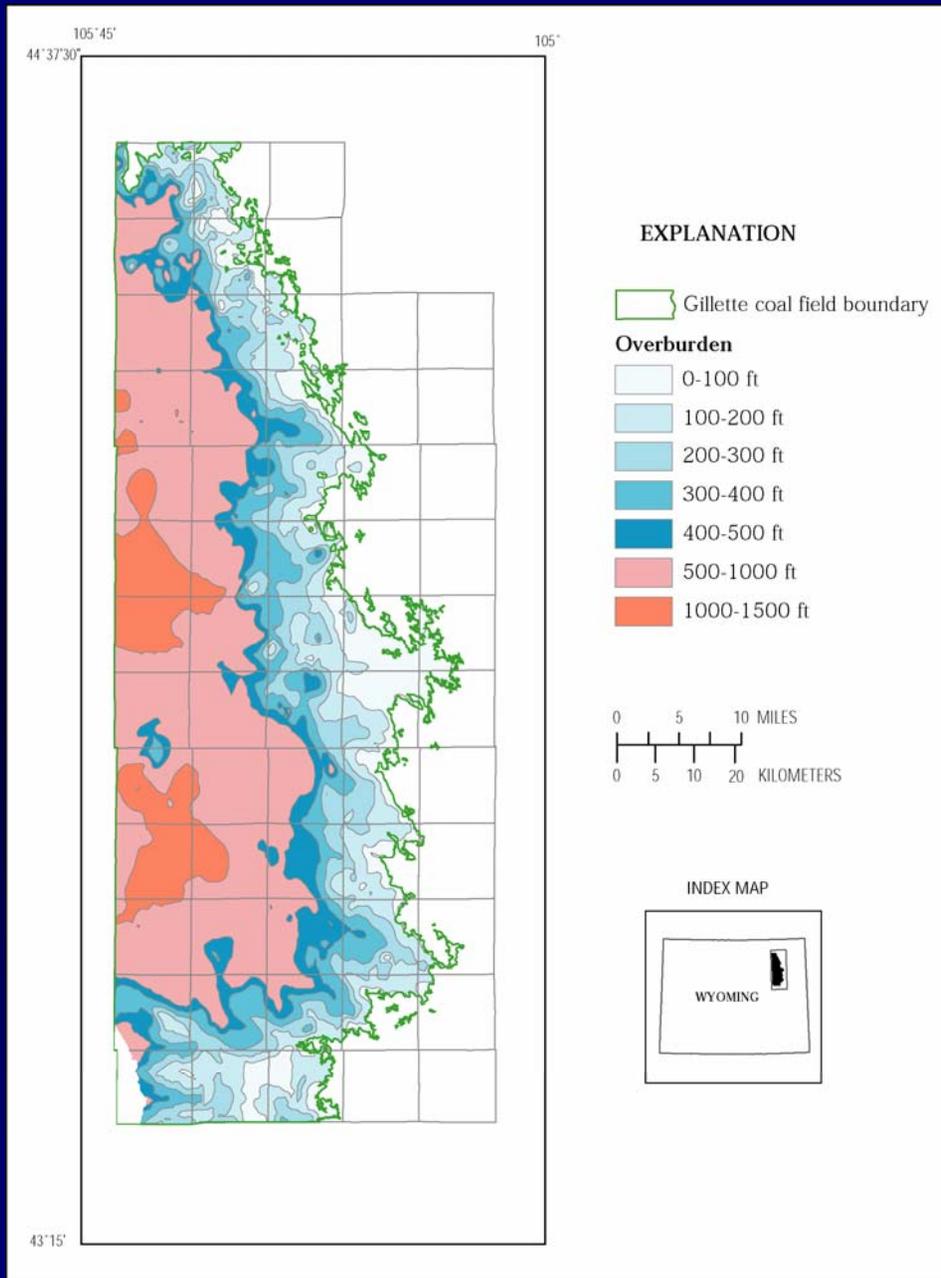


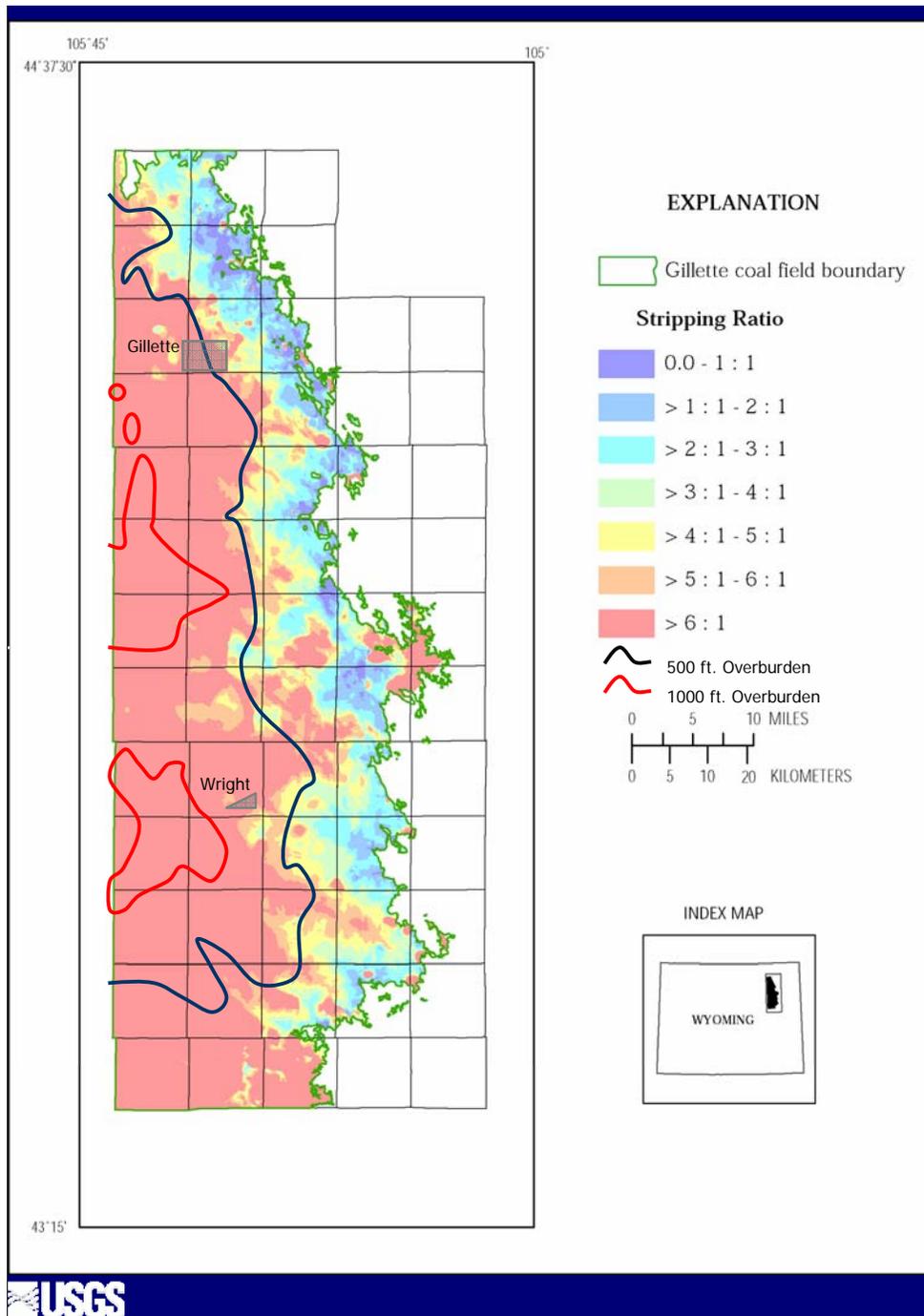
Figure 22. Comparison of a preliminary isopach map from the current assessment and that from Ellis and others, 2002. It is obvious that the total coal resources in the final assessment results will be impacted by improved delineation of the channel areas. The end results should provide a more realistic appraisal of the available coal resources.



Overburden Isopach Gillette Coalfield (Upper Wyodak)

(2002 Study
Anderson - Wyodak Bed)

Figure 23. Overburden isopach for the Anderson/Wyodak bed (Ellis and others, 2002). Fortunately, much of the major channel lies in areas of deeper cover in the western portion of the coal field.



Stripping Ratios Gillette Coalfield (Upper Wyodak)

(2002 Study
Anderson - Wyodak Bed)

Current Assessment will
include models down to 10:1
Stripping Ratio

Figure 24. Stripping ratio map for the Anderson/Wyodak bed (Ellis and others, 2002). We plan to conduct an economic evaluation of the Gillette coal field down to a 10:1 stripping ratio during the current coal assessment.

Powder River Basin Study Areas

- Gillette coal field
- Birney-Custer-Recluse coal fields (BCR)
- Sheridan-Birney coal fields

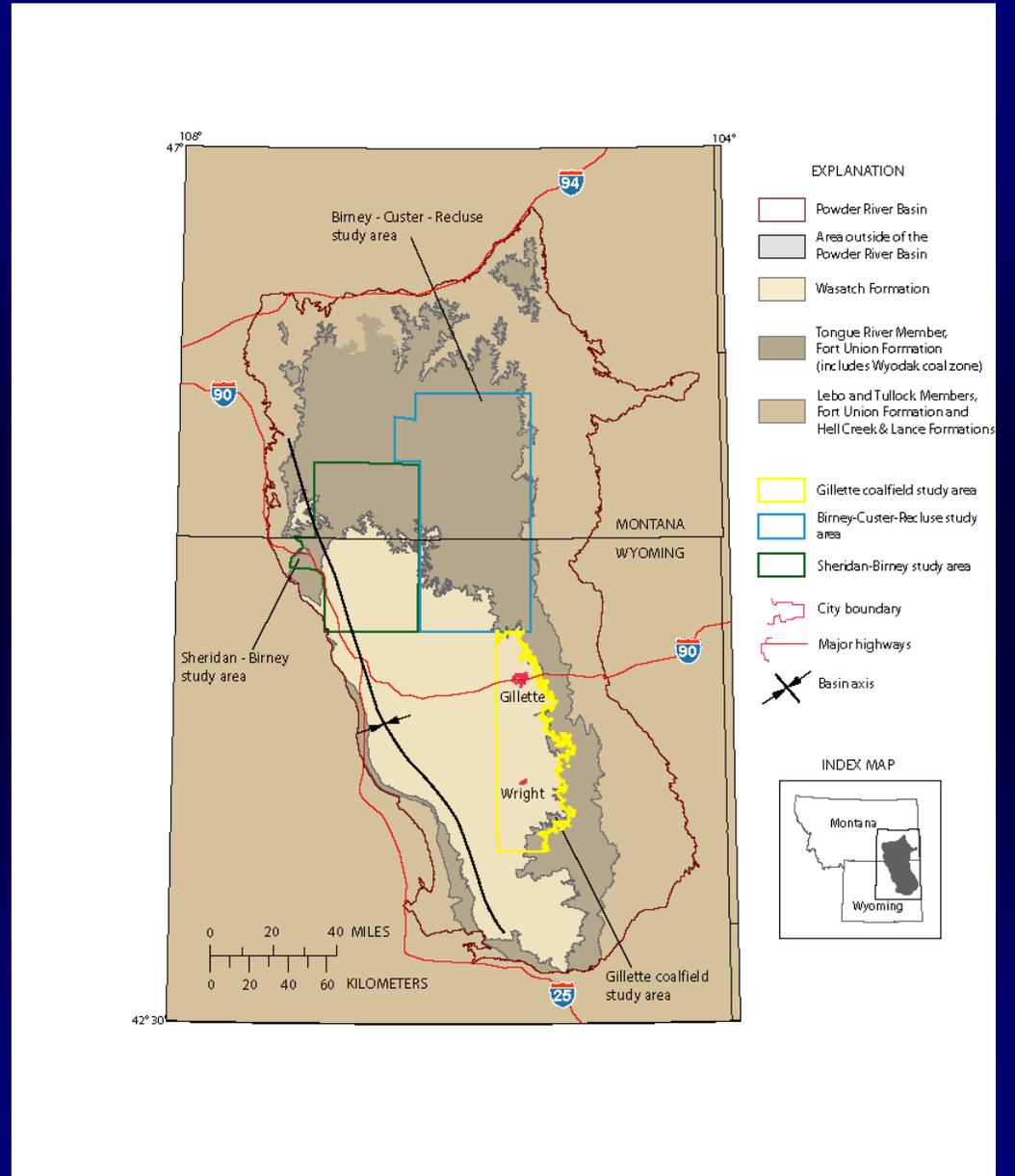


Figure 25. Once the Gillette coal field portion of the PRB is completed, the assessment will move to the north and the northwest into the Birney-Custer-Recluse (BCR) and Sheridan-Birney coal fields.

North-South Cross-Section BCR Study Area

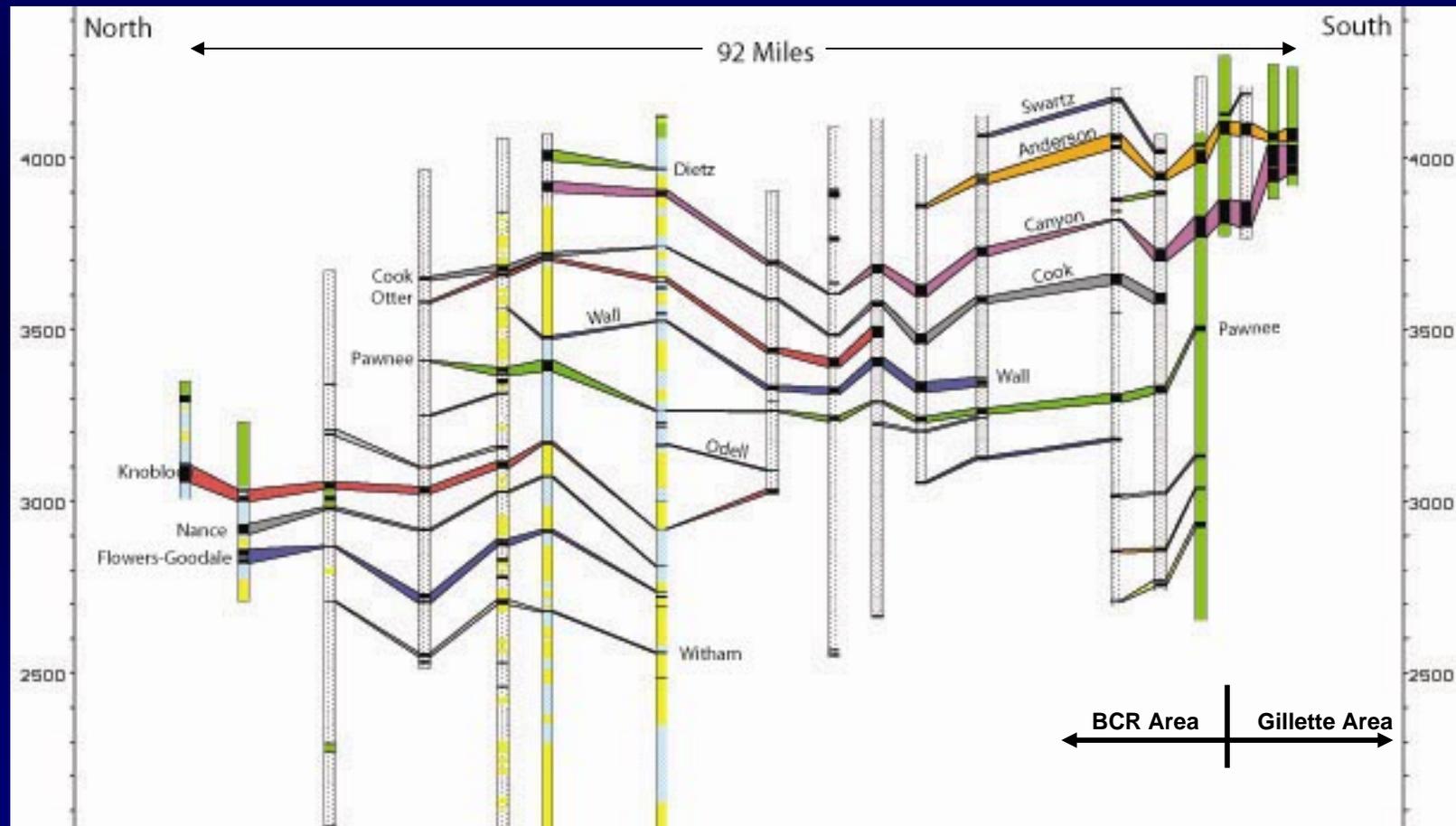
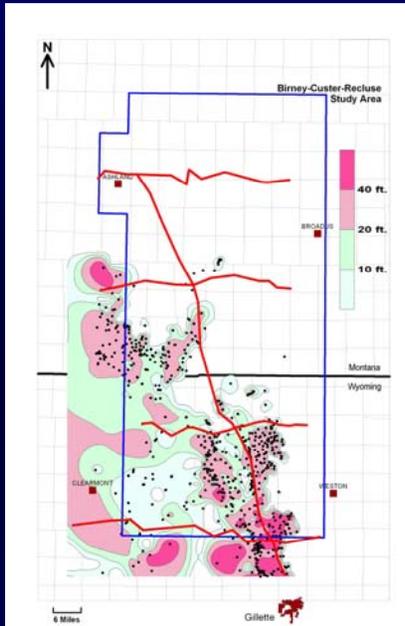


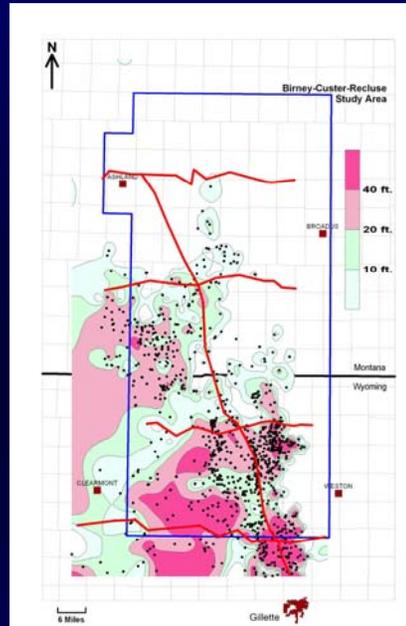
Figure 26. The coal beds including the Anderson and Canyon beds tend to thin northward from the Gillette coal field; however, more coal beds are generally present.

Major Coal Bed Distributions in the BCR



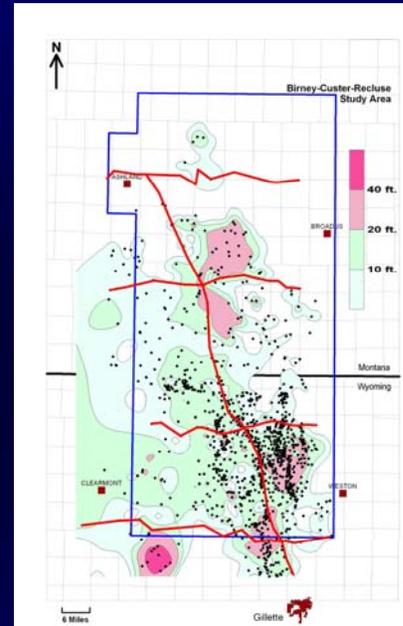
Anderson Isopach

- Maximum thickness = 86'



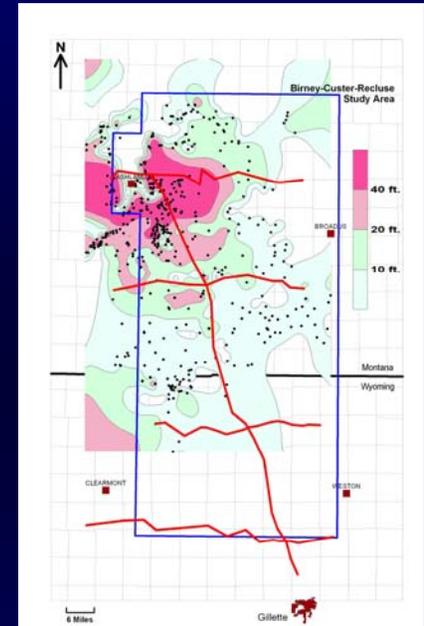
Canyon Isopach

- Maximum thickness = 98'
- Good extent
- Significant areas with thick coal



Pawnee Isopach

- Maximum thickness = 48'
- Good extent



Knobloch Isopach

- Maximum thickness = 79'
- Good extent
- Truncated to south

PRELIMINARY



Figure 27. Although the coal beds are generally not as thick and widespread as those in the Gillette coal field, significant coal resources are present in the BCR coal field.

PRB Coal Resource Assessment Summary

- Extensive CBM and additional oil and gas development, especially in the Gillette coal field, has provided an unprecedented amount of down-hole geological data.
- Better definition of channel/no-coal areas that form barriers to mining will be possible.
- These additional data will provide a more robust evaluation of the single most productive U.S. coal basin.
- The Gillette coal field assessment, including the mining economic evaluation, is planned for completion by the end of 2006.
- The geologic portion of the coal assessment work will shift to the northern and northwestern portions of the PRB before the end of 2006 while the Gillette engineering studies are finalized.



Figure 28. PRB Assessment Summary.

References

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Figure 29. References