Reporting of Exploration Results, Resources, and Reserves

An Update

Brian Groff

11 September 2020

Leadership

- Passing of Dr. Harry Parker on December 19th, 2019.
- Ian Douglas stepping down from CRIRSCO
- Don Hulse (Gustavson & Associates) and Brian Groff (Groff Engineering)
    - Co-chairs to the SME Resources & Reserves Committee
    - U.S. Representatives to CRIRSCO

CRIRSCO

- 32nd Annual PEM on September 6th, 2019
- CRIRSCO Annual Meeting was September 11th, 2019
  - Held at NMA headquarters in D.C.
  - Representatives from CRIRSCO, SME, NMA, USGS, and SEC attended.
  - Presentation from SEC staff members. Recording is available online at SME’s page for the SME Guide.
- New CRIRSCO template announced in November 2019
  - Reformatted for easier reading
  - Greater emphasis on sustainability
  - Commodity specific guidance in new appendices
- Virtual Annual Meeting September 14-19, 2020

SME Resources and Reserves Committee

- Committee meeting at the SME Annual Conference in Phoenix, AZ, in February 2020.
- Next revision to the SME Guide in progress
  - Coronavirus pandemic has slowed the process
- Numerous requests from National Reporting Organizations (NRO) for SME to recognize them as foreign Recognized Professional Organizations (RPO) have been received.
  - SME Registered Member (RM) status is one way to have “reciprocity” in other jurisdictions.
  - Does not exempt RM’s from any licensure requirements in foreign jurisdictions.
- Formal requests to the SEC from the NMA, SME, and NSSGA(?) to extend the transition period to S-K 1300 one year.

SEC

- S-K 1300 reporting requirement after January 1st, 2021
    - First fiscal year beginning on or after 1/1/2021
    - For calendar registrants, registration statement filed on or after 1/1/2021 or annual report for year ended 12/31/2021.
- Approximately five disclosures are in final review.
- No technical reports are available for viewing yet, but search EDGAR for “Exhibit 96.1”
- Registrants who read and follow the rule will not have much difficulty with SEC staff review.
    - Read and follow the rule.

Search “Modernization of Property Disclosures for Mining Registrants” in the Federal Register, published 12/26/2018. The final rule is also in the eCFR: 17 CFR 229.601(b)(96) and 229.1300 et. seq. The FR version provides context.

University of Kentucky
Department of Mining Engineering

Coal Geology and Assessment of Resources and Reserves in the Greater Green River Basin, Wyoming

Methodology

Steven Schafrik, Anastasia Xenaki

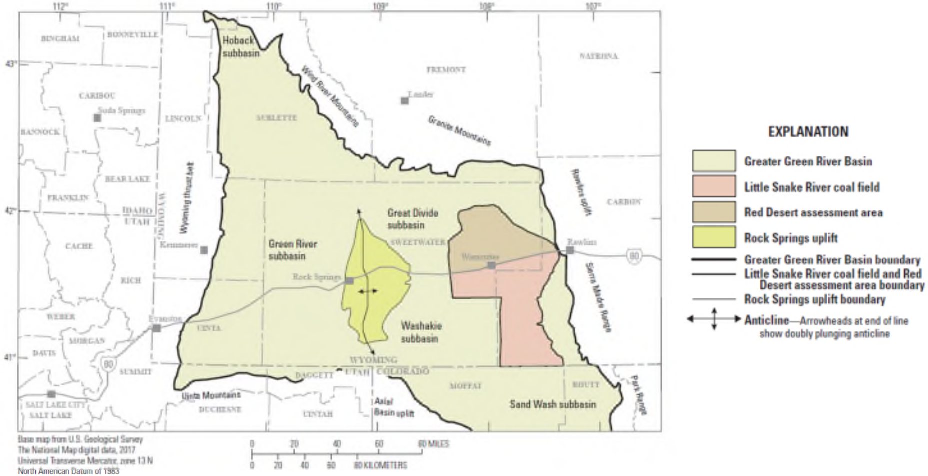
11 September, 2020

Disclaimer and Information

- "...neither a registrant nor its qualified person may use Circulars 31 and 891 to classify mineral resources when providing the disclosure required under subpart 1300."
  - Source: 83 Fed. Reg. 66,388 E.5.(iii) [May 30, 2018]

- Much of this presentation is based on the methodology described in this USGS Publication, published in 2019, but technical reviewed in 2017

Area of Study



Base map from U.S. Geological Survey
The National Map digital data, 2017
Universal Transverse Mercator, zone 13 N
North American Datum of 1983

Introduction

- Principal Report Objectives
    - Conduct regional-scale coal resources and reserve assessments of major coal beds in the United States
    - Update of the U.S. Energy Information Administration
    - Correlation of all significant coal beds within an assessment area. The coal beds must meet the minimal thickness and areal extent criteria to calculate resources and (or) reserves.

Methodology Outline

Phase I
Data Collection

- Coal bed **geology** (extent, thickness, partings, structure, overburden)
- Factors affecting **extraction** of coal (land-use and technical restrictions)
- State and county **jurisdiction** and coal **ownership**
- Coal **quality** information
- Coal **sales** price, tax information

Phase II
Geological Modeling

- **Correlate** coal beds
- Create **coal bed models**
- Use **geographic information systems** to define land-use and technical restrictions by bed

Phase III
Calculation of resources and reserves

- **Calculate** tonnages for original resources, mined out areas and restricted areas
- **Calculate** available **resources**
- Create **mine models** to **determine** reserves
- Calculate **mining costs** for remaining resources

What happens when in smaller scale

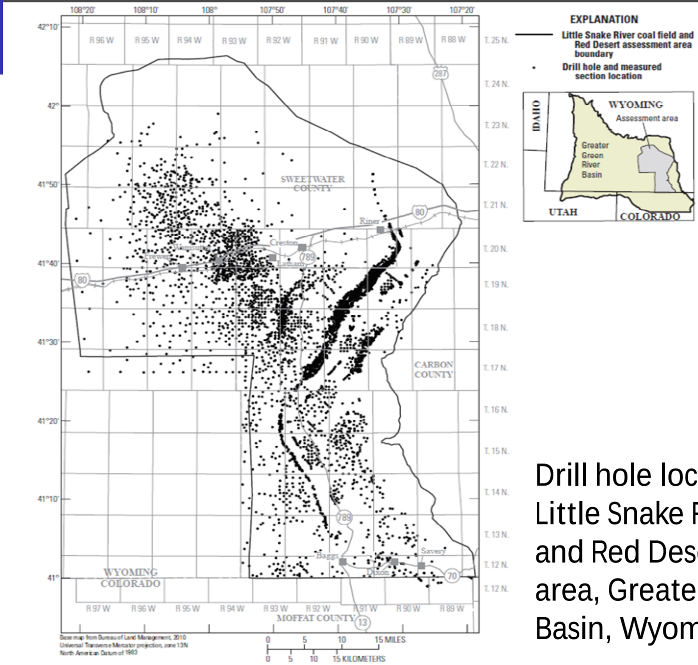
Phase I
Data Collection

- Coal quality information evaluation is important as many components can be distinguish, whose combination build to a complex notion for which several theoretical frameworks can be considered.
- Coal **sales** price, tax information etc. increases due to high competition.

Phase III
Calculation of resources and reserves

- High measurement uncertainty. Less data information increases the degree of uncertainty.
- “All models are wrong but some are useful”.
- Field data collection costs are reduced.
- Importance of ensuring accurate and appropriate data collection.

Phase II
Same as Large Scale



Drill hole locations in the Little Snake River coal field and Red Desert assessment area, Greater Green River Basin, Wyoming.

Drill Hole Data II

- Why do we need an **accurate database**?

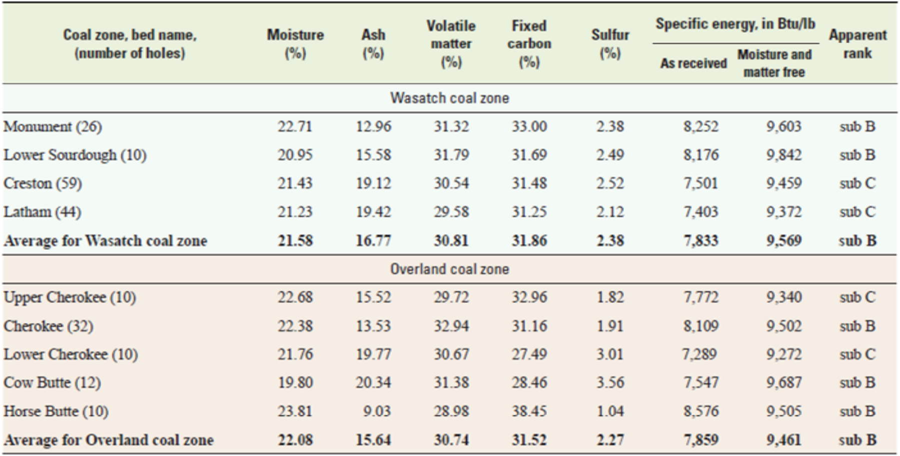
  A drill hole database is the primary source of information for the assessment. Geological correlations and subsequent models are based on this database.

- How to ensure **accuracy** in **data collection processes**?

  1. Quality assurance - activities that take place ***before*** data collection begins.
  2. Quality control – activities that take place ***during*** and ***after*** data collection.

Coralyn W. Whitney, Bonnie K. Lind, Patricia W. Wahl, Quality Assurance and Quality Control in Longitudinal Studies, Epidemiologic Reviews, Volume 20, Issue 1, 1998, Pages 71–80, https://doi.org/10.1093/oxfordjournals.epirev.a017973

Coal Quality Data



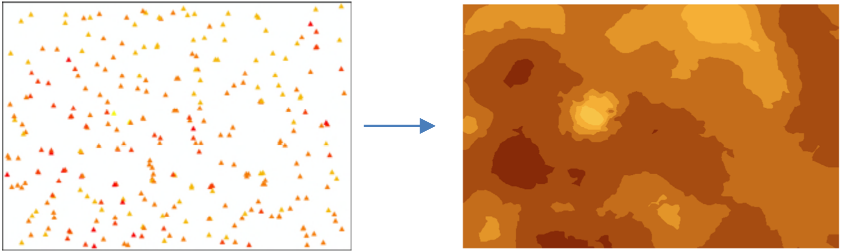
Coal zone, bed name, (number of holes)	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)	Sulfur (%)	Specific energy, in Btu/lb		Apparent rank
						As received	Moisture and matter free	
Wasatch coal zone								
Monument (26)	22.71	12.96	31.32	33.00	2.38	8,252	9,603	sub B
Lower Sourdough (10)	20.95	15.58	31.79	31.69	2.49	8,176	9,842	sub B
Creston (59)	21.43	19.12	30.54	31.48	2.52	7,501	9,459	sub C
Latham (44)	21.23	19.42	29.58	31.25	2.12	7,403	9,372	sub C
Average for Wasatch coal zone	**21.58**	**16.77**	**30.81**	**31.86**	**2.38**	**7,833**	**9,569**	**sub B**
Overland coal zone								
Upper Cherokee (10)	22.68	15.52	29.72	32.96	1.82	7,772	9,340	sub C
Cherokee (32)	22.38	13.53	32.94	31.16	1.91	8,109	9,502	sub B
Lower Cherokee (10)	21.76	19.77	30.67	27.49	3.01	7,289	9,272	sub C
Cow Butte (12)	19.80	20.34	31.38	28.46	3.56	7,547	9,687	sub B
Horse Butte (10)	23.81	9.03	28.98	38.45	1.04	8,576	9,505	sub B
Average for Overland coal zone	**22.08**	**15.64**	**30.74**	**31.52**	**2.27**	**7,859**	**9,461**	**sub B**

Part of the typical proximate analysis on a raw, as-received basis reporting calorific value, moisture, sulfur, ash, fixed carbon, and volatile matter for coal beds in the Little Snake River coal field and Red Desert assessment area, Greater Green River Basin, Wyoming.

Coal Bed Mapping

Data points

Continious surface from set of points



Input

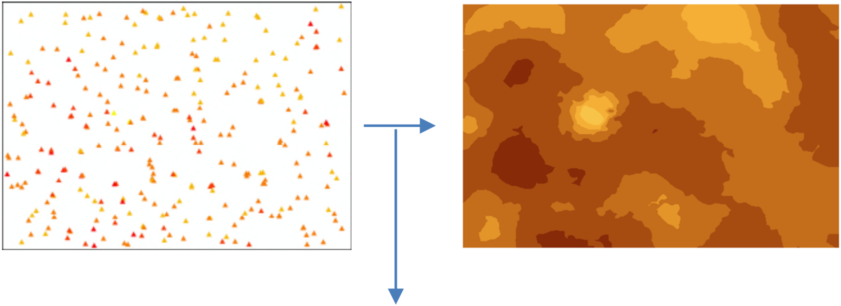
Process

Output

Example: concentration of gold in western Pennsylvania at a set of 200 sample locations.

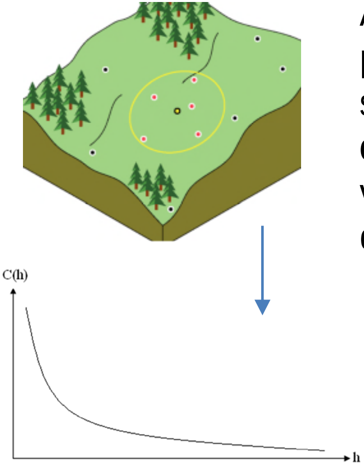
Coal Bed Modeling I: Ordinary Kriging I

- **Create a prediction surface for the same studied region using the available set of sample locations.**



Ordinary Kriging (OK)

Coal Bed Modeling I: Covariance I



As the distance between two points increases, the similarity (i.e., **covariance or correlation**) between the values at these points decreases.

-First Law of Geography

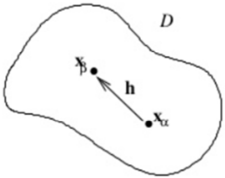
C(h): covariance
h: distance [SI]

Coal Bed Modeling I: Covariance II

In geostatistical techniques, we calculate the distances between the unknown point at which we want to make a prediction and the measured points nearby, and use the value of the covariogram for those distances to calculate the weight of each of these surrounding measured points.

Coal Bed Modeling I: Variogram I

Let h be the vector separating two points in a 2D and vector $\boldsymbol{x} = \begin{pmatrix} \boldsymbol{x_a} \\ \boldsymbol{x_\beta} \end{pmatrix}$, the coordinates of that point.



Comparison of sample values z at a pair of points (Semivariance):

$$\gamma(h) = E\left[\frac{(z(x_i) - z(x_i+h))^2}{2}\right]$$

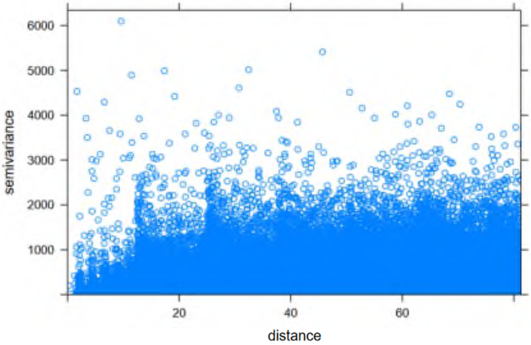
Coal Bed Modeling I: Variogram II

- $z(x_i)$: is the value of the target variable at some sample location
- $z(x_i + h)$: is the value of the neighbor at distance $(x_i + h)$.

- Suppose that there are n point observations, this yields $n(n-2)/2$ pairs from which a semivariance can be calculated.

Steps

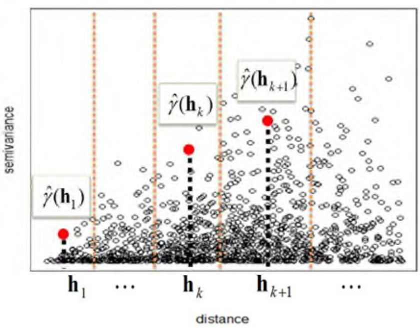
1. From the known values at various locations throughout the studied area, we can plot all semivariances versus their distances, which will produce a variogram cloud.

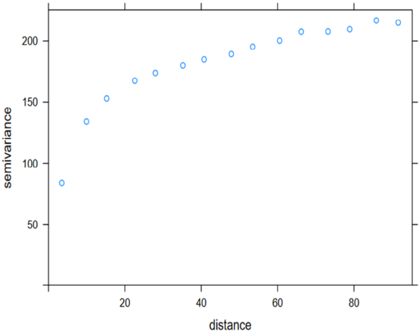


Note: A variogram can be influence by how points are collected into lag groups

Steps

2. For the ease of interpretation, values are averaged for a standard distance, called ***lag***. This comprised the standard experimental variogram.





Note: It is usually expected in this plot is for semivariances to be smaller at short distances, and to stabilize at some point. In this case, these values tend to reach a global value.

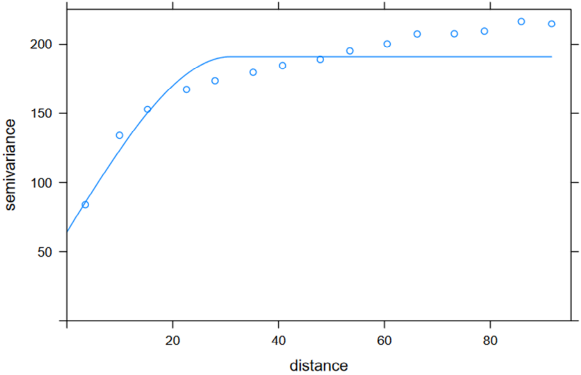
Lag Distance

- Lag distance is controlled by two features
  - Distance between samples
  - Variability of the dataset

- A good rule is to use a lag spacing of half the average nearest neighbor distance
- Don’t pick a distance a lot smaller than the distance between your samples, you will have zero value bins
- Don’t pick a distance longer than any periodicity, you will miss the phenomenon

Steps

3. Once the experimental variogram is calculated. It must be fitted to a variogram model (this case, the Spherical).



The curve-fit is subjective

Coal Bed Modeling I: Variogram IO

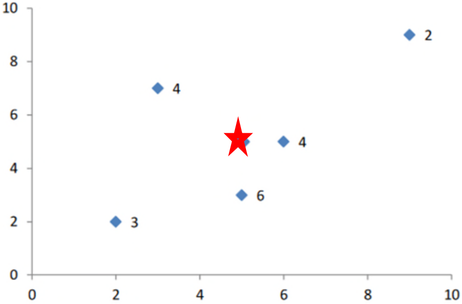
But what is a variogram anyway?

A **variogram**, might be thought of as "***dissimilarity*** between point values as a function of **distance**", such that the dissimilarity is greater for points that are farther apart.

-Eugene Brusilovskiy

At some point you have too many lags

Calculation Example



Location (x,y)	z	D to (5,5)
(2,2)	3	4.2426
(3,7)	4	2.8284
(9,9)	2	5.6569
(6,5)	4	1.0000
(5,3)	6	2.0000

Data configuration

Different possible measurement locations

Calculation Example II

- h is known, in previous table.

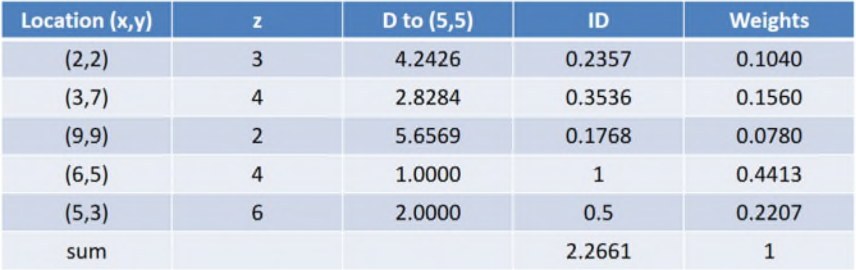
Variogram (γ) calculation:

$$\gamma(x_1, x_2) = \frac{(z_1 - z_2)^2}{2}$$

x: spatial placement in simple words, "where it is geographically"

z: measured values

Calculation Example II



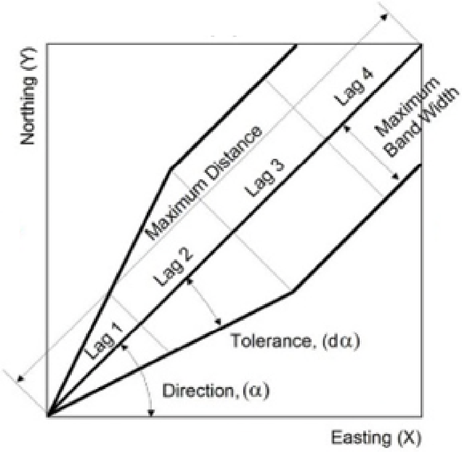
Location (x,y)	z	D to (5,5)	ID	Weights
(2,2)	3	4.2426	0.2357	0.1040
(3,7)	4	2.8284	0.3536	0.1560
(9,9)	2	5.6569	0.1768	0.0780
(6,5)	4	1.0000	1	0.4413
(5,3)	6	2.0000	0.5	0.2207
sum			2.2661	1

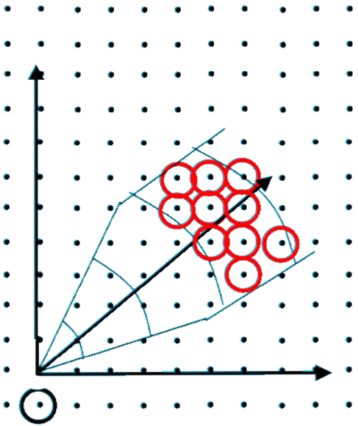
Weights were calculated using the Least Squares method

- Value at (5,5) = $\sum_{k=1}^{5} weight_i * zi$= 4.3985

Calculation Example III

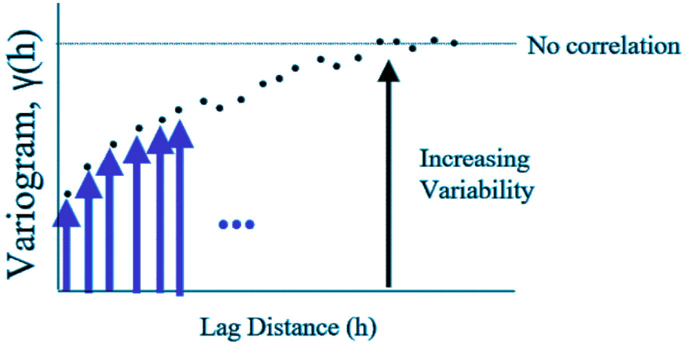
$$\gamma(h) = \frac{\sum_{N(h)} \underline{[z(u) - z(u+h)]}^2}{2N(h)}, \quad N(h): Number\ of\ elements\ in\ a\ set$$





Calculation of Variogram VII

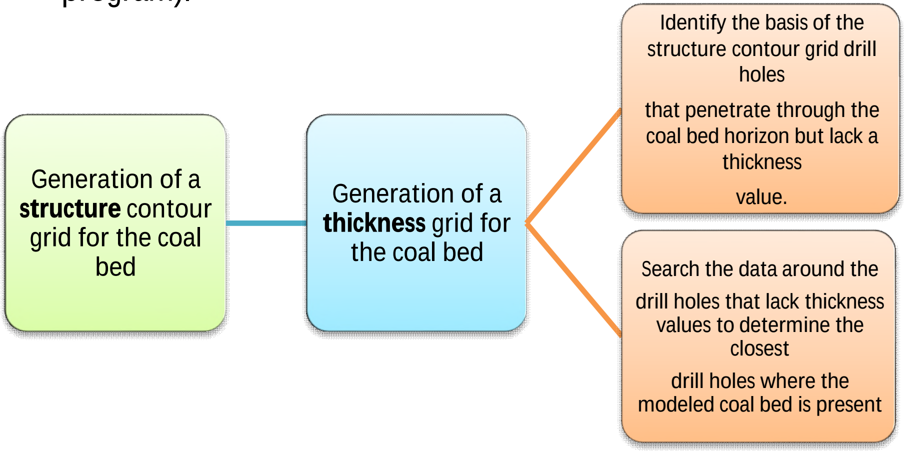
When repeating the process for all nodes ...



Source: http://www.statios.com/Resources/04-variogram.pdf

Coal Bed Modeling II

- Generate coal thickness grids using PC/Cores* (software program).



Generation of a **structure** contour grid for the coal bed

Generation of a **thickness** grid for the coal bed

Identify the basis of the structure contour grid drill holes

that penetrate through the coal bed horizon but lack a thickness

value.

Search the data around the

drill holes that lack thickness values to determine the closest

drill holes where the modeled coal bed is present

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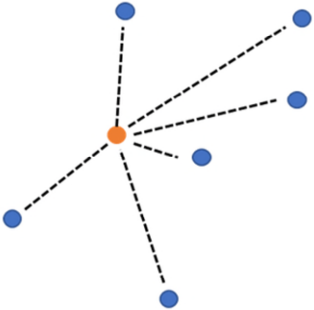
* *Mentor Consultants, 2005, PC/Cores: Glen Ellyn, Ill., Mentor Consultants software.*

Coal Modelling III

- The thickness values from those closest drill holes were applied to the thickness grid as negative values for the drill holes without thickness values. This process is known as "negative pinching" and results in the thickness .

<u>Advantage:</u>

A slightly more conservative of coal bed areal extent; especially where data points are more widely spread.



Coal Modeling IV

- Generation of depth cover grids for individual coal bed was based on the following criteria: Depth of cover grids for individual coal beds were
  - 0 to 300 ft; these are resources that could be extracted using **surface** mining methods.
  - 300-3,000 ft; these are resources that could be extracted using **underground** mining methods.

Coal Modeling V: Method of Exclusion Polygons

- Each exclusion polygon categorizes the assessment area into specific themes.
- GIS Themes: land-use restrictions, technical restrictions, and coal ownership
- Individual exclusion polygons of the land-use and technical restrictions are combined into the composite exclusion polygon
- This composite exclusion polygon was then overlaid on the thickness maps showing the areal extent of each individual coal bed.
- Determines the available and recoverable coal resources within the assessment area on a bed-by-bed basis according to all categories.

Coal Bed Assessment I

- At least 55 named coal beds were identified through correlations.
- Only 33 had sufficient areal extent and thickness to calculate meaningful resource numbers.
- The primary criteria used in this study to assess coal beds was an areal extent of at least 2 mi^2 with an average thickness of 3 ft or greater.
- The sequence for surface mining starts with the youngest beds at the ground surface.

Resources and Reserves

- Importance to determine the coal reserve base in all major U.S. coal basins. Those have to meet specified minimum criteria related to current mining and production practices, including those for quality, depth, thickness, and rank.

- Reasonable potential for becoming economically recoverable within planning horizons that extend beyond those which assume proven technology and current economics.

Coal Resource Assessment Methodology

I. PC/Cores models to ASCII grids and then exported to ArcMap.

Calculation of coal resources was converting the grids for surface topography, thickness, top of coal elevation, and base of coal elevation for each coal bed

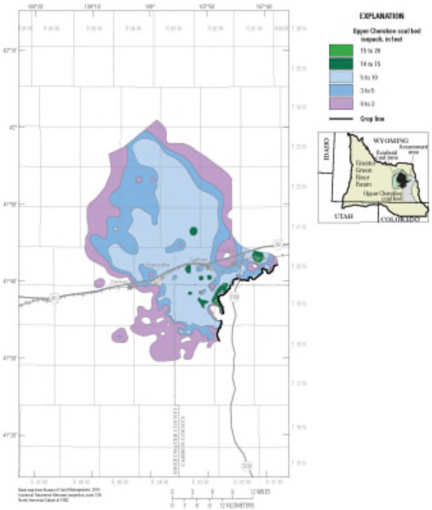
II. Partings in the coal beds were excluded from the coal resource calculations.

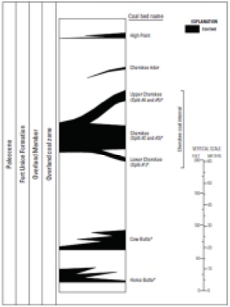
Original coal resources were calculated for all coal beds that are at least 3 ft thick. Coal resources under land-use (environmental) and technical restrictions were then subtracted from the original resource to determine recoverable resources.

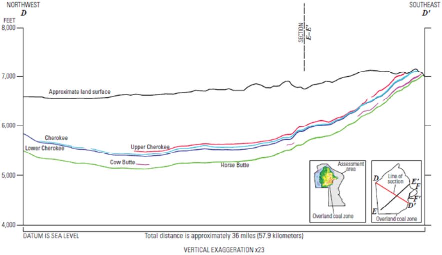
This Reports Output

- “Recoverable coal resources are essentially equivalent to coal resource categories included in the EIA’s Estimated Recoverable Reserves (ERR) database”

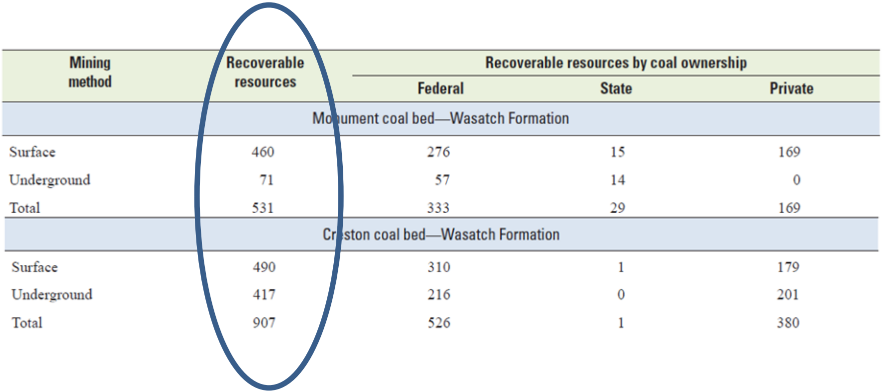
Resulting Maps







Reporting



Mining method	Recoverable resources	Recoverable resources by coal ownership		
		Federal	State	Private
Monument coal bed—Wasatch Formation				
Surface	460	276	15	169
Underground	71	57	14	0
Total	531	333	29	169
Creston coal bed—Wasatch Formation				
Surface	490	310	1	179
Underground	417	216	0	201
Total	907	526	1	380

Conclusions

- This is the first study, there are more in the pipeline
  - These intended to impact EIA's resource calculations

- This USGS methodology is not currently used for local resource studies, more reports of this nature are in the pipeline for all of the major coal basins

- Classifications of Error
  - Stop using CIR 891
  - Qualified Person is responsible
  - SIR 2014-5196 Modeling Uncertainty in Coal Resource Assessments, With an Application to a Central Area of the Gillette Coal Field, Wyoming

    https://pubs.usgs.gov/sir/2014/5196/

SME
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See you tomorrow (Saturday, September 12th) for one of the few in-person events that will happen this year

https://carlsonsportingclays.eventbrite.com
Individual registrations available!

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